Curriculum for the Master of Science Programme in Energy Engineering

Aalborg University
2012

Version 1, September 2012

The programme is offered in: Aalborg

Preface:
Pursuant to Act 695 of June 22, 2011 on Universities (the University Act) with subsequent changes, the following curriculum for the Master of Science programme in Energy Engineering is stipulated. The programme also follows the Framework Provisions and the Examination Policies and Procedures for Faculty of Engineering and Science.

The Master of Science programme in Energy Engineering is a two-year education which contains in total 6 specialisations within the areas of thermal, electrical and mechatronic control engineering.

- Thermal Energy and Process Engineering
- Fuel Cells and Hydrogen Technology
- Wind Power Systems
- Power Electronics and Drives
- Electrical Power Systems and High Voltage Engineering
- Mechatronic Control Engineering

The programme gives a possibility to obtain advanced skills within areas as for instance bio-technology, efficient use of energy, renewables, control engineering and energy distribution technology.

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1. Legal Basis of the Curriculum, etc.

1.1 Basis in Ministerial Orders
The Master of Science programme in Energy Engineering is organised in accordance with the Ministry of Science, Technology and Innovation's Ministerial Order no. 814 of June 29, 2010 on Bachelor of Science and Master of Science Programmes at Universities (the Ministerial Order of the Study Programmes) and Ministerial Order no. 857 of July 1, 2010 on University Examinations (the Examination Order) with subsequent changes. Further reference is made to Ministerial Order no. 233 of March 24, 2011 (the Admission Order) and Ministerial Order no. 250 of March 15, 2007 (the Grading Scale Order) with subsequent changes.

1.2 Faculty Affiliation
The Master of Science programme falls under the Faculty of Engineering and Science, Aalborg University.

1.3 Board of Studies Affiliation
The Master of Science programme falls under the Board of Studies of Energy in the School of Engineering and Science

2. Admission, Degree Designation, Programme Duration and Competence Profile

2.1 Admission
Admission to the Master of Science programme in Energy Engineering requires a Bachelor's degree in Electrical Energy Engineering, Thermal Energy Engineering, Mechatronic Control Engineering, Power System Engineering, Mechanical Engineering or the like.

Students with another Bachelor's degree, upon application to the Board of Studies, will be admitted after a specific academic assessment if the applicant is deemed to have comparable educational prerequisites. The University can stipulate requirements concerning conducting additional exams prior to the start of study.

2.2 Degree Designation in Danish and English
The Master of Science programme entitles the graduate to the designation of one of the following titles:

- Civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i energiteknik med specialisering i termisk energi og processteknik. The English designation is: Master of Science (MSc) in Engineering (Energy Engineering with specialisation in Thermal Energy and Process Engineering).
- Civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i energiteknik med specialisering i brændselsceller og brintteknologi. The English designation is: Master of Science (MSc) in Engineering (Energy Engineering with specialisation in Fuel Cells and Hydrogen Technology).
- Civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i energiteknik med specialisering i vindmølleteknologi. The English designation is: Master of Science (MSc) in Engineering (Energy Engineering with specialisation in Wind Power Systems).
- Civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i energiteknik med specialisering i effektelektronik og elektriske drivsystemer. The English designation is: Master of Science (MSc) in Engineering (Energy Engineering with specialisation in Power Electronics and Drives).
- Civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i energiteknik med specialisering i elektriske anlæg og højspændingsteknik. The English designation is: Master of Science (MSc) in Engineering (Energy Engineering with specialisation in Electrical Power Systems and High Voltage Engineering).
- Civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i energiteknik med specialisering i mekatronisk reguleringsteknik. The English designation is: Master of Science (MSc) in Engineering (Energy Engineering with specialisation in Mechatronic Control Engineering).

2.3 The Programme's Specification in ECTS Credits
The Master of Science programme is a 2-year, research-based, full-time study program. The programme is set to 120 ECTS credits.

2.4 Competence Profile on the Diploma
The following competence profile will appear on the diploma:

> A graduate of the Master of Science programme has competencies acquired through an educational programme that has taken place in a research environment.
>
> The graduate of the Master of Science programme can perform highly qualified functions on the labour market on the basis of the educational program. Moreover, the graduate has prerequisites for research (a Ph.D. program). Compared to the Bachelor's degree, the graduate of the Master of Science programme has developed her/his academic knowledge and independence, so that the graduate can independently apply scientific theory and method in both an academic and occupational/professional environment.

2.5 Competence Profile of the Programme

The graduate of the Master of Science programme has the following qualifications:

Knowledge

- Has knowledge in one or more subject areas that, in selected areas within energy engineering, is based on the highest international research in a subject area
- Can understand and, on a scientific basis, reflect over subject area's related to energy engineering and identify scientific problems within that area
- Demonstrate an understanding of research work and be able to become a part of the research environment
- Demonstrate and insight into the implications of research work (research ethics)
- Has advances skills in control theory, simulation techniques and optimisation theories
- Have obtained knowledge and comprehension within innovation and entrepreneurship.

Besides that the different specialisations has the following knowledge:

- The specialisation in Thermal Energy and Process Engineering:
  - Advanced knowledge and comprehension within conversion, consumption and transport of energy and advanced thermal and fluid systems.
  - Understanding of the design, modelling and optimisation of energy systems used in various energy production applications
  - Understanding of the detailed operation, functionality and interactions between the various components of key thermal energy conversion technologies
  - Have detailed insight in system integration with respect to both system efficiency and control engineering aspects of energy systems
- The specialisation in Fuel Cells and Hydrogen technology:
  - Advanced knowledge and comprehension within fuel cells and hydrogen systems

- Understanding of the design, modelling and optimisation of energy systems used in various energy production applications involving fuel cell technology
- Comprehension of the detailed operation, functionality and interaction between the various components used in fuel cell- and hydrogen production systems

- The specialisation in Wind Power Systems:
  - Advanced knowledge and comprehension within the electrical area of wind turbine technology i.e. generators, converters, connection of wind turbines to the network grid and analysis of the systems under stationary and contingency situations.
- The specialisation in Power Electronics and Drives:
  - Advanced knowledge and comprehension within efficient usage of electrical energy, intelligent energy conversion using power electronic systems and electrical machines.
  - Understanding of the operation, function and interaction between various components and sub-systems used in power electronic converters, electric machines and adjustable-speed drives
  - Knowledge enabling the design, modelling, simulation and synthesis of power converter-based systems used for conversion of electric energy.
- The specialisation in Electrical Power Systems and High Voltage Engineering:
  - Advanced knowledge and comprehension within production, transmission, distribution and consumption of electric energy both under stationary and contingency situations and by using the newest technologies within the power systems.
  - Knowledge of how to apply test methods and systems for high voltage components (non-destructive) according to applicable standards. This includes testing for electromagnetic compability.
- The specialisation in Mechatronic Control Engineering:
  - Advanced knowledge and comprehension within control engineering and understanding of the synergistic aspects in systems combining mechanical, thermal, electric and control technologies in the design process of mechatronic systems.
  - Understanding of the importance of physical and mathematical modelling in mechatronic system design
  - Understanding of more advanced control techniques, e.g. cascade control, sliding mode control, adaptive control and feedback linearization.

Skills

- Excels in the subject area's(s') scientific methods and tools and general skills related to employment within the subjects of energy engineering
- Can evaluate and select among the subject area's(s') scientific theories, methods, tools and general skills and, on a scientific basis, advance new analyses and solutions
- Can communicate research-based knowledge and discuss professional and scientific problems with both peers and non-specialists
- Have obtained skills which are related to the employment area with energy engineering
- Can use advanced laboratory test set ups and data collection methods.

Besides that the different specialisations has the following skills:

- The specialisation in Thermal Energy and Process Engineering:
  - The ability to develop, construct and operate thermal energy conversion technologies in the laboratory and in real applications
- The specialisation in Fuel Cells and Hydrogen technology:
  - The ability to construct and operate fuel cell based technologies in the laboratory and in real applications
  - Analytical skills in system integration with respect to system efficiency and control engineering aspects of fuel cell energy systems
- The specialisation in Wind Power Systems:
  - The ability to analyze the dynamic behaviour of wind turbine systems when they are connected to a power system with varying loads
  - The ability to analyse the load flow in wind power systems, including reactive power flow and the ability to analyze the stability in wind power systems
  - The ability to analyze the power quality of the system and to determine the need for power compensation
  - The ability to synthesise control systems for different types of wind turbine systems and to analyze the power electronic interface between wind turbines and grids
- The specialisation in Power Electronics and Drives:
  - Experience in the design of controllers for power electronic drive systems using classical and modern control theory
  - Experience with the practical implementation of controllers using for example digital signal processors
  - The ability to develop, construct, operate and test power electronic converters and drives in the laboratory.
- The specialisation in Electrical Power Systems and High Voltage Engineering:
  - The ability to apply different methods of analysis and synthesis for design and simulation of various electrical energy systems
  - The ability to apply different control and surveillance systems for control of the network grid. This will include power system protection and the application of power electronic compensation units.
- The specialisation in Mechatronic Control Engineering:
  - The ability to use a microcontroller or DSP as a mechatronic system component
  - The ability to apply different methods of analysis and synthesis for design and simulation of various mechatronic systems

Competence

- Can manage work and development situations that are complex, unpredictable and require new solutions within the area of energy

engineering.

- Can independently initiate and implement discipline-specific and interdisciplinary cooperation and assume professional responsibility.
- Can independently take responsibility for own professional development and specialisation
- *At the end of the MSc programme the student has achieved advanced professional competence in production, distribution and the usage of electrical, thermal and /or mechanical energy together with design, control and optimisation of energy or mechatronic systems.*
- *The competence should advance the students ability to perform functions within planning, development, counselling and research in Danish as well as international industries or public institutions. Examples could be research and development sections or leaderships in energy supply companies, the wind-, machine-, or process industry together with electro-technical- and counselling companies, etc.*

3. Content and Organisation of the Programme

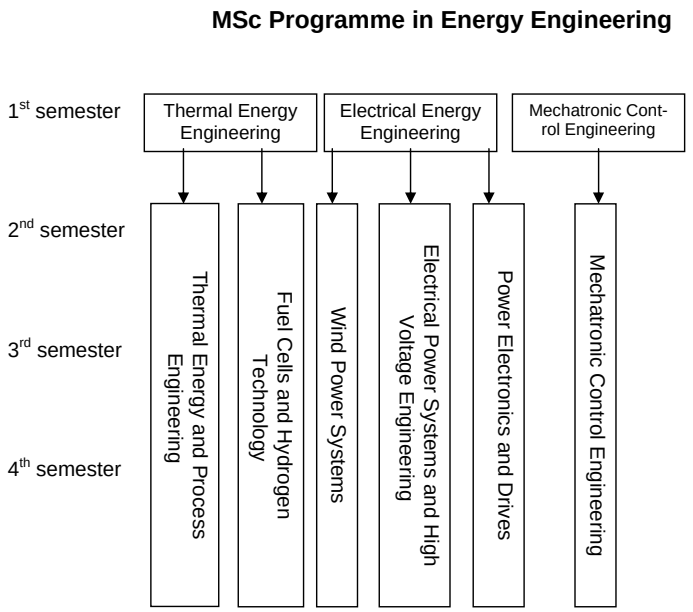
The programme is structured in modules and organised as a problem-based study. A module is a programme element or a group of programme elements, which aims to give students a set of professional skills within a fixed time frame specified in ECTS credits, and concluding with one or more examinations within specific exam periods that are defined in the curriculum.

The programme is based on a combination of academic, problem-oriented and interdisciplinary approaches and organized based on the following types of instruction that combine skills and reflection:

- lectures
- project work
- workshops
- exercises (individually and in groups)
- feedback
- study circle
- self-study

1st to 4th semesters of the programmes are taught in English and projects are to be written in English. However, the programme can be taught in Danish if no international students are enrolled.

The structure of the MSc study programme is shown in the following figure



Overview of the programme:
All modules are assessed through individual grading according to the 7-point scale or Pass/Fail. All modules are assessed by external examination (external grading) or internal examination (internal grading or by assessment by the supervisor only).

MSc in Thermal Energy and Process Engineering					
Semester	Code	Module	ECTS	Assessment	Exam
1st	M1-1	Thermo-mechanical Analysis Methods	15 (10*)	7-point scale	Internal
	M1-7	Combustion Technology and Chemical Reactors	5	7-point scale	Internal
	M1-8	Fluid Mechanics and CFD	5	7-point scale	Internal
	M1-12	Probability Theory, Statistics and English	5	7-point scale	Internal
	M1-13	Problem-based Learning, MATLAB and Control Theory*	5	7-point scale	Internal
2nd	M2-1	Modelling and Optimisation of Energy Systems	15	7-point scale	External
	M2-7	Aerodynamics and Flow	5	7-point scale	Internal
	M2-8	Design and Modelling of Thermal Systems and Fuel Processing	5	7-point scale	Internal
	M2-13	Optimisation Theory and Stochastic Processes	5	7-point scale	Internal
3rd	M3-1	Optimisation, Diagnosis and Control of Thermal Energy and Processing Systems	20	7-point scale	Internal
		Elective Courses	10**	7-point scale	Internal
		Internship (projektorienteret forløb i en virksomhed)	30	7-point scale	internal

4th	M4-1	Master's Thesis (possibly 50 ECTS)	30	7-point scale	External
Total			120		

* For international students
** Courses on 3rd semester are elective and the student must choose 10 ECTS course credits from the following course list http://www.en.ses.aau.dk/Study+Boards/Energy/Curriculum+and+rules/Alternative+courses.

MSc in Fuel Cells and Hydrogen Technology					
Semester	Code	Module	ECTS	Assessment	Exam
1st	M1-1	Thermo-mechanical Analysis Methods	15 (10*)	7-point scale	Internal
	M1-7	Combustion Ttechnology and Chemical Reactors	5	7-point scale	Internal
	M1-8	Fluid Mechanics and CFD	5	7-point scale	Internal
	M1-12	Probability Theory, Statistics and English	5	7-point scale	Internal
	M1-13	Problem-based Learning, MATLAB and Control Theory*	5	7-point scale	Internal
2nd	M2-2	Modelling and Optimisation of Fuel Cell Systems	15	7-point scale	External
	M2-7	Aerodynamics and Flow	5	7-point scale	Internal
	M2-8	Design and Modelling of Thermal Systems and Fuel Processing	5	7-point scale	Internal
	M2-13	Optimisation Theory and Stochastic Processes	5	7-point scale	Internal
3rd	M3-2	Optimisation, Diagnosis and Control of Fuel Cell and Hydrogen Technology Systems.	20	7-point scale	Internal
		Elective Courses	10**	7-point scale	Internal
		Internship (projektorienteret forløb i en virksomhed)	30	7-point scale	Internal
4th	M4-2	Master's Tthesis (possibly 50 ECTS)	30	7-point scale	External
Total			120		

* For international students
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MSc in Wind Power Systems					
Semester	Code	Module	ECTS	Assessment	Exam
1st	M1-2	Dynamics in Electrical Energy Engineering	15 (10*)	7-point scale	Internal
	M1-9	Dynamical Models of Electrical Machines and Control Systems	5	7-point scale	Internal
	M1-10	High Voltage Engineering and Design of Switch Mode Converters	5	7-point scale	Internal
	M1-12	Probability Theory, Statistics and English	5	7-point scale	Internal
	M1-13	Problem-based Learning, MATLAB and Control Theory*	5	7-point scale	Internal
2nd	M2-3	Interaction Between Generation and Load	15	7-point scale	External
	M2-9	Advanced Course in Electrical Power Systems	5	7-point scale	Internal
	M2-12	High power Converters, Devices and EMI/EMC	5	7-point scale	Internal
	M2-13	Optimisation Theory and Stochastic Processes	5	7-point scale	Internal
3rd	M3-3	Optimisation, Diagnosis and Control of Electrical Conditions in Wind Turbines and Wind Farms	20	7-ponit scale	Internal
		Elective Courses	10**	7-point scale	Internal
		Internship (projektorienteret forløb i en virksomhed)	30	7-point scale	Internal

4th	M4-3	Master's Thesis (possibly 50 ECTS)	30	7-point scale	External
Total			120		

* For international students
** Courses on 3rd semester are elective and the student must choose 10 ECTS course credits from the following course list http://www.en.ses.aau.dk/Study+Boards/Energy/Curriculum+and+rules/Alternative+courses.

MSc in Power Electronics and Drives					
Semester	Code	Module	ECTS	Assessment	Exam
1st	M1-2	Dynamics in Electrical Energy Engineering	15 (10*)	7-point scale	Internal
	M1-9	Dynamical Models of Electrical Machines and Control Systems	5	7-point scale	Internal
	M1-10	High Voltage Engineering and Design of Switch Mode Converters	5	7-point scale	Internal
	M1-12	Probability Theory, Statistics and English	5	7-point scale	Internal
	M1-13	Problem-based Learning, MATLAB and Control Theory*	5	7-point scale	Internal
2nd	M2-4	Control of Converter-fed AC Drives	15	7-point scale	External
	M2-10	Control of Electrical Drive Systems and Converters	5	7-point scale	Internal
	M2-12	High Power Converters, Devices and EMI/EMC	5	7-point scale	Internal
	M2-13	Optimisation Theory and Stochastic Processes	5	7-point scale	Internal
3rd	M3-4	Optimisation, Diagnosis and Control of Power Electronic Drives or Converters	20	7-ponit scale	Internal
		Elective Courses	10**	7-point scale	Internal
		Internship (projektorienteret forløb i en virksomhed)	30	7-point scale	Internal
4th	M4-4	Master's Thesis (possibly 50 ECTS)	30	7-point scale	External
Total			120		

* For international students
** Courses on 3rd semester are elective and the student must choose 10 ECTS course credits from the following course list http://www.en.ses.aau.dk/Study+Boards/Energy/Curriculum+and+rules/Alternative+courses.

MSc in Electrical Power Systems and High Voltage Engineering					
Semester	Code	Module	ECTS	Assessment	Exam
1st	M1-2	Dynamics in Electrical Energy Engineering	15 (10*)	7-point scale	Internal
	M1-9	Dynamical Models of Electrical Machines and Control Systems	5	7-point scale	Internal
	M1-10	High Voltage Engineering and Design of Switch Mode Converters	5	7-point scale	Internal
	M1-12	Probability Theory, Statistics and English	5	7-point scale	Internal
	M1-13	Problem-based Learning, MATLAB and Control Theory*	5	7-point scale	Internal
2nd	M2-5	Control and Surveillance of Electrical Power Systems	15	7-point scale	External
	M2-9	Advanced Course in Electrical Power Systems	5	7-point scale	Internal
	M2-12	High Power Converters, Devices and EMI/EMC	5	7-point scale	Internal
	M2-13	Optimisation Theory and Stochastic Processes	5	7-point scale	Internal
3rd	M3-5	Optimisation, Diagnosis and Control of Electrical Power Systems and High Voltage Systems	20	7-ponit scale	Internal
		Elective Courses	10**	7-point scale	Internal
		Internship (projektorienteret forløb i en virk-	30	7-point scale	Internal

		somhed)			
4th	M4-5	Master's Thesis (possibly 50 ECTS)	30	7-point scale	External
Total			120		

* For international students
** Courses on 3rd semester are elective and the student must choose 10 ECTS course credits from the following course list http://www.en.ses.aau.dk/Study+Boards/Energy/Curriculum+and+rules/Alternative+courses.

MSc in Mechatronic Control Engineering					
Semester	Code	Module	ECTS	Assessment	Exam
1st	M1-3	Control of Hydraulic Actuated Mechanical System	15 (10*)	7-point scale	Internal
	M1-9	Dynamical Models of Electrical Machines and Control Systems	5	7-point scale	Internal
	M1-11	Hydraulic and Mechanical Systems and Power Electronic Modelling	5	7-point scale	Internal
	M1-12	Probability Theory, Statistics and English	5	7-point scale	Internal
	M1-13	Problem-based Learning, MATLAB and Control Theory*	5	7-point scale	Internal
2nd	M2-6	Advanced Control of Electrical Machines	15	7-point scale	External
	M2-10	Control of Electrical Drive Systems and Converters	5	7-point scale	Internal
	M2-11	Multi Variable and Non-linear Control Methods	5	7-point scale	Internal
	M2-13	Optimisation Theory and Stochastic Processes	5	7-point scale	Internal
3rd	M3-6	Optimisation, Diagnosis and Control in Mechatronic Systems	20	7-ponit scale	Internal
		Elective Courses	10**	7-point scale	Internal
		Internship (projektorienteret forløb i en virksomhed)	30	7-point scale	Internal
4th	M4-6	Master's Thesis (possibly 50 ECTS)	30	7-point scale	External
Total			120		

* For international students
** Courses on 3rd semester are elective and the student must choose 10 ECTS course credits from the following course list http://www.en.ses.aau.dk/Study+Boards/Energy/Curriculum+and+rules/Alternative+courses.

3.1 Module Descriptions of 1st Semester

Background:
The objective of the 1st semester at the Master of Science programme in Energy Engineering is to prepare the students to follow one of the six specialisations offered:

- Thermal Energy and Process Engineering
- Fuel Cells and Hydrogen Technology
- Wind Power Systems
- Power Electronics and Drives
- Electrical Power Systems and High Voltage Engineering
- Mechatronic Control Engineering

To qualify for the 1st semester of the Master of Science programme in Energy Engineering, 5 routes are approved for students who have followed the Bachelor Education in Energy Engineering at Aalborg University:

- Electrical Energy Engineering (Aalborg Campus)
- Thermal Energy Engineering (Aalborg Campus)
- Mechatronic Control Engineering (Aalborg Campus)
- Thermal Processes (Esbjerg Campus)
- Dynamic Systems (Esbjerg Campus)

For international students an introductory 1st semester is mandatory, in which a basic course is taught to familiarize the students with problem based learning, besides the engineering courses belonging to the specialisation.

Content:
For all students:
1st semester contains engineering subjects (courses and project work) in the area of the chosen specialisation.

For students with a Bachelor of Science degree from Aalborg University
The students are required to acquire knowledge about scientific English and the project work will be documented by a scientific paper, a poster and a presentation at al conference, all in English.

For students with a Bachelor of Science degree from another university
Here the focus is on the problem-based, project-organized learning method used at Aalborg University. The students will write a project report documenting their project work.

3.1. a Project on 1st Semester Thermal Energy Engineering Specialisations
Common for students with a Bachelor of Science degree from Aalborg University heading for specialisations in Thermal Energy and Process Engineering and Fuel Cells and Hydrogen Technology

Title:
M1-1 Thermo-Mechanical Analysis Methods / Termo-mekaniske analysemetoder

Prerequisites:
Bachelor of Science in Energy Engineering with specialisation in Thermal Energy Engineering or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge
- Have comprehension of the basis for both the analytical and more especially the numerical analysis methodology for flow and thermal transmission, around or within simplified components. These components are considered as integral parts of energy machinery and devices.
- Have knowledge and comprehension for scientific English

Skills:
- Be able to verify analytical and numerical approaches by means of simple laboratory experiments.
- Be able to use methods for documenting the project work as a scientific paper and poster

Competence

- Be able to control the working and development process within the project theme, and be able to develop new solutions within thermo-mechanical analysis methods
- Independently be able to define and analyse scientific problems within the area of thermo-mechanical methods, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem-based project-oriented project work in groups of up to 6 persons.

The project should be based upon a thermal/fluid problem. The problem can be regarded as a process, or a typical thermal engineering component, which when applied or is in use is exposed to thermal and/or fluid mechanical effects, which are of a stationary or a transient nature.

The purpose of the project investigation may be either to study the stress and strain conditions provoked, or to study the requirements of design, which cannot necessarily be calculated with certainty in advance. A calculation should be made based on numerical methods in order to investigate separate parameter variations. An optimum design of the component should be obtained.

The calculations should be verified by laboratory experiments. The validity of any assumptions made should be checked.

The project must be documented as described in "Guidance for the Project of 1st semester of Master of Science in Energy Engineering" (sec. 3.1.d).

Examination format:
Oral examination with internal adjudicator as given in the Framework Provisions. The exam will be based on the documentation submitted and the rules in "Guidance for the Project of 1st Semester of Master of Science in Energy Engineering" (sec. 3.1.d).

Evaluation criteria:
As stated in the Framework Provisions

3.1.b Project on 1st Semester Electrical Energy Engineering specialisations
Common for students with a Bachelor of Science degree from Aalborg University heading for the specialisations in Electrical Power Systems and High Voltage Engineering (EPSH), Power Electronics and Drives (PED) and Wind Power Systems (WPS)

Title:
M1-2 Dynamics in Electrical Energy Engineering / Dynamik i elektriske energisystemer

Prerequisites:
Bachelor of Science in Energy Engineering with specialisation in Electrical Energy Engineering or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge

- Have knowledge and comprehension of dynamics in electrical energy engineering systems or apparatus.
- Have knowledge and comprehension of scientific English

Skills:

- Be able to analyse the dynamic behaviour of electrical energy systems or apparatus within the area of Electrical power systems, electrical drive systems or in wind power systems
- Be able to make models and simulate such dynamic systems
- Be able to use methods for documenting the project work as a scientific paper and poster
- Be able to verify the models and the simulations by measurement in the laboratory or from existing data.

Competence

- Be able to control the working and development process within the project theme, and be able to develop new solutions within the area of dynamics in electrical energy engineering.
- Independently be able to define and analyse scientific problems within the area of dynamics in electrical energy engineering, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project oriented project work in groups of up to 6 persons.

The project is based on a problem where the dynamics of an electrical energy system or an electrical apparatus has to be analyzed. The problem can be within the area of:

- Electrical power systems
- Electrical drive systems
- Wind power systems

where for instance short circuits, starting procedures, control issues etc. demands that the dynamics of the systems have to be taken into account.

The system or apparatus is analysed and modelled and has to be simulated in an appropriate simulation tool.

Verification of the models and the simulations are done by measurement in the laboratory or from existing data.

The project must be documented as described in "Guidance for the Project of 1st semester of Master of Science in Energy Engineering" (sec. 3.1.d).

Examination format:
Oral examination with internal adjudicator as given in the Framework Provisions. The exam will be based on the documentation submitted and the rules in "Guidance for the Project of 1st Semester of Master of Science in Energy Engineering" (sec. 3.1.d).

Evaluation criteria:
As stated in the Framework Provisions

3.1.c Project on 1st Semester Mechatronic Control Engineering
Common for students with a Bachelor of Science degree from Aalborg University

Title:

M1-3 Control of Hydraulic Actuated Mechanical Structure / Styring og regulering af hydraulisk aktueret mekanisk system

Prerequisites:
Bachelor of Science in Energy Engineering with specialisation in Mechatronic Control Engineering or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge

- Have knowledge about mechanical structures with complex dynamics and elements with non-linear behaviour.
- Have knowledge and comprehension for scientific English

Skills:

- Be able to apply identification methods for determining system dynamics, when system information is not available.
- Be able to apply the fundamental aspects of non-linear control theory and enable him/her to utilise the available system information to apply selected non-linear control methods on the considered system.
- Be able to use methods for documenting the project work as a scientific paper and poster
- Be able to verify the models and the simulations by measurement in the laboratory or from existing data.

Competence

- Be able to control the working and development process within the project theme, and be able to develop new solutions within the area of control of hydraulic actuated mechanical structures.
- Independently be able to define and analyse scientific problems within the area of control of hydraulic actuated mechanical structures, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project oriented project work in groups of up to 6 persons.

The project takes its base in a hydraulically actuated mechanical system, which is to be controlled as a feedback system.

Models of both the mechanical structure and the actuation system are made and system identification methods should be used for critical parts where no component/system information is available. The models or critical parts hereof should be experimentally verified to show the validity of the models.

Based on the developed models one or more selected non-linear control methods should be used to develop a control algorithm for the system, which should be implemented and verified experimentally and the results should be compared to what may be obtained with standard linear controllers.

The project must be documented as described in "Guidance for the Project of 1st semester of Master of Science in Energy Engineering" (sec. 3.1.d).

Examination format:
Oral examination with internal adjudicator as given in the Framework Provisions. The exam will be based on the documentation submitted and the rules in "Guidance for the Project of 1st Semester of Master of Science in Energy Engineering" (sec. 3.1.d).

Evaluation criteria:
As stated in the Framework Provisions

3.1.d Guidance for the Project of 1st Semester Master of Science in Energy Engineering
(For students with a Bachelor of Science degree from Aalborg University) (not INTRO)
Vejledning for projektet på 1. semester af Kandidatuddannelsen i Energiteknik
(For studerende med en bachelor fra Aalborg Universitet) (ikke INTRO)

1. Demands to the project documentation
The project should fulfil the objectives of the 1st semester and should be documented to an acceptable technical and scientific level. The documentation should include a scientific paper and a poster, which should fulfil the standard for an international conference, e.g. the IEEE specifications. Moreover, the documentation should include an appendix report - see below.

2. Project documentation
The following material, paper and electronic versions, must be submitted to the study secretary on the date given for the project submission:

- Scientific paper, max. 10 pages, which presents the primary content and results of the project work
- Appendix report (see below)
- Project poster (a paper version only)

The paper will be presented, by one or more group members, at a conference arranged within the Department of Energy Technology. The conference will be run in the same manner as an international conference. The project poster will be presented under this conference.

3. Appendix report
The appendix report should elaborate the project details and conclusions.

The purpose of the appendix report is to:

- give the supervisor the possibility of guiding the students with regard to how the scientific work is documented during the project process
- force the students to show a higher degree of responsibility for the process of documenting the on-going work. The focus here is NOT on the aesthetics and layout quality, but on its **correctness, its reliability and the information content**
- give the supervisor and the examiner the possibility of evaluating elements, which are omitted in the paper and poster

The pages of the appendix report should be numbered. A list of contents should also be included.

4. Project exam
The project evaluation will normally take place at a later date than the conference.

The project group should present its project work in accordance to the Examination Policies and Procedures, Addendum to the Framework Provision at The Faculties of Engineering.

The presentation and assessment of the project will be conducted in English.

3.1.e Project on 1st INTRO Semester of Thermal Energy Engineering Specialisations
Common for students with a Bachelor of Science degree from another university than Aalborg University heading for specialisations in Thermal Energy and Process Engineering and Fuel Cells and Hydrogen Technology

Title:
M1-4 Problem-based Project-organised Learning in Thermo-Mechanical Analysis Methods / Problemebaseret projektorganiseret læring i termo-mekaniske analysemetoder

Prerequisites:
Bachelor of Science in Energy Engineering with specialisation in Thermal Energy Engineering or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge
- Have knowledge and comprehension of the problem-based learning methods, as it is applied at Aalborg University
- Have knowledge and analytical skills within project work in connection with problems in the areas of combustion engineering
- Have comprehension of the basis for both the analytical and more especially the numerical analysis methodology for flow and thermal transmission, around or within simplified components. These components are considered as integral parts of energy machinery and devices

Skills:
- Be able to verify analytical and numerical approaches by means of simple laboratory experiments

Competence
- Be able to control the working and development process within the project theme, and be able to develop new solutions within thermo-mechanical analysis methods
- Independently be able to define and analyse scientific problems within the area of thermo-mechanical methods, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project oriented project work in groups of up to 6 persons.

The project should be based upon a thermal/fluid problem. The problem can be regarded as a process, or a typical thermal engineering component, which when applied or is in use is exposed to thermal and/or fluid mechanical effects, which are of a stationary or a transient nature.

The purpose of the project investigation may be either to study the stress and strain conditions provoked, or to study the requirements of design, which cannot necessarily be calculated with certainty in advance.

A calculation should be made based on numerical methods in order to investigate separate parameter variations. An optimum design of the component should be obtained.

The calculations should be verified by laboratory experiments. The validity of any assumptions made should be checked.

Exam format:
Individual oral examination with internal adjudicator in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

The assessment of the INTRO semester project is a stop-test. It is a precondition that this project is passed to be able to continue on the 2nd semester of the Master of Science study.

Evaluation criteria:
As stated in the Framework Provisions

3.1.f Project on 1st INTRO Semester of Electrical Energy Engineering Specialisations
Common for students with a Bachelor of Science degree from another university than Aalborg University heading for the specialisations in Electrical Power Systems and High Voltage Engineering (EPSH), Power Electronics and Drives (PED) and Wind Power Systems (WPS)

Title:
M1-5 Problem-based Project-organised Learning in Dynamics in Electrical Energy Engineering / Problemebasert projektorganiseret læring i dynamik i elektriske energisystemer

Prerequisites:
Bachelor of Science in Energy Engineering with specialisation in Electrical Energy Engineering or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge
- Have knowledge and comprehension of the problem-based learning methods, as it is applied at Aalborg University
- Have knowledge and analytical skills within project work in connection with problems in the areas of combustion engineering
- Have knowledge and comprehension of dynamics in electrical energy engineering systems or apparatus.

Skills
- Be able to analyse the dynamic behaviour of electrical energy systems or apparatus within the area of Electrical power systems, electrical drive systems or in wind power systems
- Be able to make models and simulate such dynamic systems
- Be able to verify the models and the simulations by measurement in the laboratory or from existing data.

Competence
- Be able to control the working and development process within the project theme, and be able to develop new solutions within the area of dynamics in electrical energy engineering.
- Independently be able to define and analyse scientific problems within the area of dynamics in electrical energy engineering, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation

Type of instruction:

Problem based project oriented project work in groups of up to 6 persons.

The project is based on a problem where the dynamics of an electrical energy system or an electrical apparatus has to be analyzed. The problem can be within the area of:

- Electrical power systems
- Electrical drive systems
- Wind power systems

where, for instance, short circuits, starting procedures, control issues etc. demands, that the dynamics of the systems have to be taken into account.

The system or apparatus is analysed and modelled and has to be simulated in an appropriate simulation tool.

Verification of the models and the simulations are done by measurement in the laboratory or from existing data.

Examination format:
Oral examination with internal adjudicator in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

The assessment of the INTRO semester project is a stop-test. It is a precondition that this project is passed to be able to continue on the 2nd semester of the Master of Science study.

Evaluation criteria:
As stated in the Framework Provisions

3.1.g Project on 1st INTRO Semester of Mechatronic Control Engineering
Common for students with a Bachelor of Science degree from another university than Aalborg University

Title:
M1-6 Problem-based Project-organized Learning in Control of Hydraulic Actuated Mechanical Structure / Problemebaseret projektorganiseret læring i styring og regulering af hydraulisk aktueret mekanisk system

Prerequisites:
Bachelor of Science in Energy Engineering with specialisation in Mechatronic Control Engineering or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge
- Have knowledge and comprehension of the problem-based learning methods, as it is applied at Aalborg University
- Have knowledge and analytical skills within project work in connection with problems in the areas of combustion engineering
- Have knowledge about mechanical structures with complex dynamics and elements with non-linear behaviour.

Skills
- Be able to apply identification methods for determining system dynamics, when system information is not available.
- Be able to apply the fundamental aspects of non-linear control theory and enable him/her to utilise the available system information to apply selected non-linear control methods on the considered system.
- Be able to verify the models and the simulations by measurement in the laboratory or from existing data.

Competence
- Be able to control the working and development process within the project theme, and be able to develop new solutions within the area of control of hydraulic actuated mechanical structures.
- Independently be able to define and analyse scientific problems within the area of control of hydraulic actuated mechanical structures, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project oriented project work in groups of up to 6 persons.

The project takes its base in a hydraulically actuated mechanical system, which is to be controlled as a feedback system.

Models of both the mechanical structure and the actuation system are made and system identification methods should be used for critical parts where no component/system information is available. The models or critical parts hereof should be experimentally verified to show the validity of the models.

Based on the developed models one or more selected non-linear control methods should be used to develop a control algorithm for the system, which should be implemented and verified experimentally and the results should be compared to what may be obtained with standard linear controllers.

Examination format:
Oral examination with internal adjudicator in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

The assessment of the INTRO semester project is a stop-test. It is a precondition that this project is passed to be able to continue on the 2nd semester of the Master of Science study.

Evaluation criteria:
As stated in the Framework Provisions

3.1.h Course Module on 1st Semester: Combustion Technology and Chemical Reactors

Title:
M1-7 Combustion Technology and Chemical Reactors / Forbrændingsteknik og kemiske reaktorer

Prerequisites:
Participants require a background corresponding to participation and successful completion of the courses given in thermal and fluid dynamical systems and heat transfer during the bachelor studies in Energy Engineering given at Department of Energy Technology at Aalborg University.

Objective:
Students who complete the module should:

Knowledge:
- Have knowledge about the technologies used within emission control and how chemical kinetics influences combustion processes
- Understand the analytical methods used in the analysis of combustion flames
- Understand the analytical methods used in processes involving simultaneous heat and mass transfer
- Understand the terminologies and notations used in fundamental chemical reactor analysis.
- Understand how mixing affects the conversion in actual chemical reactors
- Understand how catalysts are practically arranged and supported in various types of chemical reactors and understand how this affects the overall performance parameters

Skills:
- Be able to use software used in combustion analysis
- Be able to calculate chemical compositions arising from kinetically controlled chemical reactions considering chemical mechanisms and the Arrhenius equation
- Understand the analytical methods used in the analysis of combustion flames
- Be able to design fundamental emission control systems considering desulphurization and De-Nox by mechanical means, additives or Re-burning
- Be able to design and model the fundamental classes of chemical reactors, i.e. plug flow reactors, constantly stirred reactors and batch reactors with one and multiply simultaneous reactions considering chemical kinetics in one and multiple dimensions, isothermally or non-isothermally as well as in steady and unsteady operation
- Be able to calculate mass convection and diffusion and perform fundamental analysis on processes involving combined heat and mass transfer processes
- Be able to estimate the mass transport in porous materials

Competenc:
- Have the ability to apply and integrate the topics in an interdisciplinary correspondence with other related disciplines.
- Be able to understand the assumptions of the fundamental design of chemical reactors and combined heat and mass transfer.

Type of instruction:
Lectures supplied with independent studies.

Exam format:
Mini project and mandatory assignments with individually handed-in solutions in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions.

3.1.i Course Module on 1st Semester: Dynamical Models of Electrical Machines and Control Systems

Title:
M1-9 Dynamical Models of Electrical Machines and Control Systems / Dynamiske modeller for elektriske maskiner og regulering

Prerequisites:

A relevant Bachelor's degree

Objective:
Students who complete the module should:

Knowledge:
- Be able to comprehend dynamic models of the transformer, the synchronous machine and the induction machine
- Know about the limitations for a dynamic model of an electrical machine
- Comprehend techniques for scalar variable-speed control of induction machines
- Know about implementation of controllers for variable-speed AC-drives
- Know about basic non-linear control theory

Skill and Competence:
- Independently be able to define and analyse scientific problems involving a dynamic model of an electrical machine
- Be able to analyse and design scalar controllers for electrical drives
- Be able to use basic mathematical tools for analyzing the response and stability of non-linear systems
- Be able to apply selected non-linear control methods

Type of instruction:
The course will be taught by a mixture of lectures, workshops, exercises, mini-projects and self-study.

Exam format:
Written examination in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions.

3.1.j Course Module on 1st Semester: Fluid Mechanics and CFD

Title:
M1-8 Fluid Mechanics and CFD / Strømningslære og CFD

Prerequisites:
Introduction to Mechanics and Thermodynamics 2nd semester at B.Sc or similar
Fundamental thermal course 3rd semester at B.Sc or similar

Objectives:
Students who complete the module should:

Knowledge:
- Have knowledge about fluid kinematics
- Have knowledge about stresses in fluids, equation of motion, constitutive models and Navier-Stokes equations
- Have knowledge about ideal fluids and potential flows, including application of potential theory to simple problems
- Have knowledge and understanding of Reynolds averaging and turbulence models
- Be able to describe turbulent and laminar boundary layers including understanding of momentum equation for boundary layers
- Have knowledge of experimental methods used with fluid flows

- Have knowledge about numerical methods in fluid mechanics.
- Have knowledge about the finite volume method of computational fluid dynamics
- Have knowledge about mesh types and boundary conditions

Skills:
- Be able to describe assumptions and limitations of mathematical models for different types of flows
- Be able to determine and apply appropriate experimental methods to fluid flows
- Be able to apply appropriate analytical, semi-empirical and numerical methods for mathematical description of fluid dynamic problems
- Be able to evaluate results from such methods

Competence:
- Be able to apply proper terminology in oral, written and graphical communication and documentation within fluid dynamics
- Be able to apply the topic of the module in multi-disciplinary contexts

Type of instruction:
Lectures supplemented by self study and study groups

Exam format:
The module will be examined through a mini project (max 10 pages). This mini project will be related to the study programme of the individual student. A fluid mechanical problem will be analyzed, and the results presented according to the topics of the module. The report is supported by a short presentation (max 10 minutes).

Evaluation criteria:
As stated in the Framework Provisions.

3.1.k Course Module on 1st Semester: High Voltage Engineering and Design of Switch Mode Converters

Title:
M1-10 High Voltage Engineering and Design of Switch Mode Converters / Højspændingsteknik og design af strømforsyninger

Prerequisites:
Completed and passed Bachelors in Electrical Energy Engineering or similar

Objective:
Students who complete the module should:

Knowledge:
- Have knowledge and comprehension in the following areas:
    - Fundamentals of High Voltage Engineering
    - Generation and measurement of High AC, DC and impulse voltages
    - Non-destructive test methods in HV engineering
    - Fundamental Electrostatic field stress and dielectric breakdown
    - Fundamentals of switch mode DC/DC power supplies
    - DC/DC converter topologies and their models
    - Voltage and current mode control

Skills:
- Be able to apply theories and laboratory experiments to describe generation and measurement of high AC, DC and impulse voltages for testing HV equipment

- Be able to apply theories and laboratory experiments to describe non-destructive test methods for evaluating the quality and lifetime of dielectrics
- Be able to analyze and model switch mode converters losses and derive transfer functions
- Be able to design filters and controllers for switch mode converters
- The student will further gain skills within the areas of:
    - *Fundamentals of High Voltage engineering*
        - Introduction to HV engineering
        - Generation, according to IEC standards, of high AC, DC and impulse voltages for testing purposes in the HV laboratory
        - Measurements, according to IEC standards, of high AC, DC and impulse voltages in the HV laboratory
        - Electrostatic field theory for simple insulation systems
        - Sphere gap measurements
        - Transfer function for impulse voltage dividers - response time
        - Impulse current generation and measurement for testing purposes in the HV laboratory
    - *Non-destructive test methods in HV engineering*
        - Dynamic properties of dielectrics in time and frequency domain
        - Insulation ageing and lifetime assessment - test methods
        - Modelling of dielectric properties by means of electrical equivalent circuits
        - Dielectric loss and capacitance measurement - the Schering Bridge
        - External partial discharges, origin and practical importance for HV power system components, corona, overhead line audible noise and measurements of corona phenomena
        - Internal partial discharges, origin and practical importance for HV power system components.
        - Partial discharge detection and measurement by means of PD-instruments
        - Partial discharges in windings of inverter-fed rotating machines
    - *DC/DC converters*
        - Introduction to switch mode converters
        - Modelling of converters
        - Transformer isolated converters
        - Transfer functions
        - Closed loop control current mode and voltage mode
        - Analog controllers and digital controllers
        - Input filter design
        - Relevant standards
        - Design environment (software, hardware)

Competence:
- Independently be able to define and analyze scientific problems within the area of Power system high voltage engineering and Power Electronics
- Independently be able communicate results from Power system high voltage engineering and Power Electronics
- Independently be able to be a part of professional and interdisciplinary development work Power system high voltage engineering and Power Electronics

Type of instruction:
Lectures and laboratory experiments

Exam format:

Individual written examination with questions in both High Voltage and Power Electronics in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.1.l Course Module on 1st Semester: Hydraulic and Mechanical Systems and Power Electronic Modelling

Title:
M1-11 Hydraulic and Mechanical Systems and Power Electronic Modelling / Hydrauliske og mekaniske systemer og modellering af effektelektroniske konvertere

Prerequisites:
Fundamental mechanical engineering 4th semester at B.Sc or similar
Mechatronics and discrete control theory 5th semester at B.Sc

Objective:
Students who complete the module should:

Knowledge:

- Have comprehension about the function of hydraulic systems
- Have comprehension for modelling and control of hydraulic servo-systems
- Have knowledge about methods for modelling of the dynamics of mechanical systems
- Have comprehension for the dynamics of mechanical systems
- Have knowledge about non-linear relations, such as friction in hydraulic and mechanical systems
- Have knowledge about average models of power electronic converters
- Have knowledge and comprehension of converters and the choice of a suitable converter topology
- Have knowledge and comprehension of the linearization of power electronic converters
- Have knowledge and comprehension of semiconductor devices used in power electronic converters
- Have knowledge and comprehension of the layout of power electronic circuits

Skills:

- Be able to model the dynamics of parts of hydraulic systems
- Be able to design controllers for hydraulic servo-systems
- Be able to model dynamical mechanical structures
- Be able to analyze power electronic systems
- Be able to set up average models for power electronic converters
- Be able to linearize average models of power electronic converters
- Be able to dimension and design power electronic converters
- Be able to design converters inclusive gate drives, heat sinks and the DC-circuit

Competence:

- Be able to control the working and development process within the area of modelling, analyzes and control of hydraulic actuated mechanical systems and power electronic systems, and be able to develop new solutions within this area.
- Independently be able to define and analyse scientific problems in the area of modelling, analyzes and control of hydraulic actuated mechanical systems and power electronic systems, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation
- Independently be able to be a part of professional and interdisciplinary development work within the field of modelling, analysis and control of hydraulically actuated mechanical systems and power electronic systems,

Type of instruction:
The type of instruction is made according to the types of instructions described in the introduction to chapter 3.

Exam format:
Weeklong assignment or similar, including a mini-project in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions.

3.1.m Course Module on 1st Semester: Probability Theory, Statistics and English

Title:
M1-12 Probability Theory, Statistics and English / Sandsynlighedsregning, statistik og engelsk

Preconditions:
Linear Algebra, Calculus, Mathematics and Numerical Methods from a relevant Bachelor of Science specialisation. International students must document English language skills with a level equal to an IELTS minimum band score of 6.5 and a minimum oral score of 6.5.

Objective:
Students who complete the module should:

Knowledge

Probability theory and statistics*:*

- Have knowledge and comprehension in the area of:
  - The axiums of probability theory
  - One and multi dimensional discrete and continuous stochastic variables
  - Description of stochastic variables by density functions, distribution functions, mean values, variance, correlation and covariance
  - Examples of probability distributions:
    - Discrete: Bernoulli, binomial, Poisson and hyper-geometric
    - Continuous: Uniform, Gaussian
  - The central limit theorem
  - Estimation theory:
    - Point estimation and interval estimation (confidence intervals) for mean values and variance
    - Especially maximum likelihood estimators and Bayes estimators are treated
  - Test theory:
    - Basic philosophy behind testing of hypotheses, null hypothesis and alternative hypothesis, significance level, faults of 1st and 2nd kind, P-value
    - Test of mean value and variance in normal distributions
    - Use of statistics on real data by use of computer programs (e.g. MATLAB)

Scientific English (*for students having a bachelor degree from Aalborg University*)

- Know techniques involved in the planning, production and presentation/ communication of scientific work in English

English *(for students on the INTRO semester)*

- Develop English vocabulary as used in everyday and engineering situations

Skills

Probability theory and statistics

- Be able to apply probability theory within engineering relevant statistical and stochastic processes
- Be able to apply statistical methods in engineering projects

Scientific English (*for students having a bachelor degree from Aalborg University*)

- Apply different methods for the presentation of scientific results in the English language as a conference paper, a poster, a journal paper or orally at conferences

English (*for students on the INTRO semester*)

- Be able to speak and present a classroom presentation in understandable English.
- Be able to write a project report in understandable English
- Develop English vocabulary and pronunciation

Competence

- Independently define and analyse scientific problems in the area of probability theory and statistics
- Independently be able communicate results in a proper scientific manner in English

Type of instruction:
The course is taught through a mixture of lectures, workshops, exercises, mini-projects and self-studies.

Exam format:
The examination of the course will have one written examination in Probability and Statistics. To be allowed to attend the examination in Probability theory and Statistics, mandatory assignments for the English course must have been approved in advance. The written examination is held according to the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Assessment criteria:
As stated in the Framework Provisions

3.1.n Course Module on 1st INTRO Semester: Problem-based Learning, MATLAB and Control Theory
Common for students with a Bachelor of Science degree from another university than Aalborg University

Title:
M1-13 Problem-based Learning, MATLAB and Control Theory (INTRO only) / Problembaseret læring, MATLAB og reguleringsteknik (kun for INTRO)

Prerequisites:
A relevant Bachelor's degree

Objective:
Students who complete the module should:

Knowledge:

- Have knowledge and understanding of project organized problem based learning
- Have knowledge about group work/conflicts and ways to solve conflicts
- Have knowledge and comprehension of planning and structuring the documentation of a project
- Be able to comprehend time-domain analysis of continuous-time systems
- Be able to comprehend frequency response analysis of continuous-time systems
- Be able to apply the basic rules in discrete control theory including having knowledge about sampling systems, zero-order-hold and the influence of time delays.
- Have knowledge and comprehension of the basic features of MATLAB as a programming language

Skills:

- Be able to apply the project organized learning to actual problem related work in groups of up to 6 persons
- Be able to apply systematic methods
- Be able to analyze and to design time-invariant linear continuous-time control systems using classical methods
- Be able to analyze different design and compensation methods in control engineering
- Be able to apply discrete equivalents for continuous transfer functions.
- Be able to analyze, design and implement digital control systems
- Be able to use commercial simulation software as a control system design tool
- Be able to use the simple plotting facilities in MATLAB
- Be able to use data analysis routines in MATLAB

Competence:

- Independently be able to define and analyse scientific problems

Type of instruction:
The course will be taught by a mixture of lectures, workshops, exercises, mini-projects and self-study.

Exam format:
The examination of the course will have one written examination in MATLAB and Control Theory. To be allowed to attend the examination in MATLAB and Control theory, the Problem-based learning course part must have been passed by an oral assessment. The written examination is held according to the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As given in the Framework Provisions

3.2 Module Descriptions of 2nd Semester

3.2.a Project on 2nd Semester Thermal Energy and Process Engineering

Title:
M2-1 Modelling and Optimisation of Energy Systems / Modellering og optimering af energisystemer

Prerequisites:
1st semester on the Master of Science in Energy Engineering of one of the Thermal Energy Engineering specialisations or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at
Aalborg University that they have passed the course in Problem-based Learning (PBL)
and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should have:

Knowledge:

- Knowledge and comprehension and skills within synthesis of thermodynamic systems, their components and the interactions between these.
- Knowledge of the design, modelling and optimisation of systems involving thermal equipment such as engines, gas-turbines, steam turbines in stand-alone or combined cycle configurations.
- Knowledge of the conversion of plant-based biomass feedstocks and biological waste products to liquid fuels and the economic and strategic impact of the technologies involved.
- Knowledge and comprehension of the thermodynamic aspects of processes involved in thermal and fuel conversion plants which involve phase change and both sub- and supercritical operation.
- Knowledge and comprehension of the multiphase and chemical reaction based aspects involved in combustion processes and chemical process reactors.

Skills:

- Be able to judge the usefulness of the used different scientific methods for analysis and modelling of the energy systems.
- Be able to verify the analytical and numerical approaches by means of experimental data
- Be able to evaluate the optimisation procedures used for the energy systems.

Competence:

- Be able to control the working and development process within the project theme, and be able to develop new solutions within the energy systems.
- Independently be able to define and analyse scientific problems in the area of modelling and optimisation of energy systems, and based on that make and state the reasons for decisions made for instance with respect to their influences on the environment.
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project oriented project work in groups of up to 6 persons

The project should be based upon a thermal power plant or upon a fuel conversion process plant. The thermal plant could be a combined heat and power plant, a de-centralised power plant or a cooling plant. The power plant should be simulated to achieve an optimum plant design. In the design of the plant analytical tools are to be applied, such as numerical optimisation, non-linear dynamical modelling or process integration.
The fuel conversion process plant power should involve simulation, optimisation, design of specific components and an analysis of the economic and strategic impact of the technologies involved.

In addition the plant designed should be evaluated in relation to operational variations and/or the problems arising from start-up.

Exam format:
Individual oral examination with external adjudicator in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.2.b Project on 2nd semester Fuel Cells and Hydrogen Technology

Title:
M2-2 Modelling and Optimisation of Fuel Cell Systems / Modellering og optimering af brændselscellesystemer

Prerequisites:
1st semester on the Master of Science in Energy Engineering of one of the Thermal Energy Engineering specialisations or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should have:

Knowledge:

- Knowledge of the design, modelling and optimisation of energy systems used in various energy production applications involving fuel cell technology.
- Knowledge and comprehension of the detailed operation, functionality and interaction between the various components used in fuel cell- and hydrogen production systems.
- Knowledge needed to construct and operate fuel cell based technologies in the laboratory and in real applications.

Skills:

- Analytic skills in system integration with respect to system efficiency and control engineering aspects of fuel cell energy systems.
- Be able to judge the usefulness of the used different scientific methods for analysis and modelling of fuel cell and hydrogen systems.
- Be able to verify the analytical and numerical approaches by means of laboratory experiments
- Be able to evaluate the optimisation procedures used for fuel cell and hydrogen systems.

Competence:

- Be able to control the working and development process within the project theme, and be able to develop new solutions within fuel cell and hydrogen systems.
- Independently be able to define and analyse scientific problems in the area of fuel cells and hydrogen systems, and based on that make and state the reasons for decisions made for instance with respect to their influences on the environment.
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project oriented project work in groups of up to 6 persons

The semester focuses on modelling and optimisation of a physical fuel cell- or hydrogen based system. The semester project serves to give the students an advanced comprehension of systems based upon fuel cells- and hydrogen technology. The fundamental competence within thermodynamics and control engineering within these systems are established.

The students must develop a non-linear dynamical model of a system – for instance using block diagrams as in Simulink. Simultaneously, a data acquisition and control system is developed in for instance the Labview real time system through which basic analog data acquisition and control is interconnected.

Exam format:
Individual oral examination with external adjudicator in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.2.c Project on 2nd semester Wind Power Systems

Title:
M2-3 Interaction between Wind Generation and Load / Interaktion mellem vindmøllegeneration og last

Prerequisites:
1st semester on the Master of Science in Energy Engineering of one of the Electrical Energy Engineering specialisations or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at
Aalborg University that they have passed the course in Problem-based Learning (PBL)
and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should have:

Knowledge:

- Knowledge and comprehension of how to set up demands/specifications for the interaction between wind generators and loads for a wind power system.

Skills:

- Be able to analyse the dynamic behaviour of wind turbine systems when connection them to a power system with time varying loads
- Be able to analyse the load flow in such a system including the reactive power flow
- Be able to analyse the stability in such a system
- Be able to analyse the power quality of the system and to see if any power compensation system is needed.
- Be able to verify the analysis and models by means of laboratory experiments or by using real measured data series.

Competence:

- Be able to control the working and development process within the project theme, and be able to develop new solutions within the interaction of wind generators and loads.
- Independently be able to define and analyse scientific problems in the area of interaction of wind generators and loads, and based on that make and state the reasons for decisions made for instance with respect to their influences on the total system.
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project oriented project work in groups of up to 6 persons

The background of the project is a wind turbine system either a stand alone system or a system coupled to a power network grid which has to be controlled under time varying loads and time varying production from the wind turbines. The system is to be described and demands/specifications for the systems are to be made.

The system should be modelled and implemented in a simulation program. The system is to be analysed with respect to power quality and stability and examined if any power compensation units/systems are necessary.

Exam format:
Individual oral examination with external adjudicator in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.2.d Project on 2nd semester Power Electronics and Drives

Title:
M2-4 Control of Converter-fed AC Drives / Styring af konverterfødede AC-drivsystemer

Prerequisites:
1st semester on the Master of Science in Energy Engineering of one of the Electrical Energy Engineering specialisations or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at
Aalborg University that they have passed the course in Problem-based Learning (PBL)
and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should have:

Knowledge:

- Knowledge in modelling, analysing and simulating a system that must include a power electronic converter and an electric machine
- Comprehension of the practical implementation and test of the designed digital controller for the selected system

Skills:

- Be able to apply a systematical design procedure for selection of a digital controller for the analysed system in order to meet certain performance requirements
- Be able to verify the analysis and models by means of laboratory experiments or by using real measured data series.

Competence:

- Be able to control the working and development process within the project theme, and be able to develop new solutions within control in converter-fed AC drives.
- Independently be able to define and analyse scientific problems in the area of control of inverter-fed AC drives, and based on that make and state the reasons for decisions made for instance with respect to their influences on the total system.
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project oriented project work in groups of up to 6 persons

The project must include a power electronic converter and an AC machine.

The operating principles for the system must be described and a control problem is formulated.

A dynamic simulation model is made taking relevant dynamics into account. Different digital control methods are designed, analysed and evaluated by means of the simulation model. At least one method is selected for practical implementation in a real system incorporating a power electronic converter, an AC machine, and a real-time digital control system based on a digital signal processor or a micro controller. The whole system is tested and the developed control strategies are evaluated.

Exam format:
Individual oral examination with external adjudicator in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.2.e Project on 2nd semester Electrical Power Systems and High Voltage Engineering

Title:
M2-5 Control and Surveillance in Electrical Power Systems / Styring og overvågning af elektriske fordelingsanlæg

Prerequisites:
1st semester on the Master of Science in Energy Engineering of one of the Electrical Energy Engineering specialisations or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at
Aalborg University that they have passed the course in Problem-based Learning (PBL)
and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should have:

Knowledge:
- Knowledge about implementation and test of digital control and surveillance systems for power systems

Skills:
- Be able to apply methods for synthesizing the design and simulation of a digital control and surveillance systems in electrical power systems
- Be able to apply load flow and harmonic flow calculations in distribution and transmission systems
- Be able to analyse relay protection systems for power systems
- Be able to verify the analysis and models by means of laboratory experiments or by using real measured data series.

Competence:
- Be able to control the working and development process within the project theme, and be able to develop new solutions within control and surveillance in electrical power systems.

- Independently be able to define and analyse scientific problems in the area of control and surveillance in electrical power systems, and based on that make and state the reasons for decisions made for instance with respect to their influences on the total system.
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project oriented project work in groups of up to 6 persons

The background of the project is an electrical power system which has to be controlled and/or supervised (digital SRO-systems). The system is to be described and a specification is to be made. The system should be modelled and implemented in a simulation program. Different control and/or surveillance methods are to be simulated, analysed and evaluated with the purpose of selecting a solution.

A complete system (or parts) should be designed and implemented as a real-time system in the laboratory or real time data should be achieved from an existing system. The implemented system and the designed control and/or surveillance strategies should be tested, verified and evaluated based on the set-up in the laboratory or by real life data.

Exam format:
Individual oral examination with external adjudicator in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.2.f Project on 2nd semester Mechatronic Control Engineering

Title:
M2-6 Advanced Control of Electrical Machines / Avanceret styring af elektriske maskiner

Prerequisites:
1st semester on the Master of Science in Energy Engineering of the Mechatronic Control Engineering specialisation or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at
Aalborg University that they have passed the course in Problem-based Learning (PBL)
and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should have:

Knowledge:
- Comprehension of applied vector control strategies for electrical machines
- Knowledge about robust control theory
- Comprehension of the operating principles of a power electronic converter and be able acquiring these to design selected subsystems hereof.

Skills:
- Be able to design controllers for an induction motor based on these the above mentioned control methods

- Be able to verify the analysis and models by means of laboratory experiments or by using real measured data series.

Competence:

- Be able to control the working and development process within the project theme, and be able to develop new solutions within advanced control of electrical machines.
- Independently be able to define and analyse scientific problems in the area of advanced control of electrical machines, and based on that make and state the reasons for decisions made for instance with respect to their influences on the total system.
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project oriented project work in groups of up to 6 persons.

The project takes its base in a given electrical machine, which is used to drive a mechanical load. To control this motor a frequency converter should be used. The frequency converter or selected parts hereof should be developed in the project, including designing the power stage of the frequency converter, as well as an interface-board between the power stage and a DSP-system. In relation hereto modulation strategies and modes of operation for the converter should be analysed as basis for the control strategy of the converter.

Based on the developed frequency converter one or more vector control strategies for the motor should be developed enabling this to operate within prespecified demands for the system.

The frequency converter should be built in the laboratory and developed control strategies should be implemented, tested and compared to standard scalar control.

Exam format:
Oral examination with external adjudicator in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.2.g Course Module on 2nd Semester: Advanced Course in Electrical Power Systems

Title:
M2-9 Advanced Course in Electrical Power Systems/ Avanceret kursus i elektriske anlæg

Prerequisites:
Completed and passed Bachelors in Electrical Energy Engineering and Power Systems and Power Electronics course or similar

Objective:
Students who complete the module will have knowledge and ability to analyze more advanced topics within the area of power systems taking a starting point from today's state-of-the-art

Knowledge:

- Have knowledge and comprehension for overvoltage protection and insulation coordination
- Have knowledge and comprehension for power system protection
- Have comprehension of the mathematical tools and theories for harmonic distorted signals
- Have knowledge about the international standards for harmonics

- Have a comprehension of physical and mathematical modelling of large power systems for stationary analysis
- Have comprehension of mathematical methods for solving the load flow equations
- Have comprehension of large power system behaviour with respect to power transfer, voltage and reactive power relations and decentralized power generation infeed
- Have knowledge about the need for reactive compensation at the distribution and transmission level
- Have knowledge about different reactive compensation methods
- Have knowledge about power system transients including switching transients and the parameter determination for the components involved in the three phase power system.
- Have knowledge of numerical methods for electrostatic field calculation and assessment of electrostatic fields and fields stress control
- Have theoretical and practical comprehension of dielectric breakdown mechanisms in gaseour, liquid and solid dielectrics
- Have comprehension for the design and testing of external insulation

Skills:

- Must be able to apply theories and laboratory experiments to analyze the above mentioned areas of modern power systems. The level of knowledge will meet today's state-of-the-art.
- Must be able to analyse overvoltage protection systems and perform insulation coordination
- Must be able to design power system protection systems with respect to:
    - Overcurrent protection, Distance protection– main topic!, Differential protection, Ground fault relays
    - Power system transient simulation with playback to relay and relay test by means of modern test equipment
- Be able to analyze sources and effects of harmonic distortion
- Be able to analyze power system harmonic phenomena
- Be able to evaluate results by using measurements and instruments used for harmonic analysis
- Be able apply load flow analysis of large power systems
- Be able to apply numerical simulation tools for analyzing power system transients

Competence:

- Independently be able to define and analyze scientific problems within the area of advanced Power system technology
- Independently be able communicate results from advanced Power system technology
- Independently be able to be a part of professional and interdisciplinary development work in advanced Power system technology

Type of instruction:
Lectures, exercises and laboratory experiments

Exam format:
Written examination in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.2.h Course Module on 2nd Semester: Aerodynamics and Flow

Title:
M2-7 Aerodynamics and Flow / Aerodynamik og flow

Prerequisites:
Bachelor of Science in Energy Engineering or similar.
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Objective:
After the course the student should:

Knowledge:
- Have knowledge and comprehension for fundamental aerodynamics
- Have a comprehension for wind profile theory
- Have a comprehension of the fundamentals for gas dynamics
- Have knowledge and comprehension of multiphase flow systems.
- Have knowledge and comprehension for advanced techniques in computational fluid dynamics (CFD)

Skills:
- Be able to apply systematic methods for aerodynamic calculation methods.
- Be able to apply analytical techniques to gas dynamics
- Be able to apply equations and models for multiphase flow systems.
- Be able to apply CFD to complex fluid mechanics
- Be able to select and apply suitable models to the types of flows discussed in the course
- Be able to interpret CFD results with respect to selected models.

Competence
- Independently be able to define and analyse scientific problems within the area of aero- and gas dynamics and multiphase flow systems.
- Independently be able communicate results from CFD to others
- Independently be able to be a part of professional and interdisciplinary development work within aero- and gas dynamics and multiphase flow systems, including the use of CFD.

Type of instruction:
The course is taught by a mixture of lectures, workshops, exercises, mini-projects and self-studies.

Exam format:
Mandatory assignments with individually handed-in solutions in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.2.i Course Module on 2nd Semester: Control of Electrical Drive Systems and Converters

Title:
M2-10 Control of Electrical Drive Systems and Converters / Regulering af elektriske drivsystemer og konvertere

Prerequisite:
1st Semester courses: Dynamic Models of Electrical Machines and Control Systems; Electrical Apparatus and Power Electronics; 1st Semester Project: Dynamics of Electrical Energy Systems: or equivalent.
Objective:
Students who complete the module should:

Knowledge:
- Know basic topologies for electrical drive systems

- Know about soft switching PWM-based circuits and resonant-based circuits in power electronic converters
- Know how to control the basic topologies of converters for electrical drive systems
- Comprehend different control methods for brushless electrical machines
- Comprehend advanced techniques for control of AC machines in high performance applications
- Comprehend different sensorless control methods

Skills:
- Be capable of working with, grid connected and autonomous electrical drive systems
- Be able to apply a suitable circuit topology for a given application
- Be capable of implementing different control methods for AC-machines such as flux-oriented control and current control

Competence:
- Independently be able to define and analyze scientific problems within the area of control of electrical drive systems and converters
- Independently be able communicate results from the area of control of electrical drive systems and converters
- Independently be able to be a part of professional and interdisciplinary development work in the area of control of electrical drive systems and converters

Type of instruction:
The course will be taught by a mixture of lectures, workshops, exercises, mini-projects and self-study.

Exam format:
Written examination in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.2.j Course Module on 2nd Semester: Design and Modelling of Thermal Systems and Fuel Processing

Title:
M2-8 Design and Modelling of Thermal Systems and Fuel Processing / Design og modellering af termiske systemer og brændselsprocessering

Prerequisites:
Participants require a background corresponding to participation and successful completion of the courses given in thermal and fluid dynamical systems during the bachelor studies in energy technology given at Department of Energy Technology at Aalborg University or similar

Objective:
Students who complete the module should:

Knowledge:
- Have knowledge about advanced methods used in thermal process design and the general methods used in optimisation of thermal energy systems.
- Have knowledge about the important dynamical aspects of thermal energy systems.
- Be able to understand components and system configurations used in general fuel processing systems and fuel cell systems.

Skills:

- Be able to apply advanced mathematical methods to models of thermal systems and in order to optimize configuration parameters as well as identifying optimum system topologies.
- Be able to evaluate the results identified with respect to uncertainties posed by aspects of practical system operation including system dynamics.
- Be able to formulate models and model fundamental thermal system components considering transient operational phenomena.
- Be able to gain insight in advanced process integration technologies regarding determination of optimum heat exchanger networks.
- Be able to produce overall designs of fuel processing systems and fuel cell systems, including:
    - Understanding the chain of conversion of different feed stocks - as well biomass based as fossil fuel resources – into useable fuels in energy production and transportation.
    - The handling of fuels, fuel infrastructure and fuel storage. Particularly focusing on the aspects of hydrogen as a fuel.
    - The use of pure hydrogen and other fuels and possibly pollutants in fuel cells.

Competencies:
- Have the ability to apply and integrate the topic in an interdisciplinary correspondence with other related disciplines.
- Be able to evaluate the results of modelling and optimisation of various thermal and chemical system configurations.

Type of instruction:
Lectures supplied with independent studies.

Exam format:
Mandatory assignments with individually handed-in solutions in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions.

3.2.k Course Module on 2nd Semester: High Power Converters, Devices and EMI/EMC

Title:
M2-12 High Power Converters, Devices and EMI/EMC / Konvertere for store effekter, halvleder komponenter og EMI/EMC

Prerequisites:
Completed and passed Bachelors in Electrical Energy Engineering, Power Systems and Power Electronics or similar

Objective:
Students who complete the module will have knowledge and ability to analyze HVDC-light and power compensation systems. Knowledge of power electronic components and EMC/EMI design of power electronic converters.

Students who complete the module should:

Knowledge:
- Have knowledge for HVDC-light systems
- Have knowledge for power compensation systems based on power electronic devices
    - Shunt connected devices

    - Series connected devices
    - Shunt and series connected devices
- Have a comprehension of state-of-the-art switching devices
- Have understanding of fundamental behaviour of diodes, MOS-FETs and IGBTs
- Have and understanding of models of power electronics components such as diodes, MOS-FET and IGBT
- Have a comprehension of the fundamentals of EMI/EMC
- Have a comprehension of EMI/EMC problems in power electronic converters
- Have a comprehension for proper layout, layout guide
- Have a knowledge about EMI/EMC models and solutions
- Have comprehension for how to build EMI/EMC filters
- Have knowledge about EMI/EMC standards

Skills:
- Be able to set up specifications for and make analysis and simulations of HVDC-light systems used for instance for connection of wind farm
- Be able to set up specifications for and make analysis and simulations of power electronic compensation systems used for instance in relation to dispersed energy generating systems.
- Be able to apply proper models of diodes, MOS-FETs and IGBTs
- Be able to simulate the switching devices
- Be able to calculate the power losses of switching devices
- Be able to identify sources of EMI/EMC problems
- Be able to estimate and/or measure the EMI of a converter
- Be able to design filters

Competence:
- Independently be able to define and analyze scientific problems within the area of HVDC-light and power electronic compensation systems, switching devices and EMI/EMC
- Independently be able communicate results from HVDC-light and power electronic compensation systems, switching devices and EMI/EMC systems
- Independently be able to be a part of professional and interdisciplinary development work including HVDC-light and power compensation systems, switching devices and EMI/EMC

Type of instruction:
Lectures and laboratory experiments

Exam format:
Individual oral examination with questions in both HVDC-light, power electronic compensation systems, switching devices and EMI/EMC in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.2.l Course module on 2nd semester: Multi Variable and Non-linear Control

Title:
M2-11 Multi Variable and Non-linear Control Methods / Multivariabel og ikke-lineær regulering

Prerequisites:
1st semester on the MSc programme in Mechatronic Control Engineering or Electro Mechanical System Design or similar.

Objective:
Students who complete the module should:

Knowledge:

- Have gained an in-depth understanding of basic aspects of control design, the approaches, the key quantities to consider and the fundamental limitations inherent in the design
- Be able to, on a scientific basis, to understand and apply advanced model based control design tools
- Be able to document understanding of the following topics:
    - Multivariable systems (multiple inputs and multiple outputs MIMO)
    - Discrete time theory
    - Nonlinear systems

Skills:

- Be able to understand the fundamental performance limitations of single input and single output (SISO) systems
- Be able to represent linear systems in different ways: Transfer functions matrices, input-output equations, state space form, discrete time forms
- Be able to understand what disturbances are, and to describe their character in a suitable way
- Be able to set up design specifications for MIMO systems
- Be able to understand basic limitations in control design
- Be able to set op the configuration of multivariable controllers
- Be able to design linear multivariable controllers
- Be able to apply nonlinear methods in control design

Competence:

- Be able to undertake analysis, design and implementation of advanced control systems where experience and intuition play a very important role

Type of instruction:
The form(s) of teaching will be determined and described in connection with the planning of the semester. The description will account for the form(s) of teaching and may be accompanied by an elaboration of the roles of the participants (see chapter 3).

Exam format:
Internal, written/oral examination in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.2.l Course Module on 2nd Semester: Optimisation Theory and Stochastic Processes

Title:
M2-13 Optimisation Theory and Stochastic Processes / Optimeringsteori og stokastiske processer

Prerequisites:
Mathematical courses on the Bachelor of Energy Engineering and the course in Mathematics and English on 1st semester of Master of Science studies in Energy Engineering or similar.

Objective:
Students who complete the module should:

Knowledge:

- Have knowledge and comprehension about different types of stochastic processes in general
- Have knowledge of discrete time stochastic processes and models for real life signals
- Have knowledge about simple descriptions for stochastic processes in time and frequency domain
- Have knowledge about linear filtering of stochastic processes
- Have a comprehension of spectral estimation techniques
- Have comprehension of the fundamental concepts, terms and typical methods used within numerical optimisation of stationary linear and non-linear optimisation problems
- Have comprehension of the fundamental concepts, terms and methods used within optimisation of (dynamic) optimal control problems
- Have gained an in-depth understanding of important concepts and methods of optimisation for efficient solution of optimisation problems within different areas of engineering

Skills:

- Be able to apply discrete stochastic signals in order to perform detection and filtering
- Be able to apply detection and estimation methods in connection with stationary stochastic processes within simple problems
- Be able to use optimisation concepts and topics
- Be able to use numerical methods of unconstrained optimisation.
- Be able to use numerical (mathematical programming) methods for optimisation of multi-dimensional functions with constraints.
- Be able to solve multicriterion optimisation problems

Competence

- Be able to apply the concepts, theories and methods for solutions in the area of stochastic processes and engineering optimisation problems.
- Be able to account for the considerations involved in the process of formulating and modelling stochastic processes and engineering optimisation problems, choosing an advantageous method of solution, and implementing it in practice.

Type of instruction:
The form(s) of teaching will be determined and described in connection with the planning of the semester. The description will account for the form(s) of teaching and may be accompanied by an elaboration of the roles of the participants (see chapter 3).

Form of examination:
Internal, written or oral examination in accordance with the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.3 Module Descriptions of 3rd Semester

At the third semester only two courses are described in the study curriculum. However, they are optional courses. The student must choose 10 ECTS in total for courses, if other courses than the two given in this study curriculum are chosen, they must be approved by the coordinator of the specialisation and the study board. Courses at other specialisations at Aalborg University or from other universities might be relevant here.

3.3.a Project on 3rd Semester Thermal Energy and Process Engineering

Title:

M3-1 Optimisation, Diagnosis and Control of Thermal Energy and Processing Systems / Optimering, diagnosticering og regulering af termiske energi og proces systemer

Prerequisites:
2nd semester on the Master of Science in Energy Engineering specialisation in Thermal Energy and Process Engineering or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge:
- Have knowledge and comprehension for how to design optimisation, control- and diagnostic systems for thermal energy and process engineering systems
- Have knowledge and comprehension of different advanced control methods
- Have knowledge and comprehension of different system identification and diagnostic methods

Skills:
- Be able to judge the usefulness of the used different scientific methods for the design of optimisation, control-, and diagnostic systems for thermal energy and process engineering systems.
- Be able to verify the different scientific analysis and methods by means of laboratory experiments

Competence:
- Be able to control the working and development process within the project theme, and be able to develop new solutions within optimisation, control-, and diagnostic of thermal energy and process engineering systems
- Be able to show entrepreneurship to define and analyse scientific problems in the area of optimisation, control-, and diagnostic of thermal energy and process engineering systems, and based on that make and state the reasons for decisions made.
- Be able to set up innovative ideas within the area of optimisation, control-, and diagnostic of thermal energy and process engineering systems
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem-based project-oriented project work in groups of up to 6 persons.

The project work must be documented by a scientific paper (max. 8 pages). If judged necessary, this paper may be accompanied by a report, comprising appendices (appendix report) supporting the scientific paper. This appendix report, if submitted, should not exceed 30 pages, but is not formally assessed during the project examination.

The scientific paper will be presented at a conference arranged within the Department of Energy Technology, prior to the project examination.

The project work should be based upon a thermal energy and process engineering system to which an optimisation, control- or diagnostic system is to be set up.

First, the system is to be modelled and different system identification methods can be applied to determine the parameters of the system. The system model is verified by simulations and data time series from either a real system or a laboratory set-up.

Based on the model, the optimisation, control- or diagnostic system is set up to improve the performance of the system, either with regard to power output, energy efficiency, life time extraction, fault detections etc. and the system should be implemented and verified experimentally.

According to the study regulations given in the "Framework Provisions", the 3rd semester may also be carried out in other ways:

- The student documents the project work in a project report, within the project theme, prepared individually or in a group
- The student does project work in a company as an individual or as part of a group (voluntary internship); see section 9.4.1.1 in the Framework Provisions)
- The student follows a relevant study as a guest student at another university in Denmark or abroad
- The student composes a semester programme that comprises cross-disciplinary programme elements
- The student prepares an extended final project which covers the third and fourth semester (see section 9.4.1.3. in the Framework Provisions). The extended final project comprises 10 ECTS elective courses and 50 ECTS project work.

The courses are available on the homepage of the study board:
http://www.en.ses.aau.dk/Study+Boards/Energy/Curriculum+and+rules/Alternative+courses

The student's special preferences for the semester must be approved by the study board in advance!

Exam format:
The project group should orally present the project work and scientific paper as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University. The project group members will undergo an individual oral examination, with internal adjudicator, based on the scientific paper.

During the examination the project group presents its project work and scientific paper, as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University. The individual oral examination will be based on the scientific paper.

Evaluation criteria:
As stated in the Framework Provisions

3.3.b Project on 3rd Semester Fuel Cells and Hydrogen Technology

Title:
M3-2 Optimisation, Diagnosis and Control of Fuel Cell and Hydrogen Technology Systems / Optimering, diagnosticering og regulering af brændselscelle og brintsystemer

Prerequisites:
2nd semester on the Master of Science in Energy Engineering specialisation in Fuel cells and Hydrogen Technology or similar

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should

Knowledge:

- Have knowledge and comprehension for how to design optimisation, control- and diagnostic systems for fuel cell and hydrogen technology systems
- Have knowledge and comprehension of different advanced control methods
- Have knowledge and comprehension of different system identification and diagnostic methods

Skills:

- Be able to judge the usefulness of the used different scientific methods for the design of optimisation, control-, and diagnostic systems for fuel cell and hydrogen technology systems.
- Be able to verify the different scientific analysis and methods by means of laboratory experiments

Competence:

- Be able to control the working and development process within the project theme, and be able to develop new solutions within optimisation, control-, and diagnostic of fuel cell and hydrogen technology systems
- Be able to show entrepreneurship to define and analyse scientific problems in the area of optimisation, control-, and diagnostic of fuel cell and hydrogen technology systems, and based on that make and state the reasons for decisions made.
- Be able to set up innovative ideas within the area of optimisation, control-, and diagnostic of fuel cell and hydrogen technology systems
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project-oriented project work in groups of up to 6 persons.

The project work must be documented by a scientific paper (max. 8 pages). If judged necessary, this paper may be accompanied by a report, comprising appendices (appendix report) supporting the scientific paper. This appendix report, if submitted, should not exceed 30 pages, but is not formally assessed during the project examination.

The scientific paper will be presented at a conference arranged within the Department of Energy Technology, prior to the project examination.

The project should be based upon a fuel cell and hydrogen technology systems to which an optimisation, control- or diagnostic system is to be set up.

First the system is to be modelled and different system identification methods can be applied to determine the parameters of the system. The system model is verified by simulations and data time series from either a real system or a laboratory set up.

Based on the model, the optimisation, control- or diagnostic system is set up to improve the performance of the system, either with regard to power output, energy efficiency, life time extraction, fault detections etc. and the system should be implemented and verified experimentally.

According to the study regulations given in the "Framework Provisions", the 3rd semester may also be carried out in other ways:

- The student documents the project work in a project report, within the project theme, prepared individually or in a group
- The student does project work in a company as an individual or as part of a group (voluntary internship); see section 9.4.1.1 in the Framework Provisions)
- The student follows a relevant study as a guest student at another university in Denmark or abroad

- The student composes a semester programme that comprises cross-disciplinary programme elements
- The student prepares an extended final project which covers the third and fourth semester (see section 9.4.1.3. in the Framework Provisions). The extended final project comprises 10 ECTS elective courses and 50 ECTS project work.

The courses are available on the homepage of the study board:
http://www.en.ses.aau.dk/Study+Boards/Energy/Curriculum+and+rules/Alternative+courses

The student's special preferences for the semester must be approved by the study board in advance!

Exam format:
The project group should orally present the project work and scientific paper as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University. The project group members will undergo an individual oral examination, with internal adjudicator, based on the scientific paper.

During the examination the project group presents its project work and scientific paper, as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University. The individual oral examination will be based on the scientific paper.

Evaluation criteria:
As stated in the Framework Provisions

3.3.c Project on 3rd Semester Wind Power Systems

Title:
M3- 3 Optimisation, Diagnosis and Control of Electrical Conditions in Wind Turbines and Wind Farms / Optimering, diagnosticering og regulering af de elektriske forhold i vindmøller og vindfarme

Prerequisites:
2nd semester on the Master of Science in Energy Engineering specialisation in Wind Power Systems or similar

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should

Knowledge:

- Have knowledge and comprehension for how to design optimisation, control- and diagnostic systems for wind turbines or wind farms
- Have knowledge and comprehension of different advanced control methods
- Have knowledge and comprehension of different system identification and diagnostic methods

Skills:

- Be able to judge the usefulness of the used different scientific methods for the design of optimisation, control-, and diagnostic systems for wind turbines or wind farms.
- Be able to verify the different scientific analysis and methods by means of laboratory experiments

Competence:

- Be able to control the working and development process within the project theme, and be able to develop new solutions within optimisation, control-, and diagnostic of wind power systems
- Be able to show entrepreneurship to define and analyse scientific problems in the area of optimisation, control-, and diagnostic of wind power systems, and based on that make and state the reasons for decisions made.
- Be able to set up innovative ideas within the area of optimisation, control-, and diagnostic of wind power systems
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem-based project-oriented project work in groups of up to 6 persons.

The project work must be documented by a scientific paper (max. 8 pages). If judged necessary, this paper may be accompanied by a report, comprising appendices (appendix report) supporting the scientific paper. This appendix report, if submitted, should not exceed 30 pages, but is not formally assessed during the project examination.

The scientific paper will be presented at a conference arranged within the Department of Energy Technology, prior to the project examination.

The project should be based upon a wind turbine system or a wind farm to which an optimisation, control- or diagnostic system is to be set up.

First the system is to be modelled and different system identification methods can be applied to determine the parameters of the system. The system model is verified by simulations and data time series from either a real system or a laboratory set up.

Based on the model, the optimisation, control- or diagnostic system is set up to improve the performance of the system, either with regard to power output, energy efficiency, life time extraction, fault detections etc. and the system should be implemented and verified experimentally.

According to the study regulations given in "Framework Provisions", the 3rd semester may also be carried out in other ways:

- The student documents the project work in a project report, within the project theme, prepared individually or in a group
- The student does project work in a company as an individual or as part of a group (voluntary internship); see section 9.4.1.1 in the Framework Provisions)
- The student follows a relevant study as a guest student at another university in Denmark or abroad
- The student composes a semester programme that comprises cross-disciplinary programme elements
- The student prepares an extended final project which covers the third and fourth semester (see section 9.4.1.3. in the Framework Provisions). The extended final project comprises 10 ECTS elective courses and 50 ECTS project work.

The courses are available on the homepage of the study board:
http://www.en.ses.aau.dk/Study+Boards/Energy/Curriculum+and+rules/Alternative+courses

The student's special preferences for the semester must be approved by the study board in advance!

Exam format:
The project group should orally present the project work and scientific paper as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science,

Aalborg University. The project group members will undergo an individual oral examination, with internal adjudicator, based on the scientific paper.

During the examination the project group presents its project work and scientific paper, as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University. The individual oral examination will be based on the scientific paper.

Evaluation criteria:
As stated in the Framework Provisions

3.3.d Project on 3rd Semester Power Electronics and Drives

Title:
M3-4 Optimisation, Diagnosis and Control of Power Electronic Drives or Converters / Optimering, diagnosticering og regulering af effektelektroniske drivsystemer eller konvertere

Prerequisites:
2nd semester on the Master of Science in Energy Engineering specialisation in Power Electronics and Drives or similar

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge:
- Have knowledge and comprehension for how to design optimisation, control- and diagnostic systems for power electronics drives or converters
- Have knowledge and comprehension of different advanced control methods
- Have knowledge and comprehension of different system identification and diagnostic methods

Skills:
- Be able to judge the usefulness of the used different scientific methods for the design of optimisation, control-, and diagnostic systems for power electronic drives or converters.
- Be able to verify the different scientific analysis and methods by means of laboratory experiments

Competence:
- Be able to control the working and development process within the project theme, and be able to develop new solutions within optimisation, control-, and diagnostic of power electronic drives or converters
- Be able to show entrepreneurship to define and analyse scientific problems in the area of optimisation, control-, and diagnostic of power electronics drives or converters, and based on that make and state the reasons for decisions made.
- Be able to set up innovative ideas within the area of optimisation, control-, and diagnostic of power electronic drives or converters
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem-based project-oriented project work in groups of up to 6 persons.

The project work must be documented by a scientific paper (max. 8 pages). If judged necessary, this paper may be accompanied by a report, comprising appendices (appendix report) supporting the scientific paper. This appendix report, if submitted, should not exceed 30 pages, but is not formally assessed during the project examination.

The scientific paper will be presented at a conference arranged within the Department of Energy Technology, prior to the project examination.

The project should be based upon a power electronic drive or converter to which an optimisation, control- or diagnostic system is to be set up.

First the system is to be modelled and different system identification methods can be applied to determine the parameters of the system. The system model is verified by simulations and data time series from either a real system or a laboratory set up.

Based on the model, the optimisation, control- or diagnostic system is set up to improve the performance of the system, either with regard to power output, energy efficiency, life time extraction, fault detections etc. and the system should be implemented and verified experimentally.

According to the study regulations given in "Framework Provisions", the 3rd semester may also be carried out in other ways:

- The student documents the project work in a project report, within the project theme, prepared individually or in a group
- The student does project work in a company as an individual or as part of a group (voluntary internship); see section 9.4.1.1 in the Framework Provisions)
- The student follows a relevant study as a guest student at another university in Denmark or abroad
- The student composes a semester programme that comprises cross-disciplinary programme elements
- The student prepares an extended final project which covers the third and fourth semester (see section 9.4.1.3. in the Framework Provisions). The extended final project comprises 10 ECTS elective courses and 50 ECTS project work.

The courses are available on the homepage of the study board:
http://www.en.ses.aau.dk/Study+Boards/Energy/Curriculum+and+rules/Alternative+courses

The student's special preferences for the semester must be approved by the study board in advance!

Exam format:
The project group should orally present the project work and scientific paper as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University. The project group members will undergo an individual oral examination, with internal adjudicator, based on the scientific paper.

During the examination the project group presents its project work and scientific paper, as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University. The individual oral examination will be based on the scientific paper.

Evaluation criteria:
As stated in the Framework Provisions

3.3.e Project on 3rd Semester Electrical Power Systems and High Voltage Engineering

Title:
M3- 5 Optimisation, Diagnosis and Control of Electrical Power Systems and High Voltage Systems / Optimering, diagnosticering og regulering af elektriske anlæg og højspændingssystemer

Prerequisites:
2nd semester on the Master of Science in Energy Engineering specialisation in Electrical Power Systems and High Voltage Engineering or similar

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge:
- Have knowledge and comprehension for how to design optimisation, control- and diagnostic systems for electrical power systems or high voltage systems
- Have knowledge and comprehension of different advanced control methods
- Have knowledge and comprehension of different system identification and diagnostic methods

Skills:
- Be able to judge the usefulness of the used different scientific methods for the design of optimisation, control-, and diagnostic systems for electric power systems or high voltage systems.
- Be able to verify the different scientific analysis and methods by means of laboratory experiments

Competence:
- Be able to control the working and development process within the project theme, and be able to develop new solutions within optimisation, control-, and diagnostic of electrical power systems or high voltage systems
- Be able to show entrepreneurship to define and analyse scientific problems in the area of optimisation, control-, and diagnostic of electrical power systems or high voltage systems, and based on that make and state the reasons for decisions made.
- Be able to set up innovative ideas within the area of optimisation, control-, and diagnostic of electrical power systems or high voltage systems
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem-based project-oriented project work in groups of up to 6 persons.

The project work must be documented by a scientific paper (max. 8 pages). If judged necessary, this paper may be accompanied by a report, comprising appendices (appendix report) supporting the scientific paper. This appendix report, if submitted, should not exceed 30 pages, but is not formally assessed during the project examination.

The scientific paper will be presented at a conference arranged within the Department of Energy Technology, prior to the project examination.

The project should be based upon an electrical power system or a high voltage system to which an optimisation, control- or diagnostic system is to be set up.

First the system is to be modelled and different system identification methods can be applied to determine the parameters of the system. The system model is verified by simulations and data time series from either a real system or a laboratory set up.

Based on the model, the optimisation, control- or diagnostic system is set up to improve the performance of the system, either with regard to power output, energy efficiency, life time extraction, fault detections etc. and the system should be implemented and verified experimentally.

According to the study regulations given in "Framework Provisions", the 3rd semester may also be carried out in other ways:

- The student documents the project work in a project report, within the project theme, prepared individually or in a group
- The student does project work in a company as an individual or as part of a group (voluntary internship); see section 9.4.1.1 in the Framework Provisions)
- The student follows a relevant study as a guest student at another university in Denmark or abroad
- The student composes a semester programme that comprises cross-disciplinary programme elements
- The student prepares an extended final project which covers the third and fourth semester (see section 9.4.1.3. in the Framework Provisions). The extended final project comprises 10 ECTS elective courses and 50 ECTS project work.

The courses are available on the homepage of the study board:
http://www.en.ses.aau.dk/Study+Boards/Energy/Curriculum+and+rules/Alternative+courses

The student's special preferences for the semester must be approved by the study board in advance!

Exam format:
The project group should orally present the project work and scientific paper as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University. The project group members will undergo an individual oral examination, with internal adjudicator, based on the scientific paper.

During the examination the project group presents its project work and scientific paper, as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University. The individual oral examination will be based on the scientific paper.

Evaluation criteria:
As stated in the Framework Provisions

3.3.f Project on 3rd Semester Mechatronic Control Engineering

Title:
M3-6 Optimisation, Diagnosis and Control in Mechatronic Systems / Optimering, diagnosticering og regulering af mekatroniske systemer

Prerequisites:
2nd semester on the Master of Science in Energy Engineering specialisation in Mechatronic Control Engineering or similar

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge:
- Have knowledge and comprehension for how to design optimisation, control- and diagnostic systems for mechatronic systems
- Have knowledge and comprehension of different advanced control methods
- Have knowledge and comprehension of different system identification and diagnostic methods

Skills:
- Be able to judge the usefulness of the used different scientific methods for the design of optimisation, control-, and diagnostic systems for mechatronic systems.
- Be able to verify the different scientific analysis and methods by means of laboratory experiments

Competence:
- Be able to control the working and development process within the project theme, and be able to develop new solutions within optimisation, control-, and diagnostic of mechatronic systems
- Be able to show entrepreneurship to define and analyse scientific problems in the area of optimisation, control-, and diagnostic of mechatronic systems, and based on that make and state the reasons for decisions made.
- Be able to set up innovative ideas within the area of optimisation, control-, and diagnostic of mechatronic systems
- Independently be able to continue own development in competence and specialisation

Type of instruction:
Problem based project oriented project work in groups of up to 6 persons.

The project work must be documented by a scientific paper (max. 8 pages). If judged necessary, this paper may be accompanied by a report, comprising appendices (appendix report) supporting the scientific paper. This appendix report, if submitted, should not exceed 30 pages, but is not formally assessed during the project examination.

The scientific paper will be presented at a conference arranged within the Department of Energy Technology, prior to the project examination.

The project should be based upon a mechatronic system to which an optimisation, control- or diagnostic system is to be set up.

First the system is to be modelled and different system identification methods can be applied to determine the parameters of the system. The system model is verified by simulations and data time series from either a real system or a laboratory set up.

Based on the model, the optimisation, control- or diagnostic system is set up to improve the performance of the system, either with regard to power output, energy efficiency, life time extraction, fault detections etc. and the system should be implemented and verified experimentally.

According to the study regulations given in "Framework Provisions", the 3rd semester may also be carried out in other ways:

- The student documents the project work in a project report, within the project theme, prepared individually or in a group
- The student does project work in a company as an individual or as part of a group (voluntary internship); see section 9.4.1.1 in the Framework Provisions)

- The student follows a relevant study as a guest student at another university in Denmark or abroad
- The student composes a semester programme that comprises cross-disciplinary programme elements
- The student prepares an extended final project which covers the third and fourth semester (see section 9.4.1.3. in the Framework Provisions). The extended final project comprises 10 ECTS elective courses and 50 ECTS project work.

The courses are available on the homepage of the study board:
http://www.en.ses.aau.dk/Study+Boards/Energy/Curriculum+and+rules/Alternative+courses

The student's special preferences for the semester must be approved by the study board in advance!

Exam format:
The project group should orally present the project work and scientific paper as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University. The project group members will undergo an individual oral examination, with internal adjudicator, based on the scientific paper.

During the examination the project group presents its project work and scientific paper, as specified in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University. The individual oral examination will be based on the scientific paper.

Evaluation criteria:
As stated in the Framework Provisions

3.4 Module Descriptions of 4th Semester

3.4.a Master's Thesis on 4th Semester in Thermal Energy and Process Engineering

Title:
M4-1 Master's Thesis / Kandidatspeciale

Prerequisites:
3rd semester on the Master of Science in Energy Engineering specialisation in Thermal Energy and Process Engineering or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge:
- Have knowledge and comprehension within the area of thermal energy and process engineering at the highest international level
- Be able to critical judge knowledge and identify new scientific problems within the area of thermal energy and process engineering
- Have comprehension for the implications within the research work (research ethics)

Skills:
- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of thermal energy and process engineering

- Be able to use advanced laboratory set ups, data analysis methods and analysis and modelling methods within the field of thermal energy and process engineering.
- Be able to communicate about scientific problems both to specialist and the public.
- Have obtained skills related to the industrial area within thermal energy and process engineering

Competence:
- Be able to control complex/unexpected working and development situations within thermal energy and process engineering, and be able to develop new solutions.
- Independently be able to define and analyse scientific problems, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility.

Type of instruction:
Problem based project oriented project work individual or in groups of 2-3 persons.

- The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of thermal energy and process engineering. The project may be of theoretical or experimental nature, and will often be in collaboration with an industrial company or other research institution performing research in the area of thermal energy and process engineering.

Exam format:
Individual oral examination with external adjudicator as given in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.4.b Master's Thesis on 4th Semester in Fuel Cells and Hydrogen Technology

Title:
M4-2 Master's Thesis / Kandidatspeciale

Prerequisites:
3rd semester on the Master of Science in Energy Engineering specialisation in Fuel Cells and Hydrogen Technology or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge:
- Have knowledge and comprehension within the area of fuel cells and hydrogen technology at the highest international level
- Be able to critical judge knowledge and identify new scientific problems within the area of fuel cells and hydrogen technology
- Have comprehension for the implications within the research work (research ethics)

Skills:

- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of fuel cells and hydrogen technology
- Be able to use advanced laboratory set ups, data analysis methods and analysis and modelling methods within the field of fuel cells and hydrogen technology.
- Be able to communicate about scientific problems both to specialist and the public.
- Have obtained skills related to the industrial area within fuel cells and hydrogen technology

Competence:

- Be able to control complex/unexpected working and development situations within fuel cells and hydrogen technology, and be able to develop new solutions.
- Independently be able to define and analyse scientific problems, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility.

Type of instruction:
Problem based project oriented project work individual or in groups of 2-3 persons.

- The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of fuel cells and hydrogen technology. The project may be of theoretical or experimental nature, and will often be in collaboration with an industrial company or other research institution performing research in the area of fuel cells and hydrogen technology.

Exam format:
Individual oral examination with external adjudicator as given in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.4.c Master's Thesis on 4th Semester in Wind Power Systems

Title:
M4-3 Master's Thesis / Kandidatspeciale

Prerequisites:
3rd semester on the Master of Science in Energy Engineering specialisation in Wind Power Systems or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge:

- Have knowledge and comprehension within the area of wind power systems at the highest international level

- Be able to critical judge knowledge and identify new scientific problems within the area of wind power systems
- Have comprehension for the implications within the research work (research ethics)

Skills:

- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of wind power systems
- Be able to use advanced laboratory set ups, data analysis methods and analysis and modelling methods within the field of wind power systems.
- Be able to communicate about scientific problems both to specialist and the public.
- Have obtained skills related to the industrial area within wind power systems

Competence:

- Be able to control complex/unexpected working and development situations within wind power systems, and be able to develop new solutions.
- Independently be able to define and analyse scientific problems, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility.

Type of instruction:
Problem based project oriented project work individual or in groups of 2-3 persons.

- The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of wind power systems. The project may be of theoretical or experimental nature, and will often be in collaboration with an industrial company or other research institution performing research in the area of wind power systems.

Exam format:
Individual oral examination with external adjudicator as given in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.4.d Master's Thesis on 4th semester in Power Electronics and Drives

Title:
M4-4 Master's Thesis / Kandidatspeciale

Prerequisites:
3rd semester on the Master of Science in Energy Engineering specialisation in Power Electronics and Drives or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge:

- Have knowledge and comprehension within the area of power electronics and drives at the highest international level
- Be able to critical judge knowledge and identify new scientific problems within the area of power electronics and drives
- Have comprehension for the implications within the research work (research ethics)

Skills:
- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of power electronics and drives
- Be able to use advanced laboratory set ups, data analysis methods and analysis and modelling methods within the field of power electronics and drives.
- Be able to communicate about scientific problems both to specialist and the public.
- Have obtained skills related to the industrial area within power electronics and drives

Competence:
- Be able to control complex/unexpected working and development situations within power electronics and drives, and be able to develop new solutions.
- Independently be able to define and analyse scientific problems, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility.

Type of instruction:
Problem based project oriented project work individual or in groups of 2-3 persons.

- The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of power electronics and drives. The project may be of theoretical or experimental nature, and will often be in collaboration with an industrial company or other research institution performing research in the area of power electronics and drives.

Exam format:
Individual oral examination with external adjudicator as given in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.4.e Master's Thesis on 4th Semester in Electrical Power Systems and High Voltage Engineering

Title:
M4-5 Master's Thesis / Kandidatspeciale

Prerequisites:
3rd semester on the Master of Science in Energy Engineering specialisation in Electrical Power Systems and High Voltage Engineering or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge:
- Have knowledge and comprehension within the area of electrical power systems and high voltage engineering at the highest international level
- Be able to critical judge knowledge and identify new scientific problems within the area of electrical power systems and high voltage engineering
- Have comprehension for the implications within the research work (research ethics)

Skills:
- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of electrical power systems and high voltage engineering
- Be able to use advanced laboratory set ups, data analysis methods and analysis and modelling methods within the field of electrical power systems and high voltage engineering.
- Be able to communicate about scientific problems both to specialist and the public.
- Have obtained skills related to the industrial area within electrical power systems and high voltage engineering

Competence:
- Be able to control complex/unexpected working and development situations within electrical power systems and high voltage engineering, and be able to develop new solutions.
- Independently be able to define and analyse scientific problems, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility.

Type of instruction:
Problem based project oriented project work individual or in groups of 2-3 persons.

- The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of electrical power systems and high voltage engineering. The project may be of theoretical or experimental nature, and will often be in collaboration with an industrial company or other research institution performing research in the area of electrical power systems and high voltage engineering.

Exam format:
Individual oral examination with external adjudicator as given in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

3.4.f Master's Thesis on 4th Semester in Mechatronic Control Engineering

Title:
M4-6 Master's Thesis / Kandidatspeciale.

Prerequisites:
3rd semester on the Master of Science in Energy Engineering specialisation in Mechatronic Control Engineering or similar.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem-based Learning (PBL) and Student Responsibility at Aalborg University prior to the project examination.

Objective:
After completion of the project the student should:

Knowledge:

- Have knowledge and comprehension within the area of mechatronic control engineering at the highest international level
- Be able to critical judge knowledge and identify new scientific problems within the area of mechatronic control engineering.
- Have comprehension for the implications within the research work (research ethics)

Skills:

- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of mechatronic control engineering
- Be able to use advanced laboratory set ups, data analysis methods and analysis and modelling methods within the field of mechatronic control engineering.
- Be able to communicate about scientific problems both to specialist and the public.
- Have obtained skills related to the industrial area within mechatronic control engineering

Competence:

- Be able to control complex/unexpected working and development situations within mechatronic control engineering, and be able to develop new solutions.
- Independently be able to define and analyse scientific problems, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competence and specialisation
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility.

Type of instruction:
Problem based project oriented project work individual or in groups of 2-3 persons.

- The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of mechatronic control engineering. The project may be of theoretical or experimental nature, and will often be in collaboration with an industrial company or other research institution performing research in the area of mechatronic control engineering.

Exam format:
Individual oral examination with external adjudicator as given in the Examination Policies and Procedures, Addendum to the Framework Provision at Faculty of Engineering and Science, Aalborg University.

Evaluation criteria:
As stated in the Framework Provisions

4. Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean of Faculty of Engineering and Science and enters into force as of September 2012 for all new, enrolled students and the students who begin on the third semester MSc on 1 September 2012.

Students who wish to complete their studies under the previous curriculum from 2010 must conclude their education by the summer examination period 2014 at the latest, since examinations under the previous curriculum are not offered after this time.

In accordance with the Framework Provisions and the Handbook on Quality Management for Faculty of Engineering and Science at Aalborg University, the curriculum must be revised no later than 5 years after its entry into force.

5. Other Provisions

5.1 Rules concerning Written Work, including the Master's Thesis

In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's spelling and formulation ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency are taken as a basis for the evaluation of language performance. Language performance must always be included as an independent dimension of the total evaluation. However, no examination can be assessed as 'Pass' on the basis of language performance alone; similarly, an examination normally cannot be assessed as 'Fail' on the basis of poor language performance alone.
The Board of Studies can grant exemption from this in special cases (e.g., dyslexia or a native language other than Danish).

The Master's thesis must include an English summary.[1] If the project is written in English, the summary must be in Danish.[2] The summary must be at least 1 page and not more than 2 pages. The summary is included in the evaluation of the project as a whole.

5.2 Rules concerning Credit Transfer (Merit), including the Possibility for Choice of Modules that are part of Another Programme at a University in Denmark or Abroad

In the individual case, the Board of Studies can approve successfully completed (passed) program elements from other Master's programs in lieu of program elements in this program (credit transfer). The Board of Studies can also approve successfully completed (passed) program elements from another Danish program or a program outside of Denmark at the same level in lieu of program elements within this curriculum. Decisions on credit transfer are made by the Board of Studies based on an academic assessment. See the Framework Provisions for the rules on credit transfer.

5.3 Rules for Examinations

The rules for examinations are stated in the Examination Policies and Procedures published by Faculty of Engineering and Science on their website.

5.4 Exemption

In exceptional circumstances, the Board of Studies study can grant exemption from those parts of the curriculum that are not stipulated by law or ministerial order. Exemption regarding an examination applies to the immediate examination.

5.5 Additional Information

The current version of the curriculum is published on the Board of Studies' website, including more detailed information about the program, including exams.

5.6 Completion of the Master of Science programme

The Master of Science programme must be completed no later than four years after it was begun.

[1] Or another foreign language (upon approval from the Board of Studies).
[2] The Board of Studies can grant exemption from this.

5.7 Rules and Requirements concerning the Reading of Texts in Foreign Languages and a Statement of the Foreign Language Knowledge this Assumes

It is assumed that the student can read academic texts in English.