ASIIN Seal & EUR-ACE® Label

Accreditation Report

Bachelor's Degree Programme
Chemical Engineering

Master's Degree Programmes
Chemical Engineering
Biorefineries
Water Technology

Provided by
Lappeenranta – Lahti University of Technology

Version: 22 September 2023

Table of Content

A About the Accreditation Process

Name of the degree programme (in original language)	(Official) English translation of the name	Labels applied for [1]	Previous accreditation (issuing agency, validity)	Involved Technical Committees (TC)[2]
Kemiantekniikan kandidaatin tutkintoohjelma	Bachelor's degree programme in Chemical Engineering	ASIIN, EUR-ACE®	ASIIN, 30.6.2017 - 30.9.2023	01, 09
Master's degree programme in Chemical Engineering	Master's degree programme in Chemical Engineering	ASIIN, EUR-ACE®	ASIIN, 30.6.2017 - 30.9.2023	01, 09
Master's degree programme in Biorefineries	Master's degree programme in Biorefineries	ASIIN, EUR-ACE®		01, 10
Master's degree programme in Water Technology	Master's degree programme in Water Technology	ASIIN, EUR-ACE®	ASIIN, 30.6.2017 - 30.9.2023	01, 03
Date of the contract: 16.03.2022 **Submission of the final version of the self-assessment report:** 24.02.2023 **Date of the audit (online):** 25.04. – 26.04.2023				
Expert panel: Prof. Dr. Axel Blokesch, Frankfurt University of Applied Sciences Prof. Dr. Karl-Richard Korff, University of Applied Sciences Muenster Prof. Dr. Rüdiger Lange, Technical University Dresden Prof. Dr. Renatus Widmann, University Duisburg-Essen Dr. Nikolaus Nestle, BASF SE				

[1] ASIIN Seal for degree programmes;
[2] TC: Technical Committee for the following subject areas: TC 01 – Mechanical Engineering/Process Engineering, TC 03 – Civil Engineering, TC 09 – Chemistry, Pharmacy, TC 10 – Life Sciences

Milla Lievetmursu, Oulo University, student	
Representative of the ASIIN headquarter: Rainer Arnold	
Responsible decision-making committee: Accreditation Commission	
Criteria used: European Standards and Guidelines as of 15.05.2015 ASIIN General Criteria as of 28.03.2014 Subject-Specific Criteria of Technical Committee 01 – Mechanical Engineering/Process Engineering as of 16.03.2021	

B Characteristics of the Degree Programmes

a) Name	Final degree (original)	b) Areas of Specialization	c) Corresponding level of the EQF[3]	d) Mode of Study	e) Double/Joint Degree	f) Duration	g) Credit points/unit	h) Intake rhythm & First time of offer
Bachelor's Programme in Chemical Engineering	Tekniikan kandidaatin tutkinto / Bachelor of Science in Technology	-	6	Full time	-	6 Semester	180 ECTS	Autumn semester / 2008
Master's Programme in Chemical Engineering	Diplomi-insinöörin tutkinto / Master of Science in Technology	-	7	Full time	-	4 Semester	120 ECTS	Autumn semester / 2008
Master's Programme in Biorefineries	Diplomi-insinöörin tutkinto / Master of Science in Technology	-	7	Full time	-	4 Semester	120 ECTS	Autumn semester / 2018
Master's Programme in Water Technology	Diplomi-insinöörin tutkinto / Master of Science in Technology	-	7	Full time	-	4 Semester	120 ECTS	Autumn semester / 2016

[3] EQF = The European Qualifications Framework for lifelong learning

For the Bachelor's degree programme Chemical Engineering, Lappeenranta – Lahti University of Technology (LUT) has presented the following profile it the Self-Assessment Report:

"The BSc programme in Chemical Engineering is targeted mainly for Finnish speaking students. It has long traditions, and it received its first accreditation in 2011. Contents of the programme consist basics of different fields of chemical thermodynamics, reaction kinetics and dynamics, unit processes, process simulation and basics of process and plant design, but also language and communication studies and basics of entrepreneurship."

For the Master's degree programme Chemical Engineering, Lappeenranta – Lahti University of Technology (LUT) has presented the following profile it the Self-Assessment Report:

"MSc programme in Chemical Engineering has its roots in the beginning of 1980's and thus has a long history at LUT. Today it focuses to give students skills to design cost and energy efficient processes taking into account the current demands for circular economy, clean environment and sustainable use of natural resources. The students will learn how to design and model equipment and processes in project teamwork in close collaboration with Finnish companies in applied projects. Finishing the Master´s degree studies will give students deepened knowledge in process analysis, modelling, and development, often by utilizing suitable simulation tools."

For the Master's degree programme Biorefineries, Lappeenranta – Lahti University of Technology (LUT) has presented the following profile it the Self-Assessment Report:

"MSc programme in Biorefineries has been started in 2018 answering the needs of Finnish biomass processing industry. It is especially targeted for adults already in working life to give a possibility to update their knowledge of and skills in the field. Thus, the programme was designed to be implemented online. The program is however available for students continuing from our BSc programme in Chemical Engineering. The content of the programme was planned in co-operation with industry, and it provides the students the latest knowledge of biorefining processes and novel solutions in development of new sustainable products considering whole biorefining integration. Finishing the Master´s degree studies will give students deepened knowledge in biorefining and integrated processes from the circular economy point of view."

For the Master's degree programme Water Technology, Lappeenranta – Lahti University of Technology (LUT) has presented the following profile it the Self-Assessment Report:

“MSc Programme of Water Technology was started as an independent Master’s programme in 2020. Earlier this substance was taught under combined programme of Chemical Engineering and Water Treatment, where water treatment was an alternative specialization module. Based on the latest LUT strategy there was a need for full-fledged MSc programme focusing on water treatment by using novel methods. The crucial support from the industry helped to establish this Water Technology programme. Instead of focusing on end-of-pipe treatment for pollution prevention, this programme also focuses on resource recovery and enhanced water recycling. Consequently, it is obvious that novel and sustainable materials and technologies for water treatment are needed and thus, different advanced water treatment and purification technologies, for example advanced oxidation, membrane, and biological methods, are the core content of the studies.”

C Expert Report for the ASIIN Seal

1. The Degree Programme: Concept, content & implementation

Criterion 1.1 Objectives and learning outcomes of a degree programme (intended qualifications profile)

Evidence:

- Self-Assessment Report
- Study plans of the degree programmes
- Module descriptions
- Homepage Ba Chemical Engineering: https://forms.lut.fi/opinto-opas/Tutkinto.aspx?id=otm-8a1cf848-dbab-42f5-8271-048050c01d82&period=lut-curriculum-period-2022-2023&lang=en-US
- Homepage Ma Chemical Engineering: https://www.lut.fi/en/studies/technology/chemical-engineering
- Homepage Ma Biorefineries: https://www.lut.fi/en/studies/technology/masters-programme-biorefineries
- Homepage Ma Water Technology: https://www.lut.fi/en/studies/technology/masters-programme-water-technology
- Discussions during the audit

Preliminary assessment and analysis of the experts:

The experts base their assessment of the learning outcomes on the information provided on the websites and in the Self-Assessment Report of all four degree programmes under review.

The experts refer to the Subject-Specific Criteria (SSC) of the Technical Committee Mechanical Engineering/Process Engineering as a basis for judging whether the intended learning outcomes of the Bachelor's degree programme Chemical Engineering, the Master's degree programme Chemical Engineering, the Master's degree programme Biorefineries, and the Master's degree programme Water Technology as presented in the Self-Assessment Report

correspond with the competences as outlined by the SSC. As a result, they come to the following conclusions:

In general, the intended learning outcomes of all four degree programmes under review are aligned with the mission and strategy of Lappeenranta – Lahti University of Technology (LUT), which focuses on discovering scientific solutions on global sustainability challenges such as transition to carbon-neutral world, the sustainable use of different raw materials, water, and energy resources as well as development of a circular economy.

The three-year Bachelor's degree programme Chemical Engineering is taught in Finnish and aims at providing students with the core knowledge of engineering such as mathematics, basics of organic, inorganic, analytical and physical chemistry, chemical thermodynamics, reaction kinetics and dynamics, unit processes, process simulation and basics of process and plant design. Graduates of the Bachelor's degree programme Chemical Engineering should understand the basic phenomena, principles of experimental work/ modelling as well as process development and design in the area of chemical engineering. Practical and creative problem solving, project work, and hands-on laboratory courses are also included. Additionally, oral and written skills and the ability to utilize different source and critical evaluation of information are conveyed. Attention is given especially to students' learning outcomes on sections of 'engineering design' and 'engineering practice'. This reflects the programme's goal in providing solid problem-solving skills and knowledge in the field of engineering. In order to achieve these goals, students should acquire knowledge of the basic sciences and technological subjects of chemical engineering and be familiar with tools and technologies used in engineering research. Moreover, they should be able to put into practice concepts, techniques, and methods of chemical engineering, in line with the principles of sustainability and the needs of a circular economy. This goal is supported by the obligatory internship, which is intended to provide students with a first working experience in the professional world.

The themes of chemical engineering are enhanced by language studies, entrepreneurship training, project work and other transferable skills. In addition, students should select one minor from some other degree programme to their personal study plan (PSP) to complete their studies. The background knowledge of chemical engineering should increase students' skills and competences for the world of work after their Bachelor's studies.

Graduates of the Bachelor's degree programme Chemical Engineering should be qualified to work in the industry. However, almost all graduates will continue their studies in Master's programmes of Chemical Engineering, Biorefineries, or Water Technology.

In order to verify that the degree programmes are aligned with the EUR-ACE® Framework Standards and Guidelines (EAFSG) for engineering programmes, the experts analyse the

submitted study plan, intended learning outcomes, and module descriptions (see Appendix). The EUR-ACE® Framework Standards and Guidelines requires that engineering programmes cover the following seven competence areas: Knowledge and Understanding, Engineering Analysis, Engineering Design, Investigations, Engineering Practice, Making Judgements Communication and Team-working, and Lifelong Learning. As can been seen from the provided documents, the degree programmes under review cover all the required competence areas and the experts perceive during the audit discussions with teachers and students that the mentioned competences are conveyed in the respective courses.

As described in the Self-Assessment Report, students of the Master's degree programmes Chemical Engineering, Biorefineries, and Water Technology should acquire knowledge and skills about research methods and methodologies, laboratory safety and information searching. During their core studies the Master's students will conduct the obligatory work internship period, which is intended to provide students with working experience in the professional world. Additionally, graduates of all three Master's programmes should be able to develop novel processes that are energy and raw material efficient, or processes to recirculate wastes to valuable products. At the same time, they should understand that these processes are essential for human well-being, a clean environment, and the sustainable use of natural resources.

The Master's degree programme Chemical Engineering is designed to provide students with advanced knowledge of product and process design, modelling skills, and skills to utilize different process simulation tools in monitoring and designing processes. Graduates should have all skills that are required in the modern chemical and process industry, such as the ability to design new sustainable products and processes utilising professional simulation tools. Moreover, they should acquire the competence for a successful industrial chemical engineering career; learn analytical thinking and problem solving, solutions to environmental issues, and teamwork on projects, and discover new business opportunities related to cost and profitability analysis. Additionally, graduates should be familiar with modern methods of turning raw materials into chemical products. These products include, for instance, fuels, commodities, specialty chemicals, pharmaceuticals, and food.

The graduates should possess a set of skills for creating sustainable, environmentally friendly chemical processes and products and for becoming competent professionals in the rapidly developing, multidisciplinary area of environmental protection.

Graduates of the Master's degree programme Chemical Engineering have manifold job perspectives, for example, they can work in different fields of the process industry, for chemical companies, and for equipment manufacturers, most typically in research, development,

design, and operation. Other prospective positions include overseeing the construction of new plants, assessing safety and environmental issues, and supervising plant operations.

The Master's degree programme Biorefineries aims at providing students with science based knowledge of the industrially relevant raw materials, processes, and products in the field, as well as experience in biorefinery process development. The programme is thus closer to an "application-oriented" programme than a "research-oriented" programme with the goal of qualifying the graduates for solving problems in the industry. When designing the programme, the learning outcomes were specifically aligned with the EFCE (European Federation of Chemical Engineering) Bologna Recommendations. Knowledge and understanding emphasises modern and emerging biorefinery processes and products. Engineering Analysis is included in many project works. During the studies, students should learn about the production of materials and to design and develop processes based on modern biorefining technologies. The graduate should possess an appropriate set of skills for designing, planning, assessing, and operating sustainable biorefining processes and products. Moreover, they should have the knowledge of current biorefining technologies, products, and raw materials and have acquired skills for designing practical biorefining applications and have the necessary competences in technologies integrated into biorefineries, e.g. wastewater treatment.

Career opportunities are not restricted to the forest industry but exist more generally in all industries related to the use of biobased renewable resources. Graduates can work in all companies and institutions that focus on technologies for mitigating climate change and saving scarce natural resources, most typically in research, development, or various site operations.

The Master' degree programme Water Technology has the goal to teach students how water can be treated not only efficiently, but also in a sustainable and economical manner and to give students advanced knowledge to solve different water treatment problems. As water treatment is inadequate in many parts of the world students should obtain knowledge and skills to address water-related challenges in the future. To this end, the programme does not focus on end-of-pipe treatment for pollution prevention, but on ways towards optimal resource utilisation and enhanced water recycling. The Water Technology programme can be considered to be both; an "application-oriented" and "research-oriented" programme giving tools for solving industrial problems but also give scientific research skills for doing fundamental studies in the field of water treatment and purification from a chemical engineering point of view. The graduates should be able to work as competent professionals in the rapidly developing, multidisciplinary area of water and the environment. To this end, the graduates should acquire the required competences in critical and relevant

theories and techniques, problem-solving skills, and an ability to use knowledge, equipment and tools independently for designing and developing practical water treatment applications. Additionally, they should understand the best available techniques and advanced water treatment technologies, covering conventional water purification, advanced oxidation, and various separation methods. Moreover, they should acquire the necessary knowledge about the impact of conventional and emerging aquatic pollutants on the environment and human health, of sustainable water treatment and water reuse as well as recovering valuable compounds from waste water.

Graduates of the Master's degree programme Water Technology have job perspectives in the chemical and process industry (users of pure water) and technology companies focusing on water purification. They can also find jobs in municipal water treatment plants or research institutes, where they can develop new water treatment processes and technology, novel separation and purification materials, and water quality monitoring methods.

From the discussion with the employers, who are very satisfied with the qualification profile of the graduates, the experts gain the impression that they are well prepared for entering the labour market and can find adequate jobs in Finland and abroad. In general, all graduates have good and manyfold job perspectives.

In order to verify that the intended learning outcomes of the four degree programme are covered by the respective curriculum, LUT has submitted a matrix for each degree programme that shows, in which course which learning outcomes are targeted. The experts can deduce the correlation of the programmes' competence profile with the SSC and see how each course contributes to achieving the intended learning outcomes from the provided Matrix for each programme. Moreover, the experts confirm that the intended learning outcomes of all four programmes are aligned with the EUR-ACE® Framework Standards and Guidelines (EAFSG) for engineering programmes. The EUR-ACE® Framework Standards and Guidelines requires that engineering programmes cover the following seven competence areas: Knowledge and Understanding, Engineering Analysis, Engineering Design, Investigations, Engineering Practice, Making Judgements Communication and Team-working, and Lifelong Learning. As can been seen from the provided documents, all four degree programmes under review cover the required competence areas and the experts perceive during the audit discussions with teachers and students that the mentioned competences are conveyed in the respective courses.

In summary, the experts are convinced that the intended qualification profiles of all four programmes under review allow graduates to take up an occupation, which corresponds to their qualification. The degree programmes are designed in such a way that they meet

the goals set for them. The objectives and intended learning outcomes of all degree programmes under review are reasonable and well founded.

The experts conclude that the objectives and intended learning outcomes of the degree programmes adequately reflect the intended level of academic qualification (EQF 6 for the Bachelor's programme and EQF 7 for the Master's programmes). The programmes also correspond sufficiently with the ASIIN Subject-Specific-Criteria (SSC) of the Technical Committee 01 – Mechanical Engineering/Process Engineering and the EUR-ACE® Framework Standards and Guidelines (EAFSG).

Criterion 1.2 Name of the degree programme

Evidence:

- Self-Assessment Report

Preliminary assessment and analysis of the experts:
LUT awards a "Tekniikan kandidaatti" (TkK), Bachelor of Science in Technology (B.Sc. Tech.) to the graduates of the Bachelor's degree programme Chemical Engineering and a Master of Science in Technology (M.Sc. Tech.) to the graduates of the Master's degree programmes Chemical Engineering, Biorefineries, and Water Technology.

The experts confirm that the English translation and the original Finnish name of the Bachelor's degree programme Chemical Engineering as well as the names of the three Master's programmes, which are taught in English, correspond with the intended aims and learning outcomes as well as the content of the respective degree programme.

Criterion 1.3 Curriculum

Evidence:

- Study plans of the degree programmes
- Module descriptions
- Homepage Ba Chemical Engineering: https://forms.lut.fi/opinto-opas/Tutkinto.aspx?id=otm-8a1cf848-dbab-42f5-8271-048050c01d82&period=lut-curriculum-period-2022-2023&lang=en-US
- Homepage Ma Chemical Engineering: https://www.lut.fi/en/studies/technology/chemical-engineering

- Homepage Ma Biorefineries: https://www.lut.fi/en/studies/technology/masters-programme-biorefineries
- Homepage Ma Water Technology: https://www.lut.fi/en/studies/technology/masters-programme-water-technology
- Discussions during the audit

Preliminary assessment and analysis of the experts:
All four programmes under review are offered by the School of Engineering Sciences of Lappeenranta – Lahti University of Technology (LUT).

The Bachelor's degree programme Chemical Engineering, which is taught in Finnish, is designed for three years, offered as a full-time programme, and encompasses 180 ECTS points. The curriculum consists of

- general studies, including language and communication studies (62 ECTS points)

- intermediate specialisation studies of chemical engineering (78 ECTS points)

- Bachelor's thesis and related seminar (10 ECTS points)

- minor studies (20 ECTS points)

- electives (10 ECTS points)

In the first semesters, Bachelor's students learn about chemistry, biochemistry, mathematics, and process engineering. During the second and third study year most of the courses focus on more advanced topics in chemistry and engineering in courses such as "Fundamentals of Heat Transfer", "Basics of Renewable Energy Technology", "Fluid Mechanics", "Analytical Chemistry", "Chemical Thermodynamics", "Process and Plant Design", and "Introduction to Process Simulation" are offered. Several of the theoretical courses are supplemented by laboratory courses. In their last semester, all Bachelor's students have to complete their Bachelor's thesis and the accompanying seminar.

All three Master's degree programmes are designed for two years and offered as a full-time programmes. Students need to achieve 120 ECTS points, in order to complete the respective programme successfully.

The Master's degree programme Chemical Engineering includes core courses (9 ECTS points) on laboratory safety and research methodology, advanced specialisation courses (35 – 65 ECTS points, which includes subjects such as fluid dynamics, process simulation and monitoring, process intensification, product and process design. In addition, the curriculum includes minor studies (0 – 30 ECTS points), it is recommend to choose courses on

bio-based chemical engineering, advanced water treatment, and advanced chemistry. Students can also choose electives and have to complete a Master's thesis (30 ECTS points). Electives can be chosen from any study programme at LUT.

Novel process development methods, such as process intensification, are also covered as well as the current issues in chemical engineering, such as transition to renewable resources and recirculation of wastes, which are taught in several courses as assignments and design topics. In addition to obligatory courses, students must select four courses from the list of elective specialisation studies, which consist of courses related to bioprocesses, bioenergy solutions, circular economy in materials processing, hydrometallurgy, power to products (P2X) processes, and process data analysis. Students have also the opportunity to build a professional network through practical assignments with industrial companies in projects courses, which solve design problems received from industry partners.

In the aftermath of the audit, LUT submits new information concerning the planned changes in the curriculum of the Master's degree programme Chemical Engineering for the academic year 2024/25. The names of four courses will be slightly changed to better correspond with the course's content. Two new courses will be introduced: "P2X laboratory course", and "Gas Processing". In addition, it is planned to change the name of the degree programme to "Chemical Engineering in Energy Transition", in order to make transparent that the programme has an additional focus on transition processes in the generation of renewable carbon neutral fuels and chemicals. The courses and degree structure will be mostly the same as before, but few new courses will be introduced focusing on Power-to-X processes. The content of several courses will be revised to emphasise energy transition issues in all relevant courses. As the programme coordinators explain, the current curriculum has a lot of room for free electives and this area will be reduced in order to be able to offer new compulsory courses. As these changes are not implemented yet, the experts expect LUT to submit the final new curriculum in due time.

The Master's degree programme Biorefineries is a two-year distance learning programme. It includes core courses (19 ECTS points), which are introduction courses to M.Sc. studies and research in the field of biorefineries and chemical engineering in general. They also include studies on sustainability and the connection between technology and society. The curriculum also includes advanced specialisation courses (58 ECTS points), which are studies in biobased process engineering deal with, for example, alternative biorefineries and enabling technologies, e.g. separation technologies, biological wastewater treatment and bioeconomy. Moreover, electives as well as a Master's thesis (30 ECTS points) are offered. The Master's thesis is an advanced research project and requires approximately six months of full-time work.

The Biorefineries programme implements a wide range of technologies and materials with a clear focus on biorefining and related industries in the circular economy. Currently, production is largely based on fossil raw materials, which causes serious environmental challenges. To this end, the courses treat the use of renewable raw materials where it is technically possible and economically feasible and introduce corner technologies for mitigating climate change and saving scarce natural resources. The curriculum consists of six thematic areas: 1) raw materials and novel biobased products, 2) chemical and biochemical biomass conversion technologies, 3) separation and purification processes in biorefining, 4) process integration (materials and energy), 5) waste management, and 6) business models, sustainability, and impact of biobased industry in society.

The Master's degree programme Biorefineries is delivered as distance learning programme, which is independent of place or time. It is suited for people already in the working world in Finland or abroad, aiming for professional development and the upgrading of their qualifications. Part of the courses have teaching sessions with a fixed schedule, whereas most assignments have a flexible schedule. There are no physical in-class sessions, but some online lectures are given during regular office hours. The new Master's programme Biorefineries is designed for students that are already working so that they can get a Master's degree and keep working at the same time. One key component are virtual laboratories, which simulate the real experiments and give students the results according to their handling the parameters. Only virtual labs are offered in some courses, because students are already working and have sufficient practical experience from that background.

During the audit, the experts discuss with the programme coordinators, if subjects such as Microbiology, Biotechnology, and Bioprocess Engineering are included in the curriculum of the Biorefineries programme. The experts point out that it is important for Biorefineries students to learn about biotechnological processes in order to be able to work safely with and manipulate microorganisms. In addition, it is also important for student to learn how to integrate biotechnological processes such as fermentations into the biorefinery processes and to understand and assess their resource footprint compared to conventional processes. For this reason, they recommend offering an advanced course covering Microbiology, Biotechnology, and Bioprocess Engineering in the Biorefineries programme. As the programme coordinators confirm, there is currently no staff member at the Department of Separation Science, who could cover this area. To this end, it would be best hiring a staff member with the necessary expertise (see criterion 4.1).

The Master's degree programme Water Technology is a blended learning programme; the courses are a combination of contact teaching on the Mikkeli campus and online teaching. The curriculum includes core courses (9 ECTS points) on laboratory safety and research

methodology, advanced specialisation courses (46 – 61 ECTS points), which includes subjects such as sustainable water use, novel water treatment technologies, solution and electrochemistry, water analysis, solid-liquid separation, precipitation, crystallisation, coagulation and flotation methods in water treatment, membrane technology, biological wastewater treatment, environmental and industrial analytics, and advanced materials in adsorption and ion exchange. Students can also choose electives and have to complete a Master's thesis (30 ECTS points). Electives can be chosen from any study programme at LUT.

The Master's degree programme Water Technology focuses on existing and future water treatment challenges. Novel and advanced technologies are at the core of the studies, and course content is designed based on industrial and municipal requirements as well as recent scientific advancements. The programme has the goal to equip students with scientific knowledge and advanced skills to solve real-world water and wastewater system challenges. In addition, students must select five courses as minimum from the list of elective specialization studies providing advanced knowledge of electrochemistry, water purification methods; precipitation, crystallization, coagulation and flotation, oxidation, ion exchange and adsorption, membrane and solid-liquid separation processes, and biological wastewater treatment. Water Technology is a core field of LUT's strategy and after talks with the industrial partners, it was apparent that there is a need for graduates that are experts in water technologies (waste water treatment, water management, water purification etc.). For this reason, the former degree programme Chemical Engineering and Water Treatment was changed to Water Technology, which has a stronger focus on water treatment technologies and sciences.

In the aftermath of the audit, LUT submits new information concerning the planned changes in the curriculum of the Master's degree programme Water Technology for the WS 2023/24. The courses "Modelling and Simulation of Water and Wastewater Treatment" and "Persistent, mobile and toxic organic compounds in the aquatic environment" will be introduced as new compulsory courses. The courses "Introduction to Instrumental Water Analysis", "Solid-Liquid Separation", "Advanced Oxidation Processes & Electrochemical Methods in Water Treatment", and "Biological Wastewater Treatment" will be "upgraded" from electives to compulsory courses. As the programme coordinators explain, the current curriculum has a lot of room for free electives and this area will be reduced in order to be able to offer four new compulsory courses. According to the programme coordinators, there is a need for new courses, which will equip the graduates with current knowledge on the advances in water sector. Via the new course on modelling and simulation, students should gain skills on system performance optimization and evidence-based selections for treatment process simulations. On the other hand, the new course on persistent, mobile

and toxic organic compounds in water and wastewaters is crucial for students to gain comprehensive knowledge on the new class of emerging contaminants, their effects on human and environmental health and the relevant environmental regulations, policies, and guidelines. A new course related to modelling and simulation of water and wastewater treatment processes is considered necessary because knowledge gained from this course will facilitate the understanding of students on process optimization, design and planning, and meet the industry's demand for skilled professionals. As these changes are not implemented yet, the experts expect LUT to submit the final new curriculum in due time.

In their final year, all Master's students conduct their research activities and write a thesis. The members of the teaching staff explain on demand of the experts that they offer possible topics for the final projects according to their own research projects. Students can also develop their own concepts for their Bachelor's thesis and it is possible to conduct the thesis outside LUT. The same applies for the Master's theses.

As the programme coordinators explain during the audit, the internships (in Bachelor's as well as in the Master's programmes) usually last for a minimum of four weeks, but only two ECTS points are awarded, which equivalent to 54 hours of students' work. If students work four weeks full time during the compulsory internship, the awarded ECTS points should reflect that workload. The required minimum length of the internship is described in the respective module description in the Master's programmes but not in the Bachelor's degree programme Chemical Engineering. Here, only the workload of 54 hours is mentioned.

For any course, the students' total workload needs to be aligned with the awarded ECTS points. In case of the Master's degree programmes, only two ECTS points are awarded, although the module descriptions states that the internship lasts four to seven weeks. This discrepancy needs to be solved, and the experts suggest that the best solution would be to cancel the compulsory internship from the curriculum of the Master's programmes. Most Master's students work at least during the summer break to earn money and gain working experience and there is no need to award credits for this.

On the other hand, the experts are convinced that a compulsory internship is very useful in the Bachelor's degree programme Chemical Engineering. However, the minimum length should be four to six weeks and thus six to eight ECTS points should be awarded. In addition, the internship should be linked with the area of the degree programme, not every summer job should be acceptable.

After analysing the module descriptions and the study plans, the experts confirm that all four degree programmes under review are divided into modules and that each module is a sum of coherent teaching and learning units. All practical lab work and internships are well integrated into the curriculum and the supervision by the School of Engineering Sciences

guarantees for their respective quality in terms of relevance, content, and structure.

In summary, the experts confirm that the choice of modules and the structure of the curriculum ensure that the intended learning outcomes of the respective degree programme can be achieved.

International Mobility

LUT provides several opportunities for students to conduct stays abroad and to join exchange programmes abroad. Students who take part in student exchange programmes, e.g. via ERASMUS can gain recognition of the acquired credits after signing a learning agreement. The credits acquired abroad are transferable to LUT.

The Office of International Affairs at LUT is responsible for managing and coordinating the international activities such as coordinating and managing student mobility programmes, developing and maintaining relationships with partner institutions and organisations around the world, recruiting and admitting international students, providing support and assistance to international students during their time at LUT, such as helping with housing, visa issues, and other practical matters.

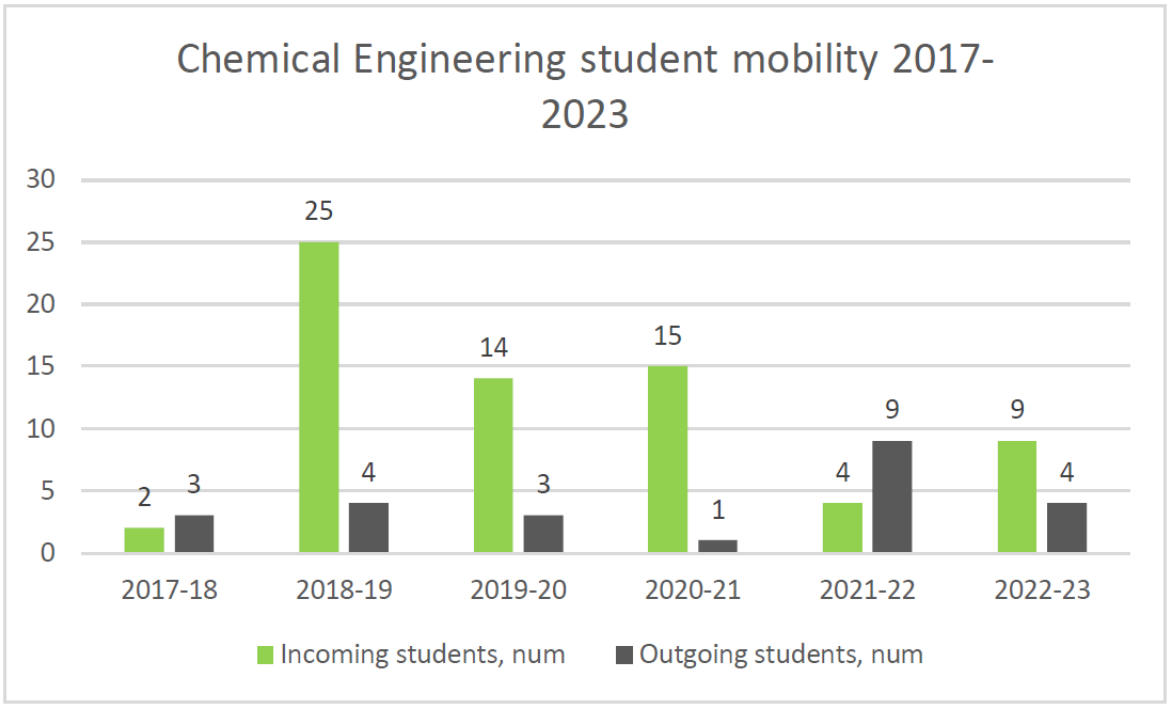


Figure 1: Students' Academic Mobility, Source: SAR LUT

Most outgoing students presented in Figure 1 have been registered in the Master's degree programme Chemical Engineering (or its former version MSc Chemical Engineering and Water Treatment), only two students from Biorefineries and one from Water Technology have taken part at exchange programmes. In general, the number of incoming students exceed

the number of outgoing students and most of the stays abroad are conducted during the Master's studies.

As described in the Self-Assessment Report, "LUT University internationalisation possibilities are open to all students and staff and internationalisation is strongly encouraged by the management. Effective implementation of internationalisation is facilitated by active staff participation at all levels. Transparency, equal opportunity, and inclusion are key priorities. International Mobility Services together with LUT schools provide support for both students and staff. Outgoing students are equipped with guidance and study counselling, intercultural training, as well as with practical advice. Internationalisation is a part of the study period for every student in the form of mobility or internationalisation at home - currently we have 94 nationalities on campus. Incoming students and staff enrich the LUT community and provide a good opportunity for internationalisation at home also for those students who cannot go abroad for an exchange period. The surrounding community will also benefit from students' civic engagement e.g., by popular initiatives Erasmus+ in schools – programme and Meet a local family -programme."

The experts confirm that several opportunities for going abroad exist, that the degree structures make exchange studies possible, and that student services offer support and advice for students interested in exchange studies at a foreign university. However, the number of outgoing students is still low. There are more incoming international students than outgoing Finnish students (in 2021 30 % of new students at LUT came from outside Finland). Although, there are several international co-operations, e.g. with other EU-Countries and LUT's International Mobility Service organises international student exchange programmes, offers advice and support, nevertheless, only a few students take this opportunity and study abroad.

The programme coordinators explain that the imbalance between incoming and outgoing students is not valid on university level but admit that in the School of Engineering Sciences there is a difference. The outgoing students sign a learning agreement and usually receive a scholarship if they at least gain 20 ECTS points, although the aim is to acquire 30 ECTS points during one semester abroad.

As the experts learn during the audit, Finnish engineering students are hesitant to go abroad, this is a general phenome in Finland and not a singular problem at LUT. One important reason for that restraint is that most Finnish engineering students (especially Master's students) work besides studying and do not want to give up their jobs for going abroad. However, LUT and the Department of Separation Science try to encourage their students to spend some time abroad and it is not out of a lack of opportunities or funds that there are only a few outgoing students but it is due to the students' own personal

decision. The experts positively note that LUT offers a double degree Master's degree programme in Chemical Engineering in co-operation with Polimi University, Italy and a triple degree Master's degree programme in Sustainable Biomass and Bioproducts Engineering in cooperation with Wroclaw Tech, Poland and Castilla-La Mancha University in Spain.

Criterion 1.4 Admission requirements

Evidence:

- Self-Assessment Report
- Homepage LUT: https://www.lut.fi/en/studies/apply-lut
- Homepage studyinfo.fi: https://opintopolku.fi/konfo/en/
- Universities act 558/2009 (Amendments up to 644/2016 included)
- Discussions during the audit

Preliminary assessment and analysis of the experts:

The admission to LUT is regulated according to the Finnish Universities Acts (558/2009 and 428/2013) and is organised by joint application system called DIA that is used by all Finnish universities. An applicant for a Bachelor's degree programme can apply for six degree programmes in order of preference in one or several universities or universities of applied sciences using the same application form. Condition for an application is the completion of the Finnish matriculation examination, a three-year vocational degree or an equivalent international high school degree. Students can be selected based on their success in the Finnish matriculation examination or by their success in the entrance examinations. The entrance examinations are organised jointly by the seven technical universities in Finland. The entrance examination is based on the Finnish high school curriculum in mathematics, physics and chemistry. Prospective students must pass the entrance examination to be selected even if there are fewer applicants than places available. This guarantees the minimum required knowledge in natural sciences and mathematics of all first year students. The further details are regulated in Sections 36 and 37 of the Finnish Universities Act (558/2009). Admission criteria and other admission information is published in the University's web pages in English and in Finnish. The annual intake of the Bachelor's degree programme Chemical Engineering is 40 new students.

The LUT Bachelor Highway programme offers an additional way to get admitted to the Bachelor's programme (maximum 5 places per year) for applicants that are not admitted via the regular admission path. Instead, they are enrolled "on probation" and have to verify after studying one year that they can cope with the demands and pass the exams. If they

are able to do so, they will be admitted to the Bachelor's degree programme Chemical Engineering as regular students.

Since 2016, students graduating with a Bachelor's degree may continue to any Master's degree programmes of the same area. For example, the graduate of the Bachelor's degree programme Chemical Engineering can choose either the Master's degree programme Chemical Engineering, the Master's degree programme Biorefineries, or the Master's degree programme Water Technology.

The students are encouraged to apply for a Master's degree programme as soon as their Bachelor's studies are finished and they are allowed to take Master's level studies even before their graduation, which assures a smooth transition from the Bachelor's studies to the Master's studies.

The admission procedure for the Master's programmes currently operates with two different recruitment channels: 1) internal students continuing their Master's degree after their Bachelor's studies at LUT; 2) external applicants with an appropriate Bachelor's degree.

The annual intake of the Master's degree programme Biorefineries is 20 external students and around 5 students are from LUT's Bachelor's programmes. The programme receives between 50 and 60 applications per year.

For the Master's degree programme Water Technology there were 112 applications this year, while the annual intake is about 20 (external) students.

The annual intake of the Master's degree programme Chemical Engineering is 20 (external) students, only in this year, no new external students will be accepted, because the curriculum and the content of some courses will be changed. There are around 50 applications for the Master's degree programme Chemical Engineering per year.

The Master's programmes are open for all graduates with a Bachelor's degree. The admission in the first stage is based on the GPA of the Bachelor's degree, programme-related studies, and work experience. In the Second stage of the admission process, a limited number of applicants will be invited to an interview. The interview will evaluate the applicant's motivation, relevant work experience, suitability to the programme and possibilities for successfully completing studies of the program as well as language and communication skills in English. In addition, all applicants must provide an English language certificate. International students from outside the EU will have to pay a tuition fee of 13.500 € per year for a Master's programme.

According to the university guideline for the recognition of prior learning and credit transfer, students may apply to have courses completed outside of LUT recognised as a substitute for a course at LUT or as part of the minor or elective studies. The decision is made

based on the learning outcomes achieved, contents, equivalences and applicability to the degree. The student must apply for the credit transfer in written form and the application can be accepted entirely or partly, or rejected. If the application is rejected, the grounds for rejection must be stated in the decision. The experts acknowledge that the rules for the recognition of achievements and competences acquired at other higher education institutions are in accordance with the Lisbon Recognition Convention.

In summary, the auditors find the terms of admission to be binding and transparent. They confirm that the admission requirements support the students in achieving the intended learning outcomes.

Criterion 1.5 Work load and credits

Evidence:

- Self-Assessment Report
- Study plans
- LUT Degree Regulation
- Module descriptions
- Discussions during the audit

Preliminary assessment and analysis of the experts:
Based on the LUT Degree Regulation, all four programmes under review use the European Credit Transfer System (ECTS) to measure the students' total workload in each course. One ECTS point corresponds to 27 hours of students' total workload, which includes attendance time in classes as well as self-studies. Completing a degree requires an annual workload of 1600 hours, which corresponds to 60 ECTS points. All LUT Bachelor's degrees encompass 180 ECTS points and Master's degree 120 ECTS points.

Compulsory courses, including possible minor studies, are prescheduled in the students' personal study plans (PSP) to help students schedule their studies and to graduate in the targeted time. The PSP outlines which courses are included in the student's degree and how they situate in the degree structure according to the curriculum. Students prepare their PSP at the early stages of their studies and review and update it together with their study counsellors.

Each degree programme has a study advisor and tutors, who are responsible for the guidance of the students in the respective degree programme. The guidance includes expert tutoring from older students for newcomers, orientation days and welcoming information

at the beginning of the academic year in September, discussions with study counsellors on the degree structure and personal study and career plans, and advice on international exchange. The tutors are involved in helping the new students to cope with the requirements of university studies and to help with the problems caused by the transition from high school to university.

During the discussion with the experts, the students confirm that most of them will take five to six years to finish their combined Bachelor's and Master's programmes and that there are no structural problems in the organisation of the programmes that hinder them to finish their studies within the expected timeframe.

The students point out during the discussion with the experts that the workload of the courses in Bachelor's degree programme Chemical Engineering is not always aligned with the real workload. Some courses with only two or three ECTS points require as much work as courses with five ECTS points. From the experts' point of view, this is due to the small-scale-structure of the courses, and LUT should think about combing small courses with related content to larger modules. Students' confirm that they can give feedback on the courses' workload in the questionnaires, but this feedback is not taken into consideration by the teachers and the ECTS distribution is not adjusted. For this reason, the experts point out that it is necessary to verify the students' total workload by considering the students' feedback and adjusting the awarded ECTS points where necessary. If possible, the number of five ECTS points for each module should be reached either by extending a course or combining two courses.

The drop-out rate in the Biorefineries and programme is approximately between 25 and 30 % and the most common reason for dropping out is that the students realise that their combined workload from studying and working is too high or that their personal situation has changed so that they are not able to continue their studies. The drop-out rate in the other two Master's programmes is lower (between 10 and 20 %) because here less students work besides studying.

The experts observe that all programmes under review have a high but manageable workload, which is balanced between the semesters so that peak loads are avoided. The students' total workload and the awarded ECTS points are detailed in every module description. Students can give their feedback on the courses and the respective workload and can comment if they think that the workload is not appropriate.

Criterion 1.6 Didactic and Teaching Methodology

Evidence:

- Self-Assessment Report
- Study plans
- Module descriptions
- Discussions during the audit

Preliminary assessment and analysis of the experts:

The learning method applied in the programmes under review is a combination of teacher-centred learning (TCL) such as classroom teaching/tutorials, demonstrations, laboratory sessions, and student-centred learning (SCL) such as group discussions, case studies, project-based learning, and laboratory work. Each course can use one or a combination of several teaching and learning methods.

The most common method of learning in the Bachelor's degree programme Chemical Engineering is class session, with several courses offering laboratory work. Lecturers generally prepare presentations to support the teaching process. With individual or group assignments, such as discussions, presentations, or written tasks, students are expected to improve their academic as well as their soft skills. Laboratory work covers laboratory preparation, pre- or post-tests, laboratory exercises, reports, discussions, and presentations. In addition, practical activities should enable students to be acquainted with academic research methods. During the audit, the students point out that teacher-distributed groups with different learning motivation/aspirations can be quite challenging and make work harder for motivated students. The experts suggest that teachers should offer more guidance for group assignments and make sure, that all students carry their load.

In the Master's degree programmes, more student centred learning models are applied in order to improve students' analytical and scientific skills. To this end, in most courses didactic methods such as cooperative learning, case studies, and project based learning are applied. In general, the focus in the Master's degree programmes is on self-organised learning and research oriented teaching and learning methods. Giving a presentation and expert-evaluation are also utilised on Master's level. Problem based learning and continuous assessment are applied as pedagogical methods in several courses. The Biorefineries programme implements Inquiry-Based Learning (IBL) on selected courses, most notably on Chemical Separation Methods course (which utilizes an advanced on-line virtual laboratory) and the capstone course Biorefinery process development project. IBL was chosen to foster investigations and assessment together with engineering analysis and engineering design.

In the Master's programmes online teaching is regularly applied, especially in Biorefineries, which is a full online programme. The Water Technology programme was also offered fully online but beginning from autumn 2023 it will be taught in blended mode in Mikkeli, where appropriate laboratory facilities can be utilized to provide an experimental foundation for the theoretical concepts introduced in the lectures. The delivery of courses is blended. The programme is a combination of on-campus and online studies. Some of the programme's basic courses can be completed as distance learning, but attendance is needed in some specialised courses and laboratory assignments in Mikkeli during each academic year.

In the Master's degree programmes all courses are taught in English. On the other hand, the Bachelor's degree programme Chemical Engineering is taught in Finnish.

In summary, the expert group considers the teaching methods and instruments to be suitable to support the students in achieving the intended learning outcomes. In addition, they confirm that the study concept of both undergraduate programmes comprises a variety of teaching and learning forms as well as practical parts that are adapted to the respective subject culture and study format. It actively involves students in the design of teaching and learning processes (student-centred teaching and learning).

Final assessment of the experts after the comment of the Higher Education Institution regarding criterion 1:

In its statement, LUT explains that the new curriculum of the Master's degree programme Chemical Engineering for the academic year 2024-25 will be published in May 2024 in the eLUT student portal. Link to the curriculum will be sent to ASIIN after that. The new curriculum of Master's degree programme Water Technology for the next academic year (2023/24) has been published on 24 May in the eLUT student portal.

The experts are glad that LUT has realised the need to cover microbiology and biotechnology in the Master's degree programme Biorefineries and that these topics will be included in the existing course 'BJ04A3010 Chemical and biochemical conversion of biomaterials'. Separate courses for cover microbiology and biotechnology might be introduced at a later stage. This is related to the fact that a new Master's degree programme in Food Processing Technology will be launched in 2024 and several new professors will be hired to this end, and microbiology and biotechnology will be covered by the new teachers.

The experts acknowledge that the internship involves more activities than just the time spent at the workplace and that students get a full salary from the employer. LUT has updated the module descriptions of the internship courses, but the discrepancy between the minimum length of four weeks, the students' total workload of 54 hours, and the awarded two ECTS points in the Bachelor's degree programme Chemical Engineering remain. The

experts still ask LUT to ask the students how much time they really spent on the internship and adjust the awarded ECTS points accordingly.

As the students mention during the audit that the workload in group assignments is sometimes unbalanced, the experts appreciate that LUT has noted this issue. Additionally, they suggest that the teachers put a stronger focus on assigning the task to students and on assessing their individual workload.

The experts consider criterion 1 to be mostly fulfilled.

2. Exams: System, concept and organisation

Evidence:

- Self-Assessment Report
- Module descriptions
- LUT Degree Regulations
- Discussions during the audit

Preliminary assessment and analysis of the experts:
At LUT various methods of examination are used. This includes written examinations such as essays, case studies and calculation problems. In addition, oral exams, laboratory work reports, learning assignments, group work, project work, literature reviews and seminars are also used depending on the competences that should be imparted and evaluated. Examinations (written or online) mainly test students' theoretical and problem-solving skills, while written reports and oral presentations test their logical thinking, innovativeness, analysis skills and broader understanding of the subjects in question. Continuous assessment, e.g. weekly assignments, is used on several courses to assure continuous accumulation of students' knowledge, skills and competence. The examination methods used in the different courses are described in the respective module descriptions (study guide) that are available to the students via eLUT.

Examinations are nowadays mostly electronic, their duration varies from one to three hours, while the standard duration of "traditional" written examination is three hours. Written examinations typically include essays, problem-solving or case-based questions and calculation problems. In addition to written examinations, other effective ways to evaluate students' competences are applied, they include exercises, seminars, group work, written reports, learning tests, simulations, presentations, and project work and expert

evaluation. The assessment methods are more varied in the Master's programmes, while in the Bachelor's the most typical assessment forms are written exams, assignments, and quizzes. In Master's programmes, more independent studies and the demonstration of advanced knowledge and skills are required. Increased digitalisation in education has made it possible to utilise online exams, exercises, and quizzes, especially in the Master's degree programmes Biorefineries and Water Technology, thereby supplementing live lectures or online-sessions. Online exams are either written exams with several questions that students have to answer in a given (short) time or assignments which take several days to complete. Additionally, it is possible to have online presentations of the results of a project.

Courses are evaluated either on the scale excellent (5), very good (4), good (3), satisfactory (2), sufficient (1) and failed (0), or pass – fail. On the five-point scale where 100 points is the maximum, the grade 5 requires 90–100, and 50 points are required to pass the course. The total score may be determined by a combination of, for instance, an examination, exercises, home assignments, and seminars. Students are entitled to receive information on their grades and have the right to view their evaluated and graded work. If they are not satisfied with the grading, they can request a revision of the grade and may submit a further appeal with the Degree Board within 14 days of receiving of the grade. Students have the right to take part in three examinations for each course they take. Students who fail to pass an examination after taking it three times may apply for an additional retake. The further details are described in the LUT degree regulations.

Examination and teaching periods are annually announced by the vice rector of education and published on eLUT. There are altogether six examination weeks during the academic year, plus an additional examination week for re-sits in summer. Students are informed about the exam dates via the Academic Calendar and can enrol for courses and examinations in the university student register "Sisu". Here, students can access their grades and the weighted average of their studies at any time. LUT has defined guidelines and procedures to support students with learning disabilities and special needs. Documented learning disability diagnoses will be taken into consideration in examination arrangements.

In addition to the examination schedule system, there is an alternative way to arrange exams. The electronic exam tool "EXAM" provides the possibility for LUT students to take exams all year round. EXAM is an electronic examination system, in which the students can take an examination during the time slot the teacher has inserted into the system. The teacher of the course uploads the examination to the system and students choose when to take the exam.

Every student at LUT is required to do conduct a research project, which is carried out as a Bachelor's thesis and seminar (10 ECTS) or Master's thesis and seminar (30 ECTS).

The Bachelor's thesis is a scientific work report written by students in the Bachelor's programme that focuses on a specific topic and usually consists of literature study, practical research, data analysis, and presentation in figures or tables as well as writing the thesis under the supervision of a teacher. Both the student and his /her supervisors might decide the topic and content of the project. In many cases, the lecturers offer particular topics connected to their research. Bachelor's theses in Chemical engineering typically concern water or wastewater in general and different treatment methods, studies of biomass, biocomposites or polymers, applications of electrochemistry, or applications of solid-liquid separation. The students have to present their results in the thesis seminar. In grading, 95 % of the grade for the Bachelor's thesis is based on the written thesis and 5 % is based on the poster presentation in the accompanying seminar.

The Master's thesis is an academic paper, which includes an independent in-depth study of a scientific topic and which creates innovation or provides new contributions to the scientific or technological development of respective scientific area. The Master's thesis is conducted with the guidance of the thesis advisor and requires six months of full-time work. Master's thesis and seminar belong to the specialisation studies of the respective Master's programme. The topic of the Master's thesis is agreed on by the supervising professor and the student and needs to be approved by the Dean of the School of Engineering Science. The topics of Master's theses in Chemical Engineering typically consider aspects related to process changes and investments, process development, utilisation of side streams and wastes, costs and profitability evaluation, reduction of process emissions, process data collection and analysis, process design, optimisation, and safety analysis, mapping and optimisation of mass and energy streams, and measurement and analysis of data in laboratory or pilot plant experiments.

Thesis topics in the Biorefineries programme are derived from topical issues of the value chain in the biorefining industry. These include availability and properties of biobased raw materials, improvement of or development of unit operations and processes, and development of new products. Most theses include an experimental study in laboratory scale or utilize data from pilot or full-scale industrial processes. Also computational methods such as model-based process optimization may be used.

In the Water Treatment programme, the topics of Master's theses typically include removal of pharmaceuticals from the wastewater by photocatalysis, low-cost adsorbents from waste materials in the wastewater treatment, ion-exchange technology in the purification of wastewater, removal and recovery of nutrients and other value-added products from wastewater e.g. using microalgae.

A large share of theses is completed in co-operation with industry partners, especially in the Master's programmes where approximately 50 % of all theses are conducted with external industry partners. In this case, students have two supervisors, one from LUT and one from the external partner. This arrangement offers good possibilities for students to gain useful skills and competences and to find work in industry after graduation. For the programmes the co-operation with the industry in terms of theses gives a natural and appropriate framework for staying aware of the needs of external stakeholders and future employers. The "Maturity Test" is part of the thesis, the abstract (content and level of language) will be evaluated, which is required by the Finnish University Act. For the grading of the thesis, LUT has established an assessment matrix as a guiding tool for both internal and external supervisors involved in the grading process, thus fostering a transparent and comparable grading of the theses.

The experts also inspect a sample of examination papers and final theses and are overall satisfied with the general quality of the samples.

In summary, the experts confirm that the different forms of examination used are competence-oriented and are suitable overall for verifying the achievement of the intended learning outcomes as specified in the respective module descriptions. The form of examination is determined individually for each course and published in the respective module description. The forms of examination are based on the main content of the modules and the level is appropriate for the respective degree programme.

Final assessment of the experts after the comment of the Higher Education Institution regarding criterion 2:

The experts thank LUT for correcting the topics for Master's theses in Chemical Engineering.

The experts consider criterion 2 to be fulfilled.

3. Resources

Criterion 3.1 Staff and Development

Evidence:

- Self-Assessment Report
- Staff Handbook

- Study plans
- Module descriptions
- Discussions during the audit

Preliminary assessment and analysis of the experts:
According to the Self-Assessment Report, the academic staff at LUT consists of professors, associate/assistant professors, post-doctoral researchers and PhD-students. In addition, there are several visiting professors and researchers working at the School of Engineering Sciences.

The composition of teaching and research personnel at LUT is based on a tenure track system. The tenure track is a professor's pathway to promotion and academic advancement. It's the process by which a lecturer becomes and an assistant or associate professor and then a full professor based on their teaching record and research activities. The members of the teaching staff are either employed in a tenure track position or a non-tenure track position. Non-tenure track positions are either research or teaching oriented, based on the needs of the School of Engineering Sciences.

The experts enquire if the academic staff members have permanent contracts and how high their teaching load is. They find out that the professors and assistant professors hold permanent positions, whereas the post-doctoral fellows and PhD-students are employed on four year contracts. The permanent staff members have all different contracts with respect to the teaching load, time for research, and administrative tasks. Some lecturers, including professors, almost do teaching only, especially in the basic chemistry courses, while other staff members, mainly professors or assistant professors, spend more time on their research activities or are involved in the administration of the School of Engineering Sciences. Most members of the academic staff have both teaching and research activities, although the focus of duties varies significantly. Approximately 50 % of the teachers at LUT have an international background and come from 94 different countries. Particular attention must be paid to the external lecturer, in view, that these teachers impart theoretical and practical content at a high methodical didactic level.

LUT puts a strong emphasis on research activities and focuses on the different aspects of a circular economy including resource efficient production and sustainable energy generation. The research activities typically include working on research projects, reporting and publishing research results and supervising final theses.

The experts notice that the composition and qualification of the teaching staff is suitable to sustain the Bachelor's degree programme as well as the Master's degree programmes.

They also confirm that enough resources are available for administrative tasks and supervision and guidance of the students.

The experts are very impressed by the excellent and open atmosphere among the students and the staff members. Especially, the programme coordinators are dedicated to the degree programmes and to the students and are striving for improving the quality of the programmes.

According to the Self-Assessment Report, the School of Engineering Sciences has currently 310 full-time employees. The Department of Separation Science that is responsible for organising the four degree programmes under review employs 107 persons.

The composition of the academic staff members in the Department of Separation Science is presented below in Table 1.

Position type	Total number of positions / Separation Science
Professors	7
Associate/Assistant Professors	12
Post-doctoral researchers	21
Doctoral Students	37
Total academic staff	77

Table 1: Academic staff members in the Department of Separation Science, Source: SAR LUT

Details of the academic qualifications of the teachers are described in the staff handbook. The teaching staff is supported by laboratory staff, who helps with analysis, takes care of the facilities and maintains the infrastructure in the laboratories. Other administrative and supporting functions of education and research have mainly been centralised in the LUT University Services Unit.

Every degree programme has a study coordinator to support the programme management and a study counsellor to advice students to plan their studies and help in any study related matter. Together with the head of the degree programme they assure the quality of curricula and find ways to help students progress in their studies.

In addition, there are centralised support units at LUT, such as the Language Centre, Academic Library, Communications and Media Services, IT Services, Financial Services, International Office, and HR Services.

During the audit, the programme coordinators strongly support the experts' point of view that it would be very beneficial for the Biorefineries programme to have an expert in Biotechnology among the teaching staff. As the area of Biotechnology is important for a degree programme in Biorefineries, LUT should think about hiring a teacher who can cover

the related topics. In addition, the experts point out that it would be useful if the Department of Separation Science would invite long term guest lecturers that cover areas where the programmes are lacking some specific but important expertise e.g. in Biotechnology (see criterion 1.3) or on desalination and carbon-capture from water.

In summary, the experts confirm that the composition, scientific orientation and qualification of the teaching staff are suitable for successfully implementing and sustaining both degree programmes.

Staff Development

LUT provides several opportunities for its staff members to improve their teaching competences and to develop their didactic and professional abilities. The university has a human resources committee through which the staff members are included in the decision-making concerning the development of the working environment and conditions. The committee's duty is to assess and develop occupational work safety and health care, and personnel training. The committee annually revises the measures for professional development and maintaining professional expertise. Training courses are communicated on LUT's intranet, and are thus available to all staff members. For example, trainings for thesis supervision, IT-tools, and project management have been arranged in recent years. Additionally, the Department of Separation Science has organised special trainings for teaching staff focusing on effective teaching, where teachers can generate new ideas for implementing teaching and examinations and share good practices. The aim is to offer high quality teaching by using modern methods and tools, but not overstraining teachers or students.

Finally, staff members conduct annual performance and development discussions with their immediate supervisor, examining the results obtained and setting goals for the near future also concerning professional development and personnel training. Through the discussions the supervisors can evaluate the training needs.

During the discussion with the experts, the teachers express their overall satisfaction with the support mechanisms and mention that research budgets allow for going abroad and visiting other research groups, LUT also offers courses for improving the teaching skills and English proficiency.

In summary, the auditors confirm that LUT offers sufficient support mechanisms and opportunities for members of the teaching staff who wish to further develop their professional and teaching skills.

During the audit, the experts inquire if the teaching staff has the opportunity to spend time abroad and to participate in international projects. They learn that LUT provides funds for

joining international conferences. In general, the teachers are satisfied with the existing opportunities and the available financial support.

The experts discuss with the members of the teaching staff the opportunities to develop their personal skills and learn that the teachers are satisfied with the internal qualification programme at LUT, their opportunities to further improve their didactic abilities and to spend some time abroad to attend conferences, workshops or seminars; even a sabbatical leave is possible. However, according to the teachers, a sabbatical is hard to organise due to the need to ensure all teaching responsibilities are covered by other teachers.

In summary, the auditors confirm that LUT offers sufficient support mechanisms and opportunities for members of the teaching staff who wish for further developing their professional and teaching skills.

Criterion 3.2 Funds and equipment

Evidence:

- Self-Assessment Report
- Visitation of the facilities
- Discussions during the audit

Preliminary assessment and analysis of the experts:

The Dean of the School of Engineering Sciences is responsible for budgeting and allocating resources to the school's activities, departments, and laboratories. The annual revenue of the school is about 31 million euros. Most of the money needed for running the degree programmes comes from the university budget, which is received from the Finnish Ministry of Education and Culture. Approximately 39 % of the school's funding comes from external sources (12 million euros in 2021), including research funding from the Academy of Finland, the Finnish Funding Agency for Technology and Innovation, the European Commission and private companies. In addition, university has an investment programme to support investments for research and teaching equipment.

The annual revenue of the Department of Separation Science is around 9 million euros (in 2021), which covers the courses and research activities conducted by the department. Approximately 55 % of the department's funding is derived from external sources such as the Academy of Finland, the Finnish Funding Agency for Technology and Innovation, Regional Councils and different foundations. As LUT's focus is on research, most of the university's budget is spent on research activities, in addition LUT has strong ties with private companies and the industry for conducting combined research projects.

The experts observe that the provided budget allows the Department of Separation Science to conduct the study programmes as well as some specific activities, including financial assistance for research, and participation in international conferences. The academic staff members emphasise that from their point of view, all programmes under review receive sufficient funding for teaching and learning activities.

The Department of Separation Science has several laboratories with 14 professorships specializing in solid-liquid separation, process development, chemical separation methods, membrane technologies, gas separation, water treatment, and bioprocesses.

Professors and assistant/associate professors, who are normally in charge of the courses and the specialisation studies, are mostly paid from public funds. Part of the funding for post-doctoral researchers comes from external sources but there are significant individual variations. The funding for doctoral students comes chiefly from research projects and from the LUT Doctoral School.

The university has two campuses, in Lappeenranta and in Lahti. Additionally, there is a water research and analysis laboratory in Mikkeli. In Lappeenranta, LUT has 21 lecture halls and 10 computer classrooms and an exam room for online exams. In Lahti, there are 44 lecture halls and 14 computer classrooms and an exam room for online exams. In Mikkeli, there are laboratories for biological water treatment and analytical processes and methods as well as a large algae laboratory.

The safety in the laboratories is of utmost importance to LUT and all students working in the lab as well are required to pass a course on laboratory safety before being allowed to enter any laboratories. Moreover, when starting independent laboratory work, students are required to fill together with their supervisor a separate safety form related to their own work and sign the form stating that they have received guidance on laboratory work safety, and that they have familiarised themselves with the location of emergency equipment and instructions in the labs.

During the audit, the experts also visit the facilities at the campus in Lappeenranta. They confirm that the laboratories are well equipped and well maintained, with good safety standards and appropriate labelling and storage of chemicals. There are enough working places are available for all students. The research capacity of the laboratories is high and sufficient for carrying out various research projects and offering final projects. The joint use of instrumentation for research and teaching is well organized and a good practice. The available analytical instrumentation is mostly appropriate, however, the experts note that it would be very useful for the improvement of research activities in the field of analytical chemistry to extend the range of available instrumentation. Highest priority should be given to purchasing an XRF instrument. With lower priority, additional analytical tools such

as a compact, possibly including a flow cell for in-process measurements, NMR should be available. This enables the elucidation of the structure and dynamics of molecules as well as concentration determinations. Moreover, a XPS for advanced membrane analysis should be considered.

With respect to online-teaching, different technologies have been introduced e.g. for recording lectures and taking exams. In addition, support for the teaching staff has been strengthened. The Digital Learning Team, helps the teaching staff in all matters related to online-teaching and digital content management.

In the discussion with the students, the experts learn, that important software is not readily accessible for the students, because the programme packages are installed on some special computers, which are not directly available for remote access and external access via licence servers is unreliable. As the experts consider it important for students to have access to the software, licences should be reliably accessible for students not only on certain computers in the labs but also via remote access. This is especially important for the Biorefineries and the Water Technology programme which are taught partly or totally online and thus students cannot easily visit the computer labs on campus. This software includes MATHLAB, COMSOL, and Aspen.

LUT Academic Library is the joint library for the LUT University and LAB University of Applied Sciences. The library operates in Lahti and Lappeenranta and provides library services in different specialist fields for students, staff, researchers, and the general public. It is also one of the European Documentation Centres in Finland. In Lappeenranta, the library has silent workplaces, several group work facilities, and a room, for students writing their thesis. In Lahti campus, these study areas are mainly situated outside the library. The library is open for students and staff members 24 hours a day, seven days a week.

Finally, the university premises in Lappeenranta also include restaurants, a student health care centre, two sports halls and a gym. The Student Union House has an office and facilities for recreational activities and meetings that are available to all students.

In summary, the expert group judges the available funds, the technical equipment, and the infrastructure (laboratories, library, seminar rooms etc.) to comply with the requirements for adequately sustaining the degree programmes.

Final assessment of the experts after the comment of the Higher Education Institution regarding criterion 3:

The experts understand that the most important software needed in Chemical Engineering is available for students in computer classrooms on campus and via remote access. As the

remote connection is sometimes slow, the experts suggest to improve the respective infrastructure so that students can reliably access the software.

The experts encourage to go ahead with purchasing a XRF instrument.

The experts consider criterion 3 to be mostly fulfilled.

4. Transparency and documentation

Criterion 4.1 Module descriptions

Evidence:

- Self-Assessment Report
- Module descriptions
- Homepage Ba Chemical Engineering: https://forms.lut.fi/opinto-opas/Tutkinto.aspx?id=otm-8a1cf848-dbab-42f5-8271-048050c01d82&period=lut-curriculum-period-2022-2023&lang=en-US
- Homepage Ma Chemical Engineering: https://www.lut.fi/en/studies/technology/chemical-engineering
- Homepage Ma Biorefineries: https://www.lut.fi/en/studies/technology/masters-programme-biorefineries
- Homepage Ma Water Technology: https://www.lut.fi/en/studies/technology/masters-programme-water-technology

Preliminary assessment and analysis of the experts:
The students, as all other stakeholders, have access to the module descriptions (study guide) via eLUT.

After studying the module descriptions the experts confirm that they include all necessary information (course name, course code, students' total workload, awarded ECTS points, teaching language, grading scale, intended learning outcomes, content, course materials, possible prerequisites, name of teacher/teachers in charge, exam methods, and assessment criteria). However, the experts observe that more information about the courses is available to the student on the Moodle platform. From the experts' point of view it would be useful to make this detailed information also available in the module descriptions (study guide), which are accessible via LUT's homepage. This way, all stakeholders would be better informed about the courses' content.

Criterion 4.2 Diploma and Diploma Supplement

Evidence:

- Self-Assessment Report
- Sample Transcript of Records for each degree programme
- Sample Diploma Supplement for each degree programme

Preliminary assessment and analysis of the experts:
The experts confirm that all graduates are awarded a Diploma and a Diploma Supplement after graduation. The Diploma consists of a Diploma Certificate and a Transcript of Records. The Diploma Supplement contains all required information about the degree programme. The Transcript of Records lists all the courses that the graduate has completed, the achieved credits, grades, and cumulative GPA.

LUT's Diploma Supplement complies with the model developed by the European Commission, the Council of Europe and UNESCO and it includes a description of the Finnish education system prepared by the Finnish National Agency for Education and approved by Finland's Ministry of Education and Culture.

Students who graduate from a Master's programme in English receive a degree certificate in Finnish and English. Students who graduate from the Finnish-language Bachelor's programme receive a certificate in Finnish and an English translation.

Criterion 4.3 Relevant rules

Evidence:

- Self-Assessment Report
- All relevant regulations as published on the university's webpage

Preliminary assessment and analysis of the experts:
The auditors confirm that the rights and duties of both LUT and the students are clearly defined and binding. All rules and regulations are published on the university's website and the students receive the course material at the beginning of each semester.

In addition, all relevant information about the degree programmes (e.g., module handbook, study plan, intended learning outcomes) is available on the homepage of the programmes.

Final assessment of the experts after the comment of the Higher Education Institution regarding criterion 4:

The experts understand that Moodle is LUT's common tool for both teachers and students where the detailed information on the courses is shared. However, they still think that it would be useful to make this information available on the respective programme's homepage so that all stakeholders can access it.

The experts consider criterion 4 to be mostly fulfilled.

5. Quality management: quality assessment and development

Evidence:

- Self-Assessment Report
- LUT Degree Regulations
- LUT Quality Manual
- Discussions during the audit

Preliminary assessment and analysis of the experts:

The highest panel at LUT is the University Board, which has nine members five of whom are external to the university community, and four have been elected from different groupings within the university. The LUT administration is headed by the Rector, who is responsible for implementing and supervising all academic processes at LUT. The Rector is supported by the Vice Rector for Research and Innovation and the Vice Rector for Education.

The Vice Rector for Education bears the university-wide responsibility for the development of degree programmes, the programme portfolio, and curriculum work. The vice rector gives instructions and guidelines on the development of curricula and regularly meets with the Director for Study Affairs and the heads of the degree programmes to discuss issues concerning the teaching and learning processes. In addition, members of the Student Union and study services representatives meet regularly. The Vice Rector for Education participates in most of these meetings.

On school level, there is the Academic Council which is authorized to formulate policies and to monitor all academic activities at school level, in this case the School of Engineering Sci-

ences. The Dean is the head of the school with the authority and responsibility for administering all teaching and learning activities within the school. On school level, there is a steering group consisting of the heads of the degree programmes, which is chaired by the Dean. Similarly, there is a steering group in the Department of Separation Science, which is chaired by the head of the degree programme and which is responsible for implementing the curricula and all related educational activities. Student representatives from the chemical engineering students' guild are invited to these meetings to discuss about possible changes in programmes but also to get current feedback from the students about the teaching and learning processes. Finally, for each degree programme there is the Head of Degree Programme, who is responsible for implementing all educational activities within the respective degree programme.

The experts discuss the quality management system at LUT with the heads of the study programmes, they learn that there is an institutional system of quality management aiming at continuously improving the degree programmes.

This system relies on internal as well as external quality assurance. The LUT quality management system has undergone an external audit of the Finnish Education Evaluation Council three times – in 2009, 2015, and 2021. LUT has passed all the audits without requirements. In addition, LUT focuses on international accreditation of its degree programmes

Internal quality assurance relies on students' and stakeholders' feedback, which is discussed in quality workshops with the goal of enhancing the programmes' quality and promoting their further development. The assessment is based on an analysis of programme performance indicators and stakeholders' feedback. The head of the respective degree programme and relevant programme managers together with students' representatives conduct the review and provide a critical report with development targets, actions to be taken and persons responsible for the implementation. Students' representatives in administration are elected among the students to represent the whole student community in various panels, for example the University Board or the Academic Council. Students' representatives are required by the Finnish Universities Act, which states that in the University Board as well as in administrative bodies of faculties there should be representatives of professors, other staff members, and students. Students' representatives are equal members of the administrative bodies and bring the students' viewpoints into the discussions.

All degree programmes at LUT are evaluated systematically according to performance indicators such as the number of graduates and applications, progress of studies, students' and stakeholders' feedback, and employment rate of graduates.

Internal assessment of the quality of the degree programmes is mainly provided through students' questionnaires. The students give their feedback on the courses by filling out the

questionnaire online each semester. Students assess various aspects such as quality of the degree, quality of teaching, quality of guidance, and satisfaction with student life. Students' opinion is quantified by means of index 1 (unsatisfactory) to 5 (excellent). In addition, teachers are able to add their own questions to the questionnaires if they want to get feedback e.g. on specific teaching methods applied in the course. Course-specific feedback reports are delivered via Moodle to the teachers responsible for the courses. The head of the degree programmes have right to monitor all course feedbacks of the programme. If an individual course receives a low average score (less than 3.3), the reasons will be reviewed thorough and further action will be taken to improve the situation. However, the students criticise during the audit that their feedback on the courses' workload in the questionnaires is not taken into consideration by the teachers and the ECTS distribution is not adjusted. For this reason, the experts point out that it is necessary to verify the students' total workload by considering the students' feedback and adjusting the awarded ECTS points where necessary (see criterion 1.5).

After the teachers have received the feedback report on their own course, they are expected to give a response to the feedback to inform students about conclusions and development actions based on the feedback. The head of the degree programme has access to review all courses' feedback, which are also combined in a degree programme specific report by a student guild representative. The aim is to encourage and motivate students to give course feedback more actively, since in many cases the response rate is too low to make justified conclusions for improvement. In 2022, LUT has introduced a new course feedback tool integrated in the Moodle platform to ease and activate students giving feedback. In addition, also graduating students and alumni are asked to fill out online questionnaires concerning their academic experience in the degree programmes.

The student guild analyses the feedback of all courses in the degree programmes in Chemical Engineering, reviews the feedback reports, and brings up the development targets in the discussion with the programme management e.g. in guild coffee meetings and the annual quality workshops. There is a student guild for Chemical Engineering at LUT and all current students and alumni can become members. It is somewhat similar to a "Fachschaft" in Germany.

Several changes have been implemented based on students' feedback. For example, scheduling of several courses has been changed in order to balance the student and teacher workload especially in Bachelor's programme. Also the digital platforms have been improved and course communication enhanced by giving more detailed course instructions and timetables. Additionally, general laboratory reporting instructions used in chemical engineering laboratory courses were checked and improved together with students.

The experts gain the impression that the feedback is taken into account by the programme coordinators and changes are made instantly. They confirm that LUT regularly monitors and reviews the degree programmes and the modules to ensure that they achieve the objectives set for them and respond to the needs of the students.

Final assessment of the experts after the comment of the Higher Education Institution regarding criterion 5:

The experts appreciate that LUT is continuously verifying students' workload and that students' feedback is taken into consideration when awarding the ECTS points. For this reason, they abstain from issuing a requirement to this respect.

The experts consider criterion 5 to be fulfilled.

D Additional Documents

Before preparing their final assessment, the panel asks that the following missing or unclear information be provided together with the comment of the Higher Education Institution on the previous chapters of this report:

- none

E Comment of the Higher Education Institution (16.06.2023)

LUT provides the following statement:

Curriculum of Master's degree programme in Chemical Engineering 2024-25

Citation from the accreditation report, page 15:

'In the aftermath of the audit, LUT submits new information concerning the planned changes in the curriculum of the Master's degree programme Chemical Engineering for the WS 2024/25…

As these changes are not implemented yet, the experts expect LUT to submit the final new curriculum in due time.' The curriculum of the academic year 2024-25 will be published in May 2024 in the eLUT student portal. Link to the curriculum will be sent to ASIIN after that.

Content of Master's degree programme in Biorefineries

Citation from the accreditation report, page 16-17:

'For this reason, they recommend offering an advanced course covering Microbiology, Biotechnology, and Bioprocess Engineering in the Biorefineries programme. As the programme coordinators confirm, there is currently no staff member at the Department of Separation Science, who could cover this area. To this end, it would be best hiring a staff member with the necessary expertise (see criterion 4.1).'

The need for microbiology and biotechnology studies in the MSc programme in Biorefineries has been recognised and in the first phase the subject will be included in the existing course 'BJ04A3010 Chemical and biochemical conversion of biomaterials'. The need for separate course or courses will be considered at a later stage.

The department will launch a new MSc Programme in Food Processing Technology in 2024, and the recruitment process for new professors has already started. The expertise of microbiology and biotechnology will very likely be covered by these persons.

Curriculum of Master's degree programme in Water Technology 2023-24

Citation from the accreditation report, page 17-18:

‘Master’s degree programme Water Technology: As these changes are not implemented yet, the experts expect LUT to submit the final new curriculum in due time.’ The curriculum of the next academic year has been published on 24 May in the eLUT student portal.

Internship in BSc and MSc programmes

Citation from the accreditation report, page 18-19:

‘As the programme coordinators explain during the audit, the internships (in Bachelor’s as well as in the Master’s programmes) usually last for a minimum of four weeks, but only two ECTS points are awarded, which equivalent to 54 hours of students’ work. If students work four weeks full time during the compulsory internship, the awarded ECTS points should reflect that workload. The required minimum length of the internship is described in the respective module description in the Master’s programmes but not in the Bachelor’s degree programme Chemical Engineering. Here, only the workload of 54 hours is mentioned.

For any course, the students’ total workload needs to be aligned with the awarded ECTS points. In case of the Master’s degree programmes, only two ECTS points are awarded, although the module descriptions states that the internship lasts four to seven weeks. This discrepancy needs to be solved, and the experts suggest that the best solution would be to cancel the compulsory internship from the curriculum of the Master’s programmes. Most Master’s students work at least during the summer break to earn money and gain working experience and there is no need to award credits for this.

On the other hand, the experts are convinced that a compulsory internship is very useful in the Bachelor’s degree programme Chemical Engineering. However, the minimum length should be four to six weeks and thus six to eight ECTS points should be awarded. In addition, the internship should be linked with the area of the degree programme, not every summer job should be acceptable.’

At LUT, the criteria of awarding ECTS credits form internship is based not only on the time spent at work but more importantly on certain activities that students are expected to complete as part of the internship course. Thus, the procedure is based more on recognition of learning than recognition of time spent on workplace.

It is also worth acknowledging that students make a trainee contract with the employer, and they get a full salary from internship employer. This internship policy is applied in all engineering degree programmes at LUT, also in degree programmes in Mechanical Engineering recently accredited by ASIIN.

Contrary to the report of the expert review team, the workload required for the internship is described in course descriptions that are publicly available in study guides for 2022-23:

- completion methods introduced in course description of BSc programme's internship course,

- completion methods introduced in course description of MSc programmes' internship course.

However, we have revised the course descriptions for the next academic year 2023-24 to be clearer and more unambiguous:

- completion methods introduced in course description of BSc programme's internship course

- completion methods introduced in course description of MSc programmes' internship course

The minimum length of four weeks and 2 ECTS credits of internship is reasonable in BSc programme since the aim is to get acquainted with the world of work and how to operate as a member of a working community. The internship is recommended to be linked with the field of the degree programme, but as it is sometimes difficult to fulfil, we accept a wide range of different tasks. This policy ensures that there will be no delay in studies due to lack of acceptable employment.

In MSc programmes the compulsory internship aims to encourage students to get connected to relevant employers and possibly even find an employment in Finland already during their studies. This is important since a big share of our MSc students come from foreign countries and we take this action to support them to find a good employment after their graduation. This is in alignment with the LUT's (and national) policy to encourage foreign experts to work and have a good career in Finland. However, we will consider the experts' suggestion to change the status of internship from compulsory to elective studies. It can be implemented earliest in AY 2024-25.

Guidance for group assignments

Citation from the accreditation report, page 26:

'During the audit, the students point out that teacher-distributed groups with different learning motivation/aspirations can be quite challenging and make work harder for motivated students. The experts suggest that teachers such offer more guidance for group assignments and make sure, that all students carry their load.'

The issue has been noted and different means are in use in group assignments to assure equal workload of group members: expert evaluation, group specific guidance sessions, selecting group members according to students' ambition level and goal for the grade.

However, the same solution doesn't fit to different cases, and it is up to the teacher to find the best arrangement. Common instructions to teachers will be given and good practices will be shared in teachers' meetings or pedagogical workshops.

Master's theses in Chemical Engineering

Citation from the accreditation report, page 29:

'The topics of Master's theses in Chemical Engineering typically include aspects of virtual engineering, control systems and high-speed applications, laser processing, fatigue life analysis of welded metal structures, welding process technology and welding metallurgy, integration of design and manufacturability aspects together with product data management and industrial design'.

The topics are not correct, the text should be replaced by the following: The topics of Master's theses in Chemical Engineering typically consider aspects related to process changes and investments, process development, utilisation of side streams and wastes, costs and profitability evaluation, reduction of process emissions, process data collection and analysis, process design, optimisation, and safety analysis, mapping and optimisation of mass and energy streams, and measurement and analysis of data in laboratory or pilot plant experiments.

Software needed in studies

Citation from the accreditation report, page 36:

'In the discussion with the students, the experts learn, that important software is not readily accessible for the students, because the programme packages are installed on some special computers, which are not directly available for remote access and external access via licence servers is unreliable. As the experts consider it important for students to have access to the software, licences should be reliably accessible for students not only on certain computers in the labs but also via remote access. This is especially important for the Biorefineries and the Water Technology programme which are taught partly or totally online and thus students cannot easily visit the computer labs on campus. This software includes MATHLAB, COMSOL, and Aspen.'

All the most important software needed in Chemical Engineering studies are available for students in computer classrooms at campus (Aspen, MatLab, Comsol) AND via LUT-VDI remote access service.

Some software may occasionally work slowly when used by LUT-VDI connection. This is informed to students by teachers and usage in computer classrooms at campus is recommended.

Laboratory instruments

Citation from the accreditation report, page 35-36:

'Highest priority should be given to purchasing an XRF instrument. With lower priority, additional analytical tools such as a compact, possibly including a flow cell for in-process measurements, NMR should be available. This enables the elucidation of the structure and dynamics of molecules as well as concentration determinations. Moreover, a XPS for advanced membrane analysis should be considered.'

The needs for different analysing instruments are regularly assigned with the research groups of Separation Science department. New investments are always based on the expected regular need for certain analyses. Analysis that is needed infrequently have been purchased from another research institute or from a commercial analysing laboratory. However, the purchase of the suggested XRF instrument is already under consideration.

Course Information

Citation from the accreditation report, page 37:

'However, the experts observe that more information about the courses is available to the student on the Moodle platform. From the experts' point of view it would be useful to make this detailed information also available in the module descriptions (study guide), which are accessible via LUT's homepage. This way, all stakeholders would be better informed about the courses' content.'

Course descriptions are made on the LUT common description template, which has predefined sectors for contents and limited space for characters. These course descriptions are done very early, up to 6 - 12 months before the course start date, so sharing a detailed course outline closer to the delivery date in Moodle is justified. Moodle is LUT's common tool for both teachers and students on the implementation and completion of the course, thus sharing detailed timetables, instructions and assignments is reasonable to be centralised there.

Students' workload

Citations from the accreditation report, page 24-25, 40-41:

'The students point out during the discussion with the experts that the workload of the courses in Bachelor's degree programme Chemical Engineering is not always aligned with the real workload. Some courses with only two or three ECTS points require as much work as courses with five ECTS points. From the experts' point of view, this is due to the small-

scale-structure of the courses, and LUT should think about combing small courses with related content to larger modules. Students' confirm that they can give feedback on the courses' workload in the questionnaires, but this feedback is not taken into consideration by the teachers and the ECTS distribution is not adjusted. For this reason, the experts point out that it is necessary to verify the students' total workload by considering the students' feedback and adjusting the awarded ECTS points where necessary. If possible, the number of five ECTS points for each module should be reached either by extending a course or combining two courses.'

'However, the students criticise during the audit that their feedback on the courses' workload in the questionnaires is not taken into consideration by the teachers and the ECTS distribution is not adjusted. For this reason, the experts point out that it is necessary to verify the students' total workload by considering the students' feedback and adjusting the awarded ECTS points where necessary (see criterion 1.5).'

Students' feedback on workload issues has always been considered seriously, and balancing student workload has been a continuous development target in recent years especially in BSc programme. Based on students' feedback, some large courses have been split into smaller units to ensure continuous progress of studies and stable accumulation of ECTS credits. According to student's feedback large courses can cause difficult situations for them: Completion of a big course may be delayed due to a failure in submission of one small part of the required assignments and ECTS credits don't accumulate in targeted time. This may cause problems in receiving student grant, which is dependent on ECTS credit accumulation. Thus, it is justified to offer smaller course units especially for BSc students whom the university studies are yet not so familiar.

In the LUT course feedback system, students are asked to evaluate their experience on workload on every course by a question: 'The workload relative to the study credits awarded'. The evaluation is asked to be given on scale 1 - 5, where 1=very light; 3=appropriate; 5=very heavy. The course feedback results from AY 2022-23 are presented in the table below.

Table: Student workload evaluation in course feedback surveys, AY 2022-23.

Courses	The workload relative to the study credits awarded, evaluation on scale 1-5 / Mean
LUT courses	3.5
Chemical Engineering courses	3.37
BSc programme in Chemical Engineering courses	3.27
MSc programme in Chemical Engineering courses	3.5

The table evidences that there is no big problems in workload allocation of BSc programme's courses. However, based on the course feedback from the two previous implementations, we had already identified a clearly higher workload of the 2nd BSc year course ´BJ01A2022 Analytical Chemistry Laboratory Work´, and the extent of the course has been already increased from 2 to 3 ECTS credits for the next academic year (2023-2024).

F Summary: Expert recommendations (21.07.2023)

Taking into account the additional information and the comments given by LUT, the experts summarize their analysis and **final assessment** for the award of the seals as follows:

Degree Programme	ASIIN-seal	Subject-specific label	Maximum duration of accreditation
Ba Chemical Engineering	With requirements for one year	EUR-ACE®	30.09.2030
Ma Chemical Engineering	With requirements for one year	EUR-ACE®	30.09.2030
Ma Biorefineries	With requirements for one year	EUR-ACE®	30.09.2029
Ma Water Technology	With requirements for one year	EUR-ACE®	30.09.2030

Requirements

For all degree programmes

A 1. (ASIIN 1.3) Verify the students' total workload for the compulsory internship and award the ECTS points accordingly.

Recommendations

For all degree programmes

E 1. (ASIIN 3.1) It is recommended to invite guest lecturers that cover areas where the programmes are lacking some specific but important expertise e.g. in Biotechnology.

E 2. (ASIIN 3.3) It is recommended to extend the range of available instrumentation for analytical chemistry. Highest priority should be given to purchasing an XRF instrument.

E 3. (ASIIN 4.1) It is recommended to include the detailed information about the courses as it is available on the Moodle platform in the module descriptions (study guide) and make it available for all external stakeholders.

For the Master's degree programme Biorefineries

E 4. (ASIIN 1.3) It is recommended to offer an advanced course covering Microbiology, Biotechnology, and Bioprocess Engineering.

G Comment of the Technical Committees (07.09.2023)

Technical Committee 01 – Mechanical Engineering/Process Engineering (07.09.2023)

Assessment and analysis for the award of the ASIIN seal:

The Technical Committee discusses the procedure and follows the assessment of the auditors without any changes.

Assessment and analysis for the award of the EUR-ACE label:

The Technical Committee agrees with awarding the EUR-ACE label to all four degree programmes.

The Technical Committee 01 – Mechanical Engineering/Process Engineering recommends the award of the seals as follows:

Degree Programme	ASIIN-seal	Subject-specific label	Maximum duration of accreditation
Ba Chemical Engineering	With requirements for one year	EUR-ACE®	30.09.2030
Ma Chemical Engineering	With requirements for one year	EUR-ACE®	30.09.2030
Ma Biorefineries	With requirements for one year	EUR-ACE®	30.09.2029
Ma Water Technology	With requirements for one year	EUR-ACE®	30.09.2030

Technical Committee 03 – Civil Engineering (04.09.2023)

Assessment and analysis for the award of the ASIIN seal:

The Technical Committee discusses the accrediting procedure and follows the assessment of the peers without any changes.

The Technical Committee 03 – Civil Engineering recommends the award of the seals as follows:

Degree Programme	ASIIN-seal	Subject-specific label	Maximum duration of accreditation
Ma Water Technology	With requirements for one year	EUR-ACE®	30.09.2030

Technical Committee 09 – Chemistry, Pharmacy (05.09.2023)

Assessment and analysis for the award of the ASIIN seal:

The procedure that was carried out on site in Finland at the end of April. With the exception of the Master Biorefineries, the degree programmes were reaccredited. The university is characterised by very good equipment, an international professorial staff, and extensive contacts to industry. However, the Technical Committee also sees that the organisation and evaluation of the compulsory internships was a major point of discussion and that there is a need for improvement here. The corresponding requirement is supported by the Technical Committee. In addition, recommendations are to be made on the integration of visiting professors or lecturers, on the information on the homepage, on the equipment in analytical chemistry, and on the curriculum in the Master Biorefineries. This is also supported by the Technical Committee.

The Technical Committee discusses the procedure and agrees with the proposed requirements and recommendations.

The Technical Committee 09 – Chemistry, Pharmacy recommends the award of the seals as follows:

Degree Programme	ASIIN-seal	Subject-specific label	Maximum duration of accreditation
Ba Chemical Engineering	With requirements for one year	EUR-ACE®	30.09.2030

Degree Programme	ASIIN-seal	Subject-specific label	Maximum duration of accreditation
Ma Chemical Engineering	With requirements for one year	EUR-ACE®	30.09.2030

Technical Committee 10 – Life Sciences (04.09.2023)

Assessment and analysis for the award of the ASIIN seal:

The procedure that was carried out on site in Finland at the end of April. With the exception of the Master Biorefineries, the degree programmes were reaccredited. The university is characterised by very good equipment, an international professorial staff, and extensive contacts to industry. However, the Technical Committee also sees that the organisation and evaluation of the compulsory internships was a major point of discussion and that there is a need for improvement here. The corresponding requirement is supported by the Technical Committee. In addition, recommendations are to be made on the integration of visiting professors or lecturers, on the information on the homepage, on the equipment in analytical chemistry, and on the curriculum in the Master Biorefineries. This is also supported by the Technical Committee.

The Technical Committee discusses the procedure and generally agrees with the proposed requirements and recommendations. However, it proposes a rewording of recommendation E1.

The Technical Committee 10 – Life Sciences recommends the award of the seals as follows:

Degree Programme	ASIIN-seal	Subject-specific label	Maximum duration of accreditation
Ma Biorefineries	With requirements for one year	EUR-ACE®	30.09.2029
Ma Water Technology	With requirements for one year	EUR-ACE®	30.09.2030

H Decision of the Accreditation Commission (22.09.2023)

The Accreditation Commission discusses the procedure and follows the assessment of the experts and the suggested change in recommendation E1.

Assessment and analysis for the award of the EUR-ACE label:

The Accreditation Commission agrees with awarding the EUR-ACE label to all four degree programmes.

The Accreditation Commission decides to award the following seals:

Degree Programme	ASIIN-seal	Subject-specific label	Maximum duration of accreditation
Ba Chemical Engineering	With requirements for one year	EUR-ACE® Upon confirmation by the ENAEE executive committee	30.09.2030
Ma Chemical Engineering	With requirements for one year	EUR-ACE® Upon confirmation by the ENAEE executive committee	30.09.2030
Ma Biorefineries	With requirements for one year	EUR-ACE® Upon confirmation by the ENAEE executive committee	30.09.2029
Ma Water Technology	With requirements for one year	EUR-ACE® Upon confirmation by the ENAEE executive committee	30.09.2030

Requirements

For all degree programmes

A 1. (ASIIN 1.3) Verify the students' total workload for the compulsory internship and award the ECTS points accordingly.

Recommendations

For all degree programmes

E 1. (ASIIN 3.1) It is recommended to invite guest lecturers who cover special topics related to the degree programme e.g., in Biotechnology.

E 2. (ASIIN 3.3) It is recommended to extend the range of available instrumentation for analytical chemistry. Highest priority should be given to purchasing an XRF instrument.

E 3. (ASIIN 4.1) It is recommended to include the detailed information about the courses as it is available on the Moodle platform in the module descriptions (study guide) and make it available for all external stakeholders.

For the Master's degree programme Biorefineries

E 4. (ASIIN 1.3) It is recommended to offer an advanced course covering Microbiology, Biotechnology, and Bioprocess Engineering.

Appendix: Programme Learning Outcomes and Curricula

According to the Self-Assessment Report, the following **objectives** and **learning outcomes (intended qualifications profile)** shall be achieved by the Bachelor's degree programme Chemical Engineering:

"After completing the Bachelor's programme in Chemical Engineering the graduate

- has acquired a basic knowledge of natural sciences to understand the basic phenomena in the field of chemical engineering
- demonstrates sufficient knowledge of the principles of experimental work in the field of chemical engineering
- demonstrates sufficient knowledge of the principles of modelling in the field of chemical engineering
- demonstrates knowledge of the principles of process development and design taking safety and environmental aspects into account
- can solve practical problems in working life based on fundamental principles of chemical engineering
- is able to start a professional career work in practical laboratory and process duties
- demonstrates good skills in project work and in creative problem solving
- demonstrates good oral skills to communicate effectively also in international environment
- demonstrates good written skills to communicate effectively also in international environment
- has an ability to utilize different sources for the acquisition of information, evaluate information critically and apply it for problem solving."

The following **curriculum** is presented:

	ECTS	Year 1				summer	Year 2				summer	Year 3				summer
		1	2	3	4	S	5	6	7	8	S	9	10	11	12	S
General studies	62															
Numerical Methods I	3															
Basics of University Mathematics	5															
Differential Calculation	5															
Differential Equations	4															
Integral Calculation	4															
Basics of Statistics	4															
Fundamentals of Heat Transfer	3															
Basics of Renewable Energy Technology	3															
Fluid Mechanics I	3															
Control Systems, Introduction	3															
Language studies *)	4															
Svenska i arbetslivet (teknik), skriftlig	1															
Svenska i arbetslivet (teknik), muntlig	1															
Academic writing in Finnish	2															
Basics of Business	2															
Innovation and Technology Management: a Basic Course	6															
Work internship in Bachelor's degree in Finland	2															
Introduction to Studies of Chemical Engineering	3															
General Chemistry	3															
Safety in Chemistry Laboratory	1															

Intermediate specialisation studies	**88**																
Basic Inorganic Chemistry	3																
Organic Chemistry	4																
General Chemistry Laboratory Works	4																
Basic Biochemistry	2																
Basic Analytical Chemistry	3																
Analytical Chemistry Laboratory Works	2																
Characterization of Solid Materials	3																
Chemical Thermodynamics	6																
Chemical Dynamics	3																
Chemical Kinetics	3																
Physical Chemistry Laboratory Course	3																
Mechanical Unit Operations	4																
Unit Operations A	4																
Unit Operations B	4																
Chemical Reaction Engineering	5																
Laboratory Course of Unit Processes	4																
Applied Chemistry Laboratory Course	4																
Introduction to Chemical Process Industries	3																
Process and Plant Design	4																
Introduction to Process Simulation	4																
Process and Occupational Safety	2					2				1	2					2	
Biorefineries	4		1			2					2					2	
Bachelor's Thesis and Seminar	10										2		1			2	
Other studies	**30**																

According to the Self-Assessment Report, the following **objectives** and **learning outcomes (intended qualifications profile)** shall be achieved by the Master's degree programme Chemical Engineering:

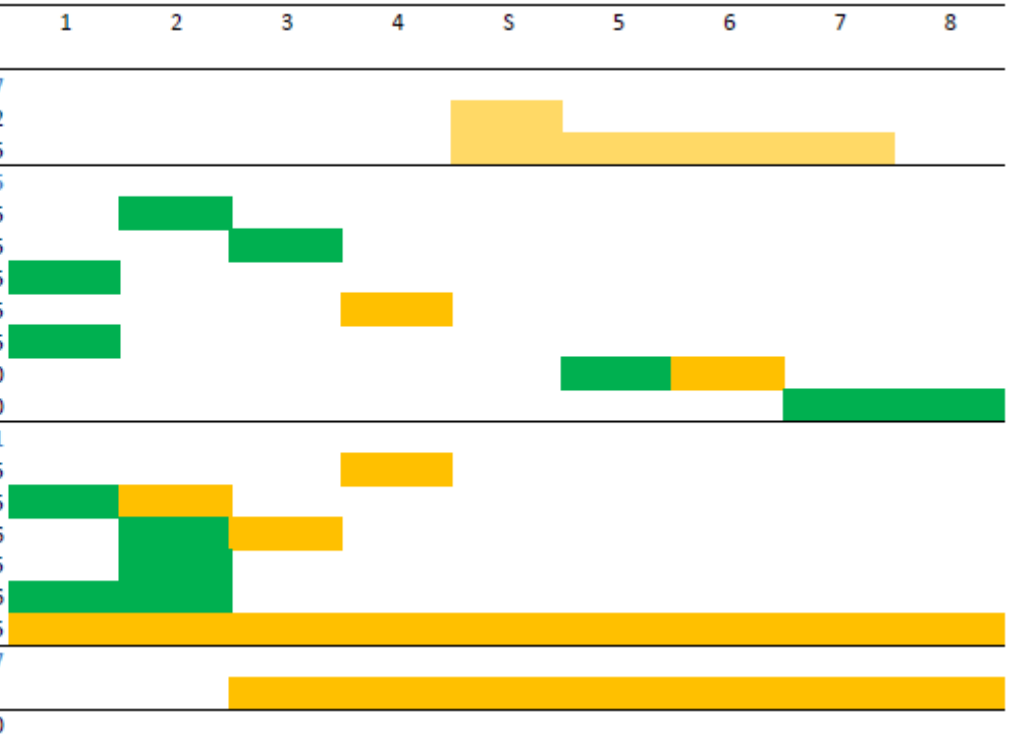
"After completing the Master's programme in Chemical Engineering, the graduate

- demonstrates solid theoretical background in core areas of chemical engineering
- demonstrates strong engineering analysis and problem-solving skills
- is able to make approximations and decisions under uncertainty based on trained engineering practice skills
- has courage to create innovations and new technical solutions
- is able to develop solutions that take into account issues in environmental protection and renewable energy transition
- possesses project working and communication skills needed in the modern working environment."

The following **curriculum** is presented:

MSc programme in Chemical Engineering

ID	Study mode	ECTS
	Core studies	7
BJ02A0032	Work Internship in Master's Degree	2
BJ02A1000	Research Methodology	5
	Advanced specialisation studies	65
BJ02A2011	Modelling of Unit Operations	5
BJ02A2030	Fluid Dynamics in Chemical Engineering	5
BJ02A2041	Advanced Process Design	5
BJ02A2051	Process Intensification	5
BJ02A2090	Process Simulation and Monitoring Applications	5
BJ02A2080	Project on Product and Process Design	10
BJ02A0041	Master's Thesis and Seminar	30
	Alternative specialisation studies	31
BJ02A2000	Knowledge Discovery and Process Data Analysis	5
BJ04A5010	Advanced Biorefineries	5
BH50A1500	Bioenergy Technology Solutions	6
BJ02A3051	Hydrometallurgy	5
BJ02A3061	Circular Economy for Materials Processing	6
BJ02A6020	Power-to-X processes	5
	Elective studies	17
	Any Lut University Course	
	Total	120



According to the Self-Assessment Report, the following **objectives** and **learning outcomes (intended qualifications profile)** shall be achieved by the Master's degree programme Biorefineries:

"After completing the Master's programme in Biorefineries the graduate

- has acquired comprehensive knowledge of modern biorefining technologies
- knows the most potential raw materials and their properties
- has good knowledge of technologies integrated to biorefineries, e.g. bioenergy production and waste water treatment
- has the ability to design and develop practical biorefining applications and products
- is able to demonstrate a critical understanding of sustainable solutions and technologies
- has good problem-solving skills and the courage to create innovations and new technical solutions
- possesses project working and communication skills needed in the modern networked environment."

The following curriculum is presented.

ID	Study module	ECTS	1	2	3	4	S	5	6	7	8
	Core studies	19									
BJ02A0050	Orientation to M.Sc. Studies	1									
BJ04A1010	Introduction to MSc Studies in Biorefineries	1									
BJ02A1000	Research Methodology	5									
BL20A0910	Technology and Society	4									
BH60A4402	Sustainability in Socio-Technological context	6									
BJ02A0032	Work Internship in Master's Degree	2									
	Advanced specializing studies: Biobased Process Engineerir	88									
BJ04A2010	Development of New Sustainable Products and Solutions	5									
BJ04A3010	Chemical and biochemical conversion of biomaterials	5									
BJ04A4010	Membrane Technology in biorefining	5									
BJ04A4020	Solid-Liquid Separation in biorefining	5									
BJ04A4040	Chemical separation methods in biorefining	5									
BJ02A4070	Principles of Thermal Gas-Liquid Processes	5									
BJ04A5010	Advanced Biorefineries	5									
BH61A060E	Bioenergy for EnTeDI	3									
BJ04A5020	Biorefinery process development project	10									
BJ04A6010	Biological Waste Water Treatment in biorefining	5									
BJ04A7010	Bioeconomy	5									
BJ02A0041	Master's Thesis and Seminar	30									
	Elective studies	13									
	Any LUT University course										
	Extra work internship										

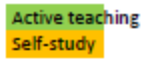
According to the Self-Assessment Report, the following **objectives** and **learning outcomes (intended qualifications profile)** shall be achieved by the Master's degree programme Water Technology:

"After completing the Master's programme in Water Technology the graduate

- has a comprehensive understanding of the best available technologies (BATs) for wastewater treatment, including adsorption, membrane processes, advanced oxidation, biological processes among other methods
- is able to demonstrate a broad knowledge in process and environmental analytics and monitoring
- has adopted the principles of sustainability in water treatment
- is able to demonstrate a critical understanding of relevant theories and techniques, problem-solving skills, and ability to independently use knowledge, equipment and tools for the design and development of practical water treatment applications.
- is able to work with others in task-orientated groups participating and interacting in the group in a productive manner
- is able to logically think through a problem and solve it."

The following curriculum is presented.

MSc programme in Water Technology



ID	Study module	ECTS	1	2	3	4	5	5	6	7	8
	Core studies	9									
BJ02A0032	Work Internship in Master's Degree	2									
BJ02A0050	Orientation to M.Sc. Studies	1									
BJ02A0060	Laboratory safety course	1									
BJ02A1000	Research Methodology	5									
	Advanced specialisation studies: Sustainable Water Technology (Obligatory)	81									
BH60A065	Sustainable water use	6									
BJ03A1011	Introduction to water treatment technologies	5									
BJ03A2040	Research project course in water treatment	10									
BJ03A2050	Introduction to Instrumental Water Analysis	5									
BJ02A3030	Solid-Liquid Separation	5									
BJ03A2070	Modeling and Simulation of Water and Wastewater Treatment Processes	5									
BJ03A2060	Persistent, mobile and toxic organic compounds in the aquatic environment	5									
BJ03A2010	Advanced oxidation processes & electrochemical methods in water treatment	5									
BJ03A1020	Biological waste water treatment	5									
BJ02A0041	Master's thesis and seminar	30									
	Alternative specializing studies (min 2 courses)	≥10									
BJ02A2041	Advanced process design	5									
BJ02A2051	Process Intensification	5									
BJ02A3061	Circular Economy for Materials Processing	5									
BJ02A1032	Solution and electrochemistry	5									
BJ02A3010	Membrane technology	5									
BJ03A1040	Advanced materials in adsorption and ion exchange	5									
BJ02A3070	Precipitation, crystallization, coagulation and flotation methods in water treatment	5									
	Elective studies	20									
	Any LUT University course										
	Extra work internship										
	Total	120									