The Research Council of Norway

Evaluation of Mathematics, ICT and Technology 2023-2024

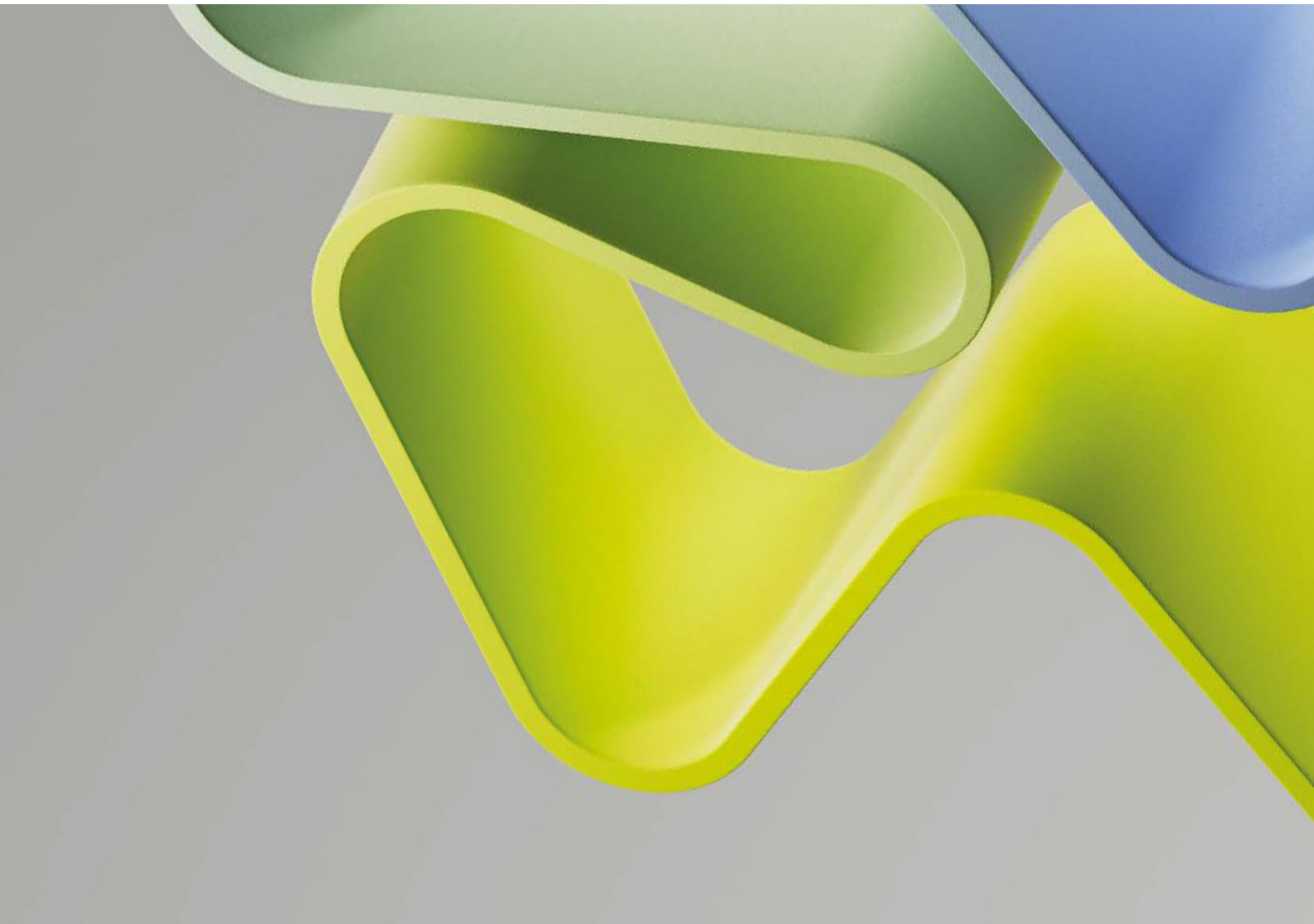
Evaluation Report for Administrative Unit

Administrative Unit: **Department of Energy and Process Engineering (EPT)**

Institution: **Norwegian University of Science and Technology (NTNU)**

Evaluation Committee Higher Education Institutions 4

December 2024



Contents

Statement from Evaluation Committee Higher Education Institutions 4

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

- Department of Building, Energy and Material Technology, UiT the Arctic University of Norway
- Department of Architecture and Technology (IAT), Norwegian University of Science and Technology (NTNU)
- Department of Civil and Environmental Engineering (DCEE), Norwegian University of Science and Technology (NTNU)
- Department of Geoscience (IGV), Norwegian University of Science and Technology (NTNU)
- Department of Structural Engineering (KT), Norwegian University of Science and Technology (NTNU)
- Department of Manufacturing and Civil Engineering (IVB), Norwegian University of Science and Technology (NTNU)
- Department of Energy and Process Engineering (EPT), Norwegian University of Science and Technology (NTNU)
- Department of Built Environment (BE), Oslo Metropolitan University (OsloMet)
- Department of Energy and Petroleum Engineering (IEP), University of Stavanger (UiS)
- Department of Mechanical and Structural Engineering and Material Science (IMBM), University of Stavanger (UiS)
- Department of Process, Energy and Environmental Technology (PEM), University of South-Eastern Norway (USN)

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 has consisted of the following members:

Professor Claudio Mazzotti, University of Bologna (Chair)

Professor David Baglee
University of Sunderland

Professor Sebastian Geiger
TU Delft

Professor Mohamed Pourkashanian
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Professor Elsa de Sá Caetano
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Professor Per Heiselberg
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Description of the Administrative Unit

The Department of Energy and Process Engineering (EPT) at the Norwegian University of Science and Technology (NTNU) is a large, internationally oriented, research-intensive unit with over 300 employees, including academic staff, technical and administrative personnel, PhDs, postdocs, and researchers with full employment status in Norway. The scientific staff comprises 26 professors, 12 associate professors, 9 adjunct professors, 11 adjunct associate professors, 41 postdocs, 86 PhD students, and 4 researchers. Despite some progress in gender balance, with 25% of associate professors being women, only 18% of the current full professors are women. Improving gender balance remains a priority.

The department is led by the Head of Department (HoD), supported by two deputy heads and a head of administration. The HoD, who holds formal responsibility for research, education, and administration, is assisted by a leadership group that meets every three weeks to address day-to-day academic and administrative issues. This group includes the HoD, head of administration, deputy heads, research group leaders, laboratory manager, financial controller, and HR leader. Research groups and permanent academic staff have the autonomy to manage and pursue their research directions while adhering to broad institutional strategies.

Over the past decade, the department has cultivated a culture of research excellence and expanded its international presence, contributing to societal challenges in energy and sustainability. Its research profile encompasses fundamental research, applied and industry-relevant research, systems-level approaches, and global environmental sustainability.

The research is organised in the following research groups:

- Industrial Ecology Programme (IndEcol)
- Process and Power (PP)
- Sustainable Energy Systems (SES)
- Thermo-fluid (TF)

The department’s research activities address long-term societal and industrial challenges related to sustainable and energy-efficient solutions. These efforts are guided by faculty and departmental strategies aligned with UN Sustainability Goals, EU strategic plans, and Norwegian Government research strategies. The current strategy aims to achieve national and international recognition for excellent research and education, become the preferred partner for collaborative research with academic and industrial partners in Norway, and maintain world-leading research laboratories. It also focuses on developing top-tier research groups in fundamental and applied science and engineering, in line with the Norwegian Government’s long-term research and education plan. Additionally, the department strives to provide a high-quality learning environment, actively participate in societal debates, and promote a diverse and gender-balanced working environment.

The department collaborates extensively with national and international partners, with Sintef being its most significant national collaborator through individual research projects and FMEs. These large consortia involve research institutes and industry partners, making the research cross-sectorial. The department is also a key partner in HighEFF, Bio4Fuels, NCCS, and ZEN. While FMEs offer significant benefits, individual research projects, typically lasting 3-4 years, are considered the best for maximising research output. These projects foster focused collaborations between academic staff and research partners, emphasising scientific excellence. Professors maintain numerous active international collaborations with

other academics and industries, developed over time based on their research track records. These partnerships often lead to joint publications and repeated proposal submissions.

Overall Assessment

Strategy, resources and organisation: EPT's strengths in these areas are the detail that has gone into the planning and implementation of strategy. Faculty strategy operates on a 5-year cycle, with annual review by EPT. EPT is divided into four main groups, each led by a group leader, who in conjunction with the HoD, and the deputy HoD for research undertake this review. KPI's are integrated into the process, though not in all areas, and assessment of the strategy implementation is based on self-assessment, which is seen as a weakness. Resources arise from two main sources, base funding from the Ministry of Education dedicated to research (2018-22 average ~50.9 MNOK/year) and Research grants (2018-22 average ~134.4 MNOK/year) that demonstrate a high degree of success.

The department is performing excellently. It is crucial that both the Faculty and the University continue to support the EPT to ensure its ongoing success in the future. This support is vital for maintaining the high standards and achievements that the EPT has consistently demonstrated.

Please note that the general and specific recommendations in this report are intended to be minor adjustments. These recommendations are designed to further bolster the department's already excellent performance. By implementing these suggestions, we can ensure that the EPT continues to thrive and achieve even greater success in the future.

Research production, quality and integrity: Research in EPT is organised into four main groups that cover the themes of "Industrial Ecology", "Process and Power", "Sustainable Energy Systems" and "Thermofluids". EPT aims to lead research applications and have been awarded 5 ERC grants over the last 10 years. In 2022, EPT had a total of 199.5 author shares in various publications. This impressive output was matched by a citation score that aligned with the Norwegian national average for energy research. There is a strong emphasis on research integrity, guided by a comprehensive code of ethics, outlining specific responsibilities for PhD supervisors, ensuring they uphold the highest standards of academic mentorship. Additionally, all PhD students are required to complete mandatory courses designed to install ethical research practices from the outset of their academic careers.

Diversity and Equality: All appointments are assessed by the equality advisor to ensure no applicants are unjustifiably excluded. EPT is proactive in trying to improve gender balance, setting up "EPT Women in Science" in 2017 with currently 30+ members, it provides networking opportunities, increases visibility and accelerate women's STEM careers. It organises workshops, lectures and events to instil skills/confidence/know-how at early academic career stage.

Relevance to institutional and sectoral purposes: EPT offers substantial teaching contributions within its specialist areas, a 2-year Master's program and two rigorous 5-year Master's program. EPT research significantly enhances the knowledge base in engineering sciences, boasting a strong international track record. This includes leading RCN projects, securing five prestigious ERC grants, publishing extensively in top-ranked journals, and contributing valuable insights to reports for major international panels such as the IPCC, IPBES, and UNEP.

Relevance to society: A diverse set of impact cases were presented, showcasing significant economic and environmental benefits in various fields related to EPT's research addressing the area of energy and sustainability. In addition, training of PhD students, ECR's, and development of new design tools and insights, particularly in the areas of energy efficiency in industrial processes and hydropower turbine design, contributing to more sustainable

engineering practices. Future prospects are good based on the overall high quality of research activities, although the lack of Norwegians interested in PhD study is a concern.

The Terms of Reference for the administrative unit is attached to the report. The Evaluation Committee considered the points raised by the unit in their Terms-of-Reference document and have commented on those throughout the report where applicable.

Recommendations

1. Commitment to goals: EPT has achieved significant milestones, such as increasing EU funding to 50% of total funding. They focus on strategic development and early-phase project ideas. It is crucial to provide both financial support and time allocation for staff to deliver on these goals.
2. SWOT analysis: EPT is internationally focused and provides high-quality teaching. They have identified internal weaknesses and are actively working to overcome them. It is important to assess the process of addressing weaknesses and strengths identified during the SWOT analysis. It is recommended that after SWOT analysis you should organising TOWS (Threats, Opportunities, Weaknesses, Strengths) analysis in order to define some subsequent actions the department might take.
3. Recruitment and retention: EPT aims to proactively recruit excellent talent and support staff to thrive. EPT needs to develop a strategy for recruiting Norwegian students, as this is crucial for capacity building and strengthening the Norwegian skilled workforce.
4. Enhance base funding utilisation: Given the substantial base funding from the Ministry of Education, it would be beneficial to ensure these funds are strategically allocated to maximise research output and innovation. Regular reviews and audits could help in identifying areas for improvement and ensuring optimal use of resources.
5. Diversify and increase research grants: EPT has shown success in securing national and international grants. To build on this, consider setting up dedicated teams or units focused on identifying and applying for diverse funding opportunities, including lesser-known grants and international collaborations.
6. Leverage success rates: The high success rate in obtaining research funding is a strong point. Promoting this success internally and externally can boost morale and attract more talented researchers to the department. Additionally, sharing best practices and strategies that led to successful grant applications can help other researchers improve their proposals.
7. Monitor and support active research groups: The active involvement of research groups, especially those integrated into big centres, is commendable. Providing continuous support, resources, and recognition to these groups can sustain and enhance their productivity. Regularly monitoring their progress and addressing any challenges they face will be crucial.
8. Invest in Infrastructure: Prioritise the upgrading and maintenance of research facilities to ensure they meet the highest standards and support cutting-edge research.
9. Enhance support for collaborations: Strengthen the support mechanisms for both national and international collaborations. This could include dedicated administrative assistance for managing partnerships, streamlined processes for joint projects, and increased funding for collaborative initiatives.
10. Support for early-career researchers: Enhance support for early-career researchers through mentorship programs, grant writing workshops, and opportunities for

international research exchanges. This will help in building a strong pipeline of future research leaders.

11. Improve age distribution and succession planning by develop a comprehensive succession plan: Collect and analyse data on upcoming retirements and potential internal candidates for promotion. Create a clear pathway for career progression to retain talent and ensure smooth transitions.
12. Showcasing the impact case studies on the website could significantly enhance external visibility. By highlighting these case studies, EPT can demonstrate the tangible benefits and successes of their projects, attracting more interest and engagement from external stakeholders. This increased visibility can lead to greater recognition, potential collaborations, and additional funding opportunities.

1. Strategy, Resources, and Organisation of Research

The EPT is a large, internationally oriented, research-intensive department with over 300 academic, technical, and administrative staff, including PhDs, Post-Docs, and Researchers. The Head of Department is supported by two deputy heads for research and education. Additionally, a leadership group, which includes the Head of Administration, the four research group leaders, the lab manager, the financial controller, and the HR leader, meets every three weeks.

The department is divided into four main groups, each led by a group leader:

- **Industrial Ecology**: This interdisciplinary group focuses on environmental sustainability analysis and includes five professors and two associate professors. In 2022, it received funding of 47.4 million NOK.
- **Process and Power**: This group conducts research in power, processes, systems, and components important to Norwegian industry. It comprises eight professors and two assistant professors.
- **Sustainable Energy Systems**: This group focuses on systems-level research in energy and renewable energy technologies. It includes six professors and a total of 33 members (distribution not specified). The group has an average annual funding of 22 million NOK over five years.
- **Thermofluids**: This group conducts fundamental and applied research in fluid mechanics and thermal energy and has received four ERC grants.

The department’s research strategies are developed by the four group leaders, the Head of Department, and the deputy Head of Department for research. These strategies are formulated on a five-year basis at the faculty level, with yearly updates from the department.

The research objectives of the department are to be nationally and internationally recognised for excellent research and research-based teaching, to be the preferred partner for both academic and industrial partners in Norway, to maintain and develop world-leading research laboratories in core areas, to maintain and develop internationally leading research groups in fundamental and applied science and engineering, and to provide a high-quality learning environment that is visible and active in society, promoting diversity and gender balance.

In 2017, EPT did not have a strategy document. Soon after, EPT initiated a strategic process, as required by NTNU every 5-6 years. All groups had individual discussions on key points and were assigned deliverables at the department level. This included lab and admin perspectives. The draft was opened for a hearing, and the process was iterative and coordinated to integrate everything coherently. In research groups, it was difficult to establish

a high-level strategic output due to the high value placed on academic freedom. EPT thus focused on how to conduct research rather than on specific topics to be tackled. A new strategy ready in 2025 is expected to be an even more useful document.

The EPT strategy is embedded, and everyone is committed. Everyone was at least invited to contribute. EPT does not look at it very frequently but uses it to make themselves aware of their achievements. EPT defined areas where they wanted to develop and advance. For example, the goal to increase EU funding to 50% of total department funding has been achieved. EPT has also improved in terms of education. The problem and challenge: The department does not own its study programmes; these are shared with other departments. EPT contributes courses and suffers from a lack of visibility. Now they are in a better position because they can enforce their own topics, and student numbers are good.

The research profile of the department spans fundamental research, applied and industry-relevant research, systems-level approaches, and environmental sustainability. EPT is one of the most successful and highest publishing departments at NTNU, with 199.5 author shares in 2022 and a three-year average of 211.9 author shares.

1.1 Research Strategy

The faculty research strategy is established on a five-year cycle and undergoes an annual review by the department. This review process involves the Head of Department (HoD), the deputy HoD for research, and four research group leaders. This structured approach ensures that the strategy remains relevant and aligned with both departmental and broader institutional goals.

The research objectives are ambitious, aiming for national and international recognition for excellent research and research-based teaching. The faculty seeks to be a preferred partner with both academic and industrial entities in Norway, maintain and develop world-leading research laboratories in core areas, and sustain internationally leading research groups in both fundamental and applied science and engineering. These objectives are in line with the Norwegian government's long-term plan for Research and Higher Education (2015-2024). Additionally, the faculty aims to provide a high-quality learning environment, be visible and active in society, and promote diversity and gender balance, which are crucial for fostering an inclusive academic community.

The current strategy for 2020-2025 aligns with NTNU's overall vision of "Knowledge for a better world." The core activities focus on sustainable energy production, energy-efficient processes, and a deeper understanding of the environmental impact of modern society. Recognising the intense competition in staff and student recruitment and in obtaining research funding, EPT must continue to improve its core activities and support functions. This continuous improvement is essential to maintain a competitive edge and attract top talent and resources.

Suggestions for improvement include evaluating the worthiness of topics for investment and considering funding perspectives, ensuring that resources are allocated efficiently and effectively.

Key Performance Indicators (KPIs) are integrated throughout the strategy, following the NTNU strategy format. While many KPIs have been identified with ambitious goals, not all areas are covered. This indicates a need for a more comprehensive approach to performance measurement, ensuring that all critical areas are monitored and evaluated.

The assessment of the research strategy implementation is based on self-assessment, which is seen as a weakness. For future strategies, it is suggested that all heads of group aim for more quantifiable goals. Despite the absence of formal KPIs, EPT has a handle on the number of applications due to obligatory paperwork. This suggests that while formal metrics may be lacking, there is still a level of oversight and control over research activities.

A SWOT analysis is used to address internal weaknesses identified within the faculty and university support. EPT is internationally focused and provides high-quality teaching, but university-wide procedures do not always favour EPT's methods. The SWOT analysis highlights aspects unfavourable to the department's performance, and EPT has often found ways to navigate these challenges. However, basic and private sector funding appears to be decreasing, which could impact the department's ability to sustain its research activities.

EPT has well-established flagship activities and processes to approach opportunities in emerging topics. Research groups, which are formal hierarchical structures, bring together academics with similar research interests. The best mechanism to cover strategic opportunities is through recruitment policy, communicated from research groups to the head of the department. Although there is no instrument to start a new group from scratch, readjustments are possible. This area could be reviewed to establish a well-defined pathway for creating new flagship initiatives, ensuring that the department remains at the forefront of research innovation.

Recommendations to the Administrative Unit:

- Strategy development: The strategy was developed using a bottom-up approach that involved all research groups and non-academic representatives. This iterative process aimed to integrate various perspectives. It is recommended to continue this approach, ensuring that all staff are consulted and support the strategy.
- Commitment to goals: The department has achieved significant milestones, such as increasing EU funding to 50% of total funding. They focus on strategic development and early-phase project ideas. It is crucial to provide both financial support and time allocation for staff to deliver on these goals.
- SWOT analysis: The department is internationally focused and provides high-quality teaching. They have identified internal weaknesses and are actively working to overcome them. It is important to assess the process of addressing weaknesses and strengths identified during the SWOT analysis.
- Recruitment and retention: The department aims to proactively recruit excellent talent and support staff to thrive. While they face challenges in attracting Norwegian PhD students, they have been successful in international recruitment. EPT needs to develop a strategy for recruiting Norwegian students, as this is crucial for capacity building and strengthening the Norwegian skilled workforce.
- Strengthen support programs: The NTNU groups "Outstanding Academic Fellows" program and strategic funds allocation are valuable assets. Expanding these programs to include more comprehensive training sessions, workshops, and mentorship opportunities could further enhance the skills and capabilities of researchers.
- Optimise sabbatical policy: The current sabbatical policy offers significant opportunities for academic growth. However, clarifying the application process and acceptance criteria could encourage more faculty members to take advantage of this benefit, leading to increased research productivity and innovation.

- Promote long-term planning: Encouraging researchers to devise long-term qualification and research plans can lead to more focused and impactful research outcomes. Providing tools and resources for effective long-term planning will be beneficial.

1.2 Organisation of Research

The organisation of research strategy development is deemed very good with goals being met in terms of the ongoing success of the main research groups. Ensuring the commitment of groups to strategic research goals involves the EPT, which aims for strategic development and better processes for initiating new projects. The current process involves several people, including group leaders and the deputy head of research, to prevent overlaps within the department and with other departmental research activities.

The faculty conducts a strategic review every five years, with annual updates from each department. There are four main research groups (see section 1.1), each led by a group leader. These research groups have the autonomy to self-manage but are expected to broadly adhere to institutional strategies. Associate and full professors initiate their own research activities, apply for funding, publish, and remain active in their communities. They are expected to stay current with the state of the art, publish in high-quality journals, present research at conferences, and build networks. The workload model is a 40/40/20 ratio of research, teaching, and administration, with teaching equivalent to one full course per semester.

All permanent academic staff are entitled to apply for a one-year sabbatical after four years (or a six-month sabbatical after two years), with a yearly application process. Sabbaticals are expected to be taken outside Norway, and several researchers from EPT take sabbaticals each year.

EPT makes significant contributions to two- and five-year master's programs, with 200 master's students overall in the 2021/22 year. This includes a five-year cross-faculty master's in mechanical engineering and Energy and Environmental Engineering, and a two-year Industrial Ecology program, an international master's hosted at EPT. Research groups contribute to teaching, with workloads coordinated by group leaders and the deputy head for teaching.

Since 2017, EPT has recruited 164 PhDs and 117 post-docs, averaging four PhDs and three post-docs per professor. PhD students must obtain 30 ECTS points from graduate courses, typically three or four courses worth 10.7.5 ECTS each. Each research group offers specialised courses and training, which are also open to other PhD students. It is common for PhD students to take at least one course in a different faculty or even at another university.

Many academic staff and PhD students are involved in outreach activities to disseminate research, and EPT hosts school visits. The organisational structure includes leader group meetings every three weeks focusing on day-to-day issues, leader group away days once a semester focusing on critical departmental issues, research group meetings for localised issues, departmental meetings twice per semester for all academic staff on thematic topics (general, teaching, research), and an annual "EPT day" where industry, employers, and students are invited to a one-day seminar on research, education, and career paths.

For research career development, new associate and full professors receive a "start-up" package, which includes one or two internally funded PhD or post-doc positions, lab space, and computing resources. There is enhanced support from internal funds for female appointees, a reduced teaching load wherever possible, and some research project funding

available as “individual overhead accounts.” EPT also covers the cost of Norwegian language lessons for new appointees and their partners.

Recommendations to the Administrative Unit:

- The current organisation of research is very effective, and no fundamental changes are necessary.
- Maintain the strategic review process every five years with annual updates from departments.
- Continue supporting the autonomy of research groups while ensuring alignment with broad institutional strategies.
- Uphold the workload model of 40% research, 40% teaching, and 20% administration.
- Ensure all permanent academic staff have access to sabbaticals as per the existing policy.
- Continue contributing significantly to master’s programs and coordinating teaching workloads effectively.
- Maintain the recruitment and support structure for PhD and post-doc positions.
- Encourage outreach activities and maintain the current organisational structure for meetings and seminars.
- Support new associate and full professors with start-up packages and reduced teaching loads and provide enhanced support for female appointees.
- Continue offering Norwegian language lessons for new appointees and their partners.

1.3 Research Funding

It is clear the department has a high degree of success in obtaining research funding, with an increasing trend over the 2018-22 period. A good level of support is available in applying for funding. Two main funding sources: Base funding from the Ministry of Education dedicated to research. From 2018-22, the average was 50,865,000 NOK (50.865 MNOK /year). Research grants. From 2018-22, the average was: National grants: 103.779 MNOK, National contract research: 7.743 MNOK, International grants: 22.899 MNOK.

EPT aims to lead research applications, targeting the FRIPRO and research project streams from RCN. Internationally, they are targeting EU Pillar 1 and Research Innovation actions in Pillar 2. They have been awarded 5 ERC grants over the last 10 years. Support available: NTNU “Outstanding Academic Fellows” programme facilitates academic development, provides international mentoring, devises long-term qualification/research plans, and supports research management/meetings/network building. NTNU strategic funds allocation (“PES” funding) helps to develop international networks for EU proposals, provides training on proposal writing, and offers research consultants for certain types of grant applications. Sabbatical policy: 1 year per 4-year period, or 6 months per 2-year period, requires an application to be accepted, though the chances of acceptance are not clear.

Statistics about the number of research proposals submitted by the EPT unit in the past years and their success rate look good. EPT has several prominent researchers, which is considered an advantage. All research groups are quite active, with some integrated into big centres.

Recommendations to the administrative unit

- Enhance base funding utilisation: Given the substantial base funding from the Ministry of Education, it would be beneficial to ensure these funds are strategically allocated to maximise research output and innovation. Regular reviews and audits could help in identifying areas for improvement and ensuring optimal use of resources.
- Diversify and increase research grants: The department has shown success in securing national and international grants. To build on this, consider setting up dedicated teams or units focused on identifying and applying for diverse funding opportunities, including lesser-known grants and international collaborations.
- Industry funding (see table 3a, section 1.5 in the Self-Assessment document) constitutes 3.6% of total R&D funding, and industrial contract research another 4.7% of total R&D funding. Increase Industrial funding: Industrial funding contributed 8.3% of total R&D funding excluding the basic grant. It would be beneficial to investigate ways to increase this, both from existing collaborations and the identification of other potential industrial funding opportunities.
- Leverage success rates: The high success rate in obtaining research funding is a strong point. Promoting this success internally and externally can boost morale and attract more talented researchers to the department. Additionally, sharing best practices and strategies that led to successful grant applications can help other researchers improve their proposals.
- Monitor and support active research groups: The active involvement of research groups, especially those integrated into big centres, is commendable. Providing continuous support, resources, and recognition to these groups can sustain and enhance their productivity. Regularly monitoring their progress and addressing any challenges they face will be crucial.

1.4 Research Infrastructures

The EPT is highly active in participation and hosting/coordination, with research areas that align closely with the department's four research groups. These areas include sustainable energy, power, processes, systems, components crucial to Norwegian industry, and both fundamental and applied research in fluid mechanics and thermal energy.

The EPT hosts the "Hydrocen Laboratories," having received 55 MNOK from RCN to refurbish and expand the Waterpower and Hydraulic laboratories. Additionally, the EPT hosts the "ECCSL Norway CCS RI," which involves upgrading and constructing multiple research facilities in the CCUS field across Norway, with a budget of around 250 MNOK. As a partner in "HighEFFLab," the EPT conducts research focused on improving heat usage in industry, with 50 MNOK allocated to operate three facilities.

The EPT is also engaged in biorefinery-related research as a partner in "NorBioLab."

In the "Smart Building Hub (SBHUB)," the EPT contributes to the Norwegian e-infrastructure for energy-flexible and healthy buildings.

Regarding international infrastructure, the EPT participates in a joint doctoral program between NTNU and CERN, with one student working on fluids for the Large Hadron Collider. The EPT is also part of ECCSEL ERIC, which includes Norway, France, Italy, The Netherlands, and the UK as founding countries. This initiative focuses on CCUS-related research and offers open access to over 100 world-class CCUS facilities across Europe.

Recommendations to the administrative unit

- Invest in Infrastructure: Prioritise the upgrading and maintenance of research facilities to ensure they meet the highest standards and support cutting-edge research.

1.5 National and international collaboration

The Energy and Process Technology (EPT) department has numerous national collaborations. They work closely with SINTEF on multiple projects related to energy, participating in interdisciplinary research centres for environmentally friendly research (FME). This collaboration has funded 28 PhD and 12 Post-Doctoral positions between 2018-2022, providing regular domestic research funding, training, employment for graduates, and joint publications.

EPT also collaborates with the Norwegian Institute for Nature Research (NINA) on projects in industrial ecology and waterpower, co-supervising PhD students and Post-Docs, resulting in joint publications and research stays. The Institute for Energy (IFE) partners with EPT on projects related to batteries, LCA, and hydrogen fuel value chains, funding several PhD and Post-Doctoral positions.

Freyr supports EPT with bilateral collaborations, funding adjunct professorships, development funding for battery research, and PhD student sponsorships. The University of Oslo collaborates on PhD supervision and joint projects, with plans to establish a national centre in fluid mechanics.

Internationally, EPT engages in research collaborations, PhD exchanges, publications, and technology implementation. The sustainable energy research group, a relatively new entity formed from a merger, aims to lead international projects like Horizon Europe. They have adapted to NTNU's methods and are increasing their success rates, with one EU project lead won in 2023.

Recommendations to the administrative unit

It is evident that there is a very wide ranging and substantial level of both national and international collaboration in areas that align with the core research areas of EPT, that have numerous benefits to EPT in terms of research output, research funding, PhD/Postdoc positions and training. Section 1.6 of the self-assessment does not explicitly cover how the administrative unit facilitates this, though it can be implied in the earlier descriptions of the support for academic staff in terms of the NNTU outstanding academic fellows' program, the PES funding to help to develop international networks for EU proposals, and the sabbatical policy. Here are some recommendations for the administrative unit based on the extensive collaborations and achievements of the Energy and Process Technology (EPT) department:

- Enhance support for collaborations: Strengthen the support mechanisms for both national and international collaborations. This could include dedicated administrative assistance for managing partnerships, streamlined processes for joint projects, and increased funding for collaborative initiatives.
- Support for early-career researchers: Enhance support for early-career researchers through mentorship programs, grant writing workshops, and opportunities for international research exchanges. This will help in building a strong pipeline of future research leaders.
- Leverage international networks: Continue to actively participate in international research networks and consortia, such as Horizon Europe, to further increase the department's visibility and influence on the global stage. This can also open up new avenues for funding and collaboration.

- By implementing these recommendations, the administrative unit can further enhance the EPT department's research output, funding opportunities, and overall impact in the field of energy and process technology.

1.6 Research staff

The EPT has prioritised improving gender balance, particularly among permanent academic staff. They focus on appointing female candidates, with all appointments evaluated at the faculty level by an "equality and diversity" ombudsman to ensure qualified candidates are considered. Progress has been made, with 25% of associate professors being female, comparable to the EVALMIT unit average of 26% in 2021. However, only 15% of professors are female, equal to the EVALMIT unit average. The majority of PhD students are from outside Norway, with 29% being female, matching the EVALMIT unit average.

In terms of age distribution, there has been significant turnover in academic staff over the last 5-7 years, with 11 retirements and 10 new associate/full professors. This has improved the age distribution, with most staff now in the 40-45 age bracket, followed by 35-40 and 45-50. The average age of professors is 56, compared to 54 in all EVALMIT departments, and the average age of associate professors is 43, compared to 45 in all EVALMIT departments.

The succession plan lacks data, except for the recruitment policy aimed at improving gender balance. The department has 26 full professors (all permanent), 12 associate professors (11 permanent), and 4 permanent researchers. Temporary research staff include 41 post-docs, 86 PhD students, 9 adjunct professors, 11 adjunct associate professors, and one researcher without a PhD. The breakdown shows relatively higher numbers of post-docs (~25%) and PhD students (~52%) compared to the EVALMIT unit averages of 16% and 43%, respectively.

The 40% research time workload model, along with a sabbatical policy of one year after four years (or six months after two years), indicates a good allocation of research time to promote the unit's goals. Sabbaticals are expected to take place outside Norway, with a mobility grant provided to cover expenses. It would be interesting to know the outcomes of the number of research staff actually taking up sabbaticals.

Project Establishment Grants (PES) enable staff to establish consortia for Horizon Europe applications and can be used for mobility to meet partners and build networks. EPT is improving gender balance through unique policies in Scandinavia and still needs applicants. In addition to networking and mentoring, EPT now has a PhD program with a department for Gender Studies and a PhD project on how to improve gender balance. They receive advice and reports, and the Head of Department has laid out a toolkit for HR to address these issues during recruiting.

Early career researchers are trained in core capabilities such as proposal writing and networking. Support is very good, albeit a bit informal, with people eager to help. Department/NTNU support includes interview training, feedback rounds, formats to exchange ideas among NTNU, appointed mentors, and mentors for female associate professors, PhDs, and post-docs. It is important to bring people from the department into these NTNU programs, as other departments are not as proactive and less successful.

The recruitment strategy and succession plan aim to ensure that EPT maintains expertise, continues to enjoy current success, and maintains or increases high-quality research output. EPT has changed its recruitment approach by focusing on excellence and proactively contacting high-profile academics who may be unhappy and on the move. EPT has a strategy to retain good people, with a constant focus from the Head of Department to thrive

at the level they aspire to. They try to facilitate personal and academic situations and be as flexible as possible within boundaries. Attracting people to Norway is a challenge, but they have managed to do so as academics wish to work in a supportive environment. EPT works hard to attract international talent, which is somewhat unusual within NTNU. They have faced challenges in attracting Norwegian students to pursue PhDs, with most PhD students coming from overseas. However, they have recently been successful in attracting more Norwegian talents. This shift indicates progress in balancing the international and local student body, enhancing the diversity and expertise within the department.

Recommendations for the Administrative Unit

By implementing these recommendations, the administrative unit can enhance its efforts in promoting gender balance, improving age distribution, supporting temporary research staff, optimising research time, strengthening project establishment, and refining recruitment and retention strategies

- Continue with “enhance gender balance initiatives” including expand recruitment efforts: Continue prioritising the appointment of female candidates, especially for senior academic positions. Consider implementing targeted recruitment campaigns and partnerships with organisations that support women in academia
- Improve age distribution and succession planning by develop a comprehensive succession plan: Collect and analyse data on upcoming retirements and potential internal candidates for promotion. Create a clear pathway for career progression to retain talent and ensure smooth transitions.
- Support for Temporary Research Staff: Explore opportunities to convert temporary positions into permanent roles where possible. Provide clear career development plans and support for post-docs and PhD students to enhance job security and satisfaction.
- Optimise Research Time and Sabbatical Policies: Track and evaluate the impact of sabbaticals on research productivity and career development. Use this data to refine sabbatical policies and ensure they meet the needs of staff.
- Enhance Early Career Support: Continue to provide targeted support for female associate professors, PhDs, and post-docs. Ensure they have access to mentors and professional development resources. Continue with refining recruitment and retention Strategies including Proactive Recruitment.

1.7 Open Science

In 2020, NTNU introduced a comprehensive policy to manage research data in alignment with the FAIR principles, (Findable, Accessible, Interoperable, and Reusable). This policy requires researchers to develop detailed data management plans and utilise online repositories for storing their data. which include guidelines for file naming conventions, metadata formats, data organisation, and backup and storage

These requirements are mandatory for all projects funded by the European Union (EU) and the Norwegian Research Council (NFR). The policy also emphasises the importance of making research data openly accessible through online repositories. However, in 2022, 32% of the research data was not openly accessible, which is similar to the EVALMIT unit’s average of 31.1%.

Regarding data ownership, the NTNU policy stipulates that the university generally retains ownership of the research data, with some exceptions. Intellectual property rights (IPR) issues are addressed and negotiated at the contract stage as necessary, ensuring clarity and agreement on data ownership and usage rights from the outset.

Recommendations on how to promote open science

Promoting open science at EPT can be improved through a combination of strategic initiatives and practical support, for example,

- Regular workshops and seminars from all research groups to educate researchers on the principles and benefits of open science.
- Offer access to software and tools that facilitate open science, such as data management platforms and open access publishing tools.
- Communication and advocacy by launching awareness campaigns to promote the benefits of open science to the research community and beyond.

2. Research production, quality and integrity

The research in the EPT department is organised into four groups, covering a spectrum from fundamental to applied and industrial-focused research.

Industrial Ecology (IndEcol) focuses on environmental sustainability analysis. This interdisciplinary group regularly contributes to IPCC assessment reports and the international resource panel. They have one ERC grant holder and numerous European and national research projects, with activities aligned with the UN sustainable development goals. Their research spans four main areas: Ecosystems and Bioresources, Energy, Transport and Buildings, Circular Economy and Resources, and Sustainable Production and Consumption.

Process and Power conducts research crucial to Norwegian industry, partnering in several EU projects and coordinating the HydroCen FME on waterpower technology. They specialise in heating and cooling technology, hydropower, natural gas technology, heat exchangers, thermal power production, and food engineering.

Sustainable Energy Systems focuses on systems-level research in energy and renewable energy technologies. Their two main research areas are E-fuels (batteries, hydrogen, and bioenergy) and Energy and Indoor Environment. They are partners in two EU projects.

Thermofluids is internationally recognised, with four ERC projects and an international chair in computational fluid mechanics. Their research areas include multiphase and free surface flows, turbulence and aerodynamics, and combustion research on biofuels and hydrogen.

In 2022, the Energy and Process Technology (EPT) department demonstrated significant academic productivity, with a total of 199.5 author shares in various publications. This impressive output was matched by a citation score that aligned with the Norwegian national average for energy research, highlighting the department’s impactful contributions to the field.

The university places a strong emphasis on research integrity, guided by a comprehensive code of ethics. This code outlines specific responsibilities for PhD supervisors, ensuring they uphold the highest standards of academic mentorship. Additionally, all PhD students are required to complete mandatory courses designed to install ethical research practices from the outset of their academic careers.

When it comes to addressing research misconduct, the university has established clear guidelines. Any suspected misconduct must be reported to the head of the department or the faculty. If the situation warrants further investigation, the Research Ethics Committee steps in to handle the case. This committee is responsible for conducting thorough investigations

and ensuring that all procedures are meticulously documented. This includes keeping detailed records of meetings and actions taken, particularly in relation to scientific publications.

Overall, the EPT is recognised internationally for its extensive range of energy-related research. It boasts numerous projects, a robust publication record, and commendable citation metrics. The department's well-established structure and procedures for maintaining research integrity further reinforce its reputation as a leading institution in the field.

2.1 Research quality and integrity

Research group Industrial Ecology Programme (IndEcol) overall assessment

IndEcol was established in 1996 within the Department of Energy and Process Engineering (EPT). Since then, the group has grown significantly and now boasts an impressive team of 75 research staff as of 2023, including 7 professors, 10 post-doctoral researchers, and 30 PhD students, all contributing to a robust research output.

Between 2018 and 2022, research income more than doubled, increasing from 22.6 MNOK to 47.4 MNOK, with 60% of the funding coming from the Research Council of Norway (RCN) and 30% from EU projects. The group holds one ERC grant and coordinates six national research centres. On average, around 50 projects are active each year, and approximately 60 to 70 articles are published annually in international peer-reviewed journals, many of which are top-ranked. IndEcol's high international standing is further evidenced by its active participation in both national and international competitive initiatives, establishing it as a leading group not just in Europe, but globally.

In terms of societal impact, IndEcol is involved in various initiatives that are highly recognised and appreciated within the Norwegian community. The group actively disseminates research findings to non-academic audiences, maintains a strong presence on social media, engages with educational institutions from kindergarten upwards, and participates in national forums and debates. Additionally, IndEcol promotes the transition to a sustainable society through direct interactions with policymakers at both national and international levels.

While there are no obvious weaknesses, challenges do arise from the breadth of activities, which could lead to efforts that are not fully aligned with the group's overall vision and impact. It is also noted that despite the growth in funding, contributions from industry and other private sectors have significantly decreased over the past two years.

Research group Process and Power (PP) overall assessment

The Process and Power research group was established in 2020 from the merger of three existing groups. A staff member from Canada was brought in to lead the group and define its strategy for the next 5-10 years. The group comprises 8 full professors and 2 assistant professors. The organisation and management ensure coherence within the group, despite the diversity of research topics.

The group has a steady flow of funding and has been highly successful in attracting funds from the Research Council of Norway (RCN) and industry, supporting a broad research profile with a strong focus on national industry and technological institutes. This highlights the high relevance of their research to national and industrial partners. The group is responsible for two major laboratories and additional infrastructure that also provides services to external users on a national level.

International visibility is achieved through publications in international archival journals, with an average of 15.7 citations per paper, which is in line with the worldwide average. The group's societal contribution is evident through its close connections with industrial partners, either directly funded or via co-funding with RCN.

While there are no obvious weaknesses, the group may exhibit a modest level of ambition. There should be a greater focus on the quality of research output rather than citations. Challenges arise from the transition period the group is currently experiencing. Additionally, the group should consider increasing the impact of its research by engaging with more industry partners on a global scale, rather than just nationally.

Research group Sustainable Energy Systems overall assessment

The Sustainable energy Systems group is a large group with 6 full professors and 33 persons in total. The research covers a broad scope from buildings to Lithium-ion batteries to catalysis.

The research group has very good resources from both basic and external funding and access to infrastructure. Funding is on the level of 22 MNOK per year over the last 5 years. NNTU provides 20% of this, a good level to support a broad research program, this is evident also by the large number of PhD students and Post-Docs. The RCN is the main source of external funding, but the groups does also attract funding from industry and EU programs.

The research profile is very broad, and is well aligned with university strategy, national agenda, and international research trends with respect to energy and sustainability. The group is involved in both national research centres and EU programs and has through this a vast academic and industrial network.

The societal contribution is very strong with the base on research around energy and sustainability., and to a large part also addressing the systems level. Thus, the profile of the group makes them well placed to contribute to economic and societal development in Norway, in particular with respect to the development of battery related industry.

In terms of weaknesses and challenges, it is noted that while the group is internationally recognised it cannot be judged at present as internationally excellent. Another aspect to this is reflected in most projects the group is a participant and not project leader. However, with the young profile of the group there is potential in the near future to reach this internationally excellent level.

Research group Thermo-fluid (TF) overall assessment

The Thermo-fluid group is mainly active in fluid mechanics and combustion. It is organised by principal investigators with a single management level. Over the last 10 years it has shifted focus to become active on an international level, with many new international staff attracted, and investments to have experimental facilities and flow diagnostics that can compete internationally. It has been successful in acquiring two ERC grants, one ERC consolidator grant, and coordinates a large Marie Curie training program. Most projects are funded by RCN, with individual PI's also acquiring EU funding.

Investments have been made to provide state of the art experimental facilities and flow diagnostics that can compete on an international level. The research output is of a very high level, and the group can be considered to be among the top 10% on an international level.

Weaknesses and challenges revolve around specific areas: the experimental strength highlights that numerical methods are underrepresented, though this could begin to be mitigated by the part-time position opened in numerical methods. There appear to be few formal collaborations outside the group, it would be advisable to consider joint projects with multiple PI's both inside and outside the group. This would promote synergy and increase the impact of the group, for example, concurrent experimental and numerical investigations could be a successful strategy. In terms of societal impact there appear to be no formal and/or direct involvement of industrial partners or public organisations in the research, so that societal impact and direct knowledge transfer appear to be modest. It would be advisable to obtain projects that are directly or partly funded by industry. This may also be beneficial in increasing the attractiveness to Norwegian students, which was another noted weakness. Finally, it is noted that the basic institutional funding is decreasing; to sustain the level of research and maintain their laboratory facilities will be a challenge if this trend continues.

3. Diversity and equality

NTNU bound by the Equality and Discrimination Act, and the mechanisms to apply this set out in a Code of Ethics. All appointments from PhD to permanent academic positions are assessed by the equality advisor to make sure no applicants unjustifiably overlooked.

EPT is proactive in trying to improve gender balance, setting up "EPT Women in Science" in 2017 with currently 30+ members, the aim being to provide networking opportunities, increase visibility within NTNU and accelerate women's STEM careers. It organises workshops, lectures and events to instil skills/confidence/know-how at early the academic career stage.

In 2021 a collaboration with the Department of Interdisciplinary Studies of Culture (KULT) a PhD student was funded to study gender balance and diversity at EPT in a systematic way, the aim being to identify quantitative measures that EPT can implement.

From these measures, it is evident that good attempts are being made to avoid discrimination and ensure equal treatment of employees.

In terms of the unit's current status (EVALMIT unit average in brackets), it can be seen that EPT's gender balance closely matches the EVALMIT average, although a little lower in the Researcher/Postdoctoral category:

- Professor, 15% (15%) female
- Associate professor, 25% (26%) female
- Researcher/Postdoctoral, 17% (24%) female
- PhD, 29% (29%) female

Recommendation to administrative unit

- Strengthen Evaluation Processes to Ensure the "equality and diversity" ombudsman has sufficient resources and authority to influence hiring decisions.
- Regularly review and update evaluation criteria to reflect best practices in diversity and inclusion.

4. Relevance to institutional and sectorial purposes

EPT research significantly enhances the knowledge base in engineering sciences, boasting a strong international track record. This includes leading RCN projects, securing five prestigious ERC grants, publishing extensively in top-ranked journals, and contributing valuable insights to reports for major international panels such as the IPCC, IPBES, and UNEP.

In terms of education, EPT offers substantial teaching contributions within its specialist areas. It provides a comprehensive 2-year Master's program and two rigorous 5-year Master's programs in Mechanical Engineering and Environmental Engineering. Additionally, IndEcol hosts specialised 2-year Master's programs in Industrial Ecology, Sustainable Energy, and Circular Economy, catering to the growing demand for expertise in these critical fields.

PhD students at EPT are required to obtain 30 ECTS points from graduate courses, ensuring a robust academic foundation. For training and mentoring, PhD students must earn these 30 ECTS points, while 5-year Master's students dedicate their final year to intensive research training. This includes a Master's project for half a semester and a full semester focused on their Master's thesis. These students are integrated into a professor's research group, providing them with hands-on experience and often receiving day-to-day supervision from PhD students. Impressively, approximately 10% of Master's theses result in a journal paper, highlighting the high quality of research conducted.

In the realm of innovation and commercialisation, researchers receive comprehensive support from the NTNU Technology Transfer Office. This office assists in spinning out ideas for commercial application, conducting thorough market research, and providing crucial support for patent and IPR issues through to the project phase. Additionally, NTNU Discovery offers financial support for the early development, verification, and quality assurance of commercially viable business ideas, fostering a culture of innovation and entrepreneurship.

Overall, EPT demonstrates excellent performance in research, education, and innovation, making significant contributions to both the academic and commercial sectors.

5. Relevance to society

A diverse set of impact cases were presented, showcasing significant advancements in various fields. These included the development of zero carbon combustion technologies in gas turbines, which aim to reduce greenhouse gas emissions. Additionally, a comprehensive life cycle analysis database was created to facilitate accurate carbon footprint calculations, aiding in the assessment and reduction of environmental impacts. Efforts to improve energy efficiency across all scales in industry were also highlighted, demonstrating practical applications that can lead to substantial energy savings. Furthermore, there was a focus on understanding the physics of hydropower turbines, which is crucial for optimising their performance and reliability.

These initiatives led to a wide range of valuable outputs. The advancement and dissemination of knowledge were achieved through numerous scientific publications and the development of a user database, which serves as a resource for researchers and industry professionals. The training of early career researchers was another key outcome, with many PhD students and post-doctoral fellows gaining valuable experience and expertise. New design tools and insights were developed, particularly in the areas of energy efficiency in

industrial processes and hydropower turbine design, contributing to more sustainable engineering practices.

Economic and environmental benefits were also realised. The improvements in energy efficiency resulted in reduced emissions, contributing to environmental sustainability. In the hydropower sector, cost savings were achieved through enhanced turbine designs that reduce the likelihood of failure, thereby lowering maintenance costs and increasing operational efficiency.

Overall, these contributions have made a significant impact on the Norwegian Long-term plan for research and higher education. They address broader societal challenges and align with the United Nations Sustainable Development Goals, promoting a more sustainable and resilient future.

5.1 Impact cases

Comments to impact case 1: Enabling Zero Carbon Combustion

The Thermo-fluids group at EPT conducts fundamental research targeted at the major scientific challenges in gas turbine combustion, including combustion instabilities (thermoacoustics), harmful emissions, and flame stabilisation. All of these are relevant to the shift towards zero carbon combustion. In particular, work with annular combustors at pressure, work on thermoacoustic, understanding of swirling flames, work on DNS and LES. Together these generate significant research output.

The impact case is described in terms of the difficulties in the use of net-zero fuels, in particular with regard to hydrogen and ammonia and their specific problems arising from combustion instability such as noisy hydrogen combustion and high emissions from ammonia. The research outcomes are framed in terms of enhancing the understanding of these problems with the aim of providing the ability to develop predictive tools to address these problems, which at present force designers down conservative non-optimal paths. In addition, the high scientific output (91 publications over 5 years) and the strengthened human capital through doctoral training with a focus on producing engineers with exceptional qualifications and skills is detailed, with 13 PhD students and 12 postdoctoral researchers trained over the last 5 years

The importance of the impact case is laid out in convincing detail and is highly relevant to moving to a sustainable future in gas turbine systems. Participation of major European gas turbine manufacturers in TF led projects is a positive sign. The relevance to other industrial heat sectors (steel, cement, glass, aluminium) is noted and further underlines the importance. The main drawback is that it is all framed in an aspirational manner, actual tangible outcomes other than the training and scientific publication numbers are lacking from the provided details.

Comments to impact case 2: EXIOBASE

EXIOBASE is the outcome of three EU projects from 2007 to 2016 and maintained by IndEcol since they ended. It is the only global environmentally extended input-output database with a clear focus on sustainability issues and a consistent sector classification. It is a tool used for scientific research, and by multiple consultant companies for spend based carbon foot printing. It is also used by policy institutions from Norway, the Swedish EPA and the European environment Agency. It has over 50000 downloads and over 400 citations. It provides consumption-based accounts for 44 economies and 5 rest-of-the-world regions, a

model approach is implemented that allows to calculate consumption-based accounts that fully respect national statistics data while accurately modelling impacts abroad.

Evidence is presented of the database use in policy in Sweden, Denmark, Norway (two examples) and the European environment Agency. Commercial use is detailed in terms of 4 known cases from the over 50,000 downloads of the database. In these terms, the relevance and importance is well demonstrated.

Comments to impact case 3: FME HighEFF – Centre for Environment Friendly energy Research

The case study is related to a large centre of Environmentally Friendly Energy Research (HighEFF) with 34 partners (15 industrial, 9 vendors, 3 research institutes, 8 universities). Led by SINTEF with NTNU the main academic partner, the driving force is the improvement of energy efficiency at different levels of industrial process ranging in scale from individual pieces of equipment to industrial sites/parks. The aim is to make Norwegian industry the worlds greenest, energy efficiency being recognised as crucial in the mitigation of climate change.

The research encompasses new equipment for heat engines, heat pumps, refrigeration cycles. New tools and methodologies to analyse/design/optimise industrial processes and energy plants. In the PnP group 6 PhD's, 4 Post-docs and 156 journal papers are connected to the project, along with various associated PhDs and publications. Two "Best paper" awards and a "2nd Best speaker" award resulted.

The case is highly relevant in terms improving energy efficiency and thus reducing greenhouse gas emissions. In terms of strengths, the numbers of PhDs and Post-doctoral staff trained along with the journal outputs is a strength. Quantification of the actual impacts though is difficult, with the evidence presented showing benefits, though not necessarily to the level targeted in the original program proposal.

Comments to impact case 4: High Head Francis Turbines (HiFrancis-project)

The HiFrancis project involved measurements and experiments to understand the physics of turbine impellers. The aim is to develop simulation methods and validated procedures that turbine manufactures can apply in designing new turbines.

The background is set out in terms of the 50-year average age of Norwegian power plants and the resulting maintenance/refurbishment requirements, in addition to a number of failures when installing new Francis turbines. The project involves 9 utility companies, 4 turbine manufacturers, 3 consultants, Energi Norge and NTNU.

Model turbine measurements were utilised to create a procedure for numerical analysis of Fluid-Structure Interaction on high head Francis turbines, thus reducing the risk of resonance breakdown in in future installations.

The case is highly relevant in terms of reducing costs and minimising breakdown in hydropower breakdown. Breakdown probability for new turbines has reduced from 10% to 5%, in an impact study the value on a worldwide basis is calculated at 5 billion NOK. In terms of the refurbishment of Kvilldal and Rana hydropower plants, Statkraft estimated value creation of 84 MNOK.

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 three 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 assessment, and the interview. The Administrative Unit had the opportunity to fact-check this summary. The Administrative Unit approved the summary with minimal adjustments.

Limitations

The Committee judged the information received through documentary inputs and the interview with the Administrative Unit sufficient to complete the evaluation.

List of administrative unit's research groups

Institution	Administrative Unit	Research Groups
Norwegian University of Science and Technology (NTNU)	Department of Energy and Process Engineering (EPT)	Sustainable Energy Systems (SES)
		Industrial Ecology Programme (IndEcol)
		Thermo-fluid (TF)
		Process and Power (PP)

Terms of Reference (ToR) for the administrative unit

The board of the Faculty of Engineering, Norwegian University of Science and Technology (NTNU) mandates the evaluation committee appointed by the Research Council of Norway (RCN) to assess Department of Energy and Process Engineering (EPT) based on the following Terms of Reference.

Assessment

You are asked to assess the organisation, quality and diversity of research conducted by EPT 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 5 aspects in your assessment:

1. As a department within the Faculty of Engineering at NTNU, EPT follows the strategic goals and priorities set at both the faculty level and centrally at NTNU. How this is to be achieved is set out in EPT's own strategy document. Strategic documentation from NTNU has been listed under "Documentation" which includes the Faculty of Engineering's Strategy 5-year plan from 2018-2022 which remains valid as a new plan is under development and EPT's 5-year strategy from 2020-2025.

2. EPT's research and teaching activities generally address the areas of energy and process engineering with an emphasis on sustainability. It is one of the largest departments at NTNU. In 2016 NTNU merged with several University colleges and several academics from the University College in Sør-Trøndelag joined EPT and were integrated into the research group for sustainable energy systems. Physically, the department is located in four different buildings on the NTNU Gløshaugen campus, including 6,000 square meters of laboratories. EPT is responsible for major foundational subjects taught across all engineering departments in fluid mechanics and thermodynamics, with approximately 900 and 450 students, respectively, each year.

3. EPT has four research groups that are well funded from national sources, the Research Council of Norway, as well as international funding bodies like the European Union. They are the Industrial Ecology group which focuses on environmental sustainability analysis, the Process and Power research group which focuses on power, processes, systems and components important to Norwegian industry, the Sustainable Energy Systems research group works with the integration of energy systems with the aim of increasing sustainability and mitigating climate change, and the Thermofluids research group performs fundamental and applied research in a range of topics within the fields of fluid dynamics and thermal energy. Both Industrial Ecology and Thermofluids are internationally leading groups.

4. EPT works systematically to ensure gender balance and diversity at the department, and has since 2017 fostered a local Women in Science initiative which today consists of 30+ members. EPT and the Department of Interdisciplinary Studies of Culture (KULT) have entered into a collaboration on a research project on gender balance and diversity at EPT, which started the Autumn of 2022.
5. EPT is an internationally diverse department which has enhanced its research profile and improved our competitiveness and participation in international arenas.

In addition, we would like your report to provide a qualitative assessment of EPT as a whole in relation to its strategic targets and research quality in terms of both national and international impact. The committee should assess whether the strategy is capable of meeting its targets based on available resources and competence. The committee should also identify any key gaps or shortcomings that should be addressed to improve the overall impact of the department.

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
- strategic plans of relevance from NTNU and its Faculty of Engineering, (hyperlinks to NTNU-sites included): o Department of Energy and Process Engineering strategy 2020-2025
    - Faculty of engineering main strategy 2018-2025 (n)
    - Faculty of engineering research strategy 2018-2022 (e)
    - NTNUs main strategy 2018-2025 (e) o NTNUs development agreement with the ministry 2023-2025 (n)
    - NTNUs wider contribution to innovation, (n)
    - NTNUs international development plan 2023-2025 (e)
    - NTNUs development plan for open science 2023-2025 (e)
    - NTNUs development plan for gender equality and diversity 2023-2025 (e)

Interviews with representatives from the evaluated units

Interviews with the EPT 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 EPT 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 EPT and RCN. EPT 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 Faculty of Engineering, NTNU and the RCN no later than two weeks after all feedback on inaccuracies has been received from EPT.

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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