UNI FREIBURG

Module handbook

REM M.Sc. Renewable Energy Engineering and Management

Academic year 2023/2024

State of 26.07.2023

Table of contents

Module handbook

Master of Science

Renewable Energy Engineering and Management

1. Introductory comments

According to § 4 of the examination regulation of the MSc Renewable Energy Engineering and Management a module handbook lists the module contents. The module handbook refers to the academic year and gives information about the time schedule, type and scope of the module related courses and examinations.

The MSc Renewable Energy Engineering and Management is a two-year course. In the first part the time schedule for the students in their respective semester (first or third semester, second or fourth semester) is given. In the second part the module descriptions (listed accordingly to the time schedule given in the first part) inform about the contents and course prerequisites of the individual modules.

The module handbook is available on the website of the MSc Renewable Energy Engineering and Management (www.rem.uni-freiburg.de). Thus students have access to the module handbook before and during their studies.

2. Schedule Winter term 2023/24

REM 3rd semester 16.10.2023 - 09.02.2024

Time	Monday	Tuesday	Wednesday	Thursday	Friday
Morning					
		EnvResEc (10-12)	EnTrans	NatProt	SusTrans
Afternoon					
	ST2	LCM	PV1	PV2	
	EnvResEc				

3-weeks block end of Feb/March 2024
Environmental and Energy Transition Law
Thesis Project in Industrial Ecology

First three weeks block in the summer term 2024
Case Study Module

Track	Module	Abbreviatio	Lecturer
EC	*Photovoltaics 1*	PV1	Preu
EC	*Photovoltaics 2*	PV2	Preu
EC	*Solar Thermal Energy 2*	ST2	Platzer
REMP	*Landscape, Nature Protection, Landuse Conflicts*	NatProt	Weinacker
REMP	*Managing RE Projects - Case Study*	CaseStudy	v. Detten
REMP	*Environmental and Resource Economics*	EnvResEc	Baumgärtner
REMP	*Life Cycle Management*	LCM	Pauliuk
REMP	*Regulation and Assessment of Energy Transition*	EnTrans	Bauknecht
REMP	*Introduction to Sustainability Tranistions*	SusTrans	Bauknecht
REMP	*Environmental and Energy Transition Law*	EETL	Zengerling
REMP	*Thesis Project in Industrial Ecology*	TPIE	Pauliuk

EST-Elective Track Modules

Optimization for Energy Systems	**Weidlich**
Complex Networks	**Schäfer**
Energy System Modeling with Python	**Weidlich**
Smart Grids	**Wittwer**
Modelling and System Identification	**Diehl**
Energy in Buildings: components + systems for energy supply	**Henning**
Numerical optimization	**Diehl**
Energy Storage	**Schossig**

3. Module descriptions

Winter term 2022/23 – third semester

- **Internship**
- **Elective Track "Energy Systems Technology"**
  - ❖ **Optimization for Energy Systems**
  - ❖ **Complex Networks**
  - ❖ **Energy System Modeling with Python**
  - ❖ **Smart Grids**
  - ❖ **Modelling and System Identification**
  - ❖ **Energy in Buildings: components and systems for energy supply**
  - ❖ **Numerical optimization**
  - ❖ **Energy Storage**
- **Elective Track "Renewable Energy Planning and Management"**
  - ❖ **Managing RE Projects – Case Studies**
  - ❖ **Landscape, Nature Protection, Landuse conflicts**
  - ❖ **Life Cycle Management**
  - ❖ **Environmental and Energy Transition Law**
  - ❖ **Technology Assessment – Theory and Practice**
  - ❖ **Regulation and Assessment of the Systemic Aspects of the Energy Transition**
  - ❖ **Introduction to Sustainability Transitions**
  - ❖ **Industrial Ecology Thesis Projekt**
  - ❖ **Managing RE projects- Case Study**

- **Cross sectional topic “Energy Conversion”**
  - ❖ **Photovoltaics 1**
  - ❖ **Photovoltaics 2**
  - ❖ **Solar Thermal Energy 2**

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses
----</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
5572</td><td colspan="2">Module name
Optimization for Energy Systems</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
3 ECTS-P (150h/60h)</td><td>Prerequisite module(s)</td><td>Follow-up module(s)
---</td><td>No. of participants</td></tr>
<tr><td>Teaching form
Lectures, exercises</td><td>Examination form
Written exam</td><td>Start date
16.10.2023</td><td>Location
t.b.a.</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Anke Weidlich</td></tr>
<tr><td colspan="4">Additional teaching staff:</td></tr>
</table>

Syllabus

Optimization is a relevant task in many domains of energy management and energy economics. The course will cover some of the most prominent optimization and modeling problems in the energy domain, and provides methods for solving such problems. The content includes the following topics:

- Optimization problems in energy economics (e. g. unit commitment, resource scheduling)
- Linear and mixed-integer linear programming
- Dynamic programming
- Multi-criteria decision analysis

The theoretical content will be taught through lectures, including many application examples from energy practice and from academia. There will be in-class exercises, some of which are carried out with standard software tools.

Learning goals and qualifications

The students have an overview of different optimization problems in the energy sector and can choose an appropriate method for problem solving. They understand the mathematical background of linear programming, mixed-integer linear programming and other techniques that are widely applied in the energy economy. They are able to formulate mathematical models (objective functions, constraints) and are able to apply optimization methods with the help of computational tools. Students are able to formulate their own model for addressing a research challenge, and carry out simple analyses to draw conclusions from model results.

Recommended reading (*available at www.ub.uni-freiburg.de)

- Suhl, L., Mellouli, T.: Optimierungssysteme : Modelle, Verfahren, Software, Anwendungen. 2nd edition, Berlin : Springer, 2009.
- Poler, R., J. Mula, M. Díaz-Madronero: Operations Research Problems: Statements and Solutions, Springer, Berlin / Heidelberg, 2014.
- Williams, H. P.: Model Building in Mathematical Programming, 5th Edition, John Wiley & Sons, 2013.

Course prerequisites

None.

Course M.Sc. Renewable Energy Engineering and Management

Availability to other courses **SSE**			**Instruction Language** English
Module No. **5559**	**Module name** **Complex Networks**		**Semester/return** 3rd Sem. / annual
Workload/presence 6 ECTS (180 h/70 h)	**Prerequisite module(s)**	**Follow-up module(s)** Elective II Energy Efficiency	**No. of participants**
Teaching form Lecture with integrated exercises	**Examination form** Written exam	**Start date** 16.10.2023	**Location** Uni Freiburg

Module coordinator:

Dr. Mirko Schäfer

Additional teaching staff

Syllabus

- the language of graph theory
- random graphs, small world and scale-free networks
- centrality measures
- economic and financial networks
- network components and the configuration model
- transport, contagion and diffusion processes on networks
- network synchronization
- network aspects of the electricity system
- large-scale renewable energy networks
- multiscale infrastructure networks

Learning goals and qualifications

After the completion of the course the student is expected to be able to

- describe how complex systems can be represented as networks
- calculate various measures for a given network
- compare the structure of different real world networks
- describe and explain network models covered in the course
- implement and analyse network models in the programming language Python, import data, plot results, visualise networks
- communicate and discuss the methods and results presented in current research papers from the field of complex networks

Recommended reading

- A.L. Barabási, Network Science, available at networksciencebook.com
- M.E.J. Newman, Networks: An Introduction
- Further literature will be announced in class

Course prerequisites

Basic knowledge of matrix and probability theory.

Course M.Sc. Renewable Energy Engineering and Management	
Availability to other courses **---**	**Instruction Language** English

Module No.	Module name		Semester/return
6002	**Energy System Modeling with Python**		3^{rd} Sem. / annual
Workload/presence 6 ECTS-P (180h: 45h class, 60h preparation, 75h project) / 4 computer lab + integrated lectures	**Prerequisite module(s)** ---	**Follow-up module(s)** ---	**No. of participants** 20
Teaching form Computer lab and lecture	**Examination form** Project and presentation*	**Start date** 16.10.2023	**Location** INATECH

Module coordinators: Prof. Dr. Anke Weidlich

Additional teaching staff: Ramiz Qussous, Tim Fürmann

*Students choose an own research challenge, decide on a model for addressing the challenge, implement it in Python, execute it with appropriate input data, plot and interpret results, and describe the project in a report. They present their project in the class.

Syllabus

• General introduction to Python, integrated development environment
• Fundamentals (data types, expressions, conditional execution, iterations, functions, files, matrix operations)
• Algorithms (flowcharts, pseudocode, complexity and runtime estimation)
• Modelling techniques and application examples from energy systems analysis (power flow analysis, merit order models, simulations, and others)
• Relevant data sources for the energy sector
• Data evaluation (data import and export, plotting results)

Incl. mandatory implementation assignments

Learning goals and qualifications

The students

• Can apply basic techniques for solving mathematical problems with Python

• Understand engineering problems described in flowcharts, and can translate flowchart descriptions into a computer program

• Can apply Python to solving mathematical problems in different scientific fields, especially in the energy and sustainability domain

• Can analyse energy system models implemented in Python

• Can create an appropriate model for approaching a research question in the energy field and implement it in Python

Recommended reading

• Literature will be announced in the lecture
• Starting book: A. Sweigart, Automate the Boring Stuff with Python: Practical Programming for Total Beginners, No Starch Press (2015)

Course prerequisites (recommended)

Energy System Operations

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
97001</td><td colspan="2">Module name
Smart Grids</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS (150 h/60 h)</td><td>Prerequisite module(s)</td><td>Follow-up module(s)</td><td>No. of participants
25</td></tr>
<tr><td>Teaching form
Lectures, Exercises, Seminar, lab experiments</td><td>Examination form
Written exam</td><td>Start date
16.10.2023</td><td>Location
University of Freiburg; Fraunhofer ISE</td></tr>
<tr><td colspan="4">Module coordinator:
Prof. Dr. Christof Wittwer (christof.wittwer@ise.fraunhofer.de)</td></tr>
<tr><td colspan="4">Additional teaching staff
Dr. Bernhard Wille-Haussmann; Dr. Robert Kohrs, NN</td></tr>
<tr><td colspan="4">Syllabus
1. Energy transport and grids
1.1. Energy and power definition;
1.2. Grid bounded transport: gas; heat; electricity
1.3. Power analysis: sankey; efficiency; duration curves;
2. Distributed and centralized generation
2.1. Transformation into renewable energy system
2.2. Grid structure; distribution and transmission grid
2.3. Components; power plants; storage, loads
2.4. Grid integration; flexibility; cross energy management
2.5. Economics: liberalized energy market; grid operation
2.6. Demand Responce, micro grids
2.7. Control and communication system: smart grid architecture models
3. System theory
3.1. System modeling and simulation: application domains
3.2. Linear and differential equations:
3.3. Thermal-electric energy system simulation: examples
3.4. Controls and Optimization of grid integrated energy systems
4. Grid theory
4.1. DC and AC Circuit calculation;
4.2. Transient and stationary power flow
4.3. Grid integration: reactive and active power flow contol</td></tr>
<tr><td colspan="4">Learning goals and qualifications
Students will learn to use the basics of designing grid integrated energy systems; fundamental aspects of power and energy definition, overview on plant and smart grid technologies, calculation and simulation of energy systems; fundamental aspects of power flow calculation and grid theory.</td></tr>
<tr><td colspan="4">Recommended reading
Duffie and Beckman: Solar Engineering of Thermal Processes. ISBN: 978-0-470-87366-3
Volker Quaschning: Renewable Energy and Climate Change: ISBN 978-0-470-74707-0.
European SmartGrids technology platform: http://ec.europa.eu/research/energy/pdf/smartgrids_en.pdf
Smart Grid Communications and Networking; Ekram Hossain isbn: 9781107014138
Modelling and Analysis of Electric Power Systems: Göran Andersson:
http://www.eeh.ee.ethz.ch/uploads/tx_ethstudies/modelling_hs08_script_02.pdf</td></tr>
<tr><td colspan="4">Course prerequisites: “Energy System Operations”</td></tr>
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<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
2080</td><td colspan="2">Module name
Modelling and System Identification</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
6 ECTS-P (180h: 64h class, 116h self-study) / 3 lectures + 1 exercise</td><td>Prerequisite module(s)
---</td><td>Follow-up module(s)
---</td><td>No. of participants</td></tr>
<tr><td>Teaching form
Lecture and exercises</td><td>Examination form
Written or oral examination</td><td>Start date
16.10.2023</td><td>Location
IMTEK; Lehrstuhl Systemtheorie</td></tr>
<tr><td colspan="4">Module coordinators: Prof. Dr. M. Diehl</td></tr>
<tr><td colspan="4">Additional teaching staff:</td></tr>
<tr><td colspan="4">Syllabus
Aim of the module is to enable the students to create and identify models that help to describe and predict the behaviour of dynamic systems. In particular, students shall become able to use input-output measurement data in form of time series to identify unknown system parameters and to assess the validity and accuracy of the obtained models.</td></tr>
<tr><td colspan="4">Learning goals and qualifications
Linear and Nonlinear Least Squares, Maximum Likelihood and Bayesian Estimation, Cramer-Rao-Inequality, Recursive Estimation, Dynamic System Model Classes (Linear and Nonlinear, Continuous and Discrete Time, State Space and Input Output, White Box and Black Box Models), Application of identification methods to several case studies. The lecture course will also review necessary concepts from the three fields Statistics, Optimization, and Systems Theory, where needed.</td></tr>
<tr><td colspan="4">Recommended reading
• Lecture manuscript
• Ljung, L. (1999). System Identification: Theory for the User. Prentice Hall
• Lecture manuscript "System Identification" by J</td></tr>
<tr><td colspan="4">Course prerequisites (recommended)
Knowledge of
• Mathematics I for Engineers and Computer Scientists
• Mathematics II for Engineers
• Differential Equations
• Systems Theory and Feedback Control</td></tr>
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<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
4113</td><td colspan="2">Module name
Energy in Buildings: components and systems for energy supply</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
3 ECTS</td><td>Prerequisite module(s)</td><td>Follow-up module(s)</td><td>No. of participants</td></tr>
<tr><td>Teaching form
Lecture</td><td>Examination form
Written exam</td><td>Start date
16.10.2023</td><td>Location
INATECH</td></tr>
<tr><td colspan="4">Module coordinators: Prof. Dr. H.-M. Henning</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">Syllabus
Covered technologies:
• Burners, condensing boiler technology
• Combined heating and power (CHP) units for buildings
• Heat pumps: heat pump systems and operation principles
• Heat transformation: principles, compression, absorption, adsorption
• Solar energy utilization: principles, solar thermal collectors, photovoltaics applied in buildings
• Energy storage: thermal storage, electrical storage and their system integration
Beside the technologies overall systems are analysed and specific figures of merit to assess different technical solutions are defined and applied. Basic methods for cost assessment as well as methods to assess building sustainability are presented and discussed.

Exercises are included into the lecture.</td></tr>
<tr><td colspan="4">Learning goals and qualifications
The students know important technical components for energy supply (heating, cooling, air dehumidification) of buildings. Classical processes such as gas burners and compression chillers are covered as well as processes involving renewable energy (especially solar energy and ambient heat). The students are familiar with the physical principles of these processes and are able to derive key figures of merit from these principles. They are aware of the state of the art in these technologies and they can describe focal points of recent research and development work in this field. They are able to assess and compare different energy supply systems for buildings based on economic, ecologic and energy related figures of merit. They are also familiar with some basic methodologies for economic assessment of technical systems (life cycle cost assessment).</td></tr>
<tr><td colspan="4">Recommended reading
Ursula Eicker: Solar Technologies for Buildings. Springer. ISBN-13: 978-0471486374
Solar Cooling Handbook 3rd Revised & enlarged Edition. by Hans-Martin Henning (Editor), Mario Motta (Editor), Daniel Mugnier (Editor). Ambra. ISBN-13: 978-3990434383</td></tr>
<tr><td colspan="4">Course prerequisites (recommended)
Energy Storage, Solar Energy, Energy in Buildings: Energy Demand and Building Physics</td></tr>
</table>

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
8010</td><td colspan="2">Module name
Energy Storage</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150h: 56h class, 94h self-study) / 3 lectures + 1 exercise</td><td>Prerequisite module(s)
---</td><td>Follow-up module(s)
---</td><td>No. of participants
-</td></tr>
<tr><td>Teaching form
Lecture and exercises</td><td>Examination form
Written or oral examination</td><td>Start date
16.10.2023</td><td>Location
INATECH</td></tr>
<tr><td colspan="4">Module coordinators: D. Schossig</td></tr>
<tr><td colspan="4">Additional teaching staff: A. Georg</td></tr>
<tr><td colspan="4">Syllabus
1. Introduction and motivation energy storage (electric, thermal, PtG): Large-scale integration of renewable energies and the role of energy storage; technical requirements of power grids; overview of energy storage options and applications; key parameter of energy storage systems; technical requirements of storage systems; economic analyses for storage systems
2. Basics of energy storage systems: Mechanical (pumped hydro, CAES, fly wheels); Electric (SuperCaps); Electrochemical (Lead-acid, NiCd, NiMh, Lithium-ion; Sodium-ion; NaS / NaNiCl); thermal storage systems; chemical storage and PtG systems
3. Design of battery systems (focus Lithium-ion): Test and characterization of cells; Battery module and system design (components, construction, cooling); Safety issues; Battery management; Thermal management; System integration (system options, power and communication interface); Peripheral components (inverter, energy management)
4. Design of thermal storage systems
Description of technologies: sensible heat storage, latent heat storage, thermochemical storage. Technical applications: long term storage, short term storage, from cold storage to high temperature storage. Component and system layout, best case examples, limits and future expectations
5. Design of hydrogen storage and PtG systems: different system layouts and main components of hydrogen and PtG storage systems, water electrolysis as core component for PtG systems, advantages and drawbacks for repowering in fuel cells and thermal engines, best case examples of PtG installations, intersectoral extention to further Power-to-X technologies

The lecture will be accompanied by a weekly exercise to deepen the understanding of the lecture's content and to discuss further details.</td></tr>
<tr><td colspan="4">Learning goals and qualifications
• Understanding the necessity of energy storage (short-term, mid-term, seasonal) for stationary applications (electric, thermal and chemical) as well as their technical and economic requirements
• Basic knowledge of different energy storage technologies such as pumped-hydro, SuperCaps, batteries, and thermal storage systems as well as hydrogen and Power-to-Gas (PtG) solutions
• Knowledge in design of battery systems with a focus on lihtium-ion technologies
• Knowledge in design of thermal storage systems
• Knowledge in design of hydrogen storage and PtG systems</td></tr>
</table>

Recommended reading
T. Letcher: Storing Energy G. Pistoia: Lithium-Ion Batteries Advances and Applications A. Jossen: Moderne Akkumulatoren richtig einsetzen J.-C. Hadorn: Thermal energy storage for solar and low energy systems P. Moseley and J. Garche: Electrochemical Energy Storage for Renewable Sources and Grid Balancing
Course prerequisites (recommended)
Basic understanding of Engineering Physics and Engineering Chemistry

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
97010</td><td colspan="2">Module name
Photovoltaics 1</td><td>Semester/return
3rd Sem. / none</td></tr>
<tr><td>Workload/presence
5 ECTS (150 h/60 h)</td><td>Prerequisite module(s)
Natural Resources and Conversion Technologies</td><td>Follow-up module(s)
Photovoltaics 1</td><td>No. of participants
Max. 25</td></tr>
<tr><td>Teaching form
Lectures, Exercises, Seminar, lab experiments</td><td>Examination form
Written assignment</td><td>Start date
18.10.2023</td><td>Location
HS1021, 14:00-18:00</td></tr>
<tr><td colspan="4">Module coordinator: PD Dr. Ralf Preu</td></tr>
<tr><td colspan="4">Additional teaching staff:</td></tr>
<tr><td colspan="4">Syllabus
In this module, fundamental concepts and a deeper understanding of photovoltaic technology are presented to the students
• Basics of semiconductor physics
• Photogeneration and recombination, carrier transport
• pn- Junction and IV-characteristics
• Silicon: Quartz, metallurgical silicon, crystallization, wafer cutting
• Industrial silicon solar cell production and advanced approaches for higher efficiency
• Module technology
• Cost of ownership
• Characterization of cells / material
• Loss mechanisms and improvements
• High efficiency cell concept
• Introduction to PV systems</td></tr>
<tr><td colspan="4">Learning goals and qualifications
As the first step in this course the student will get an overview about the basic concepts of semiconductors. This is the prerequisite for the understanding of the principles of solar cell physics which is one of the main topics of this course. Subsequently the student will study the whole production chain of silicon solar cells starting from quartz via solar cell production to module fabrication. This will be accompanied by an in-depth cost analysis of the solar cell production. The students will understand main loss mechanisms of silicon solar cells and the advantages of high-efficiency cell concepts</td></tr>
<tr><td colspan="4">Recommended reading
1. Arno Smets, Klaus Jager : Solar Energy: The Physics and Engineering of Photovoltaic Conversion, Technologies and Systems, 2016, available as cost-free download for kindle via Amazon (status 16.8.2016)
2. B. Streetman, Solid State Electronic Devices
3. S.M. Sze, Physics of Semiconductor Devices
4. Martin A. Green, Solar Cells: Operating Principles, Technology, and System Applications
5. Peter Würfel, Physics of Solar Cells
6. Jenny Nelson, The Physics of Solar Cells</td></tr>
<tr><td colspan="4">Course prerequisites</td></tr>
</table>

Basic knowledge of semiconductor physics, “Natural Resources and Conversion Technologies - Photovoltaics”

Course

M.Sc. Renewable Energy Engineering and Management

Availability to other courses			**Instruction Language**
---			English
Module No.	**Module name**		**Semester/return**
97012	**Photovoltaics 2**		3rd Sem. / none
Workload/presence	**Prerequisite module(s)**	**Follow-up module(s)**	**No. of participants**
5 ECTS (150 h/60 h)	Photovoltaics 1		Max. 25
Teaching form	**Examination form**	**Start date**	**Location**
Exercises, Seminar	Seminar Presentation, Report	19.10.2023	Herderbau, R103 14:00 -18:00

Module coordinator: PD Dr. Ralf Preu

Additional teaching staff:

Syllabus

A seminar about specific topics of PV technology, systems and costs thereof (e.g. review of different approaches for the calculation of levelized cost of PV electricity or Review of PV Technology for industrial high efficiency solar cells). The three week course will be distributed into 3 phases.

1st week: topic collection, group definition (up to 5 groups min. 2 person per group), introduction to the topic by a tutor including distribution of literature and work within the group, study of literature, one additional appointment with tutor at the end of the week to discuss open points and structure of the presentation and report.

2nd week: preparation of final presentation, two-day seminar with presence requested by all, each individual member of a group has to give a sub-presentation.

3rd week: Groups will have to hand in a report on the review (max. 10 pages) at the beginning of the week. At the end of the week a short exam will be written on all presented topics.

High quality reports might be handed in as abstracts for an international photovoltaic conference. Preparation of such an abstract and paper is beyond the scope of the course itself but can be supported by the academic staff.

Learning goals and qualifications

Based on the knowledge acquired in Photovoltaics 1 this course will deepen the knowledge of the students in PV. Furthermore students will study group work and learn to review a scientific topic in a short given time. The students will gain practice in oral presentation and written publication on a scientific level.

Recommended reading

See Photovoltaics 1 – specific literature will be distributed at the beginning of the course

Course prerequisites

Successful participation in Photovoltaics 1 or equivalent.

Course

M.Sc. Renewable Energy Engineering and Management

Availability to other courses	**Instruction Language**
---	English

Module No.	**Module name**	**Semester/return**
97015	**Solar Thermal Energy 2**	3rd Sem. / none

Workload/presence	**Prerequisite module(s)**	**Follow-up module(s)**	**No. of participants**
5 ECTS (150 h/60 h)	Solar Thermal Energy 1		Max. 25

Teaching form	**Examination form**	**Start date**	**Location**
Project, Seminar, Discussion Forum	Seminar presentation, Report	16.10.2023	HS1231, 14:00-18:00

Module coordinator: Prof. Dr. Werner Platzer

Additional teaching staff:

Syllabus

A seminar about specific topics of solar thermal technology, systems and economics thereof (e. g. review of different approaches for the determining the cost-efficiency of solar thermal projects in relation to other renewables or energy-efficiency measures or comparison of concentrator technologies for industrial processes or for concentrated solar thermal power CSP). The six-week course will be distributed into 3 phases (spread out over 6 weeks!).

1st phase: topic collection, group definition (1-3 persons per group), introduction to the topic by a tutor including distribution of literature and work within the group, study of literature, one additional appointment with tutor at the end of the week to discuss open points and structure of the presentation and report.

2nd phase: preparation of final presentation, two-day seminar with presence requested by all, each individual member of a group has to give a sub-presentation.

3rd phase: Groups will have to hand in a report on the review (max. 10 pages) at the beginning of the phase 3. Within phase 3 there is opportunity to discuss and ask questions in Online Forum and a meeting on the results presented by all participants. At the end of the phase 3 a short exam will be written on all presented topics.

High quality reports might be handed in as abstracts for an international conference like Eurosun or Solar PACES Conferences. Preparation of such an abstract and paper is beyond the scope of the course itself but can be supported by the academic staff.

Learning goals and qualifications

Based on the knowledge acquired in Solar Thermal Systems 1 this course will deepen the knowledge of the students in Solar Thermal technology and applications. Furthermore students will study and work in groups and learn to review a scientific topic in a short given time. The students will gain practice in oral presentation and written publication on a scientific level.

Recommended reading

See Solar Thermal Systems 1 – specific literature will be distributed at the beginning of the course

Course prerequisites

Successful participation in Solar Thermal Systems 1 or **equivalent** (may be discussed with the module coordinator)

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
97021</td><td colspan="2">Module name
Managing RE Projects - Case Studies</td><td>Semester/return
3rd Sem. / none</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150h/60 h)</td><td>Prerequisite module(s)
Introduction to Business Management</td><td>Follow-up module(s)
---</td><td>No. of participants
max. 25</td></tr>
<tr><td>Teaching form
Lectures, guest lectures, case studies</td><td>Examination form
Seminar presentation + report</td><td>Start date
First 3 weeks in summer term 2024 (block system)</td><td>Location
t.b.a.</td></tr>
<tr><td colspan="4">Module coordinator: Dr. Roderich von Detten</td></tr>
<tr><td colspan="4">Teaching staff:</td></tr>
<tr><td colspan="4">Syllabus

The module “Managing RE Projects - Case Studies” will deepen the knowledge gained in the management lectures before through application in energy management examples. During the three weeks, the students will work on selected "real life” management case studies for energy-projects, each to be done by smaller groups of students. Students will work as consultants for the commissioning companies on given work orders. They will have to organize autonomously on real world project cases (under the supervision of the lecturer and in contact with the companies); outcomes of the work may be used by the companies in their future operations.

The course will also contain an introduction into project management, and guest lectures from management experts in RE-organizations/ -projects from different fields.

At the end of the module, students will give a presentation on their results to the commissioning companies and the class and have to provide a report.

Note: This is a module aiming to practice professional work assignments. While there will be continuous support by the teaching staff, students’ motivation and willingness for autonomous work in groups is essential.</td></tr>
<tr><td colspan="4">Learning goals and qualifications
➢ application of business management instruments
➢ strategic thinking and application of strategic management concepts
➢ project management skills and experiences
➢ insights into different RE management fields, challenges and organizations
➢ in-depth work on real life case studies
➢ Additional general skills: rhetoric, discussion and presentation skills, competence for team work</td></tr>
<tr><td colspan="4">Recommended reading
During the module materials will be made available via the learning platform ILIAS</td></tr>
<tr><td colspan="4">Course prerequisites
None.</td></tr>
</table>

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
97022</td><td colspan="2">Module name
Landscape, Nature Protection, Landuse conflicts</td><td>Semester/return
3rd Sem. / none</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150/60h)</td><td>Prerequisite module(s)</td><td>Follow-up module(s)</td><td>No. of participants
Max. 25</td></tr>
<tr><td>Teaching form
Project work</td><td>Examination form
Project report, presentation, group work and excursion</td><td>Start date
19.10.2023</td><td>Location
HS1021 08:00-12:00</td></tr>
<tr><td colspan="4">Module coordinator: Dr. Holger Weinacker</td></tr>
<tr><td colspan="4">Additional teaching staff: Mirko Mälicke, Joao Paulo Pereira</td></tr>
<tr><td colspan="4">Syllabus
Introduction to the significance renewable energy projects for environment and landscapes

An introduction to the interrelation of the renewable energy and the impact on environment how renewable energy strategies change landscapes. Students actively will identify practical examples to study the changes in environment and landscapes related to renewable energy projects and policies. An outline is given between the difference of Life Cycle Assessment (LCA) and Environmental Impact Assessment (EIA) what is the meaning of LCA compared to EIA.

How to assess the impacts and interdependencies with the environment.

The data needs and methods for performing an EIA, are described. The scheme of an EIA process is presented and discussed. Tools for data assessment and performing (GIS) the EIA introduced. They study a real case. They reflect the situation for the EIA implementation in reference to their home countries.

Case study

The students select a case from the renewable energy field for an EIA study. They collect data and information supported by the lecturer team. They perform a simplified EIA for one case. They present the result in the group and discuss the problems reflecting the situation in different regions of the world.</td></tr>
<tr><td colspan="4">Learning goals and qualifications
Knowledge about environmental and landscape problems connected with renewable energy. Information about EIA and the EIA process. Students will be able to apply the tools for data assessment and EIA performance. They will reflect the problems on international basis.</td></tr>
<tr><td colspan="4">Recommended reading
Calvert K., Pearce J.M., Mabee: Toward renewable energy geo-information infrastructures: Applications of GIScience and remote sensing that build institutional capacity, Renewable and Sustainable Energy Reviews, doi: 10.1016/j.rser.2012.10.024</td></tr>
<tr><td colspan="4">Course prerequisites:
-</td></tr>
</table>

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses
This module is offered as core and elective module to the MSc programme Environmental Sciences</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
64101</td><td colspan="2">Module name
Environmental Economics</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150/60h)</td><td>Prerequisite module(s)</td><td>Follow-up module(s)</td><td>No. of participants
Max. 10</td></tr>
<tr><td>Teaching form
Lecture + Tutorial</td><td>Examination form
Written exam</td><td>Start date
16.10.2023</td><td>Location
Herderbau, Mon 14:00-16:00 R101, Tue 10:00-12.00 R310</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Stefan Baumgärtner</td></tr>
<tr><td colspan="4">Additional teaching staff: Nora Felber</td></tr>
</table>

Syllabus

In this course, students will learn how to analyze the natural environment and natural resources from an economic perspective. To this end, students will learn intermediate and advanced concepts and methods from ecological, environmental and resource economics, and apply them to analyze economy-environment systems.
Topics to be covered include the following:

- Review of basic concepts from microeconomics (utility, scarcity, optimization, efficiency, markets)
- Welfare analysis of markets, market failure and market regulation:
  - public goods
  - common-pool-resources
  - externalities
- Economic valuation of environmental quality and natural resources
  Decision-making under uncertainty: risk, resilience, and insurance

Learning goals and qualifications

1 = Knowledge: students know advanced theories, methods and empirical facts of environmental economics and can reproduce them
2 = Understanding: students are able to critically reflect the economic approach to analyzing the natural environment, including its premises and limitations, and can explain it in a comprehensible manner
3 = Application: students can independently apply advanced theories and methods of environmental economics to simple problems of the natural environment and resources
4 = Analysis: students are able to systematically analyze the mutual interdependencies between economic and environmental variables at an advanced level

Recommended reading

There is no single textbook for this course. References for several chapters of the course include:

- M. Common and S. Stagl: *Ecological Economics. An Introduction*, Cambridge University Press, 2005
- H.E. Daly and J. Farley: *Ecological Economics. Principles and Applications*, Washington DC: Island Press, 2004
- Endres and V. Radke*: Economics for Environmental Studies. A Strategic Guide to Micro- and Macroeconomics*, Springer, 2012
- N. Hanley, J.F. Shogren and B. White: *Environmental Economics in Theory and Practice*, 2nd edition, Palgrave Macmillan, 2007

R. Perman, Y. Ma, J. McGilvray and M. Common: *Natural Resource and Environmental Economics*, 3rd edition, Pearson Education, 2003
Course prerequisites: - Basic knowledge of environmental economics or ecological economics (alternatively: basic knowledge of microeconomics) - Good working knowledge of basic algebra and calculus

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses: This module is offered as elective to the MSc programmes Environmental Sciences, MEG, and Forest sciences</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
64087</td><td colspan="2">Module name
Life cycle management</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150h/60h)</td><td>Prerequisite module(s)
---</td><td>Follow-up module(s)
---</td><td>No. of participants
Max. 35</td></tr>
<tr><td>Teaching form
Lectures, exercises, group work</td><td>Examination form
Written assignment (33%), Term paper + group work (67%)</td><td>Start date
17.10.2023</td><td>Location
Herderbau, R100
14:00-18:00</td></tr>
<tr><td colspan="4">Module coordinator: Johan Velez, Prof. Dr. Stefan Pauliuk (stefan.pauliuk@indecol.uni-freiburg.de)</td></tr>
<tr><td colspan="4">Additional teaching staff
Johan Velez</td></tr>
<tr><td colspan="4">Syllabus
The course enables participants to conduct, interpret, document, and present life cycle assessment studies of products or technical installations using state-of-the-art tools and databases.

During the first half of the course, the motivation behind and theory of life cycle assessment, including the modelling of life cycle inventories and life cycle impact assessment, is presented. The participants conduct exercises and study the relevant literature.

During the second half, the participants learn how to conduct and document a life cycle assessment study that meets both ISO and scientific standards. The participants form small groups of 2-3, chose a product or installation, and perform a life cycle management case study. The final report on the case study is due at the end of the module. It will be graded and the result will account for two thirds of the final grade of the course.

During the second half, background lectures and discussions on the potential, limits, applications, and future development of life cycle management will be held.

A written exam (1.5 hours), the result of which accounts for one third of the final grade, will be held at the end of the course.

The module is interactive and encourages strong student participation.</td></tr>
</table>

Learning goals and qualifications

- Basic knowledge of quantitative systems analysis of human-environment systems, basics of material and energy flow analysis.
- Detailed knowledge about the state of the art, the software, and databases of life cycle assessment according to the standards ISO 14040 and 14044.
- Basic knowledge of life cycle impact assessment methods.
- Soft skills: discussion, scientific writing skills, capacity for team work.
- At the end of the course, the successful participant will be able to conduct, interpret, document, and present life cycle assessment studies of products or technical installations using state-of-the-art tools and databases.

Recommended reading

- LCA Textbook: http://www.lcatextbook.com/. Much of the basic material of the course will be based on this book.
- OpenLCA tutorials (http://www.openlca.org/videos).
- Manual of the ReCiPe impact assessment method (http://www.lcia-recipe.net/file-cabinet/ReCiPe_main_report_MAY_2013.pdf).

Course prerequisites

Calculations with Excel, Basic knowledge on vectors, matrices, matrix multiplication and matrix inversion.

Important: This course requires each participant to work on her/his own laptop with the openLCA software (http://www.openlca.org/) and the ecoinvent database installed. openLCA is freeware. A copy of the ecoinvent database will be provided at the beginning of the course.

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses This module is offered as elective to the MSc programmes MEG, Environmental Sciences, and Forest sciences</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
97024</td><td colspan="2">Module name
Environmental and Energy Transition Law</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150h/60h)</td><td>Prerequisite module(s)
---</td><td>Follow-up module(s)
---</td><td>No. of participants
Max. 25</td></tr>
<tr><td>Teaching form
Socratic lectures, group and individual work, presentations, discussions</td><td>Examination form
SL Written assignment (pass/fail)
PL Written assignment (30%, 60 min.),
PL Written individual report (3000 words) OR group presentation and report (60 min. / group and 750 words / person, 70%)</td><td>Start date
19.02.2024 - 08.03.2024</td><td>Location
Herderbau R201
09:00-17:00</td></tr>
<tr><td colspan="4">Module coordinator: Jun-Prof. Cathrin Zengerling, e-mail: cathrin.zengerling@enrlaw.uni-freiburg.de
Prof. Dr. Errol Meidinger, email: eemeid@buffalo.edu</td></tr>
<tr><td colspan="4">Additional teaching staff
Invited experts from the private and public sector</td></tr>
</table>

Syllabus

In this module students gain fundamental knowledge of environmental and energy transition law from multi-level governance and international comparative perspectives. They acquire sector-specific knowledge of environmental law in the fields of climate change, air pollution, water, oceans, biodiversity, nature protection, chemicals and waste/circular economy law. With regard to energy transition law, students become familiar with energy and planning law directed to energy efficiency and the switch from fossil fuel based to renewable energy in the sectors of electricity, heating/cooling and mobility.

Throughout the course, students learn about different legal instruments and their strengths and weaknesses in reaching regulatory goals. Both, public and private law perspectives as well as different legal traditions such as common and civil law approaches are covered. Students also get insights into the role of environmental protection and the energy transition in other international legal regimes such as world trade, investment and human rights law.

The course is taught interactively and active participation of students is encouraged. Students become familiar with various primary legal documents such as (excerpts of) international treaties, European directives, constitutions, national laws, administrative permits, land use plans as well as decisions of the judiciary, and learn how to work with them. Students apply and deepen their knowledge under guidance of the instructors in their specific fields of interest via case studies. Throughout the course, various soft skills such as debating in socratic discussions, scientific writing, interdisciplinary and intercultural teamwork are imparted.

Learning goals and qualifications

In this module students learn to:

- identify the main types and instruments of environmental and energy transition law and their distinctive characteristics (1)(2);
- understand interactions and conflicts between different types, sources and instruments of environmental and energy transition law (2);
- assess the inherent strengths and limitations of environmental and energy transition law for environmental and energy governance (5);
- realize that there are alternative ways of structuring environmental and energy transition responsibilities and powers through law (2)(4);
- formulate legal and policy arguments relevant to future environmental and energy transition law development (6);
- critically and intelligently evaluate arguments for legal change (4);
- understand the relationship between scientific knowledge, social movements, and environmental/ energy transition law (2);
- apply basic skills of legal research and legal arguments to relevant case studies (3)(6).

Classification of cognitive skills following Bloom (1956):

1 = *Knowledge*: recalling facts, terms, basic concepts and answers; 2 = *Comprehension*: understanding something; 3 = *Application*: using a general concept to solve problems in a particular situation; 4 = *Analysis*: breaking something down into its parts; 5 = *Synthesis*: creating something new by putting parts of different ideas together to make a whole; 6 = *Evaluation*: judging the value of material or methods.

Recommended reading

Sands, P., & Peel, J. (2018). *Principles of international environmental law*. Cambridge University Press.

Meidinger, Errol (2008), "Property Law for Development Policy and Institutional Theory: Problems of Structure, Choice and Change." In David Mark, Barry Smith, and Isaac Ehrlich, *The Mystery of Capital and the New Philosophy of Social Reality*. Chicago: Open Court Publishing, pp.193-227.

Reading material will be provided during the course via the e-learning platform ILIAS.

Course prerequisites

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<table>
<tr><td>Module number
95990</td><td colspan="3">Module name
Elective: Technology Assessment – Theory and Practice</td></tr>
<tr><td colspan="2">Course of study
M.Sc. Environmental Governance</td><td>Type of course
Elective</td><td>Semester / Rotation
3rd/ Winter Term</td></tr>
<tr><td colspan="2">Teaching methods
lectures, plenary discussions, group work</td><td>Prerequisites for attendance
None</td><td>Language
English</td></tr>
<tr><td colspan="3">Type of examination (Final Grade Composition)
1) PL Literature Review (Individual assessment of a self-chosen TA study along guiding questions), max. 2500 words (4 pages) (50%)
2) PL Group Research Report, 15-40 pages (50%)
*Participation in discussions & presentations is obligatory; not graded</td><td>ECTS-LP (Workload)
5 (150h)</td></tr>
<tr><td colspan="3">Module coordinator
apl. Prof. Dr. Philipp Späth, Email: spaeth@envgov.uni-freiburg.de</td><td>SWS
4</td></tr>
<tr><td colspan="4">Additional teachers involved
Additional faculty and external experts on various topics will be involved.</td></tr>
<tr><td colspan="4">Syllabus
As environmental limitations of current economic regimes and lifestyles are increasingly recognized, hope is often directed towards technological innovations (e.g. resource efficiency, ‘green’ technologies). Assumptions about the ‘superiority’ of certain technologies are a precondition for any attempt to accelerate the development and diffusion of these technologies by means of science, technology and innovation governance. However, to what extent particular technological innovations can in fact alleviate pressure on natural resources is hard to assess, particularly in the early stages of their development.
We study the promises, methods and practices involved in systematic Technology Assessments (TA) and their role in problematizing the potentials and risks involved in technological change. Starting from an overview of approaches, institutions and methods of TA, we aim to understand the dilemmas of such endeavors and how people tried to overcome them. You will first evaluate a self-chosen TA study that has been published by a recognized TA institution against common criteria. The second and third week of the module are dedicated to the development of your own technology assessment of a specific aspect important to an international hydrogen economy as promoted by the previous German Government: https://www.bmbf.de/bmbf/en/home/_documents/west-africa-can-become-the-cli-energy-powerhouse-of-the-world.html .
You will develop a TA study on a self-chosen aspect of a future hydrogen economy in a team of three to sixteen students. On the way, you will gain insights into how parliamentarian TA is conducted by the German TAB (which has been commissioned with a study on opportunities and risks of hydrogen partnerships and technologies in developing countries, too: https://www.tab-beim-bundestag.de/english/projects_opportunities-and-risks-of-hydrogen-partnerships-and-technologies-in-developing-countries.php).</td></tr>
<tr><td colspan="4">Learning goals and qualifications
In this module students learn to:
– describe various objectives and institutional forms of technology assessment (1, 4);
– understand the assumptions and world views that influenced various approaches to TA (2, 4);
– be fluent with TA terminology and practices (3);
– identify different challenges and dilemmas of expertise or consensus-oriented methods for TA (5);
– evaluate and criticize TA studies of various scopes (6);
– apply research methods (analysis of literature, interview techniques etc.) (3);</td></tr>
</table>

- position themselves with regard to different approaches to technology assessment (6);
- assess the potentials and risks potentially involved in various forms of urban food production (3-6).

Classification of cognitive skills following Bloom (1956):

1 = *Knowledge*: recalling facts, terms, basic concepts and answers; 2 = *Comprehension*: understanding something; 3 = *Application*: using a general concept to solve problems in a particular situation; 4 = *Analysis*: breaking something down into its parts; 5 = *Synthesis*: creating something new by putting parts of different ideas together to make a whole; 6 = *Evaluation*: judging the value of material or methods.

Core readings

A list of relevant texts will be made available at the start of the course; readings themselves will be made available online via Ilias. Introductory reading (pdf available on request):

Grunwald, A. (2019). "Technology assessment in practice and theory". Oxford, Routledge. pp. 1-12.

Course M.Sc. Renewable Energy Engineering and Management			
Availability to other courses ----			**Instruction Language** English
Module No. **97025**	**Module name** **Regulation and Assessment of the Systemic Aspects of the Energy Transition**		**Semester/return** 3rd Sem. / annual
Workload/presence 5 ECTS-P (150h/60h)	**Prerequisite module(s)**	**Follow-up module(s)** ---	**No. of participants** Max. 25
Teaching form Socratic lectures, group work, presentations	**Examination form** Written assignment, group work presentation	**Start date** 18.10.2023	**Locations** Herderbau R310 08:00-12:00
Module coordinator: Prof. Dr. Dierk Bauknecht			
Additional teaching staff: Guests t.b.a.			

Syllabus

In this module students gain fundamental knowledge of the system implications of renewable energies that result from the main characteristics of electricity generation from renewables, such as their variability, their low marginal costs and the changing geographical distribution. This includes three main steps:

- First, the module explores what the various system implications of renewables are and which options are available and developments take place to adapt the system accordingly.
- Second, it deals with the assessment of these options from various perspectives, especially economic and social perspectives, how this is reflected in stakeholder positions and how such an assessment can be used to inform policy-making.
- Third, the module covers policy and regulatory options to address these system implications. Which regulatory options exist, what are their pros and cons and how are they implemented in different constituencies?

The focus is not on system implications in a narrow engineering sense, but the module takes a broader look at how the power and energy system does transform and needs to transform in order to implement a system based on renewables. This includes the following aspects: Grid infrastructure; flexibility requirements; various forms of centralisation and decentralisation of power systems, sector integration; market design.

The module applies an interdisciplinary approach. It is not based on a any specific methodological approach, but rather explores what instruments are needed and useful for dealing with the above questions. The module also introduces system transformation thinking.

The module will introduce these issues at a general level and with a focus on Germany in a European context as a specific case. Students will then apply the insights to other countries or to specific system options. Active participation of students is expected throughout the course.

Learning goals and qualifications

In this module acquire knowledge on three levels:

1) Energy system knowledge: What are key system implications of renewables, options to deal with them and related regulatory approaches? What are the implications of system transformation? This includes technical, economic, social and policy knowledge.
2) How can the various options available be assessed and what needs to be taken into account for that purpose in a real-world and policy context? How can assessments made by different stakeholders be judged?
3) How can the results be presented? Discussion, presentation and writing

Recommended reading
IEA-RETD (2015) Integration of Variable Renewables (RE-integration), [A. Conway; Mott MacDonald] IEA Implementing Agreement for Renewable Energy Technology Deployment (IEA-RETD), Utrecht, Netherlands http://iea-retd.org/archives/publications/re-integration Bauknecht, D., Heinemann, C., Seebach, D., Vogel, M., 2020. Behind and beyond the meter: what's in it for the system?, in: Sioshansi, F. (Ed.), Behind and beyond the meter: Digitalization, Aggregation, Optimization, Monetization. ELSEVIER ACADEMIC PRESS, [S.l.]. Reading material will be provided during the course via the e-learning platform ILIAS.
Course prerequisites
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<table>
<tr><td colspan="4">Course
M.Sc. Environmental Governance</td></tr>
<tr><td colspan="3">Availability to other courses
M.Sc. Renewable Energy Engineering and Management</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
95996</td><td colspan="2">Module name
Introduction to Sustainability Transitions</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150h/60h)</td><td>Prerequisite module(s)
---</td><td>Follow-up module(s)
---</td><td>No. of participants
Max. 25</td></tr>
<tr><td>Teaching form
Socratic lectures, group work, presentations</td><td>Examination form
Written assignment, group work presentation</td><td>Start date
20.10.2023</td><td>Location
Herderbau R200
08:00-12:00</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Dierk Bauknecht</td></tr>
<tr><td colspan="4">Additional teaching staff: Sarah Olbrich, guests tba</td></tr>
<tr><td colspan="4">Syllabus
Today we face a variety of environmental and societal challenges such as climate change or environmental pollution. These challenges are wicked problems: they are normative both in terms of problem- and solutions-defining, characterised by a high degree of complexity and uncertainty, value-laden and highly-contested, and they are context-dependent (Markard et al. 2012; Köhler et al. 2019). To solve those problems, systemic changes are necessary that alter our ways of producing and consuming, go beyond technological fixes, and include changes on multiple dimensions. This is true for a number of socio-technical systems such as the energy system.
In recent years, Sustainability Transition Studies evolved as a new research agenda and multidisciplinary research community to contribute to solving these challenges. It has two main aims: (1) gaining a better understanding of transition dynamics, and (2) generating an impact for today’s transitions in process (governance of transitions).
This seminar introduces the field of Sustainability Transitions. We will learn about main concepts and frameworks for systemic change. We will mainly use the example of the energy transition to discuss and apply theoretical insights, but other sectors and a comparison between sectors will be discussed as well. Moreover, we will evaluate in how far theory can inform and help practitioners and decision-makers to guide and govern (energy) transitions in the making.</td></tr>
<tr><td colspan="4">Learning goals and qualifications
• Getting familiar with the field of sustainability transitions
• Understanding prominent concepts and frameworks in the field of socio-technical sustainability transitions
• Applying these concepts to transitions in the making
• Evaluating on how theoretical insights can inform practitioners and policy-makers</td></tr>
<tr><td colspan="4">Course prerequisites</td></tr>
</table>

<table>
<tr><td colspan="2">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td>Availability to other courses This module is also available to students of the MSc programmes MEG, Geography, REM, Forest Sciences, and SSE.</td><td>Instruction Language
English (German speaker available</td></tr>
</table>

Module No.	Module name		Semester/return
64116	**Industrial Ecology Projekt**		3^{rd} Sem. / none
Workload/presence 5 ECTS-P (150h/60h)	**Prerequisite module(s)** ---	**Follow-up module(s)** ---	**No. of participants** Max. 15
Teaching form Seminars and project work	**Examination form** Term paper	**Start date** 19.02.2024 - 08.03.2024	**Location** Herderbau R201 09:00-17:00

Module coordinator: Prof.Dr. Stefan Pauliuk (stefan.pauliuk@indecol.uni-freiburg.de)

Additional teaching staff
Members of the industrial ecology group

Syllabus

This module prepares the students for conducting their master thesis in the industrial ecology group, and is reserved mostly for students who intend to do so. Its introduction consists of an overview of the main system linkages, methods, and history of industrial ecology. During the main part of the course, the students work independently on either their future master thesis topic or on another self-chosen topic that can be studied using industrial ecology methods.

Important note:

This course is mandatory for all students who wish to conduct the research for their MSc thesis in the industrial ecology group. Access restrictions apply, as students need to have successfully completed the Life Cycle Management Course. Potential participants are expected to contact the module coordinator beforehand, the deadline for applying for a master thesis in the group is Jan 20 of each year. Students who do not aim for an MSc thesis in the field of industrial ecology can also apply but will not be given priority during admission.

Content:
The goal of this course is to enable students to independently conduct quantitative research on industrial systems (industrial ecology). Participants will become familiar with the state of the art of the research on industrial systems, including material and energy flow analysis, life cycle sustainability assessment, environmental (carbon, water, land) footprinting, and integrated assessment modelling. They will learn about the central steps required for a master thesis in the field of industrial ecology, and by the end of the course, they will be able to formulate a research proposal as starting point of their MSc thesis.

Course work will include seminars and the preparation of a term paper, both under supervision by members of the industrial ecology group. The term paper is an independent scientific piece of work, which will serve as basis for the course grade. It is expected to contain a literature review with a research gap, research question (goal and scope), followed by a quantitative analysis of a sustainable development strategy. Students can work on a topic of their choice, which, as experience has shown, is their future master thesis topic in most cases.

By the end of the course, students who wish to write their thesis in the group have enough input to develop their thesis proposal (which is not part of this course).

Learning goals and qualifications

After successful completion of the course, students will have an overview of the current research topics in industrial ecology, the important actors in the field, the common scientific journals and other publication channels, and the main applications of industrial ecology research in policy making and industry.

In particular, the students will be able to:

- conduct a literature search on the quantitative analysis of specific sustainable development strategies
- critically review the literature, identify research gaps, and formulate their own research questions
- independently improve skills on and apply one the central methods of industrial systems analysis, including material flow analysis, input-output analysis, and life cycle assessment
- conduct a case study and write a scientific text in German or English that adheres to the specific writing style of the environmental systems sciences
- interact with experts on environmental and industrial systems analysis on a scientific level.

Recommended reading

- **Industrial Ecology** (2nd Edition), by Thomas E. Graedel and Braden R. Allenby, ISBN 978-0130467133, 1 copy in the library

- **Guidelines for Good Scientific Practice and Supervision in the Industrial Ecology Group in Freiburg**, Stefan Pauliuk 2016. Can be obtained from module coordinator or from this link: http://www.omnibus.uni-freiburg.de/~sp1046/Documents/ScientificWork_IndEcolFreiburg_2016.pdf

- **Input-Output Analysis: Foundations and Extensions** (2nd Edition), by Ronald E. Miller and Peter D. Blair, ISBN 978-0521739023, several copies in the library

- **Practical Handbook of material flow analysis**, by Brunner and Rechberger, ISBN 0203507207, 1 copy in the library

- **Industrial Ecology open online course:** http://www.teaching.industrialecology.uni-freiburg.de/

Course prerequisites

Participants must have participated in the *Life Cycle Management* course before taking this course.

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
6900</td><td colspan="2">Module name
Internship (Praktikum)</td><td>Semester/return
2nd - 3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
10 ECTS-P (300 h)</td><td>Prerequisite module(s)
---</td><td>Follow-up module(s)
---</td><td>No. of participants
max. 75</td></tr>
<tr><td>Teaching form
Practical work</td><td>Examination form
Written report</td><td>Start date
07.08.2023</td><td>Location
t.b.a.</td></tr>
<tr><td colspan="4">Module coordinators: Prof. Dr. Stefan Pauliuk (stefan.pauliuk@indecol.uni-freiburg.de)</td></tr>
<tr><td colspan="4">Additional teaching staff
Academic experts of the respective internship institution</td></tr>
<tr><td colspan="4">Syllabus
The MSc. programmes at the Faculty of Environment and Natural Resources Freiburg as a rule include a practical training in accordance with the examination regulations for the degree programme Master of Science. The practical training is completed in institutions and companies outside the faculty or in research departments of the ZEE and his partners.
Possible internship providers include:
▪ Renewable energy and power supply companies
▪ Planning and Engineering companies
▪ Consultancy and information services (energy agencies, technology transfer institutions) and public relation
▪ Science and research dealing with renewable energies
▪ Financing and Investment companies specialising in financing environmental projects, as well as investment and development banks</td></tr>
<tr><td colspan="4">Learning goals and qualifications
The internship provides students with a first insight into potential employment sectors; in all sectors this is primarily achieved by practical work. Apart from gaining an overview of the subject, students should experience typical work processes and the human interactions in an organization. The assigned work gives students an idea of the daily work procedure at their workplace (‘everyday life experiences’). Additionally, students become familiar with the structures within the institution, as well as the interconnections with external systems.
Furthermore, the expert knowledge gained in the course of the studies is intensified and to a certain degree, applied during the practical training.</td></tr>
<tr><td colspan="4">Recommended reading
None.</td></tr>
<tr><td colspan="4">Course prerequisites
None.</td></tr>
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