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| Course Title: | Energy and Climate Protection |
| Course Number: | MaEE-EACP |
| Credits: | 6 credits |
| Term: | Fall semester |
| People: | Prof. Dr. rer.nat. habil. Satyanarayana Narra |

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| Outcome: | Students get to know the role of energy transformation, distribution and consumption on climate change. Technical measures for increasing energy efficiency, sufficiency and consistency (e. g. renewable resources) are learned and analyzed. The basic framework for conventional and renewable energy scenarios will be taught. Students achieve an understanding of the need for efforts in climate protection, get acquainted with the political and technical international framework for climate protection and learn developing approaches for solutions.<br><br>Students can analyze, compare, and evaluate different energy policies, energy situations, influence of different fuels on climate, technical solutions, as well as ecological and economic impacts with special focus on their relevance on climate change. |
| Content: | Energy transformation and supply scenarios, strategies to energy efficiency and sufficiency, environmental and economic impacts of energy usage on climate change, technical and environmental framework on energy economy, global warming, climate protection, International strategies and policies regarding climate protection, scenarios for energy production and consumption, energy efficiency. |
| References: | Energy and Climate Change: Creating a Sustainable Future.<br>David Coley, Wiley publishers, John Wiley & Sons.<br>Renewable Energy and Climate Change. V<br>olker Quaschning, Wiley, John Wiley & Sons.<br>Global Cooling: Strategies for Climate Protection. Sustainable Energy Developments Series 1. Hans-Josef Fell. CRC Press.<br>Climate Protection and Development.<br>Frank Ackerman,<br>Richard Kozul-Wright and Rob Vos. Bloomsbury Academic. |

Course Title: Environmental Hydraulics
Course Number: MaEE-EH
Credits: 6 credits
Term: Fall semester
People: Prof. Dr.-Ing. habil. Mario Oertel

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| Outcome: | Students learn about different methods for hydraulic calculation in rivers that are required for the design of naturalized river sections, removal of barriers and weirs, development of wetlands as inunda-tion areas (knowledge and application). Students will learn methods and alternative possibilities for numerical simulation of natural channels and river sections (application). They will learn to carry understand principles of the design of environmental hydraulic engineering (comprehension). Students will learn to analyse applied problems of environmental hydraulic design (analysis) and to evaluate results of numerical modeling (synthesis and evaluation). |
| Content: | The European (River) water quality framework will be introduced; renaturation of anthropogenically modified water bodies; methods for the assessment of structural water quality; basics of hydraulic design of natural rivers; theory and tools for numerical simulation are of natural rivers and of environmental hydraulics. |
| References: | Chadwick A., Morfett J., Borthwick M. (2013) Hydraulics in Civil and Environmental Engineering, Fifth Edition. CRC Press, 648 p. 238 fig. |

Course Title: Environmental Processes for Resource Protection
Course Number: MaEE-EPRP
Credits: 6 credits
Term: Fall semester
People: Prof. Dr.-Ing. Michael Bischoff

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| Outcome: | Students get to know the role of energy transformation, distribution and consumption on climate change. Technical measures for increasing energy efficiency, sufficiency and consistency (e. g. renewable resources) are learned and analyzed. The basic framework for conventional and renewable energy scenarios will be taught. Students achieve an understanding of the need for efforts in climate protection, get acquainted with the political and technical international framework for climate protection and learn developing approaches for solutions.<br><br>Students can analyze, compare, and evaluate different energy policies, energy situations, influence of different fuels on climate, technical solutions, as well as ecological and economic impacts with special focus on their relevance on climate change. |
| Content: | Air Pollution Control Technologies and Strategies<br>Solid Waste treatment with focus on biological waste including biomass to Energy Technologies<br>Industrial Waste Water Processing and minimization<br>Process design for Resource and Energy Protection |
| References: | Process engineering and design for air pollution control,<br>Jaime Benítez, Prentice Hall Computer<br>Unit Operations and Processes in Environmental Engineering<br>(PWS Series in Engineering), Richards Reynolds, Tom D. Reynold<br>Baker, R., Membrane Technology and Applications, John Wiley & Sons |

Course Title: Framework for Sustainability
Course Number: MaEE-FS
Credits: 6 credits
Term: Spring semester
People: Prof. Dr. rer.nat. habil. Satyanarayana Narra

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| Outcome: | Teaching deep complexities on global sustainability, instruments for the analysis and evaluation of social, economic and environmental parameters, driving forces for improved sustainable development, company and society interests in sustainability, barriers and motivation aspects, international programs and initiatives, ethical conceptions for sustainability, best practice examples, tools, methods, and strategies for sustainable economy.<br>Students can integrate environmental / technical knowledge into a broader perspective on the framework of sustainability and would be in a position to make rational choices based on the suggested / required development situations. Students would be in a position to advance the great transformation towards sustainability regionally and globally. |
| Content: | Fundaments of Sustainability, models and calculation of Sustainability, Approaches to Sustainable Economy, Environmental Policy, Cleaner Production, Sustainable Consumption and Production, International Strategies and Initiatives, Green and Blue Economy, Differences in International Environmental perception on sustainability |
| References: | Energy and Climate Change: Creating a Sustainable Future. David Coley, Wiley publishers, John Wiley & Sons.<br>Ecological Modernization and renewable Energy. David Toke. Palgrave Macmillan – Political Science.<br>Climate Change, Ecology and Systematics. Trevor R. Hodkinson, Michael B. Ones, Stephan Waldren, John A. N. Parnell. Cambridge University Press. |

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| Course Title: | Industrial Ecology |
| Course Number: | MaEE-IE |
| Credits: | 6 credits |
| Term: | Spring semester |
| People: | Prof. Dr. rer. nat. Dipl.-Biol. Norbert Reintjes |

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| Outcome: | Students become acquainted with relevant instruments for the assessment of environmental impacts of products and processes. For given technical and / or management questions with environmental concern they can choose and apply appropriate instruments and define adequate assumptions and requirements for execution. Students have an understanding of software for the analysis of energy and material flows and for LCAs.<br>Students are able to apply these instruments on an organizational / business level as well as to transfer the knowledge to horizontal processes (e.g. standardization, legislation) |
| Content: | Analysis of industrial systems, Environmental Indicators, Life Cycle Assessment (LCA) and related instruments, Environmental management, international standardization related to environmental aspects. Modelling of industrial processes and its related environmental impact with software (UMBERTO). Specific examples. |
| References: | Klöpffer, Grahl: Life Cycle Assessment (LCA) *<br>International Standards ISO 14000; esp. 14040, 14044 (LCA) and ISO 14031 (Environmental Management) |

Course Title: Project: Energy - Climate - Ecology
Course Number: MaEE-PECE
Credits: 6 credits
Term: Fall semester
People: Prof. Dr.-Ing. Michael Bischoff

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| Outcome: | In maximum three parallel groups with different topics, the students shall learn to work on real interdisciplinary technical and research projects and gain experience by solving task specified objectives such as 1.) application of independent engineering solutions to complex problems, 2.) usage of strategic thinking, 3.) modelling and simulation, 4.) installation and operation of test devices, 5.) scientific literature research work, 6.) project planning, 7.) project control, and 8.) evaluation of results and implementation into the industrial practice.<br>The students shall be enabled to independently analyze problems and to identify suitable solutions. They shall be aware of the important steps of the project realization and shall learn to estimate and choose the connected relevant technical measures to improve the efficiency of solving strategies. |
| Content: | Environmental Process Engineering - Selected Processes, Energy Efficiency Considerations, Cleaner Production and Sustainability Thinking and Application |
| References: | Depending on Project Target and Contents |

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| Course Title: | Project: Water & Environment |
| Course Number: | MaEE-PWE |
| Credits: | 6 credits |
| Term: | Spring semester |
| People: | Prof. Dr. rer. nat. Dipl.-Hydr. Christoph Külls |

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| Outcome: | Students know the principles of environmental impact analyses for water & environment systems (knowledge). Students are able to apply knowledge on hydrology and hydraulics to a specific project. Within the project principles of hydrological design and environmental engineering need to be used in order to analyse the environmental impact of a given measure or designed structure on the aquatic system (application). The project involves quantitative (environmental hydrology, hydraulics) and qualitative (water treatment) aspects. Students are able to analyse and synthesize both aspects (analysis) and to carry out an evaluation of environmental impact (evaluation. Students will learn to aggregate and synthesize these aspects in a report and presentation (synthesis). |
| Content: | Fundamental hydraulics, Hydraulic laboratory, Numerical 1D and 2D simulation, Data requirement, Transfer to practical projects, introduction to sensitivity analysis, Excursion / introduction to com-plex water system, sensitivity model, simulation. |
| References: | According to project |

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| Course Title: | Sustainable Water Management |
| Course Number: | MaEE-SWM |
| Credits: | 6 credits |
| Term: | Fall semester |
| People: | Prof. Dr. rer. nat. Dipl.-Hydr. Christoph Külls |

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| Outcome: | Based on a sound knowledge of hydrological processes (knowledge) students are able to establish water balances for dif-ferent hydrological compartments and systems such as representative sites, lakes, basins, aquifers and administrative units (application). Students are able to estimate water resources (regionalization of rainfall, evaporation losses, runoff assessment) and to calculate the sustainable yield (application). Based on the establishment of water balances students will learn to evaluate the sustainability of water management schemes for basins, for aquifers and for district and countries (analysis & evaluation). Students will learn to aggregate hydrological studies in terms of Integrated Water Resources Management (synthesis). |
| Content: | Quantification of hydrological processes (rainfall, evaporation, runoff, groundwater recharge); hydrological water balances; basin definition for surface and groundwater systems; Integrated Water Resources Management; Methods of the European Framework Directive and transfer to non-European basins |
| References: | Arnell (2002) Hydrology and Global Environmental Change. Pearson ed. Prentice Hall, 279 p. Jones J.A. (1997) Global hydrology. Longmann press, 398 p. Dingmann S.L. (2002) Physical Hydrology. Waveland, 648 p. |

Course Title: Urban Water Science and Technology
Course Number: MaEE-UWST
Credits: 6 credits
Term: Spring semester
People: Prof. Dr.-Ing. Matthias Grottker

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| Outcome: | Students learn the elements and functionning of urban water systems in terms of drainage and in terms of water treatment (knowledge). Students will be able to design urban drainage systems using rainfall data and plans with up to date methods of stormwater design (application). Students will be able to understand principles of water treatment and of modern sewage treatment systems (comprehension). They will be able to analyze sewage treatment systems and to identify deficiencies and development needs (analyze). The regulatory framework of the EU water framework directive in relation to urban drainage and in relation to sewage treatment will be introduced. Students learn the apply this regulatory frameworks and to evaluate existing complex systems (synthesis & evaluation). |
| Content: | Urban water protection – objectives, tasks and methods. Processes in urban water systems, hydrometry, characteristics of urban waters, urban water protection methods and case studies of urban drainage systemes and urban sewage treatment systems. |
| References: | Grigg N.S. (2012) Water, Wastewater, and Stormwater Infrastructure Management. 2nd Ed. CRC Press. |

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| Course Title: | Water and Environment |
| Course Number: | MaEE-WE |
| Credits: | 6 credits |
| Term: | Spring semester |
| People: | Prof. Dr. rer. nat. Dipl.-Hydr. Christoph Külls |

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| Outcome: | Students get acquainted with environmental impacts of human ac-tivities on the water cycle and on aquatic media (knowledge). Stu-dents will have a practical knowledge of principles and tools for environmental assessment for aquatic systems and ecohydrometric methods. Students learn about different types of impacts quantity-wise and quality-wise (comprehension). They learn about different methods for the calculation and estimation of environmental flows downstream of dams or hydro-power plants (application). Students learn to assess the impact of human activities on river regimes and river water quality and will be trained to calculate solute and pollutant transport (application). They will learn calculating and monitoring transport in soils and in groundwater (application). Students will be able to analyze environmental impacts (analysis) and to carry out a risk assessment based on the analysis of environmental impacts on the aquatic environment (synthesis & evaluation). |
| Content: | International environmental flow requirements; Aquatic chemistry and processes in aquatic systems, mixing, dispersion, reactive transport in aquatic media; solute transport in soils and in ground-water; environmental assessment and risk assessment for rivers, lakes and for groundwater; environmental standards for different types of water and water uses (drinking water, bathing, irrigation); environmental services of aquatic systems. |
| References: | Appelo & Postma (2013) Geochemistry, groundwater and pollu-tion, CRC press, 2nd edition, 649 p. Allan & Castillo (2007) Stream ecology – Structure and function of running waters. Springer, 2nd ed. Stumm & Morgan (1996) Aquatic chemistry and equilibria in natural waters. Wiley, 1022 p. |