Course of study/ focus of study: M.Sc. Nachhaltige Energiesysteme im Maschinenbau	
Module name / title	**Electrochemical Energy Conversion / Fuel Cell Systems (engl.)**
Module number	FCSYS
Module coordinator/ person responsible	Herr Prof. Dr. Achim Schmidt
Duration of the module/ semester/ frequency	1 Semester/ first or second semester/ annually
Credits (CP)/ semester hours per week (SHW)	5 LP/ 3.00 SWS
Type of module , Applicability of the module	Course-specific elective module
Workload	Contact hours: 54 h and Self-study: 96 h (Basis: 18 semester weeks (incl. exam time), 1 SHW = 60 minutes)
Module prerequisites Requirements for participation/ previous knowledge	Recommended: Thermodynamics I/II, Knowledge of Matlab/SIMULINK
Teaching language	Teaching language: English Alternate teaching language: German If there is more than one teaching language, the used teaching language will be announced by the lecturer.
Competencies gained/ Learning Outcome	Different energy conversion techniques and storage methods can be named Major fuel cell types and their distinctions can be explained The fundamentals of electrochemical energy storage/conversion (electrochemical reactions) can be applied Electrochemical as well as thermodynamic basics can be explained with an example Requirements for electrochemical systems can be analysed and evaluated (stationary as well as mobile applications) Dynamic model-based balances for electrochemical conversion can be performed System integration of electro-chemical conversion techniques can be designed Complex energy systems and their interactions can be calculated and evaluated dynamically with numerical tools, e.g. Simulink/MatLab The need for renewable energies as well as for energy storage is understood

Content of the module	1. General basics/introduction 2. Principles of energy conversion and storage 3. Introduction to physical chemistry a. Reversible electro-chemical reaction b. Gibbs enthalpy, Fundamental equation of thermodynamics c. Nernst equation d. Irreversibilities, overvoltages e. Butler-Volmer equation, Kinetics of the electrodes 4. Applications a. Fuel Cell stacks i. Requirements ii. Technologies b. Batteries i. Requirements ii. From cell to stack 5. System evaluation a. Dynamic application (e-Mobility) b. Design of a Simulink model including interfaces of all relevant sub-systems c. Energetic evaluation, Energy Management System (EMS), Control strategies 6. Laboratory (Simulink) a. Case study: Fuel-cell vehicle with Li-Ion storage for energy recuperation (Hybrid systems) b. Dynamic system simulation
Requirements for the award of credit points (Study and exam requirements)	Regular examination type for module testing: Written exam (PL) Further possible examination types: oral exam, portfolio assessment Laboratory internship: Laboratory degree (SL) Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.
Learning and teaching types/ methods/ media types	2 LVS lecture (Black board, slides, projector) 1 LVS laboratory (Computer)
Literature	P. Kurzweil: Elektrochemische Speicher. Springer (2015) T. Reddy: Linden‘s Handbook of Batteries. McGrawHill (2011) M. Sterner, I. Stadler: Energiespeicher. Springer (2014) A. Jossen, W. Weydanz: Moderne Akkumulatoren richtig eingesetzt. Inge Reichardt Verlag (2006) VDI Wärmeatlas. Springer Verlag (2006)