Hanzehogeschool Groningen
University of Applied Sciences

European Master in Renewable Energy (MSc)

Short Module Descriptions Handbook
Core semester 2021-2022

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1. Short Module Descriptions Handbook

1.1. Introduction

The European Master Renewable Energy (EMRE) program is defined by ***Program Learning Outcomes*** and ***Module Learning Outcomes contained in (learning) Modules.*** An overview of the modules of EMRE is given below. The modules are divided in CORE Modules , Specialization Semester modules and the Thesis Module.

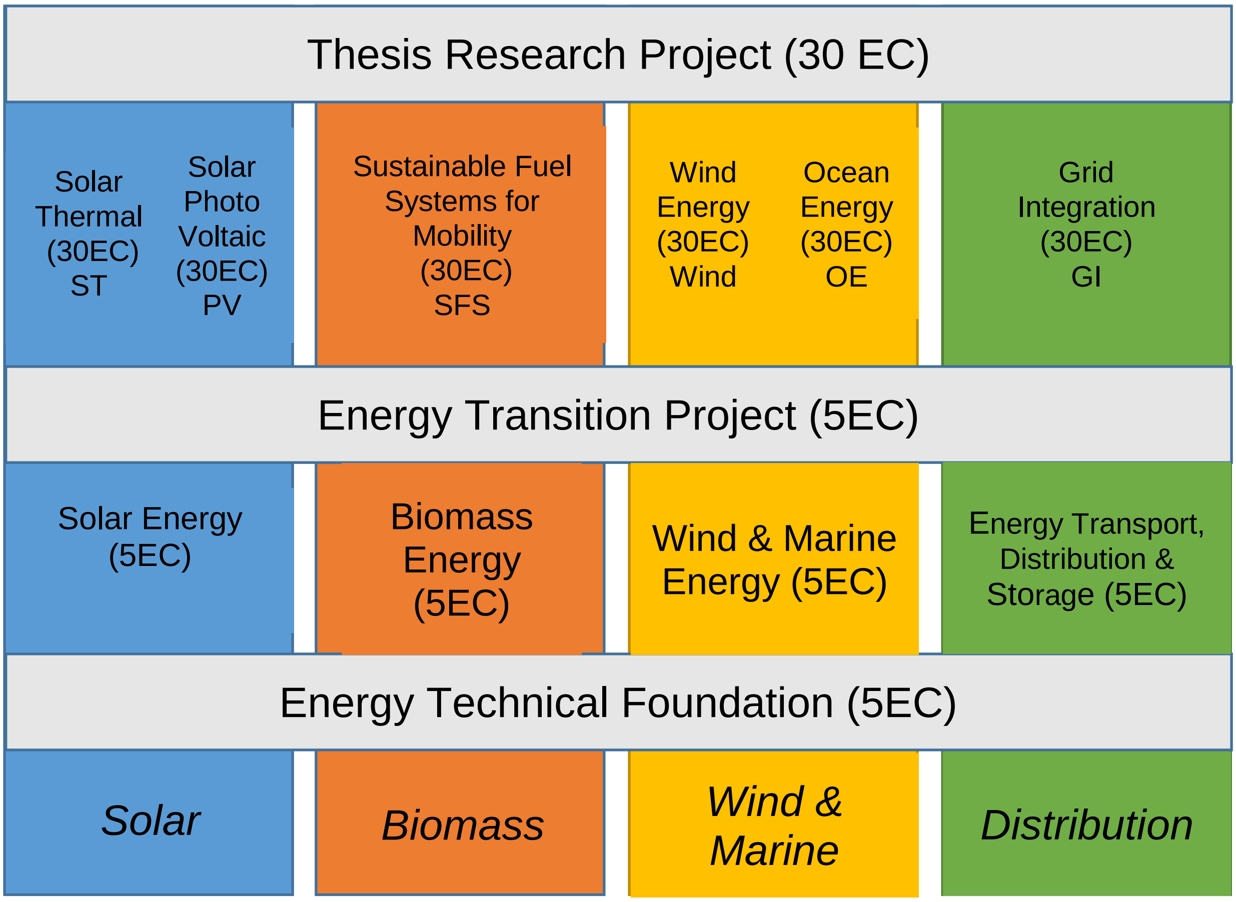

Figure 1: Overview of the EMRE modules throughout the master

1.2. Programme Learning Outcomes

EMRE at Hanze UAS is defined by the following programme learning outcomes.

E2.1
(A) Academic learning outcomes: good and applicable knowledge of, and skills in, analytical and research methodology relevant for current and future renewable energy sources; being able to conduct applied research, which combines scientific rigor and practical impact, in complex professional 'real life' situations. M.Sc.-graduates will be **reflective** professionals, with a **sound grasp of research methodology**: they will be competent to conduct applied scientific research in order to implement fundamental research insights in renewable energy innovations. The M.Sc.-graduate is competent to use a range of applied research methods and techniques **independently**:

a. to formulate a problem definition, employ specific research and analysis methods and plan and conduct research on real-life non-routine problems.
b. to translate a practical problem into questions in terms of a conceptual model, to collect relevant data and to translate the outcomes of the model into answers to the original problem.
c. to apply appropriate scientific methods and techniques, mathematics, economics and other sciences in energy systems design.
d. to communicate findings in both written and oral form in English to the problem owner and other relevant stakeholders.
e. to display a reflective attitude (investigative, critical) towards the possibilities and limitations of the scientific methods used and the development of a body of knowledge and, based on that attitude, make meaningful contributions to the energy debate.

E2.2
(B) Application-oriented learning outcomes: good and **applicable** knowledge of multiple renewable energy technologies, and a higher level in at least one particular renewable energy technology. Learning attention will focus on solar, water, biomass and wind energy in the context of the analysis and/or **originality** of **design** of near energy neutral systems (as little energy loss as possible). The MSc.-graduate is competent in:

a. multiple renewable energy technologies and – depending on the specialisation chosen by the student – specialist in at least one renewable energy technology.
b. integrating renewable energy sources (wind, solar [photovoltaic, thermal], water, biomass energy) into a flexible, distributed energy system.
c. applying the principles of integrated storage techniques.
d. analysing and improving the energy efficiency of production chains (implementing innovations).

E2.3
(C) Context-oriented learning outcomes: basic understanding of issues in energy strategy and politics at different **levels of context** (local, regional, national, global).
The MSc-graduate is competent in:

a. applying knowledge and insights of the principles of a range of renewable energy systems for optimal energy conversion.
b. **designing a (range of)** renewable energy **system(s)** for optimal energy conversion at a given location and for particular applications.
c. critically appraising codes of practice relevant to renewable energy systems.
d. analysing economic and sustainability aspects of renewable energy systems as well as technological considerations.
e. statistically assessing renewable energy resources at a specific location given appropriate data.

E2.4
(D) Integrative learning outcomes: good ability to **integrate** technical knowledge and skills with technological, strategic, social and economic issues; ability to **handle complexity**.
The MSc graduate is competent in:

a. using appropriate mathematical methods for modelling and analysing engineering problems relevant to renewable energy systems.
b. using knowledge and understanding of the socio-economic effects of introducing and using relevant technologies.

c. Making an economic evaluation of the profitability and competiveness of renewable energy projects.

E1.1
(E) Communication learning outcomes: ability to communicate **appropriately** and perform efficiently in international, **multidisciplinary teams**.
The MSc graduate is competent in:

a. carrying out tasks in a project environment.
b. participating effectively in an international, multidisciplinary team.
c. communicating effectively orally, visually and in writing at an appropriate level (in English) to clients and stakeholders.
d. communicating the link between technological projects and strategic objectives, to the management and other relevant stakeholders.

E1.2
(F) Professional development learning outcomes: ability to **learn independently** and **reflect** on oneself in a professional context.
The MSc graduate is competent in:

a. staying abreast of relevant (inter)national developments, trends and ideas in society, policy, and professional practice and to translating, developing and introducing these in an innovative manner to improve professional practice.
b. managing his or her own learning process and sharing expertise with peers and other experts in professional practice.

The next chapters provide a short module description of all Core modules.

2. CORE Hanze UAS

2.1. Energy Technical Foundation

Institute for Engineering **Subject:** *European MSc in Renewable Energy Winter Term*	**Category:** *- MSc Module* **Degree award:** *- MSc*
Emphases: -	**Sections:** -
Module reference number/Title: *Energy Technical Foundation*	
Duration: 3 weeks **Cycle:** once a year **Type of module:** mandatory **Level:** MM (MSc module) *This module should be taken in 1st semester*	**Type of program:** Lectures, Tutorials, Workshop **Language:** English **Attainable credit points:** 5 EC **Workload:** 140 hours **Required attendance:** 50 hours
Person responsible for the program: C.B. Vogt, PhD	**Person responsible for this module:** dr.ir. A.A. Bellekom
Alternative person(s) responsible for this module: dr. E.J. Hengeveld, dr.ir. J. Bekkering	**Examiner(s):** All listed persons
Objective of the module: At the completion of this topic the students understand the basics of - *heat transfer* - *thermodynamics* - *fluid mechanics* - *electric circuit analysis* - *electric power* - *three phase systems* - *electricity supply* - *numerical modelling*	

Content of the module:

The technical foundation module consists of two separate courses.

1. Energy Basics/ Electrical Engineering (3EC)
   In the first weeks of the semester students refresh their knowledge of the fundamentals of energy and power, heat transfer, thermodynamics and fluid mechanics. Attention is paid to the fundamental aspects of electrical engineering. Among others, these aspects comprise matters like circuit analysis, electric power calculations, three phase systems and electricity supply. This course serves as an introduction to the technical modules.

2. Numerical Modelling (2 EC)
   In this course, the students are provided with an overview of different numerical methods that can be applied in the context of integrated energy systems. Specifically, data analysis methods, iterative and optimization methods will be discussed. For each of these methods the relevant properties will be studied. This information will allow the students to select appropriate methods to solve numerical problems based on the requirements dictated by the research context. An introduction to MATLAB and programming is also provided within this course.

Required reading:
- Bekkering, J. *Reader Energy Basics*
- Nahvi, M. and Edminster, J.A. (2018). *Schaum's Outlines, Electric Circuits.* Seventh edition. US: McGraw-Hill E-book accessible using https://hanze-on-worldcat-org.nlhhg.idm.oclc.org/oclc/1039825497
- Slides used during the lectures.

Suggested additional reading:
- Twidell, J. and Weir, T. (2015). *Renewable Energy Resources.* London, UK: Taylor & Francis Ltd
- Freris L. and Infield, D. (2020). *Renewable Energy in Power systems.* Chichester, UK: John Wiley & Sons Ltd.
- Reddy T.A. (2011). *Applied Data Analysis and modeling for Energy Engineers and Scientists.* Boston, MA: Springer.
- Montgomery D.G. and Runger G.C. (2014). *Applied Statistics and Probability for Engineers.* New York: John Wiley & Sons Inc.
- Venkataran P. (2009). *Applied Optimization with MATLAB Programming.* New York: John Wiley & Sons Inc.

Comments:
-

Weblink:
-

Prerequisites for admission:
-

Helpful previous knowledge:
-

Associated with the module(s):
- *all technology modules*

Maximum number of students / selection criteria:

-

Types of examinations:

- *Energy Basics & Electrical Engineering: Written Exam (3 EC)*
- *Numerical Modelling: Assignment (2 EC)*

Examination periods:

- Week 4

Registration procedure:

OSIRIS: ZWVH18ETF

2.2. Energy Transition Project

Institute for Engineering **Subject:** *European MSc in Renewable Energy* *Winter Term*	**Category:** - *MSc Module* **Degree award:** - *MSc*
Emphases: -	**Sections:** -
Module reference number/Title: *Energy Transition Project*	
Duration: 3 weeks **Cycle:** once a year **Type of module:** mandatory **Level:** MM (MSc module) *This module should be taken in 1st semester*	**Type of program:** Lectures, Tutorials, Workshop, Laboratory **Language:** English **Attainable credit points:** 5 EC **Workload:** 140 hours **Required attendance:**
Person responsible for the program: C. Vogt, PhD	**Person responsible for this module:** Dr. E.J Hengeveld, I. Berg
Alternative person(s) responsible for this module:	**Examiner(s):** All listed persons
Objective of the module: At the completion of this module the students should know : - *Principles of the Theory and Application of Research Methodology* At the completion of this module the students should be able to - - *Perform the capstone assignment as an Energy Research Project* - *Reflect on, write and present project results & personal Development*	

Content of the module:
This module consists of 2 courses:

1. Research Methodology and Research Project (5 EC) Research methodology is introduced with the aim to teach students how to design, conduct and report proper applied and design research results.
2. Professional Skills and Mentoring (Pass or Fail)
   The course Professional Skills and Mentoring covers the guidance in the personal professional development of the student, in presentation skills and in project based working. After this topic the student is able to make
   a. a reflection of the students professional development, which is discussed with his mentor. This reflection will be based on the PDCA-approach.
   b. a self-evaluation report and re-orientation, based on the student's progress during the core semester.

Suggested reading:

- Reynolds, G. (2011) Presentation Zen: Simple Ideas on Presentation Design and Delivery (second edition).
- Berkely: New Riders
- Robert K. Yin; Case Study Research, Design and Methods, SAGE, 5th edition 2014 ISBN 978-1-4522-4256-9 (pbk)

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

Maximum number of students / selection criteria:

-

Types of examinations:

- Assignment Research Report
- Professional Skills Personal Development Plan & Report

Examination periods:

-

Registration procedure:

OSIRIS ZWVH18ETP

2.3. Biomass Energy

Institute for Engineering **Subject***: European MSc in Renewable Energy* *Winter Term*	**Category:** *- MSc Module* **Degree award:** *- MSc*
Emphases: -	**Sections:** -
Module reference number/Title: *Biomass Energy*	
Duration: 9 weeks **Cycle:** once a year **Type of module:** mandatory **Level:** MM (MSc module) *This module should be taken in 1st semester*	**Type of program:** Lectures, Tutorials, Workshop, Laboratory **Language:** English **Attainable credit points:** 5 EC **Workload:** 140 hours **Required attendance:** 50 hours
Person responsible for the program: C. Vogt, PhD	**Person responsible for this module:** Dr. F. Faber; Dr A. Perl
Alternative person(s) responsible for this\ module:	**Examiner(s):** Dr. F. Faber
Objective of the module / skills: At the completion of this topic the students should know - The fundamentals of conversions of residual biomass and energy crops into bio-energy - The fundamentals of biomass conversion processes and devices with the emphasis on biological conversion processes, using bioreactors. At the completion of this topic the students should be able to - Select appropriate methodologies from the range of different biomass energy technologies - Processing of analytical results obtained during a practical course on biogas production into a scientific report, drawing appropriate conclusions linked to scientific literature	

Content of the module:
With fossil fuel resources becoming limiting, a possible alternative energy resource is the use of biomass. The module ‘Biomass Energy’ describes the various processes and techniques involved in conversion of the energy stored in biomass to other types of usable bio-energy. Present conversion techniques already show the ability to connect biofuels to the current infrastructure. However, the availability of biomass as well as the current conversion efficiencies of the various conversion techniques are not sufficient to replace fossil fuels.

Basic knowledge on chemical and biological conversion processes of biomass will lead to an integral approach, increasing the potentials for biomass in the fields of energy for the generation of renewable energy. The biomass conversion techniques described in the module ‘Biomass Energy’ might play just as an important role in the transition from fossil fuels to alternative energy sources as other fields of energy such as wind and solar energy. During the course various mathematical exercises will be done. These will appear in this folders wind and solar energy. This module contributes to the overall knowledge on renewable energy sources students acquire during the core of the MSc program.

The module ‘Biomass Energy’ covers energy conversion processes related to biomass. In the module students will gain basic knowledge of various biomass conversion processes and will apply this knowledge in a lab experiment producing biogas in a bioreactor.

Suggested reading:

- Biofuels Engineering Process Technology (2008) Caye Drapcho, John Nghiem, Terry Walker
- Scientific articles:

  - Ong et al (2019). Catalytic thermochemical conversion of biomass for biofuel production: A comprehensive review. Ren. Sust. Energy Reviews 113: 109266
    - Tan et al (2016). Emerging technologies for the production of renewable liquid transport fuels from biomass sources enriched in plant cell walls. Open Access - Frontiers in Plant Science 2016 (7): Article 1854

Comments: - **Weblink:** - **Prerequisites for admission**: -	**Helpful previous knowledge:** - **Associated with the module(s):** Production of bio-energy (biogas) will have an integral approach with links to other modules. Obtaining data, but also proper handling of data, as instructed in 'Research Methodology and Research Project', should be applied during the practical execution of the Lab experiments.
Maximum number of students / selection criteria: - **Types of examinations:** • Written Exam (3 EC) • Assignment (2 EC) **Examination periods:** - End of the Module **Registration procedure:** OSIRIS: ZWVH18BME	

2.4. Wind and Marine Energy

<table>
<tr><td>Institute for Engineering
Subject: European MSc in Renewable Energy
Winter Term</td><td>Category:
- MSc Module
Degree award:
- MSc</td></tr>
<tr><td>Emphases:
-</td><td>Sections:
-</td></tr>
<tr><td colspan="2">Module reference number/Title:
Wind and Marine Energy</td></tr>
<tr><td>Duration: 9 weeks
Cycle: once a year
Type of module: mandatory
Level: MM (MSc module)
This module should be taken in 1st semester</td><td>Type of program:
Lectures, Tutorials, Workshop, Laboratory
Language:
English
Attainable credit points:
5 EC
Workload:
140 hours
Required attendance:
50 hours</td></tr>
<tr><td>Person responsible for the program:
C. Vogt, PhD</td><td>Person responsible for this module:
Dr. ir. G. Schepers</td></tr>
<tr><td>Alternative person(s) responsible for this module:
Ir. W.J. Swart Ranshuysen</td><td>Examiner(s):
Dr. ir. G. Schepers; Ir W.J. Swart Ranshuysen</td></tr>
<tr><td colspan="2">Objective of the module:
<u>After completion of the module the student is able to:</u>
Perform a resource assessment on basis of wind speed measurements
Interpret and analyze wind turbine performance measurements
Make motivated wind turbine design choices
Develop a mathematical/physical model to optimize a wind turbine design in terms of energy production, loads and costs
Determine acoustic noise levels on a wind turbine
Keep an orderly lab notebook according to the lab notebook guidelines
Make a quantitative assessment of measurement and calculation errors and uncertainties
Understand the-state-of-the-art and the potential of marine energy
Report (in written form) the results of the experiments and analyses in a scientifically correct and clear form</td></tr>
</table>

Content of the module:

In terms of scientific and technical contents this module will treat the following aspects of wind energy:

- Introduction into wind energy
  - The wind energy sector in a bird view: history, markets, scenario's and roadmaps,
  - Technological challenges and concepts
  - Off-shore wind energy versus on-shore wind energy
- Wind climate and resource assessment (measurements and modelling)
  Rotor design (aerodynamics, aero-elasticity, acoustics, costs)
  Introduction into Marine energy

Suggested reading:

- https://higherlogicdownload.s3.amazonaws.com/IEAWIND/c90e3186-96d9-46cd-b06d-3ce3684613c5/UploadedImages/Annual_Report/2018_IEAWind_Annual_Report_Exec_Summ_-_web.pdf *(wind energy developments in countries associated to IEA Wind, and a description of several research tasks)*
- https://www.iea.org/offshorewind2019/ (*Recent status report on off-shore wind)*
- Twidell and Weir Chapters 7 (*Wind Resource*) and chapter 8 (*Wind Power Technology*) from Renewable Energy Resources, Routedge, 2015
- J.F. Manwell, J.G. McGowan, A.L. Rogers *Wind Energy Explained,* Wiley Publisher
- J.G. Schepers *Engineering models in Wind Energy Aerodynamics,* November 2012, https://repository.tudelft.nl/islandora/object/uuid%3A92123c07-cc12-4945-973f-103bd744ec87 (*The blade element momentum theory which is generally considered the most difficult part of this lecture is explained in section 2.1)*
- The background material for hydro energy will be based on a collection of articles, e.g.
  - W.J.M. Batten et al: *Experimentally validated numerical method for the hydrodynamic design of horizontal axis tidal turbines* Ocean Engineering Vol. 34 Nr. 7, 2007,
- Garret and Cummins, *The efficiency of a turbine in a tidal channel,* J. Fluid Mech. (2007), vol. 588, pp. 243–251.

Comments:

-

Weblink:

-

Prerequisites for admission:

-

Helpful previous knowledge:

-

Associated with the module(s):

Wind energy is one of the largest growing renewable energy sources and it is expected to contribute significantly to the EU targets on renewable energies where it is generally produced in close vicinity to local populations. This necessitates a range of social, legal, economic , environmental and technical issues to be discussed and addressed. This underlines the strong link of the Wind Energy Module with the Energy Policy Module. Moreover, the scientific methodologies needed to carry out the module successfully is taught in the Research Project and Methodology. In this module aspects on data handling and error analysis are introduced, but also guidelines are provided to keep good lab notebooks and write lab reports. Topics such as Project Management and Presentations skills are introduced in the Research Project and Methodology module as well. More fundamental theoretical aspects on statistical analysis are taught in the numerical modelling module.

The ‘capstone assignment’ reflects the integrative nature of the European MSc in Renewable Energy. Students will obtain specific knowledge for the different parts of this assignment during the various technical modules. The assignment comprises the integration of various renewable energy production alternatives in a regional setting. The acquired theoretical knowledge and exercises on wind energy design and economics, will therefore be integrated in the ‘capstone assignment’.

Maximum number of students / selection criteria:

-

Types of examinations:

- Written Exam
- Assignment
- Lab Report

Examination periods:

- End of Module

Registration procedure:

OSIRIS: ZWVH17WHE

2.5. Solar Energy

Institute for Engineering **Subject***: European MSc in Renewable Energy* *Winter Term*	**Category:** *- MSc Module* **Degree award:** *- MSc*
Emphases: -	**Sections:** -
Module reference number/Title: *Solar Energy*	
Duration: 9 weeks **Cycle:** once a year **Type of module:** mandatory **Level:** MM (MSc module) *This module should be taken in 1st semester*	**Type of program:** Lectures, Tutorials, Workshop, Practical work **Language:** English **Attainable credit points:** 5 EC **Workload:** 140 hours **Required attendance:** 50 hours
Person responsible for the program: C.B. Vogt, PhD	**Person responsible for this module:** dr.ir. A.A. Bellekom
Alternative person(s) responsible for this module: Prof. dr. A.W. Weeber (TNO), ir. E.K. Kooi	**Examiner(s):** All listed Persons
Objective of the Module: After the completion of the module the student is able to: • understand, analyse and optimize the design and operation of solar cells, modules and systems • analyse and evaluate the similarities and differences between the various technological approaches towards solar energy conversion • apply the specific features of solar energy systems for integration in the portfolio of energy technologies • analyse, synthesize and critically evaluate information and findings in the field of solar energy and present it in a clear, fact-based and convincing way • perform calculations of solar cell device operation and of power and energy production • make basic PV system calculations and simulations • measure some of the main performance indicators of solar panels • communicate plans and results with other members of the group and effectively discuss problems encountered • Present information and findings in the field of solar energy in a clear, fact-based and	

effectively discuss problems encountered.

- describe lessons learned and explain them to professional colleagues with a similar background, but without the specific knowledge of the lessons learned.
- make basic solar thermal energy calculations.

Content of the module:
In terms of scientific and technical contents this module will treat the following aspects of solar energy:
The solar resource: properties of sunlight, insolation (amount of sunlight available)
Solar energy conversion technologies compared (electricity, heat, fuels)

Photovoltaic conversion:

- the PV sector in a bird's eye view: general introduction to history, markets, scenarios, roadmaps, etc.
- basic conversion process and efficiency limitations;
- properties of semiconductors, semiconductor processing and basic semiconductor devices;
- basic solar cell design and operation, including current-voltage characteristics spectral response and quantum efficiency;
- efficiency determining factors, routes to (very) high efficiencies, Standard Test Conditions (STC-) and non-STC (i.e. field) operation;
- photovoltaics in practice: different technologies in lab and production (flat plate and concentrator), various device architectures;
- from cells to modules: module architectures, manufacturing, lifetime & reliability, efficiency definitions, field performance;
- from modules to systems: basic aspects of system design, systems losses and energy production (specific energy yield, performance ration, capacity factor, etc.)
- practical applications: examples of PV systems and their performance;
- economic aspects: system cost (price) components and their evolution, Levelized Cost of Energy(LCoE), grid parity and other indicators;
- environmental aspects: Life Cycle Analyses (LCA), energy pay-back time, materials availability (supply chain), Cradle-to-Cradle and design-for-recycling approaches.

Solar heat:

- general introduction to solar heat
- basic aspects and formulas of heat
- basic aspects of solar radiation
- short introduction to heating systems
- overview of solar thermal collectors
- overview of heat storage types
- short introduction to solar cooling
-

-short introduction to solar thermal electric power systems

Suggested reading:

- Smets, A.H.M., Jäger, K., Isabella, O., van Swaaij, R.A.C.M.M. and Zeman, M. (2016). *Solar energy: the physics and engineering of photovoltaic conversion, technologies and systems.* UIT Cambridge.
- www.pveducation.org/pvcdrom is highly recommended.
- IEA (2011). *Solar Energy Perspectives*. https://www.iea.org/publications/freepublications/publication/Solar_Energy_Perspectives2011.pdf.
- IEA (2014). *Technology Roadmap - Solar Photovoltaic Energy.* http://www.iea.org/publications/freepublications/publication/TechnologyRoadmapSolarPhotovoltaicEnergy_2014edition.pdf
- Solar Power Europe (2020), EU Market Outlook for Solar Power 2020-2024, EU Market Outlook for Solar Power, 2020–2024 – SolarPower Europe

Comments:

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Weblink:

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Prerequisites for admission*:*

-

Helpful previous knowledge:

-

Associated with the module(s):

Solar energy, in its various forms, is a key component in the portfolio of technologies needed for the transition towards a (more) sustainable energy system. Moreover, PV is the most rapidly growing of all renewables and has reached high degrees of grid penetration in selected regions already. This necessitates a range of societal, regulatory, economic, environmental and technical issues to be discussed and addressed and underlines the strong link of the Solar Energy Module with Foundation Modules 1 and 2. Moreover, the scientific and methodological basis needed for the Solar Energy Module is taught in Foundation Module 2 and the Module Research Methodology. Finally, being an integral part of the assessment, the skills obtained the Module Presentation Techniques are highly supportive to the Solar Energy Module.

Maximum number of students / selection criteria:

-

Types of examinations:

- Written Exam SLE (3 EC)
- Assignment SLE (1 EC)
- practical work SLE (1 EC)

Examination periods:

-

Registration procedure:

OSIRIS: ZWVH21SLE

2.6. Energy Transport, Distribution & Storage

Institute for Engineering **Subject***: European MSc in Renewable Energy Winter Term*	**Category:** *- MSc Module* **Degree award:** *- MSc*
Emphases: -	**Sections:** -
Module reference number/Title: *Energy Transport, Distribution & Storage*	
Duration: 6 weeks **Cycle:** every year (first semester) **Type of module:** mandatory **Level:** MM (MSc module)	**Type of program:** Lectures, Tutorials, Lab work **Language:** English **Attainable credit points:** 5 EC **Workload:** 140 hours **Required attendance:** 50 hours
Person responsible for the program: Dr. C. Vogt	**Person responsible for this module:** Dr. ir. J. Bekkering
Alternative person(s) responsible for this module: Dr. A. Perl, C.E.J van Someren MSc.	**Examiner(s):** Dr. ir. J. Bekkering, dr. A. Perl, C.E.J. van Someren MSc.

Objective of the Module:

By completing the module the student demonstrates knowledge and understanding of:

1. applicability, design and interaction of electricity, gas and heat grids
2. consequences for quality of energy supply at increasing renewable energy penetration in energy systems
3. consequences of renewable energy penetration on capacity of and congestion in existing energy systems
4. the role of storage in energy systems, and in systems with integrated renewable energy technologies in particular
5. research and analysis methods related to an experimental setup

And is able to:

6. systematically investigate possible design concepts for a storage system based on critically analysing (empirical) data, leading to a proof-of-concept design based on technical requirements
7. do calculations on capacities and quality parameters in energy systems
8. systematically report experimental setup, method, results and conclusions in a lab report

Content of the module:

In this module students will learn the basics of electricity and natural gas infrastructures, from production, transport, distribution, storage, to demand. They will learn to assess the possibilities of the integration of renewables in existing energy infrastructures: congestion problems, maintaining quality and reliability of supply. The basics of heat grids is also covered. As such, students will develop a systemic vision of energy systems.

Suggested reading:

- Freris L, Infield D, *Renewable energy in power systems*
- SBC Energy Institute, *Electricity storage factbook*, 2013
- Çengel YA, Boles MA, Kanoğlu M, *Thermodynamics – An engineering approach*, 9th edition, 2020, McGraw-Hill
- Scientific papers on storage systems and (bio)gas storage technologies will be announced.

Comments:

-

Weblink:

-

Prerequisites for admission:

-

Helpful previous knowledge:

-

Associated with the module(s):

-

Maximum number of students / selection criteria:

-

Types of examinations:

- Assignment EDS Lab Report (5 EC)

Examination periods:

- See exam table

Registration procedure:

OSIRIS: ZWVH20ETDS

Other educational needs:

- Allowed calculators in exams: Casio FX 82 MS or Texas Instruments TI-30XB or TI 30XS Multiview
- (Access to a) Windows computer with the following specs is recommended for the solar lab (PVSyst):
    - Operation system: Windows 7, Windows 8, Windows 10 (32-bit or 64-bit)
    - Other operating systems like MAC OS and LINUX are supported through the use of a virtual machine running a supported version of Windows (VirtualBox successfully tested).
    - At least 1 GB of RAM
    - At least 1 GB of free hard drive space
    - Minimal screen resolution of 1280x720 pixels
    - .NET 4.5 framework (installed by Windows Update)
    - Graphics card supporting OpenGL 2.0 or higher

Computer should be capable to run MatLab for programming

3.Hanze UAS Core Exam Table 2021-2022

European Master in Renewable Energy Semester 1 (CORE)				2021-22				Versie 6-04-2021	
	Module Code	**EC**	**Exam Type (W/O)*** **	**Written Ex Length (hrs)**	**Assessment Object**	**1st Exam Date**	**2nd Exam Date**	**1st examiner**	**2nd Examiner**
Energy Technical Foundation	ZWVH18ETF	**5**							
Theory Electrical Engineering + Energy Basics		*3*	**W**	**2**	**Computer exam**	**29-9-21**	**11-8-2021**	S. Bellekom	J. Bekkering
Assignment Numerical Modelling		*2*	O		Report			E.J. Hengeveld	S. Bellekom
Energy Transition Project	ZWVH18ETP	**5**							
Assignment Capstone RM/RP	100%	*5*	O		Report			E.J. Hengeveld	I. Berg
Professional Skills	**Pass or Fail**	*0*	O		Personal Development Plan			J. Scheepens-Hasek	C. Vogt
BioMass Energy	ZWVH18BME	**5**							
Theory	60%	*3*	**W**	**2**	**Computer exam**	**29-11-21**	**31-1-22**	F. Faber	A. Perl
Assignment BME	40%	*2*	O		Report			F. Faber	A. Perl
Wind & Marine Energy	ZWVH17WHE	**5**							
Theory	60%	*3*	**W**	**2**	**Computer exam**	**12-6-2021**	**02-02-22**	G. Schepers	W. Swart Ranshuysen
Lab WHE	20%	*1*	O		Lab Report			W. Swart Ranshuysen	G. Schepers
Assignment WHE	20%	*1*	O		Report			G. Schepers	W. Swart Ranshuysen
Solar Energy	ZWVH21SLE	**5**							
Theory	60%	*3*	**W**	**2**	**Computer exam**	**12-3-2021**	**2-1-2022**	A. Weeber/B. Kooi	S. Bellekom
Lab SLE	20%	*1*	O		Lab Report			S. Bellekom	A. Weeber
Assignment SLE	20%	*1*	O		Presentation			A. Weeber/ B. Kooi	S. Bellekom
Energy Transport, Distribution & Storage	ZWVH20ETDS	**5**							
Theory	80%	4	**W**	**2,5**	**Computer exam**	**1-10-2022**	**2-3-2022**	J. Bekkering	C. van Someren
Assignment	20%	*1*	O		Assignment			A. Perl	J. Bekkering

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