Module Handbook

for the

English language
Study Course

“Master of Engineering in International Material Flow Management“

University of Applied Sciences Trier,
Environmental Campus Birkenfeld

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Preliminary Remarks

The module guidebook features the content of the study program entitled as “Master of Engineering in International Material Flow Management” developed by the Institute of applied Material Flow Management with the mandate of the Senate of the University of Applied Sciences Trier.

The IMAT M.Eng. study program is designed as bilateral dual degree program where the first two study semesters are taught at the partner university abroad and the third theoretical semester is taught at the Environmental Campus in Birkenfeld, Germany. At the end of the third semester the students are obliged to conduct a for weeks internship in a company or institution working in one of the areas of international MFM. The fourth semester is reserved to conduct the master thesis. The students are free to decide upon a company and location to conduct both, the internship and the master thesis.

IfaS is solely in charge for the academic content and the quality assurance. Within all IMAT dual degree programs an IMAT steering committee, under the lead of Prof. Dr. Peter Heck (CEO of IfaS), is established. The IMAT steering committees are in charge to appoint course/module lecturer based on highest quality standards. The IMAT steering committees meet at least twice a year while all IMAT lecturers are invited at least once a year to any IMAT university location to discuss the current education profile and suggest and discussion optimisations.

Despite the continuous exchange among the research and lecturer another quality assurance measure is the limitation of group sizes. One IMAT batch is limited to max. 30 students in order to ensure a feedback and dialog-oriented teaching within the program.

Content of the Module Guidebook

The module guidebook encompasses the detailed description of all 14 modules and the sub courses. The description of the courses provides the following information:

- Module / sub course number and title
- Workload divided into class/lessons and self-study[1]
- Credit points (ECTS) and Significance of the grade for the final grade
- Frequency of the offer and Duration of the Module
- Learning outcomes / competences
- Description of the Course Content
- Teaching Methods
- Recommended Qualifications
- Method of Grade Evaluation and Preconditions for the allocation of Credits
- Usage of the Module (in other study courses)
- Module representative and full-time lecturers
- Required Readings

[1] Bei der Zeitbemessung wurden die Rahmenvorgaben für die Einführung von Leistungspunktesystemen und die Modularisierung von Studiengängen verwendet (siehe Beschluss der Kultusministerkonferenz vom 15.09.2000)

The table below list all modules/sub courses together with the workload and credit points divided into the four study semester:

Modules/Subjects	Semester 1			Semester 2			Semester 3			Semester 4			
	SWH	ECTS	Workload	SWH	ECTS	Workload	SWH	ECTS	Workload	SWH	ECTS	Workload	Modulverantwortlicher
MODULE 1: ECOSYSTEM MANAGEMENT	**4**	**6**	**180**										Prof. Dr. Peter Heck
MODULE 2: REGIONAL MATERIAL FLOW MANAGEMENT	**3**	**4**	**120**	**4**	**6**	**180**							Prof. Dr. Peter Heck
2.1 Regional Development Strategies	3	4	120										
2.2 Regional Material Flow Management: Conceptional Approach and International Case Studies				4	6	180							
MODULE 3: INDUSTRIAL MATERIAL FLOW MANAGEMENT	**4**	**6**	**180**	**2**	**2**	**60**							Prof. Dr. Klaus Helling
3.1 Principles of Industrial Material Flow Management	2	3	90										
3.2 Sustainability Management and Reporting	2	3	90										
3.3 Industrial Aspects of Factor 10 (Cleaner Production)				2	2	60							
MODULE 4: INDUSTRIAL ECOLOGY & ZERO EMISSION STRATEGIES				**4**	**6**	**180**							Prof. Dr. Susanne Hartard
4.1 Industrial Ecology				2	2	60							
4.2 International ZE Policy Approaches: Case Studies from Asia, Africa and Europe				2	4	120							
MODULE 5: SUSTAINABLE WATER MANAGEMENT				**2**	**2**	**60**	**2**	**4**	**120**				Dr. Ingo Bruch
5.1. Basic Engineering Aspects of Sustainable Water Management				2	2	60							
5.2. Sustainable Water Management: Future Challenges and Best Practices							2	4	120				
MODULE 6: ENERGY SYSTEM MANAGEMENT				**2**	**2**	**60**	**2**	**2**	**60**				Dipl. Ing. Christian Synwoldt
6.1 Basic Principles of Energy System Management				2	2	60							
6.2 Energy System Design: Future Challenges and Strategies							2	2	60				
MODULE 7: RENEWABLE ENERGY AND ENERGY EFFICIENCY							**4**	**4**	**120**				Dipl. Ing. Christian Synwoldt
MODULE 8: SUSTAINABLE WASTE AND RESOURCE MANAGEMENT							**4**	**4**	**120**				Prof. Dr. Susanne Hartard
MODULE 9: BUSINESS PLANNING FOR ENGINEERS	**4**	**4**	**120**										Prof. Dr. Dirk Löhr
9.1 Business Plan Development	2	2	60										
9.2 Project Planning and Project Management	2	2	60										
MODULE 10: TECHNICAL ASPECTS OF DE-CARBONISING STRATEGIES				**2**	**2**	**60**	**4**	**6**	**180**				Prof. Dr. Eckhard Helmers
10.1 Chemistry of Global Climate Change: Important GHG Cycles							2	2	60				
10.2 Greenhouse Gas Abatement Strategies and Carbon Trading				2	2	60							
10.3 Modelling Carbon Footprints							2	4	120				
MODULE 11: SYSTEM CHANGE MANAGEMENT	**2**	**2**	**60**	**2**	**2**	**60**							Prof. Dr. Alfons Matheis
11.1 Cultural Aspects of System Change	2	2	60										
11.2 Stakeholder Management				2	2	60							
MODULE 12: PHYSICS AND CHEMISTRY FOR THE ENVIRONMENT	**4**	**4**	**120**										Prof. Dr.-Ing. Michael Bottlinger
12.1 Environmental Chemistry for Engineers	2	2	60										
12.2 Environmental Physics for Engineers	2	2	60										
MODULE 13: SELECTIVES - SEMINARS IN APPLIED MATERIAL FLOW MANAGEMENT	**3**	**4**	**120**	**6**	**8**	**240**	**2**	**4**	**120**				Dr. Michael Knaus
13.1 Selective I: MFM-Seminar of the Partner Universities	3	4	120										
13.2 Selective II: MFM-Seminar of the Partner Universities				3	4	120							
13.3 Selective III: MFM-Seminar of the Partner Universities				3	4	120							
13.4 Selective IV: Traveling University / Practical Research Project Development and Fundraising							2	4	120				
MODULE 14: INTERNSHIP							**6**	**6**	**180**				Dr. Michael Knaus
MASTER THESIS										**24**	**30**	**900**	Prof. Dr. Peter Heck
Total	**24**	**30**	**900**	**24**	**30**	**900**	**24**	**30**	**900**	**24**	**30**	**900**	

DESCRIPTION OF THE MODULES AND SUB COURSES

The description of the modules and the sub courses were designed in close cooperation with the module representative and involved full-time lecturers. In addition to the detailed information on the modules, the desired intention, the relevance of the module for the overall study aims as well as the interlinkages between the modules are described.

Module 1: ECOSYSTEM MANAGEMENT

Within this module the students learn the systemic interaction of ecosystems in order to envisage that man-made issues such as inefficiencies and waste problems are not foreseen in functioning ecosystems. In contradiction, the current man-made environmental challenges based on our current modes of economies as well as infrastructures in (energy and material) supply and (waste water and waste) sanitation systems are analysed in order to sensibilize the students for the new technology concepts taught in Modules 5 to 8. New management concepts, bio-mimicry strategies and industrial ecology attempts as new holistic supply and demand side management of regional and companies are taught in Module 2 to 4.

Module No. 1	**Workload** 180 h	**Credits (ECTS)** 6	**Semester** 1. Sem.	**Frequency of the offer** Each Fall semester	**Duration** 1 Sem.
Ecosystem Management			**Lessons** 4 SWH (60 h)		**Self-Study** 120 h
Learning outcomes / competences ▪ Understand the systemic interaction of ecosystems ▪ Understand thermodynamic principles and their effects on ecosystems and manmade systems ▪ Understand material and energy flows in ecosystems ▪ Show the interaction between the natural system and manmade systems ▪ Ability to critically evaluate global environmental issues ▪ Ability to describe possible solutions					

Description of the Course Content

1) **Introduction on Ecosystem theory**

   Clarification on the terms and conceptional models of environment, species, predators, symbiosis, population, biosphere, biotope, biodiversity and resilience in ecosystem, environmental gradients, limiting factors, potency, Biotops, Niches, ecosystem equilibrium, carrying capacity, ecological footprint

2) **Material flows in Ecosystems**

   Overview on relevant matter and energy flows in ecosystems, such as carbon cycle, phosphorous cycle, nitrogen cycle, water cycle, food chain, etc

   Clarification on the terms and conceptional models of photoautotrophic, heterotrophic, decomposers

3) **"Waste" and " waste water" in ecosystems**

   Detritus recycling, relation to manmade systems

   Organic loads in water in ecosystems and relation to manmade systems

   Natural treatment of water pollution, bio indicators for water quality, BOD, COD

4) **Soil development and function:**

   Physical, biological and chemical aspects of soil, black soil (Terra Preta) and soil degradation

5) **Energy in ecosystems**

   Application of the first two laws of thermodynamic in the ecosystem (entropy, exergy)

   Energy supply and balance of natural ecosystems as well as energy in the food chain

6) **Global environmental issues**

   Discussion on manmade problems in ecosystems as well as solutions based on Zero Emission and Material Flow Management:

   - Water problems (water pollution, water scarcity, flooding);
   - Waste problems (industrial, household, farming and military waste);
   - Energy problems,
   - Resources and sinks,
   - Agriculture and food security
   - Various others such as global warming, ocean pollution, landscape degradation; biodiversity

7) **Case studies with potential solution approaches**

Teaching Methods

Lectures, group discussions, case studies, book review

Recommended Qualifications

Basic geography, basic natural science, basic ecology

Method of Grade Evaluation

The total score for the course is 100%:

Final exam (40%), Paper presentation (40%), class participation (20%)

Preconditions for the allocation of Credits

Module exam passed as well as presentation / paper etc. successfully completed

Active participation, organizing interdisciplinary teams for joint work on case studies

Usage of the Module (in other study courses)

Module is used in the IMAT M.Sc.

Significance of the grade for the final grade

6 ECTS/ 120 ECTS

Module representative and full-time lecturers

Prof. Dr. Peter Heck

Required Readings

Bingham, Nick/ Blowers, Andrew/ Belshaw, Chris (2003): Contested Environments, Wiley.

Harris, Francis (Ed.): Global environmental issues, Wiley 2004.

Spiro, Thomas G./ Stigliani, Wiliam M.: Chemistry of the Environment (2nd edition), Tsinghua University press 2003.

Marsh, William M./ Grossa, John Jr.: Environmental Geography. Science, Land Use, and Earth Systems, Wiley 2005.

Further Readings:

Cox, C. Barry/ Moore, Peter D.: Biogeography. An ecological and evolutionary approach, 6th edition, Oxford 2000.

Ristinen, Robert R./ Kraushaar, Jacj j.: Energy and the Environment, 2nd edition, Wiley 2006.

Niele, Frank: Energy. Engine of Evolution, Shell Global Solutions, Elsevier 2005.

Worldwatch Institute: State of the World yearly publications.

Manning, Richard: Food´s Frontier. The next Green Revolution, University of California Press 2000.

Caufield, Catherine: In The Rainforest – Report from a Strange, Beautiful, Imperiled World, University of Chicago Press 1991.

Misc. Notes:

Students will work on case studies provided by the lecturer during the lessons.

Module 2: REGIONAL MATERIAL FLOW MANAGEMENT

The Module 2: REGIONAL MATERIAL FLOW MANAGEMENT is (together with Module 3: INDUSTRIAL MATERIAL FLOW MANAGEMENT) the central element of the study program interconnecting the various Modules with details in energy, water, waste and resource management.

The students learn to analyse regional systems and develop new, innovative energy and material supply and (waste and water) sanitations concepts combining economic promotion with climate protection. Based on the methodological tool kit of material flow management developed in the last ten years of extensive research by IfaS the students learn the procedural knowhow.

Using real-life case studies (next-practice examples) of IfaS the students gain practical insights in conduction and managing regional change processes and implementation of technology induced optimisation strategies.

This Module is the starting point (right after Module 1: ECOSYSTEM MANAGEMENT) of the study course and provides at the very beginning already an overview on the structure and detail elements of the entire study course. The combination of theoretical and methodological as well as practical experiences shall enable the students to develop and proceed with own MFM based research ideas and developed regional MFM or Zero Emission approaches for their native home countries/regions.

While the technical details are explained in the Modules 5 to 8, the political strategies such as 3R society attempts (in Japan) or Industrial Ecology or Circular Economy (in China) are in detail explained in Module 4. Furthermore, the students learn to calculate the GHG abatement potentials and the economic value of “de-carbonisation” in Module 10: TECHNICAL ASPECTS OF DE-CARBONISING STRATEGIES.

Module No. 2	**Workload** 300 h	**Credits (ECTS)** 10	**Semester** 1.-2. Semester	**Frequency of the offer** 2.1 Each Fall semester 2.2 Each Spring semester	**Duration** 2 Sem.
Course 2.1 Regional Development Strategies				**Lessons** 3 SWH (45 h)	**Self-Study** 75 h
Course 2.2 Regional Material Flow Management: Conceptional Approach and International Case Studies				**Lessons** 4 SWH (60 h)	**Self-Study** 120 h

Learning outcomes / competences

2.1 Regional Development Strategies

Within this course the major national policy strategies in the partner university countries are analyzed in the relevant areas of energy/energy efficiency, waste management, water management as well as land-use management. The learning outcomes are:

- Understand the national policy and strategies in the major material flow management areas
- Prepare the knowledge base to compare existing policy approaches with Zero Emission and Material Flow Management strategies as outlined in the second part of the module

2.2 Regional Material Flow Management: Conceptional Approach and International Case Studies

The course 2.2 is the backbone of the IMAT program introducing the cutting edge research ideas and conceptional approaches of Zero Emission and Material Flow Management as suitable strategies to establish new economy forms on a regional level. The learning outcomes are:

- Learn to analyse regions from cultural, economical, historical, political and administrative backgrounds (Material Flow Analysis)
- Understand the different forms of value (generations) in regions: Social, economical, ecological
- Understand how regions communicate internally and externally and how regions are governed
- Get a first overview on key Zero Emission technologies to implement regional Zero Emission strategies (extended in the Modules 5 to 8)
- Learn to use microeconomic tools to evaluate the regional added value potentials and calculate the business and development opportunities (extended in Module 9)
- Learn to develop systemic change management strategies for regions focusing on stakeholder management as well as networking and knowledge management (extended in Module 11)

The major learning outcome and competence within 2.2 are:

- Understand how to introduce regional MFM to villages, cities, counties and states in non European countries
- Learn to use MFM tools to develop and implement MFM master plans in an international context
- **Ability to design an own RMFM project in a non European region.**

Description of the Course Content

2.1 Regional Development Strategies

The course 2.1 consists of three major parts:

1) **National Policy Analysis with regards to major MFM areas**

   Analyse the current national legal framework and environmental conditions in the following development relevant areas:

   - Renewable Energy and Energy Efficiency Policy
   - Sustainable Resource and Waste Management Policy
   - Integrated Water Resource Management Policy
   - Land-use and Land-Use Change Policy
   - Other important national policy areas and development strategies
   - International policy responsibilities and commitments, e.g. Kyoto Protocol, etc

2) **Overview on national environmental issues and technologies**

   Analyse the current environmental issues

   Analyse current environmental technology options and management concepts

3) **Overview on national material flow balance and urban metabolism**

2.2 Regional Material Flow Management: Conceptional Approach and International Case Studies

The course 2.2 provides an holistic overview on the regional MFM tools and strategies applied by the Institute of Material Flow Management (IfaS) to develop Zero Emissions systems on a regional level. The course is structured alongside an regional MFM project approach:

1) **Introduction: Strategic Aspects of regional MFM and Zero Emission**

   Global environmental and economic issues and the regional dimension

   Zero Emission: new strategy for economic promotion and applied environmental/climate protection

   Overview on regional MFM tool kit and strategies

2) **Material Flow Management: Discover the potentials**

   Methods and ways to define the system boundary

   Design target-oriented qualitative and quantitative assessments methods, e.g. regional GHG balance

   Identification and modeling of current material and energy flows and future optimization potentials in the system (waste, water, wastewater, energy, agriculture, tourism, traffic, mobility etc.)

   Analyse the relevant (inter-) national legal framework and environmental conditions

   Analyse and predict the true (and hidden) system costs and expenditures

3) **Key Person and Stakeholder Management**

   Analysing the key persons and main stakeholder: Ranking them according to their importance for change management in the region or according to the quantity and qualities of material flows under their (in-) direct influence

   Evaluating the stakes of the key persons in the system and developing win-win strategies

4) Designing regional Zero Emission Technology Systems

Introduction of Key Zero Emission Technologies such as Biogas, Tri-Generation Technologies, District Heating and Cooling Grids, renewable Energies and Energy Storages, Nutrient recovery Technologies for waste water, Waste-to-energy-and-resources, etc.

Systemic design aspects of ZE technologies

Regional added value potentials and economic drivers for ZE technologies

5) Regional Added Value: Innovative Financing Tools and Financing for Innovations

Methods and tools to calculate Regional Added Value

Business planning for regional system change management

New forms of financing: regional pension funds (social participation), contracting forms and BOT models

Fundraising and Donor Management

Aggregating project-based business plans towards regional MFM master plans

6) Case Studies on international IfaS projects in regional ZE / MFM

Assessment of next-practice examples for regional ZE / MFM projects executed by IfaS in Germany and Europe

Analysis of economic promotion and climate protection strategies of German communities

Teaching Methods

Lectures, case studies, new media, group discussions, group presentations

Recommended Qualifications

Basic understanding of (ecosystem and business) management

Method of Grade Evaluation

The total score for the course is 100%:

Exam: 60 minutes (30%), Scientific paper: 25 pages (30%), Project calculation: max. 10 pages (40%), Students presentation, bonus for the best MFM project

Preconditions for the allocation of Credits

Successful exam as well as delivery of the scientific paper and project calculation

Usage of the Module (in other study courses)

Course 2.2 is used within the IMAT M.Sc. program

Significance of the grade for the final grade

10 ECTS/ 120 ECTS

Module representative and full-time lecturers

Prof. Dr. Peter Heck

Further information & Required Readings

Brunner, Paul H./ Rechberger, Helmut: *Practical Handbook of Material Flow Analysis*, Lewis Publications, 2004.

Manuskript für das Buch von Heck, Peter: Applied Material flow Management, Springer, Heidelberg New York, to be published in 2007.

Misc. Notes

Project papers will be given to students during the lecture

Module 3: INDUSTRIAL MATERIAL FLOW MANAGEMENT

Despite regions (with private and public consumption levels) a second important material and energy consumer is the industry. Within this module the students learn how to develop strategies leading to a reduction of material and energy demand in industry (material and energy efficiency) as well as to increase the economic competitiveness.

Within the sub course “3.1 Principles of Industrial Material Flow Management” students get a basic understanding on how to analyse industrial/company alongside their (horizontal and vertical) value-chains and get an appropriate toolkit to measure and monitor the results based on LCA or ISO norms. In sub course 3.2 the emphasis is placed on the “green transformation and reporting” process of companies focussing on new sustainability management and reporting processes. Finally, in sub course “3.3 Industrial Aspects of Factor 10 (Cleaner Production)” the German company management philosophy of Cleaner Production (Product Integrated Environmental Protection) is introduced and in case studies various areas for optimisation explained. While the entire module is strongly interlinked with sub course “4.1 Industrial Ecology” and the method of establishing an industrial ecology area, the sub course 3.3 is strongly linked to Module 5: SUSTAINABLE WATER MANAGEMENT, Module 7: RENEWABLE ENERGY AND ENERGY EFFICIENCY and 8: SUSTAINABLE WASTE AND RESOURCE MANAGEMENT.

Module No. 3	**Workload** 240 h	**Credits (ECTS)** 8	**Semester** 1.-2. Sem.	**Frequency of the offer** Course 3.1, 3.2 each Fall semester Course 3.3 each Spring semester	**Duration** 2 Sem.
Course 3.1 Principles of Industrial Material Flow Management				**Lessons** 2 SWH (30 h)	**Self-Study** 60 h
Course 3.2 Sustainability Management and Reporting				**Lessons** 2 SWH (30 h)	**Self-Study** 60 h
Course 3.3 Industrial Aspects of Factor 10 (Cleaner Production)				**Lessons** 2 SWH (30 h)	**Self-Study** 30 h

Learning outcomes / competences

3.1 Principles of Industrial Material Flow Management

- Understand the characteristics of MFM and how it has emerged
- Demonstrate the evidence and the business case for eco-efficiency in industrial companies
- Recognize Life-Cycle-Analysis as Best-Practice-Tool in Industrial MFM
- Knowledge of the requirements of Environmental Management Systems (ISO 14001 and EMAS)

3.2 Sustainability Management and Reporting

- Knowledge of the GRI-requirements for sustainability reporting
- Recognize the benefit of sustainability reporting for companies
- Ability for critical reflection of sustainability reports
- Understand the evidence of Corporate Social Responsibility

3.3 Industrial Aspects of Factor 10 (Cleaner Production)

- Describe the need for efficiency.
- Explain the fields with major efficiency potential.
- Describe major techniques to increase efficiency.
- Visualize the range of potentials by Best-Practice-Examples.

Description of the Course Content

3.1 Principles of Industrial Material Flow Management

The course 3.1 is the foundation for the subsequent courses 3.2. / 3.3 and consists of the following three major parts:

1) **Definition of Industrial Material Flow Management (MFM) and related terms as well as scopes**
   - Sustainability Management, Supply Chain Management, Environmental Management, Cleaner Production (CP)
   - Aims and Forms of Industrial MFM
1) **Principles and Key-Elements of Eco-Efficiency in Industry**
   - Design for Environment, Producer Responsibility, Re-engineer processes, revalorize by-products, redesign products, rethink markets
   - Case Studies on Eco-Efficiency in Industry
2) **Introduction to Life-Cycle Analysis (ISO 14040) and Environmental Management (EMAS)**
   - Principles of ISO 14040 and Case Studies Life-Cycle Analysis
   - Requirements and Differences of ISO 14001 and EMAS
   - Case Studies Environmental Management

3.2 Sustainability Management and Reporting

The course 3.2. consist of the two major parts:

1) **Overview of Sustainability management and Reporting Initiatives and Strategies in Industry**
   - Corporate Social Responsibility (ISO 2600)
   - Corporate Social Responsibility versus Green Washing
   - Carbon Footprinting (and other footprints)
   - Case Studies CSR and CF
2) **Analysis of the Global Reporting Initiative**
   - GRI-Principles for Defining Report Content and for Ensuring Report Quality
   - GRI-Standard Disclosures: Strategy, Company Profile and Stakeholder Engagament
   - GRI-Economic Indicators (Definitions and Examples)
   - GRI-Environmental and Social Indicators (Definitions and Examples)
   - Case Studies GRI

3.3 Industrial Aspects of Factor 10 (Cleaner Production)

The course 3.2. consist of the two major parts:

1) **Introduction of Cleaner Production**
   - Factor 4 or Factor 10: What level of de-materialisation is achievable?
   - Introduction of the German Production-Integrated –Environmental-Protection Approach
   - Cleaner Production (CP) as a way to realize Factor 10
   - Stakeholder Management and Motivation of employees for CP
   - Funding and support CP measures
2) **Analyzing Cleaner Production Case Studies: Lesson Learned**
   - CP Case Studies in Paper-, Painting-, Surface Plating -, Food - and Textile Industry
   - Energy related CP Case Studies, CP and Green IT

Teaching Methods Lectures, group discussions, case studies, student presentations
Recommended Qualifications **3.1 Principles of Industrial Material Flow Management** Basic understanding of industrial production processes **3.2 Sustainability Management and Reporting** and **3.3 Industrial Aspects of Factor 10** 3.1 Principles of Industrial Material Flow Management
Method of Grade Evaluation The grading of the module consists of two parts: Final exam (90 minutes - 40%) at the end of the module Scientific paper with oral presentation (20% for each course)
Preconditions for the allocation of Credits None
Usage of the Module (in other study courses) **3.1 Principles of Industrial Material Flow Management and 3.2 Sustainability Management and Reporting** IMAT M.Sc.
Significance of the grade for the final grade 8 ECTS/ 120 ECTS
Module representative and full-time lecturers Prof. Dr. Klaus Helling (Module representative) Dipl.Ing. Robert Weicht / Dipl.Ing. Eva Bertsch (Lecturers)

Further information

Literature etc.

Requirements for Students

Preparation of each class, Active Participation

3.1 Principles of Industrial Material Flow Management

Required Readings

Helling, K.(2006): Principles of Industrial Material Management, Birkenfeld

Guidelines of ISO 14001; ISO 14040; EMAS III

Wagner, B./ Enzler, S. (2006): Material Flow Management – Improving Cost Efficiency and Environmental Performance, Heidelberg

WBCSD (Ed.): The Eco-Efficiency Learning Module, 2006.

Course-related links

www.cleaner-production.de

www.iso.org

www,setac.org

www.wbcsd.org

3.2 Sustainability Management and ReportingRequired Readings

GRI-Standards for Sustainability Reporting

Helling, K.(2006): Principles of Industrial Material Management, Birkenfeld

Guidelines of ISO 26000

Misc. Notes

Project papers and Sustainability Reports of companies will be given to students during the lecture

Course-related links

www.iso.org

www.globalreporting.org

3.3 Industrial Aspects of Factor 10 (Cleaner Production)

Required Readings

Weizsäcker, E v./ Lovins, Amory/ Hunter, l. (1999): Factor 4. Doubling wealth, Halving Resource Use, Earthscan Publications

Misc. Notes

Project papers and practical examples for CP will be given to students during the lecture

Course-related links

www.pius-info.de/en/index.html

http://www.ressource-deutschland.tv/?lang=en**3.3 Industrial Aspects of Factor 10 (Cleaner Production)**

Module 4: INDUSTRIAL ECOLOGY & ZERO-EMISSION STRATEGIES

The Module 4: INDUSTRIAL ECOLOGY & ZERO-EMISSION STRATEGIES aims to provide a theoretical basis and practical introduction to the interdisciplinary research field Industrial Ecology (Management) and its roots in Ecological Economics, Systems Theory, Natural Science and Ecological Engineering. Industrial Ecology offers a basic understanding of sustainability principles from nature and their adaption to techno-sphere and therefore is strongly linked to Module 1. Students reflect on the application of material and energy flow analysis tools like MFA, SFA and LCA, Carbon Footprint as basic tools for the assessment of products and processes sustainability with linkage to Module 3: INDUSTRIAL MATERIAL FLOW MANAGEMENT and sub course "10.3: Modeling Carbon Footprints".

Industrial Ecology Management has a focus on Eco-Industrial Symbiosis, linking enterprises and organizations to connect their resources and waste flows in inter-firm and neighbor networks to exchange resources and information.

While the first part is focusing on industry/company networks, the second part focuses on entire regions and nations and the implementation of sustainability strategies and policies such as Circular Economy (China), 3R society (Japan) and sustainably societies in Europe.

Module No. 2	**Workload** 180 h	**Credits (ECTS)** 6	**Semester** 2. Semester	**Frequency of the offer** 4.1 and 4.2 each spring semester	**Duration** 1 Sem.
Course 4.1 Industrial Ecology				**Lessons** 2 SWH (30 h)	**Self-Study** 30 h
Course 4.2 International ZE Policy Approaches: Case Studies from Asia, Africa and Europe				**Lessons** 2 SWH (30 h)	**Self-Study** 90 h

Learning outcomes / competences

4.1 Industrial Ecology

- Provide a theoretical basis and practical introduction to the interdisciplinary research field Industrial Ecology and its roots in Ecological Economics, Systems Theory, Natural Science and Ecological Engineering.
- Deepen the understanding of material and energy flow analysis tools like MFA, SFA and LCA, Carbon Footprint as basic tools for the assessment of products and processes sustainability.
- Discuss basic of material and energy flow indicators of the Industrial metabolism of Industrial and developing countries in comparison.
- Discuss International Eco-Industrial Park approaches of UK, Japan, China and Europe and their effect on resources efficiency.
- Learn and explore additionally strategies like dematerialization, Slow-food, Re-Engineering and Up-Cycling are discussed on base of practical examples.
- Introduction of nature-integrated technologies, examples are recycling technologies (mobiles, PV, batteries) and nutrients recycling (P,N) cascading and new production lines on basis of renewable materials like a biorefinery.

4.2 International ZE Policy Approaches: Case Studies from Asia, Africa and Europe

- Provide an in depth knowledge of Circular Economy and Zero Emission policy strategies and implementation in key countries like Japan, Germany, China and Europe.
- Best practice analysis of country specific case studies in CE and ZE

Description of the Course Content

The sub course 4.1 Industrial Ecology is divided into 4 major parts:

1) History and roots of Industrial Ecology (IE)

Theoretical foundation of IE

Nature based principles of Industrial Ecology

Industrial metabolism - historical view and consumption aspects

2) Material and Energy intensity of processes and products

Tools for analysis of Material Flows and Intensity: MFA; SFA, MIPS, IOA

Tools for the analysis of Energy Flows: KEA, Energy Balance, Smart Metering, ISO 50001

Analysis of impacts: LCA steps and impact analysis, Carbon Footprint,

3) Eco Industrial Symbiosis and parks

Theory and strategies

International Case Studies and National Approaches of Eco-Industrial symbiosis and EIP projects

4) Case Studies on Cycling strategies and technologies
Reengineering, Repower, Retrologistic, Upcycling, Recycling, Downcycling, Cascading, Organics Cycling paths

Nutrients recovery: phosphorus, nitrogen, carbon capture and soil conservation

Biorefinery and Renewable Material Production lines (bioplastics)

Industrial Ecology Management

4.2 International ZE Approaches

1) Introduction Zero Emissions (ZE) and Circular Economy (CE)

History and Definition of ZE and CE

Current global ZE and CE trends

2) CE and ZE in Germany:

Renewable Energy Law, Closed loop and recycling law, land use strategies,

sustainable development policy, Case studies on national climate protection projects in German communities

3) CE and ZE in Japan: Ecocities, 3 R society, renewable energy policy

Overview of the environmental administration and policies in Japan,

Environmental problems and countermeasures in Japan since 1950s,

Towards the sound material-cycle society in Japan (1): laws and policies

Towards the sound material-cycle society in Japan (2): practices

Energy policies before and after the Fukushima nuclear accident

4) CE and Eco Industrial Parks in China: CE Law, eco Industrial Parks, Cleaner production

Policies and practices of eco-industrial park in China,

Policies and practices of eco-city in China

5) CE and ZE in Europe

Different national approaches on sustainable development in Europe,

Strategies of the European commission

Teaching Methods

Lectures and students group work

Recommended Qualifications
Basic knowledge (ecology, natural science)

Method of Grade Evaluation
The grading of the module consists of two parts:

Final exam (90 minutes - 40%) at the end of the module

Scientific paper with oral presentation (30% for each course)

Preconditions for the allocation of Credits

Successful exam and delivery of scientific papers

Usage of the Module (in other study courses)

The module is used as condensed version within the IMAT MSc program

Significance of the grade for the final grade

6 ECTS/ 120 ECTS

Module representative and full-time lecturers

Prof. Dr.-Ing. Susanne Hartard

Prof. Dr. Peter Heck and Prof. Dr. Li (APU) for course 4.2

Required Readings:

4.1 Industrial Ecology

Graedel, Tom H.; Allenby, Braden R.; Graedel, T.E. (2009) Industrial Ecology and Sustainable Engineering. Prentice Hall.

Graedel, Thomas E.; Braden R. Allenby (2002) Industrial Ecology (2nd Edition) [Hardcover] Publisher Prentice Hall.

Frosch, Robert A., Gallopoulos, Nicholas E. "Strategies for Manufacturing." Scientific American 261 (September 1989): 144-152. (*****)

Further information and articles (e.g. International Society of Industrial Ecology (ISIE), International Journal of Industrial Ecology, Journal of Cleaner Production) will be provided.

4.2 International ZE Policy Approaches: Case Studies from Asia, Africa and Europe

Nakano, M. (1997): The policy-making process in contemporary Japan, translated by Jeremy Scott. Hampshire: Macmillan Press; New York: St. Martin's Press.

Saich, T. (2011) Governance and politics of China, 3rd ed. Basingstoke, Hampshire: Palgrave Macmillan, 2011.

Further information, case study materials and articles will be provided.

Module 5: SUSTAINABLE WATER MANAGEMENT

Within the Module 5: SUSTAINABLE WATER MANAGEMENT the students learn the basic engineering principles of integrated water resource management (IWRM) and the combination or cross-cutting impacts on energy and water management. While the engineering foundations are laid in the first sub course 5.1, the second course explores the future global challenges of IWRM with focus on sanitation and sustainable water re-use and nutrient recovery strategies.

The course is strongly linked to Module 2: REGIONAL MATERIAL FLOW MANAGEMENT, Module 3: INDUSTRIAL MATERIAL FLOW MANAGEMENT and Module 4: INDUSTRIAL ECOLOGY & ZERO EMISSION STRATEGIES providing an engineering understanding on water related issues.

Module No. 5	**Workload** 180 h	**Credits (ECTS)** 6	**Semester** 2.-3. Sem	**Frequency of the offer** 5.1 each Spring Semester 5.2 each Fall Semester	**Duration** 2 Sem.
Course 5.1. Basic Engineering Aspects of Sustainable Water Management				**Lessons** 2 SWH / 30h	**Self-Study** 30h
Course 5.2. Sustainable Water Management: Future Challenges and Best Practices				**Lessons** 2 SWH / 30h	**Self-Study** 90 h

Learning outcomes / competences

The course is designed to provide the students an understanding about technical and economical aspects of integrated water resource management strategies (IWRM) as an important pre-requisite towards regional Zero Emission strategies.

5.1 Basic Engineering Aspects of Sustainable Water Management

Basic understanding on the global importance and challenges in water and sanitation management

Basic knowledge in water science, aquatic ecology and the hydrological cycle, with understanding of the dynamic relationship between human and natural systems

Basic knowledge on important water pollutants and water quality parameters and standards as well as physical-chemical treatment options

5.2 Sustainable Water Management: Future Challenges and Best Practices

Understand the interconnections between water, soil, energy, sustainability and regional development

Understand basic principles and design aspects of sanitary engineering infrastructure focusing on drinking water supply and treatment, sewerage and wastewater treatment

Introduction of new management and technology concept for nutrient recovery water re-use and energy efficient (autarkic) waste water treatment

Excursions to provide first-hand insights in technological aspects of the urban water infrastructure

Description of the Course Content (Overview of each class)

5.1 Basic Engineering Aspects of Sustainable Water Management

The course 5.1 is the foundation for the subsequent course 5.2. and consists of the following six major parts:

1) Introduction to global water cycle and global water problems *(hydrology)*

- Proportion freshwater / seawater, global amounts / Global dispersal of freshwater
- Water cycle: precipitation, infiltration / runoff / evapotranspiration; + equations & measurement methods
- Introduction to sustainability principles

2) Introduction to water supply and wastewater (*sanitary environmental engineering*)

- Processing of drinking water
- ww-Constituents: Biodegradable carbons, organics (COD, BOD), particles (TS, TSS, SM,…), Nitrogen (first of all NH_4, NO_2), Phosphorus (P_{tot}, PO_4, org. P, Poly-P), heavy metals, micro-pollutants,…
- History of ww-treatment

3) Impacts of pollution on ambient water quality *(hydrology, limnology)*

- Oxygen consumption
- Eutrophication
- Toxic impacts of waste water (NH3, H2S, org. Hg,…)
- Bio-accumulation (heavy metals, micro-poll.)

4) Water quality parameters and standards: drinking water, discharged waste water and sludge [emission goals], freshwater bodies [immission goals] (*sanitary environmental engineering*)

- Drinking water: microbiology, pH, NH_4, NO_3, heavy metals, organics
- Emission goals for wtp: COD, BOD_5, NH_4, NO_2, N_{tot}, P_{tot},
- Immission goals in freshwater bodies: Temp., pH, O_2, BOD_5, NH_4, NO_2, NO_3, PO_4,
- Immission goals for soils when applying sludge: Heavy metals,…

5) Watershed management – comprehension of quality and quantity targets of catchments (*hydrology*) <u>including land-use-strategies</u>

- Dilution-calculation of waste water discharging in freshwater bodies
- Ground water feed rate in relation to the natural replenishment

6) International water-related policies (*sanitary environmental engineering*)

5.2 Sustainable Water Management: Future Challenges and Best Practices

The course 5.2. consist of the following six major parts:

1) Case study on the history of water protection in Germany (*sanitary environmental engineering*)
2) Introduction to water treatment technologies and appropriate technologies for developing countries (*sanitary environmental engineering)*
3) Introduction to Biological reaction kinetics (*sanitary environmental engineering, aquatic chemistry)*
4) Introduction to water re-use and waste water avoidance strategies (*sanitary environmental engineering*)
5) Dynamic cost comparisons (*sanitary environmental engineering*)
6) Excursions to different innovative WWTP technology sites as well as comprehensive water excursion from the catchment are of drinking water to the final disposal of waste water

Teaching Methods

Lecture, debate, students short presentation, scientific text work, excursion

Recommended Qualifications

Basic knowledge on chemistry and biology (linked with Module 1: Ecosystem Management)

Method of Grade Evaluation

The grade is an weighted average (each 1/3) of the following parts:

Case studies (paper) concerning drinking water and waste water situation in the students countries (inhabitants, public water support and waste water treatment [% of pop.], water consumption per inhabitant, replenishment, recent condition of freshwater bodies) – End of Course 5.1

Case studies (paper) concerning the transferability and adaptation requirements of certain innovative WWTP or drinking water related technologies towards the students native countries – End of Course 5.2

Joint exam on the content of course 5.1 and 5.2

Preconditions for the allocation of Credits

Participation in both courses of the module

Usage of the Module (in other study courses)

Parts of the courses may be used in a condensed and less technical way for the IMAT M.Sc. program.

Significance of the grade for the final grade

6 ECTS/ 120 ECTS

Module representative and full-time lecturers

Dr. Ingo Bruch

Further information

5.1 Basic Engineering Aspects of Sustainable Water Management

Selected chapters (tba) of the following literature:

Stumm, W. & J. J. Morgan (1996): Aquatic chemistry – chemical equilibria and rates in natural waters.

Tschobanoglous, G., Burton, F. L. & H. D. Stensel (2003): Wastewater Engineering, Treatment & Reuse. Metcalf & Eddy (Ed.), Boston.

UN-Habitat (2008): Constructed wetlands manual. UN Habitat – Water for Asian cities programme. Nepal, Kathmandu.

Module 6: ENERGY SYSTEM MANAGEMENT

Sustainable energy (demand and supply) management is one of the backbones of the IMAT study course. While sub course “6.1 Basic Principles of Energy Systems” is providing the energy engineering essentials and basics, the course “6.2 Energy System Design: Future Challenges and Strategies” is focussing on the future requirements and challenges to establish 100% renewable energy supply systems as envisaged for Germany until 2050. Topics such as energy efficiency, energy grid architecture and the design of energy grids in the future (so called smart grids) will be discussed. Current existing technologies and management strategies are investigated and future innovations defined. A particular emphasis will be placed on the options for energy storage and different endues-energy forms such as heating, cooling, etc. as substantial elements in new and intelligent energy supply structures of the future.

Module No. 6	**Workload** 120 h	**Credits (ECTS)** 4	**Semester** 2.-3. Sem.	**Frequency of the offer** Course 6.1 each Spring semester Course 6.2 each Fall semester	**Duration** 2 Sem.
Course 6.1 Basic Principles of Energy Systems				**Lessons** 2 SWH (30 h)	**Self-Study** 30 h
Course 6.2 Energy System Design: Future Challenges and Strategies				**Lessons** 2 SWH (30 h)	**Self-Study** 30 h

Learning outcomes / competences

6.1 Basic Principles of Energy Systems

- Introduction in basic laws of (energy) physics, e.g. Thermodynamics, Electrodynamics, Efficiencies
- Provide the basic engineering foundations in energy relevant issues
- Provide a technical understanding on conventional energy power plant operations
- Provide the essential knowledge for the course 6.2 and module 7

6.2 Energy System Design: Future Challenges and Strategies

- Provide an understanding on electric power generation and grid operation, including electric system design and operation, and integration between utilities and Regional Transmission Organizations.
- Develop an understanding of the function and operation of transmission and distribution networks, their structure and components.
- Provide an understanding on the future-oriented Smart Grid Design requirements and components, including metering, demand response, virtual power plants, dynamic pricing, grid enhancement funding, demand analysis, promotion of “green” resources, governmental regulation, network standards, network integration.
- Analyze the risks to the Smart Grid and discuss protective measures to ensure system integrity and supply reliability.

Description of the Course Content

6.1 Basic Principles of Energy Systems

The course 6.1 is the foundation for the subsequent course 5.2. (and partly for Module 6) and consists of the following major parts:

1) Basics of energy (physics) and electricity

Energy Physics: Units, Mechanics, (Electrodynamics), Waves and Radiation, Nuclear Physics, Basic Principles of the "First Law of Thermodynamics" (Internal Energy, Enthalpy, Entropy)

Energy related definitions: Quality of energy, Primary Energy, Final Energy, Useful Energy

2) Technical analysis of the "Second Law of Thermodynamics"

Forms of energy, Quality of Energy (anergy, exergy) and energy resources

Working fluids in energy (conversion) technology

3) Conversion of energy kinds

From primary energy to end use energy and from end use energy to useful energy

End use energy: electricity, fuel, mineral oil, district heat, gas, etc. Efficiencies.

4) Cyclic processes for energy conversion and their technical outline

Introduction and Analysis of Carnot cycle in thermodynamics, Stirling cycle, Clausius-Rankine cycle, gas turbine cycle, Otto cycle, heat pump or refrigerating machine. Steam turbine, internal and external combustion engines.

5) Technical Principles of Conventional Power Plants

Basic technical principles of steam turbine power plants, gas turbine power plants,

gas and steam combined heat and power plants and nuclear power plants

6.2 Energy System Design: Future Challenges and Strategies

1) Basics of electricity

Electrical field, Kirchhoffs circuit law and Ohms Law, Circuit Elements (Resistors, Capacitors, Inductors,), semi-conductors **Electrical power generation**

Electric generators types (asynchronous, synchronous) and important subtypes (squirrel-cage rotor, doubly-fed asynchronous, permanent excited synchronous), operation and options for feed-in management
photo-voltaic cells and modules
inverters and transformers, connection to grid

2) Electric power systems

Features and structure of power (supply, transmission and distribution) systems

Design and operation of power systems and grids (operating reserve, voltage and frequency stability)

Electricity demand characteristics and Demand Side Management Options

Institutional and regulatory issues

3) Technical Aspects of Sub-Stations, Power Transmission and Distribution Design of Transmission and distribution system Overview on Substations, sub-station equipment and transmission lines Planning, design & selection aspects of tower/poles structure, conductors, insulators and other hardwares, Load Dispatch and Grid Management
4) Characteristics of RE generation Variability and predictability Electrical characteristics and power plant capabilities Geographical and seasonal balancing, storage options, value and cost of energy **5) Options to facilitate the integration of RE** Integration of renewable energy into gas Integration of renewable energies into heating and cooling networks Challenges associated with integration into heating/cooling networks Characteristics of RE with respect to integration into gas grids **6) Visions for possible future power supply systems** Conceptional design of smart grids and introduction into their elements Case study concepts for future power supply systems
Teaching Methods Lecture, In-Class Discussion, Excursion, Student presentations
Recommended Qualifications None
Method of Grade Evaluation The grading of the module consists of two parts: Final exam (90 minutes - 60%) at the end of the module Scientific Paper with Oral Presentation (depeniding on the group size) (40%)
Preconditions for the allocation of Credits Successful exam and submission of paper
Usage of the Module (in other study courses) Course 6.2 might be used as elective for the IMAT MSc. program
Significance of the grade for the final grade 4 ECTS / 120 h
Module representative and full-time lecturers Dipl. Ing. Christian Synwoldt
Further information Literature etc. – to be announced

Module 7: RENEWABLE ENERGY AND ENERGY EFFICIENCY

Based on the previous module the students get a detailed insight in renewable energies and energy efficiency strategies, two pre-requisites to develop 100% renewable and sustainable energy supply systems supporting a rational use of energy.

The implementation of Zero-Emission strategies and Circular Economy visions outlined and assessed in Module 2: REGIONAL MATERIAL FLOW MANAGEMENT and Module 4: INDUSTRIAL ECOLOGY & ZERO EMISSION STRATEGIES depends on our availability to define and maximise the renewable energy potentials in regions and geographic districts. Therefore, the course deals in one parts with the technical aspects and status quo of various renewable energy sources and provides all necessary planning tools and knowledge to design RE parks and integrating them in existing energy distribution and transmission grids.

Despite the societies ability (and based on the indigenous RE resources) the sustainability potentials strongly depend on a rational energy usage. Therefore the second part of the module provides insights in latest energy efficiency technologies and strategies for various forms of end energy use (in close cooperation with sub course "3.3 Industrial Aspects of Factor 10 (Cleaner Production)"). The GHG abatement effects of 100% energy strategies and energy efficiency projects as outlined in this module are taught in "sub course 10.2 Greenhouse Gas Abatement Strategies and Carbon Trading", where this module is an essential backbone.

Module No. 7	**Workload** 120 h	**Credits (ECTS)** 4	**Semester** 3. Sem.	**Frequency of the offer** Each Fall semester	**Duration** 1 Sem.
Renewable Energy and Energy Efficiency				**Lessons** 4 SWH (60 h)	**Self-Study** 60 h

Learning outcomes / competences

Part: Renewable Energies

- Provide an understanding on actual and future design challenges and strategies for (100%) renewable energy supply systems
- Enable students to understand the qualitative difference between conventional and regenerative supply in terms of long-term continuity, economy and ecology.
- Provide an overview on current global renewable energy policies and markets as well as push and pull factors and constraints
- Provide the technical and economical understanding on various renewable energy forms
- Provide a methodological knowledge on energy life cycle assessment and energy balances throughout the various life stages from resource extraction towards final use energy.
- Discuss the impacts of Renewable Energy on the overall Energy Grid Structure (connection towards course 6.2)
- Enable students to conduct a technical design and a business plan for renewable energy projects by analyzing best-practice-examples.

Part: Energy Efficiency

- Describe the necessity for energy efficiency and explain fields with major efficiency potential.
- Describe major technologies to increase energy efficiency for various enduse energy forms, e.g. heating, cooling, electricity, compressed air, etc.
- Enable students to conduct a technical design and a business plan for energy efficiency projects by analyzing best-practice-examples.

Description of the Module Content

The module is divided in the parts of **Renewable Energies** and **Energy Efficiency**:

The contents of the part **Renewable Energy** are:

1) **Critical assessment of conventional fuels (focus on coal, oil, gas and nuclear)**

   Life cycle analysis with focus on the environmental and economic impacts of conventional fuels

   Life energy balance of energy conversion plants based on conventional fuel

   Scarcity, global availability and resources as well as supply chains for conventional energy carriers

2) **In-depth analysis of regenerative energies (Wind, Solar, Hydro, Biomass, Geothermal Heat)**

   Basic physical principles of different RE

   Analysis of current technology options, level of innovation and mode of operation

   Economic aspects of renewable energy on a micro and macro-economic level

   Impacts on RE on regional Zero-Emission concepts and case study on bio-energy villages in Germany

3) **Systematic Approach to RE use**

   Calculatory and physical energy autonomy

   Energy-mix, seasonal / geographical balance, grid operation and management, requirements for storage systems

   storage systems, physical capabilities and optimization strategies for storage infrastructure on a macro-economic level

   identification and use of processes with inherent storage capabilities (water tower, desalination, mechanization, heating/cooling)

   Beyond counting kWhs: intended excess production of RE – paradigm shift in grid operation from supply shortfall to abundance of energy

   Synthetic fuels for transport sector

4) **Market drivers and Barriers of Renewable Energies**

   Economic Drivers and market/legal incentives of RE (Feed-in tariffs, Subsidies, Power purchase agreement, investment and financing, etc)

   Grid Parity and cost of energy (services) of different RE

   International legal and institutional frameworks for RE [quotas for renewable supply, ratification of (inter-) national agreements (e.g. Kyoto-Protocol), grid access and feed-in codes, etc]

   On- and off-grid systems: Integration in current transmission and distribution systems

The contents of the part **Energy Efficiency** are:

1) Building Energy Services Engineering

Technical aspects on heating and cooling demand of buildings (heat conductivity, heat transmission, etc)

Optimization strategies towards energy-plus buildings (e.g. solar architecture)

Engineering aspects of district heating and cooling and grid

LCA of different heating and cooling options as well as insulation and building materials

Case Studies on Energy-Plus Buildings

2) Energy Efficiency and Solar Cooling

Technical aspects of solar adsorption and absorption cooling systems

Economic analysis on existing solar cooling systems in relation to installed capacity

Case Study on the solar cooling system of the Environmental Campus Birkenfeld

3) Energy Efficiency in public sector, commercial buildings and Industry

Optimized light and heating / air-condition

Technical aspects of compressed air management

Technical aspects on steam management

Energy Demand Side Management options for industries

Case Studies on Energy Efficiency in Industry (linked with course 3.3)

4) Energy Efficiency, Smart Grid and Sustainable Mobility

Future role of energy efficiency with active smart grids

E-Mobility, drive train concepts, fuels and energy storages, space and energy efficiency

Role of Energy Efficiency in 100% RE systems

Teaching Methods

Lectures, group discussions, case studies, student presentations

Recommended Qualifications

Course 6.1 and Course 12.2

Method of Grade Evaluation

The grading of the module consists of two parts:

Final exam (90 minutes - 60%) at the end of the module

Scientific Paper with Oral Presentation (depending on the group size) (40%)

Preconditions for the allocation of Credits

Successful exam and submission of paper

Usage of the Module (in other study courses)

A condensed version (as a single course) might be offered as elective in the IMAT M.Sc.

Significance of the grade for the final grade

4 ECTS/ 120 h

Module representative and full-time lecturers

Dipl. Ing. Christian Synwoldt

Further information
Literature etc. – to be announced

Module 8: SUSTAINABLE WASTE AND RESOURCE MANAGEMENT

While Module 2: REGIONAL MATERIAL FLOW MANAGEMENT, Module 3: INDUSTRIAL MATERIAL FLOW MANAGEMENT and Module 4: INDUSTRIAL ECOLOGY & ZERO EMISSION STRATEGIES deal with material and energy efficiency strategies at the point of resource extraction and utilisation, the Module 8: SUSTAINABLE WASTE AND RESOURCE MANAGEMENT focuses on the recovery and re-use of materials (and energy) at the end of the product life times. In accordance with the European waste hierarchy different material recovery and re-use technologies and management strategies are assessed. Students learn to consider that the term waste refers to the wrong material flow at the wrong time at the wrong place. By optimising the management concept and using appropriate technologies, various “waste flows” can be turned again into valuable resources minimising the resource extraction and second pollutions.

Hence, technologies, management, and financing tools for turning waste into resources and added value are explained within the module in order to enable students to change the existing waste management system into resource providing system. In close cooperation with Module 4: INDUSTRIAL ECOLOGY & ZERO EMISSION STRATEGIES different recycling networks, in particular for rare earth metals, are evaluated. In close cooperation with Module 7: RENEWABLE ENERGY AND ENERGY EFFICIENCY the waste-to-energy section for bio waste is explaining in detail.

The module is involving several practitioners explaining the innovative aspects of waste and resource management strategies in Germany, one of the leading countries in the world in this regards. Furthermore, different excursions to innovative technology sites are sharpening the practical relevance of the module.

Module No. 8	**Workload** 120 h	**Credits (ECTS)** 4	**Semester** 3. Sem.	**Frequency of the offer** Fall semester	**Duration** 1 Sem.
Sustainable Waste and Resource Management		**Lessons** 4 SWH (60 h)		**Self-Study** 60 h	

Learning outcomes / competences

- Students will have a holistic overview on the environmental impacts of end-of-pipe based waste management systems and learn the optimisation potentials towards new Circular Economy based systems.
- Students get abreast on the latest organisational and technology options for sustainable resource management and learn how to calculate the regional added value of such systemic waste management approaches based on Material Flow Management strategies.
- Students get abreast on scarcities of certain elements (rare earth minerals) and recovery/recycling strategies
- Students get an understanding of Zero Emission options in the field of Municipal Solid Waste (MSW)

Description of the Course Content (Overview of each class)

1) Management Aspects of Sustainable Waste Management

Global overview on Municipal Solid Waste management concepts, technologies and their environmental impacts

Introduction of the legal waste management (Circular economy) framework in Europe and outlook on future German Zero Emission law in MSW management

Administrative and legal organisation of MSW collection, transportation and treatment systems on communal/regional levels

Sectoral Approach for the Implementation of Sustainable Municipal Solid Waste Management Systems in Developing Countries to link Climate Change Mitigation, Resource Efficiency and Sustainable Development

2) Technical (and economical) Aspects of Sustainable Waste Management

Technical requirements (and economics aspects) of sanitary landfill design and operation

Technical options (and economics aspects) of Waste-to-Energy technologies:

- SWOT analysis of different for the mechanical-biological treatment (stabilisation) options of MSW
- SWOT analysis of different of waste incineration and co-incineration technologies including RDF definition, renewable energy carrier definition and quality parameters (pellets, RDF)
- Emission control in waste incineration plants

Excursion to RDF production and usage sites, composting and anaerobic digestion of MSW, sanitary landfill with landfill gas utilisation

3) Recycling and Resource Management

Landfill and Urban Mining: new economic, technology and conceptual designs for resource economies

Overview on global primary and secondary resources market (scarcities, prices, dynamics, stock exchange, dependencies and resources conflicts)

Technical options (and economics aspects) for resource recovery from waste:

- Case Studies on rare earth minerals and metals use and recovery in key technologies (mobile phones, plasma displays, permanent magnets, hybrid motors, alloy in batteries, illuminants in LCD displays)
- Case Studies on plastics sorting and recycling (PET cascading, PE regranulates, tire recycling)
- Case Studies on resources in batteries (Lithium) and their recovery
- Case Studies on waste wood material recycling

Teaching Methods

Lecture, discussions, new media, students presentations, scientific text work

Recommended Qualifications

Basic knowledge on chemistry

Method of Grade Evaluation

The grading of the module consists of two parts:

Final exam (90 minutes - 60%) at the end of the module

Scientific Paper with Oral Presentation (40%)

Preconditions for the allocation of Credits Pass the exam and delivery of written report at the end of the semester
Usage of the Module (in other study courses) A condensed version of the module (in course size equivalent to 2 ECTS) might be offered as elective in the IMAT M.Sc. program.
Significance of the grade for the final grade 4 ECTS/ 120 ECTS
Module representative and full-time lecturers Prof. Dr.-Ing. Susanne Hartard plus various experts with contributions of in single sessions
Further information Selected Chapters of the following literature:
Bilitewski, Bernd; Härdtle, Georg; Marek, Klaus et al. (1996) Waste Management. Springer Berlin Heidelberg. Avraam Karagiannidis, Avraam (2012) (Ed.) Waste to Energy: Opportunities and Challenges for Developing and Transition Economies. Springer London. Further study material will be provided.

Module 9: BUSINESS PLANNING FOR ENGINEERS

The module has a twofold approach. Firstly, the sub course „Business Planning for Engineers“ will enable the students to calculate and monetary assess the technological change processes as studied in Module 2: REGIONAL MATERIAL FLOW MANAGEMENT, Module 3: INDUSTRIAL MATERIAL FLOW MANAGEMENT and Module 4: INDUSTRIAL ECOLOGY & ZERO EMISSION STRATEGIES and prepare business plans for detailed technology projects such as renewable energy or energy efficiency projects.

Secondly, the sub course “Project Planning and Project Management” will enable the students to plan and execute their own research projects (e.g. Master Thesis). The students are encouraged already prior to the start of the study course to think about a potential research project as a two-page essay on this is already part of the application process. This sub course shall help the students to break their visions down in small and manageable, communicable parts and plan the next steps ahead. The methodological skills and tools provided enable the students to structure regional change processes as studied in Module 2: REGIONAL MATERIAL FLOW MANAGEMENT.

Module No. 9	Workload 120 h	Credits (ECTS) 4	Semester 1. Sem.	Frequency of the offer Each Fall semester	Duration 1 Sem.
Course 9.1 Business Plan Development			**Lessons** 2 SWH (30 h)		**Self-Study** 30 h
Course 9.2 Project Planning and Project Management			**Lessons** 2 SWH (30 h)		**Self-Study** 30 h

Learning outcomes / competences

9.1 Business Plan Development

The objective of this course is to enable the students to conduct an elementary financial feasibility study for a business plan. The course objectives in detail are:

- Understand and apply basic financial mathematics to calculate project or business values
- Get a basic understanding of analyzing financial statements and balance sheets
- Get a sound understanding on the creation of business plans

9.2 Project Planning and Project Management

This course aims to provide an understanding of project management and controlling techniques applied to projects in the field of Material Flow Management and apply this knowledge to develop a practical research project. The course objectives in detail are:

- Explicate the fundamental factors in project success and failure
- Develop an understanding of project baseline plans, their implementation and management
- Survey the variety of approaches in project time and cost management, including current techniques, technologies and practices
- Define and structure student research projects (e.g. Master Thesis projects)

Description of the Course Content (Overview of each class)

9.1 Business Plan Development

The course 9.1 consists of the four major parts:

1) **Accounting and Controlling**

Terms and basics of cost accounting and controlling in companies

How to read and interpret a balance sheet

2) **Investment Calculations and Business Valuation**

Introduction of financial mathematics such as internal rate of return, return on invest, net present value, real options

Basics in valuation of projects, e.g Capital Asset Pricing Model, Discounted Cash Flow Calculation (DCFC)

Comparison of other value-asset and market approaches

3) **Finance and Investment**

Introduction and evaluation of financial performance indicators to interpret and measure profitability, solvency, liquidity and stability of businesses

Case Studies on evaluating and interpreting balance sheets and company financial reports

4) **Business Plan Design**

Main aspects and content of business plans

Managerial budgeting and prediction of business potentials

Market and Competitor analysis

Case Studies in Business Plan Design

9.2 Project Planning and Project Management

The course 9.1 consists of two theoretical parts and the development of a practical project management concept for the student research ideas within the master thesis semester:

1) **Introduction in Project Management and Project Life Cycle**

Introduction of Definitions to Project Management

Analysis and definition of problems, scopes and objectives (economic, ecological and social objectives of MFM projects)

Methods and tools for stakeholder analysis

2) Project Planning and Execution

Definition of the project structure and organization

Methods to create and steer project execution teams

Development of detailed and high-level project management plans

Resource and Cost Planning: Structured planning of human, material and financial resources and principle understanding of earned value management

Project Quality Management and Risk Management

Introduction and Case Studies on Microsoft Project Management Software

3) Student case Studying and Modelling of student research projects

Individual coaching of the students to outline their MFM projects and business plans

Student presentations of their MFM business plans

Teaching Methods

Lectures, group discussions, case studies, student presentations

Recommended Qualifications

None (Submission of a research paper prior to enrolment)

Method of Grade Evaluation

The grading of the module consists of two parts:

Final exam (90 minutes - 40%) at the end of the module

Scientific Paper with Oral Presentation (30% each):

Within 9.1: Analyse of a given business plan or development of an own business plan for a fictive product/project

Within 9.2: Project Management Concept for the research idea within the master thesis semester

Preconditions for the allocation of Credits

Tentative outline of a master thesis research project as well as development of PM structure for the execution

Usage of the Module (in other study courses)

Condensed version of this module might be used as elective for the IMAT MSc. program

Significance of the grade for the final grade

4 ECTS/ 120 ECTS

Module representative and full-time lecturers

Prof. Dr. Dirk Löhr

Prof. Dr. Christian Bleis (9.2)

Further information

Case study materials and other notes will be provided as supplementary references for the students.

Course 9.1 Business Plan Development

Required Readings

Schwetje, Gerald (2007): The business plan : how to win your investors' confidence, Springer Verlag

Manning, Ross, L. (2000): businessplan.com : how to write an ecommerce business plan, Oasis

Hax, Arnoldo C., Majluf, Nicolas S. (1995 2cd Ed.): Strategy Concept and Process: A Pragmatic Approach

Course 9.2 Project Planning and Project Management

Required Readings

Project Management Institute (2004): PMI's Guide to the Project Management Body of Knowledge

Module 10: TECHNICAL ASPECTS OF DE-CARBONIZING STRATEGIES

This module aims to provide a sound understanding on the current global climate change discussion. Students get abreast about the complex feedback system of various anthropogenic and natural interventions into the atmosphere and the imbedded responsible greenhouse substances and further anthropogenic pollutants.

The sub course “10.1 Chemistry of Global Climate Change: Important GHG Cycles” provides the necessary chemistry background to understand the fluxes and impacts as well as interconnections and radiative forcing of important GHG´s and ozone depleting substances and deepen the knowledge gained in Module 1: ECOSYSTEM MANAGEMENT and Module 12: PHYSICS AND CHEMISTRY FOR THE ENVIRONMENT.

The sub course “10.2 Greenhouse Gas Abatement Strategies and Carbon Trading” deals with the quantification of GHG abatement potentials of selected technical solutions for Zero-Emission strategies. These GHG potentials are transferred into monetary assets by using international carbon trading schemes. Students are getting knowledge on the mode of operation of international carbon trading schemes, e.g. the European Union Emission Trading scheme and Clean Development Mechanism. Hence, the students learn to use of carbon trading options to co-finance Zero-Emission strategies outlined in Module 2: REGIONAL MATERIAL FLOW MANAGEMENT and Module 3: INDUSTRIAL MATERIAL FLOW MANAGEMENT. These Zero-Emission strategies involve the systemic optimisation of existing energy, water, and waste management systems, which will be technically explained in detail in Module 5: SUSTAINABLE WATER MANAGEMENT, Module 6: ENERGY SYSTEM MANAGEMENT, Module 7: RENEWABLE ENERGY AND ENERGY EFFICIENCY and Module 8: SUSTAINABLE WASTE AND RESOURCE MANAGEMENT.

Within sub course “10.3 Modelling Carbon Footprints” students deepen their methodological understanding in modelling CO_{2e} cycles during all stages of production processes and develop optimisation/abatement strategies based on their theoretical knowledge gained during sub course “3.3 Industrial Aspects of Factor 10 (Cleaner Production)”.

Module No. 10	**Workload** 240 h	**Credits (ECTS)** 8	**Semester** 2.-3. Sem.	**Frequency of the offer** 10.1 & 10.3 each Fall Semester 10.2 each Spring Semester	**Duration** 2 Sem.
Course 10.1 Chemistry of Global Climate Change: Important GHG Cycles				**Lessons** 2 SWH / 30h	**Self-Study** 30h
Course 10.2 GHG Abatement Strategies and Carbon Trading				**Lessons** 2 SWH / 30h	**Self-Study** 30h
Course 10.3 Modelling Carbon Footprints				**Lessons** 2 SWH / 30h	**Self-Study** 90h

Learning outcomes / competences

In general, this module aims to provide an understanding of the important GHG cycles as well as a sound knowledge on GHG abatement and carbon trading options as well as balancing and modeling tools for project, product are technology based GHG emissions.

10.1 Chemistry of Global Climate Change: Important GHG Cycles

Course 10.1 explores the fundamentals of global climate change in the context of atmospheric changes caused by human activities in general and provides chemistry knowledge on global warming, carbon cycle, responsible greenhouse substances, but also further anthropogenic pollutants into the atmosphere. While public discussion is mainly focused on CO_2 as the main excess greenhouse effect pollutant, climate changes are imbedded in a complex feedback system of various anthropogenic and natural interventions into the atmosphere. For example, oxidative smog, black carbon emissions, ozone depleting compounds, radiative forcing substances and ozone depleting species are brought together and discussed with respect to their impacts as well as chemical and physical interconnections. The overall object is to converge an understanding of “sustainability” which includes a diversified knowledge foundation on anthropogenic atmospheric changes with emphasize on atmospheric radiation balance

10.2 Greenhouse Gas Abatement Strategies and Carbon Trading

The course objective is to introduce the institutional roots of global GHG abatement and carbon trading regimes. Based on a thorough analysis of the current flexible mechanisms of Kyoto protocol (with emphasis on the Clean development Mechanism) and the future developments post-2012 students are enabled to create, calculate and document GHG abatement and carbon trading projects in various sectors such as energy, waste and waste water.

10.3 Modelling Carbon Footprints

The course aims at understanding the fundamentals for estimating carbon footprints of products, processes and technologies. Life Cycle Analysis (LCA), used to calculate carbon footprints along supply chains, will be explained and hands-on exercises using the software tool UMBERTO for Carbon Footprint will be provided. The differences between the up-to-date international standards such as ISO 14044, ISO 14067 and PAS2050 will be examined and the advantages and disadvantages of carbon labeling discussed.

Description of the Course Content (Overview of Courses)

10.1 Chemistry of Global Climate Change: Important GHG Cycles

This course is divided as follows: Within an introductory part, the current scientific knowledge on global warming is analysed, the methods of paleoclimate reconstruction are presented. The first part is completed by the definition of atmospheric changes, the evaluation of problems and interconnections as well as the introduction of the nine main areas of atmospheric changes.

In the second part the fluxes, impacts and cycles of different GHG´s such as tropospheric and stratospheric ozone, nitrous oxides, sulfur and SF6, as well as dust, aerosols and acids are introduced and analysed. A special emphasis is placed on the global carbon cycle. The second part ends with a discussion of important single substances and separate problems (over fertilization, heavy metals, POP’s, radioactive isotopes) as well as a conclusion and summary session.

10.2 Greenhouse Gas Abatement Strategies and Carbon Trading

The course is divided into two main parts: Within the first part, the historical and future-oriented development of the global GHG abatement and carbon trading regimes based on the United Nation Framework Convention on Climate Change (UNFCCC) are explained and different (multi-) national manifestations (e.g. in EU Emission Trading Scheme) analysed. Using a business game (simulation of a COP/MOP) the students learn about the complexity, provisions and implications of international climate protection negotiation processes.

The second part will be an in-depth analysis of existing carbon trading modalities and procedures using the (programmatic) Clean Development Mechanism with its embedded assessment of baseline, additionality and sustainability. CDM case studies will be analysed in order to get familiar with the development of CDM projects.

The third part is based on practical oriented exercises, where the students analyze existing GHG abatement/carbon trading in order to understand the methodological and administrative requirements to calculate and document GHG abatement projects. Using existing project design documents (PDD) focusing on energy (renewable energy, energy demand side efficiency, fuel switch projects), organic waste management (biogas) and wastewater projects will enable the students to calculate the GHG abatement potentials of their own designated research projects in related areas.

10.3 Modelling Carbon Footprints

The course is designed to enable the students to measure, manage and reduce the carbon footprint of products, services and organisations in both, the public and the private sector. Firstly, the students learn the basic requirements of LCA and Carbon Footprinting standards like ISO 14044 and PAS 2050 and the essential differences of the various approaches.

Secondly, after a thorough introduction to the UMBERTO software tool and program feature the students develop, under close guidance, a product carbon footprint (PCF) for selective case studies and learn to interpret the results and develop optimisation scenarios.

Teaching Methods

Lectures, student presentations, Group Discussions, Excursion, Case Studies

Recommended Qualifications

Basic knowledge of anthropogenic atmospheric contaminations, alterations and interconnections (Module 1)

Basic knowledge in ISO 14.000f standards on environmental management reporting (Module3)

Basic knowledge in energy, waste and water management (Modules 2, 5,6)

Method of Grade Evaluation Total score for the course is 100% based on a weighted average of the three courses. The sub grade for 10.1 is based on a scientific paper (50%), and a presentation of the student (50%). The sub grade for 10.2 is based on a student PDD presentation (50%) and an exam (50%). The sub grade for 10.3 is based on the creation and presentation of the selected PCF model (100%). A selection of topics for the papers, PDD presentation and PCF modelling is offered, mostly topics out of the current scientific discussion on worldwide problems. If possible, students are encouraged to select a paper topic, PDD or product to be modelled in relation to their home countries situation.
Preconditions for the allocation of Credits: Successful participation within all module courses.
Usage of the Module (in other study courses): The courses 10.2 and 10.3 are offered as electives within the IMAT Master of Science program.
Significance of the grade for the final grade 8 ECTS / 120 ECTS
Module representative and full-time lecturers **Prof. Dr. Eckard Helmers (Module Representative and Course Lecturer 10.1)** Dr. Michael Knaus (Course Lecturer 10.2) Prof. Dr. Klaus Helling (Course Lecturer 10.3)

Required Readings

10.1 Chemistry of Global Climate Change: Important GHG Cycles

UN bodies publications like the “Air pollution study No 16” (Hemispheric transport of Air pollution, 2007) or like the “Report of the UNEP Technology and Economic Assessment Panel”, May 2006 (http://ozone.unep.org)

Recent IPCC reports (www.ipccc.ch)

Reports of important national agencies on air quality and climate changes, like http://www.airclim.org, www.euro.who.int (e.g. “Air quality guidelines”, 2005)

Mark Z. Jacobson (2007): United States House of Representatives Testimony for the Hearing on Black Carbon and Global Warming. http://www.stanford.edu/group/efmh/jacobson/PDFfiles/0710LetHouseBC1.pdf

10.2 Greenhouse Gas Abatement Strategies and Carbon Trading

Selected chapters (tba) of the following guidebooks:

UNEP Risoe Centre (2011): PDD Guidebook: Navigating the Pitfalls

UNEP Risoe Centre (2011): CDM Information and Guidebook

UNEP Risoe Centre (2011): Handbook for PoAs - Practical Guidance to Successful Implementation

UNEP Risoe Centre (2009): CDM Sustainable Development Impacts

Available as PDF download (free on charge) at:

http://cd4cdm.org/Guidebooks.htm

10.3 Modelling Carbon Footprints

ISO 14040:2006: Environmental management -- Life cycle assessment -- Principles and framework

ISO 14044:2006: Environmental management -- Life cycle assessment -- Requirements and guidelines

British Standards Institution (BSi): PAS 2050:2011 - Specification for the assessment of the life cycle greenhouse gas emissions of goods and services

British Standards Institution (BSi): The Guide to PAS 2050:2011 - How to carbon footprint your products, identify hotspots and reduce emissions in your supply chain

Available as PDF download (free of charge) at:

http://www.bsigroup.com/en/

ifu Hamburg GmbH: Umberto for Carbon Footprint Tutorial 1-3

Available together with trial version of the software UMBERTO for Carbon Footprint at:

http://www.carbonfootprint-software.com/en/

Misc. Notes

Further materials might be provided by the lecturers.

Module 11: SYSTEM CHANGE MANAGEMENT

The Module 11: SYSTEM CHANGE MANAGEMENT aims to train the soft skills of the students needed for the initiation of change processes. The IMAT study course intends to educate “Change Managers” that are able to implement efficiency strategies based on Material Flow Management Concepts and technologies. Hence, the students are in need of cultural sensibility as well as communication and presentation skills to complete the knowledge gained in the fields of economics and engineering. In Sub course “11.1 Cultural Aspects of System Change” the students will get a deeper insight in the “Business-Etiquette” of the particular countries through learning about their religion, culture and social structure as well as a “cross-cultural empathy”. In addition the partner universities agreed to offer introductory courses in the respective national languages without ECTS grading. At the Environmental Campus Birkenfeld students are enabled to attend introductory German language lessons. In sub course “11.2 Stakeholder Management” students learn how to approach decision makers with change processes and how to assist and guide the related actors during this change process with the purpose of implementing visionary projects.

<table>
<tr><td>Module No. 11</td><td>Workload
120 h</td><td>Credits (ECTS)
4</td><td>Semester
1.-2. Semester</td><td>Frequency of the offer
11.1 Each Fall semester
11.2 Each Spring semester</td><td>Duration
1 Sem.</td></tr>
<tr><td colspan="4">Course
11.1 Cultural Aspects of System Change</td><td>Lessons
2 SWH (30 h)</td><td>Self-Study
30 h</td></tr>
<tr><td colspan="4">Course
11.2 Stakeholder Management</td><td>Lessons
2 SWH (30 h)</td><td>Self-Study
30 h</td></tr>
<tr><td colspan="6">Learning outcomes / competences

11.1 Cultural Aspects of System Change
System change is explained by using media and social as well as life cycle ritual aspects. Intercultural communication is explained as a result of mutual understanding of culture, religion and rituals. A strong focus is given with regard to German culture, history and society.

11.2 Stakeholder Management
To convince regional stakeholders to transform material flow management (or system change) projects form the idea into reality, networking approaches can help to communicate the win-win-potentials of system change approaches. This course facilitates a basic understanding of how regional networks or business clusters can be initiated and managed.</td></tr>
</table>

Description of the Course Content (Overview of each class)

11.1 Cultural Aspects of System Change

- German history and culture: post war society development in Germany, from Nazi regime to reunification
- From politeness to social and political rituals: e.g. greeting ceremonies, New Year festival, commemoration
- Intercultural communication: basic theoretical understanding and practical examples
- Religion in Germany and its effects on society and cultural interaction: tradition of Christianity, the reformation in Germany, aspects of religion in daily German life,
- Students case studies and role play
- Wrap up Closing session

11.2 Stakeholder Management

- Introduction to network theory/-analysis: The nature of (regional or project-based) networks: Types of networks, Social cohesion of network partners/stakeholders
- Key person analysis: Local business networks and stakeholder management, strategic partnership versus strategic network, business networks or clusters alongside value-chains
- Incentives and win-win-strategies for regional networks and stakeholders: Enhancing regional competitiveness with networking: A participatory approach
- Student cas studies: On industrial or regional networking and stakeholder management
- Closing session

Teaching methods

Lectures, group discussions, case studies, student presentations

Recommended qualifications

Basic Knowledge in regional change management and understanding of how regions communicate internally and externally (Course Regional MFM Part 1)

Method of Grade Evaluation

Students presentation 30%, Students paper 50%, class participation 20%

Preconditions of the allocation of Credits

Paper, presentation, attendance

Usage of the Module

Contributes to capability of key person analysis and MFA in RMFM lecture

Significance of the grade for the final grade

4 ECTS/120 ECTS

Module representative and full-time lecturers

Prof. Dr. Alfons Matheis, Dr. Petra Rösch

Further information and Required Readings

Ronald Grimes (ed.): “Readings in Ritual Studies”. Prentice Hall, 1996.

James Curran, David Morley and Valerie Walkerdine (ed.): “Cultural Studies and Communications”. London: Arnold, 1996.

Alexander, B.C.: “Ritual and Current Studies of Ritual: Overview”. In: S. D. Glazier (ed.) Anthropology of Religion: A Handbook. Westport, CT, 1995.

Ashcroft, Bill et al. : “The Post-Colonial Studies Reader”. London: Routledge, 1995.

Bell, Catherine: “Ritual Theory, Ritual Practice”. New York, 1992.

Derrida, Jacques: “The Other Heading: Reflections on Today's Europe”.Bloomington: Indiana University, 1992.

Dodd, C.: “Dynamics of intercultural communication” (4th Ed.). Madison, WI: Brown & Benchmark, 1995. Geertz, Clifford: “ ‘Deep play’ - Ritual als kulturelle Performance”.

Ritualtheorien, hrsg. v. Belliger, Andréa und Krieger, David, J.. Wiesbaden, 2003, 99-118.

Giroux, Henry A. and McLaren, Peter (eds.): “Between Borders: Pedagogy and the Politics of Cultural Studies”. NY: Routledge, 1994.

Grimes, Ronald L.: “Beginnings in Ritual Studies. Studies in Comparative Religion”. Columbia: Univ. of South Carolina Press, 1995.

Gudykunst, William (ed.): Handbook of international and intercultural communication. Thousand Oaks: .Sage, 2002.

Hofstede, Geert. Culture's Consequences, Comparing Values, Behaviors, Institutions, and Organizations Across Nations Thousand Oaks CA: Sage Publications, 2001.

Humphrey, C. and Laidlaw, J.: “The Archetypal Actions of Ritual. A Theory of Ritual”. Oxford, 1994.

Leheny, David Richard: The Rules of Play: National Identity and the Shaping of Japanese Leisure. New York: Cornell University Press, 2003.

Littleton, C. Scott: Shinto: Origins, Rituals, Festivals, Spirits, Sacred Places. Oxford: Oxford University Press, 2002.

Parkin, D: “Ritual as Spatial Direction and Bodily Division”. In: D. de Coppet (ed.) Understanding Rituals. London: 1992, 11-25.

Said, Edward S.: “Orientalism”. NY: Vintage, 1978. Sosnoski, Daniel: Introduction to Japanese Culture. Boston: Tuttle Publishing, 1996.

Tambiah, S.J.: “A Performative Approach to Ritual”. In: Proceedings of the British Academy 65, 1979, 113-69.

Tamura Yoshiro: Japanese Buddhism: A Cultural History. (trans. by Jeffrey Hunter). Tokyo: Kosei Publishing, 2000.

Turner, V.W.: “Drama, Fields, and Metaphors: Symbolic Action in Human Society”. New York, 1974.

Turner, V.W.: “Dramatic Ritual/Ritual Drama: Performance and Reflexive Anthropology” In: Kenyon Review 1.3, 1979, 80-93.

Module 12: PHYSICS AND CHEMISTRY FOR THE ENVIRONMENT

The Module 12: PHYSICS AND CHEMISTRY FOR THE ENVIRONMENT is seen as a refreshment and enhancement of basic physics and chemistry knowledge (provided in the last high school years) as well as for providing the students with first laboratory experiences. This module is essential to harmonise the previous knowledge of the students, in particular for those students not having a BA in engineering or natural science areas, in order to create a joint starting point for further natural science and physics foundations, e.g. in sub course “5.1 Basic Engineering Aspects of Sustainable Water Management” or “6.1 Basic Principles of Energy System Management”.

Module No. 12	**Workload** 120 h	**Credits (ECTS)** 4	**Semester** 1. Sem.	**Frequency of the offer** Each Fall semester	**Duration** 1 Sem.
Course 12.1 Environmental Chemistry for Engineers				**Lessons** 2 SWH (30 h)	**Self-Study** 30 h
Course 12.2 Environmental Physics for Engineers				**Lessons** 2 SWH (30 h)	**Self-Study** 30 h

Learning outcomes / competences

Both courses are design as refreshment courses providing the essential basic knowledge in chemistry and physics.

12.1 Environmental Chemistry for Engineers

The objective of this course is to enable the students to conduct basic laboratory experiments, to refresh the basics in chemistry and enhance the chemistry foundation knowledge. The course objectives in detail are:

- Basic Knowledge of Laboratory Work: Liquid Handling, Solid Handling, Sample Preparation, Data Interpretation, Statistics
- Basic Knowledge of Analytical Methods and Unit Operations in the Lab: Density Measurements, Measurement of pH and Conductivity, Acid-Base Reaction, Titration, Extraction, UV-Vis Spectroscopy, Cell Rupture, Enzymatic Reactions, Liquid Chromatography, Gas Chromatography
- Basic Knowledge of Green Chemistry: Buffer Capacity of Natural Waters, Phosphorous Removal from Waste Waters, Natural pH Indicators, Greenhouse Effect, Biodiesel Production, Biogas Production, Biogas Analysis, Biogas Cleaning

12.2 Environmental Physics for Engineers

The main objective of this course is to provide sufficient background information about the basics of physics and chemistry.

- Identify and recognize concepts and principles related to mechanics, waves, and thermodynamics.
- Apply appropriate physical principles to solve problems pertaining to mechanics, waves and thermodynamics.
- Assess everyday observations in the terms of physics concepts.

Description of the Course Content

12.1 Environmental Chemistry for Engineers: The course 12.1 consists of the following five major parts:

1) **Introduction to laboratory work and experiment design:**

   Security Instruction and introduction to the Work with Volumetric Devices (Volumetric and Micro-Pipettes, Cylinders, Flasks, etc.) and Gravimetric Devices (Balances)

   Interpretation of Data and Application of Statistical Concepts (Calculation of Mean Value and Standard Deviation), Information about the Accuracy of the Lab Ware,

   Measurement of Densities of Liquids and Solids

2) **Theory and Practice of pH and Conductivity Measurement:**

   Correlation between pH and Concentration of Liquids, Correlation between Conductivity and Concentration of Liquids, Determination of Buffer Capacity of Natural Waters, Theory and Practice of Phosphorous Removal from Waste Waters, Effect of a Flocculation Aid for Phosphorous Removal

   Preparation of a natural pH Indicator using an Extraction Method, Determination of the Characteristics of this Natural Indicator, Theory and Practice of Acid-Base Reactions, Titration

3) **Theory and Practice of UV-Vis-Spectroscopy**

   Measurement Principle of UV-Vis-Spectroscopy, Lambert-Beer-Law, Relation between Color and Absorption Spectra, Dilution of Samples, Preparation of a Calibration Curve, UV-Vis Measurements with different Samples

   Recovery of Intra-Cellular Biomolecules by Cell Rupture, Work with Ball-Mill and Ultrasonic Device, Detection of Biomolecules with UV-Vis-Spectroscopy

4) **Theory and Practice of Green Chemistry related Issues:**

   Theory of the Greenhouse Effect, Assembling of a Set-Up and Demonstration of the Greenhouse Effect

   Theory of Biodiesel Production, Preparation of Biodiesel out of fresh and waste Kitchen Oil

   Theory of Enzymatic Reactions (Catalysis), Preparation of Solutions, Extraction of Catalase out of Yeast, Titration to get the Catalase Activity

5) **Chemistry aspects of Biogas Production**

   Assembling of a Set-Up for Biogas Production, Production of Biogas out of a Biomass Substrate

   Theory of Biogas Cleaning, Principles of Absorption of Gaseous Compounds with Liquids, Separation of a Gaseous Stream with a Scrubber, Depletion of Sour Gases from Biogas

   Basic Principle of Liquid Chromatography (SEC = Size Exclusion Chromatography), Preparation of Buffer Solution and Sample, Separation of a Mixture of Salt and Protein with Liquid Chromatography

   Basic Principles of Gas Chromatography, Measurement of Gas Contents from Bioreactors, Practice and Theory of WLD-Detectors

12.2 Environmental Physics for Engineers: The course 12.2 consists of the following three major parts:

1) **Basic aspects of Mechanics:**

   <u>Translational Kinematics:</u> Define displacement, velocity, and acceleration / Derive kinematics equations for one, two and three dimensional motion using algebra, trigonometry and calculus / Solve kinematics problems.

   <u>Force and Motion (Newton's Laws):</u> State and explain Newton Laws of Motion / Explain the concepts of mass and weight /Discuss the function of the various types of forces, such as gravitational, frictional, and elastic forces.

   <u>Work and Energy:</u> Apply the definition of work and power to solve standard text problem / Demonstrate efficient usage of work-energy concepts / Derive kinetic, gravitational, and elastic energy and the work-energy theorem

Session 4-5: Chemical Compounds

Session 6-7: Chemical Reactions

Session 8-10: Principles of Chemical Equilibrium

2) **Basic aspects of Wave, Mechanics and Dynamics:**
   Define common terms used in the description of wave motion
   Apply force and energy concepts to wave motion problems
   Analyze and wave problems pertaining to sound.

3) **Basic aspects of Thermodynamics**
   Define temperature and recognize various temperature scales.
   Define common terms and constants used in thermodynamics.
   Recognize the zeroth, first and second law of thermodynamics.
   Compute the heat required to change the temperature and phase of materials.

Teaching Methods

Practical Course in the Laboratory, In-Class Discussion of Theory, lectures and group discussions.

Recommended Qualifications

Basic Knowledge of Chemistry and Biology

Method of Grade Evaluation

The module grade will be the weighted average (50%each) of both courses:

12.1 Environmental Chemistry for Engineers: Total score for the course is 100%: Multiple choice test (70 %), quality of practical class participation (30%).

12.2 Environmental Physics for Engineers: Total score for the course is 100%: Final examination (80 %), class participation (20%).

Preconditions for the allocation of Credits

Successful I each course exam.

Usage of the Module (in other study courses)

None

Significance of the grade for the final grade

4 ECTS/ 120 ECTS

Module representative and full-time lecturers

Prof. Dr.-Ing. Percy Kampeis, Prof. Dr.-Ing. Michael Bottlinger

Further information and Required Readings

12.1 Environmental Chemistry for Engineers

Papers will be provided within the sessions

12.2 Environmental Physics for Engineers

Tipler, Mosca; Physics for Scientists and Engineers

Module 13: SELECTIVES – SEMINARS IN APPLIED MATERIAL FLOW MANAGEMENT

The sub courses (in particular 13.1 to 13.3) within the Module 13: SELECTIVES - SEMINARS IN APPLIED MATERIAL FLOW MANAGEMENT are designed to feature the special strength and areas of research of the partner universities abroad or deepen specific topics based on the current status of research and/or market demand. The topics could be:

1) E-Mobility and Sustainable Energy Politics
2) Fuel Cell Technology
3) Business Game: Development of Renewable Energy Projects including Technical Dimensioning and Business Plan Design
4) Zero Emission based Energy and Water Supply Systems for Islands
5) Solar Architecture and Solar Energy in Buildings
6) Solar Cooling: Technology, Economy and Design Aspects
7) Practical Experience in Ecological Wastewater Engineering: Case Studies from Natural Waste Water Treatment Options
8) Biofuels: Technology, Markets and Trends
9) Energy and Material efficiency in SME
10) Sustainable Land Use Management and organic Agriculture
11) Climate Change, Land-Use and Soil Management
12) Efficient Water and Soil Usage in Agriculture
13) Renewable Energy-based Water Desalination

Specific topics of the partner universities could be:

Japan

14) Japans new Energy Policy
15) Energy Efficiency Strategies in Japan
16) Japans 3R Society Strategy
17) Geothermal Potentials and Technologies in Japan
18) “Green Development Perspectives” for the Asia-Pacific Region
19) KAIZEN and other Forms of Material and Energy Efficiency in Japan

Turkey

20) Green Tourism Strategy
21) Basics of Agricultural Engineering
22) Efficient Water Management for Arid Areas
23) Nutrient Recovery in Waste Water
24) Biomass and Fertilizer: Closing Material Flows in agricultural Residue Management
25) Turkeys new Energy and Agriculture Policy
26) “Green Development Perspectives” for the Middle-East Region

The course (13.1 to 13.2) topics are jointly selected within the annual IMAT conference. The courses 13.1 to 13.3 have a workload of 120h (45h in class and 75h self-study) and will be credited with 4 ECTS.

The selective course 13.4 within the 3rd semester is reserved for student research project development.

Module No. 13	Workload 120 h	Credits (ECTS) 4	Semester 3. Sem.	Frequency of the offer Each Fall semester	Duration 1 Sem.

Course (Example)	Lessons	Self-Study
13.x Sustainable Mobility	3 SWH (45 h)	75 h

Learning outcomes / competences

Selective X: Sustainable Mobility

The course objective is to provide understanding of sustainability aspects in motorized traffic. Alternative engine technologies and alternative fuels are discussed and assessed with respect to life cycle and regional perspectives, with special emphasis on electric vehicles.

Description of the Course Content (Overview of each class)

13.X Selective X: Sustainable Mobility

Course 13.X "SUSTAINABLE MOBILITY" explores the problem of sustainability in motorized mobility. The enormous increase in traffic worldwide, based on the expansion of air traffic and the increase in motor vehicles is analyzed. Motorized mobility is discussed with respect to available resources and strategic aspects. Transport modes as sources of greenhouse gases and toxic emissions are examined. As a recent policy approach, environmental performance of the European Diesel car boom is discussed. Alternative fuels and vehicle propulsion technologies are listed and assessed for environmental efficiency. Environmental impact of electric vehicles as today’s primary technical alternative is analyzed in detail. Scenarios for technical alternatives are discussed with respect to the student’s home countries.

1) **Historical Development, Current Trends and Challenges of Mobility Systems**

Historic development of motorized traffic, energy consumption and GHG emissions by traffic, future restrictions of fossil fuels, worldwide car market, toxic emissions of cars

2) **Analysis of Diesel-based Cars**

Sustainability of the European Diesel car boom, term sustainability, soot emissions and global warming, role of nitrous oxide emissions by cars, exhaust gas cleaning, role of fine and nano particles, emission thresholds worldwide

3) **E-Mobility: Current status and future potentials**

Electric cars as an alternative : technical availability, material, energy and emission efficiency (WTT, TTW), life cycle emissions of battery electric vehicles, external costs of the traffic

Teaching Methods

13.X Selective X: Sustainable Mobility

Lectures, student presentations, Group Discussions, investigation of electric cars

Recommended Qualifications
Method of Grade Evaluation **The module grade will be the weighted average (25%each) of the four courses:** **13.X Selective X: Sustainable Mobility** Total score for the course is 100%: Scientific Paper = 50 %, Student Presentations 50%. The students are obliged to write a scientific paper. A selection of topics is offered, mostly topics out of the current scientific discussion and available alternative engine technologies and fuels. If possible, students are encouraged to work on a topic in relation to the situation in their home countries.
Preconditions for the allocation of Credits Submission of Paper
Usage of the Module (in other study courses) IMAT M.Sc.
Significance of the grade for the final grade 4 ECTS/ 120 ECTS
Module representative and full-time lecturers Prof. Dr. Eckhard Helmers
Further information **13.X Selective X: Sustainable Mobility** **Suggested Readings** A. Schäfer et al.: “Transportation in a climate-constrained world”, MIT press 2009 E. Holden: “Achieving sustainable Mobility. Every day and leisure-time travel in the EU” 2007 Further materials will be provided by the lecturer

Module 14: INTERNSHIP

Module No. 14	Workload 180 h	Credits (ECTS) 6	Semester 3. Semester (at the latest)	Duration 4 weeks

Internship: Practical MFM experience

Learning outcomes / competences

- Apply the theoretical MFM knowledge and gain practical experience
- Get a more in-depth knowledge on certain environmental technologies and services
- Develop (or deepen) the research idea for the Master Thesis

Description of the Course Content

The students are obliged to conduct a practical internship in a company, research or (non-) governmental organisation working on a real-life topic within any of the IMAT core areas such as ZE, CE, renewable energy, energy efficiency, water or waste management. The internship period is at least 4 weeks and must be conducted at the latest before the Master Thesis semester starts.

The students are encouraged to use the internship period to get a first impression on the environmental technology and management approaches of the internship provider in order to be able to start their Master Thesis research work consequently thereafter. Hence, the internship could be used to develop the first practical experience or first project steps (data analysis) for an applied Master Thesis.

Method of Grade Evaluation

The students will have to submit an internship report explaining in detail their task and work performed within the internship. Furthermore the students have to submit a letter of acknowledgement from their internship provider that they have successfully conducted the internship.

The internship will not be graded, just marked as passed or failed.

Preconditions for the allocation of Credits

Internship report and letter of acknowledgment from the internship provider.

Significance of the grade for the final grade

6 ECTS/ 120 ECTS

Module representative and full-time lecturers

Dr. Michael Knaus

The student selected in close cooperation with the module representative a suitable supervisor, either from the Trier University of applied Sciences, scientific staff of partner universities or a company representative.