Programme-specific part of the Education and Examination Regulations 2024-2025

Graduate School of Geosciences: Master's degree programme in Energy Science

The programme of the starting year of the student is the leading programme. If the programme is adjusted, the transitional arrangements (conversion of former courses) will be published in the new Education and Examination Regulations.

The Master's degree programme *Energy Science* offers the programme *Energy Science*.

Art. 2.1 – Admission requirements

1. The following conditions for admission apply:

Admission to the **Energy Science** programme is granted to students with a Dutch or foreign diploma confirming that they have acquired the knowledge, insight and skills at the university Bachelor's level. Furthermore, students need to prove that they have gained the following specific knowledge, insight and skills:

a) knowledge of and insights in the field of natural sciences at the advanced level of the major *Global Sustainability Science (GSS)*, *Science and Innovation Management (NW&I)*, *Physics* or *Chemistry* at Utrecht University (or equivalent to that level)
b) knowledge of and insights in *Thermodynamics*, *Energy Analysis* and *Mathematics*
c) academic and quantitative research skills at the advanced level of the major *Global Sustainability Science (GSS)*, *Science and Innovation Management (NW&I)*, *Physics* or *Chemistry* at Utrecht University (or equivalent to that level)

2. Students will be selected based on objective standards regarding:
   a) their previous academic performance in a relevant subject area
   b) relevant skills
   c) their command of the language or languages used in the programme
   d) the following additional selection criteria with proven relevance for the opinion on the suitability of the candidate:
      - motivation
      - average grade

This information is used to consider whether the student concerned will be able to complete the Master's Programme successfully within the set time period.
The admission requirements have been formulated clearly and transparently so that candidates know in advance what requirements must be met in order to qualify for selection.

Art. 3.1 – Aim of the degree programme

1. The degree programme aims to:
   - provide students with specialised knowledge, skills and understanding in the field of *Energy Science* so that they can achieve the final qualifications as mentioned in Article 3.1.2
   - prepare students for professional employment in one or more disciplines of *Energy Science*
   - prepare students for training as researchers in the field of *Energy Science*

2. Graduates in *Energy Science*:

1. have advanced demonstratable knowledge and understanding of energy technologies and energy systems, including their dynamics and challenges in the context of the energy transition and sustainable development.
2. are able to conduct research on energy technologies and energy system dynamics and challenges in an original and independent way.
3. have the ability to apply knowledge, research methods, and problem-solving abilities in broader and novel contexts related to energy systems and the energy transition.
4. have insight into the uncertainties and complex interactions between the energy systems and society and are able to reflect critically upon their role to influence the energy transition.
5. are able to apply knowledge and understanding in such a way that they demonstrate an academic and professional approach to their work.
6. are able to communicate conclusions, as well as the knowledge, reasons and considerations underlying these conclusions, to an audience of specialists and non-specialists alike.
7. are able to study and work independently and explore new areas of interest in energy science or related fields.

Art. 3.6 – Components of the Master's programme

1. Appendices 1, 2 and 3 describe the required courses of the programme, including the course load per course.
2. Students may choose optional courses. The course load of the optional courses are listed in Appendices 1, 2 and 3. The rules for choosing optional courses are listed in Appendix 4.
3. The requirements for the Annotation Complex Systems can be found in Appendix 6.
4. The prospectus gives a detailed description of the content and type of courses in the programme, including prior knowledge that is required to participate successfully.

Art. 4.2 – Course admission requirements

The Executive Board decides the order in which the required components of a Master's degree programme must be completed. This has been listed in Appendix 5.

Art. 4.7 –Evaluation of the quality of education

1. The Director of Education monitors the quality of education, and ensures that both the courses and the curriculum are evaluated. The Director takes into consideration the advice and suggestions given by the Education Committee regarding improving and ensuring the quality of the programme.
2. Students are informed of the outcomes of the course and curriculum evaluations.

Appendices

Appendix 1: Exam programme Energy Science, cohort 2024

1. Compulsory components (60 EC)

-	Challenges of Energy Transitions	7.5 EC
-	Energy Conversion Technologies	7.5 EC
-	Data Analytics for Sustainability	7.5 EC
-	Advanced Energy Analysis	7.5 EC
-	Energy Systems Modelling	7.5 EC
-	Energy Systems Integration	7.5 EC
-	Consultancy Project ES	15 EC
-	Master's thesis	45 EC

2. Optional components (15 EC)
Students should select optional courses for a total of 15 EC.

Appendix 2: Exam programme Energy Science, track Systems Analysis, cohort 2023

1. Compulsory components (52.5 EC)

-	Energy in the Context of Sustainability	7.5 EC
-	Energy conversion Technologies I	7.5 EC
-	Energy conversion Technologies II	7.5 EC
-	Advanced Energy Analysis	7.5 EC
-	Energy Systems Modelling	7.5 EC
-	Consultancy Project ES	15 EC

2. Thesis components (30 EC or 45 EC)

-	Master's thesis	30 EC
-	Master's thesis	45 EC

3. Optional components (22.5 EC or 37.5 EC)
Students should select optional courses for a total of 22.5 EC or 37.5 EC.

4. Conversion of former courses

Old course 2023/2024	***New course 2024/2025***
Energy in the Context of Sustainability (GEO4-2514)	Challenges of Energy Transitions (GEO4-2525)
Students that have not passed Energy Conversion Technologies I (GEO4-2502) *or* Energy Conversion Technologies II (GEO4-2503)	Energy Conversion Technologies (GEO4-2526)

Students that have not passed Energy Conversion Technologies I (GEO4-2502) *and* Energy Conversion Technologies II (GEO4-2503)	Energy Conversion Technologies (GEO4-2526) *and* Energy Systems Integration (GEO4-2527)
Photovoltaic Solar Energy Physics (GEO4-2513)	Photovoltaic Solar Energy (BETA-MPHSE)

Appendix 3: Exam programme Energy Science, track Natural Science, cohort 2023

1. Compulsory components (97.5 EC)

-	Energy in the Context of Sustainability	7.5 EC
-	Energy Conversion Technologies I	7.5 EC
-	Energy Conversion Technologies II	7.5 EC
-	Advanced Energy Analysis	7.5 EC
-	Energy Systems Modelling	7.5 EC
-	Master's thesis	30 EC
-	Natural Science Research Project	30 EC

2. Optional components (22.5 EC)
Students should select natural science courses for a total of 15 EC.
Students should select other optional courses for a total of 7.5 EC.

3. Conversion of former courses

Old course 2023/2024	***New course 2024/2025***
Energy in the Context of Sustainability (GEO4-2514)	Challenges of Energy Transitions (GEO4-2525)
Students that have not passed Energy Conversion Technologies I (GEO4-2502) *or* Energy Conversion Technologies II (GEO4-2503)	Energy Conversion Technologies (GEO4-2526)
Students that have not passed Energy Conversion Technologies I (GEO4-2502) *and* Energy Conversion Technologies II (GEO4-2503)	Energy Conversion Technologies (GEO4-2526) *and* Energy Systems Integration (GEO4-2527)
Photovoltaic Solar Energy Physics (GEO4-2513)	Photovoltaic Solar Energy (BETA-MPHSE)

Appendix 4: Rules for choosing elective courses

1. Students in the Master's programme choose elective courses from another or their own Master's programme. Courses that are obligatory in the exam programme cannot be used as elective courses.
2. Honours programmes for Master's students (e.g. Young Innovators, GHIS, Leadership Programme) do not count towards the electives in the programme.
3. Electives as mentioned in the student's academic progress review in Osiris are pre-approved by the programme leader and by the Board of Examiners. Students can enroll for those courses via Osiris. It remains the student's responsibility to make sure that the points mentioned under 6 d-f are met. If the course is from another department than the Copernicus Institute, it may be that other students have priority and that they are therefore placed on a waiting list.
4. It is possible to choose other courses than the pre-approved courses mentioned in Osiris. Any non-pre-approved elective courses must be subjected in advance to the programme leader and the Board of Examiners for approval. The programme leader will advise the Board in this matter.
5. The application for a non-pre-approved elective is done by a written request (application form) to the programme leader. Written information on the content, the level, and the study load of the course (preferably by means of a copy of the course's description from the course catalogue) must be attached. The 'Application Form Elective courses Copernicus' can be found in the Blackboard community Energy Science.
6. The programme leader tests the proposed elective course(s) on the following criteria:
    a. It must be thematically linked to the Master's programme;
    b. It concerns a course at master level (M);
    c. There is no overlap in content with courses still to be taken or already taken.

    The student is responsible for making sure that:
    d. The course is available to students of the ES programme;
    e. The student fulfills the entrance requirements of the course (if applicable). Actual participation is only possible if students satisfy the course's entrance conditions; in case of doubt they should contact the course coordinator first;
    f. The course is not taught in the same period and timeslot as another course the student has selected.
7. If the programme leader has declared that the elective course(s) meet the criteria under 6a-c (by signing the application form or sending an email confirming the approval), the student sends the

signed application form (and email if applicable) and the course information to the Board of Examiners via Osiris Case. The Board of Examiners takes the final decision on whether or not the elective is approved.

8. In the programme's course schedule, room has been reserved for taking electives. However, the student is free to deviate from this planning, e.g. because they wish to take an interesting elective course in another period. If this causes delay in the study planning, the responsibility is for account of the student! Students are therefore advised to take their electives in the reserved periods and timeslots, or use a part of the time planned for their internship and/or Master's thesis.

Appendix 5: Entrance requirements and course exclusions 2024-25

Course	**Entry requirements/recommended prerequistes**
Sustainable Food Systems (GEO4-2005)	Letter of acceptance of a Master's programme
Innovation and International Development (GEO4-2009)	Letter of acceptance MSc Sustainable Development or MSc Innovation Sciences or MSc Sustainable Business & Innovation or MSc Energy Science or MSc Water Science and Management.
Imagining the Future for Transformation (GEO4-2010)	Letter of acceptance of a Master's programme
Data Analytics for Sustainability (GEO4-2011)	Letter of acceptance MSc Sustainable Development or MSc Innovation Sciences or MSc Sustainable Business & Innovation or MSc Energy Science or MSc Water Science and Management. Recommended pre-requisites: knowledge of R and Python
Changemaking Journeys: Transformational leadership for societal impact' (GEO4-2013)	Letter of acceptance MSc Sustainable Development or MSc Innovation Sciences or MSc Sustainable Business & Innovation or MSc Energy Science or MSc Water Science and Management.
Advanced Energy analysis (GEO4-2508)	Letter of acceptance of a Master's programme Recommended prerequisites: – Strong foundation of Energy Analysis and calculus – Knowledge of Energy Conversion Technologies
Master's thesis 30 EC (GEO4-2510)	– Only for cohort 2023 and earlier – Letter of acceptance MSc Energy Science – At least 45 EC passed within the programme Energy Science including one of two course packages: • Advanced Energy Analysis (GEO4-2508) • Energy Conversion Technologies I (GEO4-2502) • Energy Conversion Technologies II (GEO4-2503) • Energy Systems Modelling (GEO4-2515) or • Advanced Energy Analysis (GEO4-2508) • Energy Conversion Technologies (GEO4-2526) And 1 out of 2 courses: • Energy Systems Integration (GEO4-2527) • Energy Systems Modelling (GEO4-2515) Recommended prerequisites: – Consultancy Project (GEO4-2519)
Energy Systems Modelling (GEO4-2515)	Letter of acceptance of a Master's programme Recommended prerequisites: – Energy Analysis (GEO3-2223) – Advanced Energy Analysis (GEO4-2508)
Tailor made course ES (GEO4-2517)	– Letter of acceptance MSc Energy Science – At least 45 EC passed within the programme
Natural Science Research Project (GEO4-2518)	– Obligatory for and only open to students in the Natural Science track, cohort 2023 and earlier – Letter of acceptance MSc Energy Science Passed examinations of one of two course packages: – Advanced Energy Analysis (GEO4-2508) – Energy Conversion Technologies I (GEO4-2502) – Energy Conversion Technologies II (GEO4-2503) or • Advanced Energy Analysis (GEO4-2508) • Energy Conversion Technologies (GEO4-2526) And 1 out of 2 courses: • Energy Systems Integration (GEO4-2527) • Energy Systems Modelling (GEO4-2515) Recommended prerequisites: – At least one natural science elective – Energy Systems Modelling (GEO4-2515)

Consultancy project (GEO4-2519)	– Letter of acceptance MSc Energy Science – Open to students in track Systems Analysis, cohort 2023 and earlier – Open to students in Energy Science, cohort 2024 and later Recommended prerequisites: – Advanced Energy Analysis (GEO4-2508) – Energy Systems Modelling (GEO4-2515)
Internship Energy Science 22.5 EC (GEO4-2520)	– Only open to students in track Systems Analysis, cohort 2023 and earlier – Letter of acceptance MSc Energy Science – Passed examinations of one of two course packages: • Advanced Energy Analysis (GEO4-2508) • Energy Conversion Technologies I (GEO4-2502) • Energy Conversion Technologies II (GEO4-2503) • Energy Systems Modelling (GEO4-2515) or • Advanced Energy Analysis (GEO4-2508) • Energy Conversion Technologies (GEO4-2526) And 1 out of 2 courses: • Energy Systems Integration (GEO4-2527) • Energy Systems Modelling (GEO4-2515) Recommended prerequisites: – Consultancy Project (GEO4-2519)
Bio-based Economy (GEO4-2521)	– Letter of acceptance MSc Energy Science or MSc Innovation Sciences or MSc Sustainable Development or MSc Sustainable Business & Innovation or MSc Water Science and Management or MSc Chemistry Recommended prerequisites: – Advanced Energy Analysis (GEO4-2508) – Life Cycle Analysis (GEO3-2124; BSc course) – Sustainability Assessment and Management Tools (GEO4-2602) – Science and Technology for Sustainable Development (SK-BCHDO; BSc course)
Energy in the Built Environment (GEO4-2522)	– Letter of acceptance MSc Innovation Sciences or MSc Sustainable Development or MSc Sustainable Business & Innovation Recommended prerequisites: – Basic principles of energy flows in the built environment, i.e. electricity, heat and gas networks. – Basic knowledge on power system planning & operation and electricity markets.
Master's thesis 45 EC (GEO4-2523)	– Only for cohort 2023 and earlier – Letter of acceptance MSc Energy Science – At least 45 EC passed within the programme Energy Science including one of two course packages: • Advanced Energy Analysis (GEO4-2508) • Energy Conversion Technologies I (GEO4-2502) • Energy Conversion Technologies II (GEO4-2503) • Energy Systems Modelling (GEO4-2515) or • Advanced Energy Analysis (GEO4-2508) • Energy Conversion Technologies (GEO4-2526) And 1 out of 2 courses: • Energy Systems Integration (GEO4-2527) • Energy Systems Modelling (GEO4-2515) Recommended prerequisites: – Consultancy Project (GEO4-2519)
Master's thesis 45 EC (GEO4-2528)	– Only for cohort 2024 and later – Letter of acceptance MSc Energy Science – At least 45 EC passed within the programme Energy Science including: • Advanced Energy Analysis (GEO4-2508) • Energy Conversion Technologies (GEO4-2526) And 1 out of 2 courses: • Energy Systems Integration (GEO4-2527) • Energy Systems Modelling (GEO4-2515) Recommended prerequisites: • Consultancy Project (GEO4-2519)

Internship Energy Science 15 EC (GEO4-2524)	– Only open to students in track Systems Analysis, cohort 2023 and earlier – Letter of acceptance MSc Energy Science – Passed examinations of one of two course packages: • Advanced Energy Analysis (GEO4-2508) • Energy Conversion Technologies I (GEO4-2502) • Energy Conversion Technologies II (GEO4-2503) • Energy Systems Modelling (GEO4-2515) or • Advanced Energy Analysis (GEO4-2508) • Energy Conversion Technologies (GEO4-2526) And 1 out of 2 courses: • Energy Systems Integration (GEO4-2527) • Energy Systems Modelling (GEO4-2515) Recommended prerequisites: – Consultancy Project (GEO4-2519)
Challenges of Energy Transitions (GEO4-2525)	– Letter of acceptance MSc Energy Science
Energy Conversion Technologies (GEO4-2526)	Letter of acceptance of a Master's programme Recommended prerequisites: – Strong foundation of thermodynamics, heat transfer and calculus
Energy System Integration (GEO4-2527)	– Letter of acceptance MSc Energy Science or MSc Innovation Sciences or MSc Sustainable Development or MSc Sustainable Business & Innovation or MSc Water Science and Management Recommended prerequisites: • Energy Conversion Technologies (GEO4-2526) • Advanced Energy Analysis (GEO4-2508)
Techniques of Futuring (GEO4-5501)	Letter of acceptance of a Master's programme

Appendix 6: Annotation Complex Systems

Description
The Master's profile Complex Systems is an interdisciplinary profile for students who are interested to broaden their knowledge and expertise within the field of Complex Systems. In this research field societal issues, such as a financial crisis, a sudden epidemic or climate change are studied from a quantitative modelling perspective. Students will get an understanding of the various models used in the complexity field and the behaviour (i.e. transitions, predictability) of these models.
The aim of the Complex Systems Profile is for students to develop or improve their

- affinity for quantitative approaches in order to address societal issues,
- ability to build models that are amenable to quantitative approaches,
- familiarity with standard (quantitative) methods in the toolbox for analysing complex systems, and
- ability to work in interdisciplinary teams.

Learning outcomes
Upon completion of the Master's profile the student

- is able to recognise the complex systems aspects when confronted with a societal problem,
- is able to develop models of complex systems and/o has a good overview of model-building for complex systems,
- has a good overview of the methods in the complex systems toolbox, can apply them to models and extract quantitative results, and
- communicate/explain complex-systems models and methods to (interdisciplinary) teammates.

Programme
The Master's profile comprises 30 EC and consists of the following parts:

- Two electives (7.5 EC each) from the following courses (**one of these electives need to be from 1-3 below**, which are termed as **core courses** for Complex Systems):

1. Introduction to Complex Systems (WISM484)
2. Advanced Topics in Climate Physics (NS-MO411)
3. Computational Aspects of Machine Learning (NS-EX426M)
4. Mathematical Biology (WISL411)
5. A Complex Systems labelled course listed under a master programme that is **different** from the one to which the student is admitted (see list below). **Note on this list**: some programmes may require one of their own

primary elective courses, labelled as Complex Systems course to be taken; the student **cannot** count them as primary electives **as well as** Complex Systems master profile courses. More information can be found in the specific programme description section of the Education and Examination Regulations.

- A Research Project on a Complex Systems topic (15 EC, Osiris code GSNS- CSRP), for which focus should be on interdisciplinary aspects and at least two supervisors from two different departments/faculties must be involved.

The topic should not correspond to the topic of the master thesis, however if the master research project deals with a complex system subject – currently available only for Theoretical Physics, Experimental Physics and Climate Physics Master programmes at Utrecht University – it is permitted to combine the research project of the master's profile Complex Systems (15 EC) with the master thesis project. In case the master research project deals with a complex system subject, the complex systems aspects must be separately assessed and a supervisor from a different department or faculty other than the department related to the student's master programme needs to be involved in assessing the complex system aspects of the research project.

The topic must be approved by the coordinator of the profile as well as by the coordinator of the master programme to which the student is admitted.

The total number of EC of each master's programme will NOT be increased by completing the master profile Complex Systems. Students receive a certificate by completing the Master's profile Complex Systems.

List of courses labelled as a complex systems course:

Master's programme	Course	Osiris code
Artificial Intelligence	Evolutionary Computing	INFOEA
Climate Physics	Waves in Geophysical Fluids	NS-MO447M
Computing Science	Network Science	INFOMNWSC
Energy Science	Energy Systems Modelling	GEO4-2515
Experimental Physics	Modelling and Simulation Fundamentals of Biophysics AND Advanced Methods in Biophysics†	NS-TP432M NS-TP464M AND NS-EX433M
Game and Media Technology	Process Mining Crowd Simulation	INFOMPROM INFOMCRWS
Mathematical Sciences	Inverse Problems in Imaging* Numerical Methods for Partial Differential Equations*	WISL435 WISL602
Nanomaterials Science	Toy Models in Science and Technology Modelling and Simulation	BETA-MTOYM NS-TP432M
Sustainable Development	Systems Thinking, Scenarios and Indicators Environmental Systems Analysis Integrated Assessment of Climate Change	GEO4-2331 GEO4-2303 GEO4-2340
Theoretical Physics	Modelling and Simulation Fundamentals of Biophysics AND Stochastic Processes in Biophysics†	NS-TP432M NS-TP464M AND NS-TP465M
Multidisciplinary Economics	Algorithms in Finance	ECMAF

† These two courses can only be taken in combination with each other since individually they are 3.75 EC courses

* Registration via elo.mastermath.nl

Entry Requirements

- The student belongs to one of the participating master programmes
- Upon consultation with the coordinator for the profile, it is also possible for students from outside Utrecht University to participate in the profile, when their master programme has an affinity to complex systems

Participating Master's programmes

- Climate Physics
- Computing Science
- Energy Science
- Artificial Intelligence
- Experimental Physics
- Game and Media Technology
- Mathematical Sciences
- Nanomaterials Science
- Sociology and Social Research
- Sustainable Development
- Theoretical Physics
- Multidisciplinary Economics

Legacy issues

The following courses were labelled as Complex Systems courses in the past academic years (noted in parenthesis).

Master's programme	Course	Osiris code
Artificial Intelligence	Seminar Social Simulation (2018-19)	INFOMSOCS
Core courses	Algorithms in Finance (2018-19, 2019-20)	WISM410
	Complex Networks (2020-21)	WISL115
	Seminar Applications of Mathematics in Radiation Research (2018-19, 2019-20)	WISM409
	Understanding Complexity: Economy and the Planet (2018-19, 2019-20)	NS-MO450M
	Mathematical Neuroscience	WISL413
Computing Science	Evolutionary Algorithms (2018-19, 2019-20), Evolutionary Computing	INFOEA
	Data Mining (2020-21, 2021-22, 2022-23)	INFOMDM
	Pattern Recognition (2020-21, 2021-22, 2022-23)	INFOMPR
Experimental Physics	Biophysics	NS-EX430M
Game and Media Technology	Games and Agents (2017-18)	INFOMGMAG
Mathematical Sciences	Interacting particle systems: Theory and applications (2018-19)	WISL431
	Introduction to Numerical Bifurcation Analysis of ODEs and Maps (2019-20, 2021-22, 2023-24)	WISL606
	Inverse Problems in Imaging (2020-21)	
	Laboratory class for scientific computing (2018-19)	WISL430
	Mathematical Biology (2017-18, 2019-20, 2021-22)	WISM454
	Mathematical Neuroscience (2020-21)	WISL411
	Nonlinear Waves (2017-18)	WISL413
	Numerical bifurcation analysis of large-scale systems (2018-19, 2020-21, 2021-22)	WISL409
		WISL425
Multidisciplinary Economics	Advanced behavioural and experimental finance (2018-19)	ECRMABEF
	The Triumph of the City	ECRMTCE
Sustainable Development	Sustainability Modelling and Indicators (2018-19, 2019-20)	GEO4-2331