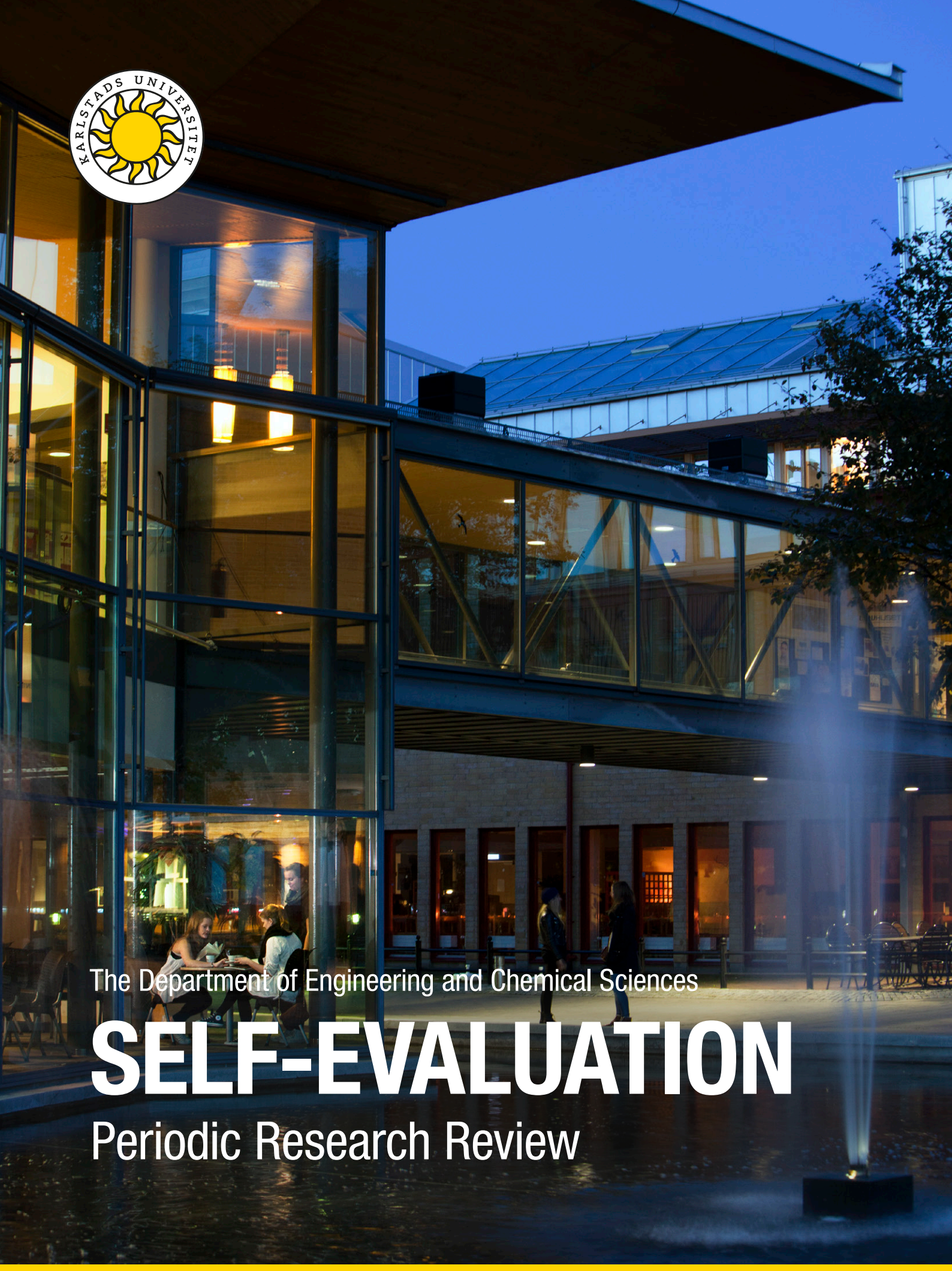


The Department of Engineering and Chemical Sciences

SELF-EVALUATION

Periodic Research Review

KAU.SE

Self-evaluation: Department of Engineering and Chemical Sciences - 2022

BRIEF SUMMARY

The four units within the Department of Engineering and Chemical Sciences, with a staff of 64, encompasses chemistry, chemical engineering, building and construction engineering, and environmental and energy systems. Purposeful strides have been taken in the direction of strengthening the department's goal-oriented, collaborative and cross-disciplinary research activities to aid society and industry, as well as boosting the quality of its pedagogy. Internationalisation, gender-parity, effective intra-departmental, inter-departmental and inter-facultative collaborations, and state-of-the-art research in circular bioeconomy - the paradigm of the future - have been and will continue to be important in keeping with the University's broad-brush strategies. The department makes a concerted effort to strengthen the nexus between research and pedagogy, encouraging researchers to participate in the degree programmes, and teachers to contribute to research projects. Together, the research groups attracted research funding to the tune of SEK 61 million in the period 2019-2021, which saw a total of 158 scientific publications being produced - the annual output increasing steadily, along with the average annual impact factors of the journals in which the articles were published. The progress attained between 2019 and 2021 puts the department on a clear growth trajectory, which it will strive to sustain in the years to come.

1. LONG-TERM OBJECTIVES AND STRATEGIES

The Department of Engineering and Chemical Sciences adopts Karlstad University's vision and supports its strategies[1]. The vision for research at the University and thereby at the Department, is the pursuit of excellence, while contributing proactively and continuously to the body of extant scientific knowledge. The Department's research profiles (described in detail in another section) are clearly formulated and well-known in both academic and industrial research circles, within Sweden as well as internationally. While fundamental research occupies an important position in the scheme of things, a robust tradition of multidisciplinarity and applied research relevant for industry and society, has mushroomed over the years. The active involvement of the teaching staff in research projects feeds into study programmes and benefits students in the process. There is a marked mutually symbiotic relationship between the Department's doctoral programmes and the prevalent research milieu at the University in general.

The Department's objectives, and the strategies adopted to attain them, are formulated systematically in a 'scorecard', and are discussed periodically in intra-departmental conferences. Congruous with the University's vision for the future (referred to above), the Department envisages positioning itself as a nationally and globally renowned pedagogical and research-oriented academic entity in the fields of sustainable development, bioeconomy anchored in the forestry sector, and applied chemistry/chemical engineering.

Thus, the long-term objectives consistently and continually pursued by the Department can be summarised as follows:

a) To educate and equip students with the skill sets and knowledge sought after by prospective employers in the job market, and encourage them to contribute to sustainable development in their careers in the future.
b) To ceaselessly strengthen our research capabilities and competencies, while competing and collaborating at both national and international levels, in both fundamental and applied research.

2. ORGANISATION AND MANAGEMENT

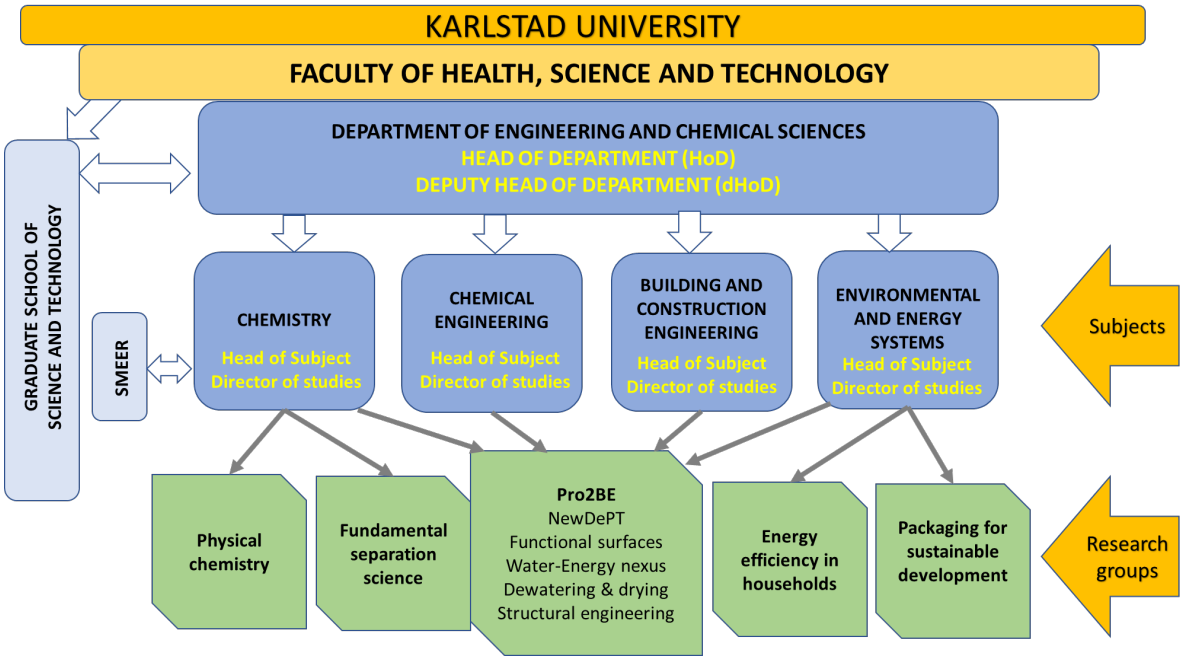
2.1 DEPARTMENTAL ORGANISATION

The Department of Engineering and Chemical Sciences is a part of the Faculty of Health, Science and Technology. At the helm of affairs is the Head of Department (HoD) who is responsible for budgeting, staffing and overseeing the work environment, while focusing on developing and implementing plans to facilitate, support and motivate professional development of the employees, thus fuelling progress towards the attainment of the Department's objectives. The HoD is assisted by the deputy Head of Department (dHoD) who directs attention particularly to the study programmes.

[1] https://www.kau.se/en/about-university/about-karlstad-university/about-university/vision-and-stratregy-2030

The Department is essentially a composite one, constituted by four different units, which are as follows, in alphabetical order: **Building and Construction Engineering (BCE)**, **Chemistry (CH)**, **Chemical Engineering (CE)**, and **Environmental and Energy Systems (EES)**.

Each of these four units has a representative, Head of Subject – (HoS), who in close coordination with the HoD, contributes to its smooth functioning and the continuous improvement of its study and research programmes. Likewise, every unit has a Director of Studies (DoS) entrusted with the responsibility of monitoring the conduct of the courses. All subjects have monthly staff meetings. The HoD, dHoD, HoS and DoS constitute a governing body which has periodic discussions and makes strategic decisions about future research and tertiary education imparted by the Department, which includes different Bachelor degree and Master degree programmes as well as short externally funded professional courses. All subjects except BCE offer PhD programmes. BCE, however, has several externally financed research projects.



The research conducted in the Department is organised in research groups (see 2.2). Researchers in these groups meet regularly to discuss published calls for research proposals, status and progress of ongoing projects (including decisions regarding conferences to attend) and networking possibilities, as well as refining research strategies and goals. Some of these groups maintain a 'scorecard' to establish a vision, chart out three-year plans and set shorter term annual goals to pursue.

Research students working towards a Licentiate degree or a Doctoral degree are affiliated either to the Faculty's graduate school or to an externally funded graduate school. Graduate schools are active arenas for discussions about research ethics, graduate student courses, progress of doctoral research, etc. An aim of the Faculty's graduate school is to have a multidisciplinary research faculty (collegium) comprising all the supervisors in the Department.

The administrative personnel and the technical/engineering support staff, who draw their salaries from the Department, are affiliated to the faculty-level Administration unit. One research engineer, however, is directly employed in the (analytical) Chemistry unit.

2.1.1 Financial resources

In the period 2019-2021, the total research funding amounted to SEK 61 million, with an almost equal contribution from both internal and external sources. The external sources include, predominantly, Formas, the Knowledge Foundation, Vinnova, Interreg Sweden-Norway, the Swedish Agency for Economic and Regional Growth, the Swedish Research Council, the Swedish National Space Agency, Knut and Alice Wallenberg Foundation, Re:Source, and Paper Province.

2.2 RESEARCH ORGANISATION

A large part of the research at the Department is gathered in **Pro2BE** (Processes and Products for a Circular Bioeconomy)[2]. Pro2BE encompasses the following research areas: **NewDePT** (New Development for Pellet Technology)[3], **Functional surfaces and sustainable materials**[4], **Water-Energy nexus**[5], **Dewatering & drying**[6], and **Sustainable structural engineering**[7]. Pro2BE has a clear research profile, a research programme and a research director. The **Fundamental Separation Science Group (FSSG)**[8] belongs to the (analytical) Chemistry unit, and collaborates both with the pharmaceutical sector and Pro2BE. While this group aims to acquire deeper knowledge in separation by combining fundamental theory with carefully designed experiments, its activities comprise biochemical research as well. The **Physical Chemistry Group**[9] collaborates with scientists from Materials Physics (Dept. of Engineering & Physics), and Mathematics (Dept. of Mathematics and Computer Science), in research on organic and perovskite solar cells where it contributes with knowledge in solution chemistry, molecular interactions and spectroscopy. **The Packaging for Sustainable Development Group**[10] works as part of the EES unit, in close collaboration with the Service Research Centre at the Faculty of Arts and Social Sciences. It combines environmental systems analysis with behavioural science, focusing on how packaging design influences food waste behaviour in order to advise on optimising adverse environmental impacts. **Energy efficiency and energy-use optimisation research** in the EES unit comprises both improving the energy efficiency of industrial systems and household appliances (focusing on white goods and drying processes), as well as energy advice for households. **Science, Mathematics and Engineering Education Research (SMEER)**[11], which is evaluated separately in its capacity as an autonomous research centre, focuses on research in didactics. In this context, the reference to didactics relates to chemistry education.

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2 https://www.kau.se/en/pro2be

3 https://www.kau.se/en/pro2be/research-areas/newdep-research-pellet

4 https://www.kau.se/en/pro2be/research-areas/functional-surfaces-and-sustainable-materials

5 https://www.kau.se/en/pro2be/research-areas/water-energy-nexus

6 https://www.kau.se/en/pro2be/research-areas/dewatering-and-drying

7 https://www.kau.se/en/pro2be/research-areas/sustainable-structural-engineering

8 https://www.kau.se/en/pro2be/research-areas/analytical-chemistry and https://www.fssg.se/

9 https://www.kau.se/en/chemistry/research/physical-chemistry

10 https://www.kau.se/en/packaging-sustainable-development/read-more/packaging-saves-food-research-group

11 https://www.kau.se/en/smeer

2.3 RESEARCH CULTURE

Research conducted in the Department is collaborative and oriented towards project goals. Doctoral students work effectively in coordination with experienced senior employees, getting acculturated to the prevailing research milieu. Professors are guaranteed 30% research time, which includes supervision of doctoral students, participation in courses related to research and development, and representation on the advisory committee planning and discussing research activities. Senior and junior lecturers are granted 20% and 10% of their working hours respectively, to pursue continuing professional development. Researchers who are instated as the HoD, Dean or Deputy Dean get “repatriation time” to recommence their research.

2.3.1 Disciplinary transparency (interdisciplinary cooperation)

There has been a constant emphasis on collaboration as vital for reaching a ‘critical intellectual mass’, and tackling complex research questions from a holistic perspective. All the research groups have cross-disciplinary collaborations within the University. Interdisciplinary graduate schools conduct seminars, offer courses and organise regular meetings wherein research plans and dissertations are reviewed.

2.3.2 Internationalisation

One of the strategic goals of the University for the period 2019-2023, has been to demonstrate a greater degree of internationalisation in its operations, to facilitate a better exchange of ideas. This is effected through travels where a part of research project funds is allocated to travel to enable researchers to visit collaborators and test sites/pilot plants. Doctoral students travel to international conferences (a minimum of one conference for a licentiate degree and two for a doctoral degree), and researchers undertake study tours to widen their networks. The Department also administers a seminar series in which international researchers have participated. This is easier as hybrid meetings are becoming normal. Non-Swedish colleagues enrich the Department with new perspectives and networks. When the Department seeks EU or international research funding, internationalisation is both a pre-requisite and a big plus.

2.3.3 Gender equality

While approximately two-thirds of the researchers in the Department are male, the gender ratio among students is closer to parity. The HoD frequently reviews the allocation of working hours for male and female senior researchers, for teaching and research, with the support of the Gender Studies unit, to identify any anomalies in this regard. In the Chemical Engineering unit, the HoD keeps track of unscheduled time (this was done at the beginning and end of 2022), to unearth any gender-related discrepancies. In the ongoing revision of the Department’s websites, gender equality aspects are consistently taken into account so that both female and male researchers are given equal space in text and images.

2.4 NOTABLE STRENGTHS AND CHALLENGES

Strengths: 1) The research groups are marked by their multidisciplinarity. 2) Pro2BE has a clear research profile, a well-defined research programme and a dedicated research director. 3) The research programmes are characterised by a high degree of disciplinary transparency. 4) Internationalisation has been conspicuous over the last decade. 5) Gender parity is ingrained in the department’s work culture. 6) Research is both fundamental and applied,

encompassing all technological readiness levels (TRL 1-9). The department, thus, focuses on both developing new applications for the future, as well as improving the existing ones.
Challenges: 1) Coordination among the research areas in Pro2BE requires an active research director, and a deputy research director. 2) A robust research culture is sustained by the conduct of regular seminars, and this needs to be better entrenched in the Department in the future. 3) Many groups have few senior researchers, which renders the groups a little fragile.

3. COMPETENCE / EXPERTISE PROFILE

By virtue of the strong collaborative links which exist among the four units in the Department, in teaching and research, its pedagogical quality and research competence are sustained. It must be mentioned, when it comes to teaching, that teachers from EES conduct courses administered by CE. Students of BCE & EES on the one hand, and CE & Chemistry on the other, sign up for cross-listed courses. There have been instances when one DoS has been responsible for the conduct of courses in the entire department.

3.1 ENSURE RESEARCH EXPERTISE AND STAFF

The staff is composed of 64 employees (45 men and 19 women). There are 9 professors, 3 adjunct professors, 2 senior professors, 23 senior lecturers of whom 9 are associate professors (docents), 14 lecturers, 8 doctoral students and 2 postdocs and 3 project assistants (10 listed in the background data and 3 employed at 2021´s end).

The HoD ascertains that there is a clear executable plan to strengthen existing competence and boost it further, by recruiting new personnel. Within the research groups, there is an emphasis on career development whereby junior researchers get opportunities to co-supervise theses and act as project leaders. The groups are proactive in submitting research proposals to secure funding for doctoral/postdoctoral research and adjunct professors. Such proposals are accorded high priority, as they are key to the sustenance of progressive research and effective pedagogy.

3.2 ACADEMIC COLLABORATIONS AND NETWORKS

At the Department, we apply for funding through consortiums comprising academic partners, companies, industry associations and other organisations. Research collaboration with other universities has, thus, often originated via the networking provided by funding organisations such as VINNOVA, the Knowledge Foundation, the Swedish Energy Agency, Interreg, and Horizon Europe, yielding applications and projects with academic partners from Sweden, Finland, Spain, Italy, France and Germany.

Pro2BE was founded due to a recognition that academic collaborations within the Department are crucial for success in a competitive academic environment. The research groups by themselves are too small to be able to handle the very big research projects. Since 2021, Pro2BE is a partner of Treesearch[12] - a consortium of leading Swedish universities, industries, private foundations and the Swedish Government. **NewDePT** is setting up networks and starting them by collaborating in applying for research funds and writing peer-review articles

[12] www.treesearch.se

together. **Functional surfaces and sustainable materials** is home to the Paper Surface Centre, a research and communication platform. **Water-Energy Nexus** has a strategy of seeking out networks of both academic and industrial actors, notably Waste Refinery and the Swedish Network for Industrial and Urban Symbiosis (SINUS). Visits to other universities, as guest researchers, have also been fruitful. **Sustainable Structural Engineering** focuses on being engaged in externally funded research, often with RISE and Linnaeus University.

FSSG, bolstered by its high-quality publications and conference presentations, has attracted like-minded researchers and expanded its network over time. The group's unique approach to fundamental separation science, is characterised by the combination of advanced fundamental separation theory with experimental work.

Physical Chemistry collaborates within the SOLA consortium (SOLution-borne materials for organic electronic Applications) with the universities in Lund and Linköping, as well as Chalmers in Gothenburg. Their strategy is to liaise with the most useful and relevant partners in relation to the research they wish to conduct.

Packaging for Sustainable Development initiated and led the international research network Packaging Saves Food (PSF), along with members from other European countries, Australia, and the USA. They cooperate closely and publish articles together with both researchers from the PSF and others. Their strategy is to identify prominent researchers in the field and create joint projects in transdisciplinary groups.

Energy efficiency and energy-use optimization research submitted six multidisciplinary project applications in 2019-2021 (SEK 20 million) with intra-university partners from Cultural Geography, National Economics, Risk and Safety, Psychology, Information Systems, and Communication Studies, and inter-university partners from Dalarna University, Chalmers, and Linnaeus University, as well as companies. Though the group did not succeed in acquiring funds, the silver lining is the creation of networks in the collaborative process.

SMEER is the node from which the science, mathematics and engineering education research is coordinated. The activities are based on international and national networks, practice-oriented research related to school, university and working life.

3.3 RESEARCH INFRASTRUCTURE FOR EXPERIMENTS

First and foremost, researchers at the Department have built a well-equipped experimental setup, and for some specific research fields, also very good computational/simulation capabilities. This encompasses state-of-the-art analytical equipment, in-house customised testing rigs and standard analysis and measurement equipment to cater to both molecular-level analyses and pilot-scale tests.

The Department has access to regional testbeds: 1) The 'biomass factory' on the University premises, for biological conversion/valorisation of organic materials, pelletisation, extrusion and coating. 2) Coating equipment at UMV coating systems in Säffle. 3) LignoCity 2.0 in Bäckhammar with RISE Bioeconomy as the partner in charge. 4) Circle Lab in Torsby with 3D-printers. 5) Printing press at Broby Grafiska.

Purchase of instruments and software licenses using internal funds is prioritised if the requirement for research and teaching can be clearly justified. Such purchases may also be done by taking recourse to external project funding.

Since Pro2BE is part of Treesearch, the researchers have access to a national infrastructure. The list of this infrastructure can be accessed via https://treesearch.se/infrastructure/?all. The Physical Chemistry group has designed and developed equipment for solution-chemical experiments under microgravity conditions. Further, the group is well-equipped in spectroscopy, viscometry, and for modelling solution chemistry and phase-separation under concentration gradient.

3.4 NOTABLE STRENGTHS AND CHALLENGES

Strengths: 1) The researchers of the Department have reliable access to state-of-the-art equipment in laboratory facilities and test beds. 2) The Department has a long-term plan for continuing professional development and clear strategies for networking.
Challenges: 1) Many research groups are not yet sufficiently well-established academically on an EU-level to participate in projects like Horizon Europe. 2) We have a lack of enlisted PhD students and postdocs; more researchers are needed to make efficient use of the good infrastructure to produce high quality research.

4. RESEARCH AREAS AND RESULTS

4.1 OBJECTIVES AND STRATEGIES

Our endeavours, according to the Departmental scorecard, can be characterised as follows:

1. An unwavering scientific approach, ranging from a microscopic level to a system-wide, macroscopic scale.
2. A strong interlinkage among theoretical models, fundamental knowledge and advanced applications.
3. Experimental rigour, proven experience and technical acumen.

The strategic goals formulated to attain the afore-listed objectives, again according to the Departmental scorecard, are:

1. To ensure that we always operate in a dynamic research milieu.
2. To consolidate interest towards research in the field of bioeconomy.
3. To strive to augment the inflow of external funds.
4. To establish ourselves as key players on a regional, national and global level.
5. To adapt our research outcomes to benefit society and humankind in general.

The critical factors influencing and enabling progress in the right direction are:

1. Our research enriches the education imparted to our students.
2. Obstructions and hurdles to more effective intra-departmental, inter-departmental and inter-facultative collaboration ought to be eliminated.
3. Existing networks must be harnessed to seek external research funding, while new networks must be constantly developed, to improve research productivity.
4. Research experience must be prioritised when new recruitments are made.

5. New interfaces for collaborations must be identified.
6. Time must be allocated to researchers for the drafting of research proposals.

4.2 RESEARCH FOCUS AND ACCOMPLISHMENTS

Pro2BE focuses on the transformation of the present-day anthroposphere which is based on the consumption of non-renewable, abiotic resources, to one based on a circular bioeconomy. The research encompasses: 1) Fundamental materials research applied to products and processes of the biomaterials-based sectors. 2) Process technology research and understanding for development and innovation. 3) Systems analysis to find the right path to transit to sustainable utilisation of resources - social capital, money, materials and energy. The research embraces pellets processing, effects of storage and drying on pellets, utilisation of side-stream byproducts in forestry and agriculture, fermentation of biomass for energy, drying technologies including fluid transport modelling and energy analysis, pulping processes and cellulose derivatives, paper chemistry, paper coating technology, development of coating materials and mass transport modelling for barrier applications, technology and processing of bio-based composites and wood-based building materials. Pro2BE has hosted and partnered with researchers in bioeconomy/forestry research in EU projects (Framework Programme, ITN, EraNET, Interreg Sweden-Norway), VINNOVA (The Niche Research Programme, the SIOs Bioinnovation and Re:Source), the Swedish Agency for Economic and Regional Growth, projects funded by the Knowledge Foundation (Synergy 3, Strategic Recruitments, Expertkompetans, Avans, HÖG). Pro2BE also figures on the IVA-100 list[13] in which the Royal Swedish Academy of Engineering Sciences (IVA) catalogues projects deemed to immensely benefit society and the economy in the future.

Specific groups in Pro2BE

- **NewDePT - New Development for Pellet Technology:** This research is about how renewable bioresources can be sustainably valorised to high-quality pellets. Research focuses on four areas: 1) Overheating and degassing (as part of the projects SVINPELS and InnoPels, workshops are organised to harness the academia-industry nexus to contribute to the body of knowledge). 2) Exploration of the possibility of diversifying the resource base of raw materials. 3) Pelletising pure substances to understand interfacial properties and bonding mechanisms in pellet durability and strength (a research area attracting many citations and widespread application in biorefineries). 4) Production of specialty pellets (with specific properties) from, for example, cellulose and bio-char.
- **Functional surfaces and sustainable materials:** The research encompasses coating and printing process technology, rheological behaviour, interaction and structural composition of coating materials, barrier technology and performance in packaging, modelling of mechanical properties and mass transport performance of coatings, use and performance of renewable materials in barrier applications, chemical pulping of wood, dissolution of cellulose and novel material concepts based on

[13] https://www.iva.se/en/published/new-list-research-project-with-high-potential-for-business-and-societal-benefit/ and https://press.kau.se/posts/pressreleases/forksningsprojekt-fran-karlstads-universitet

lignocellulose. This group has been very successful in both national and European collaborative research projects (EU FP6&7, ERANET, COST).

- **Water-Energy nexus:** The focus of the group's research is on environmental technologies which can be brought onstream to valorise side-streams from paper mill wastes into biochar, bioplastics, biopolymers, biogas and soil amendments. The group adopts a systems approach to problem-solving, by combining efficient conversion processes with sustainability assessment (by availing of material flow and energy analyses, and environmental life-cycle analysis). In the period 2019-2021, this group led two Interreg Sweden-Norway projects, four projects with company-consortia on biochar as a soil amendment, participated in three research projects on biopolymers, and spearheaded the project 'Research Milieu for a Forestry-based bioeconomy'.
- **Dewatering and drying:** While the scope here is mainly dewatering, drying, energy efficiency in paper and pulp technology, and wood chemistry, the topics are dewatering and rewetting of high-vacuum suction boxes on a paper machine (lab and pilot scales), numerical models for dewatering behaviour during vacuum dewatering, air-drying of tissues, and paper-sheet forming with polyvinylamine additives. These energy-efficient, environment-friendly and cost-effective solutions are in great demand from both traditional paper and pulp companies, as well as new start-ups.
- **Sustainable structural engineering** focuses largely on wood-based construction materials. Over the last decade, interest in this area of research has blossomed in Sweden, and erecting wooden buildings up to 10 storeys tall, by availing of prefabricated modules, is now clearly both attractive and possible. The subject is characterised to a high degree by applied research, and a broad anchoring among stakeholders is therefore important for both academic researchers and industries. The group has been granted five research projects during 2019-21, to the tune of SEK 12 million.

FSSG, or the Fundamental Separation Science Group, is a compact and competitive research group, composed of senior scientists from both academia and the biotech/computing sector, hailing from different backgrounds - chemistry (bio-, and pharmaceutical), engineering and scientific computing. The scientists conduct fundamental, theoretically-advanced separation science research to arrive at a better understanding, and thereby facilitate utilisation, of methods in analytical, pharmaceutical, bio- and organic chemistry. One area is the thermodynamics and kinetics of liquid separation and supercritical fluid separation systems, or biosensor arrays. The other one is computer-assisted process optimisation and mechanistic modelling. During 2019-2021, FSSG published in high-impact-factor journals and conferences (see link[14]). FSSG also contributes expertise and research activity to Pro2BE.

Physical Chemistry aims to play a key role in the field of molecular and new materials for photovoltaics (solar cells). The group contributes with knowledge in solution chemistry, spectroscopy, molecular interactions, and modelling, to fundamental and applied research in this field. One unique aspect of the research is that experiments are performed under microgravity conditions, funded by the Swedish National Space Agency and the European Space Agency.

[14] https://fssg.se/self-evaluation

Researchers in the **Packaging for Sustainable Development group** study the effects of packaging design on food waste, and analyse the same from a socio-environmental perspective that factors in user behaviour. The group has established a new area on how packaging design can influence food waste and how these effects can be calculated from an environmental perspective. This includes new methods to integrate behaviour in life cycle assessment. The research has been widely cited.

Energy efficiency and energy-use optimisation (in buildings and households). Research in energy-efficient dishwashers and tumble-dryers is one part. Industries provide data, and research in the group contributes with a structured and goal-oriented, scientific analysis of the same. The other part - research on energy-use consulting, involving the Swedish Energy Agency, Linköping University and municipal climate and energy advisors - has resulted in publications, popular science articles and an interactive blog[15] with advice, insights, tips and opinions.

4.3 RESEARCH IN RELATION TO THE UNIVERSITY'S STRATEGY

Research in topics related to the forestry sector has long been among the University's key strategies. Of late, the scope has been expanded to include the entire bioeconomy. During the period 2017-2020, a project by the name 'Research Environment for a Forestry-Based Bioeconomy', worth SEK 17 million and co-sponsored by the Swedish Agency for Regional and Economic Growth and Region Värmland, led to the formalisation of Pro2BE and the appointment of a research director for the same.

The University upholds a strong tradition of multidisciplinary applied research - characterised by both academic excellence and industrial/societal relevance - which the Department respects and imbibes. The industrial/societal relevance here is quite central to strengthening collaborations with stakeholders in society and industry. One of the cornerstones in the University's profile - 'Our extensive doctoral programmes are well-integrated into the university's research environments' - is reflected in the way the Department has been functioning. Here, it is apt to mention VIPP (named earlier) (2011-2016) and VIPP+ (2014-2020), which were collaborations among the Chemical Engineering and Environmental and Energy Systems units, and the Service Research Centre (CTF). Together, they housed 19 researchers both Licentiate and PhD. In 2022, a fresh application for a graduate school, called EXACT, was sent to the Knowledge Foundation by Chemical Engineering, Environmental and Energy Systems, Chemistry, and the group DAMI4.0 within the Computer Science division, seeking funding for 13 doctoral students, of which 9 where granted.

The Department targets an increase in external project funding, the number of doctoral students and thereby scientific journal publications. While the forthcoming Industrial Research College will be a step in this direction, it must be mentioned at this juncture that the Department has already registered an increase in the number of doctoral students (Background Data - BD - Table 1.1), scientific journal publications (BD - Table 5.1), and research funding applications (BD - Table 4.1). The increase in the number of applications did not, however, result in a corresponding increase in the acceptance rate, leading to a drop in the 'success rate'. It should

[15] https://energyadviceblog.wordpress.com/

be noted though, that the time spent in drafting unsuccessful applications is not to be looked upon as a 'sunk cost', as those very applications can be modified and repurposed later, and the partnerships struck during the application process can always be sustained. Figure 7.1 (Appendix) illustrates the fact that not only have the number of publications increased over the 3-year period, but also the quality, as reflected by the average impact factor.

4.4 NOTABLE STRENGTHS AND CHALLENGES

Strengths: 1) Rise in number of publications and external funding. 2) Clear focus on impact. 3) The Department follows the University's strategy right down to the researcher level.
Challenge: 1) There is a need to acquire funding to recruit more doctoral students and postdoctoral researchers and senior researchers.

5. COLLABORATION AND INTERACTION WITH THE SURROUNDING COMMUNITY

'Our teaching and research are characterised by close cooperation with the community.' This is one of the University's strategic goals for the period 2019-2023. Within the Department, most of the projects are close collaborations with industry and society, which is a clear evidence of relevance. Other research projects are fundamental science projects, which do not engage companies. However, they attract funding from organisations like The Wallenberg Foundation (with a crystal-clear focus on excellence and excellent researchers). This is indisputably indicative of competitive and timely research, with focus on long-term societal needs. This mix yields a more robust financial structure for the Department's research, as the external funding is spread over different organisations.

Financiers that the Department interacts with usually expect 50% industrial co-funding. The Knowledge Foundation emphasises that the industrial funders participate actively in the project, contribute to it and benefit therefrom. Though this makes the industrial partners' capacity to co-finance the project a limiting factor for its scope and scale, the relevance and applicability of the research is guaranteed. The Faculty usually contributes to the overhead expenditures incurred on projects.

5.1 INTERACTIONS EXPLAINED

The Department plays a part in the major regional project Vinnväxt Paper Province 2.0 (2013-2023), funded by VINNOVA and other regional actors. The objective is to set up an internationally recognised milieu for innovation, benefiting the forestry-based bioeconomy in the Värmland region. The total investment for research, development, commercialisation of new products/services and productivity enhancement in the industry, is to the tune of SEK 130 million. Paper Province is now a cluster organisation that connects 130 industries and organisations. Many researchers in the Department have landed projects with industrial partners through Paper Province connections.

The Department collaborates with various regional actors within the framework of the Academy of Smart Specialisation, the strategic partnership between Karlstad University and Region Värmland (RV), as part of a regional research and innovation strategy based on the

European Smart Specialisation concept[16]. One of the most prioritised specialisations within this strategy is forest based bioeconomy, where Pro2BE are collaborating with actors within the industry sector, aiming to develop the region as a leader in the Swedish bioeconomy sector. The partnership between RV and KAU has been extended to 2028.

Bioeconomy are key to sustainable socio-economic development in the years to come. By simultaneously increasing the efficiency of existing production systems and seeking to replace the abiotic and non-renewable with bio-based, eco-friendly alternatives, **Pro2BE** is, undeniably, playing a vital role in sustainable development. Pro2BE research is motivated by clear and concrete research challenges faced by the industry. Continued dialogue with industry partners on a basis of mutual trust, is of paramount importance to comprehend these challenges in their entirety. Interdisciplinary research at the Department provides researchers with a good understanding of challenges posed, and opportunities presented by the intended transition to a sustainable bioeconomy, enabling them in the process to harness their skills, expertise and networks to address industrially-relevant problems. Research is conducted in collaboration with academic and non-academic partners like RISE, Stora Enso, Billerud, UMV Coating, Cellcomb AB, ASKO, BTG Instruments AB, SCA Pellets, Valmet, Albany International, Mellanskog's Forest Owners' Association and the Swedish Forest Agency. Duni Rexcell Tissue, Nordic Paper and Rottneros collaborate in undergraduate education at the Department. Certain analytical instruments are leased to companies (which generates funds to service and repair the instruments).

The **FSSG** group has a strong collaboration with the Swedish biotech and pharmaceutical sector: AstraZeneca, Bio-Works Technologies AB, Cytiva Biacore, QIAGEN DNA Synthesis AB, and Ridgeview Instruments AB. The group has published four articles in popular science magazines like Life Science Sweden and Kemivärlden (the Chemistry World), during the period 2019-2021. In a radio interview (local radio P4), FSSG researchers explained how they used data processing algorithms to reanalyse important SARS.CoV2 RBD/ACE2 interactions and challenge the accuracy of the original results published in the journal Nature.

Packaging for Sustainable Development researchers collaborate with a range of entities - government agencies, retailers on the Swedish market (ICA, COOP, AxFood, Lidl), industrial firms and the general public. Their research has been featured often in national and regional news. Their book *Stoppa matsvinnet! - en förpackad lösning* [Stop food waste! - A packaged solution] presents issues related to packaging and food waste to a wider readership and won an award in the category 'Food, climate and environment' in the Swedish Food Literature of the Year competition.

Energy efficiency and energy-use optimisation has contributed to developments in design of dishwashers and tumble-dryers; energy advice research has resulted in a toolkit enabling energy and climate advice in Sweden to be more effective.

Bearing in mind the Department's goal of disseminating research results to society, industry representatives are invited to participate in its seminar series. Concerted efforts are made to publish 'open access' scientific journal articles, supported by funding from the University library. These expenses are accounted for in the budgeting of research projects.

[16] https://www.kau.se/en/external-relations/research-and-innovation-collaboration/research-collaboration/academy-smart

5.2 NOTABLE STRENGTHS AND CHALLENGES

Strength: 1) Fruitful collaborations with industries and the Värmland region in education, research and development.
Challenges: 1) Greater visibility and outreach is called for, to attract the attention of more innovators, entrepreneurs, industrial firms and societal/governmental organisations in Sweden and beyond. The department has tried to do this on its own, failing a more proactive approach from the central communications unit of the University. 2) The Department is keen on involving more SMEs (Small and Medium Enterprises) in research projects, but understanding each other's expectations and limitations is a must. While extensive internationalisation is beneficial, linguistic hurdles sometimes need to be overcome. 3) Many financiers with the capacity to invest in projects will prefer high-TRL, applied research, while the Department also needs to ensure academic excellence, and this will necessitate 'sticky' compromises.

6. INTERACTION BETWEEN RESEARCH AND EDUCATION

'We offer well-respected, excellent academic environments, in which research and teaching are closely connected,' reads one of the University's strategic goals for 2019-2023. On a departmental level, all teachers are encouraged to participate in research, and all researchers are encouraged to contribute to the pedagogical activities of the Department.

6.1 SCIENCE-INDUSTRY-EDUCATION NEXUS

Following the dictum of 'Catch them young,' we commence early with the Children's University (Barnens universitet) initiative, in which some of our researchers teach children about their research. The research-pedagogy nexus enables the dissemination of new knowledge to students. Guest lectures and study visits to industrial facilities in the Värmland region are integral to most of the courses, which strengthen contacts with the industry, enhancing the possibility of joint research projects and opportunities for students to work on their future Master's thesis (refer to Figure 6.1 in which the progression is illustrated). Many such Bachelor's and Master's projects are completed by students who are hosted by the industries and guided by the research groups. In third-cycle courses, the Department avails of lectures given by teachers from other universities, and industry personnel, to keep the students abreast of the 'state-of-the-art'. The national collaboration of Treesearch and doctoral courses organised in that context, provides a specific interaction for research and education as the courses are open to participation from the industry. To date, the Department has two such doctoral courses.

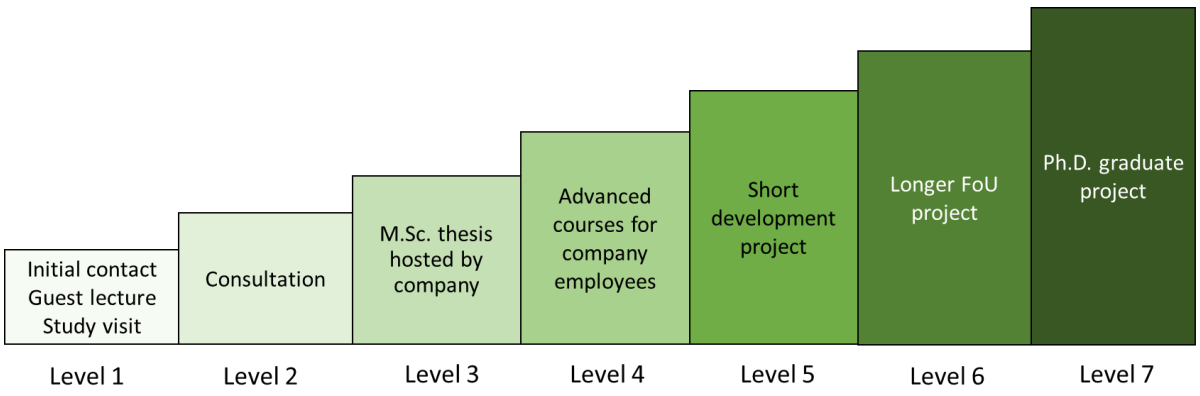


Fig. 6.1 An illustration on our systematic approach to facilitate that study tours and guest lectures in degree programmes can lead on to deeper collaborations and academia-industry research cooperation.

As indicated earlier, all teachers are encouraged to participate in research, and this ensures that all the three cycles (as far as the courses are concerned) benefit research, and are benefited by it, in turn. Moreover, some researchers are involved in training industry personnel in courses commissioned by the industries, which is organised by Karlstad University's contract education, KUUAB (Karlstads universitets uppdrags AB). Of late, a course for the paper and pulp sector, and a course on scientific information retrieval and reporting for Research and Development tasks, have been commissioned. The Department thus plays a part in fulfilling one of the University's goals, which is to contribute to a sustainable future by investing in training personnel from industries which are keen on transitioning to a greater degree of sustainability in their operations, in the years to come.

6.2 RESEARCH AND EDUCATION COMPLEMENTING EACH OTHER

Final-year Master's degree students in the EES unit, pursue a course titled 'Bioeconomy Products and Processes,' in which the projects they work on are sourced from research conducted within Pro2BE. Their work feeds into the research, fuelling it further in the process, and setting up a mutually reinforcing relationship. Laboratory work conducted by students in the courses Environmental Chemistry, Cleaning Technology and Advanced Cleaning Technology, doubles up as introductory experiments in research projects, with the objective of testing ideas instead of seeking precisely measured outputs.

In the Building Engineering programme (BCE unit), there is a very clear synergy between research on the one hand, and pedagogy and textbook publishing on the other, as evidenced by the courses Träkonstruktion (Wooden Constructions) and Hållbart Byggande (Sustainable Building/Construction).

Research-inspired chemistry courses are, for example, the profile courses 'Advanced Analytical Chromatography - Theory and Practice' and 'Pharmaceuticals: Analysis of Chemicals in Project Form' in the Drug Analysis Bachelor's Programme, and the courses 'Surfaces, Interfaces, and Colloids' and 'Macromolecular Physical Chemistry'.

Several engineering programmes have an introductory course in sustainable development, in which research outcomes from projects related to packaging and food waste (related to the research group - Packaging for Sustainable Development) are used in examples during teaching.

All the research groups offer students options for their Master's thesis linked to ongoing projects. In the EES and BCE units, students present and defend their thesis in a 'conference' organised within the Department with companies, with hosting companies and the students' family and friends invited to attend.

6.2.1. Education being research

Over the last few years (including the period 2019-2021), some Master's theses have been adapted/converted to scientific journal publications, thanks to continued collaboration between motivated students and supportive supervisors. A couple of examples have been footnoted[17].

6.3 CURRENT PLANS FOR THE FUTURE

The synergy between pedagogy and research is now proven and well-entrenched within the Department. Often, it has been noticed that industries are willing to support degree programmes, while being research partners. In 2018, the Department decided to improve the degree of applicability and relevance of university education and professional training to the needs of the industry. This decision led to the application of grants for the development of new courses:

a) Pro2BE KK Avans Bioeconomy (advanced level, for students in CE and EES units)
b) KK Expertkompetens Driven (advanced level, for paper technology professionals)

These are now ready to get underway, commencing with student theses and evolving to projects.

6.4 NOTABLE STRENGTHS AND CHALLENGES

Strengths: 1) Strong established synergy between pedagogy and research, bolstered by a robust university-industry nexus. 2) Research instrumentation used in courses. 3) Master's thesis projects linked to research projects. 4) Active researchers doubling up as teachers.
Challenges: 1) When researchers who are not proficient in spoken Swedish are tasked with teaching assignments, students may find it a bit challenging. 2) Too few doctoral courses arranged.

7. APPENDIX

In the three-year period of 2019 to 2021, the four units of the Department of Engineering and Chemical Sciences, together, produced 10 books, 8 book chapters, 11 conference presentations, 2 scientific reports, 1 collection, 3 reviews and 123 peer-reviewed articles (as depicted in Figure 7.1). The number of articles showed a marked rise from 34 in 2020 to 53 in 2021. The 123 articles and 3 reviews were distributed among 80 different journals. Almost all the books and book chapters were the outputs of the Building Engineering unit of the Department.

As shown in Figure 7.1 below, the average impact factors were 3.86 (2019), 4.39 (2020) and 4.68 (2021). The overall average for the three-year period was 4.36. Over one-sixth of the 126 articles (plus reviews) were published in journals with impact factors above 6.

[17] Jalan I, Lundin L, van Stam J. 2019. Using solubility parameters to model more environmentally friendly solvent blends for organic solar cell active layers. Materials, 12: 3889-3901.
Mikhelkis L, G Venkatesh. 2020. Techno-economic and partial environmental analysis of carbon capture and storage (CCS) and carbon capture, utilization and storage (CCU/S): Case study from proposed waste-fed district-heating incinerator in Sweden. Sustainability, 12, 5922. DOI: 10.3390/su12155922.

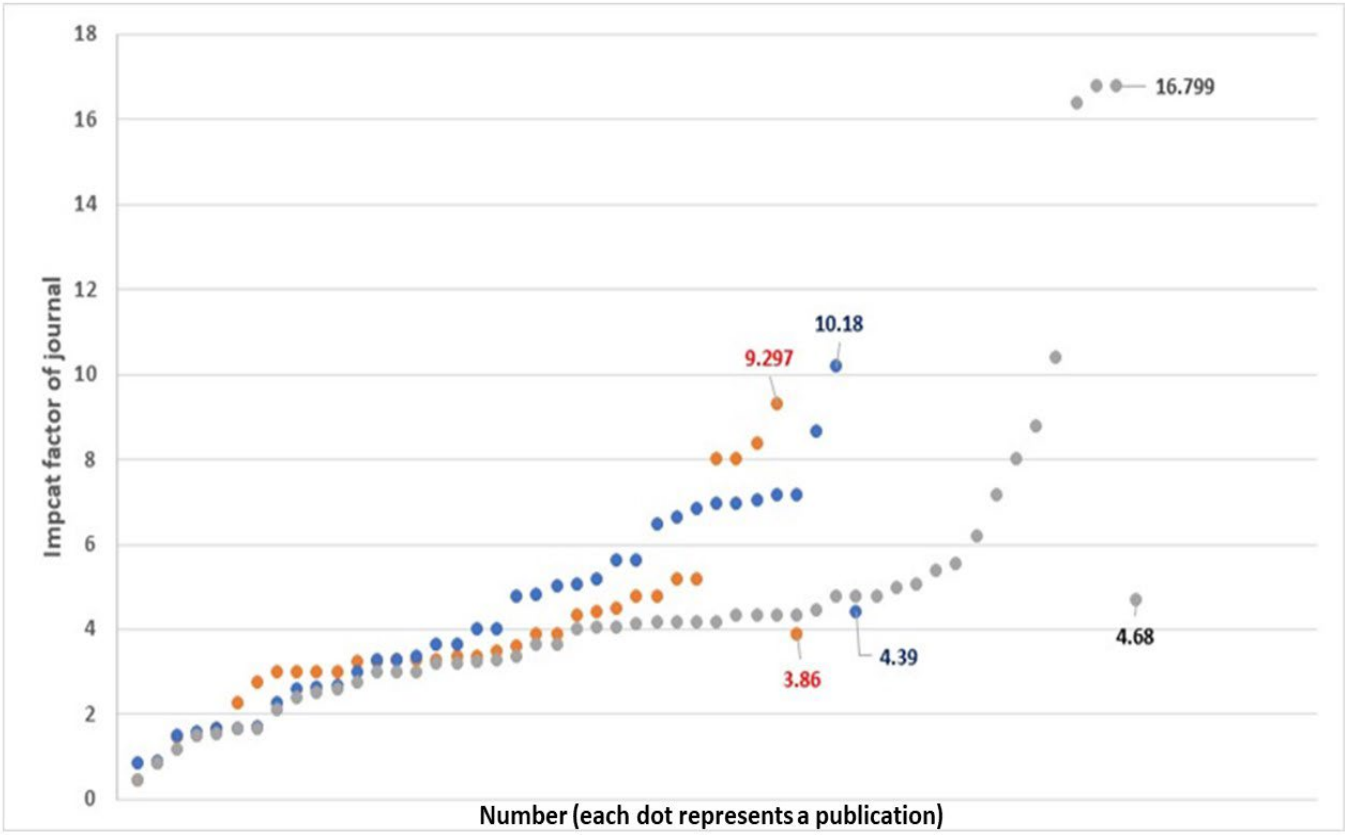


Figure 7.1: Impact factors of the journals in which the articles and reviews were published (2019 in orange, 2020 in blue and 2021 in grey; the highest factors and the annual averages are shown. Dots represent publications arranged from left to right in increasing order of impact factors of the journals in which they are published)

The Department of Engineering and Chemical Sciences

BACKGROUND DATA

Periodic Research Review

KAU.SE

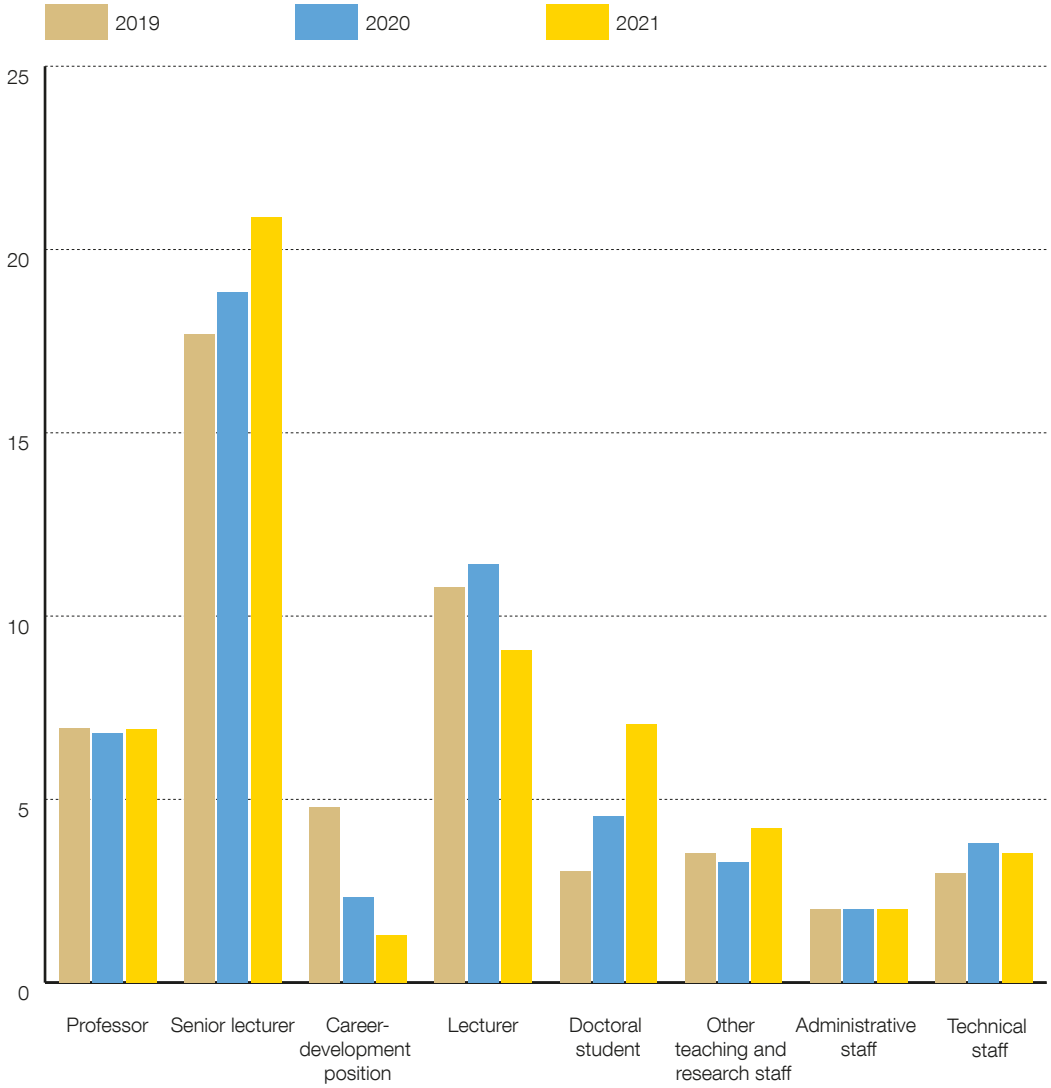
INTRODUCTION

The purpose of the background data is to provide an overview of the evaluation unit, the Department of Engineering and Chemical Sciences, regarding: staff, financial resources, research funding, internationalisation, bibliometrics, collaborations and utilization of research for the period of 2019-2021. Details regarding data source or possible deviation will be stated in the individual figure text.

STAFF

Table 1.1. Staff categories of the evaluation unit

The graph shows the workforce involved in research activity at the evaluation unit over a three year period. Research activity includes internal funding, external research funding and comissioned research funding. Staff categories included in the table are professor, senior lecturer, lecturer, doctoral student, administrative staff, technical staff, other teaching and research staff, as well as career-development positions.



Source: KULI

STAFF

Table 1.2. Staff at the evaluation unit (only the past year, 2021)

The table shows staff, based on position, engaged in research at the Department of engineering and chemical sciences.

NAME	POSITION	DEPARTMENT
PROFESSOR		
Berghel, Jonas	Professor	Engineering and chemical sciences
Fornstedt, Torgny	Professor	Engineering and chemical sciences
Granström, Karin	Professor	Engineering and chemical sciences
Lestelius, Magnus	Professor	Engineering and chemical sciences
Moons, Ellen*	Professor	Engineering and chemical sciences
Muntean, Adrian*	Professor	Engineering and chemical sciences
Månsson, Bengt	Professor	Engineering and chemical sciences
Nilsson, Lars	Professor	Engineering and chemical sciences
Swerin, Agne	Professor	Engineering and chemical sciences
van Stam, Jan	Professor	Engineering and chemical sciences
Wikström, Fredrik	Professor	Engineering and chemical sciences
Lacki, Karol	Adjunct professor	Engineering and chemical sciences
Perstorper, Mikael	Adjunct professor	Engineering and chemical sciences
Rättö, Peter	Adjunct professor	Engineering and chemical sciences
Järnström, Lars	Professor senior	Engineering and chemical sciences
Nilsson, Thomas Martin	Professor senior	Engineering and chemical sciences
SENIOR LECTURER		
Al-Beywanee, Bestoun S. Ahmed*	Senior lecturer, reader	Mathematics and computer sciences
Almssad, Asaad	Senior lecturer, reader	Engineering and chemical sciences
Biel, Anders	Senior lecturer, reader	Engineering and physics
Fellesson, Markus*	Senior lecturer, reader	Karlstad Business School
Govindarajan, Venkatesh	Senior lecturer, reader	Engineering and chemical sciences
Naqvi, Syed Muhammad Raza	Senior lecturer, reader	Engineering and chemical sciences
Renström, Roger	Senior lecturer, reader	Engineering and chemical sciences
Samuelsson, Jörgen	Senior lecturer, reader	Engineering and chemical sciences
Sandberg, Maria	Senior lecturer, reader	Engineering and chemical sciences
Ståhl, Magnus	Senior lecturer, reader	Engineering and chemical sciences
Williams, Helen	Senior lecturer, reader	Engineering and chemical sciences
Brunzell, Lena	Senior lecturer	Engineering and chemical sciences
Carlsson Kvarnlöf, Gunilla	Senior lecturer	Engineering and chemical sciences
Drechsler, Michal	Senior lecturer	Engineering and chemical sciences
Frodeson, Stefan	Senior lecturer	Engineering and chemical sciences
Håkansson, Helena	Senior lecturer	Engineering and chemical sciences
Lin, Wamei	Senior lecturer	Engineering and chemical sciences
Mesic, Behudin	Senior lecturer	Engineering and chemical sciences
Mohammadi, Ali	Senior lecturer	Engineering and chemical sciences
Muntean, Stela Andrea*	Senior lecturer	Engineering and physics
Rezk, Kamal	Senior lecturer	Engineering and chemical sciences
Rova, Maria	Senior lecturer	Engineering and chemical sciences
Saenz-Mendez, Patricia	Senior lecturer	Engineering and chemical sciences
Sjöstrand, Björn	Senior lecturer	Engineering and chemical sciences
Smedja Bäcklund, Anna	Senior lecturer	Engineering and chemical sciences
Vessby, Johan	Senior lecturer	Engineering and chemical sciences
Gustavsson, Christer	Adjunct senior lecturer	Engineering and chemical sciences

LECTURER		
Andersson, Tim	Lecturer	Engineering and chemical sciences
Beiron, Jens	Lecturer	Engineering and chemical sciences
Eriksson, Marcus	Lecturer	Engineering and chemical sciences
Forsberg, Tomas	Lecturer	Engineering and chemical sciences
Götlind, Mikael	Lecturer	Engineering and chemical sciences
Johansson, Svea	Lecturer	Engineering and chemical sciences
Kjeang, Are	Lecturer	Engineering and chemical sciences
Lockner, Emil	Lecturer	Engineering and chemical sciences
Lunde, Torodd	Lecturer	Engineering and chemical sciences
Najar, Karim	Lecturer	Engineering and chemical sciences
Olin, Malin	Lecturer	Engineering and chemical sciences
Pettersson, Kenny	Lecturer	Engineering and chemical sciences
Rehnström, Carina	Lecturer	Engineering and chemical sciences
Wahlberg, Sara	Lecturer	Engineering and chemical sciences
DOCTORAL STUDENT		
Haseeb, Abdul	Doctoral student	Engineering and chemical sciences
Hashemzehi, Mozhgan	Doctoral student	Engineering and chemical sciences
Jalan, Ishita	Doctoral student	Engineering and chemical sciences
Maharjan, Rajan	Doctoral student	Engineering and chemical sciences
Mattsson, Lisa	Doctoral student	Engineering and chemical sciences
Saxegård, Simon	Doctoral student	Engineering and chemical sciences
Siwale, Workson	Doctoral student	Engineering and chemical sciences
Zywalewska, Martyna	Doctoral student	Engineering and chemical sciences
CAREER-DEVELOPMENT POSITION		
Abdulgadir, Alamin	Postdoc	Engineering and chemical sciences
Lakade, Sameer Shamrao	Postdoc	Engineering and chemical sciences
OTHER ACADEMIC STAFF		
Enmark, Martin	Research project administrator	Engineering and chemical sciences
Eskandari, Samieh	Research project administrator	Engineering and chemical sciences
Gozali, Ebrahim	Research project administrator	Engineering and chemical sciences
Häggström, Jakob	Research project administrator	Engineering and chemical sciences
Javed, Asif	Research project administrator	Engineering and chemical sciences
Kudahettige Nilsson, Rasika Lasanthi	Research project administrator	Engineering and chemical sciences
Lesko, Marek	Research project administrator	Engineering and chemical sciences
Martinez Hermosilla, Gonzalo	Research project administrator	Engineering and chemical sciences
Szabados, Gergely	Research project administrator	Engineering and chemical sciences
TECHNICAL STAFF		
Ericsson, Leif Karl Enar*	Research engineering	Engineering and physics
Forssén, Patrik	Research engineering	Engineering and chemical sciences
Andersen, Mikael	Research engineering	Faculty office, HNT
Larsson, Anders	Research engineering	Faculty office, HNT
Gustafsson Birgitta	Research engineering	Engineering and chemical sciences
Pettersson Lars	Research engineering	Engineering and chemical sciences
ADMINISTRATIVE STAFF		
Tyrfelt Christina	Student affairs officer	Office for student affairs
Klang Lotta	Faculty administrator	Faculty office, HNT
Klint Hidén Maria	Faculty administrator	Faculty office, HNT
Olsson Carina	Communications officer	Communications office

* Employed at another department, participating in joint research projects.
Source: Primula

THIRD-CYCLE STUDIES

Table 2.1. Doctoral students

The table contains doctoral students divided by discipline, year of admission, and degree of activity for year 2021. Industry/collaboration/external doctoral students are marked with (I).

ADMISSION SUBJECT	NAME	DEGREE OF ACTIVITY 2021V	DEGREE OF ACTIVITY 2021H	YEAR OF ADMISSION	INDUSTRY/ COLLABORATION/ EXTERNAL (I)
Chemistry - Analytical Chemistry	Abdul Haseeb	100	100	2020	
Chemistry - Physical Chemistry	Ishita Jalan	80	80	2018	
Chemistry - Chemistry Education	Sara Wahlberg	36	50	2019	
Chemistry Education	Hanna Christophliemk	3	3	2015	(I)
Chemistry Education	Mozhgan Hashemzehi	100	93	2020	
Chemistry Education	Pyry Hämäläinen	15	10	2012	(I)
Chemistry Education	Yana Svetlozarova Petkova-Olsson	3	3	2012	
Environmental and Energy Systems	Carina Rehnström		47	2020	
Environmental and Energy Systems	Lisa Mattsson	42	50	2011	
Environmental and Energy Systems	Martyna Karen Zywalewska	100	10	2020	
Environmental and Energy Systems	Simon Saxegård	80	80	2020	
Environmental and Energy Systems	Workson Siwale	100	100	2019	

Source: Ladok

Table 2.2. Graduate licentiate and doctoral students

Completed Degree of Licentiate or Doctor over the past three years.

SUBJECT	NAME	DEGREE	2019	2020	2021
Chemical Engineering	Caroline Wilke	Degree of Doctor			1
Chemical Engineering	Björn Sjöstrand	Degree of Doctor		1	
Chemical Engineering	Aron Gustav Tysén	Degree of Doctor	1		
Chemical Engineering	Sofia Thorman	Degree of Doctor	1		
Chemical Engineering	Linda Östberg	Degree of Licentiate		1	
Chemical Engineering	Jonas Kihlman	Degree of Licentiate			1
Chemistry Education	Torodd Lunde	Degree of Doctor		1	
Chemistry Education	Sara Wahlberg	Degree of Licentiate	1		
Environmental and Energy Systems	Stefan Frodeson	Degree of Doctor	1		
Environmental and Energy Systems	Daniel Ekbåge	Degree of Doctor		1	
TOTAL SUM			**4**	**4**	**2**

Source: Ladok

FINANCIAL RESOURCES

Table 3.1 Profit and loss statement for research per year

Amounts in SEK 1 000

	2019	2020	2021
INCOME			
Direct government funding[1]	17 411	18 108	20 291
External funding[2]	18 008	16 317	16 627
Internal income[3]	582	153	603
INCOME TOTAL	**36 001**	**34 578**	**37 522**
EXPENDITURE			
Staffing costs[4]			
Salaries teachers	-17 347	-15 807	-17 411
Remunerations	-141	-140	-164
Salaries administration and technical staff	-739	-888	-548
Other staff costs	-213	-69	-98
Other operating expenses			
Other operating expenses[5]	-3 908	-3 612	-4 057
Internal costs			
Internal staff cost	-3	-6	-
Premises	-20	-	-
Other internal costs[6]	-14 730	-14 175	-13 343
EXPENDITURE TOTAL	**-37 101**	**-34 696**	**-35 621**
TRANSFERS			
Funds for financing grants	1 758	2 317	935
Grants paid	-1 758	-2 317	-935
Transfers Total	**-**	**-**	**-**
SUBTOTAL	**-1 100**	**-118**	**1 901**

Source: KULI/Raindance

[1] Block funding directly allocated to the university by the Swedish government.

[2] Includes revenue from fees, other reimbursements and funding. Funding which can include grants from Councils, other public research funding agencies, municipalities, regions and research foundations.

[3] Internal transactions includes, for example, grants and/or compensations from other parts of the university or from the evaluation unit as well.

[4] Staffing costs refer to costs for personel who receive salary from the evaluation unit.

[5] Other operating expenses can include materials, costs for hired expertise, other consultants, travel costs, costs for premises of campus, depreciation etc.

[6] Includes for example, internal staff costs, lecture halls, laboratories, offices and other internal expenses such as indirect costs for the faculty and university levels, printing costs etc.

Table 3.2. External research funding

The table shows ongoing research projects and projects granted during 2019-2021. Project titles are added as a note below the table.

Amounts in SEK 1000

FUNDER	2017	2018	2019	2020	2021	2022	2023	TOTAL AMOUNT GRANTED
Swedish companies[1]					390			390
Foundations[2]			67					67
Swedish companies[3]				240				240
Interreg EU[4]	1 333	1 333	889					3 556
Interreg EU[5]				1 284	1 926	642		3 852
Swedish research council for sustainable development[6]	927	927	927					2 781
Swedish research council for sustainable development[7]				873	873	873		2 619
Swedish research council for sustainable development[8]				40	580	630	550	1 800
The Knowledge Foundation[9]	1 473	950	950					3 373
The Knowledge Foundation[10]	292	300	308					900
The Knowledge Foundation[11]	47	2 891	2 838	2 119				7 896
The Knowledge Foundation[12]		1 428	2 856	2 856	2 856	1 428		11 425
The Knowledge Foundation[13]		179	179					359
The Knowledge Foundation[14]			1 013	1 013				2 027
The Knowledge Foundation[15]			682	682	682	682		2 726
The Knowledge Foundation[16]					216	659	677	1 552
The Knowledge Foundation[17]					1 691	3 382	3 382	8 456
Foundations[18]	674	674	674	674	674			3 372
KTH Royal Institute of Technology[19]			300					300
KTH Royal Institute of Technology[20]			150					150
KTH Royal Institute of Technology[21]				150				150
Government of Sweden[22]			98	104	113	234		550
The Swedish Environmental Protection Agency[23]				80	-			80
Region Värmland[24]			756	774	793			2 323
Swedish National Space Agency[25]		1 275	1 315					2 590
Swedish National Space Agency[26]				1 573	1 573			3 146
Swedish Energy Agency[27]		108	603	492				1 204
Swedish Energy Agency[28]		-	261	833	687			1 781
Public funds[29]		473	812	242				1 527
Public funds[30]					89			89
Chalmers University of Technology[31]				150				150
Foundations[32]					104	145		248
Foundations[33]			17					17
Swedish companies[34]				40				40
Swedish companies[35]				50				50
Swedish companies[36]					64	100	100	264
Swedish companies[37]				360				360
Swedish Agency for Economic and Regional Growth[38]	4 327	4 437	4 046	315				13 126
Swedish Agency for Economic and Regional Growth[39]			3 882	2 222				6 104
Swedish Agency for Economic and Regional Growth[40]			400			490		890
Other NP organisations[41]					320	606	606	1 532

Foreign companies[42]					160			160
Swedish Governmental Agency for Innovation Systems[43]	1 274	1 246	1 070	411				4 000
Swedish Governmental Agency for Innovation Systems[44]		120	260	21				402
Swedish Governmental Agency for Innovation Systems[45]			500	200				700
Swedish Governmental Agency for Innovation Systems[46]			79	1 019	391	241		1 729
Swedish Governmental Agency for Innovation Systems[47]				75	75			150
Swedish Governmental Agency for Innovation Systems[48]				70	222			292
Swedish Governmental Agency for Innovation Systems[49]					87	773	795	1 655
Swedish Research Council[50]	950	950	950					2 850
Foundations[51]				490				490
Other NP organisations[52]				340				340
TOTAL			**26 883**	**19 793**	**14 566**			

Source: Raindance

Projects

[1]Cotunity för AstraZeneca
[2]Microbial IV
[3]NBk-berikad askpellets
[4]IMTRIS
[5]Biosirk
[6]Matsvinn
[7]Modellering trähusbyggande
[8]Effektiva dimensioneringshjälp
[9]PARB
[10]AFFLIERAD FORSKARE GUSTAVSSON
[11]SYNERGI 16 (KKS)
[12]Multibarr
[13]Waste-man
[14]Pro2BE
[15]Lektor ytbehandling
[16]Adjungerad professor i Byggteknik
[17]Impaqcdt Synergi
[18] Knut och Alice Wallenberg stiftelse
[19]FPIRC Treesearch course
[20]FPIRC Treesearch
[21]Treesearch - Regen. Cellulose
[22] NATDID Ambassadörsuppdrag
[23]Bok matsvinn
[24]Shaping the Bioeconomy Future
[25]Mikrogravitation IV
[26]Mikrogravitation V
[27]EM Bioolja
[28]Svinpels
[29] Biop
[30]Blended biofuel pellets
[31]Treesearch Packaging Materials
[32]HTC-PHA
[33]Hedborgs Stiftelse
[34]Paper Surface Centre
[35]Regional produktion av biopoly
[36]Valmet Pyry
[37]Förstudie KLwaste
[38]Fosbe/TVV
[39]Fosbe/TVV
[40]Lignocity 2.0
[41]Sustainable Eaters-Recycling
[42]CPG7909-WP1 för ABT
[43]Pappersbaserade 3D-förpackningar
[44]IHS WP5
[45]Vinnväxt 2.0 etapp 2
[46]NärSkog 2
[47]CelluPac
[48]Högpresterande syllar
[49]InnoPels
[50]Molekylära II
[51]Biochar pellets
[52]ES3D Förstudie

EXTERNAL RESEARCH FUNDING STATISTICS

Table 4.1. External research funding statistics. *Amounts in SEK 1000.*

YEAR	NUMBER OF GRANT PROPOSALS SUBMITTED	SUCESS RATE %	AMOUNT APPLIED	AMOUNT GRANTED
2019	18	33%	42 000	8 000
2020	21	38%	37 000	7 000
2021	40	28%	88 000	25 000

Source: Information retrieved from Podio (2019) and Raindance application portal (2020, 2021).

BIBLIOMETRIC ANALYSIS AND REFERENCE LIST

BACKGROUND

The research activity at Karlstad University is expressed, among other things, in scientific publications. This report aims to map the publishing activity and its development over time for the Department of Engineering and Chemical Sciences. The report also shows the proportion of internationally co-authored publications where at least one of the authors is affiliated with a university outside Sweden as well as the proportion of publications that are open access, i.e. freely available online.

METHOD

The following tables are based on registered publications in DiVA (Digital Scientific Archive), the local publication repository where researchers, teachers and students register their research publications and essays. DIVA covers all subject areas and publication types

Publication extraction for the years 2019-2021 has been based on the researchers individual Kau: ID, which links them with their respective publications. The list of researchers that are included in the analyses was provided by the HR department and includes also researchers that are no longer part of the unit but were employed during 2019-2021.

The analysis includes all publications where at least one of the authors is affiliated with Karlstad University. The publication subcategories presentation, entries, abstracts and “other” have been omitted from the analysis because these entries are registered to a very varying extent by the researchers. Doctoral dissertations and licentiate theses are reported in detail in other parts of the evaluation and have therefore also been omitted here.

PUBLISHING OUTPUT

Table 5.1. Shows the total number of publications the unit has produced for each year between 2019-2021.

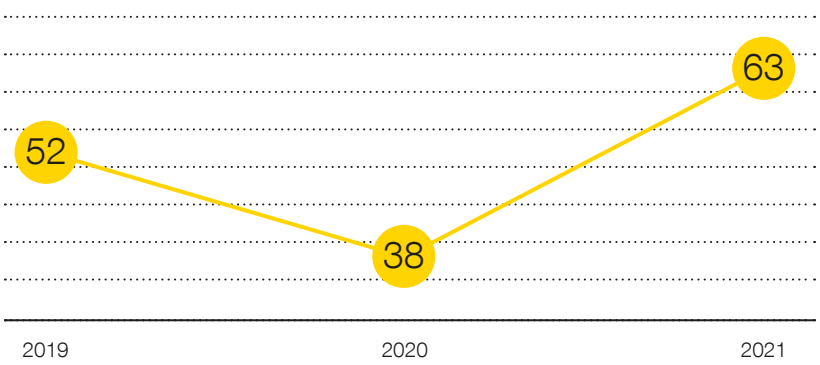


Table 5.2. Number of publications for each publication type

The table shows a detailed compilation of the unit´s publications sorted by publication type and content.

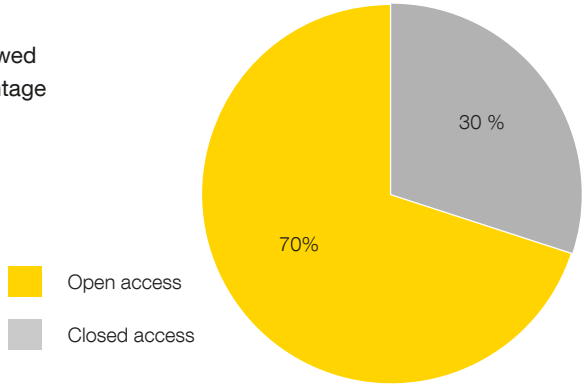
	PEER-REVIEWED	OTHER ACADEMIC	OTHER (POPULAR SCIENCE, DISCUSSION, ETC.)
	Peer-reviewed	Scientific but not peer-reviewed	Other (popular scientific, debate)
Article in journal	120	2	2
Article, review	3		
Book	2	7	1
Chapter in book	5	3	
Conference article	2	3	
Report	2		
Collection (Editor)	1		
TOTAL	**135**	**15**	**3**

OPEN ACCESS

The Swedish government and many research funders demand that research that is financed with public funds needs to be published open access to make it more accessible for anyone who is interested. So far, this requirement only applies to scientific publications in journals, which is why this report focuses on the proportion of open access for scientific articles.

Table 5.3. Share of peer-reviewed articles that are open access vs. those that are behind paywalls

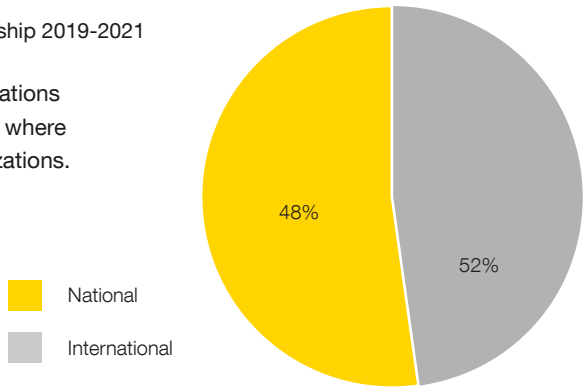
Comparison of the percentage of peer-reviewed articles that are open access and the percentage that are not.



NATIONAL AND INTERNATIONAL CO-AUTHORSHIP

Table 6.1. National and international co-authorship 2019-2021

Compares the proportion of the unit's publications with an international profile and publications where all authors were affiliated to Swedish organizations.



INNOVATIVE IDEAS

Table 7.1. Number of evaluated innovative ideas per employee. Number of innovative ideas that have received funding. Number of registered intangible assets (patent, trademark, design) based on the operations of the Innovation Office Fyrklövern. Reported annually to the government.

YEAR	NUMBER OF EVALUATED IDEAS	NUMBER OF IDEAS THAT RECEIVED FUNDS	NUMBER OF REGISTERED INTANGIBLE ASSETS
2019	2	2	1
2020	1	0	0
2021	1	0	0

Source: The Innovation Office Fyrklövern

The Background data report is produced by the Periodic research review's administrative Support group; Sofia Andersson, Lovisa Stedt, Charlotte Månsson, Karin Brattfjord, Lotta Utterberg, Magnus Åberg och Patrik Bångerius.

December 2022

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NOTE! The list aims to facilitate the understanding of which publications are included in the analysis. It is complete but does not follow any reference style to perfection.

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Periodic research review at Karlstad University concerning The Department of Engineering and Chemical Sciences- Assessment panel report.

Members of the assessment panel:
Professor Eva Thorin, Mälardalen University
Professor Thaddeus Maloney, Aalto University,
Professor Inger Andersson, Uppsala University

Brief summary

The department conducts good research disseminated at international level and shows strong improvement during the last years. The outreach at regional and national level is good. Collaboration with industry is strong, especially with the forest industry, including projects, education courses, fluid university/company mobility in Master's and PhD studies and access to pilot infrastructure for the private sector. This also contributes to connecting research to education. It could be worth tracking the number of industry Master's and PhD theses and looking for ways to enhance this collaboration. Integration of research and education is also promoted by active participation of faculty staff in teaching. More visible common vision, goals and strategy could help to move the research to the next level of international excellence. Further consolidation of the research towards research in the field of bioeconomy could be an option. More strategic international collaboration is also important. There is a potential for recruiting more PhD students. It is positive that the doctoral students are affiliated with graduate schools, securing access to graduate level courses aside from what is offered by the department**.** Multidisciplinary research is mentioned as important for building value-added projects and achieving high-impact results. A clearer strategy for fostering multidisciplinary excellence could be developed, including non-traditional chemical engineering faculty positions, shared professorships, and sabbaticals. Key performance indicators (KPIs) around important strategic targets could be beneficial to develop and follow. This includes internationalization, multi-disciplinarity and gender equality, research and societal impact targets.

1. Research and scientific development

The Department of Engineering and Chemical Sciences performs research within the areas of chemistry, chemical engineering, building and construction engineering, and environmental and energy systems. The Department has a clear ambition to follow the University strategies. A specific focus is on strengthening the connection and integration of research and education. Both fundamental research and applied as well as multidisciplinary research are important parts of the environment. The research is partly published in internationally well-known journals and conferences and there is a clear ambition to increase publications in high impact journals. There is a clear improvement in the number of applications as well as approved projects for external funding during the last years. It is desirable to increase funding. The international seminar and travels promoted within the research environment should also be used to further develop collaborations for external funding. The ambition (and self-confidence) could be improved concerning the possibilities to develop to meet the standards for more funders (for example VR, Formas and EU). Applications are made in teams but there is a potential for further improvements. It is also mentioned that several projects and collaboration exist with several European countries. International exchange activities (international visiting professors, international exchange PhD students etc.) could be one way to further enhance the internationalisation. Seminar activities in interdisciplinary as well as international context is a vital part of research development.

With 9 professors and 9 associated professors (docents) and only 8 PhD students, the potential for employing more PhD students is large. The supervision capacity should be used to a larger extent. The department has the ambition to increase the number of PhD students and in connection to that also externally funded projects and scientific publications.

The research of the Pro2BE group is co-ordinated to a larger unit which helps to reach a critical mass and focus. However, the organisation of the research in different research groups is unclear. Some groups also seem to have a very narrow area of the research (for example the group Energy efficiency and energy-use optimisation) and it may be more beneficial with larger and broader groups to increase flexibility in the growth of the research as well as better possibilities for internal support and collaboration with the aim of strengthening research and the integration of research and education. Research related to the building engineering program should be further developed and collaboration increased. The vulnerability of the smaller research groups with few senior researchers is also highlighted in the self-evaluation. The vision and objective for the department is stated to be "…. positioning itself as a nationally and globally renowned pedagogical and research-oriented academic entity in the fields of sustainable development, bioeconomy anchored in the forestry sector, and applied chemistry/chemical engineering". However, this vision is not clear in the organisation of the research groups and in the presentation of their work. Further consolidation of the research towards research in the field of bioeconomy might be an option. More visible common vision, goals and strategy might help in the further development towards international excellence. Furthermore, conditions and processes could be standardised across the whole department, reducing existing differences between research groups. An important part of this is to include processes and practices for renewal of the research. This can be done by the activation and promotion of innovative thinking, new research, and new areas. A powerful way to enhance fertilization and radical renewal is to open recruitments for qualified international scientists.

Infrastructure availability seems to be good with access to both experimental labs at the university and to test beds. However, the status of the equipment is unclear and there are some indications that renewal and update of the facilities is necessary. The availability of funding for the renewal of laboratory and pilot infrastructure was unclear.

2. Academic qualifications and ensuring competence maintenance in the short and long term.

The areas of expertise are diverse considering the size of the department, and include chemistry, chemical engineering, building and construction engineering and environmental and energy systems. Nearly half of the workforce is either at the professorial or senior lecturer stage and this means that the level of competence is high. However, senior researchers are not evenly distributed between the research groups, and this needs attention to ensure competence throughout. The submitted material contains no information on the age structure of the department, but in a unit of this size, it is important to be proactive in recruiting new staff to meet needs caused by retirements in time. Another way to ensure critical mass of staff at different points of career development is to reorganize into larger research teams.

Considering the number of staff (in the order of 60-70), the division between four units and five research groups means that each unit/group is rather small and the number of senior researchers in some groups is small. This has consequences e.g., for the participation in grant applications for external funding and calls for a well-functioning organization and smooth collaboration between the research groups.

There are approximately 60 academic staff (Professors, Senior Lecturers, Lecturers, other academic staff) and 10 doctoral students/postdoctoral fellows among the employees (according to the Background data). The department is thus top-heavy with respect to academic staff compared to doctoral students and postdoctoral fellows. It is therefore highly desirable to increase the number of doctoral students and career development fellows in the future.

The doctoral students are affiliated with graduate schools, either organized by the Faculty or by externally funded graduate schools. This furthers day-to-day interactions between students in a small population and reduces the risk that students feel isolated. Affiliation with graduate schools also secures access to graduate level schools/courses aside from what is offered at the department. Positive is that all professors teach, also at the undergraduate level.

Concerning opportunities for career development, there are clear rules for the tenure process at all levels, but international evaluation and competition could be strengthened. Discussions with early career researchers revealed a high level of motivation to stay in academia and satisfaction with the support offered by the department in the tenure process and with grant applications.

3. Organisation, leadership, and management

The Department of Engineering and Chemical Sciences is part of the Faculty of Health, Science and Technology. It has a standard organization with units based on subjects (see Figure on page 4 of the self-evaluation) with a Head of Department (HoD) who is responsible for department budget and economy, administration of staff, and of the maintenance and development of the work environment. The latter includes the planning and support of the professional development of employees with the goal of attaining the Department's objectives and visions. The HoD is assisted by the deputy Head of Department (dHoD) who's main responsibility is the maintenance and development of the study programmes. Each of the four units has a representative, Head of Subject (HoS), who works in close cooperation with the HoD with the aim to achieve a smooth running of and positive development of the study and research programmes of the Department. Every unit has a Director of Studies (DoS) responsible of running and monitoring of the courses. The HoD, dHoD, HoS and DoS together form a governing body in charge of the Department's future research and tertiary education including Bachelor degree, Master degree and PhD programmes as well as externally funded professional courses (all subjects except BCE offer PhD programmes). The running of each subject is performed through periodic discussions at monthly staff meetings.

The research conducted in the Department is organized in five Research groups: (Physical chemistry, Fundamental separation science, Processes and products for a circular bioeconomy (Pro2BE), Energy efficiency in households, and Packaging for sustainable development). The Research groups span one or more (up to four) Subjects, i.e., each Research group has members out of more than one Subject area and this likely strengthens collaborative links between the units. Members of the Research groups meet regularly to discuss research strategies and goals, research proposals, status and progress of ongoing projects, conference participation and networking possibilities. This interchange is likely to promote interaction between members of the Department in various constellations but could also be disruptive to the every-day work of individual researchers. There is an awareness of this; it is noted in the Self-evaluation that the need for coordination among the research areas requires an active research director/deputy director. The tasks, possibilities and benefits of the functions need to be continuously followed up by the department.

Pro2BE is the largest research group and includes several rather diverse research topics: New Development for Pellet Technology (NewDePT), Functional surfaces and sustainable materials, Water-Energy nexus, Dewatering & drying, and Sustainable structural engineering. Pro2BE thus gathers a large part of the research at the Department. Pro2BE has a research programme and is led by a research director.

Because of the complex organization of research, each research group is likely small and there may thus be a lack of senior researchers in some groups. This may negatively influence the participation in large-scale grant applications such as Horizon Europe. It is therefore crucial to collaborate with other research groups in academia and industry on local, national, and international level. For instance, the Physical Chemistry group collaborates with scientists from the departments of Engineering & Physics, Mathematics and Computer Science, in research on organic and perovskite solar cells. This project also involves collaborations on the national level with Chalmers and the universities of Lund and Linköping (SOLution-borne materials for organic electronic Applications, SOLA project). The Fundamental Separation Science Group (FSSG), which belongs to the Analytical Chemistry unit, collaborates with the pharmaceutical sector. Such outreach activities are vital and should be encouraged.

4. Collaboration, utilization and impact of research

The research environment has a large network of both national and international academic collaborators, even though it is noted as a challenge that “Many research groups are not yet sufficiently well-established academically on an EU-level to participate in projects like Horizon Europe.” Also, collaboration with industry and other organisations is well-developed on a regional level. Several externally funded projects involve collaboration through national research consortiums and networks. Some measures have been taken to promote international collaboration by, for example, resources for travel and visits. It is also good that requirements on participation in international conferences is included in PhD education.

The fact that the department has several adjunct professors is also an indication of good collaboration with industry. Also, the large amount of externally funded projects from KKS and Vinnova indicates good collaboration with industry. The connection to the forest industry sector is strong.

It is important to continue external collaborations, and this could be further developed with more strategic partnerships for long term collaboration with key external partners. This can be facilitated by the department developing and profiling strategic areas where it is internally competitive and highly visible. Given the existing critical mass, history, connections, and infrastructure around bioeconomy-related themes, this would seem a logical starting point for developing international centre-of-excellence status.

Publications are dominated by open access (70%) and journal publications appear to some extent in recognised international journals. The number of publications has increased during the recent years. However, with so many persons active in research there should be potential for more publications. With more PhD students the outreach through conference presentations could also increase.

For some of the research groups, popular science publications and a blog for the public is mentioned. Otherwise, it is not clear how the societal impact of research is communicated to the public. Development of a communication plan for all research at the department, also including planned activities for outreach to the public, could be one way to improve this.

5. Internationalisation, gender equality, research integrity and multidisciplinary collaboration

The Department of Chemical Engineering and Chemical Sciences at Karlstad University has the dual mission to support the local economy and to be internationally competitive. This is challenging since these goals can be mutually exclusive. Therefore, it is important that the department determines in what way and to what extent it wants to internationalize. Currently, it is evident that the chemical engineering department plays a very strong part in supporting the local industry, particularly in the bioeconomy. This is evidenced through the various projects, continuing educations courses, fluid university/company mobility in Master's and PhD thesis studies and accessibility of pilot infrastructure to the private sector. To support these activities, there are some international faculty and PhD students. Furthermore, the research staff participates in international conferences and collaborates with universities outside Sweden in publications and projects. However, should the department wish to lift its international profile further, steps could be taken to recruit top academics to KaU. Such candidates would bring with them their own international networks and further enrich new scientific openings and excellence. In our view, it would be possible to engage internal staff at the chemical engineering department, on all levels, and still maintain the role as a vital and trusted partner of the local industry. The junior staff, including international staff, with whom we discussed, appeared highly motivated for future research opportunities at KaU. The recruitment of international scientists to the department demands a more comprehensive analysis of the career system and its attractiveness to top talent.

"Multidisciplinarity" was mentioned several times in the self-evaluation and interviews. It is apparent, that staff have a firm grasp on the importance of working with partners outside of chemical engineering to build value-added projects and achieve high impact results. However, we urge the department to think more deeply about the types of cross-disciplinary networks they want to build and the actual targets that will be achieved. It is also critical to understand the role of the chemical engineering department in such networks. Non-traditional chemical engineering faculty positions, shared professorships and sabbaticals are some of the tools that could be exploited to foster multidisciplinary excellence.

In the area of gender equality, it is apparent that the department does many things right and it takes the issue seriously. For example, male/female working hours are tracked and the Gender Studies unit is engaged in the process. However, based on the live interviews it is wise to stay vigilant about the actual opportunities and career development for female staff.

The various dimensions of ethics play a bigger role in research and education today. It was mentioned that a course in ethics is currently available, which we consider to be a positive step to ensuring this issue is given due consideration.

Key performance indicators (KPIs) around important strategic targets could be beneficial to develop and follow. This includes internationalization, multi-disciplinarity and gender equality, research and societal impact targets. The KPIs would be useful in both internal development discussions and external reviews.

6. Connection between education and research

To maintain top quality undergraduate and graduate education, it is essential that the knowledge generated in the various research projects flows into the actual teaching. So, it is critical that all the faculty staff actively participate in teaching. This includes professors, docents, post-docs and PhD students. Furthermore, industry partners and visiting scientist can enrich the teaching staff and help expand the course offering. It was apparent from the self-evaluation and the interviews, that there is active engagement in teaching. The comment was made that there is too much teaching responsibility of senior staff. Although resource allocation must be considered, it is positive that research staff are engaged in the daily teaching of the students. Some staff also participate in continuing education, mainly targeted at local companies. In addition to renewing the competence of employed technical staff, this helps keep the academic teaching staff to stay current on industrial practices. Likewise, teaching support of pre-university students through the Barnens universitet initiative demonstrates strong societal impact.

Another important avenue for connecting research to education is the engagement of Master thesis projects and PhD projects by the industry. This is a win-win for students, staff, and the industrial partners. Students gain work experience, motivation and exposure, staff build connections to industry partners, companies can recruit talented students and draw on the knowledge of academic staff. Our impression was that this aspect of company-university collaboration was a great strength at the Department of Chemical Engineering. However, we did not go into details. It is probably worth tracking the number of industry Master’s and PhD theses and looking for ways to enhance this collaboration. Sometimes, it can be a challenge to ensure the academic quality of industry-led PhD or Master's theses. However, when functioning well, a high engagement of the students by the industry enhances many aspects of the departments societal impact.

Students have access to good-quality courses. There is collaboration with Treesearch, which has an extensive course offering. Further engagement in EU Erasmus programs or other networks can help increase the course offering and encourage mobility and network building.

7. Concluding assessment and recommendations for continued development

The conclusion from the assessment is that the department conducts good research with both regional, national, and international outreach even if the amount and level differ between different parts and groups of the department. Recommendations for further development are given below.

- More visible common vision, goals and strategy could help to move the research to next level of international excellence. Further consolidation of the research towards research in the field of bioeconomy might be an option.
- To lift its international profile further, steps could be taken to recruit top academics to KaU.
- The ambition (and self-confidence) in applying for funding from more types of funding agencies (for example VR, Formas and EU) could be increased. There is also a potential to improve the strategy and teamwork and utilising the existing international networks in attracting external funding.
- The supervision capacity should be fully used, and more PhD students should be enrolled.
- Increase of the flexibility for research growth and possibilities for internal support and collaboration with the aim to strengthen the research is vital, as is the integration of research and education by gathering the research in groups with both a broader focus and more people.
- Research related to the building engineering program should be further developed and collaboration increased.
- Processes and practices for renewal of the research should be more clearly defined, for example by the activation and promotion of innovative thinking, new research, and new areas and open recruitments of qualified international scientists.
- Proactive recruitment of new staff is critical to ensure long-term competence in all subject areas.
- External collaboration could be further developed with more strategic partnerships for long term collaboration with key external partners.
- Research outreach, especially to the public, could be improved with the help of a dedicated communication plan.
- Renewal and update of the experimental facilities may be necessary to meet the demands of forefront international research in the area.
- A clearer strategy to foster multidisciplinary excellence could be developed, including non-traditional chemical engineering faculty positions, shared professorships, and sabbaticals.
- Key performance indicators (KPIs) around important strategic targets, including internationalization, multi-disciplinarity and gender equality, research and societal impact targets could be beneficial to develop and follow.