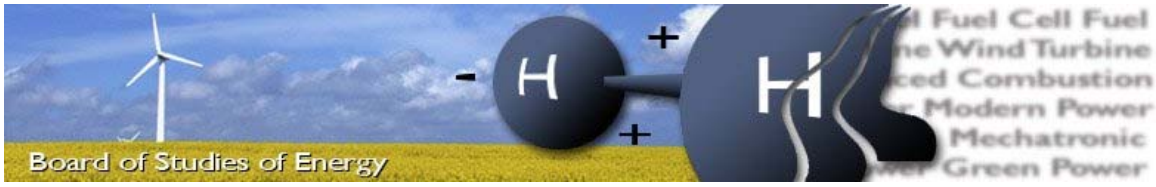


Fuel Cells and Hydrogen Technology (HyTec)

Introduction

The continuous depletion of fossil fuel reserves and environmental issues associated with the exploitation of these energy resources promote the development of automotive, stationary and consumer applications powered with fuel cells to enable a sustainable and clean future energy supply.

Fuel cells and hydrogen systems are important technologies that could contribute positively to the world energy situation. Already fuel cells are used commercially in a wide range of applications in products. Other applications will follow in subsequent decades.

Programme description

The HyTec specialisation aims at educating students to MSc standard in an innovative, dynamic and challenging environment through a blend of project work primarily focused on fuel cell and hydrogen system development and covers advanced aspects. These include energy system modelling, heat and mass transfer, control engineering and experimental work, studying the different hydrogen and fuel cell related components and energy system aspects. A new laboratory is built with possibilities to construct and operate fuel cell based technologies in real applications.

The university collaborates with several industrial partners, and with leading research institutions and universities throughout the world. These currently require new engineers, qualified in the fuel cell and hydrogen technology area.

The objectives are as follows:

- To provide students with general knowledge of the design, modelling and optimization of energy systems used in various energy production applications involving fuel cell technology.
- To enable the student to comprehend the detailed operation, functionality and interaction between the various components used in fuel cell- and hydrogen production systems.
- That the student should develop analytic skills in system integration with respect to system efficiency and control engineering aspects of fuel cell energy systems.
- To obtain the knowledge needed to construct and operate fuel cell based technologies in the laboratory and in real applications.
- To impart to the student knowledge related to the practical realisation and implementation of fuel cell systems, especially pertaining to innovative aspects, business planning and financial considerations.


Advanced Fuel Cell System experimental test facilities at Institute of Energy Technology.

The themes for the three semesters study Fuel Cells and Hydrogen Technology imparting an in-depth understanding of the technologies of fuel cell systems and for hydrogen production and storage. The programme is multidisciplinary, integrating general engineering disciplines such as thermal systems, fluid dynamics, control engineering and electrical engineering.

1st Semester (see profile description for 1st semester of the specialisations in Energy Engineering)

2nd Semester

Project theme: Modelling and optimisation of fuel cell systems

2nd semester projects will study modelling and optimization of a *physical* fuel cell- or hydrogen based system. The project serves to develop the students advanced knowledge of systems utilizing fuel cells- and hydrogen technology. The fundamental competences required for thermodynamics engineering and control of thermo-dynamic systems will be developed.

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.

The courses offered on the 2nd semester are:

- Innovation and entrepreneurship
- Optimisation theory
- Chemical reactors and mixing
- Heat and mass transfer
- Multiphase flow
- Dynamic modelling of thermal systems
- Fuel processing technology
- Combustion processes and the environment

Project examples:

- Modelling and optimization of hydrogen production systems

- Theoretical and experimental investigation of transient carbon monoxide poisoning in PEM fuel cell stacks

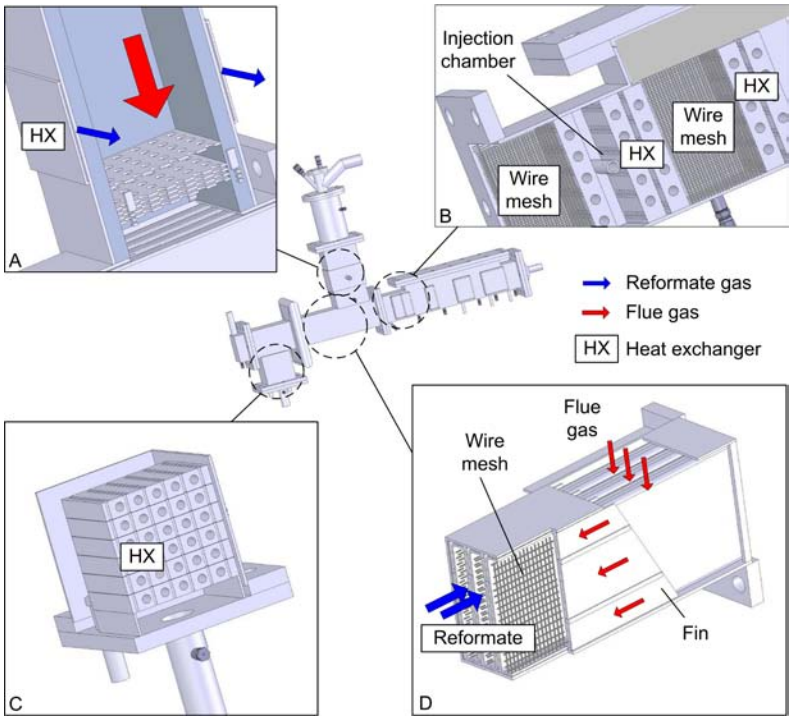
3rd Semester

Project Theme: Advanced process integration of fuel cell systems

The project should focus on the design and optimization of an advanced fuel cell system intended for either propulsion or power generation, or an advanced hydrogen production or storage facility. In the design of the plant, analytical tools are to be applied, such as numerical optimization, process integration or exergy based analysis.

In addition the plant designed should be evaluated in relation to operational variations and/or the problems arising from system dynamics. Experimental work can be included to the extent this is relevant by using existing experimental facilities at the institute or developing new laboratory setups.

A project report, and a scientific paper must be written. The paper should be presented at an internal conference at the end of the semester.



Development and characterisation of a bioethanol based hydrogen production facility.

The courses offered on the 3rd semester:

At this semester all the courses are PE courses, and the students must follow a course load corresponding to at least 8 ECTS, of which 2 ECTS are mandatory for all students under the Board of Studies of Energy, the rest is elective and can for instance be courses offered at other specialisations or research intensive packages either within the specialisation or multidisciplinary packages. The elective courses will/or can be changed from year to year.

Mandatory courses:

- Stiff systems and differential algebraic equations
- Linear optimal control theory

Courses of which at least 6 ECTS must be chosen could for instance be in the area of:

- Non-intrusive measurement methods
- Advanced CFD techniques
- Non-linear control theory
- Solution of hyperbolic partial differential equations
- Fuel cells and hydrogen technology
- Renewable energy analysis
- Wind energy technology
- Process integration and pinch technology
- Wind energy technology

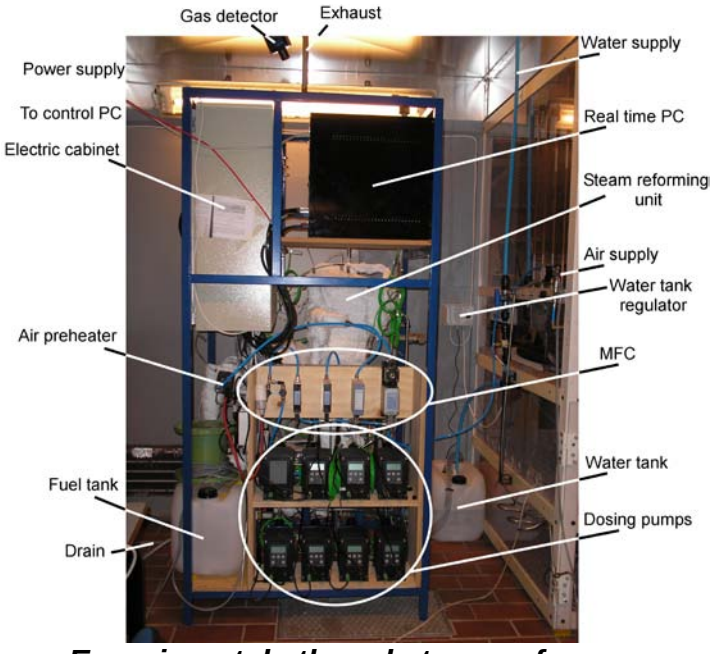
Project examples:

- Design and construction of an ethanol based laboratory fuel cell system
- Modelling and optimisation of an automotive fuel cell system
- Optimization and process integration of an integrated fuel cell reforming system

4th Semester

Project theme: Master thesis in Thermal Energy Technology

The final project may study new subjects or be an extension of the project work of previous Semesters. Subject matter will remain in the hydrogen and fuel cell area. The project may be of a 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 cell technology.



Experimental ethanol steam reformer.

Examples of master thesis projects are:

- Development of a fuel cell based automobile
- Optimization and adaptation in the energy system of fuel cell based CHP systems

Specific admission requirement

Successful completion of 1st semester of the M.Sc specialization in Thermal Energy Engineering or for international students finished Introduction Semester under the Board of Studies of Energy, or equivalent.

For further information:

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Study Advisory

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