M.Sc.

Hydrogen Technology

Dean of Studies: Prof. Dr.-Ing. Johannes Völkl

Valid for students starting the program winter semester 2022/2023

(SPO 20221)

Module catalogue

This version is under constant development by the responsible lecturer. It is applicable to lectures, lab or computer courses. All regulations and provisions are in accordance with the university study regulations.

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1 Study and examination regulations

The current valid study and examination regulations of the University of Applied Science Rosenheim can be found on the homepage:

https://www.th-rosenheim.de/home/infos-fuer/studierende/studienorganisation/formalia/studienregelungen/studien-und-pruefungsordnungen/

2 Programme content and organization

2.1 Programme description

The master's programme Hydrogen Technology is developed to give students an application-oriented education focused on Hydrogen. The goal is to deepen and specialize one's knowledge in production, storage, transport and application of Hydrogen, and related fields. The programme offers modules to gain in-depth technological as well as applied and competence-oriented knowledge. The theoretical base is supplemented with a project within the area of Hydrogen Technology and current challenges of applied research and development projects.

To achieve this goal the programme is organized as a combination of compulsory fundamental modules; specialization modules with a stronger theoretical background; application and competence-oriented modules; as well as a project thesis including a project seminar. The programme is completed with a master's thesis.

All students must take the compulsory modules HTF 01 "Fundamentals of Hydrogen and Safety" and HTF 02 "Scientific methods and writing." This corresponds to 10 CP.

From the Specialization and Application & Competence-oriented Elective Modules a total of 40 CP must be earned to complete the programme. One must select at least 10 CP from the Specialization group and 10 from the Application & Competence-oriented group. The modules and their assignment to these groups are summarized in this module handbook and may be updated by the faculty board.

The theoretical foundation is supplemented by a project thesis, with an accompanying project seminar, on topics from the area of Hydrogen Technology and current challenges of applied research and development projects. This corresponds to 10 CP.

The independent and creative application of knowledge on a problem from Hydrogen Technology is demonstrated in the master's thesis at the end of the programme. The thesis is worth a total of 30 CP.

2.2 Recommended programme organization

Table 1: Recommended programme organization

Semester	Module number	Module name	Module group	CP
1	HTF 01	Fundamentals of Hydrogen and Safety	Compulsory	5
	HTF 02	Scientific Methods and Writing	Compulsory	5
	HTS		Specialization	10
	HTS		Application & Competence-oriented	10
2	HTS		Specialization	10
	HTS		Application & Competence-oriented	10
	HTM 01	Project Thesis		10
3	HTM 02	Master's Thesis		30
Total				**90**

At least 10 CP must be earned from the module group "Specialization."

At least 10 CP must be earned from the module group "Application & Competence-Oriented."

In total, 40 CP must be earned from the groups "Specialization" and "Application & Competence-Oriented."

3 Elective modules

In the following the modules, which can be selected in the “Hydrogen Technology” master’s programme are listed. Besides the compulsory courses the courses are classified into the following groups:

- Specialization
- Application & Competence-Oriented

The course listed in Table 2 and 3 show the current classification of courses and whether the course is being held in summer or winter semester.

In accordance with §5 of the study regulations, it is possible to select courses from the catalogue of the University of Applied Science Rosenheim or other Universities, which are not listed in Table 2 and 3. This selection must be approved by the programme’s examination board. The approval must be carried out for each student individually. These courses must match the technical and academic profile of the “Hydrogen Technology” master’s programme. Students receive information from the examination board in advance, if the selection is approvable. The corresponding application for approval can be found on the homepage of the master’s programme.

Table 2: Module list in winter term

Module		Compulsory group	Specialization group	Application & Competence-oriented group
HTF 01	Fundamentals of Hydrogen and Safety	**X**		
HTS 01	Chemical H_2 Conversion: Applications and Industrial processes			**X**
HTS 02	Homogeneous Catalysis			**X**
HTS 06	Hydrogen Storage, Transport and Distribution Systems		**X**	

Table 3: Module list in summer term

Module		Compulsory group	Specialization group	Application & Competence-oriented group
HTF 01	Fundamentals of Hydrogen and Safety	**X**		
HTF 02	Scientific Methods and Writing	**X**		
HTS 04	Advanced Thermodynamics for Hydrogen Applications		**X**	
HTS 05	Sources and Generation of Hydrogen		**X**	
HTS 03	Energy Politics and Laws			**X**
HTS 07	Electrochemical Process Engineering		**X**	
HTS 08	Techno-economic Analysis and Simulation			**X**

4 Regulations and Provisions

4.1 Project thesis with project seminar

A list of possible project topics is provided in the learning campus. The student contacts supervisors early to discuss details of the topic and to define the scope of the work. The start of a topic not present on the list is possible. All project theses deal with challenges in the field of Hydrogen Technology. A summary of the regulations and provisions is shown in Table 4.

Table 4: Regulations and provisions for the project thesis

Topic generation	A list of project topics is given in the learning campus. Details and the specific scope are to be discussed with the supervisors. The title does not need to be in the project list.
Thesis application	The student has to apply for the allocation of the topic to the regulation board after the student and the supervisor agree on a topic and its scope. The application form is in the learning campus. The application procedure is shown in Figure 1.
Examiner	The student nominates an examiner for the project thesis in the application process. The nomination is approved by the examination board. The examiner is responsible for the assessment of the project thesis.
Examinations	The project thesis with project seminar consists of one Admission Requirement and two successful examinations. • Admission Requirement: after discussing the topic and the objective with the desired supervisor, these topics are presented to the other students in a seminar. The admission requirement consists of the presentation and the participation in these seminars. The dates will be communicated in the learning campus. • Oral Examination: a seminar presentation of the project thesis in the module's project seminar is required. This examination consists of 20 minutes of presentation and 10 minutes of discussion. The examination is held during the lecture term. The seminar date is assigned by the student secretary in coordination with the supervisor. As an alternative, the presentation can also be given as part of an academic or technical conference in the presence of the examiner.

- Written project thesis: the thesis is submitted as a written scientific report. The submission deadline is defined in the application form for the project topic. The deadline should be in the semester term in which the project thesis was started. The report should be submitted in a digital format such as a pdf-file.

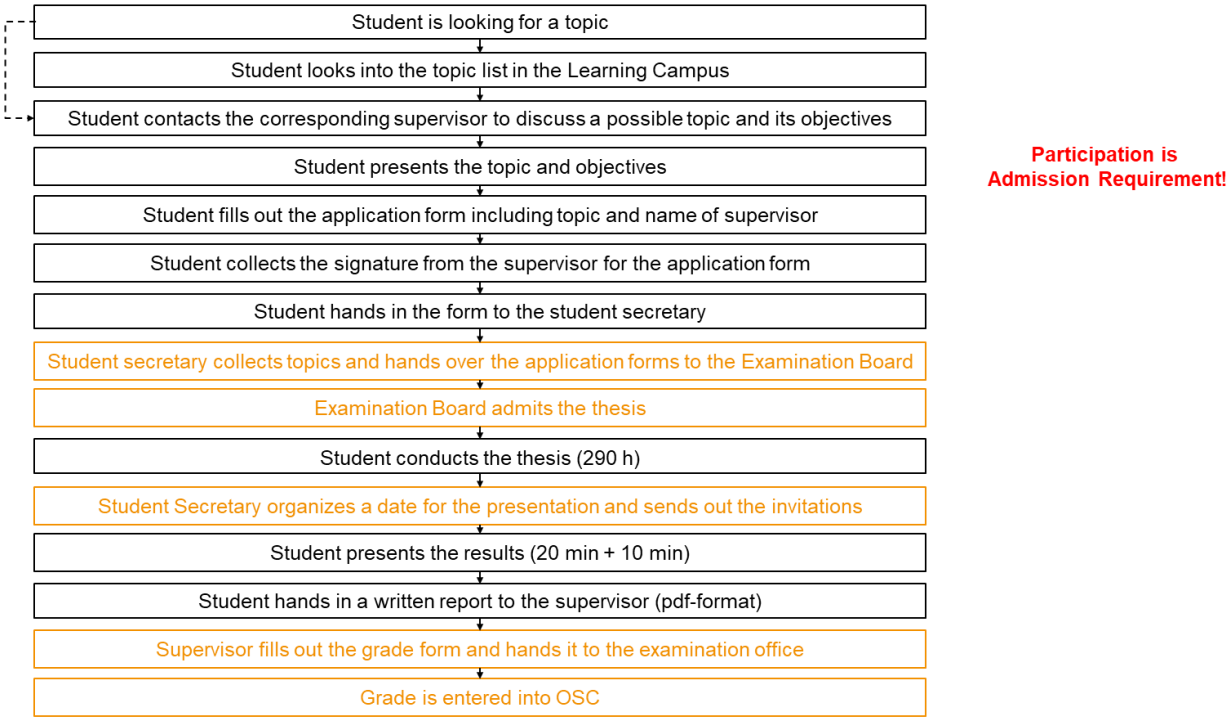

Figure 1: Process for application and subsequent procedures for the Project Thesis

4.2 Record of attendance

In accordance with the study regulations, there is compulsory attendance for the following modules:

- HTF 01: Fundamentals of Hydrogen and Safety
- HTS: Specialization and Application & Competence-Oriented Elective Courses
- HTM 01: Project Thesis including Project Seminar

4.2.1 Record of attendance for HTF 01 Fundamentals of Hydrogen and Safety

The record of attendance for this course is defined in the beginning of the semester by the lecturer. The announcement is published by the examination office.

4.2.2 Record of attendance for HTS: Specialization and Application & Competence-Oriented Elective Courses

The record of attendance for this course is defined in the beginning of the semester by the lecturer. The announcement is published by the examination office.

4.2.3 Record of attendance for Project Thesis with Project Seminar

Attendance is verified by a personal signature on the participation list.

The student has to attend all seminar presentations held in the class in which the project thesis was started.

5 Module catalogue

5.1 Compulsory Modules

5.1.1 HTF 01: Fundamentals of Hydrogen and Safety

Module Responsible	Prof. Dr.-Ing. Johannes Völkl
Lecturer	Prof. Dr.-Ing. Philipp Keil, Prof. Dr.-Ing. Wolfgang Arlt
Module Group	Compulsory
Module Duration	1 semester
Term	Winter / Summer
Course Type	• Lecture: 80% • Exercise: 20% • Computer Course: 0% • Lab Course: 0%
Credit Points (ECTS)	5
Weekly Working Hours	4
Total Workload	150 hours
Prerequisites	Fundamental understanding of (chemical) engineering
Learning Goals	Basic and advanced understanding of Hydrogen, its properties and characteristics and the main aspects of the safe handling, storage and transport of Hydrogen
Content	• Repetition of (chemical) engineering fundamentals • Fundamental properties of Hydrogen • Thermodynamic characteristics of Hydrogen and its applications • Safety topics regarding the handling, storage and transport of Hydrogen
Material	Lecture notes as downloadable files (learning campus)

Examination	Admission requirements, type and duration according to Study Regulations (SPO), updated at the beginning of each term, announcements published by the examination office
Literature	Specific literature for each chapter, current papers, will be announced during lectures

5.1.2 HTF 02: Scientific Methods and Writing

Module Responsible	Prof. Dr.-Ing. Johannes Völkl
Lecturer	Tbd
Module Group	Compulsory
Module Duration	1 semester
Term	Winter / Summer (starting summer term 2023)
Course Type	• Lecture: tbd • Exercise: tbd • Computer Course: tbd • Lab Course: tbd
Credit Points (ECTS)	5
Weekly Working Hours	
Total Workload	150 hours
Prerequisites	
Learning Goals	
Content	
Material	
Examination	Admission requirements, type and duration according to Study Regulations (SPO), updated at the beginning of each term, announcements published by the examination office
Literature	Specific literature for each chapter, current papers, will be announced during lectures

5.1.3 HTM 01: Project Thesis with Project Seminar

Module Responsible	Prof. Dr.-Ing. Johannes Völkl	
Lecturer	Nominated by the examination board	
Module Group	Compulsory	
Module Duration	1 semester	
Term	Winter	
Course Type	Project thesis with presentation in a project seminar	
Credit Points (ECTS)	10	
Weekly Working Hours		
Total Workload	Total	300 hours
	Project thesis work:	290 hours
	Seminar with own presentation:	10 hours
Prerequisites	None	
Learning Goals	The learning goals should include the following competencies as defined by "Qualifikationsrahmen für die Deutschen Hochschulabschlüsse" for master's programs in Germany: • Instrumental Competencies Knowledge and understanding as well as competencies for solving problems in new situations • Systemic competencies o Dealing with complex challenges o Making decisions based on academic and scientific principles, even under uncertainties o Acquiring new knowledge independently o Working independently on an extensive academic and scientific topic • Communication competencies o Present one's own scientific conclusions to an audience of experts and non-experts in a clear and meaningful way o Discuss scientific topics, challenges and ideas with experts and non-experts	

	The project report and presentation are supporting the general study goal of generating and deepening language, presentation and communications skills. Collaborative skills are trained by working on a scientific topic with other people and discussing challenges and results within a project team.
Content	• Literature research • Definition of the problem to be solved • Planning of experiments and steps to solve the problem • Experimental work and/or academic research • Preparation of a project report and a project presentation
Material	Material provided by the supervisor, own research
Examination	• Oral Examination: A seminar presentation of the project thesis in the course's project seminar is required. This examination consists of 20 minutes of presentation and 10 minutes of discussion. The examination is held during the lecture term. The seminar date is assigned by the student secretary in coordination with the supervisor. As an alternative, the presentation can also be given as part of an academic or technical conference in the presence of the examiner. • Written project thesis: The thesis must be handed in as a written scientific report. The submission deadline is defined with the application form for the project topic. The deadline should be within the semester term in which the project thesis was started. The report should be submitted in a digital format, such as a pdf-file.
Literature	

5.1.4 HTM 02: Master's Thesis

Module Responsible	Prof. Dr.-Ing. Johannes Völkl
Lecturer	Nominated by the examination board
Module Group	Compulsory
Module Duration	1 semester
Term	Winter / Summer
Course Type	Master's thesis
Credit Points (ECTS)	30
Weekly Working Hours	
Total Workload	Total 900 hours
Prerequisites	30 CP required to apply for a thesis topic (according to study regulations of the "Hydrogen Technology" master's program)
Learning Goals	The learning goals include the following competencies as defined by "Qualifikationsrahmen für die Deutschen Hochschulabschlüsse" for master's programs in Germany: • Instrumental Competencies Knowledge and understanding as well as competencies for solving problems in new situations • Systemic competencies o Dealing with complex challenges o Making decisions based on academic and scientific principles, even under uncertainties o Acquiring new knowledge independently o Working independently on an extensive academic and scientific topic • Communication competencies o Present one's own scientific conclusions to an audience of experts and non-experts in a clear and meaningful way o Discuss scientific topics, challenges and ideas with experts and non-experts

	The report and presentation of the results of the master's thesis support the general study goal of acquiring and deepening language, presentation and communication skills. Collaborative skills are trained by working on a scientific topic with other people and discussing challenges and results within a project team.
Content	• Literature research • Definition of the problem to solve • Planning of experiments and steps to solve the problem • Experimental work and/or academic research • Preparation of a report and presentation
Material	Material provided by the supervisor, own research
Examination	• Oral Examination: The oral examination is a seminar presentation of the project thesis within the course's project seminar. This examination consists of 20 minutes of presentation and 10 minutes of discussion. The examination is held during the lecture term. The seminar date is assigned by the dean of studies in coordination with the supervisor. Alternatively the presentation is given as part of an academic or technical conference if the examiner is present. • Written project thesis: The thesis is a written scientific report. The submission deadline is defined in the application form. The deadline is in the semester term in which the project thesis was started. The report is submitted in a digital format, such as a pdf-file.
Literature	

5.2 Module Group: Specialization and Application & Competence-Oriented

5.2.1 HTS 01: Chemical H_2 Conversion: Applications and Industrial Processes

Module Responsible	Prof. Dr.-Ing. Johannes Völkl
Lecturer	Prof. Dr.-Ing. Johannes Völkl
Module Group	Application & Competence-Oriented
Module Duration	1 semester
Term	Winter
Course Type	• Lecture: 50% • Exercise: 50% • Computer Course: 0% • Lab Course: 0%
Credit Points (ECTS)	5
Weekly Working Hours	4
Total Workload	150 hours
Prerequisites	Basic knowledge in Chemistry, Thermodynamics and (Process) Modeling
Learning Goals	Students acquire in-depth knowledge of Hydrogen conversion processes • Understanding the different routes for Hydrogen conversion based on desired products and the origin of hydrogen • Understanding the material cycle of the chemical industry and bringing this understanding into the context of new developments • Comparing different routes based on economic and sustainability quality parameters • Analyzing the different processes to get all reactants for the conversion processes around Hydrogen • Deepening the understanding of Hydrogen conversion processes by working on an individual case study of a selected example of a Hydrogen conversion process

Content	• Overview of Hydrogen conversion processes • Overview of the material cycle of the chemical industry • Overview of different sources for all important components of the material cycle • Introduction of economic and sustainability performance indicators • Comparison of different routes of hydrogen conversion processes • Individual case study on a selected example of a hydrogen conversion process
Material	Lecture notes as downloadable files (learning campus)
Examination	Admission requirements, type and duration according to Study Regulations (SPO), updated at the beginning of each term, announcements published by the examination office
Literature	Specific literature for each chapter, current papers, will be announced during lectures

5.2.2 HTS 02: Homogeneous Catalysis

Module Responsible	Prof. Dr. Dominik Pentlehner
Lecturer	Prof. Dr. Dominik Pentlehner
Module Group	Application & Competence-Oriented
Module Duration	1 semester
Term	Winter
Course Type	• Lecture: 50% • Exercise: 0% • Computer Course: 0% • Lab Course: 50%
Credit Points (ECTS)	5
Weekly Working Hours	4
Total Workload	150 hours
Prerequisites	Profound knowledge in Chemistry
Learning Goals	• Overview and knowledge of the catalytic methods in chemistry, e.g., heterogeneous, homogeneous, transition metal catalysis or organocatalysis • Understanding of the working principle (reaction mechanism) of homogeneous catalysts • Ability to run experiments under inert atmosphere
Content	• Definitions, advantages and disadvantages compared to other catalytic methods • Reaction mechanisms and experimental setups for homogeneous catalysis • Organometal-chemistry and transition metal catalysis • Organocatalysis • Stereoselective reactions • Photocatalysis
Material	Lecture notes as downloadable files (learning campus)

Examination	Admission requirements, type and duration according to Study Regulation (SPO), updated at the beginning of each term, announcements published by the examination office
Literature	Specific literature for each chapter Overview: Breitmaier, E., Jung, G.: Organic Chemistry; Thieme

5.2.3 HTS 03: Energy Politics and Laws

Module Responsible	Prof. Dr.-Ing. Johannes Völkl
Lecturer	Prof. Dr.-Ing. Dipl. Wirtsch.-Ing. Rudolf Hiendl
Module Group	Application & Competence-Oriented
Module Duration	1 semester
Term	Winter
Course Type	• Lecture: 100% • Exercise: 0% • Computer Course: 0% • Lab Course: 0%
Credit Points (ECTS)	5
Weekly Working Hours	4
Total Workload	150 hours
Prerequisites	None
Learning Goals	Basic understanding of Energy Politics and Laws with a special focus on Renewable Energy and Hydrogen Technology
Content	• Overview of Energy Politics • Overview of Energy Laws
Material	Lecture notes as downloadable files (learning campus)
Examination	Admission requirements, type and duration according to Study Regulations (SPO), updated at the beginning of each term, announcements published by the examination office
Literature	Specific literature for each chapter, current papers, will be announced during lectures

5.2.4 HTS 04: Advanced Thermodynamics for Hydrogen Applications

Module Responsible	Prof. Dr.-Ing. Johannes Völkl
Lecturer	tbd
Module Group	Specialization
Module Duration	1 semester
Term	Summer
Course Type	• Lecture: % • Exercise: % • Computer Course: % • Lab Course: %
Credit Points (ECTS)	5
Weekly Working Hours	4
Total Workload	150 hours
Prerequisites	Fundamental understanding of (chemical) engineering
Learning Goals	tbd
Content	tbd
Material	Lecture notes as downloadable files (learning campus)
Examination	Admission requirements, type and duration according to Study Regulation (SPO), updated at the beginning of each term, announcements published by the examination office
Literature	Specific literature for each chapter, current papers, will be announced during lectures

5.2.5 HTS 05: Sources and Generation of Hydrogen

Module Responsible	Prof. Dr.-Ing. Johannes Völkl
Lecturer	tbd
Module Group	Specialization
Module Duration	1 semester
Term	Summer
Course Type	• Lecture: % • Exercise: % • Computer Course: % • Lab Course: %
Credit Points (ECTS)	5
Weekly Working Hours	4
Total Workload	150 hours
Prerequisites	Fundamental understanding of (chemical) engineering
Learning Goals	tbd
Content	tbd
Material	Lecture notes as downloadable files (learning campus)
Examination	Admission requirements, type and duration according to Study Regulation (SPO), updated at the beginning of each term, announcements published by the examination office
Literature	Specific literature for each chapter, current papers, will be announced during lectures

5.2.6 HTS 06: Hydrogen Storage, Transportation and Distribution Systems

Module Responsible	Prof. Dr.-Ing. Johannes Völkl
Lecturer	Dr. Tim Bieringer
Module Group	Specialization
Module Duration	1 semester
Term	Winter
Course Type	• Lecture: 50% • Exercise: % • Computer Course: 50% • Lab Course: %
Credit Points (ECTS)	5
Weekly Working Hours	4
Total Workload	150 hours
Prerequisites	Fundamental understanding of (chemical) engineering
Learning Goals	Overview and knowledge of the requirements, challenges, and solutions for hydrogen storage and transportation in a carbon neutral economy. Knowledge, comparative analysis and application-oriented evaluation of technologies for the storage and transport of hydrogen.
Content	• Overview of Hydrogen storage methods • Overview of Hydrogen transport methods • Detailed discussion of selected storage methods • Detailed discussion of selected transport and distribution methods • Comparison of different methods to store and transport Hydrogenr
Material	Lecture notes as downloadable files (learning campus)
Examination	Admission requirements, type and duration according to Study Regulation (SPO), updated at the beginning of each term, announcements published by the examination office

Literature	Specific literature for each chapter, current papers, will be announced during lectures

5.2.7 HTS 07: Electrochemical Process Engineering

Module Responsible	Prof. Dr.-Ing. Johannes Völkl
Lecturer	tbd
Module Group	Specialization
Module Duration	1 semester
Term	Summer
Course Type	• Lecture: % • Exercise: % • Computer Course: % • Lab Course: %
Credit Points (ECTS)	5
Weekly Working Hours	4
Total Workload	150 hours
Prerequisites	Fundamental understanding of (chemical) engineering
Learning Goals	tbd
Content	tbd
Material	Lecture notes as downloadable files (learning campus)
Examination	Admission requirements, type and duration according to Study Regulation (SPO), updated at the beginning of each term, announcements published by the examination office
Literature	Specific literature for each chapter, current papers, will be announced during lectures

5.2.8 HTS 08: Techno-Economic Analysis and Simulation

Module Responsible	Prof. Dr.-Ing. Johannes Völkl
Lecturer	tbd
Module Group	Application & Competence-Oriented
Module Duration	1 semester
Term	Summer
Course Type	• Lecture: % • Exercise: % • Computer Course: % • Lab Course: %
Credit Points (ECTS)	5
Weekly Working Hours	4
Total Workload	150 hours
Prerequisites	Fundamental understanding of (chemical) engineering
Learning Goals	tbd
Content	tbd
Material	Lecture notes as downloadable files (learning campus)
Examination	Admission requirements, type and duration according to Study Regulation (SPO), updated at the beginning of each term, announcements published by the examination office
Literature	Specific literature for each chapter, current papers, will be announced during lectures