The Faculty of Engineering and Science
The Study Board for Civil Engineering

AALBORG UNIVERSITY
DENMARK

Curriculum for

The Master's Programme in

Indoor Environmental and Energy Engineering

Aalborg University

September 2017

Version 2

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dekan

Campus: Aalborg

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Preface:
Pursuant to Act 261 of March 15, 2015 on Universities (the University Act) with subsequent changes, the following curriculum for the Master's program in Indoor Environmental and Energy Engineering is stipulated. The program also follows the Joint Programme Regulations and the Examination Policies and Procedures for The Faculty of Engineering and Science.

Table of Contents

Chapter 1: Legal Basis of the Curriculum, etc.

1.1 Basis in ministerial orders

The Master's program in Indoor Environmental and Energy Engineering is organised in accordance with the Ministry of Science, Innovation and Higher Education's Order no. 1061 of June 30, 2016 on Bachelor's and Master's Programs at Universities (the Ministerial Order of the Study Programs) and Ministerial Order no. 1062 of June 30, 2016 on University Examinations (the Examination Order). Further reference is made to Ministerial Order no. 258 of March 18, 2015 (the Admission Order) and Ministerial Order no. 114 of February 13, 2015 (the Grading Scale Order) with subsequent changes.

1.2 Faculty affiliation

The Master's programme falls under the Faculty of Engineering and Science, Aalborg University.

1.3 Board of Studies affiliation

The Master's programme falls under the Board of Studies for Civil Engineering in the School of Engineering and Science. The programme belongs to the Institutions of Higher Education in Engineering's nationwide External Examiner Corps in the field of Civil Engineering.

1.4. External Evaluation Corps

The programme falls under the external evaluator corps: ingeniøruddannelernes censorkorps - bygning

Chapter 2: Admission, Degree Designation, Programme Duration and Competence Profile

2.1 Admission

Applicants with a legal claim to admission (retskrav):
Applicants with one of the following degrees are entitled to admission:

- Bachelor of Science in Engineering (Civil Engineering with specialisation in Indoor Environmental Energy), Aalborg University
- Bachelor of Science in Engineering (Civil Engineering; Indoor Environmental and Energy Engineering)

Applicants without legal claim to admission:
Bachelor's programmes qualifying students for admission:

- Bachelor of Engineering in Civil Engineering with specialization in Indoor Environmental Engineering, Aalborg University
- Bachelor of Science in Architectural Engineering, Technical University of Denmark
- Bachelor of Engineering in Architectural Engineering, Technical University of Denmark
- Bachelor of Science in Civil Engineering, Technical University of Denmark
- Bachelor of Engineering in Civil Engineering with specialization in Building Energy, Technical University of Denmark
- Bachelor of Engineering in Architectural Engineering with specialisation in Energy and Indoor Climate, Aarhus University
- Bachelor of Engineering in Civil and Structural Engineering with specialisation in Energy and Indoor Climate, Aarhus University
- Bachelor of Engineering in Civil Engineering with specialisation in Energy Design. VIA University College, Horsens

All applicants must, as a minimum, document English language qualifications comparable to an "English B level" in the Danish upper secondary school (gymnasium) (the Admission Order).

2.2 Degree designation in Danish and English

The Master's program entitles the graduate to the designation civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i indeklima og energi. The English designation is: Master of Science (MSc) in Engineering (Indoor Environmental and Energy Engineering).

2.3 The programme's specification in ECTS credits

The Master's programme is a 2-year, research-based, full-time study programme. 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 Candidatus graduate has the following competency profile:**
> A Candidatus graduate has competencies that have been acquired via a course of study that has taken place in a research environment.

A Candidatus graduate is qualified for employment on the labour market on the basis of his or her academic discipline as well as for further research (PhD programmes). A Candidatus graduate has, compared to a Bachelor, developed his or her academic knowledge and independence so as to be able to apply scientific theory and method on an independent basis within both an academic and a professional context.

2.5 Competence profile of the programme

The graduate of the Master's programme:

Knowledge

- Must be able to describe the mathematical models for the dynamic conditions of buildings and HVAC systems
- Must have knowledge about basic architectural design methodology, the integrated design process and integrated building concepts
- Must understand the relationship between the thermal comfort, indoor air quality and health issues and the heat, mass and momentum transfer in the micro-environment of a human being
- Must have knowledge about the design philosophy and calculation methods which can be used to minimize the environmental impact of a building throughout its life cycle
- Must be able to describe the energy system of a building and its interaction with the Building Energy Management Systems (BEMS)
- Must be able to understand the background and theory of sensitivity analysis and uncertainty analysis in indoor environmental and energy engineering
- Be able to critically evaluate knowledge and identify new scientific problems within the field of Indoor Environmental and Energy Engineering

Skills

- Must be able to evaluate buildings by using assessment and certification methods for high performance buildings
- Must be able to apply both simple and advanced calculation methods for analysis and simulation of temperature conditions and heat flows in buildings and elements in HVAC systems under dynamic load conditions
- Must be able to apply, combine and evaluate advanced methods for analysis of the interplay between energy systems, architectural concepts, building design, building use, outdoor climate and HVAC systems both in the design and operation of buildings
- Must be able to investigate, explain and develop indoor environmental and energy engineering models using sensitivity analysis and uncertainty analysis
- Must be able to perform CFD simulations in ventilation settings including the establishment of proper boundary conditions
- Be able to apply a wide range of engineering methods in research and development in the field of Indoor Environmental and Energy Engineering

Competencies

- Must be able to combine, optimise and evaluate models for energy transport in buildings and HVAC systems
- Must be able to handle complex and research-oriented cases related to development of low-energy, energy-neutral and energy-producing buildings

- Must be able to identify and discuss the optimal solution for an air distribution system based on theory and/or experiments
- Be competent to solve new and complicated technical problems by the use of advanced mathematics, scientific and technological knowledge

Chapter 3: Content and Organization of the Programme

The programme is structured in modules and organized 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 work and evaluation methods that combine skills and reflection:

- project work
- lectures
- classroom instructions
- study groups
- workshop
- exercises
- laboratory tests
- measurements and testing in the field
- portfolio work
- independent study

The modules are evaluated either through written or oral exams as started in the description of the modules in the Appendix.

For individual written exams the study board selects among the following possibilities:

- written exam based on handed out exercises
- multiple choice
- ongoing evaluation of written assignments

For individual oral exams the study board selects among the following possibilities:

- oral exam with or without preparation
- oral exam based on project report
- oral exam based on presentation seminar
- portfolio based oral exam

If the number of students following a module is small and/or if the number of students having to attend a re-exam is small the study board can decide that an exam is conducted either as an oral or written individual exam for economic reasons. In the first case decision must be notified before the start of the teaching activity in the latter case the students must be notified when the examination date is decided.

1st to 4th semesters of the programme 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.

3.1 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).

Of a total of 120 ECTS, 90-120 ECTS are assessed by the 7-point scale and 45-65 ECTS are assessed by external examination.

Semester		Module	ECTS	Assessment	Exam
1st		Ventilation, Airflow and Contaminant Transport in Buildings[5] (P)	15	7-point scale	External
		Numerical Methods (C)	5	7-point scale	Internal
		Fluid Mechanics and Computational Fluid Dynamics (CFD) (C)	5	7-point scale	Internal
		Building Related Fluid Mechanics (C)	5	7-point scale	Internal
2nd		Integrated Design of Buildings and Building Services[5] (P)	15	7-point scale	Internal
		Stochastic Modelling and Design Optimisation (C)	5	7-point scale	Internal
		Integrated Building Energy Design (C)	5	7-point scale	Internal
		Environmental Assessment Methods and Life Cycle Cost Analysis (C)	5	7-point scale	Internal
3rd	A	Building Commissioning and Operation[1) 5)] (P)	20	7-point scale	Internal
		Advanced Modelling of Energy Transport in Buildings and HVAC Systems[1) 5)] (P)	20	7-point scale	Internal
		Control and Analysis of Building Energy Systems (C)	5	7-point scale	Internal
		Fault Detection in Buildings (C)	5	7-point scale	Internal
	B	Academic Internship[2)] (P)	30	Pass/Fail	Internal
	C	Study at Other University (P,C)	20-30	-[3)]	-[3)]
4th		Master's Thesis (P)	30	7-point scale	External
3rd – 4th		Long Master's Thesis (P)	50	7-point scale[4)]	External[4)]
Total			120		

(P): Project module
(C): Course module

1) 20 ECTS points of project modules on the 3rd semester are elective and the student must choose one of the projects when selecting option A.
2) The study board must approve on the content of the Academic Internship, before it is commenced.
3) Assessment and exam according to the curriculum at the other university. The study board must approve on the contents before the study is commenced. The amount of ECTS followed at the other university must be between 10-30 ECTS such that the size of the master's thesis is the remainder of the ECTS up to 60 ECTS for both the 3th and the 4th semester.
4) See module description for Master's thesis. By long thesis the Master's thesis is made at the 3rd and 4th semester and is 50 ECTS plus 10 ECTS of course modules from A.
5) Students not familiar with Problem-based Learning at Aalborg University must attend the course "Problem-based Learning (PBL) and Student Responsibility" as an integrated part of the project module on 1st, 2nd or 3rd semester, at the first semester studying at Aalborg University.

The students are given options in the project modules as they can select among different projects within the same general theme. Moreover, the Master's Thesis on the 4th semester can be selected freely within the field of Indoor Environmental and Energy Engineering. The students have the choice of making a long master's thesis comprising both 3rd and 4th semester.

The study board of civil engineering can decide, that the contents of a course module on a semester is taught in the project module in the same semester, by increasing the ECTS extend of the project module by the same number of ECTS. The decision is taken regarding to capacity and/or economy.

3.2 Indoor Environmental and Energy Engineering 1st semester

3.2.1 Ventilation, Airflow and Contaminant Transport in Buildings
Ventilation, luftstrømninger og forureningstransport i bygninger

Prerequisites: Students holding a bachelor degree from another university than Aalborg University must pass the course Problem Based Learning and Project Management at Aalborg University, prior to sitting the exam.

The module builds on knowledge gained in the modules Numerical Methods, Fluid Mechanics and Computational Fluid Dynamics, Building Related Fluid Mechanics or similar.

Objective: Students who complete the module:

Knowledge:

- Must understand the theoretical and experimental assessment of heat, mass, and momentum transfer in ventilated enclosures.
- Must understand the relationship between the thermal comfort, indoor air quality and health issues and the heat, mass and momentum transfer in the micro-environment of a human being

Skills:

- Must be able to develop and perform model and/or full-scale experiments related to fluid flow and contaminant transport in ventilated enclosures
- Must be able to measure, evaluate and further develop various flow elements for typical room air distribution systems.
- Must be able to perform CFD simulations in ventilation settings including the establishment of proper boundary conditions.
- Must have the ability to design and evaluate different types of air distribution systems in a room and in a building.

Competencies:

- Must be able to identify and discuss the optimal solution for an air distribution system based on theory and/or experiments
- Must be able to perform and reflect on experiments related to personal exposure assessment and contaminant transport
- Must be able to communicate the results of the project work in a project report
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work

Type of instruction: Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format: Oral exam based on presentation seminar and project rapport.

Evaluation criteria: Are stated in the Framework Provisions.

3.2.2 Numerical Methods
Numeriske metoder

Objective: Students who complete the module:

Knowledge:

- Must be able to understand the analytical solution of partial differential equations including
  - Linear equation systems, Gaussian elimination, factorization methods
- Must be able to understand numerical solution methods including
  - Iterative solution of equations e.g. Gauss-Seidel, ill-conditioned systems of linear equations, matrix eigenvalue problems, solution of non-linear equations, interpolation, splines, numerical solution of integrals, numerical solution of first-order and second-order differential equations

Skills:

- Must be able to apply numerical methods to solve mathematical problems
- Must be able to apply finite difference and finite element methods including
  - The finite difference method
  - The finite volume method
  - Difference approximations, elliptic equations, Dirichlet og Neumann boundary conditions, parabolic equations, explicit and implicit methods, the Theta method, hyperbolic equations
  - The finite element method

Competencies:

- Must be able to apply numerical methods in engineering
- Must be able to contribute independently to professional and multidisciplinary work with a professional knowledge on numerical methods
- Must be able to identify personal learning needs and be able to structure the learning within numerical methods

Type of instruction: Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format: Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.2.3 Fluid Mechanics and Computational Fluid Dynamics (CFD)
Strømningslære og CFD

Objective: Students who complete the module:

Knowledge

- Must have knowledge about fluid kinematics
- Must have knowledge about stresses in fluids, equation of motion, constitutive models and Navier-Stokes equations
- Must have knowledge about ideal fluids and potential flows, including application of potential theory to simple problems.
- Must have knowledge and understanding of Reynolds averaging and turbulence models
- Must be able to describe turbulent and laminar boundary layers including understanding of momentum equation for boundary layers
- Must have knowledge about numerical methods in fluid mechanics.
- Must have knowledge about the finite volume method of computational fluid dynamics.
- Must have knowledge about mesh types and boundary conditions.

Skills:

- Must be able to describe assumptions and limitations of mathematical models for different types of flows
- Must be able to apply appropriate analytical, semi-empirical and numerical methods for mathematical description of fluid dynamic problems.
- Must be able to evaluate results from such methods

Competences:

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

Type of instruction: Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format: Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.2.4 Building Related Fluid Mechanics
Bygningsrelateret strømningsmekanik

Objective: Students who complete the module:

Knowledge:

- Must obtain a detailed knowledge of building related heat, mass, and momentum transport
- Must obtain knowledge of building related application of similarity principles and turbulence modelling
- Must understand different simplified procedures, as the generation of flow elements
- Must understand the principles of heat and mass transfer in the micro-environment of a human being

Skills:

- Must be able to develop the basis for model and/or full-scale experiments
- Must be able to develop flow elements for room air distribution
- Must be able to setup and perform advanced CFD simulations of ventilated buildings including occupant modelling
- Must be able to develop proper boundary conditions for CFD in ventilation
- Have the ability to choose, design and evaluate the different types of air distribution in a room and in a building
- Have the ability to apply relevant models in building related fluid mechanics

Competencies:

- The student must be able to establish, evaluate and reflect on models on room air distribution and personal exposure assessment in building related fluid mechanics
- The students must be able to combine and reflect on the various methods applied in the area of building related fluid mechanics and establish relevant solutions

Type of instruction: Project work with supervision, etc. supplemented with instructions, workshops, presentation seminars, lab tests.

Exam format: Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.3 Indoor Environmental and Energy Engineering 2nd semester

3.3.1 Integrated Design of Buildings and Building Services
Integreret design af bygninger og bygningsinstallationer

Prerequisites: The module builds on knowledge corresponding to 1st semester and knowledge gained in the modules Stochastic Modelling and Design Optimisation, Integrated Building Energy Design and Environmental Assessment Methods and Life Cycle Cost Analysis or similar.

Objective: Students who complete the module:

Knowledge:

- Must have knowledge about basic architectural design methodology, the integrated design process and integrated building concepts
- Must have knowledge on choice of passive energy technologies in relation to indoor environment and building services
- Must be able to understand the interplay between microclimate, buildings and their services
- Must be able to understand the interplay between sustainable energy system, building energy demand and renewable energy production
- Must have knowledge of stochastic performance modeling of buildings

Skills:

- Must be able to apply and combine design methods for passive energy technologies
- Must be able to apply and combine design methods for energy efficient building design
- Must be able to apply, combine and evaluate advanced methods for analysis of the interplay between energy systems, architectural concepts, building design, building use, outdoor climate and HVAC systems
- Must be able to evaluate building energy performance and assess their robustness through sensitivity and uncertainty analyses

Competencies:

- Must be able to apply proper terminology in oral, written and graphical communication and documentation of problems and solutions within integrated design of buildings and building services.
- Must be able to handle complex and research-oriented cases related to development of low-energy, energy-neutral and energy-producing buildings
- Must be able to take part in a professional and interdisciplinary collaboration on design of integrated building and energy concepts
- Must be able to communicate the results of the project work in a project report
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work

Type of instruction: Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format: Oral exam based on presentation seminar and project rapport.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.3.2 Stochastic Modelling and Design Optimisation
Stokastisk modellering og design optimering

Objective: Students who complete the module:

Knowledge:

- Must be able to understand the background and theory of sensitivity analysis and uncertainty analysis in indoor environmental and energy engineering
- Must be able to explain selected methods for stochastic modelling of indoor climate and energy consumption
- Must be able to explain how sensitivity analysis and uncertainty analysis are used in design optimization

Skills:

- Must be able to investigate, explain and develop indoor environmental and energy engineering models using sensitivity analysis and uncertainty analysis
- Must be able to quantify the influence of uncertainty in indoor environmental and energy engineering using stochastig modelling
- Must be able to apply sensitivity analysis and uncertainty analysis in design optimization

Competencies:

- Must be able to choose proper modelling of single zone and multizone buildings and discuss inherent model limitations
- Must be able to discuss and reflect on the accuracy of indoor environmental and energy engineering models subject to uncertainty

Type of instruction: Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format: Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.3.3 Integrated Building Energy Design
Integreret energidesign af bygninger

Objective: Students who complete the module:

Knowledge:
- Must have knowledge about the integrated design process
- Must have knowledge about integrated building concepts
- Must have knowledge of basic architectural design methodology
- Must have knowledge of methods for energy efficient building design
- Must have knowledge of passive energy technologies
- Must be able to understand the microclimate around buildings
- Must be able to understand the interplay between microclimate and buildings
- Must be able to describe the calculation methods related to airflow and pressure distribution around buildings
- Must be able to explain the wind and bouyancy driven flows in single zone modelling
- Describe the mathematical models for multizone modelling

Skills:
- Must be able to apply basic design methods for passive energy technologies
- Must be able to apply advanced methods for analysis of the interplay between building design, building use and outdoor climate
- Must be able to simulate and analyze the natural airflow of a single zone and a multizone building

Competencies:
- Must be able to choose proper modelling of natural and hybrid ventilation in single zone and multizone buildings and discuss inherent model limitations
- Must be able to discuss and reflect on the prospects and limitations of integrated building energy design

Type of instruction: Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format: Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.3.4 Environmental Assessment Methods and Life Cycle Cost Analysis
Bæredygtige vurderingsmetoder og LCC analyse

Objective: Students who complete the module:

Knowledge:

- Must have knowledge about the design philosophy and calculation methods for minimizing the environmental impact of a building throughout its life cycle
- Must have knowledge about the energy and environmental assessment of buildings including material production and transportation, building construction, operation, refurbishment, recycling, demolition and removal
- Must have knowledge about sustainable technologies and environmental design concepts
- Must have knowledge about assessment and certification methods for high performance buildings
- Must have knowledge about LCC analysis
- Must have knowledge about Cost Optimization

Skills:

- Must be able to perform a Life Cycle Assessment a building
- Must be able to evaluate buildings by using assessment and certification methods for high performance buildings
- Must be able to perform a LCC analysis
- Must be able to automate basic cost optimization

Competencies:

- Must be able to discuss and reflect on the prospects and limitations of Environmental Assessment Methods and Tools
- Can evaluate methodologies of building certification methods
- Must be able to evaluate and choose between different building designs based on LCC Analysis and Cost Optimization
- Must be able to discuss and reflect on the prospects and limitations of LCC Analysis and Cost Optimization

Type of instruction: Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format: Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.4. Indoor Environmental and Energy Engineering 3rd semester

3.4.1 Building Commissioning and Operation (P)
Bygningens ibrugtagning og drift

Prerequisites: The module builds on knowledge corresponding to 2nd semester and knowledge gained in Control and Analysis of Building Energy Systems and Fault Detection in Buildings or similar.

Objective: Students who complete the module:

Knowledge
- Must have knowledge about building Commissioning and Operation
- Must have knowledge about standards and state of art within building Commissioning
- Must have knowledge about energy efficient operation of buildings.

Skills
- Must be able to apply commissioning processes for energy efficient building design and operation
- Must be able to apply, combine and evaluate advanced methods for analysis of the interplay between energy systems, building use, outdoor climate, HVAC systems and Building Management Systems (BEMS)
- Must be able to analyse a building with focus on operation and reduced running cost.

Competencies:
- Must be able to apply proper terminology in oral, written and graphical communication and documentation of problems and solutions within Commissioning and Operation of building and its services
- Must be able to optimise the operation of buildings based on measurement and analysis of the performance of the building
- Must be able to handle complex cases related to Commissioning and Operation of energy efficients buildings
- Must be able to communicate the results of the project work in a project report
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work

Type of instruction: Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format: Oral exam based on presentation seminar and project rapport.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.4.2 Advanced Modelling of Energy Transport in Buildings and HVAC Systems
Avanceret modellering af energitransport i bygninger og VVS installationer

Objective: Students who complete the module:

Knowledge
- Must be able to describe the mathematical models for the dynamic conditions of buildings and HVAC systems

- Must be able to explain the analytic and/or numerical solutions of these models
- Must be able to understand how building models and HVAC system models are combined and interact

Skills

- Must be able to analyse and simulate a thermal system under varying load conditions
- Must be able to apply both simple and advanced calculation methods for analysis and simulation of temperature conditions and heat flows in buildings and elements in HVAC systems under dynamic load conditions
- Must be able to apply experimental methods for verification of the calculated systems
- Must be able to establish proper boundary conditions comprising heat conduction, radiation and convection

Competencies:

- Must be able to evaluate, optimise and combine models for energy transport in buildings and HVAC systems
- Must be able to communicate the results of the project work in a project report
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work

Type of instruction: Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format: Oral exam based on presentation seminar and project rapport.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.4.3 Control and Analysis of Building Energy Systems
Styring og analyse af bygningers energisystemer

Objective: Students who complete the module:

Knowledge:
- Must have knowledge on basic control theory, transfer functions, essential strengthening and accuracy of control
- Must have knowledge on feedback control and classical control (P, PI, PID)
- Must have knowledge on models for thermal systems and facilities
- Must have knowledge on state space modelling and control
- Must have knowledge on dynamical modelling and control of HVAC systems

Skills:
- Must be able to perform analysis and simulation of operational conditions of thermal systems and facility functions
- Must be able to setup a numerical model of the control system/design
- Must be able to device and perform control of a building HVAC system
- Must be able to prescribe functional requirements for building systems control

Competencies:
- Must be able to choose and compare different control designs and regulator types
- Must be able to establish evaluate and reflect on control of building energy systems

Type of instruction: Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format: Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.4.4 Fault Detection and Diagnosis in Buildings
Detektering af fejl og diagnosticering af bygningen og dens tekniske systemer

Prerequisites: A BSc degree in Civil Engineering, Indoor Environmental and Energy Engineering or similar and knowledge gained in the course Control and Analysis of Building Energy Systems or similar.

Objective: Students who complete the module:

Knowledge:

- Must be able to describe the energy system of a building and its interaction with the Building Energy Management Systems (BEMS)
- Must be able to understand the different communication protocols
- Must be able to explain commissioning processes
- Must have knowledge on the different sources of faults in buildings
- Must be able to describe methods and tools for fault detection at the component, subsystem or whole building level (model- and monitoring-based techniques)
- Must be able to perform time series analysis

Skills:

- Must be able to use a Building Energy Management System (BEMS)
- Must be able to select a commissioning plan based on risk and cost analysis
- Must be able to detect the sources of faults in buildings
- Must be able to apply fault detection methods and tools based on short-term tests, including Functional Performance Testing (FPT)
- Must be able to apply fault detection methods and tools based on passive monitoring of buildings

Competencies:

- Must be able to combine advanced modelling and measurement techniques to test the performance of components, sub-systems or whole buildings
- Must be able to analyse the energy system of a building and apply in practice different fault detection tools
- Must be able to rank, prioritize and solve faults

Type of instruction: Project work

Exam format: Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria: As stated in the document Vurderingskriterier.

3.4.5 Academic Internship
Projektorienteret forløb i en virksomhed

Prerequisites: Corresponding to the knowledge gained in 1st and 2nd semester or similar.

Objective: Students who complete the module:

Knowledge:

- Must have knowledge about analytical, numerical and/or experimental methods for investigation of advanced problems within the company's field.

Skills:

- Must be able to apply advanced analytical, numerical and/or experimental methods for analysis and assessment of advanced problems within the company's field.
- Must be able to compare and evaluate limitations and uncertainties related to the methods used for solving advanced problems within the company's field.

Competencies:

- Must be able to apply proper terminology in oral, written and graphical communication and documentation of problems and solutions within the company's field.
- Must be able to communicate the results of the project work in a project report

Type of instruction: Internship in a company and project work. The study board must approve on the content of the project work before the internship is commenced.

Exam format: Oral exam based on presentation seminar and project rapport.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.5 Indoor Environmental and Energy Engineering 4th semester

3.5.1 Master's Thesis (30 ECTS)
Kandidatspeciale

Prerequisites: The module builds on knowledge corresponding to the first three semesters of the master programme. (for long Master's Thesis this applies only to the two first semesters).

Objective:
After completion of the project, the student should within the following topics:

Knowledge:

- Have knowledge and comprehension within the field of the specialization at the highest international level
- Be able to critically evaluate knowledge and identify new scientific problems within the field of the specialization
- Have understanding of implications within the related research area including research ethics

Skills:

- Independently explain choice of scientific theoretical and/or experimental methods
- During the project and when finalising it make an independent and critical estimation of the chosen theories and methods as well as the analyses, results and conclusions
- Be able to apply a wide range of engineering methods in research and development in the field of specialization
- Be able to communicate relevant scientific and professional aspects of project work in a clear and systematic way both to specialists and the public

Competencies:

- Be able to work independently with a project on a specific problem within the field of the specialization at the highest international level
- Independently be able to define and analyse scientific problems and based on that make and state the reasons for the decisions made
- Be competent to solve new and complicated technical problems by the use of advanced mathematics, scientific and technological knowledge
- Be able to evaluate the progress of the project independently and select and include additional literature, experiments or data when needed in order to maintain a scientific basis for the project
- Be able to control complex and unexpected working situations and be able to develop new solutions
- Must be able to communicate the results of the project work in a project report

Type of instruction: Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format: Oral exam based on presentation seminar and project rapport.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

3.5 Indoor Environmental and Energy Engineering 4th semester

3.5.1 Master's Thesis (50 ECTS)
Kandidatspeciale

Prerequisites: The module builds on knowledge corresponding to the first three semesters of the master programme. (for long Master's Thesis this applies only to the two first semesters).

Objective:
After completion of the project, the student should within the following topics:

Knowledge:

- Have knowledge and comprehension within the field of the specialization at the highest international level
- Be able to critically evaluate knowledge and identify new scientific problems within the field of the specialization
- Have understanding of implications within the related research area including research ethics

Skills:

- Independently explain choice of scientific theoretical and/or experimental methods
- During the project and when finalising it make an independent and critical estimation of the chosen theories and methods as well as the analyses, results and conclusions
- Be able to apply a wide range of engineering methods in research and development in the field of specialization
- Be able to communicate relevant scientific and professional aspects of project work in a clear and systematic way both to specialists and the public

Competencies:

- Be able to work independently with a project on a specific problem within the field of the specialization at the highest international level
- Independently be able to define and analyse scientific problems and based on that make and state the reasons for the decisions made
- Be competent to solve new and complicated technical problems by the use of advanced mathematics, scientific and technological knowledge
- Be able to evaluate the progress of the project independently and select and include additional literature, experiments or data when needed in order to maintain a scientific basis for the project
- Be able to control complex and unexpected working situations and be able to develop new solutions
- Must be able to communicate the results of the project work in a project report

Type of instruction: Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format: Oral exam based on presentation seminar and project rapport.

Evaluation criteria: Are stated in the Document Vurderingskriterier.

Chapter 4: Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean of the Faculty of Engineering and Science and enters into force as of 1. September 2017.

Students who wish to complete their studies under the previous curriculum from 2015 must conclude their education by the summer examination period 2018 at the latest, since examinations under the previous curriculum are not offered after this time.

Chapter 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 good 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 program 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 Joint Programme Regulations for the rules on credit transfer.

5.3 Rules concerning the completion of the Master's Programme
The Master's Programme must be completed no later than four years after it was begun.

All students who have not participated in Aalborg University's PBL introductory course during their Bachelor's degree must attend the introductory course "Problem-based Learning and Project Management". The introductory course must be approved before the student can participate in the project exam. For further information, please see the School of Engineering and Science's website.

5.4 Rules for examinations
The rules for examinations are stated in the Examination Policies and Procedures published by The Technical Faculty of IT and Design, The Faculty of Engineering and Science, and the Faculty of Medicine on their website.

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

5.5 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.

5.6 Rules and requirements for the reading of texts
At programmes that are taught in Danish, it is assumed that the student can read academic texts in modern Danish, Norwegian, Swedish and English and use reference works, etc., in other European languages. At programmes taught in English, it is assumed that the student can read academic text and use reference works, etc., in English.

5.7 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.