The Research Council of Norway

Evaluation of Mathematics, ICT and Technology 2023-2024

Evaluation Report for Administrative Unit

Administrative Unit: **Energy and Energy Technology (ENET)**

Institution: **Institute for Energy Technology (IFE)**

Evaluation Committee Institutes

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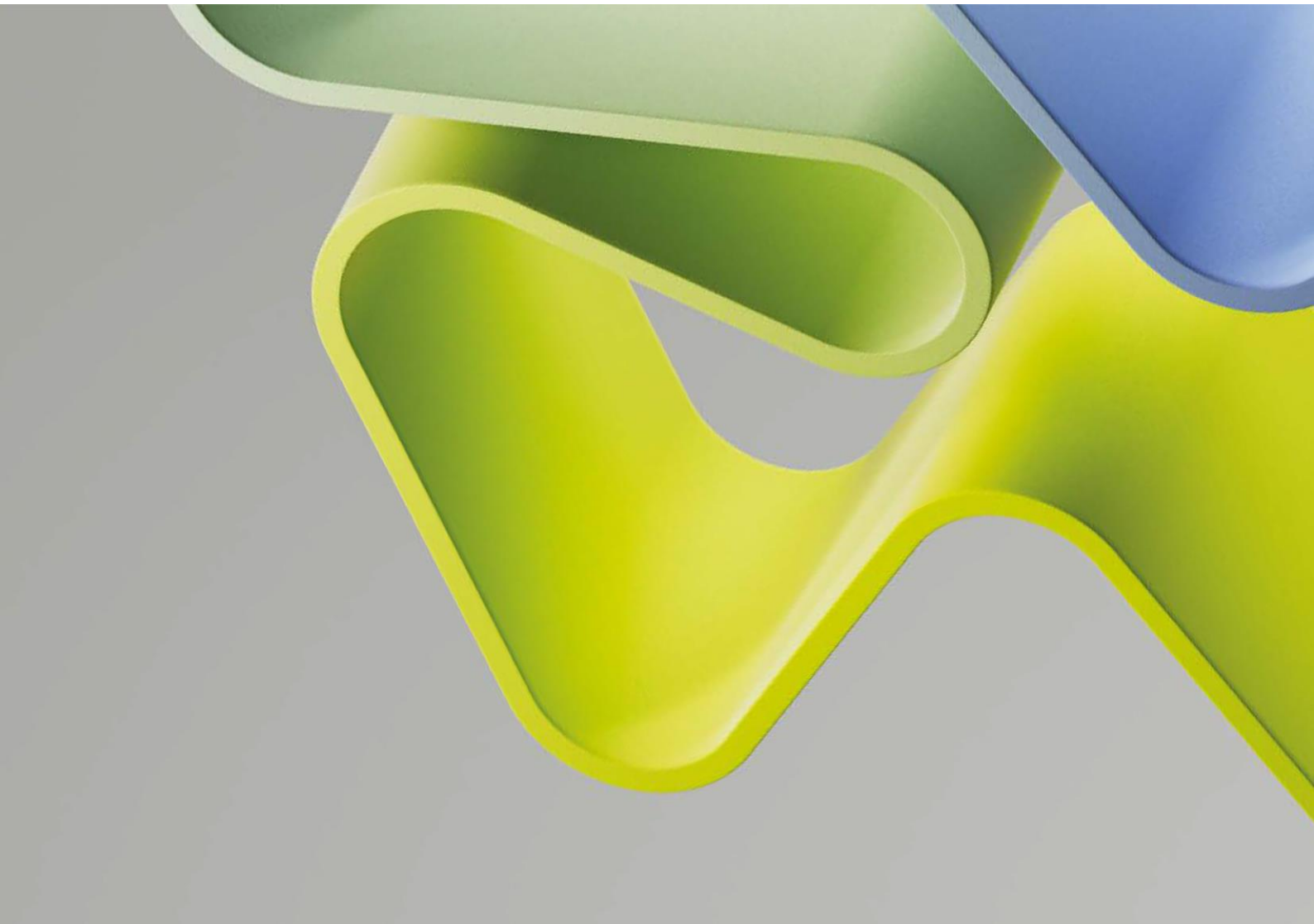

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Statement from Evaluation Committee Institutes

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 units:

- 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:

Professor Krikor Ozanyan (Chair),
The University of Manchester

Professor Kieran Conboy,
University of Galway

Professor Kari Mäki,
VTT Technical Research Centre of Finland

Professor Camilla Hollanti,
Aalto University

Professor Norman Fleck,
University of Cambridge

Professor Anthony Davison,
École Polytechnique Fédérale de Lausanne

Professor Deborah Greaves,
University of Plymouth

Professor Angele Reinders,
Eindhoven Institute of Technology

Description of the Administrative Unit

The Institute for Energy Technology (IFE) is a non-profit, independent research foundation conducting research in the areas of energy, environmental technology, physics, materials science, petroleum technology, nuclear safety and reliability and man-machine systems (man-technology-organisation). IFE is organised into two Research Divisions, one of which is IFE Energy and Environmental technology (ENET), located at Kjeller. The ENET division was established in 2021 after a re-organisation and is now organised into four Research Areas (Energy Materials, Energy Systems, Process Technology and Environmental Technology). The administrative unit has 13 research groups, termed departments, in the 4 research areas of Process Technology, Energy Systems, Energy Materials and Environmental Technology. ENET has submitted 5 research groups for evaluation under EVALMIT.

As of 2022, IFE-ENET employed 182 people in scientific positions (not including administrative or management), including 1 MSc, 47 scientists, 49 Senior Scientist, 13 Principal Scientists, 7 Chief Scientists, 33 Engineers and 3 Chief Engineers. They also have established a separate department for European affairs with 5 FTE employees. Around 30% are female and around 56% hold a PhD.

Their administrative and scientific goals, as set out in their 2022-2026 Strategy, include organic growth, workplace ethics, production of excellent research, presence within the research community, sustainability, development of infrastructure and increasing their EU portfolio of projects.

IFE-ENET engages in international collaboration at the department level, manifesting through research projects. Recently, they have set up a separate department for European affairs, aiming to increase funding from Horizon Europe.

Their large collaborative efforts typically take place within national research centres such as SFI, FME and Petrocenter. IFE-ENET hosts three laboratories that are part of European infrastructure named ECCSEL-ERIC. They note that they have hosted 2 research centres for environmentally friendly energy, with a third centre award in 2024.

IFE-ENET has national collaborations with other research institutes such as SINTEF, NORCE, NIVA and NILU, and extensive academic collaborations with University of Oslo. They name the multiphase flow simulator OLGA as their most important contribution to Norway – paving the way for subsea solutions in the oil industry.

IFE-ENET outline a number of strengths and opportunities that better position them in the future. They identify their laboratories, people, competence and adaptability as internal strengths, and their substantially increasing portfolio of EU projects as an external opportunity. However, they highlight the transfer of IFE's remaining nuclear activities to the government as a large external threat. ENET claim they will be forced to move from their existing labs, with the government providing a loan to cover the cost of a new laboratory. This new laboratory however is likely too small, causing an existential threat for departments in ENET.

Overall Assessment

There is a spectrum in research quality of the research groups. Some have evolved from oil/gas activity and have a legacy of high-quality work and an international reputation in oil/gas. The challenge for the administrative unit is to manage the scope of the research groups so that they do not over-reach themselves, and to help the groups make high quality appointments. Roadmaps and action plans at the level of the research groups will help the admin unit steer the scope of the research group activities. Targeted support can be given by the admin unit to work with researchers on proposals and collaborations in strategic areas. Careful monitoring of the direction of research groups is needed to ensure alignment with the overall strategy. No explanation is given by ENET for their lack of impact case studies; such case studies would provide evidence of the degree of alignment between research group activity and the overall strategy of ENET.

It is imperative for ENET to maintain its high quality labs and the associated highly competent technical staff who can design and construct purpose-built test rigs and apparatus. Both the physical labs. and the accompanying technical staff give ENET its competitive edge. There is a strong argument to expand both labs. and associated staff in order for ENET to achieve its ambition of greater international participation in the particular areas of battery technology, materials technology, hydrogen and its already-established Corrosion Technology department. EU funding is an obvious route to pursue on this. This is achievable due to the evolution of activity of these groups. For example, the Corrosion group has diversified into CCS and hydrogen in a natural manner. This is welcomed by the Evaluation Committee.

The benchmarking of the research groups is diverse in approach but lacking in detail. For example, the benchmarking of the DHT group is heavily focussed on financial profit with insufficient detail on research quality and quantity, and internationalisation. In broad terms the degree of quantitative benchmarking is limited. The admin unit should set benchmarks for research quality.

There is no explanation by ENET for their lack of impact case studies.

The main strengths of the admin unit are as follows.

ENET is ambitious and has expanded by 100 employees over the last 5 years. It has done this in the context of a move from oil/gas to renewables, with 60% of projects in oil/gas that have been lost over the last 2 years, and similarly a 50% loss in funding for the physics of neutron source. ENET is now at its limit of growth due its recent large growth and the fact that its physical space is limited.

The 5 research group reports reveal that the admin unit allows them to function in a largely independent manner, yet helps co-ordinate activities such as equality and diversity, influence of sectorial policy and help in attracting EU funding. The technical autonomy of the research groups makes it challenging for the admin unit to steer the research activities to align with overall research goals.

ENET is attracting more EU funding due to its establishment of a European Affairs Office and the fact that it does relevant research for industry. It behaves in a synergistic manner with its competitor institutes.

ENET is highly successful in its retention of Masters and PhD students: 25% of Maters students and 50% of PhDs are subsequently hired. ENET is popular with students: both nuclear and renewables are attractive topics.

The main weaknesses of the admin unit are as follows.

ENET somewhat lacks a competitive edge over its larger and more established competitors. The Energy activity within ENET is young, and it needs to build up its industrial links. ENET needs a plan to give it a larger set of attractive and distinctive skills in the energy sector. ENET will need to take some business risks in order for it to evolve and survive in the long term. ENET currently re-orientates the focus of research areas that over time become marginalised: this is a reactive approach, and a more pro-active approach is warranted.

ENET lacks floor space, and this limits its opportunities for receiving new industrial clients, as explained in the self-assessment report of the admin unit. The severe reduction in size of facility does place an existential threat on several successful research groups in ENET, as evidenced by the 5 research group reports. The labs. of ENET are its main competitive strength particularly for the Corrosion research group. One issue is whether ENET needs to expand to achieve its core mission. Additional projects may be a mixed blessing: they are useful if they lead to high quality activity and help achieve ENET's mission. The future prospects of the admin unit are therefore good, but the challenge of insufficient floor space is emphasised.

Whilst a basic grant of 10% is a challenge to ENET, it has the merit of making for an agile organisation. It is certainly a challenge for ENET to invest in strategic directions in the energy sector. It does appear that the organisation can compete successfully with its 40% overhead, which is much less than that of many international universities.

As requested in the Terms of Reference, the evaluation committee also evaluated two further aspects of the admin unit – the future strategy, and the extent to which the admin unit will be capable of meeting their targets based the available resources and competence.

The stated strategy of the admin unit is to address societal needs on a national, European, and international level in the 7 areas of Hydrogen, Energy systems, Solar Photovoltaics, Batteries, CCS, Nuclear and Human centred digitalisation.

This strategy is too broad and too diffuse to be achievable. It appears that the actual strategy is to work broadly on energy systems of the above 7 topics in preference to specific detailed research projects on particular topics.

Although wind power is a major opportunity at the national level, it is a highly competitive field and ENET has chosen not to engage with it. This is a strategic decision within ENET. In contrast, Solar has grown and has split into 2 groups (solar systems and solar technology).

The evaluation committee concludes that the resources and competence within the admin unit are sufficient for it to be able to meet the targets of their current activity. The personnel are in place to achieve this, along with suitable equipment.

ENET declares that the departments (that is the research groups) grow organically. Detailed, short-term, concrete plans also exist for each department. It is unclear to the evaluation committee how this balance is maintained between top-down management and bottom-up growth. This is not detailed in any of the research group self-assessment reports.

There is a disconnect between (i) the highly developed strategic plan of the administrative unit and accompanying low-level firm actions ('subgoals') and (ii) reality as expressed by the 5 Research Group assessments.

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

Recommendations

1. The research strategy of the self-assessment report states that the institute's financial situation of low core funding does not lend itself too excessive risk-taking. This is regrettable. A greater degree of ambition is warranted by actively promoting areas that have been identified as ripe for research. This is a relatively low risk strategy given the sphere of research of ENET.

ENET needs to aquire new infrastructure, and make use of national and international infrastructure as needed.

ENET is sufficiently small as an organisation that it does need to be careful in its investment of infrastructure: it cannot afford to make too many mistakes. This is a challenge as there is always risk in new ventures.

ENET has a coherent research strategy to promote research groups that are BOTH leading in Europe and have a potential for growth. ENET management presented itself as effective and dynamic in its control of the number and nature of its research groups. However, there is no mention of this in the research group reports; rather the research group reports suggest that they run their activity in an independent manner with only minor input from the administrative unit.

2. The benchmarking of the research groups is diverse in nature and lacking in detail. For example, the benchmarking of the DHT group is heavily focussed on financial profit with insufficient detail on research quality and quantity, and internationalisation. In broad terms the degree of quantitative benchmarking is rather limited. The admin unit should set benchmarks for research quality.

3. There is a need for benchmarking at the level of the administrative unit. For example, there needs to be a management function to help research groups thrive, and to steer them if the group is too thinly spread (as in the case of SOLTEK and BTD) and to help steer IP issues. It is important for the administrative unit to remain agile and not prescriptive if the research groups are to thrive.

5. Organisation of outreach activity at the level of the administrative unit makes sense and should be continued. It is critical to protect researcher thinking time.

A strategy is needed to ensure competence building, for example by making use of the core grant for this purpose.

6. There are clear and well-established links with strategic partners. There is a need to seek out larger, strategic international collaborations. Many of the Researchers within ENET did their PhDs overseas and so international research networks already exist.

7. ENET must continue to behave in a lean and agile manner if it is to continue to compete for funding, given its low level (10%) of income from basic grants.

8. ENET needs to continue to attract funding from large infrastructure projects such as INFRA from the RCN, and RIA projects from Horizon Europe. A greater presence on the international stage, with appropriate international collaborations, will increase research competence and increase the reputation nationally. This is consistent with the ambition to be nationally leading.

9. ENET needs to be distinctive from its competitors by developing specialist infrastructure and expertise.

10. National infrastructure needs to be carefully managed that it does not generate too much of an administrative burden. The NABLA infrastructure carries a minimal overhead burden as the centre is virtual, but it has the risk that it provides little direct benefit to ENET.

There is benefit in building a greater amount of both national and international infrastructure in order to maintain a leadership position and continue to attract strong job applicants and research contracts.

11. The self-assessment report of the admin unit does not provide any detail on the mechanisms for identifying and implementing short-term actions. There exists an opportunity for stronger alignment between the strategic plan and the actions of the research groups.

12. The use of GitLab for sharing code is welcomed, and work should continue on such data-sharing platforms. This also brings important visibility and marketing elements to ENET.

13. ENET scientists should make every effort to broaden their reach into Universities over a wider range of subject to engage as many of the 13 departments as possible in collaborative research with Universities. The existing collaborative arrangement with University of Oslo (Birkelandsenteret) is a mechanism to stimulate this initiative.

14. A two-way interchange with universities and with industrial clients brings much benefit to both individual employees and to ENET, but it poses challenges to maintain adequate activity on projects.

15. ENET must continue to make its environment attractive to appeal to and retain employees; there is significant competition from other research institutes in the energy sector, from industry and universities. The Evaluation Committee supports the strategy of retraining employees to take on new project areas; to achieve this it is imperative that new hires, as well as existing employees have a broad and deep understanding of their field. ENET is of the view that this is the case, and the data support this in terms of growth and transition in research topics.

1. Strategy, Resources, and Organisation of Research

The strategic *goals* for Energy and Environmental technology (ENET) are:

- To grow organically to increase economic robustness and develop an organisation that delivers cost efficient and high quality services to projects and employees;
- To produce both excellent and relevant research and utilise scientific and technical resources across structural boundaries;
- To become a significant authority within the research community in Norway through active participation and visibility;
- To develop, maintain and operate infrastructure that is leading in an international research market; and
- To increase its EU portfolio and its impact on the European research stage.

There are some quantifiable goals for the admin unit, for example an increase in ENET workforce to 250 employees by 2026. Evidence is lacking to show that this goal will be achieved.

Energy and Environmental technology (ENET) sits within the Institute for Energy Technology (IFE) and is organised in 4 research areas called Energy Materials, Renewable

Energy Systems, Process Technology and Environmental technology. In total, the research areas of ENET comprise 13 groups, termed ‘departments’, each comprising a total of 10-25 scientists, engineers, and technicians. As explained in the self-assessment of the admin unit, the 5 research group submissions sit within the 4 research areas:

- Reservoir Technology sits within Process Technology,
- Hydrogen Technology sits within Renewable Energy Systems (ENSYS)
- Both the Battery Technology group and the Solar Energy Materials and Technology group sit within Energy Materials;
- Environmental Industrial Processes group sits within Environmental Technology.

ENET declares that the departments (that is the research groups) grow organically. Yet, it has detailed, short-term, concrete plans for each department. It is unclear to the evaluation committee how this balance is maintained between top-down management and bottom-up growth. This is not detailed in any of the research group self-assessment reports.

ENET has an additional department for European affairs with 5 FTE employees. Whilst it is true that the level of European research support has increased recently, the extent to which this is due to the activity of this department is not detailed.

There is tension between the time required to manage MSc students and the high internal cost structure. The involvement of MSc students’ needs to be reviewed as MSc students consume much time in their training and their research output is limited. It is unclear how many of these students proceed to employment by ENET.

1.1 Research Strategy

There is a disconnect between (i) the highly developed strategic plan of the administrative unit and accompanying low-level firm actions (’subgoals’) and (ii) reality as expressed by the 5 Research Group assessments. The self-assessment report of the admin unit does not provide any detail on the mechanisms for identifying and implementing short-term actions. This should be clarified in order to bring together stronger alignment between the strategic plan and the actions of the research groups.

The admin unit’s research strategy document (2022-2026) identifies what is needed for high quality productivity in research, and how innovation takes place. However, there is little explicit evidence to demonstrate that this approach is working at the grass-roots level of the Research Groups.

The overall *ambition* of ENET is very broad but is also somewhat generic and imprecise:

(i) A leading provider of research, innovation and value creation in Norway and the EU, and to be a key driver for a resilient, fair and sustainable society.

(ii) Leading test and experimentation facilities in Norway, and International expert in energy and environmental research; and

(iii) Best-in-class workplace attractiveness, and influential in the public debate in our areas of expertise.

There are 6 thematic core ambitions for ENET as identified in the strategy document: Hydrogen, Energy systems, Solar, Photovoltaics, Batteries, and carbon capture and storage (CCS). The relationship between its *research area*s (Process Technology, Energy Systems, Energy Materials and Environmental Technology) and *topics of core ambitions* is unclear. Core ambitions are areas with expertise, but also where there is growth potential.

ENET has identified that growth and current research volume is limited in the areas of Sustainable minerals and metals, Petroleum, Process modelling, and Wind. Has ENET made management decisions to provide less resource to the more mature areas with less potential? In fact, some of these areas are the most successful commercially to ENET and ENET enjoys a high international research presence and reputation in these areas. ENET needs to be decide whether it wants to maintain these areas in the future or wants to force their decline.

The Scientific goal for ENET is to be the best in Norway, and the best in Europe in CO2 flow measurement and materials testing. However, there is no mention in the self-assessment report of the competition and how the admin unit can achieve advantage over the competition in this area.

ENET declares 5 strategic areas in its strategic plan to 2026 (with no information beyond 2026): (i) hydrogen, (ii) energy systems, (iii) solar PV, (iv) batteries and (v) carbon capture and storage (CCS). It desires to be nationally leading in areas (i) –(iv) and best in Europe in CO2 flow and in materials testing aspects of (v).

ENET's self-assessment report states that prioritisation of resources (investments or new hires) are based on market assessments and business plans, in addition to the strategy. It gives the example of investment in a new battery laboratory and associated new hires. In recent years, ENET has invested a substantial amount of its savings in a new battery-laboratory which has driven significant growth in project acquisition, new hires and project-funded investments in the laboratory; this research group was established in 2018 and as of 2023 has 19 permanent researchers according to the Battery Technology Group research report.

Likewise, the Tracer Technology Department has expanded its activities from petroleum to environmental flows of CO2. The ENET self-assessment explains that ENET attempts to achieve these goals by the submission of more research proposals in appropriate areas: this may or may not help achieve the desired goal. Stated plans such as the development of a module design capability for Solar PV is more likely to help achieve a National leadership. Scientific leadership requires quality in addition to quantity, and a strategy is needed to increase research quality. Enhancing the local research environment, and greater links with Norwegian Universities will help in this regard.

ENET has stated that its broad long-term ambition is to become the national leader in a number of areas within the energy sector, but it has given no detail on how it will achieve this in the longer term, in terms of resources and competence. The Evaluation Committee assumes that the current strategy will continue to comprise top-down resource allocation and bottom-up evolutionary development as opportunities arise.

Recommendations to the administrative unit.

- The research strategy of the self-assessment report states that the institute's financial situation of low core funding does not lend itself to excessive risk-taking. This is regrettable. A greater degree of ambition is warranted by actively promoting areas that have been identified as ripe for research. This is a relatively low risk strategy given the sphere of research of ENET.

1.2 Organisation of Research

Only 10% of basic funding is provided. The management style is declared to be hands-off by the administrative unit, and so it is important to have a lean management structure at the top level of the admin unit for financial reasons.

ENET has a coherent research strategy to promote research groups that are BOTH leading in Europe and have a potential for growth.

ENET is ambitious and has expanded by 100 employees over the last 5 years. It has done this in the context of a move from oil/gas to renewables, with 60% of projects in oil/gas lost over the last 2 years, and a 50% loss in funding for the physics of neutron source. ENET is now at its limit of growth due to its recent large growth and to the fact that its physical space is limited.

The ENET administrative unit appears to be of an appropriate size to help the activity of the departments. It is unclear whether the administrative unit provides a service support function to the Departments or manages them. ENET management presented itself as effective and dynamic in its control of the number and nature of its research groups. However, there is no mention of this in the research group reports; rather the research group reports suggest that they run their activity in an independent manner with only minor input from the administrative unit. This indicates that the groups could or should have a stronger degree of support from a central management function to help research groups thrive, and to steer them if the group is too thinly spread (as in the case of SOLTEK and BTD) and to help steer IP issues. BUT it is important for the administrative unit to remain agile and not prescriptive if the research groups are to thrive.

Though there is benchmarking at the level of each of the research groups evaluated under EVALMIT (discussed below), there is no clear benchmarking provided in the self-assessment of the admin unit.

The Evaluation Committee supports the strategy of retraining employees to take on new project areas. To achieve this, it is imperative that both existing employees and new hires have a broad and deep understanding of their field. ENET is of the view that this is the case, and the data support this in terms of growth and transition into new research topics

The administrative unit does little to organise education of masters and PhD students. This is handled at the project level within the departments (that is, the research groups).

The arrangement of a large number (13) of relatively small departments in ENET gives both agility to these departments and self-identity. It also becomes clear quickly when a group is flourishing or struggling.

The research group reports within ENET are:

- Solar Energy Materials and Technology (SOLTEK),
- Battery Technology Dept (BTD),
- Environmental Industrial Processes (DEIP),
- Hydrogen Technology (DHT) and
- Reservoir Technology (DRT).

A summary of the organisational details for each research group is now given in the following paragraphs in order to illustrate the research activity within the ENET admin unit.

SOLTEK conducts photovoltaic research and has expanded from silicon to new solar cell architectures, with new materials, new devices, new collaborations and new financing. There are many international players in this important market. The group is spread thinly and is committed to education and training of young researchers. The group has good facilities, and this attracts international collaboration.

BTD conducts research across the battery value chain, with a focus on material development and battery technology. BTD has no stated strategy in its research group report but receives good support from ENET. The BTD group lacks ambition to increase its international profile, and this may in part be due to its very wide portfolio, with the attendant risk of superficial research. The administrative unit could play a more active role in stimulating the BTD to have greater user interactions.

DEIP is evolving from activity in mineral refinery to green energy (mainly novel methods for CO2 capture and hydrogen production). The research comprises both experiments and numerical simulation, involving numerical studies of integrated chemical processes. This interaction makes good sense, but the scope of the activity is very broad. The DEIP research group report and web-site are inadequate in their detail; also, the group report is inadequate in its benchmarking for evaluation purposes. Despite this, the research group assessment states that DEIP has a cohesive strategy for its research activities, recruitment and internationalisation.

DHT covers the supply chain of hydrogen technology. The group is internationally strong and is well-recognised, and the size of group is in balance with the planned research activities. There is a danger that the breadth of activities (including managing 2 large infrastructures) will make it difficult to maintain its high international profile.

DRT is a high-quality research group in geochemistry and geomechanics, involving both experimental work and numerical simulation. The administrative unit could invest more in advanced laboratory infrastructure but before doing so a clearer research vision of DRT is warranted.

The Corrosion group has diversified into CCS and hydrogen in a natural manner. This is welcomed by the Evaluation Committee.

Although wind power is a major opportunity at the national level, it is a highly competitive field and ENET has chosen not to engage with it. This is a strategic decision within ENET. In contrast, Solar has grown and has split into 2 groups (solar systems and solar technology).

Recommendations to the administrative unit

- The admin unit should implement a central management function
- The admin unit should set benchmarks which includes clear benchmarks for research quality to guide assessment at the level of the unit and the level of research groups
- Organisation of outreach activity at the level of the administrative unit makes sense and should be continued. It is critical to protect researcher thinking time.
- The Evaluation Committee supports the strategy of retraining employees to take on new project areas. To achieve this, it is imperative that both existing employees and new hires have a broad and deep understanding of their field. ENET is of the view that this is the case, and the data support this in terms of growth and transition into new research topics.

1.3 Research Funding

The research groups have a healthy portfolio of grants, including the role of project coordinator for the large grants ENCASE, ACT and HEU.

The breakdown of grant income is 55% from national grants, 37% from industry and 8% from international grants. This is consistent with the ambition of the admin unit to be

nationally leading in several areas, but the low level of international grants is a concern, as leading institutions will have a greater international presence. The current activity is helping address short term needs of Norwegian industry. The admin unit needs to press the research groups to have a more outward looking profile.

The proportion of funding secured from international grants is low and should be increased to reflect international competitiveness. A strategy is needed to increase their international funding profile, along with sources of international funding to prioritise. This is necessary in order for ENET to increase its domestic reputation in terms of research excellence, consistent with its strategic objectives.

The Corrosion Technology Department enjoys a large income stream from industrial research on CO2 and H2S. As stated in the self-assessment report, this activity is a result of long term commitment to the building up of competence and infrastructure during a changing environment from oil/gas to CO2 storage. The challenge is for this Department to continue to thrive scientifically as well as economically by maintaining strong academic links.

Evaluation of the administrative unit

- ENET is attracting more EU funding due to its establishment of a European Affairs Office and the fact that it does relevant research for industry. This office has revolutionised the way that EU projects are handled, and is seen as a success story both by the administrative unit and by the research groups that have reported. The number of EU projects was only 2-3 five years ago and now is approximately 50. The success rate is now 30% for EU projects. It is recognised that it is important to cut EU proposals at an early stage when are likely to fail.
- ENET behaves in a synergistic manner with its competitor institutes.

Recommendations to the administrative unit.

- ENET needs to continue to attract funding from large infrastructure projects such as INFRA from the RCN, and RIA projects from Horizon Europe. A greater presence on the international stage, with appropriate international collaborations, will increase research competence and increase the reputation nationally. This is consistent with the ambition to be nationally leading.
- ENET is sufficiently small as an organisation that it needs to be careful in its investment of infrastructure: it cannot afford to make too many mistakes. This is a challenge as new ventures necessarily involve some risk.

1.4 Research Infrastructures

ENET lists 6 national infrastructures in their self-assessment report. Three are in environmentally friendly energy (Norwegian advanced Battery laboratories NABLA, Norwegian fuel cell and hydrogen centre and Norwegian laboratory for Si solar cell technology), one is in petroleum technology (multiphase flows), and two are in neutron technology. The activity in Norwegian fuel cell and hydrogen centre will expire in 2024 but the others have a longer life. These infrastructures are important to maintain a high profile by ENET both nationally (and internationally for the case of neutron research). Some of these centres are virtual in nature, for example NABLA has a node at six institutions spread throughout Norway. Each node has complementary specialities, but details are missing on how a synergistic activity is realised in terms of sharing of facilities and staff, and how the cost structure stimulates such interactions.

ENET hosts three labs as part of the ESFRI project ECCSEL ERIC (European CO2 capture and storage lab. infrastructure). This is a high profile and important activity with the EU, but

it is not yet clear how significant carbon capture will become viable within Norway, and the extent to which it will contribute to the EU economy.

Most of ENET's departments rely upon their labs to provide them with their main competitive strength. In the emerging landscape of BIG DATA, access to trustworthy experimental data is of increasing importance, and this gives an opportunity for ENET.

All collaborative projects with substantial public funding aim to fulfil the FAIR principles. However, the generation of scientific databases is non-trivial as it is often unclear which data should be kept and which are irrelevant for future purposes. Substantial funding is required to put data storage practices and infrastructure in place. Inadequate funding is in place to achieve this objective, and an alternative is to work alongside industrial partners to get the partners to take care of relevant data storage.

Recommendations to administrative unit.

- ENET needs to be distinctive from its competitors by developing specialist infrastructure and expertise.
- National infrastructure needs to be carefully managed that it does not require too great an administrative burden. The NABLA infrastructure carries a minimal overhead burden as the centre is virtual but there exists the risk that it provides little direct benefit to ENET.

1.5 National and international collaboration

International collaborations are organised at the departmental level: this is natural and efficient. IFE-ENET's department for European affairs has succeeded in dramatically increasing the level of European funding from 5% to 20% between 2022 and 2024. Efforts to hire international researchers will bring an increased international network of collaborators.

ENET has been successful in establishing national industrial networks in the form of virtual research centres in 'environmentally friendly energy'. Such activity needs to be carefully managed so that it is useful, and cost-effective for ENET.

ENET has had a long history of collaboration with the University of Oslo in the sector of multiphase flow. This is an excellent example of a synergistic collaboration and other examples should be sought in the renewable energy area, such as offshore wind.

ENET encourages its scientists to take up part time positions at Universities: this should aid collaboration and high quality publications in leading international journals.

The strategic research alliance between IFE, NIVA (water research) and NILU (air research) makes good sense as there is some overlap between the activities of these institutes (for example in reservoir technology and carbon capture and storage).

Likewise, strategic partnerships with competitors in multiphase flow, petroleum and CO2) are welcome, but IFE needs to remain clear on its unique selling points. It is noted that the alliance with competitors has been successful in many joint industry projects.

Established links with major industrial partners such as Norsk Hydro are important to ENET. In particular, there is a continued need for energy efficient aluminium electrolysers.

The NIFU RCN Research evaluation reveals that the publication journal domain of ENET within Materials Science and Chemistry is approximately twice that of Energy; this needs to be considered by ENET as a number of journals in the Energy domain enjoy a high profile and high citation rate. Co-authorship of papers is an indicator of national and international collaboration. ENET Researchers typically have twice as many international collaborators as national collaborators. However, there appear to be very few formal international collaborations: the only one listed in the self-assessment report is the collaboration with

PSI-Switzerland on neutron research. The National Collaborators are centred on the University of Oslo, NTNU and SINTEF. International Collaborators are centred on Scandinavia. An opportunity exists for more imaginative and broader international collaborations, particularly within the EU.

Recommendations to administrative unit.

- ENET scientists should make every effort to broaden their reach into Universities over a wider range of subject to engage as many of the 13 departments as possible in collaborative research with Universities. The existing collaborative arrangement with the University of Oslo (Birkelandsenteret) is a mechanism to stimulate this initiative.

1.6 Research staff

It is noted from *Statistics Norway, SSB: Analysis of research personnel* that there was 25% growth in personnel in the Institute Sector of Norway from 2013 to 2021. The Institute for Energy Technology (ENET) had a decrease of researchers from 208 to 197 in the same period. This may be partly due to the evolution of ENET away from the Nuclear Sector, but ENET is challenged by strong competition from other institutes in the Energy Sector.

ENET has a comparable number of foreign PhDs to those of its competitors in 2021 (26 for ENET). A large number of PhDs is a healthy metric as it promotes international collaborations and the internationalisation of research. 30% of ENET Researchers have a PhD, and the average age of its employees is 44-45: these metrics are comparable to those of its competitors.

The career structure in ENET is clearly defined in 7 categories from Master of Technology to Chief Scientist, and is based on pertinent objective criteria and performance reviews. There is a large fraction (27%) in the senior scientist grade, and this seems to be due to the fact that several departments have existed for a long period of time with a mature workforce. Detail is missing on the self-assessment report on procedures within the administrative unit to support recruitment or career progression of staff.

There is no sabbatical leave system in place, but there is an opportunity to have part-time positions at a local University such as the University of Oslo. This is important for a number of reasons: to link ENET activities to that of academic work within Norwegian Universities, to provide a wider range of collaborative colleagues, to attract Masters and PhD students and academic researchers to spend time at ENET. The inward mobility of visitors into ENET is healthy and no doubt contributes to the quality and quantity of collaborative research. But mobility needs to be a 2-way activity to be sustainable.

Recommendations to the administrative unit

- A two-way interchange with universities and industrial clients brings much benefit to both individual employees and to ENET, but it poses challenges to maintain adequate activity on projects.
- ENET must continue to make its environment attractive to appeal to and retain employees in the face of stiff competition from other institutes, industry and Universities that work in the energy sector.
- ENET is highly successful in its retention of master's and PhD students: 25% of Maters students and 50% of PhDs are subsequently hired. ENET is popular with students: both nuclear and renewables are attractive topics.

1.7 Open Science

IFE has the policy that research output should be published in open, high quality journals as much as possible, but consistent with the limits set by confidentiality and non-disclosure agreements. There is a welcome increasing trend in the proportion of publications that are

open access: whereas 20-25% of publications were open access before 2017, more than 50% are now open access.

There are clear and commonly accepted guidelines for the ownership of data and of confidentiality. A pragmatic approach has been adopted by ENET, for example it is recognised that industry partners both own and handle the management of their own data.

The efforts by the Norwegian Infrastructure for Multiphase Flows to open up a database of historical data to the scientific community is applauded. It is accepted that a lock-in period of 2-5 years for data generated in collaboration with industrial partners may need to continue due to the need for customer confidentiality.

Recommendations on how to promote open science

- The use of GitLab for sharing code is welcomed, and work should continue on such data-sharing platforms. This also brings important visibility and marketing elements to ENET.

2. Research production, quality and integrity

The overall scientific focus of the admin unit is on supporting research in the areas of energy and environmental technologies. This spans a range of research areas, from process technologies relating to corrosion and reservoirs, analysis of energy systems, renewable and wind technologies, through to energy materials, including for solar and batteries, and environmental technologies to support environmental safety and radiation protection and environmentally friendly industrial processes.

IFE-ENET adheres to IFE's institutional Code of Conduct, which the evaluation committee find to be satisfactory. ENET has a code of conduct in terms of behaviour and issues of integrity, and has established a 'whistleblower system'. The detailed methodology on how to embrace appropriate ethics is welcome and sends a strong positive message to the research and industrial communities.

2.1 Research quality and integrity

The leading areas of publication value in Energy are identified from the NIFU bibliographic database as battery technology, materials technology and hydrogen. These are also 'hot topics' where significant funding streams are available. ENET has been successful in attracting new research projects and new hires in these fields: this is healthy.

The Corrosion Technology Department enjoys a large income stream from industrial research on CO2 and H2S. As stated in the self-assessment report, this activity is a result of long term commitment to the building up of competence and infrastructure during a changing environment from oil/gas to CO2 storage. The challenge is for this Department to continue to thrive scientifically as well as economically by maintaining strong academic links.

The benchmarking of the research groups is diverse in nature and lacking in detail. For example, the benchmarking of the DHT group is heavily focussed on financial profit with insufficient detail on research quality and quantity, and internationalisation. In broad terms the degree of quantitative benchmarking is rather limited.

The strengths, weaknesses and challenges facing each of the 5 research groups are now summarised.

SOLTEK: It has a long history of working in silicon technology, but recently the shift has been to photochromic materials. A strength is the acquisition of complete infrastructure to investigate the entire value chain of PV manufacture. Also, there are strong links with the National Universities (hosted 79 students and 289 papers from 2012 to 2022). SOLTEK has produced 2 successful spin-out companies, and a string of patents. The SOLTEK group is small to cover all the activities in the PV value chain. Consequently, the challenge is to identify those areas of expertise that give it a competitive edge. Also, there is a challenge to compare its level of expertise with that of groups in Asia. There is a challenge to improve the quality of its current research publications, and to identify where it sits in terms of TRL readiness and patent position.

BTD: The main weakness is the low level of research quality in the international context. The activity is spread too thinly, and there is a need to strategically focus on some topics. The group has produced historic patents but it is unclear whether any of them have been exploited by ENET and its industrial partners. The challenge now is to increase its ambition from national to international, and thereby remain attractive for industrial collaborations. Co-ordination of European projects may help in this regard.

DEIP: The research is a mixture of green energy and mineral refinery, with a significant fraction of its funding (52%) from the EU. The case has not been made for a significant Societal impact, and the research quality is limited with low citations. This area of research clearly brings environmental and thereby Societal benefits: circularity of batteries and solar panels, CO2 capture and hydrogen production. The homepage states: the *Department is a research partner in the FME "Norwegian Centre for Sustainable Bio-based Fuels and Energy, Bio4Fuels".* It is unclear whether this department serves a useful role or whether its members and activities should be subsumed within other ENET departments: modelling and experiments on industrial processes need to be very closely coupled to physical phenomena involved.

DHT: The activity of this research group has evolved from neutron science to the value chain of hydrogen technology. The research output is at a high international level in terms of originality, significance and rigour. Its work on water electrolysers and fuel cells is of clear societal value and should be encouraged. The group has a strong organisational structure and recently achieved increased funding. Its research enjoys strong support from the administrative unit. There is a healthy spread in TRL level of research activity: it is noted that activity at a high TRL level can stimulate more fundamental problems at a lower TRL level. A challenge exists to generate patents from the research at high TRL level.

DRT: The research quality and breadth of activity are impressive. Also, a healthy degree of international collaboration takes place. The group is top heavy with senior researchers and a refresh by employing more junior researchers is warranted. It is important for the group to lead a proportion of its projects, to be in the driving seat, rather than being purely reactive. A more pro-active research strategy is needed to ensure the long-term survival of the group.

Research group Solar Energy Materials and Technology overall assessment

Silicon feedstock production and wafering need a lot of energy. Hence, the PV community regards Norway as the best place in Europe for these processes, owing to its focus on cost and energy-effective approaches. Two big companies in silicon and photovoltaics – NorSun and REC – have been built on these advantages, and the Norwegian government funds research groups capable of doing in-depth research to improve products and processes, and to embed this competitive sector in the country. SOLTEK is one of a number of groups

with long experience on specific topics related to the production of silicon for photovoltaics. Recently, SOLTEK has expanded towards new materials, for batteries and for BIPV applications. From this research, a new material emerged which gave rise to two spin-offs that have reached the commercialisation stage. SOLTEK uses laboratories and facilities that the IFE department has shared with other university and industrial groups, thus facilitating close interaction and cross-fertilisation of ideas towards the development of joint interests and projects. This approach also made it possible for SOLTEK to participate in university teaching and dissemination activities, obtaining in exchange connections with junior talents, who could immediately be employed in their research activities. SOLTEK participates in several EU project (mainly based on networking) and EU initiatives through IFE department.

Research group Energy Materials (ENMA), Battery Technology Department overall assessment

The department of Battery Technology at IFE focuses on research across the battery value chain, from battery materials to characterisation of commercial cells. Topically the group is well placed with respect to the growing Norwegian and European industry and there is also an explicit goal of the group to work with industry. The research group has a good track record in attracting external funding but the level of funding from European projects is lower than expected. From the stated objective the ambitions of the research group are mainly national. The research is internationally recognised but not excellent, with the work on Si anodes as the most visible area. There should be room for improvement of the research quality, considering the importance of the field for sustainable development and industrial interest, but this would call for an increased ambition and strategically focusing on some topics. With respect to societal contributions there is a focus on patents, but one could have expected a better account for the involvement of partners in this work.

Research group Department for Environmental Industrial Processes overall assessment

The Operations Research and Economics Research Group is a well-established research group. It conducts its research in a broad spectrum of projects and thereby plays an important role in many projects. They are in a good funding situation, well above critical mass and with a good gender balance. They have a clear interdisciplinary profile which is an advantage when generating research in many different interdisciplinary projects. In the day-to-day operations it seems that the group does not give enough attention to research dissemination. The activities are clearly weak when looking at the available resources. Even an internally modest goal of one peer-reviewed paper per year cannot be achieved. To be recognised internationally it is important to perform better on this part and keep it in mind when planning projects. Benchmarks are nicely formulated but difficult to measure and, therefore, follow up on.

Research group Department for Hydrogen Technology overall assessment

The main strengths of the research group include very strong organisational structure, very good resources in terms of personnel, administration, and infrastructure. The group has been successful in acquiring external funding, especially from RCN. Industry funding, as well as EU funding, show positive trends. With the recent increased funding share and available resources, the group is likely to achieve their goals. The main weaknesses include the lack of research quality in their benchmarking and a somewhat modest journal publication outcome. Innovation and commercialisation activities are also missing, although direct industry collaboration takes place within the research projects. In overall, the

organisational environment supports the research extremely well and the research and publication quality are well above average when benchmarked to the national context. The research group contribution to the research outcome has varied a lot (from modest to extremely high) depending on the research topic. The societal impact and user involvement is on par what is expected for groups with similar resources or even considerable. The majority of the research outcome (including scientific publications) can be recognised internationally in terms of originality, significance and rigour, and in overall, the group can be considered internationally strong and well recognised. However, selection of review papers (instead of original research articles) as the example publications of their “best” work may indicate a somewhat low number of original high-quality research results.

Research group Department for Reservoir Technology overall assessment

As noted above the quality of the group’s research is excellent both in terms of publications as well as the breadth of their research projects and the group’s collaborators nationally and internationally. The group members are very strong in the international context. Based on the content of the self-assessment report the main weakness of research group lies in its lack of specific research goals and more general research vision. As a result, they have no benchmarks based on these against which to evaluate their research quality and societal impact. A further weakness is that group appears to consist mostly of senior researchers and engineers. The proportion of women in the group seems particularly poor although it is recognised that the gender balance in reservoir engineering is poor.

3. Diversity and equality

The self-assessment report of ENET has no text and comment on diversity and equality, but points to its homepage ife.no and hyper-links to 5 online policy documents. The findings below are obtained from these 6 hyper-links. There is little information on the degree of success by ENET in achieving diversity and equality, and obstacles that it has overcome.

ENET has a detailed statement on its policy and practices on its homepage that appear to be consistent with Norwegian law.

36% of the research staff are women; it is clear from the IFE gender equality plan that IFE is making many efforts to increase this proportion. This number is considered good against the backdrop of a small proportion of women working as researchers in the Sciences within Norway and other European countries. But it can be increased further.

IFE established in 2022 a Gender Equality Committee but it is unclear what this committee has achieved. A Employee Promotion Plan (EPP) was also established in 2022 that takes care of systematically appraising the career development of the female employees at IFE. This is an excellent idea.

The main sentence in the IFE gender equality plan (on ife.no homepage) is unclear:

IFE's recruitment process is based on needs and is based on objective criteria that without compelling reason must be influenced by the candidates' gender, pregnancy, maternity or adoption leave, care responsibilities, ethnicity, religion, outlook on life, disability, sexual orientation, gender identity, or gender expression.

The IFE has a clear code of conduct document on its webpage that states:

‘IFE does not accept violations of applicable legislation or the Code of Conduct. Alleged irregularities may be investigated by internal auditors or by other internal or external resources. Depending on the degree of intent and severity, IFE may initiate disciplinary

measures, terminate the employment contract or report the issue to the relevant authorities if employees breach the Code of Conduct or applicable legislation. The same applies to managers that disregard or tolerate such breaches.'

4. Relevance to institutional and sectorial purposes

The main activity is aimed at addressing sector-specific objectives. The strategy drills down from high level ambitions within the sector down to specific actions within each research group, termed department. The functioning of the ENET admin unit appears to be good in this respect. The ENET admin unit permits the activity within the 5 research groups to be very broad and thinly spread, and this may impact the quality and reputation of ENET in the long term.

ENET has contributed to policy development through the various 21-strategies, such as Energy21 and OG21 and through direct communication with ministries, politicians, and relevant organisations. ENET has led to the establishment of a new research centre for nuclear science and technology, in collaboration with NMBU and UiO, to address societal needs in this important technology area.

The biggest impact in terms of innovation and commercialisation is the multiphase flow simulator software package OLGA dating back to 1980. This software was instrumental in subsea solutions in the oil industry. Additionally, ENET has commercialised the company ZEGpower that produces blue hydrogen from natural gas, with integrated CO2 capture. Other commercialisations range from a company Sunphade AS that makes a solar control film for windows to Agilera AS which manufactures radiopharmaceuticals. The culture within EENT is the research staff are motivated to be scientists, but with an eye on innovation and commercialisation. New ideas are brought forward at the departmental level, with possible financial investment by the associated investment company IFE Invest AS. The IP for many industrial projects remains with the industrial partner. In many projects, personnel from industrial partners spend periods working at ENET to participate in research projects. The ENET admin unit needs to make a strategic decision on whether it wants to increase the amount of its commercialisation or whether it wants to continue to function in a more research and consulting capacity. The size and scope of its activity makes it challenging to achieve both objectives.

ENET contributes towards master and PhD level education by the co-supervision of students in collaboration with its academic partners. This is a synergistic activity provided the students make a positive contribution to the research and are not a net drain. Currently, there are only 10 MSc students at ENET. Careful thinking is needed before this number is increased by a large factor: it is unclear whether the student education is leading to new hires in ENET.

5. Relevance to society

ENET works in the area of climate, energy and the environment. These are topics of high relevance to Society globally and are increasingly high profile in terms of national and international funding. It is anticipated by the evaluation committee that ENET will continue to be successful in attracting funding provided it continues to promote high quality capabilities within its labs and focusses upon its research quality. The evaluation committee is of the view that ENET must continue to behave in a lean and agile manner if it is to continue to compete for funding, given its low level (10%) of income from basic grants. By

behaving in a lean and agile way, the unit is better able to respond to changes in societal priorities and needs.

5.1 Impact cases

No impact cases were provided for evaluation.

This is a surprise to the evaluation committee, as it should be possible to give some relevant impact case studies for a research foundation that was established in 1948.

The evaluation committee recommend the admin unit invest some time and effort into collecting data and information on their impact to support communication activities and any future evaluations.

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 for clarity.

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
Institute for Energy Technology (IFE)	Energy and Energy Technology (ENET)	Department for Environmental Industrial Processes Energy Materials (ENMA), Battery Technology Department Department for Reservoir Technology Solar Energy Materials and Technology Department for Hydrogen Technology

Terms of Reference (ToR) for the administrative unit

The board of IFE mandates the evaluation committee appointed by the Research Council of Norway (RCN) to assess the two research divisions in IFE; Energy- and Environmental Technology (ENET) and Digital Systems (DS), based on the following Terms of Reference.

Assessment

You are asked to assess the organisation, quality and diversity of research conducted by Energy- and Environmental Technology and Digital Systems as well as their 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 life sciences 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 [n] aspects in your assessment:

1. Relevance of the research to Norwegian and European industry partners

2. Ability of the organization to adapt to changes in the market

3. Ability of the organization to deliver high quality research within profits requirements set by the research council of Norway

4. Sustainability impact and execution in the research strategy

In addition, we would like your report to provide a qualitative assessment of Energy- and Environmental Technology and Digital Systems as a whole in relation to their strategic targets. The committee assesses the strategy that the administrative units intend to pursue in the years ahead and the extent to which they will be capable of meeting their 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 life sciences secretariat at Technopolis Group.

The documents will include the following:

- a report on research personnel and publications within life sciences commissioned by RCN
- a self-assessment based on a template provided by the life sciences secretariat

Interviews with representatives from the evaluated units

Interviews with personell connected to Energy- and Enivironmental Technology and Digital Systems 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 IFE 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 life sciences secretariat. The committee may suggest adjustments to this format at its first meeting. A draft report should be sent to IFE and RCN by [date]. The two research divisions Energy- and Enivironmental Technology and Digital Systems should be allowed to check the report for factual inaccuracies; if such inaccuracies are found, they should be reported to the life sciences secretariat no later than two weeks after receipt of the draft report. After the committee has made the amendments judged necessary, a corrected version of the assessment report should be sent to the board of IFE and the RCN no later than two weeks after all feedback on inaccuracies has been received from IFE.

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)

The Research Council of Norway

Norges forskningsråd
Besøksadresse: Drammensveien 288
Postboks 564
1327 Lysaker

Telefon: 22 03 70 00

post@forskningsradet.no
www.forskningsradet.no

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