howest
university of applied sciences

European Master in
Sustainable Energy System Management (MSc)

Short Module Descriptions Handbook
Specialization:
Sustainable Energy and the Digital Transformation
2024-2025

CONTENT

1 SHORT MODULE DESCRIPTIONS HANDBOOK

1. INTRODUCTION

1.1.1 SPECIALISATION – 'SUSTAINABLE ENERGY AND DIGITAL TRANSFORMATION'

The SESyM Master focuses on the multidisciplinary aspects of energy systems. It provides management and communication skills, as well as the necessary technical knowledge to tackle the challenges of the energy system transition. The technical, legal, and economic frameworks of the system integration of all energy resources taught in an international context will make SESyM graduates high-value candidates for the entire energy industry.

The specialization 'Sustainable energy & the digital transformation' can be followed in Kortrijk – Belgium. We, Howest – Univeristy of Applied Science are located in 'Kortrijk Weide'. This part of Kortrijk is an **energy hub where research and education work closely together**. On Kortrijk Weide there is a heat grid, lots of renewable energy sources, and different research projects are integrating smart controls to control multiple buildings in real time to optimize energy flows. Next, we are investing in energy storage systems to create a fully operational smart grid at this energy campus.

If we zoom into Kortrijk Weide, you will have classes in 'The Reactor', the energy lab of Howest. At this location, researchers are working together with students in different themes such as energy storage, renewable energy sources, smart grids, Artificial intelligence, and XR…. This lab is also working closely together with industrial partners (Snowball, Alpro, Beauvent,…) & the city of Kortrijk, which is defined as a smart city.

You can apply for the specialization‘ Sustainable energy & the digital transformation’ after succeeding in the first semester at 1 of the chosen core providers. Figure 1 shows the details of the SESym track.

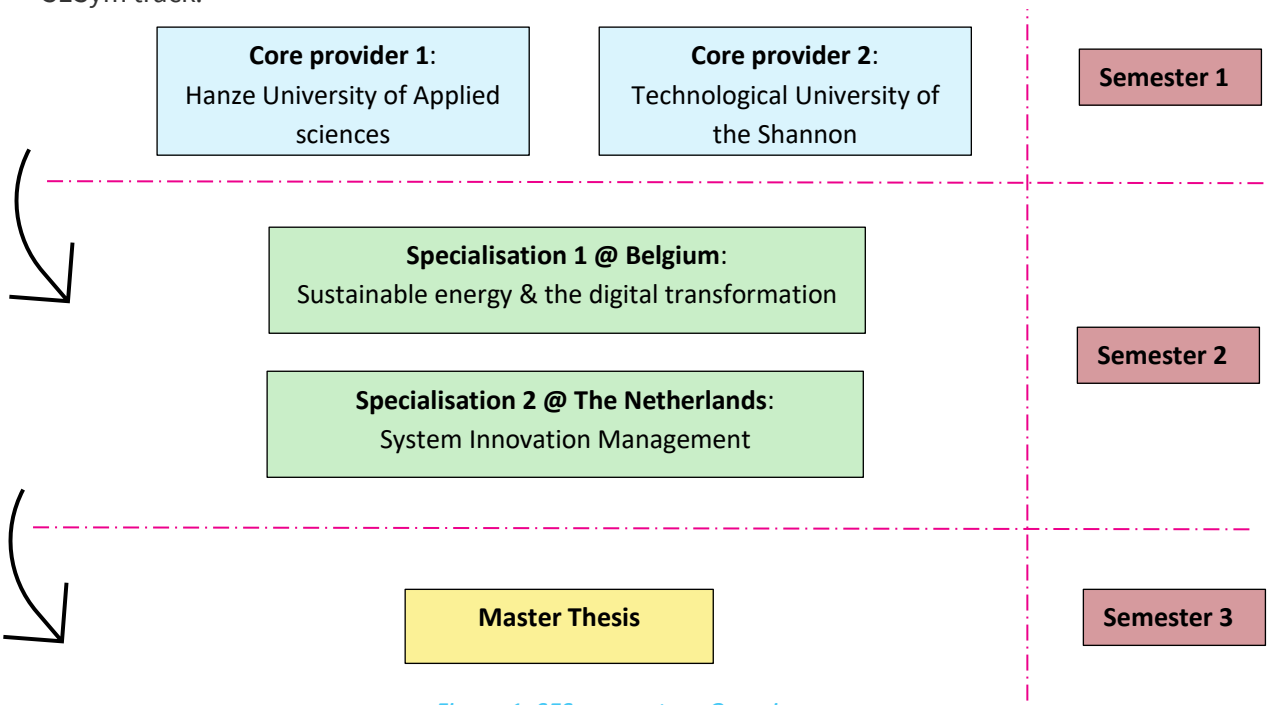

Figure 1: SESym master - Overview

The specialization ‘Sustainable energy and digital transformation’ combines various skills. This syllabus shows the details for each of the modules. This specialization offers a healthy combination of energy & digitalization. The energy transition can’t succeed without the digital aspect.

The fascinating thing about the program is that we take everyone who follows this specialization, without prior knowledge or the preliminary phase, into the digital aspect of the sustainable energy transition and this in a very understandable way. We try to do this through a healthy combination of theory, practice, and company visits. There are no specific knowledge requirements if you are accepted into the SESyM master. Of course, there is recommended course material to achieve a smooth start which can be found at the back of this handbook.

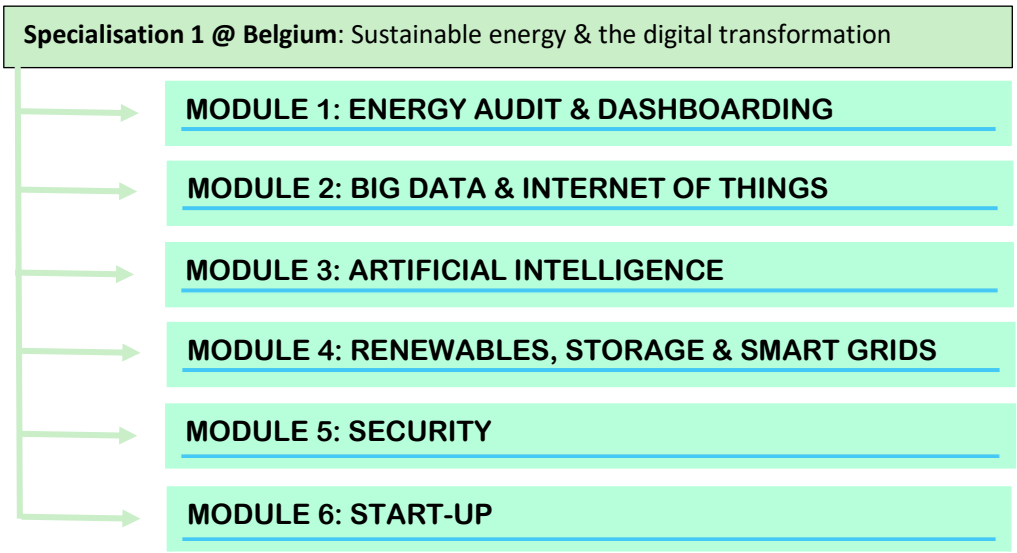

Figure 2: Program modules

2 MODULE DESCRIPTION – SPECIALISATION SEMESTER

1. ENERGY AUDIT & DASHBOARDING

1.1 OBJECTIVE OF THE MODULE

Part 1 – Energy Audits:

This module presents an overview of energy audits to identify opportunities for energy cost and energy (electrical and thermal) reduction in existing installations. Students will gain an understanding on how to procure an energy audit, how to carry out an energy audit, how to evaluate energy audits results, and how to plan the implementation of the opportunities.

Students will also be able to specify, procure, and review energy audits.

Part 2 – Dashboarding:

Building on the concepts learned in Energy Audits, this part focuses on Key Performance Indicators (KPIs) and strategic goals:

- Understanding KPIs and aligning them with strategic objectives.
- Visualizing strategic goals and KPIs to monitor progress.
- Using tools like Grafana and PowerBI to create real-time and historical data visualizations through dashboards.
- Includes a company visit to observe real-world dashboarding practices.

Part 3 – Project:

In this practical application, students will apply their theoretical knowledge to the Howest case study. Howest is a vibrant educational institution where numerous advanced technologies are present. The campus is equipped with solar panels, a charging park, energy storage (both thermal and electrical), a district heating network and CHP's among other innovations. The goal of the Howest case is to:

- Determine relevant KPIs based on the strategic goals of Howest.
- Extract and analyze the necessary information from databases.
- Create effective visualizations of these KPIs using Grafana and PowerBI.

1.2 CONTENT OF THE MODULE

Table 1 & 2 are giving a more detailed overview of the courses, responsible persons & examination details for tis module.

Table 1: Content – Module 'Energy audits & dashboarding'

Syllabus	Lectures	Tutorials
Part 1: Energy audits	20	5
- ISO 50001 - Determine an energy strategy - Creating a measurement plan - Measurement of thermal and electrical energy - Equipment - Setting up an energy audit - Key Factors of an energy audit		
Part 2: Dashboarding	5	5
- Introduction of captation & visualization of energy data with different tools (Ex. PowerBI, Grafana,…) - Building real-time and historical dashboards - Analyzing of energy data and anomaly detection (ex. Energis) - Determine key performance indicators based on strategic goals - Real examples of dashboards		
Part 3: Project	-	15
Combining the knowledge of part 1 & 2 in a practical approach on our own campus buildings. This will be done as a bigger project, where you will work together with the team & the professors.		

Suggested reading:

- Kieran Healy, Data Visualization: A Practical Introduction. Princeton University Press, 2018.
- Claus O. Wilke, Fundamentals of Data Visualization, O'Reilly Media.

Helpful previous knowledge:

- Basic Excel skills
- Understanding timeseries databases (https://www.timescale.com/blog/what-is-a-time-series-database/)

Table 2: Program details – module 'Energy audits & dashboarding'

Description	Details
Contact persons:	**Program responsible:** Van Ryckeghem Jurgen **Module responsible:** Bauwens Arne & Deryckere Ward
Language	English
Attainable credit points:	6 ECTS
Type of program:	Lectures Tutorials Team project
Type of examinations:	Theoretical exam Project presentation
Examination periods:	June/september

2. BIG DATA & INTERNET OF THINGS

2.1 OBJECTIVE OF THE MODULE

In today's interconnected world, mastering the ability to handle and interpret vast amounts of data is essential for any business professional. The "Big Data & Internet of Things" module provides an in-depth look at how sensors and devices generate massive data streams, offering both challenges and opportunities.

This course teaches you to design sophisticated IT infrastructures using cloud services to collect, process, and analyze real-time, streaming data. You'll gain practical experience through real-world case studies, learning to transform raw data into actionable insights that drive informed, timely decisions.

Whether you're looking to optimize operations, enhance customer experiences, or drive innovation, this module equips you with the skills needed to thrive in the age of digital transformation. Join us to unlock the potential of IoT and Big Data, and lead the way in business technology.

As part of this module, a company visit relevant to the covered topics will also be arranged.

2.2 CONTENT OF THE MODULE

Tables 3 & 4 give a more detailed overview of the courses, responsible persons & examination details for this module.

Table 3: Content - Module 'Big data & Internet of Things'

Syllabus	Lectures	Tutorials	Laboratory
Connecting & collecting data	6	1	8
- Connecting & authorizing devices - Ingesting data - Streaming & batch data			
Storing Data	14	1	6
- Introduction to data architecture - Relational vs. non-relation databases - Time series stores			
Cloud Services	10	1	6
- Introduction to cloud services - Cloud architecture - Cloud storage - Cloud deployment			

Suggested reading:

- Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems by Martin Kleppmann
    - Publisher: O'Reilly Media; Illustrated edition (2 May 2017)
    - ISBN: 1449373321
- Computer Networking: A Top-Down Approach by James F. Kurose
    - Publisher: Pearson Education Limited
    - ISBN: 9781292405469

Helpful previous knowledge:

- Basic computer concepts: https://learn.microsoft.com/en-us/training/paths/explore-basic-computer-concepts/
- Basic networking and Linux concepts: https://ubuntu.com/tutorials/command-line-for-beginners#1-overview

Table 4: Program details – module 'Big data & Internet of Things'

Description	Details
Contact persons:	**Program responsible:** Van Ryckeghem Jurgen **Module responsible:** Heyvaert Esli & De Gelas Johan
Language	English
Attainable credit points:	6 ECTS
Type of program:	Lectures Tutorials Laboratory
Type of examinations:	Theoretical exam
Examination periods:	June/september

3. ARTIFICIAL INTELLIGENCE

3.1 OBJECTIVE OF THE MODULE

In this module, we introduce you to the world of machine learning & Neural Networks. The programming language used in this course is Python. At the beginning, there will be an introductory tutorial to Python and the most used libraries throughout the course.

The theory will be illustrated with general examples and directly applied to challenges in the energy context such as forecasting of renewable energy, clustering of energy consumption profiles and planning of flexible assets. The first you will learn is working with time series datasets, where you should be able to identify trends, anomalies, and correlations between the variables. Next to preprocessing of the data, you will be able to select the right machine learning method to address your challenge. As a complementary experience, there is a visit to a company in the region that specialized in forecast and its use for trading energy in the spot market.

3.2 CONTENT OF THE MODULE

Tables 5 & 6 give a more detailed overview of the courses, responsible persons & examination details for this module.

Table 5: Content – Module 'Artificial Intelligence'

Syllabus	Lectures	Tutorials	Laboratory
Introduction	6	2	2
- Data Science - Introduction to AI use cases			
Machine Learning	12	-	4
Supervised learning Regression methods • Linear regression • Ensemble methods - random Forests Classification methods • Support vector machines, Hyperparameter tuning • Naive Bayes **Unsupervised Learning** Clustering			
Introduction to Neural Networks	2	-	2
- Introduction - Neural Networks & AI			

Energy cases	**-**	**3**	**-**
- Data preprocessing and visualization - Forecasting of energy consumption/generation - Clustering of energy data			

Suggested reading:

- Domingos, Pedro. The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World. Basic Books, 2015.
- James, G., Witten, D., Hastie, T., Tibshirani, R., & Taylor, J. (2023). An Introduction to Statistical Learning: with Applications in Python (1st ed.). Springer.

Helpful previous knowledge:

- Basic programming
- Python and Jupyter environment

Table 6: Program details – module 'Artificial intelligence'

Description	Details
Contact persons:	**Program responsible:** Van Ryckeghem Jurgen **Module responsible:** Acuna Roncancio Paula & Gevaert Wouter
Language	English
Attainable credit points:	6 ECTS
Type of program:	Lectures Tutorials Laboratory
Type of examinations:	Permanent evaluation of the laboratories Theoretical exam
Examination periods:	June/september

4. RENEWABLES, STORAGE & SMART GRIDS

4.1 GENERAL

In this module, we dive deeper in the energy transition. Topics such as renewable or sustainable energy sources, the challenges of energy storage, and the grid of the (near) future (smart grids) will be discussed. This course is designed to provide you with a comprehensive understanding of the latest technologies & developments in this sector. there is a practical approach through various company visits and the application of theory in practice through case studies & lab assignments in our state-of-the-art energy lab 'The Reactor'.

The 1st theme is focusing on a technological approach of different thermal & electrical renewable & sustainable energy sources. With the gained knowledge you will be able to optimize these energy sources on a specific consumer (company) profile with a technological & economical approach.

The 2nd theme is going more in detail about energy storage technologies. Energy storage is a critical component of modern renewable energy systems. In this course, we will cover various energy storage technologies, including batteries, flywheels, supercapacitors, thermal storage,… . You will learn about the importance of energy storage in balancing supply and demand, ensuring grid stability, and enabling higher penetration of renewable energy sources. We will also discuss the dimensioning of storage systems to match energy production and consumption profiles, as well as strategies for integrating and controlling these systems effectively.

The 3th theme, called Smart grids represents the future of electrical networks. This section will introduce you to the definition and characteristics of smart grids, which use advanced technology to enhance the efficiency, reliability, and sustainability of electricity distribution. We will explore the components of smart grids, such as sensors, communication systems, and advanced metering infrastructure, and discuss how they work together to create an intelligent and responsive energy network. Additionally, we will examine the control strategies for grid balancing, including demand-side management and peak shaving, and the role of electric vehicles in smart grids.

4.2 CONTENT OF THE MODULE

Tables 7 & 8 give a more detailed overview of the courses, responsible persons & examination details for this module.

Table 7: Content - module 'Renewables, storage & smart grids'

Syllabus	Lectures	Tutorials	Laboratory
Renewable energy systems	15	-	5
- Technological approach off solar energy (electricity and thermal) - Technological approach off wind energy - (μ)CHP technologies - Dimensioning of decentralized production versus consumption profiles - Control strategies for optimized self-consumption and self-sufficiency - Configuration of a renewable energy system - Importance of datasets for accurate data handling and dimensioning - Company visit 1 **–** Renewable/sustainable decentralized energy plant			
Smart Grids & Flexibility	15	-	10
- Definition & characteristics of smart grids - Problems & challenges of future grids - DC- versus AC grids - Control strategies for grid balancing (demand side management, peak shaving, dynamic price) - Electric vehicles and smart charging technologies - Smart control of assets - Flexibility (residential & industrial flexibility) - Local energy communities & energy sharing - Company visit 2: Transfo Site - Zwevegem			
Energy storage	10	-	5

- Understanding the fundamentals of storage technologies
- Electrical and thermal storage technologies
  - batteries, hydrogen, flywheels, supercapacitors, thermal storage,…
- Dimensioning storage systems (together with renewable systems) for a company
- Hybrid storage systems
- Control strategies for implementing energy storage
  ○ Optimised self-consumption, peak shaving, Time of Use,…
- Dimensioning storage systems versus yield and consumption profiles
- Company visit 3: Colruyt – Halle (Hydrogen & renewables)			

Suggested reading:

- Electricity storage and renewables: Costs and markets to 2030
    - Publisher: IRENA
    - ISBN: 978-92-9260-038-9
- Ember - https://ember-climate.org/ (weblink)

Table 8: Program details – module 'Renewables, storage & smart grids'

Description	Details
Contact persons:	**Program responsible:** Van Ryckeghem Jurgen **Module responsible:** Van Ryckeghem Jurgen, Boucquey Nikolaas
Language	English
Attainable credit points:	6 ECTS
Type of program:	Lectures Tutorials Laboratory
Type of examinations:	Permanent evaluation of the laboratories Theoretical exam
Examination periods:	June/september

5. SECURITY

5.1 GENERAL

In this module, we study the information security impact from a non-IT point of view.

Information security starts with the activity of threat modeling, which includes the identification of threats followed by the assessment of the risk imposed by these threats. Threats may be related to hackers, but can also be related to other causes such as malicious insiders, errors, and external causes (e.g. fire). The threat modeling approach mainly assumes domain knowledge and how the system is meant to be interconnected. There is no need to have programming or IT network knowledge.

This threat model is based on threats that are theoretically possible when studying the system. We then complement this view with open-source threat intelligence information about real-life threat actors. Such threat intelligence information is typically more detailed and fine-grained.

We then complete this view by identifying and describing solutions for the prioritized threats. A solution provides a contribution to the overall purpose of mitigating the prioritized risks. A solution can be a typical security solution, such as a good authentication process. The overall architectural decisions to design the system in a given way are also an indispensable part of a solution.

In order to provide you insight in such architectural designs, we cover high-level solutions of how to interconnect systems. Interconnecting systems owned by different independent parties is challenging but also important in the context of energy sharing and cooperation. We will cover some of these solutions such as blockchain and multi-party computation.

All of this needs to be performed in a growing context of legislation. The EU legislation related to data protection, information security (NIS2), and AI Act are looked at in detail.

The course goal is a group activity that develops this overall approach for a specific case in the energy-sharing context. Problem-based learning is used, with coaching or guidance from the lecturer and intermediate steps providing feedback.

Suggested reading:

- Chao Long, Jianzhong Wu, Yue Zhou, Nick Jenkins,: “Peer-to-peer energy sharing through a two-stage aggregated battery control in a community Microgrid”, Applied Energy, Volume 226, 2018, Pages 261-276, https://doi.org/10.1016/j.apenergy.2018.05.097.
- Pwc: “Use Cases for Blockchain Technology in Energy & Commodity Trading”, https://www.pwc.com/gx/en/industries/assets/blockchain-technology-in-energy.pdf
- Chao Long, Jianzhong Wu, Yue Zhou, Nick Jenkins: “Aggregated battery control for peer-to-peer energy sharing in a community Microgrid with PV battery systems,” Energy Procedia, Volume 145, 2018, Pages 522-527, https://doi.org/10.1016/j.egypro.2018.04.076.
- Mechanical Engineering Magazine: “Developing Blockchain for the Energy Sector”, https://youtu.be/AFdV530ZkWA?si=Iqp9_Q9m1mk8YQaE
- Eman Alqahtani, Mustafa A. Mustafa: “Zone-Based Privacy-Preserving Billing for Local Energy Market Based on Multiparty Computation”, July 2023, https://arxiv.org/abs/2307.08778

- Thomas Heyman, Toreon: “Threat modelling a wind farm”, https://www.cybersecuritycoalition.be/content/uploads/Threat-modeling-a-wind-farm.pdf
- I. Zografopoulos, J. Ospina, X. Liu and C. Konstantinou, "Cyber-Physical Energy Systems Security: Threat Modeling, Risk Assessment, Resources, Metrics, and Case Studies," in IEEE Access, vol. 9, pp. 29775-29818, 2021, https://ieeexplore.ieee.org/document/9351954

5.2 CONTENT OF THE MODULE

Tables 9 & 10 give a more detailed overview of the courses, responsible persons & examination details for this module.

Table 9: Content - Module 'Security'

Syllabus	Lectures	Laboratory
Threat identification	2	1
Threat impact and likelihood assessment	2	1
Threat intelligence	1	1
Security controls and architectural solutions	3	1
Legislation	2	1

Table 10: Program details – module ‘Security’

Description	Details
Contact persons:	**Program responsible:** Van Ryckeghem Jurgen **Module responsible:** Galle Johan
Language	English
Attainable credit points:	3 ECTS
Type of program:	Lectures Team project
Type of examinations:	Permanent evaluation group work Theoretical exam (multipical choiche)
Examination periods:	June/September

6. START-UP (STRATEGIC MANAGEMENT OF ENTREPRENEURIAL VENTURES)

6.1 GENERAL

In today's VUCA world strategy plays an important role in positioning a business in the market. Since strategy is all about making deliberate choices this module will explore the four key strategic avenues a startup may pursue: intellectual property, architecture, value chain, and disruption. This module will give insights into how a new business in the energy space can create a competitive advantage through validated strategic positioning.

6.2 CONTENT OF THE MODULE

Tables 11 & 12 give a more detailed overview of the courses, responsible persons & examination details for this module.

Table 11: Content – Module – 'Start-up'

Syllabus	Lectures	Tutorials
Topic 1: Traditional Strategy	2	1
Business Model Canvas recap Pestel analysis The New Business Road Test Blue Ocean Strategy		
Topic 2: Choice and Commitment	6	-
Three axioms of entrepreneurship Paradox of entrepreneurship Choosing competition Choosing customers Choosing technology Choosing identity		
Topic 3: Strategic Pathways	4	1
Investment: control vs execution Orientation: collaboration vs competition Intellectual Property Architecture Value Chain Disruption		

Suggested reading:

- Gans, Stern and Wu: Foundations of Entrepreneurial Strategy (2019)
- Rob Fitzpatrick: The Mom Test (2013)

Helpful previous knowledge:

- Understanding of business modelling and the business model cavas
- An understanding of key players in today's energy landscape

Table 12: Program details – module 'Start-up'

Description	Details
Contact persons:	**Program responsible:** Van Ryckeghem Jurgen **Module responsible:** Vansevenant Vic
Language	English
Attainable credit points:	3 ECTS
Type of program:	Lectures Tutorials
Type of examinations:	Permanent evaluation Theoretical exam (multipical choiche)
Examination periods:	June/september

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