1. **Modulhandbuch**

Modulhandbuch

zum Re-Akkreditierungsantrag

für den Studiengang

International Material Flow Management

(Master of Science)

der Hochschule Trier,

Standort Umwelt-Campus Birkenfeld

Dokument vorbereitet von:

Prof. Dr. Peter Heck, Prof. Dr. Klaus Helling und Dr. Michael Knaus

Stand 08. April 2014

Preliminary Remarks

The module guidebook encompasses the detailed description of all modules and provides the following information:

- Module title and acronym
- Workload divided into class/lessons and self-study
- Credit points (ECTS) and significance of the grade for the final grade
- Frequency of the offer and duration of the module
- Objectives and learning outcomes
- Description of the Course Content
- Teaching Methods
- Recommended Qualifications
- Method of Grade Evaluation
- Module representative and full-time lecturers
- Required Readings

The following table lists all modules lists with details of the semester week hours in class (SWH), the workload and the credit points based on the European credit transfer system (ECS). The utilisation of the ECTS is based on the workload of the modules based on the existing code of conduct and the previous experiences of the re-accreditation and evaluation of the various IMAT programs (IMAT MSc and IMAT MEng). [1]

The module guidebook can be created in mutual consultations with the module responsible persons and involved lecturers in order to develop a stringent and “manageable” study program highlighting and covering all aspects of regional and industrial material flow management and related policy and technology strategies from an economical perspective.

The module guidebook had been created in English language purposely in allow for a distribution to designated students already at the application process (as a download link on the IMAT website) in order to add to the overall quality management by providing transparency and full information on the study content already prior to the beginning of the study program.

Prior the relevant module information short information provide the integration of the module in the overall context of the study program providing the linkages to the other modules.

The module guidebook is used as a central element within the IMAT quality management. It shall allow our lecturers to explore the interconnectivity of the modules, give the practitioners with short term (or single session assignments) an idea about the overall framework and of utmost importance to let out costumers – the students – decide if that study program suits their need and interest!

[1] Siehe Beschluss der Kultusministerkonferenz vom 15.09.2000.

MSc in International Material Flow Management Modules/Subjects	Semester 1			Semester 2			Semester 3			Semester 4		
	SWH	ECTS	Workload	SWH	ECTS	Workload	SWH	ECTS	Workload	SWH	ECTS	Workload
MODULE 1: GLOBAL ENVIRONMENTAL CHALLENGES AND ZERO EMISSION POLICY STRATEGIES	4	6	180				**Option 1: Internship** Within option 1 students are conductiong an internship in companies, research organisations and (non) governmental entities with a duration of 15 weeks and (min) 20 semester week hours (SWH) per week. **Option 2 : Study Semester Abroad** Within option 2 students can conduct a theoretical study semester at any university with an equvivalent work load of 20 SWH per week and a duration of 15 weeks.			**Master Thesis Semester**		
MODULE 2: REGIONAL MATERIAL FLOW MANAGEMENT	4	6	180									
MODULE 3: MFM PROJECT MANAGEMENT AND FINANCING	4	6	180									
MODULE 4: ECONOMIC ASPECTS OF SUSTAINABLE ENERGY SYSTEMS	4	6	180									
MODULE 5: INDUSTRIAL MATERIAL FLOW MANAGEMENT				4	6	180						
MODULE 6: INDUSTRIAL ECOLOGY AND ECO-INDUSTRIAL PARKS				4	6	180						
MODULE 7: ECONOMIC ASPECTS OF SUSTAINABLE RESOURCE MANAGEMENT				4	6	180						
MODULE 8: ECONOMIC ASPECTS OF SUSTAINABLE WATER MANAGEMENT				4	6	180						
MODULE 09: SELECTIVES - SEMINARS IN APPLIED MATERIAL FLOW MANAGEMENT	4	6	180									
MODULE 10: SELECTIVES - SEMINARS IN APPLIED MATERIAL FLOW MANAGEMENT				4	6	180						
MODULE 11: INTERNSHIP / STUDY SEMESTER ABROAD							20	30	900			
MODULE 12: MASTER THESIS										20	30	900
Total	20	30	900	20	30	900	20	30	900	20	30	900

Modul 1: GLOBAL ENVIRONMENTAL CHALLENGES AND ZERO EMISSION POLICY STRATEGIES

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 sensibilise the students for the new technology concepts taught in Modules 4, 7 and 8. New MFM 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, 5 and 6.

<table>
<tr><td colspan="3">GLOBAL ENVIRONMENTAL CHALLENGES AND ZERO EMISSION POLICY STRATEGIES</td><td>6 ECTS / 4 SWH</td></tr>
<tr><td><u>Module Acronym:</u>
EnvChallenges</td><td colspan="2"><u>Workload:</u>
180</td><td><u>Duration:</u>
1 Semester</td></tr>
<tr><td><u>Module Type</u>
Lecture</td><td><u>Lessons:</u>
60</td><td><u>Self-Study:</u>
120</td><td><u>Estimated Group Size:</u>
30</td></tr>
<tr><td colspan="4"><u>Objectives and Learning Outcomes:</u>
The module has a twofold learning approach.

The Students have learned the systemic interaction of ecosystems. They have understood the thermodynamic principles and their effects on ecosystems and man made systems. The Students can describe material flow and energy flow in ecosystems and are able to show the interaction between natural system and man made systems. They have learned to analyse the global environmental issues.

Due to the increasing demand for resources and the high load on the sink capacity the costs for the human society are increasing. Especially in fast developing countries like China and India or in high developed environmentally conscious states like Japan and Germany these developments lead to a strong demand for new macroeconomic conceptions and strategies for a sustainable society. The terms and names given for these conceptions as well as the concrete motivations behind are different within each country.
This part of the module has demonstrated the situation in selected countries and explained the relevant strategies. The students understood the targets of a Material Flow Management Societies (MFM), Zero Emission (ZE) and Circular Economy (CE) as well the differences compared to throughput economies. Case studies from different countries helped to practice the basic understanding of the new development strategies.</td></tr>
<tr><td colspan="4"><u>Content of Course/Module:</u>
1) 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 and biodiversity.</td></tr>
</table>

2) Introduction on Ecosystem theory

Clarification on the terms and concept models of environment (e.g. species, predators, symbiosis, population, biosphere, biotope, biodiversity and resilience in ecosystem, environmental gradients, limiting factors, potency, biotopes, niches, ecosystem equilibrium, carrying capacity, ecological footprint).

3) 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 concept models of photoautotrophic, heterotrophic and decomposers

4) “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

5) Soil development and function:

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

6) 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

7) Case studies with potential solution approaches

1) Introduction of CE related terms and approaches

Clean technology, efficiency strategies, decentralised versus central supply and disposal, product and process integrated environmental protection.

2) Economical aspects of CE:

Ecological Economics, Steady State Theory etc.

3) Introduction on international policy models:

Sustainable Society, 3R Society, CE, Recycling Economy, Material Flow Society, Zero Emission Communities etc.

4) SWOT Analysis and differentiation of the various models and concepts

Student presentations on different countries and their situation as well as their strategies on achieving sustainable development based on the focal concepts;

Summary of seminar reflection on the findings and problems still to be solved.

Teaching Method:

Lectures, group discussions, case studies

Recommended Qualifications:

Basic understanding of ecosystems

Method of Grade Evaluation:

The total score for the course is 100%:
Final exam (40%), Paper presentation (40%), class participation (20%)

Scope and Duration of Examination:

The scope and duration of the examination will be individually organized by the module representative and announced at the start of the module.

Impact of the Module Grade on the cumulative Grade:

6/120 (= 5%)

Module Frequency:

Annual

Responsibility for the Module:

Prof. Dr. Peter Heck

Responsibility for the Lectures:

Prof. Dr. Peter Heck & guest lecturers

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.

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.

EPA: Beyond RCA. Waste and Materials Management in the Year 2020, Washington 2003.

Task Force of Circular Economy and Cleaner Production: Strategy and Mechanism Study for Promotion of Circular Economy and Cleaner Production in China, Beijing 2003.

Bringezu Stefan, Schütz Helmut: Total Material Requirement of the European Union, Copenhagen 2001.

Luks, Fred, Hammer, Marc: Material Flow Analysis, Discourse Analysis and the Rhetoric’s of (Ecological) Economics, Bonn 2003.

Wagner, Lorie A.: Materials in the Economy – Material Flows, Scarcity, and the Environment, US Geological Survey Circular 1221, Denver 2002.

OECD, Special Session on Material Flow Accounting, Paris 2000.
OECD: Sustainable Development. Indicators to Measure Decoupling of Environmental Pressure from Economic Growth, Paris 2002.

Modul 2: Regional Material Flow Management

The Module 2: REGIONAL MATERIAL FLOW MANAGEMENT is (together with Module 5: 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. Therefore, the module provides an overview on regional adaptation of political strategies such as 3R society attempts (in Japan) or Industrial Ecology or Circular Economy (in China) as explained in Module 1. Part .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. Despite the managerial aspects of regional MFM the students learn the essential elements of stakeholder management and intercultural communication as an integral part of changing systems and systems behaviour.

The module describes and provides the knowledge to determine the regional added value of regional development strategies, while the micro-economic details (and technical foundations) are explained in the Modules 3, 4 and 7 to 8.

<table>
<tr><td colspan="3">REGIONAL MATERIAL FLOW MANAGEMENT</td><td>6 ECTS / 4 SWH</td></tr>
<tr><td><u>Module Acronym:</u>
RegMFM</td><td colspan="2"><u>Workload:</u>
180</td><td><u>Duration:</u>
1 Semester</td></tr>
<tr><td><u>Module Type</u>
Lecture</td><td><u>Lessons:</u>
60</td><td><u>Self-Study:</u>
120</td><td><u>Estimated Group Size:</u>
30</td></tr>
<tr><td colspan="4"><u>Objectives and Learning Outcomes:</u>
The module 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 students have learned to analyse regions from cultural, economical, historical, political and administrative backgrounds (Material Flow Analysis). They understood the different forms of value (generations) in regions: social, economical, ecological and understood how regions communicate internally and externally and how regions are governed. Furthermore they got a first overview on key Zero Emission technologies to implement regional Zero Emission strategies (extended in the Modules 6 to 8). The students have reviewed to use microeconomic tools to evaluate the regional added value potentials and calculate the business and development opportunities (extended in Module 6). They were enabled to analyse successful regional MFM projects and search for weakness and potentials for improvement and have learned to develop systemic change management strategies for regions focusing on stakeholder management as well as networking and knowledge management. The students have got the knowledge, how to use MFM tools to develop and implement MFM master plans in an international context and to design an own regional MFM projects later within the master thesis semester.</td></tr>
</table>

Content of Course/Module:

1) **Introduction to regional MFM and urban metabolism processes**

   Introduction of regional MFM tool kit

   Definition of Regions and System Boundaries by cultural, historical, political, administrative aspects

   Regionalisation and Globalisation: New strategies for regions in a globalised economy

2) **Regional Key Person Analysis:**

   Analysing the key persons, ranking the key persons according to their importance for change management in the region

3) **Regional Stakeholder Management:**

   Evaluating the stakes of the key persons in the system, checking on their potential influence for new technologies, looking for losers and winners of a system change

4) **Regional Material Flow Analysis (MFA):**

   Analysing the most important material and energy streams in the system such as waste, water, wastewater, energy, agriculture, tourism, traffic, mobility etc.

   Turning questionnaires into project information, communicating system change, modeling material streams

   Analyzing regional development processes: Drivers, pull and push factors, barriers and obstacles of regional changes

5) **New regional MFM based management strategies**

   New management strategies and technologies for regional energy production and distribution management

   New management strategies and technologies for regional waste management

   New management strategies and technologies for regional water management

   New management strategies and technologies for regional transportation management

6) **Local added value strategies on a regional scale**

   New business models for regional investments

   Introduction of economic modeling of regional MFM projects

   Carbon management, carbon trading and carbon finance

   Green financing (e.g. contracting, cooperatives, etc) and fundraising strategies

   MFM Master Plan development

7) **Student assessment and presentation of international best practice examples on regional MFM projects**

Methods of Teaching:

Lectures and student presentations

Recommended Qualifications:

None

Method of Grade Evaluation:

The total score for the course is 100%:
Exam: 60 minutes (50%), Scientific paper: 25 pages (50%),

Scope and Duration of Examination:

The scope and duration of the examination will be individually organized by the module representative and announced at the start of the module.

Impact of the Module Grade on the cumulative Grade: 6/120 (=5%)
Module Frequency: Annual
Responsibility for the Module: Prof. Dr. Peter Heck **Responsibility for the Lectures:** Prof. Dr. Peter Heck & IfaS project managers
Required Readings: Brunner, Paul H., Rechberger, Helmut: Practical Handbook of Material Flow Analysis, Lewis Publications, 2004. IfaS Study Reports Selected articles from international journals BMU publications on technological topics

Modul 3: MFM Project Management and Financing

The module has a twofold approach. Firstly, the module part „MFM business planning and financing“ will enable the students to calculate and monetary assess the technological change processes as studied in modules 2 and 5 to 6 and prepare business plans for detailed technology projects such as renewable energy or energy efficiency projects of the modules 4 and 7.

Secondly, the module part “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.

MFM PROJECT MANAGEMENT AND FINANCING			**6 ECTS / 4 SWH**
Module Acronym: MFM Finance	**Workload:** 180		**Duration:** 1 Semester
Module Type Lecture	**Lessons:** 60	**Self-Study:** 120	**Estimated Group Size:** 30

Objectives and Learning Outcomes:

The students have got an understanding on various economic tools to model and predict the regional added value of regional development strategies (as outlined in Module 2 and 6) as well as the microeconomic valuation tools to conduct a business plan and a financial statement on a project level (as a pre-requisite for modules 4, 7 and 8. Hence, the students have been enabled to conduct a financial feasibility for research projects in the internship and master thesis.

In addition to the financing and economic modelling, the students have been provided the knowledge on different project management techniques applied to research (and applied research) projects in the field of Material Flow Management and were enabled to apply this knowledge to develop a practical research project in the field of Material Flow Management. They got to know the fundamental factors in project success and failure and developed an understanding of project baseline plans, their implementation and management. Furthermore they have surveyed the variety of approaches in project time and cost management, including current techniques, technologies and practices.

Content of Course/Module:

1) **Basics of cost accounting and controlling:**

   Terms and basic concepts

2) **Introduction in calculating investments:**

   Static and dynamic methods, internal rate of return, net present value, real options (basic understanding)

3) **Basics in valuation of projects:**

   Cost calculation, discounted cash flows, comparison approach

4) **Basics of finance:**

   Balance sheets, equity and liabilities, equity ratio etc.

   Finance planning

5) **Managerial budgeting, making a business plan, incl. case study [8 h]**

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

   Project definition: Problem analysis, stakeholder analysis, analysis of objectives (economic, ecological and

social objectives of MFM projects)

Project Planning – Definition of the project structure, description of tasks, 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

7) Introduction to MS Project

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

Methods of Teaching:

Lectures, group discussions, case studies, student presentations

Recommended Qualifications:

Basic understanding of micro-economics

Method of Grade Evaluation:

Scope and Duration of Examination:

The scope and duration of the examination will be individually organized by the module representative and announced at the start of the module.

Impact of the Module Grade on the cumulative Grade:

6/120 (=5%)

Module Frequency:

Annual

Responsibility for the Module:

Prof. Dr. habil. Dirk Löhr

Responsibility for the Lectures:

Prof. Dr. habil. Dirk Löhr

Prof. Dr. Christian Bleis

Required Readings:

PMI's Guide to the Project Management Body of Knowledge (PMBOK® 2004).

Module 4: Economic Aspects of Sustainable Energy Systems

The module aims to provide the students 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 in regional or industrial systems (closely linked to modules 2, 5 to 6).

The implementation of Zero-Emission strategies and Circular Economy visions outlined and assessed in Module 2: REGIONAL MATERIAL FLOW MANAGEMENT and Module 6: INDUSTRIAL ECOLOGY & ECO-INDUSTRIAL PARKS 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 Cleaner Production parts of module 5).

<table>
<tr><th colspan="3">ECONOMIC ASPECTS OF SUSTAINABLE ENERGY SYSTEMS</th><th>6 ECTS / 4 SWH</th></tr>
<tr><td><u>Module Acronym:</u>
Sus.Energy</td><td colspan="2"><u>Workload:</u>
180</td><td><u>Duration:</u>
1 Semester</td></tr>
<tr><td><u>Module Type</u>
Lecture</td><td><u>Lessons:</u>
60</td><td><u>Self-Study:</u>
120</td><td><u>Estimated Group Size:</u>
30</td></tr>
<tr><td colspan="4"><u>Objectives and Learning Outcomes:</u>

Part: Renewable Energies

In this part, the students have learned to understand actual and future design challenges and strategies for (100%) renewable energy supply systems and the economic implications and have understood the qualitative difference between conventional and regenerative supply in terms of long-term continuity, economy and ecology. The students got an overview on current global renewable energy policies and markets as well as economical (and technical) push and pull factors and constraints and gained and an economical understanding on various renewable energy forms.

Furthermore, this part of the module has provided technical foundations and a methodological knowledge on energy life cycle assessment and energy balances throughout the various life stages from resource extraction towards final use energy.

Part: Energy Efficiency

The students have understood the necessity for energy efficiency and could explain fields with major efficiency potential. They were enabled to describe major technologies to increase energy efficiency for various end-use energy forms, e.g. heating, cooling, electricity, compressed air, etc.

Hence, (in combination with module 3) the students were enabled to conduct a business plan for renewable energy and energy efficiency projects by analyzing best-practice-examples.</td></tr>
<tr><td colspan="4"><u>Content of Course/Module:</u>

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</td></tr>
</table>

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

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

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

Economic evaluation of different storage systems

Identification and use of processes with inherent storage capabilities and economic modelling (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

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

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

Economic aspects of district heating and cooling and grid

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

2) Energy Efficiency and Solar Cooling

Technical principles 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

Economic aspects and 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

Methods of Teaching:

Lectures, group discussions, case studies, student presentations

Recommended Qualifications: None
Method of Grade Evaluation: The total score for the course is 100%: Final exam (90 minutes - 50%) and scientific paper with oral presentation (50%)
Scope and Duration of Examination: The scope and duration of the examination will be individually organized by the module representative and announced at the start of the module.
Impact of the Module Grade on the cumulative Grade: 6/120 (=5%)
Module Frequency: Annual
Responsibility for the Module: Dipl.-Ing. Christian Synwoldt **Responsibility for the Lectures:** Dipl.-Ing. Christian Synwoldt
Required Readings: Renewable energy and climate change, Volker Quaschning, IEEE Press, 2011 Renewable Energy Systems, Martin Kaltschmitt et al, Springer, 2013 Introduction to Wind Energy Systems, Wagner, Hermann-Josef, Springer, 2013 Planning and installing photovoltaic systems : a guide for installers, architects and engineers, DGS, 2013 Electrical Transmission Systems and Smart Grids, Miroslav M. Begovic, Springer 2013

Module 5: 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. Practical case studies on the German company management philosophy of Cleaner Production (Product Integrated Environmental Protection) will be used to provide the practical insights to the topic.

In the first part of the module, the 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 the second part the emphasis is placed on the “green transformation and reporting” process of companies focussing on new sustainability management and reporting processes.

The entire module is strongly interlinked with module 6 “Industrial Ecology” and the modules 4 and 7 to 8..

INDUSTRIAL MATERIAL FLOW MANAGEMENT			**6 ECTS / 4 SWH**
Module Acronym: Ind.MFM	**Workload:** 180		**Duration:** 1 Semester
Module Type Lecture	**Lessons:** 60	**Self-Study:** 120	**Estimated Group Size:** 30

Objectives and Learning Outcomes:

The students have understood the characteristics of industrial MFM and how it has emerged. They got the knowledge to demonstrate the evidence and the business case for eco-efficiency in industrial companies. Furthermore they recognized Life-Cycle-Analysis as Best-Practice-Tool in Industrial MFM. The students have gained knowledge of the requirements of Environmental Management Systems (ISO 14001 and EMAS) and of the GRI-requirements for sustainability reporting and have recognized the benefit of sustainability reporting for companies. The students have been enabled to critically reflect sustainability reports and understood the evidence of Corporate Social Responsibility.

Content of Course/Module:

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

2) **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

3) **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

4) **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

5) 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 Engagement

GRI-Economic Indicators (Definitions and Examples)

GRI-Environmental and Social Indicators (Definitions and Examples)

Case Studies GRI

6) 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

Methods of Teaching:

Lectures, group discussions, case studies

Recommended Qualifications:

Basic understanding of industrial management and production processes

Method of Grade Evaluation:

The total score for the course is 100%:

Final exam (90 minutes - 40%) and scientific paper with oral presentation (60%)

Scope and Duration of Examination:

The scope and duration of the examination will be individually organized by the module representative and announced at the start of the module.

Impact of the Module Grade on the cumulative Grade:

6/120 (=5%)

Module Frequency:

Annual

Responsibility for the Module:

Prof. Dr. Klaus Helling

Responsibility for the Lectures:

Prof. Dr. Klaus Helling and guest lecturers

Required Readings:

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.

GRI-Standards for Sustainability Reporting

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

Guidelines of ISO 26000

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

Course-related links

www.cleaner-production.de

www.iso.org

www,setac.org

www.wbcsd.org

www.iso.org
www.globalreporting.org

www.pius-info.de/en/index.html
http://www.ressource-deutschland.tv/?lang=en**3**

Module 6: Industrial Ecology and Eco Industrial parks

The Module 6: INDUSTRIAL ECOLOGY & ECO-INDUSTRIAL PARKS 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 5: INDUSTRIAL MATERIAL FLOW MANAGEMENT.

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 neighbour networks to exchange resources and information.

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

<table>
<tr><th colspan="3">INDUSTRIAL ECOLOGY AND ECO-INDUSTRIAL PARKS</th><th>6 ECTS / 4 SWH</th></tr>
<tr><td>Module Acronym:
IE-EIP</td><td colspan="2">Workload:
180</td><td>Duration:
1 Semester</td></tr>
<tr><td>Module Type
Lecture</td><td>Lessons:
60</td><td>Self-Study:
120</td><td>Estimated Group Size:
30</td></tr>
<tr><td colspan="4">Objectives and Learning Outcomes:
The students became a theoretical and practical introduction to the modern interdisciplinary research field Industrial Ecology and its roots in Ecological Economics, Systems Theory, Natural Science and Ecological Engineering. They have deepened their knowledge 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. The students have acquired the basic knowledge of material and energy flow indicators of the Industrial metabolism of Industrial and developing countries in comparison and have discussed International Eco-Industrial Park approaches of UK, Japan, China and Europe as well as their effect on resources efficiency. Hence, the students have learned to analyse or design an own EIP in their native countries.
Furthermore, they have learned and explored additional strategies like dematerialization, Slow-food, Re-Engineering and Up-Cycling on base of practical examples as well as nature-integrated technologies, such as recycling technologies (mobiles, PV, batteries) and nutrients recycling (P,N) cascading and new production lines on basis of renewable materials like a biorefinery.</td></tr>
<tr><td colspan="4">Content of Course/Module:
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</td></tr>
</table>

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

4) **Case Studies on Up-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)

Methods of Teaching:

Lectures and student case studies

Recommended Qualifications:

None

Method of Grade Evaluation:

The total score for the course is 100%:
Final exam (90 minutes - 40%) and scientific paper with oral presentation (60%)

Scope and Duration of Examination:

The scope and duration of the examination will be individually organized by the module representative and announced at the start of the module.

Impact of the Module Grade on the cumulative Grade:

6/120 (=5%)

Module Frequency:

Annual

Responsibility for the Module:

Prof. Dr.-Ing. Susanne Hartard

Responsibility for the Lectures:

Prof. Dr.-Ing. Susanne Hartard and practioneers from companies

Required Readings:

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.

Module 7: Economic Aspects of Sustainable Resource Management

While modules 2, 5 and 6 deal with material and energy efficiency strategies at the point of resource extraction and utilisation, this module 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 6 different recycling networks, in particular for rare earth metals are evaluated. In close cooperation with module 4 the waste-to-energy section for bio waste is explained in detail. A special focus is placed on the sustainable utilisation of biological residues and the production of biogas and fertilizer as well as wooden-based resources for district heating systems-

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.

<table>
<tr><th colspan="3">ECONOMIC ASPECTS OF SUSTAINABLE RESOURCE MANAGEMENT</th><th>6 ECTS / 4 SWH</th></tr>
<tr><td>Module Acronym:
SusRes</td><td colspan="2">Workload:
180</td><td>Duration:
1 Semester</td></tr>
<tr><td>Module Type
Lecture</td><td>Lessons:
60</td><td>Self-Study:
120</td><td>Estimated Group Size:
30</td></tr>
<tr><td colspan="4">Objectives and Learning Outcomes:
Students have gained a holistic overview on the environmental and economic impacts of end-of-pipe based waste management systems and have learned the optimisation potentials towards new Circular Economy based systems. The students have become an overview on the latest organisational and technology options for sustainable resource management and have gathered the knowledge to calculate the regional added value of such systemic waste management approaches based on Material Flow Management strategies. The students have got a broad overview on different utilisation and recycling options for different waste streams such as plastics, organics, rare earth minerals, etc and got an overview on the economic aspects of secondary raw material utilisation. After finishing this module, the students have an understanding of Zero Emission options in the field of Municipal Solid Waste (MSW), industrial waste as well as electric and electronic waste.</td></tr>
<tr><td colspan="4">Content of Course/Module:
1) Management Aspects of Sustainable Waste Management
Global overview on Municipal Solid Waste management concepts, technologies and their environmental and economic 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</td></tr>
</table>

Systems in Developing Countries to link Climate Change Mitigation, Resource Efficiency and Sustainable Development

2) Economical and Technical Aspects of Sustainable Waste Management

Basic technical principles and economics 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)

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)

Basic technical principles and economics of 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 re-granulates, tire recycling)
- Case Studies on resources in batteries (Lithium) and their recovery

4) Case Studies on sustainable utilisation of biological residues

Basic technical principles and economics of biogas and biochar technologies

Technical and economic aspects of production of wood pellets and utilisation in district heating systems

Methods of Teaching:

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

Recommended Qualifications:

Basic knowledge on chemistry

Method of Grade Evaluation:

The total score for the course is 100%:
Final exam (90 minutes - 50%) and scientific paper with oral presentation (50%)

Scope and Duration of Examination:

The scope and duration of the examination will be individually organized by the module representative and announced at the start of the module.

Impact of the Module Grade on the cumulative Grade:

6/120 (=5%)

Module Frequency:

Annual

Responsibility for the Module:

Prof. Dr.-Ing. Susanne Hartard **Responsibility for the Lectures:** Prof. Dr.-Ing. Susanne Hartard plus various experts with contributions in single sessions
Required Readings: 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 8: Economic Aspects of Sustainable Water Management

Within this module the students learn the economic aspects of sustainable water management services (freshwater production and distribution as well as waste water treatment) as well as the basic engineering principles of integrated water resource management (IWRM). Furthermore, the module explain the combination or cross-cutting impacts on energy and water management and 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 modules 2, 5 to 6 providing an economical and basic engineering understanding on water related issues.

ECONOMIC ASPECTS OF SUSTAINABLE WATER MANAGEMENT			6 ECTS / 4 SWH
Module Acronym: SusWater	**Workload:** 180		**Duration:** 1 Semester
Module Type Lecture	**Lessons:** 60	**Self-Study:** 120	**Estimated Group Size:** 30

Objectives and Learning Outcomes:

This module has provided the students an understanding of economical (and basic technical) aspects of integrated water resource management strategies (IWRM) as an important pre-requisite towards regional Zero Emission strategies as well as on the global importance and challenges in water and sanitation management. The students have got the basic knowledge in water science, aquatic ecology and the hydrological cycle combined with an understanding of the dynamic relationship between human and natural systems, in particular the interconnections between water, soil, energy, sustainability and regional development.

The student have understood the economic aspects as well as the basic technical principles and design aspects of sanitary engineering infrastructure focusing on drinking water supply and treatment, sewerage and wastewater treatment as well as new technology concept for nutrient recovery water re-use and energy efficient (autarkic) waste water treatment. Relevant excursions have provided first-hand insights in technological aspects of the urban water infrastructure.

Content of Course/Module:

1) **Introduction to global water cycle and global water problems**
   - Proportion freshwater / seawater, global amounts / Global dispersal of freshwater
   - Water cycle: precipitation, infiltration / runoff / evapotranspiration; + equations & measurement methods
   - Introduction to sustainability principles
   - International Water-related policies, case study on the history of water protection and water policies in Germany
   - Introduction to the Millennium Water Targets of the United Nation University as well as the global issue of water scarcity and water pollution

2) **Introduction to water supply and wastewater**
   - Economics and technical aspects of drinking water
   - Historical development, economics and technical aspects of waste water treatment
   - Technical Aspects of Water Treatment Technologies, Water Re-use and Waste Water Avoidance Strategies

3) Principles of Economic Valuation of (Waste) Water Management Services

- Basic economical and managerial aspects of Water Treatment Technologies
- Basic economical and managerial aspects of Water Re-use and Waste Water Avoidance Strategies

4) Case Studies in Sustainable Water Management

- Case studies on appropriate technologies for water treatment in developed countries
- Case studies on appropriate technologies for water treatment in developing countries

Methods of Teaching:

Lectures, group discussions, case studies

Recommended Qualifications:

Basic knowledge of Ecosystem Management and micro-economics

Method of Grade Evaluation:

The total score for the course is 100%:
Final exam (90 minutes - 50%) and scientific paper with oral presentation (50%)

Scope and Duration of Examination:

The scope and duration of the examination will be individually organized by the module representative and announced at the start of the module.

Impact of the Module Grade on the cumulative Grade:

6/120 (=5%)

Module Frequency:

Annual

Responsibility for the Module:

Dr. Ingo Bruch

Responsibility for the Lectures:

Required Readings:

Modules 9 and 10: Selectives (I and II)

The modules 9 and 10 are designed to allow the student to deepen their knowledge in various specialized fields supporting the overall context of developing and executing MFM, ZE and CE projects on industrialise and regional levels. The students can choose their electives from various courses offered within the IMAT MSc and the IMAT engineering program as well courses offered in the master programs at the Environmental campus Birkenfeld.

In the previous years the following courses were offered as electives:

- GHG Abatement and Carbon Trading Strategies
- Traveling University
- Scientific Writing and Research Management
- Practical Examples of Factor 10 in Industry
- Stakeholder Management and Networking
- System Change Management
- Renewable Energy Policies within the European Union
- MFM Modelling and Carbon Footprinting
- E-Mobility and Sustainable Energy Politics
- Fuel Cell Technology
- Business Game: Development of Renewable Energy Projects including Technical Dimensioning and Business Plan Design
- Zero Emission Systems for Islands
- Solar Architecture and Solar Energy in Buildings
- Solar Cooling: Technology, Economy and Design Aspects
- Biofuels: Technology, Markets and Trends
- Sustainable Land Use Management and Organic Agriculture
- Climate Change, Land-Use and Soil Management
- “Green Development Perspectives” for the Asia-Pacific Region
- KAIZEN and other Forms of Material and Energy Efficiency in Japan
- “Green Development Perspectives” for the Middle-East Region
- Green Tourism Strategy
- German as a Foreign Language

The modules 9 and 10 are created as courses with a workload of 180h (60h in class and 120h self-study) and will be credited with 6 ECTS. Sometimes it can be reasonable to split the modules into two courses, each with a workload of 90h (30h in class and 60h self-study) and will be credited with 3 ECTS.

As an example the selective “Greenhouse gas abatement and carbon trading” is shown in order to illustrate the interconnection of the selectives with the overall modules of the courses.

SELECTIVES I – EXAMPLE ON COURSE "GREENHOUSE GAS ABATEMENT AND CARBON TRADING"			6 ECTS / 4 SWH
Module Acronym: CarbonTrading	**Workload:** 180		**Duration:** 1 Semester
Module Type Lecture	**Lessons:** 60	**Self-Study:** 120	**Estimated Group Size:** 15

Objectives and Learning Outcomes:

The students have obtained the knowledge on the institutional roots of global GHG abatement and international carbon trading regimes as well as current valid flexible mechanisms of the Post-Kyoto periode (with emphasis on the Clean development Mechanism and Nationally Appropriate Mitigation Actions). The students were enabled to create, calculate and document GHG abatement and carbon trading projects in various sectors such as energy, waste and waste water intensifying their knowledge gathered in the modules 4, 7 and 8 with regards to the environmental (in particular climate change) aspects of the sustainable technologies.

The students have gathered the knowledge to apply carbon financing options to co-finance the developed regional and industrial optimisation projects as outlined in modules 2, 5 and 6 and have been enabled to analyse the GHG abatement potentials within their master thesis.

Content of Course/Module:

The course is divided into three 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.

Methods of Teaching:

Lecture, group discussion, reading and business game (COP simulation)

Recommended Qualifications:

Basic Knowledge from Modules 4, 7 and 8

Method of Grade Evaluation:

The grade is based on a student PDD presentation (50%) and an exam (50%). The grade of the course is weighted equally for the module grade.

A selection of topics for the PDD presentation is offered in relation to their home countries situation.

Scope and Duration of Examination:

The scope and duration of the examination will be individually organized by the module representative and announced at the start of the module.
Impact of the Module Grade on the cumulative Grade: 3/120 (=2,5%)
Module Frequency: Annual
Responsibility for the Module: Dr. Michael Knaus **Responsibility for the Lectures:** Dr. Michael Knaus
Required Readings: 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

Module 11: Internship / Study Semester Abroad

<table>
<tr><td colspan="3">INTERNSHIP</td><td>30 ECTS</td></tr>
<tr><td><u>Module Acronym:</u>
INTERN</td><td colspan="2"><u>Workload:</u>
900</td><td><u>Duration:</u>
1 Semester</td></tr>
<tr><td><u>Module Type</u>
Internship or
Study Semester</td><td><u>Lessons:</u>
Depending on the partner university</td><td><u>Self-Study:</u>
Depending on the partner university</td><td><u>Estimated Group Size:</u></td></tr>
<tr><td colspan="4"><u>Objectives and Learning Outcomes:</u>
The practical period intends to deepen the theoretical knowledge in a practical internship at a company, research institute and/or (non-) governmental entity.
Alternatively the students can opt for a study semester abroad at a IMAT partner university deepen his intercultural skills and theoretical knowledge by attending courses at the partner university.</td></tr>
<tr><td colspan="4"><u>Content of Course/Module:</u>
Study Semester Abroad: Depend on the academic calendar of the IMAT partner university. The IMAT faculty member, the IMAT administration office as well as the academic exchange office of the ECB offer to provide the necessary information (course and exchange options).
The students are obliged to select the courses to be attended in close consultation with the IMAT study programme representative and provide a written report at the end of the study semester.</td></tr>
<tr><td colspan="4"><u>Methode of Teaching:</u></td></tr>
<tr><td colspan="4">Recommended Qualifications<u>:</u>
none</td></tr>
<tr><td colspan="4"><u>Method of Grade Evaluation:</u>
The students have to provide a research report on their internship highlighting on the achieved learning outcomes oft he internship or the study semester abroad. The required report has an estimated length of 5.000 words.</td></tr>
<tr><td colspan="4"><u>Scope and Duration of Examination:</u></td></tr>
<tr><td colspan="4"><u>Impact of the Module Grade on the cumulative Grade:</u>
None</td></tr>
<tr><td colspan="4"><u>Module Frequency:</u>
Annual</td></tr>
<tr><td colspan="4"><u>Responsibility for the Module:</u>
Dr. Michael Knaus</td></tr>
<tr><td colspan="4"><u>Required Readings:</u></td></tr>
</table>

Module 12: Master-Thesis and Oral Defence

MASTER-THESIS AND ORAL DEFENCE			ECTS 30
Module Acronym: Master	**Workload:** 900		**Duration:** 1 Semester
Module Type a) Master Thesis b) Oral Defence	**Lessons:** 0	**Self-Study:** 900	**Estimated Group Size:**
Objectives and Learning Outcomes: The students have been enabled to apply indepently specific methods, concepts and approaches towards their master thesis case studies. The students have been gathering all essential knowledge to evaluate the economical, technical, social and environmental impacts and draw the necessary conclusion in a scientific manner. The students have been enabled to write the master thesis in a scientific language and defend their findings			
Content of Course/Module: The master thesis is an independent final student work. The students create scientifically solutions for a specific case/problem using the gathered scientific knowledge and tools (theoretical, experimental, empirical or practical). The results of the master thesis will be defended in an oral colloquium with an estimated length of 30 minutes.			
Methode of Teaching: Individual creation a master thesis within one semester with an accompanying oral defence. The students are supervised by at least one faculty member.			
Recommended Qualifications:			
Method of Grade Evaluation: The grades are based on the written master thesis and the oral defence based on the current examination regulation (Prüfungsordnung).			
Scope and Duration of Examination: The scope and duarzion of the master thesis including the oral defence are one semester (6 month) and start with the registration of the thesis. The oral defence has an estaimated length of 30 minutes in accordance to examination regulation. The written master thesis must be graded at least with C (4,0).			
Impact of the Module Grade on the cumulative Grade: 25% (30 out of 120ECTS)			
Module Frequency: Each Semester			
Responsibility for the Module: At least one Faculty members. Additional external supervisors can be accepted.			
Required Readings: Depending on the topic of the master thesis. Recommendation for Scientific Writing:			

Balzert, H., C. Schäfer, M. Schröder, U. Kern: Wissenschaftliches Arbeiten. 1. Auflage, Herdecke 2008