HAW Hamburg, Hochschule für Angewandte Wissenschaften Hamburg

Hamburg University of Applied Sciences

Master programme „Renewable Energy Systems – Environmental and Process Engineering“

Course content

Please note important remarks at the end of the section.

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Numerical Mathematics	4	5	WT & ST	English	obligatory

- Introduction to MATLAB programming,
- Introduction into basic problems with the representation of numbers on a computer (types of errors, error propagation, extinction),
- Numerical Solution of Linear Equation Systems
  - Ill-conditioned linear equation systems,
  - Overdetermined linear equation systems (pseudo-inverse matrix).
- Curve Fitting Methods
  - Least squares fit,
  - Linearization,
  - Cubic splines.
- Optimization with the Nelder-Mead Simplex Method
- Numerical Integration
  - Trapezoidal Rule,
  - Simpson’s Method.
- Numerical Solution of Differential Equations
  - Methods of Euler, Heun and Runge-Kutta,
  - Error estimation.

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Data Acquisition and Processing	4	5	WT & ST	English	obligatory

- Introduction to LabVIEW programming,
- statistical evaluation of measured data
  - basic statistical quantities (mean, variance and standard error, median etc.)
  - hypothesis tests
  - parameter estimation
- acquisition and processing
  - Fourier Transform und series: basics, examples and discretization
  - Sampling Theorem: Aliasing, smoothing Windows etc.
  - Digital Filters: linear filters (FIR and IIR)

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Wind Energy	2	3	ST only	English	obligatory

- Introduction:
  - History of wind energy, current status, economical importance
- Wind energy
  - Appearance of Wind, local effects, wind shear, turbulence, time variation
  - Measurement of wind, analysis of wind data, energy estimations
- Wind energy conversion systems
  - Technical concepts of conversion systems, vertical and horizontal axis, wind rotors
- Aerodynamics of modern wind turbines
  - Airfoil, Blade shape, momentum theory, rotor design
- Mechanics
  - Energy transmission, gear box, brakes, pitch control, azimuth control, housing, tower, base plates
- Electrical power generation
  - Electrical concepts, Generators, inverters, transformer, grid connection
- Operation of wind turbines
  - Power control, monitoring, servicing and maintenance

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Assessment of Wind Energy Projects	2	2	ST only	English	obligatory

- Applied engineering of wind farms
- Assessment of location
- selection of system
- yield prognosis and simulation, yield optimizing, park design
- economical calculation
- German and international energy policy.
- Licensing procedure for wind energy projects in different countries
- Environmental impact analyses
- Noise emission measuring and control

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Energy Practice (Lab)	2	3	ST only	English	obligatory

Several experiments in the laboratory on renewable energy systems:

- Temperature dependency of solar cells
- Electrical characterization of photovoltaic modules and generators
- Performance of fuel cells
- Production of Biodiesel
- LiBr - absorption refrigeration
- Numerical determination and analysis of wind turbines
- Simulation of PV systems

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Biofuels	4	5	ST only	English	optional

- global challenges of energy supply considering demand, potentials, climate change and CO2 balances
- thermodynamic, chemical, ecological and economical fundamentals of conventional and alternative fuels
- Chemistry of biomass
- Chemistry and thermodynamics of biological and thermochemical conversion of biomass into liquid and gaseous fuels
- 1st, 2nd and 3rd generation biofuels considering latest research and development results including activities at the Hamburg University of Applied Sciences

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Biogas Engineering	2	2	WT only	English	optional

- "Highlights", energetical considerations, physicochemical factors influencing the methane content of a biogas reactor, "wet and dry" anaerobic digestion processes, online and offline parameters of laboratory reactors. The importance of the inoculum-sludge for the start-up period. Biology of the anaerobic digestion: The anaerobic food chain, anaerobic fatty acid oxidizers, interference with nitrate and sulphate, toxicity of ammonium and H2S, influence of volatile fatty acids, substrate affinity, interspecies hydrogen transport, the „energetical window" and the dependence on the right H2-concentration of an anaerobic digestion process. Role of the process parameters HRT and OLR, factors forcing a two-step anaerobic digestion process, continuously driven reactors, schemes of different types of anaerobic digesters, diversifications and examples of biogas plants for renewable biomass.
- homework „Data Bank Search":
  An elaborate information package belonging to the search is offered on an E-Learning-platform. Different and individual key words of the literature search are issued to the participants. These key words have to be linked to find a proper amount of literature to a special subject (e.g., find all literature and patents for micronutrients being necessary for the biogas process, but only the most important and new 100 literature citations). The data bank search is performed in Hamburg in 2-3 libraries to load the data direct in place. The extensive reworking and assorting is done at home.

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Biogas Engineering Practice	2	3	WT only	English	optional

- The content of the lecture of the same name shall be demonstrated by some examples. For this aim quantitative anaerobic digestions of biomass are performed simultaneously in mini-fermenters. The mini-fermentations are recorded online and many of them are equipped with methane sensors. 6 working stations with up to 96 mini-fermenters in series are ready for use by max. 12 participants. The practical course is not restricted to a special time of presence, it is quite individually grouped. Time for about two introductions and two discussions has to be reserved. The experiments can also be extended to a full-length project.

- The instrumental equipment belongs to the research and transfer center for “regenerative energy and energy efficiency” (FTZ REEVE), research group Scherer

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Plant Engineering	2	3	WT only	English	optional

- Project sequence: organization, planning and project controlling
- Preliminary planning, feasibility study and basic engineering
- Systematic product and process development, process evaluation, process optimization
- Order acquisition, quotations, contracts
- Determination of the process sequence, process design of plant components
- Mechanical design, construction and arrangement of plant components, plant model
- Engineering of main systems and components
- Procurement, inspection and dispatch
- Construction and erection, planning and execution
- Commissioning and operation
- Documentation

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Photovoltaic system engineering	4	5	WT only	English	optional

- Introduction:
  - status quo of PV-technology and -market, scope of application of PV-systems, overview of system design, solar irradiation
- Characteristics of PV system devices
  - PV-panel, inverter, charge controller, battery, monitoring systems, mounting systems, market overview, recent innovations
- Grid connected systems
  - electrical system design, simulation, performance ratio, yield optimization, grid connection
- Off grid and hybrid systems
  - load analysis, electrical system design, simulation, operation strategies, embedding of wind generators, small hydro power systems, diesel back up
- Mounting and mechanical design
  - roof mounting on top and integrated, façade systems, tracking systems, static aspects
- Requirements of grid authorities, environmental aspects and subsidies
- Installation and operation
  - steps from planning to construction, monitoring and service

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Solar Cells	2	3	WT only	English	optional

Special Aspects of Semiconductor Physics
intrinsic and impurity conduction, absorption in direct and indirect semiconductors, carrier lifetime and recombination, carrier diffusion, p-n junction

Basic Solar Cell Structure and Technology
base, emitter, contacts, grid, antireflection coating, texturing, passivation, oxidation, impurity diffusion, CZ- and FZ-silicon

Advanced Solar Cell Structure and Technology, Modules
local back surface field, interdigitated back contact cells, bifacial cells, buried contacts, laser ablation, laser fired contacts, laser soldering, passivation by a-Si layer, heterojunction cells, porous silicon, module production

Thin Film Solar Cells
materials, substrates, deposition techniques, large area modules

Measurement Techniques
I-V characteristics, spectral response, life time measurements, short circuit current topography (LBIC), electroluminescence image

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Solar Thermal Systems	2	2	ST only	English	optional

Special Aspects of Thermodynamics
thermal capacity and conductivity, thermal transfer and insulation, heat transition coefficient

Collectors
structures and fabrication, materials, selective absorber, flat-plate and evacuated tube collectors, heat pipes, efficiency, thermal losses

Systems
swimming pool heating, thermosyphon system, systems with forced circulation, low/high flow, pipes, regulators

Thermal Storage
short/long-term storage, domestic hot water storage tanks, heat exchanger

Characteristics
heat demand, solar fraction, collector cycle efficiency, saved primary energy

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Process Heat	2	3	ST only	German	optional

- economical heat transport and heat storage
- heat recovery for warm water, hot water and steam production
- power production from waste heat and renewable heat sources
- combined heat and power production (CHP), part load behaviour
- pinch-point-analysis, exergy analysis, entropy analysis
- gain output from heat pumps and heat transformers
- heat recovery and refrigeration with thermal and mechanical vapour compression
- thermal seawater desalination and absorption cooling

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Fuel Cells	2	3	ST only	English	optional

- Introduction
- Fundamentals of a Fuel Cell
- Thermodynamics
- Efficiency
- Voltage-Current-Characteristics
- Types of Fuel Cells
  - Classification of Fuel Cell Systems
  - Alkaline Fuel Cell (AFC)
  - Proton Exchange Membrane Fuel Cell (PEMFC)
  - Phosphoric Acid Fuel Cell (PAFC)
  - Molten Carbonate Fuel Cell (MCFC)
  - Solid Oxide Fuel Cell (SOFC))

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Advanced Electrical Engineering	2	2	WT only	English	optional

- dc current circuits
- single phase and three phase alternating current
- transformers
- synchronous and asynchronous generators
- topologies of wind power plants
- electricity grid and distribution
- grid connection and feed in

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Power Electronics and Grids	2	2	ST only	English	optional

- power electronic switches
- fundamental circuits of power electronics
- frequency converters
- electricity grid and distribution
- control and protection of electrical grids
- conditions for grid connection
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Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Computational Simulation Techniques	2	2	WT only	English	optional

This lecture contains the numerical techniques to solve coupled partial differential equations including explicit algorithms, boundary conditions and spatial discretisation. The commercial software package ANSYS CFD is introduced and used to simulate flow fields. Numerical solution parameters are treated and the convergence behaviour is explained and studied.
The physical flow phenomena laminar and turbulent flows and shock waves are introduced and the way how to handle them in a numerical simulation is explained.

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
CFD Simulation for Biogas Plants	2	3	WT only	English	optional

The lecture "CFD Simulation for Biogas Plants“ deals with multi-components flows as they occur in bio gas plants. Mixture consisting of gases or liquids and porous media are explained as well as drying processes.
The programming of variable component properties and heat transfer mechanisms in the ANSYS CFD language CEL is covered.

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Wind Turbine Design with CFD	2	3	WT only	English	optional

The lecture "Windturbine Design with CFD" includes the airfoil section theory and dicusses the numerical investigation of lift and drag curve with the help of CFD. The two dimensional results are transferred to 3D wing section theory in order to determine the local chord length distribution of the rotor.
Instationary computations are carried out to analyse the design parameter chord length, number of revolutions and nacelle design etc. and to determine the wind pressure force on the structure.

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Project Work	4	5	WT & ST	English	optional
specific projects related to the scientific work done currently at the faculty life sciences of the Hamburg University of Applied Science in the field of renewable energy systems					

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Specialisation	2	2 or 3	WT & ST	English or German	optional
additional lectures from the master programme or relevant lectures from master programmes of our faculty or other faculties or universities can be chosen according the regulations					

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Project Finance	2	2	ST only	English	obligatory

- Analytical approaches to financial decision-making
- Subjective and objective applications of decision-making processes
- Expected value reasoning
- contractual agreements, technology, sponsors, risk identification and mitigation,
- sources of capital, financial structuring, the use of financial modeling, accounting considerations, and tax considerations.
- Various sources of financing will be discussed
- Financial modeling will be used to understand the economics, risks and sensitivities of a project.
- Business trends including seasonality, cycles, and random variations
- Decision trees

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Marketing Strategy	2	3	ST only	English	obligatory

- Deterministic Strategy
- Environmental Forces, Structural Inertia, Life cycles Rational Strategy
- The Planning Process, Analysis, Modernist and Functional approaches Developmental Strategy
- Resources such as brands, Capabilities Interactive Strategy
- Competitive Exclusion, Niche, Benchmarking, Positioning, Differentiation Unpredictable Strategy
- Post-modernism

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Project Management	2	2	WT only	English	obligatory

(content under revision)

- Project life cycle
- Project scope, time, cost, and quality management
- Project integration management
- Project quality management: planning, assurance and control
- Identifying and working with stakeholders
- Project management tools / Working with Microsoft project
- Communications management and project risk management

Name of course	Hours per week	Credit points	winter term / summer term	language	obligatory / optional
Master Thesis	6 month	30	WT & ST	English or German	obligatory

- specific research and projects related to the scientific work done currently at the faculty life sciences of the Hamburg University of Applied Science or other scientific institutes or companies working in the field of renewable energy systems
- the master thesis is supervised by a professor of the faculty and by an engineer or researcher from the external company or institute

Remarks:

- The course content description is a rough guideline. The content of the lectures can be modified individually by the lecturers.
- Courses can be shifted from winter term to summer term or vice versa due to availability of the lectures and due to needs of the faculty. Have a look at the actual class schedule.
- The regulations how to choose the courses, how to do exams, how to count credit points etc. are published in the programme regulations elsewhere.