Forskningsrådet

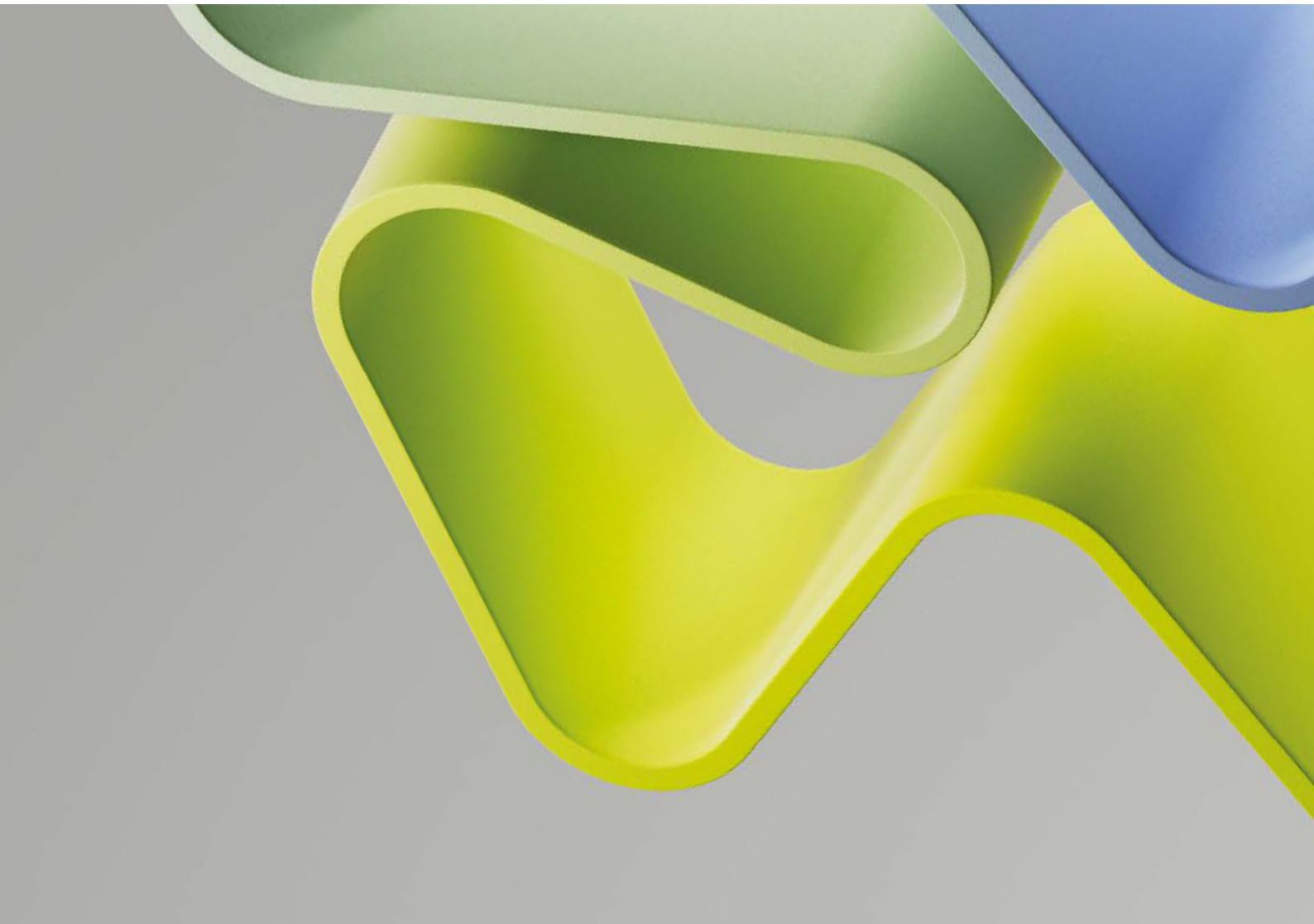
Evaluation of Natural Sciences 2022-2024

Evaluation report

Department of Physics

Norwegian University of Science and Technology - Faculty of Science

January 2024



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Statement from Evaluation Committee II

The members of this Evaluation Committee have evaluated the following administrative units at the higher education institutions within natural sciences in 2022-2023 and submitted a report for each administrative unit:

- Department of Chemistry, Norwegian University of Science and Technology
- Department of Physics, Norwegian University of Science and Technology
- Department of Chemical Engineering, Norwegian University of Science and Technology
- Department of Materials Science and Engineering, Norwegian University of Science and Technology
- Department of Geoscience, University of Tromsø
- Department of Chemistry, University of Tromsø
- Department of Physics and Technology, University of Tromsø
- Department of Energy Resources, University of Stavanger
- UNIS – The University Centre in Svalbard

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

The Evaluation Committee has consisted of the following members:

Professor **Amelie Hagelauer** (chair)

Technical University of Munich, Germany

Dr. **Eric Deville**

IFP Energies Nouvelles, France

Professor **Christian Ruegg**

Federal Institutes of Technology ETH Zurich, Switzerland

Professor **Guido Mul**

University of Twente, The Netherlands

Professor **Sigridur Suman**

University of Iceland, Iceland

Description of the administrative unit

Norwegian University of Science and Technology – NTNU
Department of Physics – IFY

The administrative unit

The unit employs 165.15 FTE research staff out of which 31 are professors, 16 associate professors, 6 researchers, 21.7 postdocs, 87.25 PhD students and 3.2 adjunct professors. The unit performs research in a wide variety of research areas including Biophysics and Medical Technology, Astrophysics and Particle Physics, Porous Media Physics, QuSpin (Centre for Quantum Spintronics), Science Education Research, Computational Physics, Atmospheric and Laser Physics, Soft and Complex Matter Physics and Material Physics. The work is organised in nine research groups.

The belonging research groups

IFY consists of nine research groups – Soft and Complex Matter Lab research group, Computational Physics research group, Atmospheric and Laser Physics research group, Biophysics and Medical Technology research group, Astrophysics and Particle Physics research group, Porous Media Physics research group, Material Physics research group, QuSpin research group and Science Education Research group.

The administrative unit works in relation to the unit's strategies

To achieve the goals (see below) and realize the vision of the IFY strategy for 2018-2025, "Physics for excellent knowledge", the unit works to maximise synergies through, among other things, developing robust research groups with defined research strategies; recruiting permanent scientific staff to consolidate research groups; support participation in international research consortiums; facilitate international mobility; and establish and upgrade existing research infrastructure. The planned research-field impact is directed to sectors implicit within the research topics and contributing to NTNU's Strategic Research Areas (NTNU Health, NTNU Oceans, NTNU Energy, NTNU Sustainability), NTNU's Enabling Technologies (NTNU Biotechnology, NTNU Digital, NTNU Nano) as well as to UNs sustainability goals.

The unit works in relation to the belonging sector

IFY conducts research and education that contributes to increased sustainability through research-based education and fundamental research. Examples are within low-energy systems that can later be applied to create new low-energy technologies with clear global impacts related to lower energy consumption, but also within medical technology and the health sector in terms of improved therapies and diagnostics, as well as reduced carbon emission by new methods for CO_2 storage. It supports development of innovative solutions through collaborations with different sectors and in active participation in e.g., Center for Research-based Innovation, expecting a wider impact on the society and a tighter connection between the university and the industrial/public sector. Long-term efforts in creating larger collaborative groups with clear strategies supported with appropriate infrastructure and networks will create scientific and societal impact.

Where the unit will be in the future

According to the IFY strategy for 2018-2025, the main goals to reach the vision for IFY are:

- To have a consolidated and collaborative staff and a solid base for national and international leadership and development
- To have very high quality on research within the prioritized thematic areas material physics, quantum technology, physics for health and porous media physics

- That all research groups should be internationally recognized or leading within their thematic areas
- That NTNU-IFY should be a preferred partner within its prioritised research areas and central within development of physics-based knowledge and methods nationally

Overall assessment

The Evaluation Committee commends NTNU-IFY for its excellent output, overall strategy and management priorities that are focused and well aligned with NTNU's strategic research areas and enabling technologies as well as national goals. NTNU-IFY is excellent at national and international level. For a large department like NTNU-IFY expectations are very high to cover a wide range of research topics, meet deliverables in teaching, create impact in other sectors e.g. industry, medicine, and in dialog with society. The unit meets these expectations.

NTNU-IFY is very active in major local and national initiatives with two centres of excellence, participation as nodes in national research infrastructures and networks, and joint projects and grants with many partners from academia, industry, and medicine.

National funding from RCN and from other national sources per PI is among the highest at NTNU. There are some successes with EU grants (projects and ERC) but given the large number of professors NTNU-IFY has not been able to exploit the full potential of these funding instruments to support scientific excellence and careers.

The local research infrastructures are of high quality, accessibility is high and collaboration locally and in national networks is encouraged and working well. Participation of Norway and of NTNU-IFY in international research infrastructures is rather limited and has not been a priority of the unit.

The NTNU-IFY management and operations concerning topics like recruitment, diversity and inclusion, open research data, open access, etc are state-of-the-art. Support for technology transfer is available and provided centrally, support for grant application is available and apparently effective for national funding. Support for international mobility and career development is coherent and excellent at international level.

The recent merger with colleges has created new opportunities in teaching of the broad physics curricula, research training, and collaboration with outside partners. The process is ongoing and includes discussions and ideas for consolidation of topics and composition of research groups in NTNU-IFY as well as at the interfaces and in collaboration with other departments.

The NTNU-IFY has an excellent track record. It is well positioned for sustainable success and to be nationally and internationally leading in the chosen research fields.

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

The Evaluation Committee recommends three areas of improvement and focus for future development:

- There is a clear potential to increase international visibility and funding by applying for more EU grants and specifically ERC. Dissemination of information on calls, support for grant writing and efficient grant administration will encourage PIs and accelerate success in this area

- The consolidation of activities (topics, critical mass of groups, focus on priority research areas) following the merger should be continued and include a broader discussion and

portfolio analysis between departments with overlap and potential synergies in education, research, and technology transfer

- Research infrastructures are enablers and should be addressed more strategically. This includes also international projects with potentially large leverage for the unit e.g. the European Spallation Source ESS with substantial contribution from Norway, among other initiatives.

1. Strategy, resources, and organisation of research

NTNU-IFY is an excellent research unit and is internationally recognized. Its top-level strategic planning meets international standard and is well-aligned with strategic research areas and cross-cutting technologies defined by the faculty and the university. The resources are adequate relative to the research quality and include wide success in the acquisition of external funding (top tier of NTNU). EU funding and the engagement in and exploitation of international research infrastructures could be address more strategically.

1.1 Research Strategy

The administrative unit has a well-defined strategy, which is embedded in that of the faculty of natural sciences and is well-aligned with NTNU's strategic research areas and enabling technologies. But the strategy of the groups themselves is less aligned with the overall strategy of the department and university or such aligned is not demonstrated in the documentation and final research group reports. The individual group evaluations are very divers, some groups have no joint strategic goals. The overall activities match the unit's strategic goals well. The yearly update of the staff and budget plan based on the priorities of the strategy is very valuable.

1.2 Organisation of research

The organization of the unit in terms of topics is rather broad and could be more focused (fewer groups with critical mass and closer collaboration). Collaboration within NTNU-IFY should be strengthened further via joint centres of excellence, shared infrastructure, and national and international networks and projects. The overall organisation seems to be suitable. The management group manages, coordinates, and develops the educational programme and monitors and supports the research groups. The unit has a high level of understanding of its role and envisions ambitious opportunities for future research.

1.3 Research funding

The overall funding level is good, and the unit is very successful in acquiring externally funded projects in Norway from a range of agencies and sources including industry. There is the clear potential to increase funding from the EU. EU funding includes one ERC consolidator grant, which is below expectations for a unit with 47 full or associate professors.

1.4 Use of infrastructures

The local research infrastructures are of high quality. Start-up funds are used to invest, and sharing is common practice. The accessibility is high also across departments (some of the use is charged) and collaboration locally and in national networks is encourage and working well.

The unit participates in several national infrastructures as node. These activities are well aligned with the research topics of the groups e.g. in the NTNU Nanolab, are efficient and increase the national visibility of NTNU-IFY.

On the European level the unit has access to CERN and ESRF. But the participation of Norway and of NTNU-IFY in international research infrastructures is rather limited and has not been a priority of the department. For some initiatives with substantial contribution from Norway such as the European Spallation Source ESS a more strategic positioning of the unit and of NTNU would be an opportunity to leverage previous investment.

1.5 National and international collaboration

The level of national and international collaboration is very high, and it is of good quality. Collaborations include leading academic institutions as well as successful partnerships with international organisations such as NASA and ESA, hospitals, public-private partnerships in research like SINTEF and the private sector.

The success in international research collaboration could be reflected more in joint international funding of projects. The opportunities of EU grants for collaborative projects and networks could be exploited more systematically.

1.6 Research staff

The composition of staff is well balanced and adequate. NTNU-IFY has managed to greatly increase the number of women in permanent positions in recent years reaching 30%, which is a success and meeting expectations in similar international research organisations.

The unit offers systematic career development for early career researchers and PostDocs, which includes individual development plans.

There are few limits for international mobility of staff, it is encouraged and regularly used. Junior staff have access to mobility grants e.g. from RCN. International recruitment has recently been affected by changes in the geopolitical situation and related control of knowledge transfer.

2. Research production, quality and integrity

The unit has overall significant output in a broad range of topics and in its specific sector as well as beyond. The Evaluation Committee notes the diverse performance of the different groups from publications of good quality to very good or excellent (c.f. feedback to individual groups below). The productivity is good as well, but again varies strongly between different groups. The publications show evidence of national and international recognition of excellent research.

Research integrity is good and in line with international best practise.

2.1 Research quality and integrity

Research group: Atmospheric and Laser Physics

The Atmospheric Physics and Laser Physics subgroups are rather small by international standards. The connection of the two subgroups is mainly through the formation of a joint teaching group in Optics. Their research and strategy are quite distinct and therefore it is difficult to consider and evaluate the two subgroups as one group. Besides the different focus of the two subgroups, they are also characterized by an uneven level of external funding. Although the professors of the two groups have – individually – a significant standing and international influence, it is difficult to assess the standing of the groups from the self-assessment report. It is mentioned that the AP group is internationally recognized and participates in large-scale, international programmes, but it is not clear in which ones. The quality of the LP group research, which is technologically orientated, is more apparent, as it relates to its strong impact on the Norwegian industry. The group has listed three patents and two prototypes. The research of both groups has a considerable social impact weight.

Research group: Astrophysics and Particle Physics

Individual members of the group are well-known in their areas of expertise, but there is too little cross-linking between them for the collective group to be stronger than its parts. Few of the research papers presented as representative of the group's output have had strong impacts. It will be essential for the group to make strategic choices between the many projects presented as opportunities for the future if it is to have higher scientific impact. Little information was provided to substantiate societal impact of the group and more interaction with users/non-academic collaborators is important.

Research group: Computational Physics

Computational Physics is a very dynamic domain which can have a strong impact at all levels of mat erial science, from teaching to academic and industrial research, as well as dissemination to a broad audience. However, the small size of the group and the lack of interactions between group members limits their impact. The strengths and weaknesses of the group are as follows: The group does not have an overarching research goal and strategy. The research group is sub critical in size so that its overall visibility at national and international levels is limited. The objectives of the group for the recognition within NTNU as well as at international level could have been defined more precisely to increase international visibility.

Research group: Material Physics

The research group has an overcritical size so that it is capable to advance the topics of the group and to support the output and visibility of the research unit. The involved professors of the research unit give guidance to the sub-groups and support the training, teaching, and visibility of the research unit. As a result, the number and quality of high impact journal publications is above average. Also, through the professor's contacts international collaborations are established and become foundational. A well-equipped research infrastructure is available e.g. TEM or a photovoltaics lab infrastructure which makes the Material Physics unit an attractive partner for all sorts of research projects with academia and industry.

The group's goals and objectives are of varying ambition and depth and as such do not form a unifying overall strategy. They are more detailed at group level and as such do not necessarily unify so that synergies between sub-groups are not exploited to the maximum. The sub-groups are of varying scientific focus, output, visibility etc. As such, the synergistic interplay of the sub-groups is not always visible and obvious. There are no obvious incentives to collaborate within the research unit or to grow as a sub-group within the research unit. With such a measure, synergies between research units could be better encouraged and exploited.

Research group: Porous Media Physics

In the Porous Media Physics research group there is a division between two sub-units. The X-ray physics group is an established group, whereas the porous media laboratory stands at the beginning of a transition into a new phase of activity also regarding the staffing situation. Supported by major basis funds this transition has already started. The X-ray physics group provide analytical methodologies which are available only at few places in Europe, and they perform the work on a high technical level. A perspective or even a vision for future development is however missing. The porous media laboratory on the other side presents some concrete and important ideas. The development on the level of the PIs is quite promising, but the porous media laboratory stands at the very beginning. It cannot be judged how they are going to perform, considering the major international competitors focusing on flow in porous materials as well. To become more competitive, capabilities in the preparation of tailor-made porous materials are currently missing. However, the scientific output, the acquisition of external funding and the established network of cooperation in Norway and Europe opens a lot of perspectives for future developments. A major obstacle is that the two units are currently not acting together or searching for synergies but seem to be rather separate from each other. Porous Media Physics are a group that is very strong supporting the production of excellent research. The research quality is internationally excellent in terms of originality, significance, and rigour but falls short of the highest standards of excellence. The group is contributing to the economic development in Norway, and this is on par with what is expected from groups in the same research field.

Research group: QuSpin - Center for Quantum Spintronics

The overall quality assessment is outstanding and the group belongs to the top research groups worldwide. The panel is deeply impressed by the high coherence of research and research community they have built up in Trondheim, at all levels, starting from an exceptionally large number of PhD students, postdocs, and faculty members. The group has attracted a high level of funding which deserves to be increased with highest priority. The group is well embedded in the University infrastructure. The group has achieved top marks in basically all evaluation criteria (except societal impact). One weakness is the glaring underrepresentation of women scientists, especially at the professor level. There should be a special focus to improve on this gender imbalance. The societal impact could be improved.

Research group: Soft and Complex Matter Lab

A key strength of the Soft and Complex Matter Lab research group is the interdisciplinary approach to the investigated topics and the ability to combine fundamental and applied research in soft matter and complex systems, dealing with hot topics in the field. For these reasons, the group is certainly a strong and original one in Norway and internationally. Another important strength is the active collaboration between the different members of the group, which ensures a productive and successful way to progress in research. The group is also very good at establishing long-term stable international collaborations with leading research groups around the world. Overall, the group deserves to be highlighted in the evaluation's national assessment of the area because it conducts high-standard research, it is competitive for prestigious funding and has the ambition to tackle innovative scientific questions at the boundary between fundamental and applied research, always ensuring collaboration and cross-fertilization of ideas among its members.

Research group: Biophysics and Medical Technology

The Biophysics and Medical Technology group has a broad research profile, based on two pillars: biophysics (fundamental research) and medical technologies (new methods for diagnostic and therapy) in five different areas (medical physics, biomaterials, drug-delivery, biomedical optics, and computational molecular dynamics). This structure assures the diversity of research but makes

difficult consolidation of the group along the broader projects. The long tradition in fundamental biophysics results in a very good publication record in high-quality journals and collection of unique instrumentation available at the lab. The success of this second pillar is clearly visible in the high-quality output: well financed projects, publications, patents, international collaborations. The composition of the Biophysics and Medical Technology group indicates a healthy relation between the number of senior and younger researchers and proves that the offered research topics attracts interest of students. A closer collaboration with hospitals and the general public may strengthen the feedback with stakeholders and help in future studies.

Research group: Science Education Research

A broad range of development and research activities are carried out, although the work seems to be driven more by personal interest and opportunism rather than following a coherent strategy. However, some of the publications are in top international journals. Hence the group is visible both nationally and internationally. One of the focus areas for the group is knowledge transfer to schools and within the university. Here, benchmarks are being met. There is also some evidence of the creation of digital education resources, although it is unclear how that integrates with the above efforts. The major strength of the group is that everything is there: high quality research output, extensive development activities, and knowledge transfer. The major weakness that there is a lack of alignment and coherence. It seems safe to assume that this lack of coherence is temporary and a natural by-product of the merging of two groups and the ongoing re-structuring. Hence, we believe the combined group has high potential, but is currently in a consolidation phase where overall strategy is still being worked out.

2.2. Open Science

The department refers to various NTNU policies concerning open access (OA) and open science and related offering by the NTNU Library. Examples of activities include a central fund for covering OA fees, mandatory training for PhD students, application of the DORA declaration, data management plans at project level, among others.

No active monitoring is mentioned that can be required by funding agencies or targets that have been set concerning OA publication.

While open science is encouraged in all activities of NTNU-IFY there is awareness of confidentiality in education research data and of potential conflicts concerning export control in areas of key technology with potential dual use.

3. Diversity and equality

Diversity and equality are regulated in various NTNU policies, which the NTNU-IFY fully embraces. NTNU-IFY seems fully committed to an inclusive work culture with key elements being openness, integration, and transparency.

Diversity is highlighted as a challenge for some, very successful research groups in the evaluations at the group level. However, recruitment process follows international good practice and fighting unconscious bias is mentioned explicitly in the self-assessment report.

4. Relevance to institutional and sectorial purposes

The unit has strong and coherent activities that contribute to all sector-specific objectives. The Evaluation Committee was impressed by several commercialisation and innovation results that were presented and cover a wide range of topics, industries, and applications. Overall, the unit is very ambitious and effective in collaborations ranging from leading universities to industry and international partner organisations.

As usual in many academic institutions, the level of engagement and impact depends on the personal interests and field of scientific activity. Infrastructure and central services to support research commercialisation and outreach are available. It is not manged top down but covers all areas where society has high expectations of a leading institute of technology such as NTNU.

Master students are tightly connected to the research activities of the staff members. No information is provided on training in transferrable skills or mentoring. The unit has a very high throughput of PhD candidates with a very short average time to completion. Research projects are the basis for PhD education and in addition PhD candidates follow courses in two doctoral schools for physics and biophysics.

5. Relevance to society

NTNU-IFY is fully aware of its responsibility beyond pure scientific excellence and has successfully contributed in various areas to meet expectations. As one of the largest physics departments in the country the expectations are high that it not only demonstrates impact, but also leadership in some key topics of science, innovation, and sustainability. The case studies demonstrate such ambition and success e.g. for the Norwegian aluminium industry and laser technology. A broader view and related priorities are however not demonstrated in the self-assessment report, e.g. concerning UN SDG, impact of new technologies on society, etc but happens via the strategic planning of NTNU and its strategic research areas and enabling technologies.

The case studies include two very successful examples for translation and commercialisation (biotech, laser), one long-term collaboration with industry (aluminium) and one from educational research that is relevant to the curriculum in secondary schools. All of these are very relevant to society and industry in Norway and are aligned with overall strategic goals.

Comments to impact case 1

Several groups active in science education research were transferred to NTNU-IFY in 2018. Two recent projects are highlighted: KreTek and ReleQuant that both were realised with support from RCN and in collaboration with other partners e.g. University of Oslo leading the second. Both projects use Design Based Research (DBR) as methodological frame with the aim to impact educational policy and improve teacher competence and resources. In the DRB framework research, implementation and impact often go in parallel and not in sequence. The introduction of new concepts in quantum mechanics and of older concepts in chemistry like the chemical bond was followed and a subject of this active research project. The impact is demonstrated by traditional indicators like publications and by application in the curricula and textbooks in upper secondary schools. Overall, a convincing case going beyond pure scientific excellence in the discipline. Approximately 400 teachers and 500 students per year have so far profited from the results and initiatives, which is a substantial 20% of the physics students in the final year of upper secondary school.

Comments to impact case 2

Micro-scale hydrogel beads are an important enabler in current bio-medical research. Members of NTNU-IFY had several RCN funded projects developing new hydrogels and micro-fluidic processes, resulting in the pioneering CLEX method, patents, and a spin-off company ClexBio with substantial venture capital investment. The direct impact is specifically in tissue engineering. The case is an example for success in translation and commercialisation in biophysics. Given the size of NTNU-IFY examples for spin-offs, translation, and commercialisation in several of the core activities of the department could be expect c.f. case 4 from the laser group.

Comments to impact case 3

Norway has a very active and successful aluminium production industry serving a wide range of sectors from car manufacturing to construction. In a broad collaboration with NTNU-IFY, NORTEM (TEM network), SINTEF and several companies (Nydro, Alcoa, Steertech) the properties of aluminium alloys for various applications have been studied, understood, and optimised. The TEM facilities and related method development have been key for the success of many projects, funded by RCN, innovation programmes and centres, over the past 20 years. The impact is demonstrated with publications, patents and clear statements by companies concerning the economic success of new products, which cannot be easily quantified. The training of students (MSc and PhD level) is highlighted as success and important contribution to a highly skilled workforce for Norwegian industry. The case demonstrates high awareness in NTNU-IFY of the specific needs and opportunities of collaboration with local industry.

Comments to impact case 4

Several large initiatives including European ERA-NET and COST projects have produced cutting-edge knowhow in fibre laser technology that is used in the large market of tuneable, ultra-short pulse lasers for materials processing. The group has actively patented the results and is commercialising them via its own spin-off ATLA as well as in partnership with large companies like IPS Photonics. The direct impact goes beyond industry and includes laser community work e.g. conferences and societies, education, and the successful careers of young scientists.

List of administrative unit´s research groups

Institution	Administrative Unit	Research Groups
Norwegian University of Science and Technology	Department of Physics	Soft and Complex Matter Lab research group
		Computational Physics research group

		Atmospheric and Laser Physics research group
		Biophysics and Medical Technology research group
		Astrophysics and Particle Physics research group
		Porous Media Physics research group
		Material Physics research group
		QuSpin research group
		Science Education Research group

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 (see appendix 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

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

Limitations

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

Appendices (link to website)

1. Description of the evaluation of EVALNAT
2. Invitation to the evaluation including address list
3. Evaluation protocol
4. Self-assessment administrative units
5. Grading scale for research groups

Website: https://www.forskningsradet.no/tall-analyse/evalueringer/fag-tema/naturvitenskap/

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