Courses 1st year LUT

Course title	Course contents	Learning outcomes
Advanced Topics in Modelling of Energy Systems	Advanced problems in the modelling of energy systems needed by engineers and researchers. The course lectures provide mathematical basis for problem formulation, and exercises providing a chance to work with various computational packages.	Upon completion of the course the student will be able to: 1. create stationary and time dependent mass, momentum and energy balances for various kinds of energy systems, 2. perform design tasks, utilize mathematical software in calculation, and analyze the characteristics of energy systems, 3. include material property definitions into mathematical software or into own code when simulating energy systems, 4. create, solve and analyze the set of stationary and time dependent balance equations using Excel and MATLAB, 5. create, solve and analyze stationary energy systems with IPSEpro software package, and 6. create, solve and analyze time dependent energy systems with APROS software package.
Electrical Power Transmission	The description of the electricity transmission system. Frequency and voltage control. Calculation of load flow, fault currents and stability in a meshed network. DC power transfer. Relay protection.	Upon completion of the course the student will be able to: 1. describe the operation principle of an electric power system, 2. explain and determine the principles of frequency and voltage control in an electric power system, including the special features of the Nordel system, 3. calculate the power flow and fault currents in meshed power transmission systems, 4. calculate the static and transient stability of a single generator, 5. describe the basic techniques and application targets of DC transmission, 6. explain the implementation principles of fault protection in a meshed power transmission network.
Electricity Market	The restructuring of the electricity markets, power exchange, electricity trade, balance management.	Upon completion of the course the student will be able to: 1. describe the characteristics of the different business sectors in the Nordic electricity market, 2. explain electricity price formation, 3. explain the operation principle of the power exchange, 4. identify and describe the products of the power exchange, 5. identify the risks and risk management methods in electricity trading, 6. describe the tasks of the different parties in an electric power system in maintaining technical and commercial power balance, including demand side management, 7. describe the motivations and principles of electricity market deregulation.

Energy and Society	The course focuses on societal, political, historical and cultural perspectives on energy systems development and ongoing energy transition. The course's approach to the energy systems is sociotechnical, which means that social processes and human agency shape technology and energy system as much as technology and energy system shape social processes and everyday modern way of living. The five approaches of the course are 1) energy systems as sociotechnical systems, 2) energy policy and actor groups, 3) historical approach to energy system change, 4) cultural framing of energy technology, 5) interplay of energy market entrants, energy prosumers and large energy companies. In addition, during the course students plan together with teacher an energy seminar on some of the most topical, ongoing energy discussion (e.g. geopolitics, energy conservation and efficiency, hydrogen economy, power-to-X)	Upon completion of the course the student will be able to: 1. perceive energy systems as sociotechnical systems 2. understand societal, political, historical and cultural aspects of energy system change 3. analyse how different actor groups such as corporate representatives, entrepreneurs, industry associations, politicians and media representatives influence ongoing energy transition 4. argument and write own perspectives as experts and engage with wider societal discussions on some aspects of energy
Energy Economics	Use of energy statistics. Profitability of energy projects. The variation in energy demand and duration curves. Energy markets. Environmental impacts in energy production, especially carbon dioxide emissions. Energy Union and Finland. Impact of emissions trading on electricity prices and energy tariffs. Energy taxation. Peat production and its effect in Finland. Climate and energy strategy. Fuel supply and economics. Energy vision 2050.	After completion of the course, students will be able to utilise energy economic calculation methods and to calculate the additional cost in the energy production costs caused by emission trading. Students will be able to describe the basic concepts of Finnish energy economics and explain the structure of energy taxation in Finland, and calculate the energy taxes of fuels. Students will understand the structure of energy tariffs and will be able to compile a duration curve of the consumption curve of energy.

Energy Efficiency	The course provides the student with an introduction to the significance and development potential of energy efficiency in energy production, transmission, distribution and end use. The focus is on electric energy and systems approach. The lecture topics are the efficiency of energy production processes, the efficiency of electricity transmission and distribution and the efficiency of energy end use. The course is arranged as a series of lectures delivered by experts. The lecture topics may vary from year to year.	Upon completion of the course the student will be able to: 1. determine actions for the energy efficiency of the energy conversion process, 2. estimate the overall energy efficiency of the energy conversion system, 3. identify applications of electric energy usage and apply methods that can be used to improve the energy efficiency.
Energy Resources	The course provides an overview on the availability of energy resources and related emissions and techno-economic maturity of related energy conversion technologies, which induces a fundamental structure for the future energy system and the related energy transition pathway. The course comprises the main energy resources for the current and future energy system: crude oil, natural gas, coal, uranium, hydropower, bioenergy, solar energy, wind energy, geothermal energy, and ocean energy. These energy resources have different theoretical, technical and economic potentials as well as geographic variations in availability. The resources also differ considerably in the impact of the emissions related to the respective energy conversion technologies being relevant for the degree of sustainability. A broad variety of energy conversion technologies at different levels of maturity are used for utilising the resources.	Upon completion of the course the student will be able to: 1. Identify the constraints and potentials of all relevant energy sources in a global context. 2. Describe all relevant energy conversion technologies on the basis of their energy resource. 3. Analyse the principal structure of future energy systems on the basis of energy resource characteristics. 4. Describe the special relevance of wind and solar energy in the ongoing energy transition.

Energy Systems Engineering	History and fundamentals of thermodynamics and energy engineering. Modern problems of power plant engineering. Combined heat and power production, especially from biomass. Fundamentals of steam and gas turbines in energy production. Engineering design: heat and mass balances in the design of small scale energy systems. Systems engineering. Planning and implementation of energy systems. Economic optimization of energy system projects.	Upon completion of the course the student will be able to 1. describe different types of energy production processes, 2. utilize thermodynamics and heat and mass balances in the design of small scale energy systems, 3. use a “Systems Engineering” type approach to define the design values for energy production processes, 4. define small scale bioenergy production projects, 5. understand how plant requirements affect the planning and implementation phases of small energy systems, and 6. define economic constraints to small scale energy processes.
Fluid Machinery	Axial and radial turbomachinery design, design of hydro turbines, design of wind turbines, fluid machinery operating maps, velocity triangles. The course is affiliated on the sustainability of energy systems and based on international scientific research.	Upon completion of the course the students are able 1. To choose a right type of fluid machinery for each application 2. To calculate velocity triangles for different machines 3. To make a preliminary design for different fluid machinery 4. To understand principles of flow theories behind design methodologies.
Power Exchange Game for Electricity Markets	Electricity purchase/sale, OTC markets, physical products on the power exchange (Elspot and Elbas), financial products on the power exchange (DS Futures and Futures), risk management.	Upon completion of the course the student will be able to: Plan electricity purchase and sale in an economically viable way, recognize the most common risk management instruments and basic mechanisms of demand response in electricity markets, and exploit financial products of the power exchange in risk management and trade electricity in day ahead and intraday markets. These skills will be practised in a power exchange game, after which the student will be able to analyse and interpret the game results.
Power Plant Design	Special features of different power plant types. Engineering design: planning and design of power plants and distributed energy systems, simulation and modelling. Implementation of power plant projects. Utilisation and control of power plants, emission reduction. Future energy systems.	Upon completion of the course the students will be able to 1. explain the advanced processes of thermal power plants (excl. nuclear energy), 2. describe the methods used for the reduction of emissions related to energy production, 3. estimate the impact of power plant control on the utilization economy and usability, 4. apply thermodynamics and mass and energy balances to improve the efficiency and the operation of the energy processes, 5. design power plant processes for the production of electricity and heat and select the appropriate auxiliary equipment, and 6. describe the phases in the implementation of power plant projects.

Renewable Energy Technology	The course is focused on the conversion of the resources to electricity. The RE technologies discussed in the course are: wind turbines, solar photovoltaics, solar thermal electricity generation and hydropower plants. The storage technologies covered comprise a general overview and in particular include battery storage, pumped hydro energy storage and Power-to-X technologies, including seawater reverse osmosis desalination. All technologies are classified with respect to their applications, efficiency, maturity, economics, industrial scaling and expected relevance for the ongoing energy transition.	Upon completion of the course the student will be able to: 1. Identify the major renewable energy (RE) conversion technologies, mainly converting resources to electricity. 2. Describe the major characteristics of the technologies, in particular applications, efficiency, economics, industrial scale and future prospects. 3. Analyse the need for storage and Power-to-X technologies and their different fields of application based on their key technical and economic features.

Courses 2nd year LUH

Course title	Course contents	Learning outcomes
Combustion Technology	• Fundamentals, types and spread of flames • Balance of amount of substance, mass and energy • Chemical kinetics • Ignition processes • Characteristic numbers • Calculation and model approaches • Emissions • Technical applications	This course conveys fundamentals of combustion technology and its applications. After successfully completing the course, students will be able to • differentiate between types of combustion and describe different types in detail, • make up the balance for combustion processes, • explain typical examples of applications for various types of combustion, • identify potentials for reducing emissions and to evaluate them.
Electrical Energy Storage	Electrical energy storage application areas and their associated business models, storage characteristics and applications,important storage technologies, operational behaviour of energy storages, basic energy storage operation concepts	This course imparts knowledge on the selection and application of electrical energy storage. Successfully completing the modules of this course provide: • an overview of important electrical energy storage application areas and their associated business models • the ability to calculate important parameters of storage characteristics and storage applications • knowledge of important storage technologies, explaining their function, and familiarity with their properties and fields of application • the ability to describe/explain the operational behaviour of energy storages based on a simulation model (Unified Energy Model) and how to effectively use the model to calculate storage application (using MS Excel) • an understanding of the basic energy storage operation concepts and the ability to formulate basic strategies for selected applications • an overview of the approaches for technology selection and dimensioning
Electrical Machines and Drives	The overview includes knowledge on construction, in-service behavior and control as well as application range and economic importance of these motors. The lecture is designed for developers of drive systems and for users of small electrical machines in order to support them in the choice of a motor in a specific case of operation	This lecture gives a basic overview of electrical machine types with special emphasis on small motors and servo drives with an output power smaller than 1 kW.

Electrical Machines for eAutomotive Traction Applications	Introduction, Lecture Overview, Organization, Emobility Market Development & Overview, Power & Torque Requirements for Passenger Cars, WLTC Cycle + Simlified Mass & Drag Model of an Vehicle, Power & Torque Requirements for Electrical Machines, Complex Numbers, PM Machine: Working Principle, Rotating Fields 1: Why m Phases, Rotating Fields 2: Why N Slots, Windings Basic Topologies: Slot / Pole Combinations, Deep Dive: Harmonics 1 & 2, PM Machine: Motor Assembly, PM Machine: Electromagnetic Design, PM Machine: Key Performance Data, Losses and Efficiency, PM Machine: Manufacturing & Costs, Current Excited Synchronous Machine: Working Principle, Current Excited Synchronous Machine: Permance & Efficiency; Tutorials	This course enables students to understand key requirements as well as design challenges for electrical machines in the context of the eautomotive market. Next to fundamentals and working principles of electrical machines, several design aspects, manufacturing techniques and product costs are covered. Basic and new technologies are presented and compared according to market demands
Electric Power Systems	Mathematical description of symmetrical and unsymmetrical three phase power systems. Transformation of unsymmetrical three phase power systems into three coupled single-phase systems using symmetrical components method. Getting to know of positive, negative and zero sequence equivalent circuits of generators, motors, mains networks, transformers, lines, reactors, capacitors. Getting to know measures for compensation and short circuit current limiting. Calculation of short circuits according to IEC 60909 and calculation of symmetrical and unsymmetrical line-to-ground faults and interruptions.	Students aquire an increase of their knowledge of the structure and the functions of electric power systems as well as of the individual electric devices. After successfully completing the module, students should be able: - to mathematically describe symmetrical and unsymmetrical three phase power systems and their electric devices - to apply the symmetrical components method to unsymmetrical three phase power systems - to describe, parameterise and apply the equivalent circuits of the positive, negative and zero sequence equivalent circuits of generators, motors, mains networks, transformers, lines, reactors, capacitors - to carry out short circuits calculation according to IEC 60909 - to apply the symmetrical components method tot he calculation of symmetrical and unsymmetrical line-to-ground faults and interruptions
Electrothermal Processing (Electrotechnology)	Principles of electrotechnologies, energy demand of electrothermal processing; advantages of electrothermal processing against fuel-fired processing; direct and indirect heating methods; fundamentals of direct and indirect heating; fundamentals and applications of direct and indirect resistance heating; fundamentals and applications of induction heating; fundamentals and applications of dielectric heating; calculation, simulation and design of induction heating installations; energy efficiency and CO2 aspects of electrothermal processing	Learning of fundamentals and applications of principles and the industrial use of electrotechnologies, training in calculation and design of electrothermal processes

Heavy-Duty Gas Turbines	The course consists of a weekly lecture and tutorial. To pass the course, students have to take part and evaluate a lab experiment during the semester. The content of the course includes: • ideal and real cycle processes • design and technical requirements for compressors • aerodynamics, cooling and vibration behaviour of turbines • strength and dynamic behaviour of rotor and casing • chemical basics of combustion, flame stability and flue gases • combustion chamber and burner design • electrical power conversion practical implementations in power plants	The aim of this course is to teach the basics of the design and construction of thermal flow-machines, using heavy-duty gas and steam turbines as an example. After completing the course, students should have a broad understanding of the multiple disciplines needed to design an efficient heavy-duty gas turbine: mechanics, thermodynamics, fluid dynamics, heat transfer, combustion technology, material sciences and electrical power conversion.
Power Electronics	Power Electronics for high efficient energy conversion, Applications, Components, Line-commutated converter, dc/dc-Converter, dc/ac-Converter	The lecture gives an introduction into the general topics of modern power electronics with a strong focus on the operation principle of power electronic circuits and their components. After participation, the students will be able to explain the basic characteristics of power semiconductors, design passive components for typical applications, calculate, and simulate converter stages. They will also be able to understand and characterize the interaction between one or multiple converters and the grid.