# Module Handbook
# Sustainable Fuel Systems for Mobility - Groningen

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| Fakultät 5: Mathematik und Naturwissenschaften<br>Institut für Physik<br>*Subject:* European Master in Renewable Energy<br>Summer Term 2017 | *Category:*<br>- Master Module<br>*Degree award:*<br>- Master |
| *Emphases:*<br>- | *Sections:*<br>- |
| *Module reference number/Title:*<br>**pre381 - Processes, Models & Modelling** | |
| *Duration:* 1 semester<br>*Cycle:* once a year<br>*Type of module:* mandatory<br>*Level:* MM (master module)<br>*This module should be taken in* 2nd semester | *Type of program:* -<br>Lecture, Laboratory, Excursion<br>*Language:* English<br>*Attainable credit points:* 10,00 CP<br>*Workload:* 280 hours<br>*Required attendance:* 100 hours |
| *Person responsible for the programme:*<br>Ir. G. Kuiken | *Person responsible for this module:*<br>Prof. Dr. J. Dam |
| *Alternative person(s) responsible for this module:*<br>Dr.Ir J. Bekkering | *Examiner(s):*<br>Prof Dr. J. Dam, dr A Perl, Dr.Ir J. Bekkering |
| *Objective of the module / skills:*<br>To have demonstrated knowledge and understanding of<br>- Theoretical concepts<br>- Material Aspects<br>- Control & Measurement aspects<br>- Gas: Production/Conversion/ Treatment/Storage (Hydrogen, BioGas, Green Gas, LNG)<br>- Liquid: Gas to Liquid; Ethanol, Hydrogen, LNG<br>- Solid (Clean Coal, BioMass)<br>To be able to:<br>- Present an overview of the processes<br>- Understand the processes for fuel production with a focus on downstream<br>- Apply theory and concepts in models with a set of constraints for optimizing production and supply chains production and supply | |
| *Content of the module:*<br>Theoretical concepts<br>- Combustion | |

- Electromagnetics
- Fluid dynamics
- States (static, transients, phase change)

Materials
- Elaboration of subtopics

Control & Measurement
- Pressure, Heat, Temperature, Flow
- Equipment (valves, pipes, storage, pumps, compressors, Exchangers, Cooling)
- Instrumentation for measuring (Symbols, process diagrams, sensors)

Gas: Production/Conversion/ Treatment/Storage (Hydrogen, Bio Gas, Green Gas, LNG)
- Hydrogen: production (electrolysis, Sabatier, P2G)
- CBG & CNG: compression, storage, application
- Application of Sustainable Gasses in mobility
- Sustainability of gas supply chains
- Liquid: Gas to Liquid; Ethanol, Hydrogen, LNG
- Elaboration of subtopic lectures and lab work

Solid (Clean Coal, Biomass)
- Biochemical
- Thermochemical
- Chemical

Storage
- Introduction
- Overview non electrochemical storage devices (Compressed Air, Pumped Hydro, Fly Wheels, Superconducting magnetic energy storage, Capacitors, Comparison technologies)
- Overview electrochemical storage (Batteries, Hydrogen, Methane)

*Suggested reading:*

To be announced at the beginning of the lecture period

*Comments:*

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*Weblink:*

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*Prerequisites for admission:*

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*Helpful previous knowledge:*

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*Associated with the module(s):*

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*Maximum number of students / selection criteria:*

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*Types of examinations:*

Theoretical Concepts (20%): Written exam (1.5 hours)

Measurement & Control (20%): Assignment (written report and presentation)

Fuels (20%): Assignment (written report and presentation)

Storage (20%): Written exam (1.5 hours)

Supply Chain Design (20%): Assignment (written report and presentation)

*Examination periods:*

Theoretical Concepts: April

Measurement & Control: March

Fuels: March

Storage: March

Supply Chain Design: April

*Registration procedure:*

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| *Emphases:*<br>- | *Sections:*<br>- |

*Module reference number/Title:*

## pre382 - Biochemical Conversion

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| *Duration:* 1 semester<br>*Cycle:* once a year<br>*Type of module:* mandatory<br>*Level:* MM (master module)<br>*This module should be taken in* 2nd semester | *Type of program:* -<br>Lecture, Laboratory, Excursion, Tutorial<br>*Language:* English<br>*Attainable credit points:* 10,00 CP<br>*Workload:* 280 hours<br>*Required attendance:* 100 hours |
| *Person responsible for the programme:*<br>Ir. G. Kuiken | *Person responsible for this module:*<br>Dr. J.P. Nap, Dr. F. Faber, Dr. M. Ciepliek (ECN) |
| *Alternative person(s) responsible for this module:*<br>- | *Examiner(s):*<br>Dr. F. Faber, Dr. M. Barankin, Dr. M Ciepliek (ECN) |

*Objective of the module / skills:*

To have demonstrated knowledge and understanding of
- Chemistry to calculate the thermodynamic outcome of various (bio-) chemical reactions.
- Distinguishing the many choices in biological conversion processes
- The practical challenges that influence availability and reliability of a plant
- Unit operations that are required for a given process

To be able to
- Make mass and energy balances in biological conversion processes
- Set up a biological conversion experiment (e.g. anaerobic digestion or photo bioreactors)
- Model a biofuel production plant and calculate energy conversion efficiencies
- Contribute to discussions with experts

Basic biochemistry
- Molecule concept (Basic chemistry)
- Thermodynamics (calculations on energy and work of chemical reactions)
- Metabolism: various metabolic processes related to biofuel production
  - Photosynthesis: energy efficiencies and energy content
  - Biomass: sources and availability, composition

The making of renewables
- Types of biofuels (Bio-ethanol, Bio-methane, Bio-diesel, Bio-hydrogen, Bio-kerosene and bio-oil, Power to biofuel, Comparison with fossil)

- Biological conversion techniques
  - Anaerobic Digestion (Bio-methane)
  - Fermentation (Bio-ethanol)
  - Fermentation (Bio-hydrogen)
  - Transesterification (Bio-Diesel)
- Pre-treatment technology: increasing conversion efficiencies
- Modelling: calculations on microbial growth and biofuel production
- Bioreactor design and operation, bio-methane, bio-ethanol and algal oils (foto bioreactors)
- New technologies in biofuel productions (increasing efficiencies by genetic engineering)
- Economy: modelling and LCA analysis for cost effect biofuel production

The use of biofuels
- Bio refinery and upgrading
- End-use specifications (combustion properties, energy density, storage properties, logistics)
- Mobility
  - Fuel suitability
  - Engine types
  - E-bike; hybrid car, other
  - Infrastructure
- Energy balance
  - Evaluation business cases

*Suggested reading:*

To be announced at the beginning of the lecture period

*Comments:*

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*Weblink:*

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*Prerequisites for admission:*

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*Helpful previous knowledge:*

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*Associated with the module(s):*

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*Maximum number of students / selection criteria:*

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*Types of examinations:*

Basic Chemistry (20%): Written exam (1.5 hours)

Making (30%): Written exam (1.5 hours)

BioEthanol (20%): Assignment (written report and presentation)

Aspen Programming (30%): Assignment (written report and presentation)

*Examination periods:*

May

*Registration procedure:*

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| *Emphases:*<br>- | *Sections:*<br>- |

*Module reference number/Title:*

## pre383 - Thermochemical Conversion

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| *Duration:* 1 semester<br>*Cycle:* once a year<br>*Type of module:* mandatory<br>*Level:* MM (master module)<br>*This module should be taken in* 2nd semester | *Type of program:* -<br>Lecture, Laboratory, Tutorials<br>*Language:* English<br>*Attainable credit points:* 5,00 CP<br>*Workload:* 140 hours<br>*Required attendance:* 50 hours |
| *Person responsible for the programme:*<br>Ir. G. Kuiken | *Person responsible for this module:*<br>Prof. Dr. J. Dam |
| *Alternative person(s) responsible for this module:*<br>- | *Examiner(s):*<br>Prof. Dr. J. Dam |

*Objective of the module / skills:*

To have demonstrated knowledge and understanding of
- distinguishing between many choices in thermochemical conversion processes
- unit operations that are required for a given process
- the practical challenges that influence availability and reliability of a plant
- literature being published in the field

To be able to
- make mass and energy balances
- evaluate new concepts in terms of efficiency and economics
- set up a conversion experiment
- contribute to discussions with experts

*Content of the module:*

1. Conversion techniques:
- Combustion
- Torrefaction
- Pyrolysis
- Gasification
- Hydrothermal Upgrading

2. Reactor design / modelling

*Suggested reading:*

To be announced at the beginning of the lecture period

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| *Comments:*<br>-<br>*Weblink:*<br>-<br>*Prerequisites for admission:*<br>- | *Helpful previous knowledge:*<br>-<br>*Associated with the module(s):*<br>- |

*Maximum number of students / selection criteria:*

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*Types of examinations:*

Assignment (written report and presentation)

*Examination periods:*

June

*Registration procedure:*

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| *Emphases:*<br>- | *Sections:*<br>- |
| *Module reference number/Title:*<br>**pre384 - New Business** | |
| *Duration:* 1 semester<br>*Cycle:* once a year<br>*Type of module:* mandatory<br>*Level:* MM (master module)<br>*This module should be taken in* 2nd semester | *Type of program:* -<br>Lecture, Laboratory, Excursion, Tutorials<br>*Language:* English<br>*Attainable credit points:* 5,00 CP<br>*Workload:* 140 hours<br>*Required attendance:* 50 hours |
| *Person responsible for the programme:*<br>Ir. G. Kuiken | *Person responsible for this module:*<br>Dr. M. Schoondorp |
| *Alternative person(s) responsible for this module:*<br>- | *Examiner(s):*<br>Dr. M. Schoondorp |
| *Objective of the module / skills:*<br>To have demonstrated knowledge and understanding of<br>- The various context factors and issues around sustainable fuel systems, mobility and system integration<br>- Working with energy concepts and issues around sustainable fuel systems and mobility<br>To be able to<br>- evaluate legal and social issues around sustainable fuel systems, mobility and system integration<br>- judge and provide argumentation turning theory into practice<br>- integrate concepts and new developments in solutions<br>- perform a basic LCA (hands-on) and interpret the outcomes of more complex LCA | |
| *Content of the module:*<br>- Concept of Algae Fuels<br>- Business Model Theory<br>- Life Cycle analysis, regulation, risk assessment, finance<br>- Development of own concepts<br>- The art of elevator pitches | |
| *Suggested reading:*<br>Algae Biofuels (pdf)<br>Outline Business Model Canvas (provided) | |

| Scientific Articles (provided) | |
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| *Comments:*<br>-<br>*Weblink:*<br>-<br>*Prerequisites for admission:*<br>- | *Helpful previous knowledge:*<br>-<br>*Associated with the module(s):*<br>- |
| *Maximum number of students / selection criteria:*<br>-<br>*Types of examinations:*<br>Concepts of Algae Fuels (20%): Assignment (written report and presentation)<br>Business Model Theory and LCA Regulation (40%): Assignment (written report and presentation)<br>Development of own concepts & the elevator pitches (40%): Oral presentation<br>*Examination periods:*<br>May<br>*Registration procedure:*<br>- | |