The Research Council of Norway

Evaluation of Mathematics, ICT and Technology 2023-2024

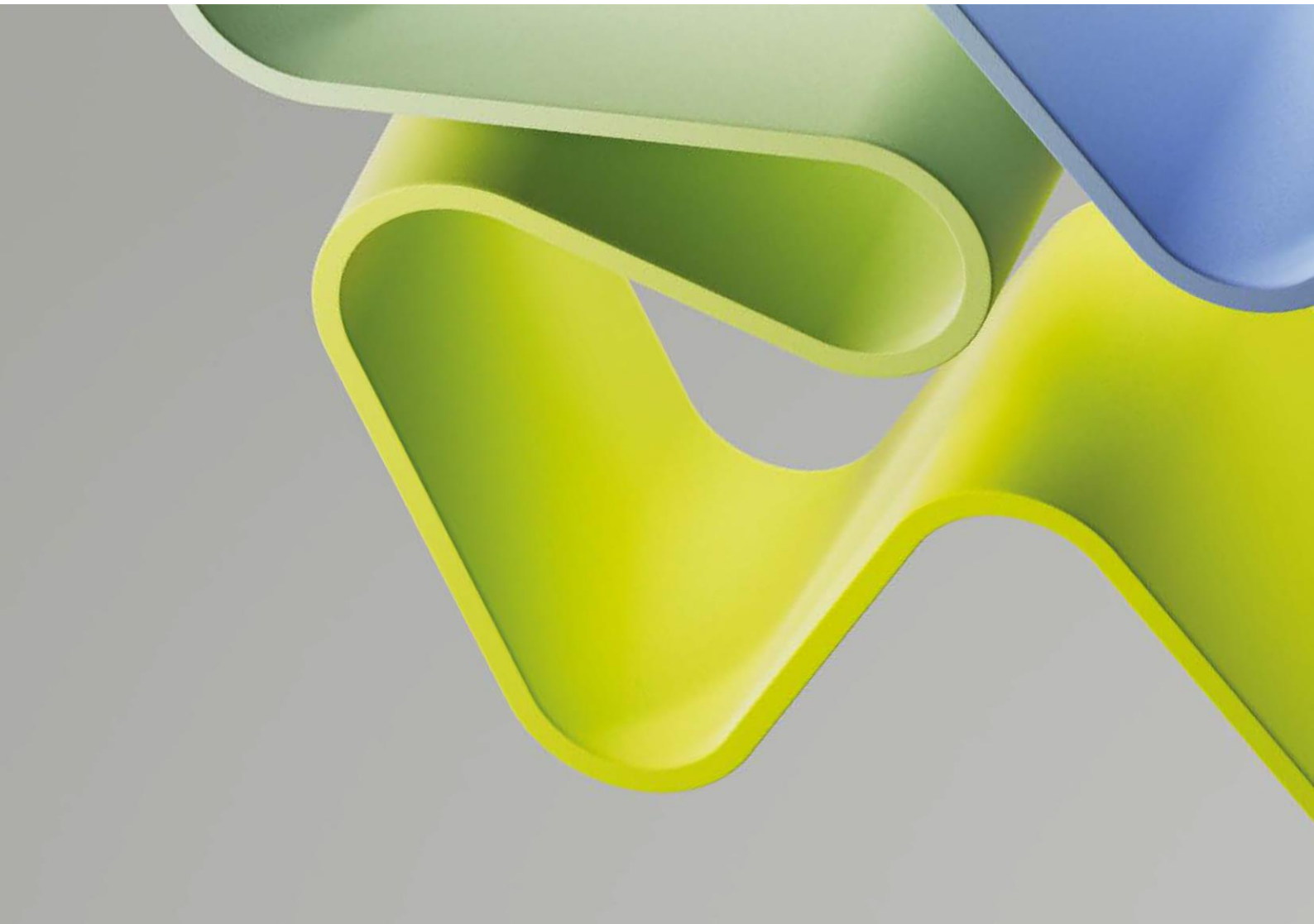
Evaluation Report for Administrative Unit

Administrative Unit: **Department of Architecture and Technology - IAT**

Institution: **Norwegian University of Science and Technology - NTNU**

Evaluation Committee Higher Education Institutions 4

December 2024



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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 Elsa de Sá Caetano, University of Porto

Professor Sebastian Geiger, TU Delft

Professor Per Heiselberg, Aalborg Universitet

Professor Mohamed Pourkashanian, University of Sheffield

Description of the Administrative Unit

The Department of Architecture and Technology (IAT) of the Norwegian University of Science and Technology (NTNU) comprises around 70 employees, including both permanent staff (scientific and administrative) and fixed-term researchers such as postdocs and PhD candidates. The team includes 9 professors, 23 associate professors, 6 lecturers, 4 scientific assistants, 14 PhD candidates, and 2 postdocs. Women represent 33% of the professors, 40% of the associate professors, and 57% of the PhD candidates. The scientific staff is diverse, featuring artists, architects, and engineers, which are essential skills for designing and transforming buildings and neighbourhoods.

The current evaluation is aimed at mathematics, ICT and technology and about 1/3 of the employees in the department falls under this heading (i.e. mostly technology).

Academic activities are structured into four research groups, each led by a group leader. These groups collaborate closely, especially in teaching, and increasingly in research, architectural, and artistic endeavours. A common administrative team supports all groups with educational and financial tasks, including contracting, ordering, and budgeting. The groups meet 2 to 4 times monthly to discuss relevant administrative, educational, research, architectural, and artistic activities. The group leaders are part of the department's leadership team, which also includes the head of the department, the head of administration, and deputies for education and research. The research is organised in the following research groups:

- Form
- Energy and the Environment
- Tectonics – Constructions and Materials
- Building Conservation and Transformation

The unit adheres to the university's primary objective of ensuring that its activities benefit society and that its findings are trustworthy and scientifically sound. Until 2021, the unit did not have its own strategy but aligned its R&D activities with the faculty's vision of shaping a sustainable future (2018-2025). Recently, the department has begun developing its own vision and goals, focusing on the development of architecture and built environments based on circularity, technology, aesthetics, and ethics. The goal is to advance circular architecture and built environments through research, architectural and artistic practice, and the education of independent candidates with integrated knowledge in architectural design, tectonics, preservation, and energy use. The vision and goals will be further refined into a comprehensive strategy during 2024.

The department's collaborations with other institutions arise from employee activities and include partners in externally funded projects and centres, as well as informal educational collaborations. These extensive national and international partnerships are crucial for addressing societal and building industry issues, central to the department's study programs. Hosting national centres and international innovation projects, the department spans the building sector's value chain and crosses into the energy sector. Attracting industry and public partners, along with leading research institutes and universities, is vital for successful project proposals and tackling significant societal challenges. The department collaborates actively with SINTEF Community, particularly in the FME Centres ZEB and ZEN, sharing leadership roles to find the best candidates for these large centres and projects. This

partnership also extends to developing and operating shared laboratories. Additionally, the department collaborates across faculties and departments to ensure the right expertise is available for its projects.

Overall Assessment

The vision of the department reads: “Development of architecture and built environments based on circularity, technology, aesthetics, and ethics”. It is the goal of the department “to contribute to the development of circular architecture and built environments through research, architectural and artistic practice.” The vision has not yet been followed by a research strategy although this is essential to exploit the potential of developing a research environment with a unique interdisciplinary profile addressing the specific societal challenges facing Architecture and the Built Environment in the coming decades, both in Norway and internationally and to contribute to the innovation needs in the building sector [ToR d, e]. This is especially relevant for the Energy and Environment Group, which is in competition with other research groups with similar competences both in NTNU and internationally and would benefit from defining a unique research strategy and profile [ToR a, 3].

The organisational structure is contributing to a collaborative approach to research, teaching and supervision, while allowing each research group to develop in accordance with the available resources, although the interdisciplinarity potential in research could be strengthened [ToR a, 1].

The committee did not have the opportunity to properly evaluate the department’s strategy since it seems that several groups did not contribute to the self-assessment and to the interview. The expert panel recognised that there are fundamental differences in terms of approach, type of research products, and pathways to innovation. As a result there is a lack of clarity if the Department aims to operate as a single, coherent unit that follows an overarching strategy or pursues a PI-centric model where groups define their individual research goals with limited cross-disciplinary cooperation and without following a department-wide strategy [ToR a].

The Department, to date, have not developed a clear strategy on how to evaluate its different areas and it is not known if it has mapped all the different types of products produced by its RGs or mainly the bibliographic ones [ToR a, b]. The Department is reacting to the recent change of national policy which considers for the definition of the intensity of funding mainly parameters related to the number of students and their rate of graduation.

Research funding has been increasing in the last five year including the funding from EU. Although research collaboration with a number of industries and stakeholders is reported in various national projects and the department reports a change in research strategy in the last 5-10 years, to also emphasising innovation and commercialisation activities, direct funding from industry for commissioned research has contributed minimally to the total funding [ToR b].

The department and the Energy and Environment Research group has access to excellent research infrastructure that may be difficult to sustain in the future, which should be a priority of the department to ensure.

The department considers collaboration with national and international partners as very important to address problems of relevance for society and the building industry and is participating in several projects with broad representation of partners from academia and industry. However, this collaboration could be reflected more clearly in research funding and in research publications co-published with national and international partners [ToR b].

The publication volume compared to the number of research staff is lower than seen in other academic units in the evaluation. The department states that the reason may be found in the fact that architectural and artistic practice are equally important to “research” and do not

always find way into scientific journals. As the research production is given for the department as a whole and not for individual research groups it has not been possible to verify this. Anyway, the share of articles published that are among the 10% most cited publications (13,4%) is well above the average level of similar departments in the building sector (around 10%) and a similar percentage of publications are co-published with selected top ranked international institutions indicating a high quality of the research output [ToR b]. Although it is recognised that architectural and artistic products can hardly be categorised together with journal papers, the Department did not try to illustrate in the self-assessment or in the interview which type of other products are developed, their importance and impact, leaving the Committee blind.

The gender balance is much better than seen in other academic units in the evaluation with a total share of female researchers of 39% compared to 25% in average. This trend is the case in all staff categories [ToR c].

The research at the department contribute to advancing knowledge and solutions in the field covered by the department vision and also contributes to UN Sustainable Development goals. These contributions are primarily realised through the hosting of centres and projects like NTNU Wood, FME ZEN, ARV, and syn.ikia). The impacts cases illustrate the importance of research outcomes to be adopted by policies and new regulations to provide an impact in both research and in the building sector. The Zero Emission Building definition has succeeded to influence policies and regulations and led to considerable development in whole the building sector value chain including design, construction, new technologies and building operation and management. The daylight project has provided valuable research results and new understandings, but not succeeded in influencing policies and regulations making impact in the building sector less visible. This underpins the importance of both having focus on research excellence as well as innovation and commercialisation activities.

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

Recommendations

The evaluation committee recommends that:

1. A research strategy is developed for the Department as a whole as well as for the research group on Energy and the Environment. The research strategy may focus on exploitation of the interdisciplinarity potential in the department. This is especially relevant for the Energy and Environment Group, which is in competition with other research groups with similar competences both in NTNU and internationally and would benefit from defining a unique research strategy and profile.
2. The collaboration between the research groups in the department are strengthened to exploit the interdisciplinarity potential not only in education, but also in research and PhD supervision.
3. A procedure or some criteria are established to properly consider the naturally heterogeneous products produced by the different RGs.
4. The Department considers the differences of approaches and objectives among the RGs like an opportunity more than a threat and exploit the opportunities of future evaluations for the benefit of the whole department. This is especially important in relation to the development of a more environmentally friendly built environment and circular solutions, where interdisciplinary collaboration between engineers and architects are crucial.
5. A strategic approach and practices to support early career researchers in their career development is developed and implemented. This includes ensuring mobility options

to establish and maintain research networks as well as a procedure for assistance to/mentoring of less experienced researchers in the application phase. The competition for research funding is increasing and it is essential, especially for less experienced researchers, with support in the application phase to improve the quality and funding probability.

6. The new opportunities for direct research funding from the building industry should be pursued. The focus on whole life carbon emissions from buildings and the changes in building regulations (EU, EPBD) increase the need for research and development in the building industry and provides new opportunities for direct industrial funding
7. A strategy for sustaining the existing research infrastructure is developed by seeking collaboration with other research units and departments. The present research infrastructure may be difficult to sustain in the future where basic funding are more based on education and students' graduation.
8. A more strategic approach is applied to development and maintaining of both national and international research collaboration as well as on co-publishing of research results to increase visibility and quality.
9. The department develops a clear open science strategy and implement open science practices including support services for researchers for data management and storage as well as open access to ensure implementation of FAIR principles in all research projects.

1 Strategy, Resources, and Organisation of Research

The Department of Architecture and Technology (IAT), has about 70 employees, divided between permanent staff and fixed term researchers. The scientific staff include artists, architects, and engineers, with competences needed when designing and transforming buildings and neighbourhoods.

The academic activities are organised in four research groups (with a group leader for each):

- Form,
- Energy and the environment,
- Tectonics – Constructions and Materials,
- Building Conservation and Transformation

Only one of the groups (Energy and the Environment) contributed of the research evaluation and to the self-assessment report.

The research strategy of the Department is in line with the institutional strategy of NTNU and is mainly related, to the Committee knowledge, to the strategic research areas of Sustainability and Energy and to the objectives that NTNU's activities should benefit society as a whole and comply with best scientific practice.

The research topics at the department are divided in four different areas that are all very relevant for fulfilling the research vision and goal. The topics include: 1) sustaining aesthetics, art, and culture as fundamentally important aspects of sustainable architecture, 2) sustainability issues of the built environment enabling the design of buildings and neighbourhoods with a positive impact on humans and their environment throughout their life cycle, 3) solving aesthetic aspects of architecture, while requiring more sustainable use and reuse of materials and structures and 4) building conservation, architectural history, traditional crafts, and transformation of buildings.

The cohesiveness and adequacy of the AU's strategy and organisation for its research activities cannot be extensively assessed since they were not properly presented in the self-assessment report and during the interview. Only the global vision and goal of the AU can be found while other aspects are provided only for one RG only (Energy and Environment).

1.1 Research Strategy

In 2021 the department developed its own research vision and goal. The vision of the department reads: "Development of architecture and built environments based on circularity, technology, aesthetics, and ethics". It is the goal of the department "to contribute to the development of circular architecture and built environments through research, architectural and artistic practice, and the education of independent candidates with integrated knowledge within Architectural design and aesthetic expertise, Tectonics and construction understanding, Preservation, and further development of existing built environments and Energy use and greenhouse gas emissions in the built environment". It was the plan that the vision and goal should be further developed into a strategy during 2024. However, a new governmental basic funding scheme to be implemented shortly, has postponed the process.

The developed vision and goal has the potential to contribute to the development of a research environment, addressing the specific societal challenges facing Architecture and the Built Environment in the coming decades both in Norway and internationally and to contribute to the innovation needs in the building sector. The department however still needs to translate these into a clear research strategy for the whole department and for the individual research groups,

It is not clear from the evaluation if the research effort is similar in between the four topics the department are addressing. However, the department does state in the self-evaluation report that traditionally the externally funded research activities has been centred around two groups (without mentioning which groups), while the research effort of the other groups has been limited to their basic research funding from the institution. A contributing factor is probably that more funding is available in some areas (e.g. energy and sustainability) than in others (architecture and art). This provides a risk of relatively small research groups below critical mass that become very dependent on individuals.

Recommendations to the administrative unit.

- It is recommended to develop a research strategy for the whole Department as well as for the individual research groups including Energy and the Environment.
- There is presently a large push for a more environmentally friendly built environment and circular solutions and a strong need for research to support the development in industry. The department has competences in many areas needed to develop a more sustainable built environment, from architecture and art to building and environmental engineering (LCA), integrated energy design, building physics, building materials. The research strategy should develop and exploit this interdisciplinarity.
- This is especially relevant for the Energy and Environment Group, which is in competition with other research groups with similar competences both in NTNU and internationally and would benefit from defining a unique research strategy and profile.
- The Department should find a procedure or some criteria to properly consider the naturally heterogeneous products produced by the different RGs. Only in this way, the first recommendation can be properly achieved and its success monitored in time.

1.2 Organisation of Research

At the department, the research activities are conducted by four research groups. Each research group has a group leader, which is part of the leader group at the department, together with the head of department, head of administration, and deputies on education and research. A common administration is supporting the groups on education and economy. Although the research groups meet 2 to 4 times each month, the collaboration between groups seems to be at a low level.

The various research, architectural and artistic activities are usually a result of scientific staff initiatives, and most initiatives are connected to external partners, such as municipalities, property developers or contractors. If a new long-term funding comes up, new permanent positions can be agreed upon within the leader group and with the faculty, in order to ease the workload on the existing permanent staff and build capacity around the group being successful with externally funded projects.

Collaboration exists between several of the groups, particularly regarding teaching. All groups contribute to the Master of Architecture program, while the Energy and Environment Group contributes the most to the SustArch-program and the Building Conservation and Transformation Group contributes to the TradBygg-program.

All groups have PhD candidates connected to their activities. PhD projects include theoretical studies but are also in many cases connected to practical problems that need to be solved in society (in e.g. a research centre like FME ZEN) or connected to architectural and artistic practice. The department uses strategic funding to help some staff (3 persons) without a PhD obtain a PhD by reducing their teaching load. This will probably not be possible in the future when basic funding seems to be decreasing. The department aims to have some post doc positions, allowing promising employees that have completed a PhD to stay in the department also after their PhD.

This is a suitable organisation structure, securing a collaborative approach to teaching and supervision, while allowing each research group to develop in accordance with the available resources. The structure has the potential to develop shared objectives for funding, researcher training, development of publications and other research products as well as dissemination, thereby promoting the group's financial stability, further academic development and cohesive scientific outputs. In terms of research, it is not completely clear from the self-assessment report, how the described organisation is effective in developing collaborative research objectives among the RGs and since only one group are included in the present exercise.

Recommendations to the administrative unit.

- The present research challenges in the built environment calls for an interdisciplinary research approach. Therefore, it is recommended to strengthen the collaboration between the research groups in the department and to exploit the interdisciplinarity potential in research and PhD supervision. This is especially important in relation to the development of a more environmentally friendly built environment and circular solutions, where interdisciplinary collaboration between engineers and architects are crucial.

1.3 Research Funding

The research funding has in average for the last five years consisted of basic funding (33%) national research grants (56%) and EU research grants (11%). Research funding has been increasing in the last five year including the funding from EU. Although research collaboration with a number of industries and stakeholders is reported in various national

projects, direct funding from industry for commissioned research has contributed minimally to the total funding over the last five years. The externally funded research activity is centred around two groups, which is related to available funding that in some areas (e.g. energy and sustainability) is higher than in others (architecture and art). Once this is recognised, no further strategic approaches or proposals are suggested from the Department to overcome or mitigate this situation.

The assessment report does not include information about support from the department regarding development of research proposals, review and quality assurance when applying for external funding. However, all applications and budgets need to be approved by the department head before submission (based on project economy, relevance of research to department aims, and capacity).

Recommendations to the administrative unit.

- The competition for research funding is increasing and it is essential, especially for less experienced researchers, with support in the application phase to improve the quality and funding probability. It recommended to establish a procedure for assistance to/mentoring of less experienced researchers in the application phase.
- Especially in a perspective of reducing basic funding, it is essential to set a strategy to increase the attractiveness of those areas naturally less prone to external or private grants, eventually trough interdisciplinary activities.
- The focus on whole life carbon emissions from buildings and the changes in building regulations (EU, EPBD) increases the need for research and development in the building industry and provides new opportunities for direct research funding that should be pursued.

1.4 Research Infrastructures

The department is co-host of a national research infrastructure (ZEB-lab) together with SINTEF Community, NTNU Department of Energy and Process Engineering and NTNU Department of Civil and Environmental Engineering. The department leads the activities in the ZEB-Lab.

The department also hosts a number of laboratories to support research activities (ZEB Living Lab, the Space Laboratory (ROOMLAB), the daylight laboratory, the Climate HubLAB, Formlab, NTNU Mobile Sensory LAB and the laboratory for traditional construction crafts) as well as an Architecture Workshop, used for model-making and larger scale constructions, especially for architecture students.

The department does not participate in international infrastructures.

In the engineering field access to research infrastructure is key to achieve and maintain a high scientific research quality. The Energy and Environmental research group has the critical mass to be able to sustain extensive research infrastructures which is not only an important asset in research, but also in supporting local companies and collaborators as well as in engaging M.Sc students in research activities.

Recommendations to administrative unit.

- The department and the Energy and Environment Research group has access to excellent research infrastructure that may be difficult to sustain in the future. It is recommended to develop a strategy for sustaining the research infrastructure by seeking collaboration with other research units and departments.

1.5 National and international collaboration

The department considers collaboration with national and international partners as very important to address problems of relevance for society and the building industry. Collaboration primarily comes through joint externally funded projects and centres, but also from more informal collaboration through educational activities.

National collaboration is mainly through participation in national research centres (NTNU Wood and FME ZEN) and include close collaboration with SINTEF Community, other NTNU departments, governmental bodies (like NVE and DiBK), industry partners and other stakeholders like municipalities.

International collaboration is both through projects focusing on academic collaboration but also from European innovation projects involving both research organisations and industry.

However, the collaborations could be reflected more clearly in research funding and research publications co-published with national and international partners.

Recommendations to administrative unit.

- It is recommended that the department apply a more strategic approach to development of national and international research collaboration and on co-publishing of research results to increase visibility and quality, involving, when possible, all areas.

1.6 Research staff

The permanent staff of the department consists of architects, artists and engineers/physicists, where all do research, architectural and/or artistic practice. In the department, architectural and artistic practice are equally important to research.

The self-assessment does not mention general strategies or practices to support researcher careers and to help early-career researchers to make their way into the profession. However, it is mentioned that the department uses strategic funding to help some staff (3 persons) without a PhD obtaining a PhD by reducing their teaching load and aims to have some post doc positions, allowing promising employees that have completed a PhD to stay in the department. No strategy is described for allowing or pushing staff without PhD to obtain one, without the direct support of the Department.

New permanent scientific positions and positions following employees' retirement, are agreed upon through the strategic personnel plan (valid for the whole department), with discussions/input from the four research groups.

The share of professors/senior researchers of 59% of scientific staff is considerably higher than the evaluated academic units in average (41%) and the average age of staff is also higher with about 40% of professor above the age of 62. The share of female researchers in all staff categories (39% in total) is considerably higher than the average in evaluated academic units (25% in total). Although the permanent staff comes from 11 countries, the share of permanent staff with a foreign PhD degree is much lower than in evaluated academic units in average (14% compared to 40%).

The department applies normative distribution of time for research, architectural or artistic practice. University lecturers and scientific assistants typically have 25% research, architectural or artistic practice, while associate professors and professors have about 50% research, architectural, or artistic practice although some employees in practice spend more time of teaching than expected.

In the department, permanent staff has the possibility to apply for a sabbatical every 6-7 years, with one application deadline each year. The number of staff on sabbatical each year depends on the teaching and funding.

Besides, the department also support and encourage a number of mobility options including 1) participation in conferences and seminars; 2) exchange through educational/research projects for both students and employees; 3) Exchange through leading and taking part in EU-projects; 4) Participation in IEA Energy in Buildings and Communities Annex meetings, where it encourages PhD candidates to participate for networking and presentation of results and 5) PhD candidates to stay 3-6 months at an international partner. These mobility options are in line with the AU's strategy and are very important especially for young researchers to establish and maintain research networks and collaboration leading to improved research output and quality.

Recommendations to the administrative unit

- Considering the age distribution and the relative high number of permanent positions it is recommended to develop and implement a strategic approach and practices to support early career researchers in their development. This includes ensuring mobility options to establish and maintain research networks.
- Considered the relatively high share of professors above the age of 62, it is recommended to set a robust strategy for reducing the effects of their retirement, especially in a time of budget reduction and of change in the funding policy from the government.

1.7 Open Science

The department follows the open science strategies of the NTNU and it is expected that researchers follow these procedures. However, it seems that the department need to apply a more direct approach to ensure that researchers comply with the open science strategy as less than 50% of the department publications presently are open science compared to a national average of about 77%.

NTNU is primarily to own all results that have been created through the use of the university's/society's resources to open the way for broad application of the results. NTNU has an intranet-page detailing how to fulfil the FAIR-principles within NTNU.

The department has not presented a clear policy regarding ownership of research data, data management and storage as well as open access and confidentiality, except those required in larger research projects. Neither does the department provide support services for researchers to comply with this policy in the complete life cycle of research data management.

Recommendations on how to promote open science

- It is recommended that the department implements a clear open science strategy and implement open science practices.
- It is also recommended to provide support services for researchers for data management and storage as well as open access to ensure implementation of FAIR principles in all research projects.

2 Research production, quality and integrity

The department has four research groups with different research areas. These include:

- The Form Group, which aims to sustain aesthetics, art, and culture as fundamentally important aspects of sustainable architecture to reinforce the architect's contribution to society while strengthening artistic competence within the field.
- The Energy and Environment Group, which aims to solve sustainability issues of the built environment enabling the design of buildings and neighbourhoods with a positive impact on humans and their environment throughout their life cycle.
- Tectonics Group, which focus on the aesthetic aspect of architecture that can be defined as the way buildings are designed and built while requiring more sustainable use and reuse of materials and structures.
- Building Conservation and Transformation Group, which focus on research in building conservation, architectural history, traditional crafts, and transformation of buildings.

The publication volume is given for the department as a whole and not for individual research groups. The publication volume compared to the number of research staff is lower than seen in other academic units in the evaluation. The department states that the reason may be found in the fact that architectural and artistic practice are equally important to “research” in the department and that the architects’ and artists’ results do not always find way into scientific articles and journals, but can instead be buildings, installations or artistic works presented to an audience.

Although it is recognised that architectural and artistic products can hardly be categorised together with journal papers, the Department did not try to illustrate in the self-assessment or in the interview which type of other products are developed, their number, their importance and impact, leaving the committee blind. Anyway, the research quality is quite high as the share of articles published that are among the 10% most cited publications (13,4%) is well above the average level of similar departments in the building sector (around 10%) and a similar percentage of publications are co-published with selected top ranked international institutions.

The department does not have a specific policy for research integrity but refer to NTNU guidelines and codes for how to deal with these topics.

2.1 Research quality and integrity

Research group Energy and Environment overall assessment

The group has clearly demonstrated its excellent capacity to produce research outputs in internationally leading scientific peer-reviewed journals. Research topics are original and innovative, in line with European and international trends. The group also seems to have a good ability to attract national and European funding. However, there is not a table with the funding of the last five years, since the Department of Architecture and Technology does not report its funding at research group level, so it is difficult to judge the quantity of the funding over the years.

The group has also clearly demonstrated its very good capacity in teaching activities at Master level, in involving PhD students and young researchers, and in creating an international environment, since the staff members come from 8 different countries.

The group's overall performance is very good. However, the group needs to refocus its communication activities and to develop a clear strategy to improve its societal contribution, which seems limited.

The main **strengths** of the group are:

- very good qualification and internationalisation of the research group
- excellent quality of publications, at international level
- excellent laboratory facilities.

The main **weaknesses** of the group are:

- weak communication strategy (no dedicated web page)
- limited societal contribution
- limited collaboration with industry and public administration.

3 Diversity and equality

The university has developed a plan for gender balance, equality, diversity and inclusion that is published on a university portal together with notification guidelines for reporting any form of discrimination. It is not clear how this action plan is implemented in the department, although it is mentioned in the self-evaluation that the department aims at providing equal opportunities in all positions and activities within the department.

In relation to gender balance the total share of female researchers is much higher than in the academic units in average in the evaluation (39% compared to 25%). This relatively high share of females compared academic units in average in the evaluation is the case in all staff categories.

Also, among the department management team, the department aims for gender balance: E.g. the head of department is male, while the head of administrating is female. One deputy is female (education), and one deputy is male (research). Two study program leaders are female, and one is male.

The share of permanent staff with a foreign PhD-degree is much lower compared to the academic units in average in the evaluation (15% compared to 35%, 4 out of 27), while none of the researchers/postdocs has a foreign PhD-degree.

4 Relevance to institutional and sectorial purposes

The department vision and goal provide a focus on development of circular architecture and built environments through research, architectural and artistic practice, and education to enable a quicker transition to a more sustainable future.

The department reports a change in strategy in the last 5-10 years from promoting open research, as publications, or/and architectural and artistic works have been the main indicator resulting in scientific advancement, to also emphasising innovation and commercialisation activities which are becoming important in research assessment. This change has especially been the case in the research group "Energy and the Environment" through participation in larger research centres (FME ZEB and ZEN) and in EU projects. To support the change in focus, the department has employed an innovation manager, mainly connected to FME ZEN but also available to the rest of the department. Still contractual research collaboration with industry is at a very low level.

The department delivers a research-based education and integrates research achievements in the education at master and PhD level. Most of the PhD candidates at the department are connected to externally funded projects and their education is therefore very much intertwined with the research projects, and connected to topics of interest to industry, public companies, or society.

All master students are invited to participate in the ongoing research or architectural practice projects, especially when doing their thesis work. The self-evaluation does not include any evaluation to what extent students actually accept such invitations.

5 Relevance to society

The goal of the department is to contribute to the development of circular architecture and built environments through research, architectural, and artistic practice, and education.

The AU's research and educational activities are clearly contributing to the Norwegian Long-term plan for research and higher education related to Climate, the environment and clean energy. The research outputs and educational programme offered are very important for the restructuring towards a low-emission society and the developed concepts and technologies are contributing to the transition to a greener society.

The research at the department contribute to advancing knowledge and solutions in the field covered by the department vision and also contributes to UN Sustainable Development Goals (e.g. 7 Affordable and Clean energy, 11 Sustainable cities and communities, 13 Climate action, and 17 Partnerships for the goals). These contributions are primarily realised through the hosting of centres and projects like NTNU Wood, FME ZEN, ARV, and syn.ikia.

The impacts cases illustrate the importance of research outcomes to be adopted by policies and new regulations to provide an impact in both research and in the building sector. The Zero Emission Building definition has succeeded to influence policies and regulations and led to considerable development in whole the building sector value chain including design, construction, new technologies and building operation and management. The daylight project has provided valuable research results and new understanding, but not succeeded in influencing policies and regulations making impact in the building sector less visible. This underpins the importance of both having focus on research excellence as well as innovation and commercialisation activities.

The department leads the ZEB Laboratory, a national research infrastructure (the extent of use of this infrastructure of other relevant research institutions is not mentioned).

The department also mentions to make a contribution through education of the next generation of architects and candidates in programmes like the 5-year Master Program in Architecture, 4-year Bachelor in Traditional building crafts, and the International Master of Science in Sustainable architecture and aims to attract top students to its educational programs (actions not mentioned as well as the number of foreign students attending the programme).

5.1 Impact cases

Comments to impact case 1: Zero Emission Buildings Definition and Related Applications

The Zero Emission Buildings (ZEB) definition was developed by the Energy and the Environment Research Group in collaboration with SINTEF Community and ZEB Centre partners as an outcome of the Zero Emission Buildings (ZEB) project hosted by NTNU from

2009 to 2016. The ZEB definition also includes the concept of the “nearly Zero Energy Building” (nZEB).

The Zero Emission Building Definition is relevant and very important for the development of the built environment and will continue to have a strong impact on the design of sustainable buildings and the integration of renewable energy technologies in many years to come in both Norway and internationally. It has also had a strong impact on the research today where several research projects focus on bringing the zero-emission concept to a neighbourhood scale.

The developed definition has significantly influenced the EU’s energy efficiency strategies, so the latest version of key directives now considers emissions from all life cycles of the building process, i.e. including both operational and embodied carbon emissions. The ZEB definition has also influenced policy development. The Norwegian government has incorporated zero-emission building concepts into its building standards, codes and regulations, reflecting the impact of the ZEB project’s research.

The ZEB definition and concept have also had an impact on the development of new technologies and solutions for building design including advanced materials and construction techniques, innovative energy supply systems, and smart technologies for energy management and control. It has also influenced planning and development of entire communities. This holistic approach to sustainable urban development, represents a significant shift in thinking about and planning cities.

Comments to impact case 2: Daylighting solutions and systems for retrofitting buildings in the Nordic climate to low energy, 0-energy or ZEB standard

The “DayLighting” project was carried out by the Energy and the Environment Research Group at the department from mid-2013 to mid-2016 in collaboration with the ZEB Research Community at NTNU/SINTEF, Link Arkitektur, and Glass og Fasadeforening. The project included a comprehensive study aimed at enhancing the utilisation of natural light in buildings, particularly those transitioning to low-energy or zero-energy standards. The aim was to develop a deep understanding of the optical qualities, light, and energy efficiency of systems and products, including those with integrated electrical light sources. This is very relevant and important, as natural light is needed for our health and comfort and under pressure in the development of low-energy or zero-energy buildings.

The research was disseminated through various channels, including international scientific journals, professional magazines, popular science articles, and courses arranged by Lyskultur. A Daylighting guide for stakeholders who plan on upgrading buildings to low-energy, 0-energy, or ZEB standard was developed. Additionally, a series of popular scientific articles was published in the “Lyskultur”, the only Norwegian professional lighting journal.

The beneficiaries of the research include building owners, architects, and engineers who plan on upgrading buildings to low-energy, 0-energy, or ZEB standard. The project’s findings and developments are mentioned to be widely adopted in the building sector (however not documented in the impact case). The results seem not to have resulted in new regulations requirements on daylight availability and/or in new best practice standards.

The research is also mentioned to benefit the glass and façade industry, as well as the lighting industry, by providing new research findings necessary for the development of new products. However, examples of improvement of existing or development of new technologies in the industry is not given.

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 minor adjustments.

Limitations

The Committee judged that the Administrative Unit's self-assessment report was insufficient to assess all evaluation criteria fully, and some information gaps remained after the interview with the Administrative Unit.

List of administrative unit's research groups

Institution	Administrative Unit	Research Groups
Norwegian University of Science and Technology - NTNU	Department of Architecture and Technology - IAT	Energy and Environment Group

Terms of Reference (ToR) for the administrative unit

The vice-dean of Research of Faculty of Architecture and Design, NTNU, mandates the evaluation committee appointed by the Research Council of Norway (RCN) to assess Energy and Environment Research Group of the Department of Architecture and Technology, NTNU, based on the following Terms of Reference.

Assessment

You are asked to assess the organisation, quality and diversity of research conducted by Energy and Environment Research Group 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 4 aspects in your assessment:

1. Scientific areas where the group could/should be strengthened (this can be new areas or with regard to capacity).

2. Administrative support – How could the group be further strengthened through improved administrative support?

3. Coordination on university level with research groups in other departments and faculties working on similar or adjacent topics – How can collaboration improve research quality, impact, and NTNU's visibility within the groups' research areas for NTNU as a whole?

4. Research-based teaching and learning – How can educational activities (e.g. MSc in Sustainable Architecture) benefit from ongoing research activities – and also, conversely, how can research activities benefit from education activities.

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

Documentation

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

The documents will include the following:

- a report on research personnel and publications within mathematics, ICT and technology commissioned by RCN
- a self-assessment based on a template provided by the mathematics, ICT and technology secretariat

Interviews with representatives from the evaluated units

Interviews with the Energy and Environment Research Group 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 Energy and Environment Research Group are made available to the committee and the panels, and before any assessments are made based on these data. The RCN should be notified if questions concerning impartiality and confidence are raised by committee members during the evaluation process.

Assessment report We ask you to report your findings in an assessment report drawn up in accordance with a format specified by the mathematics, ICT and technology secretariat. The committee may suggest adjustments to this format at its first meeting. A draft report should be sent to the Energy and Environment Research Group and RCN. The Energy and Environment Research Group 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 vice-dean for Research at the Faculty of Architecture and Design, NTNU, and the RCN no later than two weeks after all feedback on inaccuracies has been received from Energy and Environment Research Group.

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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