

Curriculum for the master's degree programme in Biorefinery Engineering

Curriculum 2017

This curriculum was approved by the Senate of Graz University of Technology in the meeting dated 30 January 2017.

This degree programme is legally based on the Universities Act of 2002 (UG) and on the provisions of the Statute of TU Graz as amended.

(Please note: The English version of this document is a courtesy translation. Only the German version is legally binding.)

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I General provisions

§ 1. Object of degree programme and qualification profile

The engineering sciences master's degree programme in Biorefinery Engineering comprises four semesters. The total scope of the programme is 120 ECTS credit points according to § 51 para. 2 subpara. 26 Universities Act (UG).

The master's degree programme in Biorefinery Engineering is held in English according to § 71e para. 4 UG.

Graduates of this programme are awarded the university degree of "Diplom-Ingenieurin"/"Diplom-Ingenieur", abbreviated: "Dipl.-Ing." or "DI". The international equivalent of this university degree is "Master of Science", abbreviated: "MSc".

(1) Object of degree programme

The master's degree programme in Biorefinery Engineering provides students with the engineering sciences knowledge and skills necessary for the construction and operation of technical systems for the use of biogenic resources. After completing this master's degree programme, students are able to recognise and categorise trends in the bio-based industry and to convert innovations into business models. As a result of the interdisciplinary structure of the master's degree programme, students are capable of taking on leadership tasks in an international and interdisciplinary environment. In research-led traineeships at the university or with industry partners, students are familiarised with state-of-the-art technologies. The degree programme takes into account the interdisciplinary challenges of using biogenic resources at both a technical and a non-technical level. The degree programme's close link with practice and its orientation towards innovation enable students to carry out high-quality, structured research work and to develop innovative systems with a scientific basis to convert biogenic resources into energy and high-quality products economically and with great ecological responsibility as part of a modern bioeconomy.

Internationality

All the courses are held in English. Students are offered practice-oriented courses in cooperation with international academic and industrial partners as well as courses by external teachers as part of the curriculum. Participation in international practical internships, conferences and summer schools is strongly recommended within the framework of the students' education. This is intended to provide students with the best possible preparation for careers in an international working environment.

Social competence and soft skills

Projects as part of international practical courses, lectures within the framework of summer schools, written assignments and teamwork to solve practice-oriented problems in groups help to develop social competence and soft skills.

(2) Qualification profile and competencies

The master's degree for the master's programme in Biorefinery Engineering of Graz University of Technology is awarded to students who have demonstrated the following knowledge, skills and competencies:

Knowledge and understanding

Graduates of the master's degree programme in Biorefinery Engineering have considerably broadened and deepened their specialist knowledge in the following areas:

Technical basics: These include the description and calculation of tasks from the field of thermodynamics and chemical thermodynamics, and of transport processes within the field of mass transfer and heat transfer.

Biorefinery: This includes fundamental knowledge of the basics and raw materials of biorefinery, the conceptual design and engineering of processes in biorefineries, and the economic and ecological assessment of the entire value chain.

Material flows: These include both the characterisation of the input materials, and the characterisation of the intermediate and end products, as well as knowledge of the required analytical methods.

Engineering: This includes the process simulation and electrotechnical and thermotechnical basics.

Students understand the technical, logistical and economic challenges that result from the use of biogenic raw materials. They acquire the basic knowledge to develop and apply ideas and approaches to implement innovative technical systems to use biogenic resources in their working environment. By deepening their knowledge in one of the two catalogues of electives, students further develop their understanding of specific technical, ecological and economic aspects of an innovative bioeconomy. Students are able to generate added value along the entire value chain, to identify, adapt and implement suitable technologies and to expand their knowledge independently with the aid of the relevant literature.

Applying knowledge and understanding

Graduates

- have become familiar with complex scientific methods for the analysis and evaluation of biogenic resources as well as for the development of processes for their use and are able to apply these methods;
- are able to apply their knowledge and their skills to solve technical problems along the entire value chain of biogenic resources in new and unfamiliar situations as well as to adapt technical solutions to the relevant spatial context;

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- can design and operate processes for the production of bio-based materials;
 - are able to interpret terminology and schools of thought in an interdisciplinary specialist area of the use of biogenic resources. They are capable of supporting cooperation with various specialists who work along the entire value chain of biogenic resources through their process engineering expertise or using it to further develop processes;
 - are able to understand, formulate and plan a task in an industrial and scientific environment and to present possible solutions;
 - possess a thorough scientific education, work independently, analyse critically and generate new ideas;
 - understand the potential uses of research results and integrate these results into their own work or carry out further research work themselves, and
 - are able to understand the guidelines in the bio-based industry and to contribute to work on guideline-oriented processes effectively.

Making assessments

Graduates are able to

- handle complex situations that require interdisciplinary cooperation;
- formulate scientifically founded assessments for the technical use of biogenic resources, including assessments on the basis of incomplete or limited information;
- take the ecological, societal, social and ethical effects into account in their scientific activities;
- assess technical challenges regarding the use of biogenic resources under given regional, economic, social and ecological conditions and express a sound technical opinion, and
- reflect on their own work and use relevant information in their own activities continuously.

Communicative and social competencies

Graduates

- have mastered communication and presentation techniques;
- are able to write scientific texts;
- are able to quote correctly and appropriately;
- are flexible, able to adapt and to work in a team;
- are able to take on leadership tasks;
- are able to act as a link between various specialist disciplines in an interdisciplinary environment;
- are able to combine ecological, economic and social aspects with technical topics, and
- can present complex scientific relationships and results in a comprehensible form, including for a non-scientific audience.

Organisational competencies

Graduates

- can use learning strategies that enable them to further develop their knowledge independently;
- are able to take the initiative, and
- can put together and lead interdisciplinary projects teams to solve problems.

(3) Demand for and relevance of the degree programme for science and on the job market

Within the framework of the European Strategic Energy Technology Plan (SET-Plan), the SET-Plan Roadmap on Education and Training was developed. This road map indicates the lack of a sufficient education capacity for qualified personnel to plan, construct and operate complex technology systems for the comprehensive use of bioresources (biorefineries). This interdisciplinary education should include all technical fields of knowledge for the conversion of biogenic raw materials, as well as chemical and process engineering, chemistry and biotechnology, and also impart knowledge of energy technology, environmental technology and logistics. Of particular importance is the ability for interdisciplinary cooperation with experts from other specialist disciplines who act along the entire value chain of biogenic resources. At a European level, the road map shows an annual requirement of up to 3,000 graduates of technical master's degree programmes in this field of knowledge, who are required both in the area of plant engineering and in the operation of biorefineries. This makes biorefinery engineers key experts, both for the implementation of an innovative bioeconomy, and for the change to a sustainable energy system in Europe.

II General requirements

§ 2. Admission requirements

- (1) Admission to a master's degree programme requires a subject-related bachelor's degree of a university or university of applied sciences or another equivalent degree of a recognised Austrian or foreign post-secondary educational institution (§ 64 para. 5 UG).
- (2) The master's degree programme in Biorefinery Engineering builds upon the content of the bachelor's degree programme in Environmental Systems Sciences/Natural Sciences – Technology offered as part of NAWI Graz. Graduates of this degree programme fulfil the admission requirements for the master's degree programme in Biorefinery Engineering.

In addition, graduates of the bachelor's degree programmes listed in Annex III fulfil the admission requirements, but must complete courses of the bachelor's degree programme in Chemical and Process Engineering as part of the free-choice subject and the elective modules.

This master's degree programme constitutes a specialisation in the field of biorefinery engineering for graduates of a natural sciences or engineering sciences

bachelor's degree programme with reference to systems sciences or chemistry, the focus of which is not, however, chemical and process engineering.

- (3) If the degrees are generally equivalent and only certain supplementary qualifications are required for full equivalence, additional courses and examinations of the natural sciences and engineering sciences bachelor's degree programmes of TU Graz with a maximum scope of 30 ECTS credit points may be prescribed in order to obtain full equivalence. According to § 10 below, recognition of these additional qualifications to be obtained is permitted up to a maximum workload of 5 ECTS credit points for the free-choice subject.
- (4) In order to obtain an overall scope of 300 ECTS credit points for the graduate and postgraduate degree programmes together, students shall not be assigned courses in the master's programme which they have already completed as part of their bachelor's degree and which were part of their qualification for the master's degree programme.

§ 3. Allocation of ECTS credit points

All achievements to be obtained by the students are assigned ECTS credit points. These ECTS credit points are used to determine the relative weight of the workload of the individual academic achievements; the workload of one year must comprise 1500 hours and 60 ECTS credit points are awarded for this workload (corresponding to a workload of 25 hours per ECTS credit point). The workload comprises the self-study part and the semester hours. One semester hour corresponds to 45 minutes per study week of the semester.

§ 4. Organisation of the degree programme

The master's degree programme in Biorefinery Engineering with a workload of 120 ECTS credit points comprises four semesters and has the following modular structure:

	ECTS
Compulsory module A: Engineering Basics	13
Compulsory module B: Mass and Heat Transfer	12.5
Compulsory module C: Chemical and Analytical Aspects of Biorefineries	7
Compulsory module D: Biorefinery Economic, Ecological and Social Aspects	9
Compulsory module E: Bioresources	9
Compulsory module F: Biorefinery Technologies	6.5
Compulsory module G: Biorefinery and Energy Systems	6
Compulsory module H: Biorefinery Project	7
Elective module: "Energy Utilisation" or "Material Utilisation and Recovery"	14
Free-choice subject	6
Master's thesis	30
Total	120

§ 5. Types of courses

The following types of courses are offered at TU Graz (see Annex IV, extract from the Guideline on the types of courses by the Curricula Committee of the Senate of TU Graz dated 6 October 2008, published in the University Gazette of TU Graz dated 3 December 2008):

- (1) Lectures (VO): Introduction to the sub-areas and methods of the field
- (2) Lectures with integrated exercises (courses with continual assessment) (VU): Introduction to the sub-areas and methods of the field including independent application using examples
- (3) Exercise-based courses (with continual assessment) (UE, KU, PT, EX) (exercises, design exercises, projects, excursions): Deepening and/or broadening of theoretical knowledge through practical, experimental, theoretical and/or design work
- (4) Laboratory courses (LU) (courses with continual assessment): Practical, experimental and/or design work to deepen and/or broaden theoretical knowledge with particularly intensive tutoring
- (5) Seminar-type courses (courses with continual assessment) (SE, SP) (seminars, seminar projects): Introduction to scientific work and scientific discourse and argumentation. Writing papers, and presenting and discussing them

§ 6. Group sizes

The maximum numbers of participants (group sizes) are as follows:

Lecture (VO) Lecture component of VU	No restriction
Exercise (UE, KU, PT, EX) Exercise component of VU	25
Laboratory course (LU)	6
Seminar (SE, SP)	20

§ 7. Guidelines for the allocation of places on courses

- (1) If the number of students registered for a course exceeds the number of available places, parallel courses are to be provided. If necessary, these parallel courses may also be provided during the semester break.
- (2) If it is not possible to offer a sufficient number of parallel courses (groups), the students are to be admitted to the course according to the following priority ranking:
 - a. Students who are required to complete the course according to their curriculum
 - b. The sum of the successfully completed courses of the respective study programme (total ECTS credit points already achieved)
 - c. The date (early date has priority) of the fulfilment of the participation requirement
 - d. Students who have already been placed on a waiting list or who must repeat the course are to be given priority on the next course.
 - e. The further ranking is made according to the grade of the examination or the average grade of the examinations (weighted on the basis of the ECTS credit points) of the respective course(s) that are specified as the participation requirement.
 - f. Students who do not need to complete such courses in order to fulfil their curriculum are only considered based on the number of free places. It is possible to be included on a separate waiting list. The abovementioned provisions shall apply accordingly.
- (3) Students who complete a part of their studies at TU Graz in the context of mobility programmes are given priority for up to 10% of the available places.

III Course content and curriculum

§ 8. Modules, courses and semester allocation

The individual courses of this master's degree programme and their grouping into compulsory and elective modules are indicated hereinafter. The knowledge, methods or skills to be provided in the modules are described in more detail in Annex I. The semester allocation is a recommendation and ensures that the sequence of courses builds optimally on previous knowledge and that the workload of an academic year does not exceed 60 ECTS credit points.

Master's degree programme in Biorefinery Engineering							
Course	SSt	Type	ECTS	Semester incl. ECTS			
				I	II	III	IV
Compulsory module A: Engineering Basics							
Thermodynamics	2	VO	3	3			
Thermodynamics	2	UE	2	2			
Chemical Thermodynamics I	2	VO	3		3		
Chemical Thermodynamics I	1	UE	1		1		
Introduction to Process Simulation and Process Design	1	VO	2		2		
Introduction to Process Simulation and Process Design	2	UE	2		2		
Subtotal for compulsory module A	10		13	5	8		
Compulsory module B: Mass and Heat Transfer							
Transport Processes I ¹	2	VU	3	3			
Transport Processes II ¹	2	VU	3	3			
Mass Transfer Unit Operations	3	VO	4.5		4.5		
Mass Transfer Unit Operations	2	UE	2		2		
Subtotal for compulsory module B	9		12.5	6	6.5		
Compulsory module C: Chemical and Analytical Aspects of Biorefineries							
Bio-based Materials: Processing, Engineering and Analysis	2	VO	3	3			
Bio-based Materials: Processing, Engineering and Analysis	2	LU	2	2			
Materials Chemistry	1.33	VO	2		2		
Subtotal for compulsory module C	5.33		7	5	2		
Compulsory module D: Biorefinery Economic, Ecological and Social Aspects							
Business Development for Bioresources ²	5	SE	5		(5)	5	
LCA of Bioresource Value Chains	2	VO	3			3	
LCA of Bioresource Value Chains	1	UE	1			1	
Subtotal for compulsory module D	8		9			9	
Compulsory module E: Bioresources							
Bioprocess Technology I	2	VO	3	3			
Crop Bioresources – Characterisation and Properties	2	VO	3	3			
Lignocellulose Bioresources – Characterisation and Properties	2	VO	3	3			
Subtotal for compulsory module E	6		9	9			

Master's degree programme in Biorefinery Engineering							
Course	SSt	Type	ECTS	Semester incl. ECTS			
				I	II	III	IV
Compulsory module F: Biorefinery Technologies							
Chemical Engineering of Bio-based Products	2	VO	3		3		
Chemical Engineering of Bio-based Products	1.5	UE	1.5		1.5		
Lignocellulosic Biorefinery Processes	1.5	VO	2			2	
Subtotal for compulsory module F	5		6.5		4.5	2	
Compulsory module G: Biorefinery and Energy Systems							
Thermal Conversion Routes for Energetic Biomass Utilisation I	2	VO	3	3			
Fundamentals of Electrical Power Systems for Biorefineries	2	VO	3		3		
Subtotal for compulsory module G	4		6	3	3		
Compulsory module H: Biorefinery Project							
Biorefinery Project	6	PT	6			6	
Industry Excursion Biorefinery	1	EX	1		1		
Subtotal for compulsory module H	7		7		1	6	
Total for the compulsory modules	54.3		70	28	25	17	
Elective module "Energy Utilisation"			14	2	3	9	
Elective module "Material Utilisation and Recovery"			14	2	3	9	
Total for the elective modules according to § 9 below			14	2	3	9	
Master's thesis			30				30
Free-choice subject according to § 10 below			6		2	4	
Overall total			120	30	30	30	30

¹ 1.33 SSt/lecture component; 0.67 SSt/exercise component

² offered in both semesters

Weighting of courses with continual assessment in the degree programme:

LV name	LV type	ECTS
Thermodynamics	UE	2
Chemical Thermodynamics I	UE	1
Chemical Engineering of Bio-based Products	UE	1.5
Transport Processes I	VU	1
Transport Processes II	VU	1
Mass Transfer Unit Operations	UE	2
Bio-based Materials: Processing, Engineering and Analysis	LU	2
Business Development for Bioresources	SE	5
LCA of Bioresource Value Chains	UE	1
Introduction to Process Simulation Plant Design	UE	2
Industry Excursion Biorefinery	EX	1
Biorefinery Project	PT	6
Total		25.5

§ 9. Elective modules: catalogues of courses

Courses from one of the two catalogues of electives with a workload of 14 ECTS credit points must be completed.

As part of the elective module, courses to deepen knowledge of a foreign language (English or German) with a workload of up to 3 ECTS credit points may be completed.

For the elective module “Energy Utilisation”, courses from the following catalogue of courses must be completed.

Energy Utilisation					
Course	LV		ECTS	Semester allocation	
	SSt	Type		WS	SS
Energy Storage and Conversion	1.33	VO	2		2
Student Camp	3	PT	3	3	(3)***
Bioresource Value Chain Optimisation	2	VO**	3	3	
Bioresource Value Chain Optimisation	1	UE**	1	1	
High Pressure Intensive Course	5	SE	5		5
Liquid Biofuels	1	SE	1		1
Fuel Cells and Energy Storage	2	VO	3		3
Operations Management in Bioresource Chains	3	VU**	4		4
Development and Operation of Power Systems	2	VO**	4		4
Renewable-based Energy Mixes	1.3	VO**	2	2	
Energy Systems Analysis	2	VO	3		3
Selected Topics of Biorefinery Engineering	1.5		3		3
- Industrial Topics	1.5	VO	3		3
- Advanced Scientific Topics	1.5		3		3
Biomass Fractionation Processes for Biorefineries	1.5	VO**	3	3	
Computer-aided Biorefinery Processes Design	3	VU**	4	4	
Particle Technology I	3	VO	4.5		4.5
Particle Technology I	2	UE	2		2
Hydrogen Production and Storage	2	VO	3	3	
Thermal Conversion Routes for Energetic Biomass Utilisation II	2	VO	3		3
Paper and Board Production Basics	2	VO**	3	3	
Advanced Studies of Polymer Electrolyte Fuel Cells	3	VU	4		4
Chemical Reaction Engineering I	3	VU	4	4	
Planung und Betrieb elektrischer Energiesysteme*	2	VO	3	3	
Dezentrale Energieerzeugung und Kraftwärmekopplung*	2	VO	3		3
Applikationssoftware und Programmierung VT*	2	VU	2		2
Erneuerbare Energien*	1	VO	1.5		1.5

* Courses are offered in German.

** Courses are offered every second academic year.

*** can be offered additionally in this semester

For the elective module “Material Utilisation and Recovery”, courses from the following catalogue of courses must be completed.

Material Utilisation and Recovery					
Course	LV		ECTS	Semester allocation	
	SSSt	Type		WS	SS
Bioresource Value Chain Optimisation	2	VO**	3	3	
Bioresource Value Chain Optimisation	1	UE**	1	1	
Student Camp	3	PT	3	3	(3)**
High Pressure Intensive Course	5	SE	5		5
Fluid Phase Properties	3	VU	3	3	
Mass Transfer Unit Operations Laboratory	1	LU	1		1
Mass Transfer Unit Operations Laboratory II	2	LU	2	2	
Algae Biorefineries	2	VO**	3		3
Operations Management in Bioresource Chains	3	VU**	4		4
Bioresources and Bio-based Products	2	VO**	3	3	
Laboratory Course Bioprocess Technology	5	LU	5		5
Lignocellulosic Biorefinery Laboratory	3	LU	3		3
Nanocellulose Processes and Products	1	VO	1.5	1.5	
Carbohydrate Chemistry	2	VO**	3		3
Residue- and By-product-based Bioresources – Characterisation, Properties and Pathways	2	VO**	3	3	
REACH – Registration, Evaluation, Authorisation and Restriction of Chemical Substances	2	VO	3		3
Chemical Reaction Engineering II	2	VU	2.5		2.5
Selected Topics of Biorefinery Engineering	1.5	VO	3		3
- Industrial Topics	1.5	VO	3		3
- Advanced Scientific Topics	1.5	VO	3		3
Biomass Fractionation Processes for Biorefineries	1.5	VO**	3		3
Carbohydrate Technologies	1.33	VO	2		2
Computer-aided Biorefinery Processes Design	3	VU**	4	4	
Particle Technology I	3	VO	4.5		4.5
Particle Technology I	2	UE	2		2
Downstream Processing for Biomolecules	2	VU	2	2	
High-pressure and Supercritical Fluid Processes	2	SE	2		2
Biopolymers for Advanced Material Applications	1.5	VO	2	2	
Advanced Chemical Reaction Engineering	3	VU**	4		4
Paper and Board Production Basics	2	VO**	3	3	
Chemical Reaction Engineering I	3	VU	4	4	
Applikationssoftware und Programmierung VT*	2	VU	2		2
Chemisch-Thermische Abwasserreinigung*	3	VU	4	4	
Produktionsintegrierter Umweltschutz*	2	VU	3		3
Luftreinhaltung / Abluftreinigung*	3	VU	4		4

* Courses are offered in German.

** Courses are offered every second academic year.

*** can be offered additionally in this semester

Courses with the title “Selected Topics of Biorefinery Engineering” are assigned to the elective module “Material Utilisation and Recovery” and the elective module “Energy Utilisation”. Courses with different subtitles shall be classified as different courses.

§ 10. Free-choice subject

- (1) The courses to be completed as part of the free-choice subject in the master's degree programme in Biorefinery Engineering are designed to provide individual emphasis and further development of the students. They can be freely selected from the courses offered by any recognised Austrian or foreign universities, as well as any Austrian universities of applied sciences and university colleges for education. Annex II contains recommendations for free-choice courses.
- (2) If no ECTS credit points are assigned to a free-choice course, one ECTS credit point is awarded for every semester hour (SSt) of this course. If such courses are lecture-type courses (VO), they are assigned 1.5 ECTS credit points for each semester hour.
- (3) Students also have the possibility of completing a vocational internship or short study periods abroad as part of the free-choice subject according to § 13 below.

§ 11. Master's thesis

- (1) The master's thesis is proof of the student's capability to perform scientific research and development tasks independently and with academic grounding as far as content and methodology are concerned. The scope of work of the master's thesis must enable students to finish their thesis within a period of six months.
- (2) The topic of the master's thesis must be taken from one of the compulsory or elective modules. The Dean of Studies shall decide on exceptions.
- (3) Before a student starts work on their master's thesis, it must be registered via the responsible dean's office with the involvement of the Dean of Studies. The topic, the area of expertise of the topic and the supervisor as well as the institute must be stated.
- (4) 30 ECTS credit points are awarded for the master's thesis.
- (5) The master's thesis is to be submitted for evaluation in printed and in electronic form.

§ 12. Registration requirements for courses/examinations

- (1) Admission to courses/examinations is subject to the following prerequisites:

Course	Prerequisite
Business Development for Bioresources (SE)	Bio-based Materials: Processing, Engineering and Analysis VO
Laboratory Course Bioprocess Technology (LU)	Bioprocess Technology I VO

Admission to the master's degree examination before a committee requires proof of the positive assessment of all examination results according to §§ 8 to 9 above as well as proof of the positive assessment of the master's thesis.

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- (2) Students who must fulfil admission requirements for the master's degree programme in Biorefinery Engineering according to § 2 (3) above must have successfully completed these before participating in laboratory courses (LU) and lectures with integrated exercises (VU) with laboratory course components.

§ 13. Study periods abroad and internship

(1) Recommended studies abroad

Students are recommended to complete a semester abroad during their degree programme. For this purpose, the third semester of this master's degree programme is particularly worth considering. Modules or courses completed during the studies abroad shall be recognised by the Dean of Studies in the case of equivalence. Students are referred to § 78 para. 5 UG (prenotification) for the recognition of examinations during studies abroad.

In addition, an application may be sent to the Dean of Studies to have achievements from shorter study periods abroad such as active participation in international summer or winter schools recognised as part of the free-choice subject.

(2) Internship

Students are recommended to complete a vocational internship as part of the free-choice subject.

In this context, every working week in full-time employment shall correspond to 1.5 ECTS credit points. Active participation in a scientific event shall also be valid as an internship. This internship shall be approved by the Dean of Studies and should be a meaningful addition to the degree programme.

IV Examination regulations and degree certificate

§ 14. Examination regulations

Courses are evaluated individually.

- (1) Examinations for courses held as lectures (VO) cover the complete content of the course. Examinations are held exclusively orally, exclusively in writing, or in writing and orally as a combination.
- (2) For courses held as lectures with integrated exercises (VU), exercise-based courses (PT, UE), laboratory courses (LU), design exercises (KU), seminar-type courses (SE, SP), and excursions (EX), a student's performance is continually assessed on the basis of that student's contributions and/or through accompanying tests. The assessment must always consist of at least two examinations.
- (3) Examinations with positive results are to be assessed as "very good" (1), "good" (2), "satisfactory" (3) or "sufficient" (4); those with negative results are to be assessed as "insufficient" (5).
- (4) If a module includes separate examinations for the relevant courses, the overall module grade is to be determined by:
 - a. multiplying the grade of each examination result in connection with the module with the ECTS credit points of the corresponding course;
 - b. adding the values calculated according to lit. a.;
 - c. dividing the result of the addition by the sum of the ECTS credit points of the courses, and
 - d. rounding the result of the division to a whole-numbered grade if required. The grade must be rounded up if the decimal place exceeds 0.5. Otherwise, the grade must be rounded down.
 - e. A positive module grade can only be awarded if every individual examination result is positively assessed.
 - f. Courses which are assessed exclusively by successful/unsuccessful participation shall not be included in this calculation according to lit. a. to d.
- (5) The master's degree examination before a committee consists of:
 - the presentation of the master's thesis (maximum duration: 25 minutes);
 - the defence of the master's thesis (oral examination), and
 - an examination from the module to which the master's thesis is assigned.The module is determined by the officer responsible for study matters of the university to which the student is admitted on a proposal by the candidate. The total duration of the master's degree examination before a committee is generally 60 minutes and shall not exceed 75 minutes.
- (6) The master's examination senate consists of the supervisor of the master's thesis and two further members nominated by the Dean of Studies after hearing the candidate's suggestion. The senate is chaired by a member of the examination senate who is not the supervisor of the master's thesis.
- (7) The grade of the examination before a committee is determined by the examination senate.

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- (8) In order to assist students in completing their degrees in a timely manner, courses with continual assessment must allow students to submit, supplement or repeat partial course requirements, in any case at least one partial course requirement to be determined by the course director, by no later than four weeks after the course has ended. If the registration period for a key course ends within this time frame, this possibility must be extended until the end of the registration period. Laboratory courses are excluded from this regulation.

§ 15. Degree certificate

- (1) The master's degree programme is completed by attaining a positive assessment of the courses of all the compulsory and elective modules, the free-choice subject, the master's thesis and the master's degree examination before a committee.
- (2) A degree certificate shall be issued for successful completion of the degree programme. The degree certificate for the master's degree programme in Biorefinery Engineering contains
- a list of all modules (examination subjects) according to § 4 above (including the ECTS credit points) and their assessments;
 - the title and the assessment of the master's thesis;
 - the assessment of the final examination before a committee;
 - the entirety of the ECTS credit points for the free-choice subject according to § 10 above, and
 - the overall assessment.

The overall assessment "pass" shall be awarded for the degree programme if every module, the master's thesis and the master's degree examination before a committee have been assessed positively. The overall assessment "pass with distinction" shall be awarded if no module nor the master's thesis and the examination before a committee has been awarded a lower assessment than "good" and if at least half of the assessments awarded (modules, master's thesis, examination before a committee) are "very good".

V Legal validity and transitional provisions

§ 16. Legal validity

This curriculum 2017 (TUGRAZonline abbreviation 17U) shall come into effect on 1 October 2017.

Annex to the curriculum for the master's degree programme in Biorefinery Engineering

Annex I

Module descriptions and type of performance review

Unless otherwise indicated in the module description, the performance review for a module is carried out through the completion of all the examinations for courses and the courses with continual assessment prescribed in the module.

Module A	Engineering Basics
ECTS credit points	13
Content	<ul style="list-style-type: none"> • Laws of thermodynamics • Heat conduction and important applications of thermodynamic concepts in technology • Graphic representation of state variables, thermal equations of state for pure substances, Gibbs thermodynamics, application of Maxwell relations, caloric standard data, thermodynamics of mixtures, calculation of equilibria • Basics of computerised design of chemical plants • Kinetics and transport processes
Intended learning outcomes	<p>After completion of the module, students are capable of</p> <ul style="list-style-type: none"> • understanding and describing the concepts and theorems of thermodynamics; • applying their knowledge to the analysis of thermodynamic processes; • applying the first and second law of thermodynamics to systems (ideal and real gas) and the equilibria of heterogeneous systems (chemical equilibrium, phase transitions); • understanding different methods used for the calculation of material properties, phase and reaction equilibria in process engineering basic operations and plants and assessing magnitudes with these methods; • assessing the possibilities and limitations of computerised design of chemical plants and basic operations, and • establishing or calculating flow diagrams of systems and basic operations using Aspen.
Teaching and learning activities and methods	Lecture, exercise
Frequency	Every academic year

Module B	Mass and Heat Transfer
ECTS credit points	12.5
Content	<ul style="list-style-type: none"> • Basics of the transport of mass and momentum of moving fluids • Comprehensive insight into the dynamics of incompressible frictional and frictionless movements • Basics of diffusive and convective transport of thermal energy and components in mixtures • Introduction to thermal separation processes • Calculation methods and interpretation methods for the separating operations absorption, distillation and extraction
Intended learning outcomes	<p>After completion of the module, students are capable of</p> <ul style="list-style-type: none"> • solving problems of heat conduction, convective heat transfer, diffusive mass transport and convective mass transfer in multiphase systems; • applying what they have learnt to practical problems in chemical technology, and • calculating thermal basic operations by various methods and estimating orders of magnitude.
Teaching and learning activities and methods	Lecture, exercise, lecture with integrated exercises
Frequency	Every academic year

Module C	Chemical and Analytical Aspects of Biorefinery
ECTS credit points	7
Content	<ul style="list-style-type: none"> • Analytical methods: theoretical and practical introduction to direct analytical methods for the identification of bio-based materials • Conversion and processing of bio-based materials, theoretical and practical introduction to viscose preparation and processing • Detailed overview of the categories of bio-based materials, from biopolymers to proteins or DNA • Introduction: how new materials with defined properties can be produced by means of chemical reactions or physical separation • Strategies for tuning bio-based materials both in the bulk and on the surface
Intended learning outcomes	<p>After completion of the module, students are capable of</p> <ul style="list-style-type: none"> • understanding and applying basic and advanced bioanalytical methods; • analysing and interpreting data independently and in a team, and assessing challenges in analytical work; • classifying and analysing bio-based materials; • processing bio-based materials; • understanding functionalisation strategies for influencing the material properties of bio-based materials and applying these, depending on the functional groups and the bio-based materials themselves; • combining bio-based materials with other materials, producing and assessing so-called composite materials, and • communicating on a technical basis in an interdisciplinary environment.
Teaching and learning activities and methods	Lecture, laboratory course
Frequency	Every academic year

Module D	Biorefinery Economic, Ecological and Social Aspects
ECTS credit points	9
Content	<ul style="list-style-type: none"> • Basic methods of developing project ideas • Principles of the biotechnological market • Stakeholders' interests, analyses and maps • Terminology of the international life-cycle assessment (LCA) discourse • Bioeconomic innovations with the aim of substituting fossil fuels • Economic state of the art for biorefineries and study of the influence of biorefinery on products and economic developments
Intended learning outcomes	<p>After completion of the module, students are capable of</p> <ul style="list-style-type: none"> • understanding strategies of the biotechnological industry; • understanding and presenting the role of the availability of raw materials; • understanding and assessing the influence of biorefineries on the markets, as well as understanding typical business models of biorefinery; • presenting relevant aspects of innovation management; • developing business models for circular biotechnological projects and products; • critically analysing economic evaluation methods; • developing LCA structures by ISO standards; • selecting suitable economic evaluation procedures and allocation principles; • applying LCA tools to specific biological value chains; • understanding and assessing the role of the availability and the complexity of raw materials combined with biorefinery; • acting as experts for biogenic problems along the value chain in an interdisciplinary environment, and • working on technical issues in groups and taking on an individual role in the team.
Teaching and learning activities and methods	Lecture, exercise, seminar
Frequency	Every academic year

Module E	Bioresources
ECTS credit points	9
Content	<ul style="list-style-type: none"> • Definitions and overview of the current state of biorefineries • Discussion of potential obstacles, perspectives and opportunities of biorefineries • Relationships between the technical application of biotechnological basic operations and the specific properties of catalysts used in biotechnology • Main components of plant-based value chains • Special features, properties and potential technical uses of main crop plants
Intended learning outcomes	<p>After completion of the module, students are capable of</p> <ul style="list-style-type: none"> • describing the main types of biorefineries; • understanding and applying the linking of kinetics and transport processes for the planning and development of industrial biotechnological processes; • applying the quantitative rules of the technical applications of biotechnological basic operations using examples from industry; • assigning the required cultivation areas to the mass flows of different phytonutrients, and • setting up mass and energy balances from the field to the product.
Teaching and learning activities and methods	Lecture, exercise
Frequency	Every academic year

Module F	Biorefinery Technologies
ECTS credit points	6.5
Content	<ul style="list-style-type: none"> • Overview of the availability and composition of biomass from lignocellulose • Wood treatment and processing, alternative raw materials • Pulp production • Important process steps of lignocellulosic biorefinery • Mechanical separation processes in the bio-based industry • Thermal separation processes in the bio-based industry (including membrane processes)
Intended learning outcomes	<p>After completion of the module, students are capable of</p> <ul style="list-style-type: none"> • understanding different pulping processes and their impacts on products and raw materials; • understanding and interpreting the essential basic operations of the reprocessing of bio-based materials, and • creating or developing a data basis in order to make an appropriate selection for a given separation task.
Teaching and learning activities and methods	Lecture, exercise
Frequency	Every academic year

Module G	Biorefinery and Energy Systems
ECTS credit points	6
Content	<ul style="list-style-type: none"> • Basics of the thermochemical conversion of biomass • Biomass feedstocks and their characterisation • Application of the main thermochemical conversion processes • Polygeneration of biomass • Technical and economic analysis of plant concepts • Overview of the determinant elements in electrical power systems, their functions and relevant parameters • The concept of electrical efficiency, energy flow and system dynamics • Safety measures
Intended learning outcomes	<p>After completion of the module, students are capable of</p> <ul style="list-style-type: none"> • naming and describing thermochemical conversion processes; • understanding concepts of the production of heat, electricity and fuels based on the thermochemical conversion of biomass; • identifying possible transformation processes depending on the particular biomass feedstock, and developing plant concepts for them; • defining mass and energy balances for plant concepts for heat and/or power generation and calculating the basic operating parameters; • performing simple technical and economic analyses for the meaningful implementation of plant concepts; • making estimations for units and system layouts; • defining grid structures and functional units as well as their role in the electrical power system, and • critically analysing financial aspects of the impacts of electricity markets on electrical power systems, and the production processes as well as the user behaviour.
Teaching and learning activities and methods	Lecture
Frequency	Every academic year

Module H	Biorefinery Project
ECTS credit points	7
Content	<ul style="list-style-type: none"> • Solving a scientific or design problem • Presenting the results in the form of a scientific report and an oral presentation • Excursion to a company related to and/or relevant for biorefinery • Working independently on a technical problem in the field of biorefinery • Working on a problem in a(n) (interdisciplinary) team
Intended learning outcomes	<p>After completion of the module, students are capable of</p> <ul style="list-style-type: none"> • using the knowledge acquired in previous courses to solve scientific problems; • documenting results in an appropriate form; • independently applying the principles and methods of scientific work; • presenting results; • taking on leadership tasks in an interdisciplinary team; • working on a task in a group; • applying theoretical knowledge to real tasks; • understanding and independently working on a practical task in an industrial and/or scientific environment; • solving a task based on complete and incomplete data sets, and • compiling a schedule for a project and estimating the duration of the own activities.
Teaching and learning activities and methods	Project, excursion
Frequency	Every academic year

Annex II

Recommended courses for the free-choice subject

Free-choice courses can be freely chosen from the courses offered at any recognised Austrian and foreign universities, as well as any Austrian universities of applied sciences and university colleges for education according to § 10 of this curriculum.

In order to broaden students' basic knowledge in the modules of this degree programme, courses in foreign languages, social competence, technology assessment and women's and gender studies are recommended. In particular, we would like to refer students to the courses offered by the TU Graz service department Languages, Key Competencies and In-House Training or treffpunkt sprachen of Uni Graz, the Centre for Social Competence of Uni Graz as well as the Inter-University Research Centre for Technology, Work and Culture (IFZ).

Please note that courses for the free-choice subject may also be chosen from the catalogues of electives.

Additionally the following course is recommended:

Course	SSt	Type	ECTS	Semester
Tutorial Thermodynamics	2	UE	2	I

Annex III

Admission to the degree programme

Admission for graduates of the bachelor's degree programme in Chemistry

Graduates of the bachelor's degree programme in Chemistry offered as part of NAWI Graz are admitted to this master's degree programme in Biorefinery Engineering, whereby the following courses of the bachelor's degree programme in Chemical and Process Engineering must be completed as part of the master's degree programme according to § 2 (3) above:

Admission module 1: Introduction for graduates of the bachelor's degree programme in Chemistry			
Course	SSt	Type	ECTS
Mass and Energy Balances	2	VU	3
Chemical Reaction Engineering I	3	VU	4
Total for the admission module 1	5		7

The course "Mass and Energy Balances" (3 ECTS credit points) is assigned to the elective module and the course "Chemical Reaction Engineering" (4 ECTS credit points) is assigned to the free-choice subject.

If the prescribed courses were already completed as part of the bachelor's degree programme that grants admission to the master's degree programme, § 2 (4) of this curriculum shall apply accordingly.

Annex IV

Types of courses offered by TU Graz

The types of courses are defined in the relevant regulations of the standard curriculum (decision of the Senate of Graz University of Technology dated 6 October 2008, announced in University Gazette No. 5 dated 3 December 2008), as follows:

1. Lectures (VO)

In lecture-type courses, students are given a didactically well-structured introduction to the sub-areas of the subject and its methods. In lectures, the content and methods of a subject are presented.

2. Exercise-based courses (UE, KU, PT, EX)

In exercises, abilities and skills are taught as part of a scientific pre-vocational education to deepen or broaden the subject matter of the respective lectures. These exercises may comprise practical, experimental, theoretical or design work. The curriculum may specify that the successful completion of the exercise is a requirement to register for the examination of the respective lecture.

a) UE

In exercises, students develop the ability to apply their subject knowledge to solve specific problems.

b) KU

In design exercises, abilities and skills are taught as part of a scientific pre-vocational education to deepen or broaden the subject matter of the respective lectures by means of design work. Special equipment or a specially equipped room is required.

c) PT

In projects, experimental, theoretical or design applied work is carried out, or small research papers are written, taking into account all necessary steps. Projects are completed with a written paper that is part of the assessment. Projects can be carried out as teamwork or individual work; in the case of teamwork, it must still be possible to assess individual performance within the team.

d) EX

Excursion-type courses help to illustrate and consolidate the content of this type of course. Due to their practical relevance outside the place of study, excursions help to illustrate the content developed in other types of courses.

3. Lecture with integrated exercises (VU)
In addition to the introduction in sub-areas of the subject and its methods, lectures with integrated exercises (VU) also offer guidance on independent acquisition of knowledge or independent application using examples. The percentage of lectures and exercises is specified in the curriculum. These courses are courses with continual assessment.
4. Laboratory courses (LU)
Laboratory courses (LU) deepen and/or broaden the subject matter of the respective lectures by means of practical, experimental or design work. Students are taught abilities and skills as part of a scientific pre-vocational education and training with particularly intensive tutoring. An essential component of the laboratory courses is the drawing up of short logs on the work carried out.
5. Seminar-type courses (SE, SP)
Seminar-type courses enhance scientific work and discussion, and are intended to introduce students to expert-level discourse and argumentation. In this context, students must write papers or give an oral presentation and take part in critical discussions. Seminars are courses with continual assessment.
 - a) SE
Seminars introduce students to scientific methods, to the development and critical assessment of their own work results, to special topics in scientific literature and provide them with exercises in technical discussions.
 - b) SP
In seminar projects, students apply scientific methods to work on experimental, theoretical or design applied problems; or they carry out short research assignments, taking into account all the necessary steps. Seminar projects are completed with a written paper and an oral presentation that are part of the assessment. Seminar projects can be carried out as teamwork or individual work; in the case of teamwork, it must still be possible to assess individual performance within the team.
6. Orientation course¹ (OL)
Orientation courses introduce students to the study programme. They are intended to provide information and an overview of the study programme. Participation in these courses is compulsory.

The regulations referred to at the beginning also encompass provisions concerning the implementation and assessment of the different types of courses. In particular, they stipulate the following:

¹ Orientation courses are indicated in the "Study Law" chapter of the TU Graz Statute (decision of the Senate dated 24 June 2013, announced in the University Gazette dated 7 August 2013), but not in the abovementioned Guideline.

In lectures (type of course VO), the assessment takes place by way of a final examination that – at the discretion of the examiner – may be a written examination, an oral examination, a written and an oral examination, as well as a written or an oral examination. The examination procedure must be announced in the course description.

Courses of the type VU, SE, SP, UE, KU, PT, EX and LU are courses with continual assessment.

Abbreviations used in this curriculum: EX: excursion; KU: design exercise; LU: laboratory course; LV: course; OL: orientation course; PT: project; SE: seminar; SP: seminar project; SS: summer semester; SSt: semester hours; UE: exercise; VO: lecture; VU: lecture with integrated exercises; WS: winter semester