

Deliverable D3.1

Training modules for HEI and VET students

7 Syllabuses for HE training modules

7 Syllabuses for VET training modules

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Deliverable details

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Introduction

This deliverable is embedded in the overall educational strategy of the SymbioTech project and represents the next step following the identification of training needs and the definition of the training implementation framework. It builds directly on the findings and recommendations of the **SME SymbioTech Training Needs Mapping Report and Learning Pathway's Structure (D2.2)** and the **SymbioTech Training Implementation Requirement Plan (D2.3)**, which defined the competence framework, learning outcomes, and implementation conditions required for the preparation of SymbioTech Managers in the field of Digital Industrial Symbiosis (DIS).

Against this background, the present deliverable focuses on the structured development of the content of the SymbioTech training modules. Its primary objective is to translate the strategic directions, learning objectives, and competence requirements identified in the previous deliverables into concrete, coherent, and pedagogically sound learning modules. The development of the modules follows a learner-oriented and practice-driven educational approach, placing emphasis on active learner engagement, the integration of theory with real-world application, and the development of transferable, job-relevant skills.

The modules are designed to support flexible and modular learning pathways for both Higher Education Institutions (HEI) and Vocational Education and Training (VET) levels. Each module combines theoretical foundations with applied learning activities, including case studies, digital tools, simulations, and interactive exercises, thereby fostering critical thinking, problem-solving capabilities, and cross-sectoral collaboration. These elements directly respond to the competence gaps and training priorities identified through the SymbioTech training needs analysis.

In line with the principles outlined in D2.3, the module development process is aligned with quality assurance mechanisms, micro-credential approaches, and lifelong learning principles. The training content is designed to be suitable for digital, blended, and hybrid delivery formats, enabling accessibility, scalability, and adaptability across different national and institutional contexts. Particular attention is given to ensuring coherence between learning objectives, learning outcomes, learning activities, and assessment methods across all modules.

Overall, this deliverable serves as a bridging instrument between the strategic design of the SymbioTech training programme and its practical implementation. It provides a consistent and actionable framework for module development, ensuring that the training content effectively supports the preparation of current and future SymbioTech Managers capable of designing, facilitating, and managing Digital Industrial Symbiosis initiatives within complex industrial and circular economy ecosystems.

Part A

7 Syllabuses for HE training modules

1. Concise Syllabus Template – HEI (EQF6)

Module Title: The Industrial Symbiosis (IS) framework

EQF Level: 6

ECTS Credits: 4 ECTS

Total Workload (hours): 100 hours

- Contact hours (lectures, labs, seminars, workshops, etc.): 40 hours
- Guided self-study: 30 hours
- Project work: 30 hours

Delivering Institution: UNIVERSITY OF PATRAS (UPAT), Greece

1.1 Module Overview

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This module introduces the fundamental concepts and principles of Industrial Symbiosis (IS), a key component of the European Green Deal and the EU Circular Economy Action Plan. It provides learners with a structured understanding of IS foundations, including definitions, scope, historical evolution, and connections with circular economy and eco-industrial parks. The module also explores EU policy frameworks influencing IS adoption, contemporary business models and typologies, digital matching tools and algorithms, material and energy flow mapping, stakeholder engagement strategies, and the design and evaluation of symbiotic networks. Learners additionally examine IS performance indicators, benefits, barriers, risks, and factors affecting successful implementation.

The module is designed for HEI students, educators, business managers, consultants, facilitators, research organizations, business support institutions, and policy-making bodies engaged in sustainability and resource-efficient innovation.

It serves as a foundational component of the SymbioTech training pathway, preparing participants for advanced modules on Digital Industrial Symbiosis and Environmental Management Systems.

A general understanding of sustainability or industrial operations is helpful but not required. Basic analytical skills and an interest in collaborative problem-solving support effective engagement with the module's theoretical and practical components.

1.2 Learning Outcomes (LOs)

The intended learning outcomes are divided into the three EQF domains:

▪ **Knowledge.** *Students will:*

1. comprehensively understand the IS principles/elements, barriers, benefits, the role of IS within Circular Economy frameworks and the policy contexts such as the EU Fit for 55 and taxonomy regulations (LO1),
2. be familiar with historical development and evolution from traditional IS practices to digital IS approaches (LO2),
3. be aware of the current business models through which the IS can be implemented (LO3).

▪ **Skills.** *Students can:*

4. critically analyze industrial clusters to identify symbiotic opportunities using tools such as QGIS and Sankey diagrams (LO4),
5. apply business model typologies and stakeholder analysis to design viable IS partnerships (LO5),
6. collect data, map material and energy flows, and use this data for decision-making (LO6),
7. present and communicate IS opportunities effectively in written and oral formats (LO7).

▪ **Competences (Autonomy & Responsibility).** *Students are able to:*

8. design and evaluate IS projects taking into consideration technical, economic, and environmental aspects (LO8),
9. work collaboratively in multidisciplinary teams, engaging stakeholders and managing project workflows (LO9),
10. integrate EU policies and international standards in project proposals, based on ethical and sustainability-oriented mind-set (LO10),
11. continuously improve IS knowledge and practical skills through self-direct learning and reflective practice (LO11).

1.3 Indicative Learning Schedule / Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	Introduction to IS, historical evolution and worldwide applicability.	Lecture / workshop / e-learning	IS definitions, scope, elements, motives and linkages with circular economy and eco-industrial parks. From the IS case of Kalundborg in 1960s to Digital IS of the 2020s.	LO1, LO2	Vimal et al. (2020), Neves et al. (2020), Ashton et al. (2022), Angelis-Dimakis et al. (2023), Khan et al. (2023).	Interactive lecture with guided discussion on IS, CE and sustainability issues. Case studies of success and failure stories of IS.
2	EU policy context.	Seminar / e-learning	IS fit for the EU package 55 and EU taxonomy alignment. EU regulatory frameworks related to IS.	LO1, LO10	European Green Deal, Fit for 55' package, EU taxonomy for sustainable activities.	Seminar-based introduction to EU regulations. Expert webinars.
3	Business models for IS.	Lecture / workshop / e-learning	IS business models and typologies.	LO3, LO5, LO8	Ponis (2021), Demartini et al. (2022), Erol et al. (2023), Iyer et al. (2024).	Case studies of available business models.
4	Algorithms and digital tools for IS.	Seminar / e-learning	Symbiotic matching algorithms and digital tools.	LO2, LO4	Angelis-Dimakis et al. (2021), Silva et al. (2022), Iyer et al. (2024), QGIS, SankeyMATIC Software tutorials.	Seminar-based introduction to algorithms and digital tools. Expert webinars. Hands-on labs using software tools.
5	Exchanging resources, and material and energy flows.	Lecture/ workshop / e-learning	Mapping material and energy flows in clusters.	LO6	Neves et al. (2020), Xue et al. (2023), Cagno et al. (2023).	Case studies of exchanging resources.

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
6	IS stakeholders and networks.	Lecture/ workshop / e-learning	Stakeholder analysis and engagement strategies. Design of symbiotic networks and value chains.	LO4, LO5, LO9	Neves et al. (2020), Aviso et al. (2022), Angelis-Dimakis et al. (2023), Khan et al. (2023).	Group work/brainstorming regarding stakeholders' selection criteria and engagement. Case studies of involved stakeholders to IS networks. Case studies of existing networks of IS.
7	Evaluating IS performance and IS benefits.	Lecture/ workshop / e-learning	Determining and reporting IS KPIs. Operational, economic, marketing, environmental and social benefits of IS.	LO1, LO8	Agudo et al. (2022), Agudo et al. (2023), Agudo et al. (2024), Vimal et al. (2020), Khan et al. (2023).	Group work/brainstorming to comment on IS KPIs. Group work/brainstorming to comment on and compare operational, economic, marketing, environmental, and social aspects/benefits.
8	IS barriers and risk management and factors influencing IS.	Lecture / workshop / e-learning	Barriers and risks influencing IS implementation and mitigation strategies. Factors influencing IS implementation and effectiveness.	LO1, LO2, LO3, LO8	Ponis (2021), Taqi et al. (2022), Henriques et al. (2022), Angelis-Dimakis et al., (2023), Karman et al. (2024).	Group work/brainstorming to comment on IS barriers and risks. Problem solving workshop. Group work/brainstorming to comment on factors influencing IS.
9	Practical IS project.	Project and assessment	IS opportunity assessment for a local cluster.	LO4, LO7, LO8, LO9, LO10, LO11	All the above-mentioned readings/material.	Group project presentation.
10	Exams in IS.	Assessment	Final exams and assessments.	LO1, LO2, LO3, LO7	All the above-mentioned readings/material.	Written and oral exams (open-ended questions, multiple choice questions, quizzes, etc.).

1.4 Teaching & Learning Methods

▪ *Learning approach*

A hybrid learning approach will be adopted for this module. In other words, both Synchronous and Asynchronous learning will be used. Specifically, through Synchronous learning, trainers and students will gather virtually at the same time and place (in a digital classroom) and interact in real-time. On the other hand, based on Asynchronous learning, the students can access materials which will be available on a digital platform (uploaded by trainers). These materials (e.g. pre-recorded lectures, presentations, word/pdf files, figures, videos, etc.) will describe theoretical issues and practical case studies. Thus, students can interact with each material at their own pace over longer periods.

▪ *Key Teaching methods*

Multiple key teaching methods will be used throughout the Module such as Interactive lectures with guided discussion, Case studies, Seminars, Expert webinars, Workshops, Hands-on labs, Group work and Project, Written and Oral Exams. Issues related to Industrial Symbiosis (IS), Circular Economy (CE) and Sustainability will be reflected in the above-mentioned teaching methods.

▪ *Approaches and methods supporting active learning and practical application of knowledge*

Synchronous learning approach is well-suited to creating immediate engagement of trainers and students and faster exchanging of information, thus, helping to build a sense of community and clarify misconceptions. Moreover, asynchronous learning approach is more flexible. It allows more time for students to explore and engage with material and allows access to a wider range of students.

Moreover, the key teaching methods (such as lectures) will provide the theoretical knowledge of IS for a comprehensive understanding of the IS principles, elements and practices. This knowledge along with the many practical examples provided through the practical-oriented teaching methods (such as IS case-studies, hands-on labs) set the foundations for a HEI student and a business manager to be an IS manager. Expert webinars and seminars will further contribute to enhancing the theoretical and practical knowledge of IS. Teamworking, which is promoted through teaching methods such as Workshops, Group works and Projects, makes the IS manager able to successfully collaborate with stakeholders and develop effective IS networks.

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1.5 Assessment Methods & Evidence

The Module employs a mixed assessment strategy that combines students' active participation and engagement, group project presentation and written and oral exams (open-ended questions, multiple choice questions, quizzes, etc.) to evaluate both the level of students' theoretical knowledge of the IS concept as well as their practical ability to develop sustainable and competitive IS frameworks consisting of appropriate stakeholders which exchange multiple resources. Not only summative (final graded submissions) assessments are included to support learning progression but also formative (ongoing participation and feedback during all the key teaching methods).

Assessment components & evidence of achievement of learning outcomes:

- *Participation & Engagement (Weight 10%).* Active participation in all teaching methods adopted such as lectures, case studies, seminars, webinars, workshops, hands-on labs, group work and project development.
- *Group Project presentation (Weight 30%).* A 3,000-word analytical report evaluating a real or simulated local IS opportunity, including cluster analysis, flow mapping, and business model recommendations.
- *Final written and oral exams (open-ended questions, multiple choice questions, quizzes, etc.) (Weight 60%).* Exams testing theoretical knowledge, policy understanding, and practical tools competence.

1.6 Bibliography & Tools**1.6.1 Required**

Agudo, F. L., Bezerra, B. S., & Gobbo Júnior, J. A. (2023). Symbiotic readiness: Factors that interfere with the industrial symbiosis implementation. *Journal of Cleaner Production*, 387, 135843. <https://doi.org/10.1016/j.jclepro.2023.135843>

Agudo, F. L., Bezerra, B. S., & Gobbo Júnior, J. A. (2024). An overview of Brazilian companies' readiness to implement industrial symbiosis. *Business Strategy and the Environment*, 33, 1066–1080. <https://doi.org/10.1002/bse.3327>

Agudo, F. L., Bezerra, B. S., Paesa, L. A. B., & Gobbo Júnior, J. A. (2022). Proposal of an assessment tool to diagnose industrial symbiosis readiness. *Sustainable Production and Consumption*, 30, 916–929. <https://doi.org/10.1016/j.spc.2022.01.013>

Angelis-Dimakis, A., Arampatzis, G., Alexopoulos, A., Vyrkou, A., Pantazopoulos, A., & Angelis, V. (2023). Industrial symbiosis in the Balkan-Mediterranean region: The case of solid waste. *Environments*, 10(1), <https://doi.org/10.3390/environments10010001>

Angelis-Dimakis, A., Arampatzis, G., Pieri, T., Solomou, K., Dedousis, P., & Apostolopoulos, G. (2021). SWAN platform: A web-based tool to support the development of industrial solid waste reuse business models. *Waste Management & Research*, 39(3), 489–498. <https://doi.org/10.1177/0734242X21989413>

Ashton, W. S., Chertow, M. R., & Althaf, S. (2022). Industrial symbiosis: Novel supply networks for the circular economy. In L. Bals, W. L. Tate, & L. M. Ellram (Eds.), *Circular economy supply chains: From chains to systems* (pp. 29–48). Emerald Publishing Limited. <https://doi.org/10.1108/978-1-83982-544-620221002>

Aviso, K. B., Laddaran, A., & Ngo, J. S. (2022). Modelling stakeholder goals in industrial symbiosis. *Process Integration and Optimization for Sustainability*, 6, 543–558. <https://doi.org/10.1007/s41660-022-00226-6>

Cagno, E., Negri, M., Neri, A., & Giambone, M. (2023). One framework to rule them all: An integrated, multi-level and scalable performance measurement framework of sustainability,

circular economy and industrial symbiosis. *Sustainable Production and Consumption*, 35, 55–71. <https://doi.org/10.1016/j.spc.2022.10.016>

Demartini, M., Tonelli, F., & Govindan, K. (2022). An investigation into modelling approaches for industrial symbiosis: A literature review and research agenda. *Cleaner Logistics and Supply Chain*, 3, 100020. <https://doi.org/10.1016/j.clscn.2021.100020>

Erol, I., Peker, I., Ar, I. M., & Searcy, C. (2023). Examining the role of urban-industrial symbiosis in the circular economy: An approach based on N-Force field theory of change and N-ISM-Micmac. *Operations Management Research*, 16, 2125–2147. <https://doi.org/10.1007/s12063-023-00393-w>

EU taxonomy for sustainable activities. Available at: https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

European Green Deal. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Fit for 55' package. Available at: https://commission.europa.eu/topics/climate-action/delivering-european-green-deal/fit-55-delivering-proposals_en

Henriques, J. D., Azevedo, J., Dias, R., Estrela, M., Ascenço, C., Vladimirova, D., & Miller, K. (2022). Implementing industrial symbiosis incentives: An applied assessment framework for risk mitigation. *Circular Economy and Sustainability*, 2, 669–692. <https://doi.org/10.1007/s43615-021-00069-2>

Iyer, S. V., Sangwana, K. S., & Dhiraj, D. (2024). Development of an industrial symbiosis framework through digitalization in the context of Industry 4.0. *Procedia CIRP*, 122, 515–520. <https://doi.org/10.1016/j.procir.2024.01.075>

Karman, A., Prokop, V., & Lopes de Sousa Jabbour, A. B. (2024). Circular economy practices as a shield for the long-term organisational and network resilience during crisis: Insights from an industrial symbiosis. *Journal of Cleaner Production*, 466, 142822. <https://doi.org/10.1016/j.jclepro.2024.142822>

Khan, Z. A., Chowdhury, S. R., Mitra, B., Mozumder, M. S., Elhaj, A. I., Salami, B. A., Rahman, M. M., & Rahman, S. M. (2023). Analysis of industrial symbiosis case studies and its potential in Saudi Arabia. *Journal of Cleaner Production*, 385, 135536. <https://doi.org/10.1016/j.jclepro.2023.135536>

Neves, A., Godina, R., Azevedo, S. G., & Matias, J. C. O. (2020). A comprehensive review of industrial symbiosis. *Journal of Cleaner Production*, 247, 119113. <https://doi.org/10.1016/j.jclepro.2019.119113>

Ponis, S. T. (2021). Industrial symbiosis networks in Greece: Utilising the power of blockchain-based B2B marketplaces. *The JBBA*, 4(1). [https://doi.org/10.31585/jbba-4-1-\(4\)2021](https://doi.org/10.31585/jbba-4-1-(4)2021)

QGIS Software tutorials. Available at: https://docs.qgis.org/3.40/en/docs/training_manual/index.html

SankeyMATIC Software tutorials. Available at: <https://sankeymatic.com/manual/>

Silva, M. G., de Carvalho, T. S., Castagna, A. G., Strauhs, F. do R., & Piekarski, C. M. (2022). The role of online platforms to enable the process of industrial symbiosis: An analysis of tools available in the market. *Cleaner Production Letters*, 3, 100021. <https://doi.org/10.1016/j.clpl.2022.100021>

Taqi H. M. M., Meem, E. J., Bhattacharjee, P., Salman, S., Ali, S. M., & Sankaranarayanan, B. (2022). What are the challenges that make the journey towards industrial symbiosis complicated? *Journal of Cleaner Production*, 370, 133384. <https://doi.org/10.1016/j.jclepro.2022.133384>

Vimal, K. E. K., Jayakrishna, K., Ameen, T., Afridhi, S. S., Vasudevan, V., & Sreedharan, R. (2020). An investigation on the impact of industrial symbiosis implementation on organizational performance using analytical hierarchical approach. *Benchmarking: An International Journal*, 27(2), 886–911. <https://doi.org/10.1108/BIJ-12-2018-0423>

Xue, X., Wang, S., Chun, T., Xin, H., Xue, R., Tian, X., & Zhang, R. (2023). An integrated framework for industrial symbiosis performance evaluation in an energy-intensive industrial park in China. *Environmental Science and Pollution Research*, 30, 42056–42074. <https://doi.org/10.1007/s11356-023-25232-0>

Additionally, students are required to study all educational materials (lectures, presentations, notes, worksheets, and supplementary documents) uploaded by the instructor on the course platform, as they form an integral part of the module's core learning resources.

1.6.2 Recommended

Akyazi, T., Goti, A., Bayon, F., Kohlgruber, M., & Schroder, A. (2023). Identifying the skills requirements related to industrial symbiosis and energy efficiency for the European process industry. *Environmental Sciences Europe*, 35, 54. <https://doi.org/10.1186/s12302-023-00762-z>

Barrau, E., Tanguy, A., & Glaus, M. (2024). Closing the loop: Structural, environmental and regional assessments of industrial symbiosis. *Sustainable Production and Consumption*, 50, 87–97. <https://doi.org/10.1016/j.spc.2024.07.015>

Behzad, M., Abello-Passteni, V., Videla Labayru, J. T., & Martínez Ramírez, P. (2024). Developing an assessment model for uncovering potential synergies of regional industrial symbiosis: A case study of Valparaíso region, Chile. *Journal of Cleaner Production*, 444, 141245. <https://doi.org/10.1016/j.jclepro.2024.141245>

Buda, G., & Ricz, J. (2023). Industrial symbiosis and industrial policy for sustainable development in Uganda. *Review of Evolutionary Political Economy*, 4, 165–189. <https://doi.org/10.1007/s43253-023-00097-8>

Chen, X., Dong, M., Zhang, L., Luan, X., Cui, X., & Cui, Z. (2022). Comprehensive evaluation of environmental and economic benefits of industrial symbiosis in industrial parks. *Journal of Cleaner Production*, 354, 131635. <https://doi.org/10.1016/j.jclepro.2022.131635>

Lybæk, R., Christensen, T. B., & Thomsen, T. P. (2021). Enhancing policies for deployment of industrial symbiosis: What are the obstacles, drivers and future way forward? *Journal of Cleaner Production*, 280, 124351. <https://doi.org/10.1016/j.jclepro.2020.124351>

Filimonau, V., & Ermolaev, V. A. (2022). Exploring the potential of industrial symbiosis to recover food waste from the foodservice sector in Russia. *Sustainable Production and Consumption*, 29, 467–478. <https://doi.org/10.1016/j.spc.2021.10.028>

Haq, H., Välisuo, P., Kumpulainen, L., Tuomi, V., & Niemi, S. (2020). A preliminary assessment of industrial symbiosis in Sodankylä. *Current Research in Environmental Sustainability*, 2, 100018. <https://doi.org/10.1016/j.crsust.2020.100018>

Hariyani, D., & Mishra, S. (2024). A descriptive statistical analysis of enablers for integrated sustainable-green-lean-six sigma-agile manufacturing system (ISGLSAMS) in Indian manufacturing industries. *Benchmarking: An International Journal*, 31(3), 824–865. <https://doi.org/10.1108/BIJ-06-2022-0344>

Omolola Oni, O., Nevo, C. M., Hampo, C. C., Ozobodo, K. D., Olajide, I. O., Ibidokun, A. O., Ugwuanyi, M. C., Nwoha, S. U., Okonkwo, U. U., Aransiola, E. S., & Ikpeama, C. C. (2022). Current status, emerging challenges, and future prospects of industrial symbiosis in Africa. *International Journal of Environmental Research*, 16, 49. <https://doi.org/10.1007/s41742-022-00429-2>

Sgambaro, L., Chiaroni, D., Lettieri, E., & Paolone, F. (2024). Exploring industrial symbiosis for circular economy: Investigating and comparing the anatomy and development strategies in Italy. *Management Decision, ahead-of-print*(ahead-of-print). <https://doi.org/10.1108/MD-04-2023-0658>

Yazan, D. M., van Capelleveen, G., & Fraccascia, L. (2022). Decision-support tools for smart transition to circular economy. In T. Bondarouk & M. R. Olivas-Luján (Eds.), *Smart industry – Better management* (Advanced Series in Management, Vol. 28, pp. 151–169). Emerald Publishing Limited. <https://doi.org/10.1108/S1877-636120220000028010>

2. Concise Syllabus Template – HEI (EQF6)

Module Title: Life Cycle Assessment Principles for assessing the environmental benefits and drawbacks of sharing resources

EQF Level: 6

ECTS Credits: 4 ECTS

Total Workload (hours): 100 hours

- Contact hours (lectures, labs, seminars, workshops, etc.): 30 hours
- Guided self-study: 30 hours
- Project work: 40 hours

Delivering Institution: DERMOL SVETOVANJE D.O.O. (Dermol d.o.o.), Slovenia.

2.1 Module Overview

This module introduces learners to the principles and integrated application of Life Cycle Assessment (LCA), Life Cycle Costing (LCC), and Social Life Cycle Assessment (S-LCA) using FootprintCalc software as the central tool for sustainability analysis. Its purpose is to equip learners with the ability to model, interpret, and communicate the environmental, economic, and social impacts of products and systems throughout their life cycles in line with ISO 14040/14044 standards.

Key topics include life cycle thinking, Circular Economy (CE) and Industrial Symbiosis (IS) concepts, data collection and inventory building, integration of LCC and S-LCA indicators, and interpretation of results through multi-criteria decision analysis and sustainability dashboards.

The module targets higher education students (EQF 6) preparing for careers in sustainability management, circular business design, and industrial symbiosis coordination, including future SymbioTech managers. It connects with related modules on Digital Industrial Symbiosis, Circular Business Models, and Sustainable Innovation, providing a methodological foundation for applied sustainability analysis.

Recommended prior knowledge includes a basic familiarity with sustainability principles, environmental management, or digital tools; however, no specific prerequisite modules are required.

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2.2 Learning Outcomes (LOs)

The intended learning outcomes are divided into the three EQF domains:

▪ **Knowledge.** *Students will:*

1. describe the role of sustainability, Circular Economy (CE), and Industrial Symbiosis (IS) in relation to life cycle and systems thinking (LO1),
2. identify and explain the main principles, frameworks, and interrelations of Life Cycle Assessment (LCA), Life Cycle Costing (LCC), and Social Life Cycle Assessment (S-LCA) within Life Cycle Sustainability Assessment (LCSA) (LO2),
3. understand the four main phases of an LCA (Goal and Scope Definition, Inventory Analysis, Impact Assessment, and Interpretation) and the principles, requirements, and guidelines of ISO 14040/14044 (LO3),
4. recognize how LCA supports resource efficiency, circular design, and sustainability-oriented decision-making in CE/IS contexts (LO4),
5. know the structure and purpose of web-based sustainability tools (e.g., FootprintCalc) and databases (e.g., Idemat 2025) (LO5).

▪ **Skills.** *Students can:*

6. apply ISO-based reasoning to evaluate the quality, transparency, and reliability of LCA, LCC, and S-LCA studies (LO6),
7. use web-based software (e.g., FootprintCalc) to build Bills of Materials (BoM) and Life Cycle Inventory (LCI) datasets, integrating environmental, economic, and social data (LO7),
8. apply impact assessment methods (e.g., EF 3.1, ReCiPe) to analyse and interpret sustainability results and trade-offs (LO8),
9. develop, visualise, and communicate sustainability dashboards and multi-criteria analyses (MCDA) to support informed decision-making (LO9).

▪ **Competences (Autonomy & Responsibility).** *Students are able to:*

10. conduct simplified LCA, LCC, and S-LCA studies independently using FootprintCalc (LO10),
11. critically evaluate data quality, methodological assumptions, and limitations in sustainability assessments (LO11),
12. collaborate effectively in multidisciplinary CE/IS projects and communicate sustainability recommendations clearly to diverse stakeholders (LO12).

2.3 Indicative Learning Schedule / Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	Introduction to Sustainability, CE and IS	Lecture / e-learning	Overview of sustainability concepts, Circular Economy (CE), Industrial Symbiosis (IS), and the role of life cycle thinking.	LO1	Kirchherr et al. (2017)	Interactive lecture with guided discussion, concept mapping, and a short reflection exercise.
2	Introduction to LCA, LCC, and S-LCA Conceptual Frameworks	Seminar / e-learning	Foundations of Life Cycle Assessment (LCA), Life Cycle Costing (LCC), and Social LCA (S-LCA)	LO2, LO4	Visentin et al (2021), Valdivia et al. (2021)	Seminar-based introduction to each framework. Group brainstorming and guided Discussion to compare environmental, economic, and social aspects. Case analysis of a simple product system applying the three perspectives. Q&A with instructor.
3	ISO 14040 and ISO 14044 Frameworks for Life Cycle Assessment	Seminar / e-learning	ISO principles, phases, terminology, and alignment with real-world LCA practice.	LO3, LO6	ISO (2006)	Guided walkthrough of ISO 14040/14044 structure and terminology. Group mapping of the LCA phases with practical examples. Discussion of a published LCA case study aligned with ISO standards. Instructor-facilitated reflection on challenges and good practices in ISO-conformant LCA implementation.

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
4	Building and Managing Inventory Data	Lecture / Workshop / e-learning	Create Bill of Materials and LCI dataset; import data into FootprintCalc; identify key flows and impact categories.	LO5, LO7	FootprintCalc (2024), Sustainable Impact Metrics Foundation (SIMF), 2023	Supervised lab work with real-time guidance; pair work for BoM creation; practice exercises; and troubleshooting sessions using sample datasets.
5	Environmental, Economic, and Social Assessment	Project / e-learning	Run LCA calculations using EF 3.1 or ReCiPe; integrate LCC and S-LCA indicators; visualise trade-offs using MCDA dashboards.	LO8, LO9	Valdivia et al. (2021), UNEP (2020)	Team-based project simulation; group analysis of LCA results; development of comparative dashboards; peer review of outputs.
6	Sustainability Interpretation and Decision Support	Project / Workshop / e-learning	Interpret integrated results, identify sustainability hotspots, evaluate trade-offs, and translate findings into actionable recommendations for CE/IS decisions.	LO10, LO11, LO12	Klöpffer & Grahl (2014), Daddi et al. (2017)	Problem-solving workshop, presentation practice, scenario-based discussion, and preparation of sustainability briefs and visual presentations.
7	Digital Tools for CE/IS Decision-Making	Lecture / Seminar / e-learning	Explore digital CE/IS platforms (e.g., FootprintCalc MCDA, Simapro demo sets, IS mapping tools).	LO5, LO7, LO9	Tool documentation (FootprintCalc, Simapro demo), SIMF datasets	Demonstration with guided tool exploration; short tasks modelling resource exchanges; instructor feedback

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
8	Case Studies in Industrial Symbiosis and Circular Economy	Seminar / e-learning	Examine real CE/IS cases; evaluate systemic impacts using life cycle thinking; discuss scalability and barriers.	LO1, LO4, LO11, LO12	Chertow (2007), Ažman Momirski et al. (2021)	Group case analysis; role-play of stakeholders; structured debate; comparative matrix development.
9	Policy, Standards, and Corporate Strategies Supporting LCA in CE/IS	Lecture / e-learning	EU Green Deal, taxonomy, standards, EPDs, and how policy frameworks influence LCA-based decisions.	LO2, LO3, LO6, LO11	European Commission (2020), ISO (2017) guidelines on EPDs	Interactive lecture; policy mapping; analysis of real EPDs; discussion on implications for SMEs and IS networks.
10	Final Project Integration and Presentation	Project / Workshop / Assessment	Students prepare and present a CE/IS project integrating LCA–LCC–S-LCA findings and recommendations.	LO6, LO8, LO10, LO11, LO12	All the above-mentioned readings/material	Coaching session; peer consultation; structured final presentations; reflective evaluation of project outcomes

2.4 Teaching & Learning Methods

▪ *Learning approach*

The module adopts a hybrid learning model that combines synchronous and asynchronous components. Synchronous sessions bring trainers and students together in real time in a virtual classroom, enabling direct interaction, immediate feedback, and a shared sense of community. Asynchronous learning allows students to access materials—such as pre-recorded lectures, presentations, documents, figures, and videos—through a digital platform at their own pace. These resources cover both theoretical foundations and practical case studies, giving learners flexibility while supporting deeper engagement with the content. The pedagogical strategy emphasises active and practice-oriented learning. Students apply theoretical concepts to real sustainability challenges, while also developing digital competence through structured use of LCA assessment tools (e.g., FootprintCalc) and data visualisation software.

▪ *Key Teaching methods*

Teaching methods include interactive lectures, seminars, hands-on workshops, supervised computer labs, and group projects. FootprintCalc serves as the primary analytical tool throughout the module. Learners also work with case studies, participate in peer discussions, and complete scenario-based exercises that simulate decision-making in Circular Economy (CE) and Industrial Symbiosis (IS) contexts.

▪ *Approaches and methods supporting active learning and practical application of knowledge.*

The synchronous format supports immediate engagement, real-time clarification of complex topics, and collaborative interaction among learners and trainers. In contrast, the asynchronous format offers flexibility and self-paced study, enabling students to explore materials in greater depth and broadening access for diverse learners. The combination of theoretical instruction and practical activities—such as supervised computer labs and group projects—provides a strong foundation for developing LCA-related competencies. These methods equip both HEI students and business managers with the skills needed to act as effective LCA practitioners. Collaboration and teamwork, embedded throughout the module, further prepares learners to work successfully with stakeholders in real-world sustainability and circular economy environments.

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2.5 Assessment Methods & Evidence

The module employs a mixed assessment strategy that combines project-based, practical, and reflective components to evaluate students' ability to apply FootprintCalc in integrated sustainability analysis. Both formative (ongoing feedback during workshops and labs) and summative (final graded submissions) assessments are included to support learning progression.

Assessment components & evidence of achievement of learning outcomes:

- *Group Project (Weight 40%).* A collaborative Life Cycle Sustainability Assessment (LCSA) case study using FootprintCalc, integrating LCA, LCC, and S-LCA perspectives. Evidence

includes a Bill of Materials (BoM), inventory model, impact interpretation, and a multi-criteria decision analysis (MCDA) Report or presentation.

- *Practical Lab Assignment (Weight 30%)*. Individual submission of a FootprintCalc model file accompanied by a short methodological reflection on data handling and assessment choices.
- *Individual Report (Weight 20%)*. A written reflection (approx. 1000 words) demonstrating understanding of LCSA interpretation and its relevance for decision-making in Circular Economy or Industrial Symbiosis contexts.
- *Participation (Weight 10%)*. Active engagement in workshops, peer discussions, and feedback sessions, demonstrating continuous learning and contribution to group work.

2.6 Bibliography & Tools

2.6.1 Required

Ažman Momirski, L., Mušič, B., & Cotič, B. (2021). Urban strategies enabling industrial and urban symbiosis: The case of Slovenia. *Sustainability*, 13(9), 4616. <https://doi.org/10.3390/su13094616>

Chertow, M. R. (2007). “*Uncovering*” industrial symbiosis. *Journal of Industrial Ecology*, 11(1), 11–30. <https://doi.org/10.1162/jiec.2007.1110>

Daddi, T., Nucci, B., & Iraldo, F. (2017). Using Life Cycle Assessment to measure environmental benefits of industrial symbiosis. *Journal of Cleaner Production*, 147, 157–164. <https://www.sciencedirect.com/science/article/abs/pii/S095965261730104X>

European Commission. (2020). *A new Circular Economy Action Plan for a cleaner and more competitive Europe*. Brussels: European Commission. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0098>

FootprintCalc. (2024). *FootprintCalc: Free product footprint calculator for LCA, LCC and S-LCA integration*. <https://www.footprintcalc.org/>

International Organization for Standardization. (2017). *ISO 14025:2017 — Environmental labels and declarations — Type III environmental declarations — Principles and procedures*. <https://www.iso.org/standard/64758.html>

ISO. (2006). *Environmental Management – Life Cycle Assessment – Principles and Framework (ISO 14040:2006)*. ISO. https://www.en-standard.eu/une-en-iso-14040-2006-environmental-management-life-cycle-assessment-principles-and-framework-iso-14040-2006/?gad_source=1&gad_campaignid=21676868379&gbraid=0AAAAADPppxtDLHMB7riYH8e_A8sOwoyai&gclid=Cj0KCQjw35bIBhDqARIsAGjd-cabwVmVrZsOGV8H1O8D9K-z-LUYx3gDMOrBMzl6uZDDPFNwPqRE2scaAjR6EALw_wcB

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation & Recycling*, 127, 221–232. <https://doi.org/10.1016/j.resconrec.2017.09.005>

Klöpffer, W., & Grahl, B. (2014). *Life Cycle Assessment (LCA): A Guide to Best Practice*. Wiley-VCH. [https://www.wiley.com/en-us/Life+Cycle+Assessment+\(LCA\)%3A+A+Guide+to+Best+Practice-p-9783527655649](https://www.wiley.com/en-us/Life+Cycle+Assessment+(LCA)%3A+A+Guide+to+Best+Practice-p-9783527655649)

UNEP. (2020). *Guidelines for Social Life Cycle Assessment of Products and Organizations*. <https://www.unep.org/resources/report/guidelines-social-life-cycle-assessment-products>

Sustainable Impact Metrics Foundation (SIMF). (2023). *IDEMAT database. openLCA Nexus*. <https://nexus.openlca.org/database/IDEMAT>

Valdivia, S. et al. (2021). Principles for the application of life cycle sustainability assessment. *The International Journal of Life Cycle Assessment*, 26, 1900–1905. https://www.researchgate.net/publication/353984208_Principles_for_the_application_of_life_cycle_sustainability_assessment

Visentin, F., Bonoli, A., Inal, A., Lundberg, K., Mizara, A., Zampori, L., Sala, S., Cerutti, A. K., & Cucurachi, S. (2020). Life cycle sustainability assessment: A systematic literature review. *Journal of Cleaner Production*, 263, 121430. <https://doi.org/10.1016/j.jclepro.2020.121430>

2.6.2 Recommended

Asia-Pacific Economic Cooperation (APEC). (2004). *Life cycle assessment – Best practices of ISO 14040 series*. APEC Secretariat. https://www.apec.org/docs/default-source/Publications/2004/2/Life-Cycle-Assessment-Best-Practices-of-International-Organization-for-Standardization-ISO-14040-Ser/04_cti_scsc_lca_rev.pdf

Ecochain Technologies. (2024). *Explained: LCA standards*. Ecochain Technologies Help Center. <https://helpcenter.ecochain.com/en/articles/9515835-explained-lca-standards>

European Commission, Joint Research Centre (JRC). (2010). *ILCD handbook – General guide for life cycle assessment: Detailed guidance*. Publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC48157/ilcd_handbook-general_guide_for_lca-detailed_guidance_12march2010_isbn_fin.pdf

United Nations Economic Commission for Europe (UNECE) & United States Environmental Protection Agency (EPA). (2022). *Introduction to life cycle assessment methodology and standards*. https://unece.org/sites/default/files/2022-06/1_2_GHG_EPA.pdf

2.6.3 Software & Digital Tools

FootprintCalc (Idemat 2025 Rev. A3 database), <https://www.footprintcalc.org/>

Excel / Power BI (for MCDA visualisation)

Optional: OpenLCA for comparative modelling, <https://www.openlca.org/>

3. Concise Syllabus Template – HEI (EQF6)

Module Title: Inter-organisational relations

EQF Level: 6

ECTS Credits: 4 ECTS

Total Workload (hours): 100 hours

- Contact hours (lectures, labs, seminars, workshops, etc.): 30 hours
- Guided self-study: 40 hours
- Project work: 30 hours

Delivering Institution: AKADEMIA GORNICZO-HUTNICZA IM. STANISŁAWA STASZICA W KRAKOWIE (AGH University), Poland.

3.1 Module Overview

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Inter-organisational collaboration is a foundational capability in modern sustainability transitions and circular economy transformations. Industrial Symbiosis (IS) depends on structured cooperation among diverse organisations—manufacturers, utilities, municipalities, logistics providers, technology firms, regulators, NGOs and intermediaries—who must coordinate resource exchanges, align incentives, establish shared visions and sustain cooperation over long periods of time.

This module provides a deep, comprehensive exploration of how such cooperation arises, how it evolves and how it can be strengthened. Students are introduced to the *core theoretical frameworks* explaining organisational behaviour in multi-actor systems: resource dependency theory (RDT), transaction cost economics (TCE), network theory, institutional theory, relational governance concepts and behavioural theories of trust.

At the same time, the module focuses heavily on *practice-based skills* needed in IS coordination:

- stakeholder mapping, actor analysis and network boundary identification,
- diagnosis of collaboration risks and barriers,
- designing and communicating governance structures,
- negotiation and consensus-building in complex settings,
- managing conflict, distrust and competing interests,

- detecting and addressing resistance to change,
- mediating disagreements and facilitating productive dialogue,
- fostering trust, transparency and long-term commitment.

The module emphasises *experiential, interactive and applied learning*. Students participate in extensive simulations, scenario-based workshops, conflict-resolution roleplays, and collaborative lab activities using real mapping and analysis tools like QGIS or PowerMap.

They learn to navigate real-world IS coordination challenges, such as:

- reluctance to share data or costs,
- asymmetries in power, resources and negotiation capacity,
- conflicting time horizons and strategic priorities,
- competing interpretations of risk and value,
- political pressures and institutional constraints.

Graduates of this module will be well-prepared to work as IS coordinators, circular economy facilitators, industrial cluster managers, sustainability project leaders, or analysts supporting regional development and cross-sector cooperation.

3.2 Learning Outcomes (LOs)

The intended learning outcomes are divided into the three EQF domains:

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- **Knowledge.** Students will:
 1. explain in detail the assumptions, origins and implications of RDT, TCE and network theory, and evaluate how these theories explain organisational decision-making in IS networks (LO1),
 2. analyse the multi-level drivers (economic, organisational, societal, policy-based) influencing collaboration readiness and willingness in circular economy ecosystems (LO2),
 3. describe institutional pressures shaping inter-organisational behaviour, including isomorphism, compliance with regulations, and the role of legitimacy (LO3),
 4. identify typical patterns of power asymmetry (e.g. dominant firms vs. SMEs; private sector vs. public authorities) and assess how they affect collaboration outcomes (LO4),
 5. compare governance models such as hierarchical, relational, contractual and hybrid governance, and evaluate their suitability for IS contexts (LO5),
 6. understand cognitive, behavioural and structural causes of conflict between organisations and articulate how such conflicts can escalate or be mitigated (LO6).

▪ **Skills.** *Students can:*

7. create complex, multi-layered stakeholder maps including flows, influence lines, decision arenas, coalitions and potential conflict points (LO7),
8. conduct stakeholder interviews and interpret qualitative data to support engagement plans (LO8),
9. design governance frameworks that balance accountability, flexibility and fairness, including shared KPIs, clear responsibilities, transparency protocols and monitoring mechanisms (LO9),
10. prepare and deliver persuasive multi-stakeholder presentations that clearly articulate benefits, risks, value creation opportunities and engagement pathways (LO10),
11. apply negotiation techniques (e.g. BATNA, interest-based negotiation, reframing, anchoring) in simulated conflict situations (LO11),
12. facilitate difficult meetings, mediate disputes and guide actors through structured conflict-management processes (LO12),
13. use behavioural diagnostics to identify resistance drivers (e.g. fear of loss, uncertainty, identity threat) and design tailored interventions (LO13).

▪ **Competences (Autonomy & Responsibility).** *Students are able to:*

14. take responsibility for guiding collaborative processes and maintaining long-term trust among IS partners (LO14),
15. navigate complex political, organisational and interpersonal contexts using an ethical, transparent and accountability-driven approach (LO15),
16. serve as neutral facilitators and mediators when organisations experience conflict, deadlock or misalignment (LO16),
17. evaluate and integrate EU policy frameworks (e.g. Circular Economy Action Plan, IED, EMAS, EU Taxonomy) into IS collaboration design (LO17),
18. operate effectively in multidisciplinary teams with engineers, economists, planners, regulators and community representatives (LO18),
19. demonstrate adaptive communication, resilience under pressure and reflective learning from practice-based scenarios (LO19).

3.3 Indicative Learning Schedule / Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	Foundations of Collaboration	Lecture + Dialogue Session	Deep theoretical introduction covering RDT, TCE, network theory; discussion of why symbiotic networks succeed or fail; review of benchmark cases (Kalundborg, Ulsan, Dunkirk); exploration of interdependency structures and coordination failures.	LO1, LO2, LO3	Lewicka, Zakrzewska-Bielawska (2019), Salmone et al. (2020)	Extended theoretical exposition, guided dialogue, reflective comparative analysis
2	Drivers & Barriers in IS	Case Study Lab	Comprehensive barrier framework: regulatory risks, market volatility, technological uncertainty, corporate culture, organisational inertia; mapping macro–meso–micro barriers; work with real-world failed IS cases, root-cause analysis and scenario-based barrier mitigation.	LO2, LO3, LO8, LO17	Saha (2020)	Case laboratory, barrier-mapping exercise, problem-framing workshop
3	Stakeholder Mapping	Technical Lab	Advanced multi-layer stakeholder and network mapping: power-interest matrices, conflict prediction matrices, influence hierarchies, flow diagrams, connector–broker–bottleneck identification; work with GIS-based systems and real industrial datasets.	LO3, LO7, LO13, LO19	Toolkits + datasets	Technical mapping lab, scenario simulation, structured tool-based analysis
4	Governance Models	Seminar + Design Exercise	Design of hybrid governance models mixing formal and relational components; exploration of accountability frameworks, transparency rules, coordination roles, risk-management models; group assignment designing governance for a hypothetical IS cluster.	LO4, LO14	Shi (2019)	Seminar, group design challenge, peer evaluation

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
5	Trust & Relational Governance	Workshop	Simulated trust-building tasks; diagnosing erosion of trust; analysing communication climates; co-design of trust contracts, transparency mechanisms and shared learning structures; role-based scenarios to practice building long-term partnerships.	LO3, LO15, LO16	Lewicka, Zakrzewska-Bielawska (2022), Alosi et al. (2025)	Role play, guided emotional-intelligence training, collaborative drafting
6	Communication & Negotiation	Simulation + Feedback Cycle	Complex multi-party negotiation simulation involving competing objectives, information asymmetry, cooperative bargaining, and strategic persuasion; structured feedback on verbal, non-verbal and written communication styles.	LO9, LO10, LO11, LO18, LO19	Negotiation textbooks	Simulation-based learning, multi-level debrief, communication audit
7	Conflict Resolution	Roleplay + Diagnostic Lab	Conflict mapping workshop: structural vs. behavioural conflict, interests vs. positions, escalation ladders; mediator training; designing conflict resolution pathways; diagnosing interpersonal and inter-organisational tension triggers.	LO5, LO6 LO12, LO16, LO18	Conflict case materials	Structured mediator rotation, conflict mapping lab
8	Resistance to Change	Workshop + Action Planning	Three-level resistance analysis: individual (fear, uncertainty), organisational (structural inertia), institutional (policy lock-in); modelling change pathways; action plan creation; behavioural intervention design.	LO5, LO13, LO19	Organisational Behaviour literature	Workshop, coaching cycle, reflective behavioural assessment

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
9	Stakeholder Engagement Design	Lab + Co-creation	Designing high-inclusion engagement pathways; mapping power dynamics; building co-decision mechanisms; scenario planning for alignment; designing interventions for disputed resource flows; collaborative prototyping.	LO8, LO13, LO14, LO18	Engagement guides	Lab, design charrette for designing collaboration structures and stakeholder engagement frameworks, participatory methods
10	Monitoring Collaboration	Seminar + Indicator Development	Advanced collaboration metrics: structural KPIs, relational KPIs, early-warning indicators; detecting weak signals of partnership degradation; constructing monitoring dashboards; interpreting data to inform governance adjustments.	LO4, LO14	IS monitoring frameworks	Indicator development workshop, scenario stress-testing

3.4 Teaching & Learning Methods

■ *Learning Approach*

A hybrid learning model will be adopted in this module, combining both **Synchronous** and **Asynchronous** learning environments to maximise engagement, reflection and practical skills acquisition.

In **Synchronous learning**, students and instructors meet in real time, either in the classroom or online to conduct interactive discussions, negotiation simulations, conflict-resolution roleplays, mapping labs and facilitation workshops. These activities allow for immediate feedback, real-time behavioural observation and collective sense-making, all of which are essential for mastering inter-organisational communication and collaboration.

In **Asynchronous learning**, students access materials via a digital platform at their own pace. These materials, readings, case descriptions, demonstration videos (e.g. governance design), stakeholder-mapping tutorials, and analytical toolkits, allow learners to explore theoretical frameworks deeply (RDT, TCE, network theory, institutional theory) and prepare for the applied activities conducted during synchronous sessions.

This blended model ensures flexibility, supports diverse learning preferences, and strengthens deep conceptual understanding before students engage in high-intensity simulations and role-based exercises.

■ *Key Teaching Methods*

A wide range of teaching methods will be used throughout the module, including:

- Interactive lectures with guided dialogue (theoretical foundations of inter-organisational collaboration, governance models, power dynamics, conflict theory)
- Case studies (real Industrial Symbiosis networks, failed collaborations, regional multi-actor partnerships)
- Seminars and expert webinars (practitioners, IS coordinators, policy experts, mediators)
- Workshops (trust-building, resistance analysis, engagement design)
- Hands-on labs (stakeholder mapping, conflict mapping, governance prototyping, flow and influence analysis)
- Simulation exercises (multi-party negotiations, mediation roleplays, coordination scenarios)
- Group work and collaborative projects (designing governance frameworks and engagement strategies)
- Written and oral examinations (testing theoretical knowledge and application to complex scenarios)

Although the module focuses on Inter-organisational Relations, many activities integrate Industrial Symbiosis (IS), Circular Economy (CE) and Sustainability contexts to reflect real settings where multi-actor collaboration is essential.

▪ *Approaches and Methods Supporting Active Learning and Practical Application*

The teaching approach is designed to develop both analytical thinking and interpersonal competences required for successful coordination in complex organisational ecosystems.

- Synchronous sessions enable real-time feedback, behavioural observation, immediate clarification of misunderstandings, and active co-creation of solutions. They build a sense of belonging and enhance students' confidence in negotiation, facilitation and conflict-resolution tasks.
- Asynchronous sessions promote reflective, self-paced learning. Students can revisit theoretical materials, analyse case readings, and prepare their stakeholder maps or governance ideas before live workshops. This flexibility supports deeper comprehension of complex theoretical frameworks.
- Interactive lectures provide foundational theoretical knowledge necessary for analysing inter-organisational structures, power relations, governance modes and collaboration drivers.
- Case studies and hands-on labs translate theory into practice by exposing students to real-world collaboration challenges such as misaligned incentives, trust erosion, power asymmetries and policy pressures.
- Workshops, simulations and roleplays allow students to practice facilitation, negotiation, mediation and conflict-resolution techniques in realistic settings. These activities develop emotional intelligence, communication adaptability and decision-making under pressure.
- Group projects reinforce teamwork, collaborative sense-making, and the ability to design multi-actor engagement and governance structures, skills essential for future IS coordinators, circular economy facilitators and sustainability leaders.
- Through these combined methods, students develop the capability to navigate complex organisational relations, build trust among stakeholders, and foster long-term collaboration in industrial and circular economy networks.

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3.5 Assessment Methods & Evidence

The module adopts a comprehensive assessment strategy combining theoretical evaluation with practice-based evidence of students' abilities to analyse, design and facilitate inter-organisational collaboration. Assessment methods are designed to reflect the real competences needed in Industrial Symbiosis coordination, multi-actor negotiation, governance design and conflict management. Both **summative** (graded) and **formative** (continuous feedback and engagement) components are integrated to support deep learning, behavioural improvement and professional readiness.

Assessment Components

- *Participation & Engagement (Weight 10%).* Students' active involvement in interactive teaching methods—dialogue sessions, negotiation labs, conflict-resolution roleplays,

stakeholder-mapping workshops, governance design exercises, and facilitation practice sessions. Evidence includes engagement quality, preparation, collaboration, reflective contributions and in-class analytical tasks.

- *Group Project Presentation (Weight 30%).* A 3,000-word analytical report + group presentation diagnosing a real or simulated inter-organisational collaboration opportunity within an IS or circular-economy context. The report includes:
 - multi-layer stakeholder mapping and power–influence analysis,
 - identification of collaboration barriers, risks and conflict points,
 - governance model design (roles, responsibilities, transparency rules, kpis),
 - negotiation and engagement plan,
 - proposed conflict-management and trust-building mechanisms,
 - evidence-based recommendations for strengthening long-term relational stability.

Assessment focuses on analytical depth, correctness of theory use (RDT, TCE, network theory, institutional theory), clarity of governance design and the feasibility of proposed interventions.

- *Final Written and Oral Exams (Weight 60%).* A combination of:
 - written exam (open-ended questions, short analytical essays, multiple-choice questions),
 - oral examination (scenario-based questions testing problem-solving and communication).

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The exam evaluates students’:

- understanding of core theories explaining inter-organisational behaviour and governance,
- ability to diagnose collaboration risks and power asymmetries,
- knowledge of trust dynamics, conflict escalation and resistance mechanisms,
- familiarity with EU policy frameworks affecting inter-organisational cooperation (Circular Economy Action Plan, EMAS, EU Taxonomy),
- capacity to propose realistic, theory-based interventions improving coordination and collaboration.

Evidence of Achievement

Evidence collected during assessment includes:

- stakeholder maps, conflict maps, governance prototypes and workshop outputs,
- negotiation scripts, facilitation notes and mediator-role reflections,
- scenario analyses and applied problem-solving exercises,
- oral demonstrations of communication and persuasion skills,

- written assignments demonstrating theoretical integration and critical reasoning.

This evidence provides a holistic picture of students' readiness to coordinate multi-actor collaboration, mediate disputes, design governance structures and support IS network development.

3.6 Bibliography & Tools

3.6.1 Required

Alosi, A., Katana, K., Annunziata, E., Mirata, M., Rizzi, F., & Frey, M. (2025). *Management of paradoxical tensions in industrial symbiosis: An exploration at the inter-organizational level*. *Journal of Industrial Ecology*, 29(2), 602–616. <https://doi.org/10.1111/jiec.13625> Semantic Scholar+4Online Library+4SciSpace+4

Lewicka, D., & Zakrzewska-Bielawska, A. (2019). Interorganizational trust in business relations: Cooperation and cooptation. In A. Zakrzewska-Bielawska & M. Cygler (Eds.), *Contemporary challenges in cooperation and cooptation in the age of Industry 4.0: 10th Conference on Management of Organizations' Development (MOD)* (pp. 155–174). Springer International Publishing. https://doi.org/10.1007/978-3-030-30549-9_9

Salomone, R., Cecchin, A., Deutz, P., Raggi, A., & Cutaia, L. (Eds.). (2020). *Industrial symbiosis for the circular economy: Operational experiences, best practices and obstacles to a collaborative business approach*. Springer International Publishing.

Saha, P. (2020). *The process of building inter-organizational collaboration for industrial symbiosis: Two cases from Finland — ECO3 & Envitech*. Tampere University: <https://trepo.tuni.fi/bitstream/handle/10024/123739/SahaPuja.pdf?sequence=2&isAllowed=y>

Shi, Lin.(2019). Industrial symbiosis: Context and relevance to the Sustainable Development Goals (SDGs). In W. Leal Filho, A. M. Azul, L. Brandli & P. G. Özuyar (Eds.), *Responsible Consumption and Production* (pp. 23-42). Springer. DOI: 10.1007/978-3-319-71062-4_19-1. ResearchGate+1

3.6.2 Recommended Reading

Anderson, D., & Anderson, L. A. (2020). *The change leader's roadmap: How to navigate your organization's transformation*. Wiley.

Chatman, J. A., & O'Reilly, C. A. (2016). *Paradigm lost: Reinvigorating the study of organizational culture*. In *Research in Organizational Behavior* (Vol. 36, pp. 199–224). Elsevier.

Cloke, K., & Goldsmith, J. (2011). *Resolving conflicts at work: Ten strategies for everyone on the job* (3rd ed.). Jossey-Bass.

Edmondson, A. C. (2019). *The fearless organization: Creating psychological safety in the workplace for learning, innovation, and growth*. Wiley.

Fisher, R., Ury, W., & Patton, B. (2011). *Getting to yes: Negotiating agreement without giving in* (3rd ed.). Penguin Books.

Grant, A. (2021). *Think again: The power of knowing what you don't know*. Viking.

Groysberg, B., Lee, J., Price, J., & Cheng, J. (2018). *The leader's guide to corporate culture*. Harvard Business Review Press.

Heath, C., & Heath, D. (2010). *Switch: How to change things when change is hard*. Broadway Books.

Johnson, D. W., & Johnson, R. T. (2014). *Joining together: Group theory and group skills* (12th ed.). Pearson.

Kotter, J. P. (2014). *Accelerate: Building strategic agility for a faster-moving world*. Harvard Business Review Press.

Lewicka, D., & Zakrzewska-Bielawska, A. F. (2022). *Trust and distrust in interorganisational relations—Scale development*. *PLOS ONE*, 17(12), e0279231. <https://doi.org/10.1371/journal.pone.0279231>

4. Concise Syllabus Template – HEI (EQF6)

Module Title: AI and machine-learning to predict material flows and optimize supply chain/process

EQF Level: 6

ECTS Credits: 4 ECTS

Total Workload (hours): 100 hours

- Contact hours (lectures, labs, seminars, workshops, etc.): 40 hours
- Guided self-study: 30 hours
- Project work: 30 hours

Delivering Institution: IMC HOCHSCHULE FÜR ANGEWANDTE WISSENSCHAFTEN KREMS GMBH (IMC KREMS), Austria.

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4.1 Module Overview

The transition of Industrial Symbiosis (IS) to Digital Industrial Symbiosis (DIS) is crucial. This module explores how to incorporate Artificial Intelligence (AI) and Machine Learning (ML) into material flow management to drastically improve the efficiency of supply chains, predict supply and demand trends, optimize logistics, and reduce waste. It provides learners how artificial intelligence (AI) and machine learning (ML) methods can be used to accelerate the digital transformation of IS ecosystems. They learn how data-driven algorithms can be used to predict material and energy flows, detect inefficiencies, and support real-time decision-making in circular supply chains. Through simulations, and case studies, learners develop competencies in selecting and applying suitable ML models to solve real-world industrial problems. For instance, forecasting secondary resource availability, identifying symbiotic matches, and optimizing logistics. The module emphasizes practical integration with IS platforms and the ethical use of data in circular economy contexts.

This module is designed for HEI students, educators, business managers, consultants, research organizations, business support institutions, and policy-making bodies engaged in sustainability, material-flow forecasting and optimization.

Competences gained in this module serve as helpful for symbiotic energy management technologies and models. For instance, prediction of resource availability supports resource minimization and optimization.

A general knowledge of sustainability, digital transformation from IS to DIS is helpful to uptake in the context. Basic programming skills helps learners to implement the algorithms otherwise via digital tools learners can use algorithms.

4.2 Learning Outcomes (LOs)

The intended learning outcomes are divided into the three EQF domains:

▪ **Knowledge.** *Students will:*

1. understand circular economy and industrial symbiosis (LO1),
2. demonstrate understanding of how Artificial Intelligence (AI) and Machine Learning (ML) enable process improvement and resource optimization within industrial symbiosis networks (LO2),
3. critically explain supervised and unsupervised ML approaches, e.g., time-series forecasting, clustering, predictive modeling and their relevance to circular economy applications (LO3),
4. understand key industrial material flow data features (LO4),
5. understand ethical, legal, and social challenges of AI use, e.g., bias, privacy, and transparency (LO5).

▪ **Skills.** *Students can:*

6. collect, clean, and prepare industrial datasets using data science tools such as Python and Pandas for ML model building and analysis (LO6),
7. develop and test ML models (e.g. ARIMA, LSTM, k-means) for use cases including material flow forecasting, anomaly detection, and resource optimization (LO7),
8. interpret results from ML model outputs to generate actionable insights for supply chain enhancement, waste valorization, and process redesign (LO8),
9. effectively communicate analytical findings through the use of visualization platforms (e.g., Power BI, QGIS, SankeyMATIC) with clarity to both technical and non-technical stakeholders (LO9).

▪ **Competences (Autonomy & Responsibility).** *Students are able to:*

10. independently select appropriate digital/machine learning approaches for analyzing and optimizing industrial resource flows in complex, multi-stakeholder settings (LO10),
11. evaluate and balance the merits and limitations of AI tools to determine the most suitable technique for a given industrial symbiosis scenario, taking into account performance, cost, simplicity, and sustainability (LO11),

12. initiate and contribute to the digital transformation of organizations by recommending data-driven practices for improving industrial symbiosis operations (LO12),
13. work collaboratively and ethically in interdisciplinary teams, consistently communicating AI-supported insights, and ensuring responsible use of data and transparency of algorithmic decision-making (LO13).

4.3 Indicative Learning Schedule / Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	Introduction to IS and circular economy	Lecture / e-learning	Definitions, examples of IS in circular economy context.	LO1	Akrivou et al. (2022), Rincón-Moreno et al. (2020).	Blended: interactive lecture, case examples
2	Introduction to the application of AI and ML in IS	Lecture / workshop / e-learning	Definitions, fundamentals of AI and ML, evolution from traditional IS to DIS.	LO1, LO2, LO3	Vimal et al. (2020), Ashton et al. (2022), Neves et al. (2020)	Blended: interactive lecture, group discussion, case examples
3	Data sources & structures of material flow, mapping resource flows (material/energy & energy flows)	Lecture/ workshop / e-learning	Introduction to data structures, data cleaning techniques, and methods for symbiotic matching, digital platforms & tools, introduction to Pandas/Python for IS data	LO3, LO4, LO5	Xue et al. (2023), Cagno et al. (2023), Neves et al. (2020), Angelis-Dimakis et al. (2021), Silva et al. (2022), software tutorials	Lecture, stepwise exercises, practical mapping software use, demonstration
4	Traditional machine learning algorithms, ML-pipelines, models versioning & testing	Lecture / workshop / e-learning	Methods for classification & clustering (unsupervised machine learning) and their application in material flow, uses for ML-pipeline, models testing and maintain versioning	LO2, LO3, LO7, LO10	Namoun et al. (2022), Demetriou et al. (2024), Filippou et al. (2023), Nguyen et al. (2020) Luo et al. (2021), Chandrasekaran et al. (2023)	Blended, case study analysis, group Brainstorming
5	Time Series Forecasting and used tools and technologies	Lecture / workshop / e-learning	Methods for time series forecasting and their application in material and energy flows, examples of tools and technologies for predictions	LO2, LO3, LO4, LO7, LO10	Vimal et al. (2020), Cagno et al. (2023), Neves et al. (2020)	Blended, case study analysis, group brainstorming

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
6	Introduction of supply chain and role of AI in supply chain management	Lecture / workshop / e-learning	Supply chain, its impacts and benefits of AI in the management with tools introduction	LO4, LO5, LO7, LO8, LO10	Demartini et al. (2022), Zamani et al. (2022)	Blended, case study analysis
7	Logistic flows optimization	Lecture / workshop / e-learning	Importance of logistic flows optimization, methods for routing optimization and their constraints	LO4, LO5, LO7, LO8, LO10	Xue et al. (2023), Cagno et al. (2023), Neves et al. (2020), Aviso et al. (2022)	Blended: interactive lecture, group discussion, case examples
8	Machine learning for predictive analysis and maintenance	Lecture/ workshop / e-learning	Methods for prediction & anomaly detection, introduction of data source for maintenance using predictive analysis.	LO2, LO7, LO8, LO9, LO10	Vimal et al. (2020), Namoun et al. (2022)	Blended: interactive lecture, group discussion, case examples
9	Integration of ML/AI in IS and limitations & bias in AI and data ethics	Lecture / workshop / e-learning	Methods for integrating AI in IS, challenges/limitations using AI, ethical, legal and social aspects in AI/ML for IS (bias, privacy, transparency)	LO4, LO5, LO10, LO11, LO13	Ponis (2021), Demartini et al. (2022), Angelis-Dimakis et al. (2023)	Blended, case study analysis, group brainstorming
10	Practical IS project.	Project and assessment	Group project: developing a predictive material flow model for ISs	LO6, LO8, LO9, LO10, LO11, LO12, LO13	All the above-mentioned readings/material and platforms	Group work, project-based learning, peer & instructor feedback and group project presentation.
	Final Assessment & Reflection	Assessment	Final exams and assessments.	LO1, LO2, LO3, LO4, LO5, LO9	All the above-mentioned readings/material.	Written and oral exams (open-ended questions, multiple choice questions, quizzes, etc.).

4.4 Teaching & Learning Methods

▪ *Learning approach*

The module adopts a blended learning approach that integrates face-to-face sessions, online activities, and guided self-study into a coherent pedagogical design. Learners progressively move from conceptual understanding of AI, machine learning, and industrial symbiosis towards independent application of these concepts in realistic DIS contexts. The learning environment is student-centred and competence-oriented, fostering analytical thinking, ethical reflection, and interdisciplinary collaboration aligned with the intended learning outcomes (LO1–LO13).

▪ *Key teaching methods*

Teaching is structured around a combination of lectures, seminars, hands-on workshops and computer labs, case-based learning, and project-based work. Lectures introduce theoretical foundations, frameworks, and policy contexts, while seminars are used to critically read academic literature, EU regulations, and business models. Workshops and labs focus on practical skills in data handling, model development, and visualization using tools such as Python, Power BI, QGIS, and SankeyMATIC. Case studies and group projects expose learners to authentic industrial datasets and scenarios, enabling them to design and evaluate AI-enabled industrial symbiosis solutions. Asynchronous e-learning tasks, quizzes, and preparatory readings support continuity between contact sessions and encourage ongoing engagement.

▪ *Approaches to active learning and practical application*

Active learning is embedded through collaborative problem-solving, inquiry-based tasks, and iterative feedback cycles. Students work in interdisciplinary teams to clean and analyze industrial material flow data, select suitable machine learning approaches, and interpret model outputs for decision making in circular supply chains. Simulations, scenario analyses, and design-oriented project work require learners to apply theoretical knowledge to complex, real-world challenges, culminating in tangible outputs such as analytical reports, dashboards, and presentations tailored to both technical and nontechnical stakeholders. Continuous formative feedback and structured reflection activities further support the development of autonomy, professional judgement, and responsible data-driven practice.

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4.5 Assessment Methods & Evidence

Assessment components

The assessment strategy combines formative and summative elements to evaluate both conceptual understanding and practical application of AI and machine learning methods in industrial symbiosis. Summative assessment is centered on an integrative project, a written exam, and a communication component, while formative activities (quizzes, lab tasks, draft submissions) provide feedback and scaffold learning across the module.

Summative assessment methods (indicative weighting):

- *Final group AI project (industry inspired case study for predictive model) (Weight 35%).*
- *Practical exercise (Tool based exercises) (Weight 25%).*
- *Final exam (short essays, problem-based questions and multiple-choice questions) (Weight 30%).*
- *Participation and engagement in seminars, labs, and peer feedback (Weight 10%)*

Evidence of achievement of learning outcomes

Students demonstrate their learning through an analytical project dossier (code, data processing logs, model outputs), a structured technical report, a set of visual artefacts (dashboards, maps, Sankey diagrams), and an oral presentation or screencast tailored to mixed audiences. The written exam provides evidence of theoretical understanding and critical reflection on AI/ML concepts, industrial symbiosis, and relevant policy and ethical frameworks. Formative assessments, including low-stakes quizzes, interim project checkpoints, and feedback on drafts, support progression toward these summative outputs without carrying major weighting in the final grade.

4.6 Bibliography & Tools

4.6.1 Required

Akrivou, C., Łękańska-Andrinopoulou, L., Manousiadis, C., Tsimiklis, G., Oikonomopoulou, V., Papadaki, S., Krokida, M., & Amditis, A. (2022). Industrial symbiosis marketplace concept for waste valorization pathways. *E3S Web of Conferences*, 349, 11005. <https://doi.org/10.1051/e3sconf/202234911005>

Rincón-Moreno, J., Ormazabal, M., Álvarez, M. J., & Jaca, C. (2020). Shortcomings of Transforming a Local Circular Economy System through Industrial Symbiosis: A Case Study in Spanish SMEs. *Sustainability*, 12(20), 8423. <https://doi.org/10.3390/su12208423>

Filippou, K., Aifantis, G., Papakostas, G. A., & Tsekouras, G. E. (2023). Structure Learning and Hyperparameter Optimization Using an Automated Machine Learning (AutoML) Pipeline. *Information*, 14(4), 232. <https://doi.org/10.3390/info14040232>

Nguyen, T., Maszczyk, T., Musial, K., Zöller, M., & Gabrys, B. (2020). AVATAR - Machine Learning Pipeline Evaluation Using Surrogate Model. *ArXiv*, *abs/2001.11158*.

Luo, Z., Wang, J., Li, C., Xiong, L., & Zhao, Y. (2021). MLCask: Efficient management of component evolution in collaborative data analytics pipelines. In *2021 IEEE 37th International Conference on Data Engineering (ICDE)* (pp. 1655–1666). IEEE. <https://doi.org/10.1109/ICDE51399.2021.00146>

Chandrasekaran, J., Cody, T., McCarthy, N., Lanus, E., & Freeman, L.J. (2023). Test & Evaluation Best Practices for Machine Learning-Enabled Systems. *ArXiv*, *abs/2310.06800*.

Angelis-Dimakis, A., Arampatzis, G., Alexopoulos, A., Vyrkou, A., Pantazopoulos, A., & Angelis, V. (2023). *Industrial symbiosis in the Balkan-Mediterranean region: The case of solid waste. Environments*, 10(1), <https://doi.org/10.3390/environments10010001>

Angelis-Dimakis, A., Arampatzis, G., Pieri, T., Solomou, K., Dedousis, P., & Apostolopoulos, G. (2021). *SWAN platform: A web-based tool to support the development of industrial solid waste reuse business models. Waste Management & Research*, 39(3), 489–498. <https://doi.org/10.1177/0734242X21989413>

Ashton, W. S., Chertow, M. R., & Althaf, S. (2022). *Industrial symbiosis: Novel supply networks for the circular economy*. In L. Bals, W. L. Tate, & L. M. Ellram (Eds.), *Circular economy supply chains: From chains to systems* (pp. 29–48). Emerald Publishing Limited. <https://doi.org/10.1108/978-1-83982-544-620221002>

Aviso, K. B., Laddaran, A., & Ngo, J. S. (2022). *Modelling stakeholder goals in industrial symbiosis. Process Integration and Optimization for Sustainability*, 6, 543–558. <https://doi.org/10.1007/s41660-022-00226-6>

Cagno, E., Negri, M., Neri, A., & Giambone, M. (2023). *One framework to rule them all: An integrated, multi-level and scalable performance measurement framework of sustainability, circular economy and industrial symbiosis. Sustainable Production and Consumption*, 35, 55–71. <https://doi.org/10.1016/j.spc.2022.10.016>

Demartini, M., Tonelli, F., & Govindan, K. (2022). *An investigation into modelling approaches for industrial symbiosis: A literature review and research agenda. Cleaner Logistics and Supply Chain*, 3, 100020. <https://doi.org/10.1016/j.clscn.2021.100020>

Demetriou, D., Polydorou, T., Petrou, Nicolaides, D., Petrou, M. F. (2024). A clustering machine learning approach for improving concrete compressive strength prediction. *Engineering Reports*, 6(6), e12934. <https://doi.org/10.1002/eng2.12934>

Henriques, J. D., Azevedo, J., Dias, R., Estrela, M., Ascenço, C., Vladimirova, D., & Miller, K. (2022). *Implementing industrial symbiosis incentives: An applied assessment framework for risk mitigation. Circular Economy and Sustainability*, 2, 669–692. <https://doi.org/10.1007/s43615-021-00069-2>

Karman, A., Prokop, V., & Lopes de Sousa Jabbour, A. B. (2024). *Circular economy practices as a shield for the long-term organisational and network resilience during crisis: Insights from an industrial symbiosis. Journal of Cleaner Production*, 466, 142822. <https://doi.org/10.1016/j.jclepro.2024.142822>

Namoun, A., Tufail, A., Khan, M. Y., Alrehaili, A., Syed, T. A., & BenRhouma, O. (2022). Solid Waste Generation and Disposal Using Machine Learning Approaches: A Survey of Solutions and Challenges. *Sustainability*, 14(20), 13578. <https://doi.org/10.3390/su142013578>

Neves, A., Godina, R., Azevedo, S.G. & Matias, J.C.O. (2020) *A comprehensive review of industrial symbiosis. Journal of Cleaner Production*. 247. doi:10.1016/j.jclepro.2019.119113.

Ponis, S. T. (2021). *Industrial symbiosis networks in Greece: Utilising the power of blockchain-based B2B marketplaces. The JBBA*, 4(1). [https://doi.org/10.31585/jbba-4-1-\(4\)2021](https://doi.org/10.31585/jbba-4-1-(4)2021)

QGIS Software tutorials. Available at:
https://docs.qgis.org/3.40/en/docs/training_manual/index.html

SankeyMATIC Software tutorials. Available at: <https://sankeymatic.com/manual/>

Silva, M. G., de Carvalho, T. S., Castagna, A. G., Strauhs, F. do R., & Piekarski, C. M. (2022). *The role of online platforms to enable the process of industrial symbiosis: An analysis of tools available in the market. Cleaner Production Letters*, 3, 100021. <https://doi.org/10.1016/j.clpl.2022.100021>

Taqi H. M. M., Meem, E. J., Bhattacharjee, P., Salman, S., Ali, S. M., & Sankaranarayanan, B. (2022). *What are the challenges that make the journey towards industrial symbiosis complicated? Journal of Cleaner Production*, 370, 133384. <https://doi.org/10.1016/j.jclepro.2022.133384>

Vimal, K. E. K., Jayakrishna, K., Ameen, T., Afridhi, S. S., Vasudevan, V., & Sreedharan, R. (2020). *An investigation on the impact of industrial symbiosis implementation on organizational performance using analytical hierarchical approach. Benchmarking: An International Journal*, 27(2), 886–911. <https://doi.org/10.1108/BIJ-12-2018-0423>

Xue, X., Wang, S., Chun, T., Xin, H., Xue, R., Tian, X., & Zhang, R. (2023). *An integrated framework for industrial symbiosis performance evaluation in an energy-intensive industrial park in China. Environmental Science and Pollution Research*, 30, 42056–42074. <https://doi.org/10.1007/s11356-023-25232-0>

Zamani, E. D., Smyth, C., Gupta, S., & Dennehy, D. (2022). Artificial intelligence and big data analytics for supply chain resilience: a systematic literature review. *Annals of operations research*, 1–28. Advance online publication. <https://doi.org/10.1007/s10479-022-04983-y>

4.6.2 Recommended

Agudo, F. L., Bezerra, B. S., & Gobbo Júnior, J. A. (2023). *Symbiotic readiness: Factors that interfere with the industrial symbiosis implementation. Journal of Cleaner Production*, 387, 135843. <https://doi.org/10.1016/j.jclepro.2023.135843>

Agudo, F. L., Bezerra, B. S., & Gobbo Júnior, J. A. (2024). *An overview of Brazilian companies' readiness to implement industrial symbiosis. Business Strategy and the Environment*, 33, 1066–1080. <https://doi.org/10.1002/bse.3534>

Agudo, F. L., Bezerra, B. S., Paesa, L. A. B., & Gobbo Júnior, J. A. (2022). *Proposal of an assessment tool to diagnose industrial symbiosis readiness. Sustainable Production and Consumption*, 30, 916–929. <https://doi.org/10.1016/j.spc.2022.01.013>

Barteková, E. and P. Börkey (2022), *Digitalisation for the transition to a resource efficient and circular economy, OECD Environment Working Papers*, No. 192, OECD Publishing, Paris, <https://doi.org/10.1787/6f6d18e7-en>.

European Commission. (2020). EU Taxonomy Regulation (Regulation (EU) 2020/852). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32020R0852>

European Green Deal. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Fit for 55' package. Available at: https://commission.europa.eu/topics/climate-action/delivering-european-green-deal/fit-55-delivering-proposals_en

Khan, Z. A., Chowdhury, S. R., Mitra, B., Mozumder, M. S., Elhaj, A. I., Salami, B. A., Rahman, M. M., & Rahman, S. M. (2023). *Analysis of industrial symbiosis case studies and its potential in Saudi Arabia*. *Journal of Cleaner Production*, 385, 135536. <https://doi.org/10.1016/j.jclepro.2022.135536>

Mantese, G.C. & Amaral, D.C. (2018) Agent-based simulation to evaluate and categorize industrial symbiosis indicators. *Journal of Cleaner Production*. 186, 450–464. doi:10.1016/j.jclepro.2018.03.142.

Neves, A., Godina, R., Carvalho, H., Azevedo, S.G. & Matias, J.C.O. (2019) *Industrial Symbiosis Initiatives in United States of America and Canada: Current Status and Challenges*. In: *Proceedings of 2019 8th International Conference on Industrial Technology and Management, ICITM 2019*. 2019 pp. 247–251. doi:10.1109/ICITM.2019.8710744.

Sgambaro, L., Chiaroni, D., Lettieri, E., & Paolone, F. (2024). *Exploring industrial symbiosis for circular economy: investigating and comparing the anatomy and development strategies in Italy*. *Management Decision*, <https://doi.org/10.1108/MD-04-2023-0658>

5. Concise Syllabus Template – HEI (EQF6)

Module Title: Blockchain technologies, to create transparent and secure tracking and certification systems for material and energy flows

EQF Level: 6

ECTS Credits: 4 ECTS

Total Workload (hours): 100 hours

- Contact hours (lectures, labs, seminars, workshops, etc.): 40 hours
- Guided self-study: 30 hours
- Project work: 30 hours

Delivering Institution: DIMITROVA LIDIA (LIDI), Netherlands.

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5.1 Module Overview

This module introduces the fundamentals and applied use of blockchain technologies in the context of industrial symbiosis (IS) and circular economy. Students will explore how blockchain can be leveraged to create secure, immutable, and transparent systems for tracking material and energy flows across complex industrial networks. The module focuses on enhancing data integrity, real-time traceability, and compliance with environmental and sustainability standards (e.g. CSRD, EFRAG, ISO 14000). Through a combination of theoretical input, case study analysis, and applied labs, students will gain practical insights into blockchain-based product passports, digital twins, and certification systems that support low-carbon transitions and inter-organisational accountability. The module is especially relevant for future SymbioTech Managers aiming to digitize resource management in multi-actor industrial ecosystems.

5.2 Learning Outcomes (LOs)

The intended learning outcomes are divided into the three EQF domains:

- **Knowledge.** Students will:
 1. understand blockchain architecture, including distributed ledgers, consensus algorithms, and smart contracts (LO1),

2. be familiar with tokenisation, oracles, traceability protocols, and compliance frameworks (LO2),
3. have in-depth awareness of ethical, legal, and governance issues in blockchain-based sustainability systems (LO3).

▪ **Skills.** *Students can:*

4. design smart contract logic (LO4),
5. map and model traceability flows for raw materials, recycled inputs, or renewable energy (LO5),
6. utilise evaluation frameworks to compare blockchain solutions for traceability, auditing, or reporting purposes (LO6),
7. draft Digital Product Passport templates for IS applications (LO7).

▪ **Competences (Autonomy & Responsibility).** *Students are able to:*

8. independently assess the suitability of blockchain solutions in real-world sustainability scenarios (LO8),
9. exercise judgment in managing transparency vs confidentiality conflicts in industrial data (LO9),
10. collaborate across technical and business teams to advocate for trust-based innovation in circular systems (LO10),
11. communicate the potential and limitations of blockchain-based traceability to multiple stakeholders (technical, legal, managerial) (LO11).

5.3 Indicative Learning Schedule / Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	Introduction to Blockchain and DLT Architecture	Lecture / workshop / e-learning	Interactive demo: how blocks link in a ledger	LO1, LO2	Bahga & Madiseti (2016), Wang et al. (2020), Westerkamp et al. (2018), Samaniego & Deters (2023), Brownworth (n.d.)	Interactive lecture with key insights into the Blockchain fundamentals.
2	Blockchain and Circular Economy	Lecture/ workshop / e-learning	Case analysis: Circularise, Everledger	LO6, LO8	Ventura et al. (2024), Xia et al. (2025), Vladucu et al. (2024)	Case study of Circularise and Everledger for deep understanding of available technologies.
3	Smart Contracts and Tokenisation of Resources for IS	Lecture / workshop / e-learning	Design token for material streams	LO2, LO4, LO5	Westerkamp et al. (2018), Fu et al. (2023), Zuo et al. (2025)	Activity with exercises related to designing smart contracts and tokens.
4	Traceability in Supply Chains and Digital Product Passports	Lecture/ workshop / e-learning	Create a basic DPP template	LO2, LO5, LO7	Zhang et al. (2023), Sezer et al. (2021), Malik et al. (2021)	Activity whereby students need to create a DPP template, investigating design decisions.
5	Energy Certificates and Blockchain	Lecture/ workshop / e-learning	Simulate renewable energy tracking	LO2, LO5	Fu et al. (2023), Liu et al. (2024), Zuo et al. (2025)	Engage in a simulation for realistic energy tracking of renewables.

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
6	IoT & Oracles Integration	Lecture/ workshop / e-learning	Designing a sensor dashboard	LO1, LO2	Bahga & Madiseti (2016), Wang et al. (2020), Samaniego & Deters (2023), Schmid & Lefèvre (2024)	Analyse examples of existing sensor dashboards and use critical thinking to apply principles to a provided example use case.
7	Privacy, Security & Compliance	Lecture/ workshop / e-learning	Ethics case: Traceability vs confidentiality	LO2, LO3	Cali et al. (2021), Sezer et al. (2021), Malik et al. (2021), Khan & Salah (2022)	Group debate or individual analysis of trade-offs between traceability and confidentiality
8	Group Design Sprint	Project and assessment	Ideation workshop: resource trace project	LO5, LO6, LO10, LO11	Not Relevant	Group work/brainstorming to propose a solution to an existing problem using course topics.
9	Final Presentations	Project and assessment	Group project pitches	LO9, LO10, LO11	Not Relevant	Group project presentation.
10	Exam	Assessment	Final exams and assessments.	LO1, LO2, LO3	All the above-mentioned readings/material.	Written and oral exams (open questions, quizzes, etc.).

5.4 Teaching & Learning Methods

- *Learning approach*

For this module a hybrid approach is used. This involves a combination of trainer lead sessions alongside self-study resources. The trainer lead sessions will take place in a digital classroom where students will join lessons at specified hours. This digital social environment enhances understanding through interpersonal communication. Self-study resources will be accessible to students to use whenever they suit best. These resources include pre-recorded lectures, presentations, documents, figures, and videos. Such an approach allows for a balance between structure and freedom, aimed to benefit students with various preferences and learning habits. This flexibility further allows multi-media touchpoints that provide a more comprehensive intuition about the topics at hand as they are viewed and presented through a different lens, especially with the combination of written text, video material, interactive simulations, and engaging teachers.

- *Key Teaching methods*

To offer complete learning experience, various teaching methods will be leveraged. Most prominently interactive lectures, seminars, hands-on workshops, supervised computer labs, and group projects. The contents of this module, which cover the topics of Blockchain, Industrial Symbiosis (IS), Circular Economy (CE), Supply Chain Tracking, and Smart Contracts will be delivered by blending the aforementioned teaching methods.

- *Approaches and methods supporting active learning and practical application of knowledge.*

By blending the teaching methods within this module, each can be used to extract significant value. Social engagement and personal trust allow for an interactive and personalised experience, offering the opportunity for students to clarify any uncertainties they have about their understanding of the topics. The asynchronous aspect allows students to work at their own pace, reducing the stress for students which benefit from working ahead or revising prior topics. The different format of learning materials also benefits students as they may select which formats are most effective for their own learning style. Outside of the mandatory topics, supplementary resources will be available for students that are deeply interested in particular topics.

As a result of group projects, teamwork and communication skills will be gained from this module. The knowledge and skills will be directly applicable to the real-world work environment. This allows the students to be prepared for projects in the LCA context.

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5.5 Assessment Methods & Evidence

Assessment components & evidence of achievement of learning outcomes:

This module, in line with the diverse teaching methods, will have an array of assessment methods to detect the progress students have made both in terms of knowledge and skills development. Such assessment methods include exams, group projects, lab reports, and interactive participation in class.

- *Group Project (Weight 40%)*. Propose a solution to an existing problem using course topics. The use of generative AI for brainstorming and researching existing problems and solutions is permitted.
- *Lab Report Portfolio (Weight 30%)*. All design assignments combined will account for this grade.
- *Final Exam (Weight 30%)*. Technical and scenario-based questions, energy modeling and regulatory alignment.

5.6 Bibliography & Tools

Bahga, A., & Madiseti, V. K. (2016). Blockchain platform for industrial internet of things. *Journal of Software Engineering and Applications*, 9(10), 533–546. <https://doi.org/10.4236/jsea.2016.910036>

Cali, U., Kuzlu, M., Pipattanasomporn, M., Elma, O., & Reddi, K. (2021). Cybersecurity of renewable energy data and applications using distributed ledger technology. *arXiv*. <https://arxiv.org/abs/2110.11354>

Fu, X., Tan, W., & Xu, Y. (2023). Blockchain-based renewable energy certificate trade for low-carbon communities of active energy agents. *Sustainability*, 15(23), 16300. <https://doi.org/10.3390/su152316300>

Khan, M., & Salah, K. (2022). Blockchain for transparent and secure supply chain management in renewable energy systems. *International Journal of Sustainable Technology and Renewable Applications*, 11(1), 22–34.

Malik, N., Dedeoglu, V., Kanhere, S. S., & Jurdak, R. (2021). PrivChain: Provenance and privacy preservation in blockchain-enabled supply chains. *arXiv*. <https://arxiv.org/abs/2104.13964>

Samaniego, M., & Deters, R. (2023). A Digital Twin approach for blockchain-based IoT resource management. *arXiv*. <https://arxiv.org/abs/2309.01042>

Schmid, D., & Lefèvre, J. (2024). Blockchain-based certification for the EU hydrogen market: Design considerations and challenges. *Frontiers in Blockchain*, 5, 1408743. <https://doi.org/10.3389/fbloc.2024.1408743>

Sezer, E., Topal, A., & Nuriyev, U. (2021). Auditability, transparency, and privacy-preserving mechanisms for blockchain-based supply chain traceability. *arXiv*. <https://arxiv.org/abs/2103.10519>

Silvestri, L., Forcina, A., Introna, V., Santolamazza, A., & Cesarotti, V. (2020). Maintenance transformation through Industry 4.0 technologies: A systematic literature review. *Computers in Industry*, 123, 103335. <https://doi.org/10.1016/j.compind.2020.103335>

Ventura, V., La Monica, M., Bortolini, M., Cutaia, L., & Mora, C. (2024). Blockchain and industrial symbiosis: A preliminary two-step framework to green circular supply chains. *Circular Economy and Sustainability*, 22, 17–30.

Wang, Q., Zhu, X., Ni, Y., Gu, L., & Zhu, H. (2020). Blockchain for the IoT and industrial IoT: A review. *Internet of Things*, 10, 100081. <https://doi.org/10.1016/j.iot.2019.100081>

Westerkamp, M., Victor, F., & Küpper, A. (2018). Tracing manufacturing processes using blockchain-based token recipes. *arXiv*. <https://arxiv.org/abs/1810.09843>

Xia, H., Li, J., Li, Q. J., Milisavljevic-Syed, J., & Salonitis, K. (2025). Integrating blockchain with digital product passports for managing reverse supply chain. *Transportation Research Part E: Logistics and Transportation Review*, 202, 104336. <https://doi.org/10.1016/j.tre.2025.104336>

Zhang, B., Lee, J., & Song, H. (2023). A blockchain-based supply chain traceability framework using digital certificates. *International Journal of Logistics Research and Applications*.

Zuo, K., Wang, S., & Li, J. (2025). A non-transferable trade scheme of green power based on blockchain. *Energies*, 17(16), 4002. <https://doi.org/10.3390/en17164002>

6. Concise Syllabus Template – HEI (EQF6)

Module Title: Symbiotic energy efficiency/management technologies and models

EQF Level: 6

ECTS Credits: 4 ECTS

Total Workload (hours): 100 hours

- Contact hours (lectures, labs, seminars, workshops, etc.): 30 hours
- Guided self-study: 40 hours
- Project work: 30 hours

Delivering Institution: VSB - TECHNICAL UNIVERSITY OF OSTRAVA (VSB - TUO), Czechia.

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6.1 Module Overview

This module provides an introduction to energy systems, renewable energy, and sustainable energy management. Students will gain a solid understanding of electricity production and consumption, renewable energy sources, energy efficiency in buildings, industrial energy flows, community energy models, financial and valuation methods, and emission allowances management.

The module combines theory with practical applications through lectures, workshops, seminars, e-learning, case studies, and simulations. Students will apply their knowledge in exercises such as energy audits, energy storage simulations, efficiency interventions, community energy modeling, and urban blue-green infrastructure design. Group projects and analytical tasks will further develop their decision-making, forecasting, and optimization skills.

Prerequisites Note: A basic understanding of spreadsheet software (e.g., Excel) and general economic principles is recommended.

By the end of the module, students will be able to analyze energy systems, assess environmental and economic impacts, design and evaluate energy-saving measures, and make informed decisions regarding energy management strategies.

6.2 Learning Outcomes (LOs)

The intended learning outcomes are divided into the three EQF domains:

▪ **Knowledge.** *Students will:*

1. understand energy systems & flows: Comprehend key concepts of electricity production, renewable and non-renewable sources, and distribution in the context of energy management (LO1),
2. define energy efficiency & services: Explain the principles of energy services, drivers for efficiency (cost, risk, technology), and the role of energy audits (LO2),
3. distinguish business models: Differentiate between traditional supply models and performance-based models (ESCO, EPC, PPA), including community energy and shared-ownership frameworks (LO3),
4. understand financial & risk principles: Grasp the methods for financial valuation (ROI, IRR, Payback) and identify risks associated with cash flow and energy projects (LO4),
5. comprehend regulatory mechanisms: Understand the legislative framework for emission allowances, trading schemes, and urban energy policies (LO5).

▪ **Skills.** *Students can:*

6. analyze energy data: Perform calculations to balance industrial energy flows, identify efficiency opportunities, and optimize consumption (LO6),
7. evaluate building & urban solutions: Assess the energy performance of buildings and design blue-green infrastructure (e.g., green roofs) to mitigate urban heat islands (LO7),
8. apply forecasting models: Use time-series analysis and stochastic models to forecast uncertain variables in energy markets (LO8),
9. conduct economic analysis: Calculate cash flows for renewable energy projects and perform valuation using deterministic and random variables (LO9),
10. compare contracting options: Analyze and select optimal contractual approaches (e.g., guaranteed savings vs. shared savings) based on specific constraints (LO10).

- **Competences (Autonomy & Responsibility).** Students are able to:
- 11. make strategic investment decisions: Synthesize risk and economic analysis to make and defend informed decisions regarding renewable energy investments (LO11),
- 12. design symbiotic energy models: Develop viable business or operational models for community energy sharing and decentralized power generation (LO12),
- 13. optimize emission strategies: Formulate strategies for managing emission allowances to achieve compliance and economic optimization (LO13),
- 14. solve complex energy problems: Integrate technical, environmental, and social aspects to propose holistic solutions for sustainable energy management (LO14).

6.3 Indicative Learning Schedule/Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	Introduction to electric energy, management of electricity production, and consumption in the context of renewable and non-renewable resources.	Lecture / e-learning	Basic concepts of electrical energy, production cycles, distribution, and consumption vs. energy management in economic entities.	LO1, LO6,	Cleveland, & Morris (2015), Randolph & Masters (2018), Rubino, Sapio, & La Scala (2021)	Interactive lectures, discussion.
2	Renewable energy sources	Lecture / workshop/ e-learning	Types of renewable sources, environmental/social impacts, and grid integration.	LO1, LO2, LO7	Sebestyén (2011), Alam et al. (2020), Beck et al. (2025), European Commission (2017)	Energy source sorting game. Interactive map activity - where renewable works best. Minicase study: Renewable energy in my country/region/city/home.
3	Industrial energy flows (consumption balancing)	Lecture / workshop / e-learning	Monitoring/metering energy, balancing, optimization, and energy storage.	LO1, LO6, LO8	Ionita et al. (2023), Nolzen, Leenders & Bardow (2023), Guo et al. (2024)	Household energy audit. Minicases (e.g. Blackout Scenario). Energy storage simulation.
4	Symbiotic (Community) energy sharing	Lecture / Seminar / e-learning	Community energy sharing concepts, technical infrastructure, and legislative framework.	LO3, LO10, LO12	Leghissa, G. (2024), Chen, T., et al. (2025), European Community Power Coalition (2021)	Community energy model simulation (e.g. using case studie or role - play).

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
5	Reducing the energy consumption of buildings	Lecture/ workshop / e-learning	Energy standards, insulation optimization, consumption monitoring, sustainability enhancement.	LO2, LO6, LO7	Gkotsis et al. (2024), Energy Efficiency (2024), Widuto (2022)	Implementing efficiency measures on practical cases, complete interactive exercises.
6	Blue-green infrastructure (symbiosis in the heat islands)	Lecture/ workshop / e-learning	Urban cooling, green roofs, living walls, biodiversity support, blue-green symbiosis.	LO7, LO14	SALUTE4CE-Handbook (2022), Gartland (2008), Brázdrová & Kupka (2023)	Design interventions, field visits, data analysis.
7	Financial Modelling and Forecasting on Energy Markets	Lecture/ workshop	Data analysis, models of development, and forecasting of market variables.	LO4, LO8,	Bunn, Derek (2004), Prosser, Matthias (2025), Rees, Michael (2018)	Lecture with guided case studies on modeling random variables at energy markets.
8	Valuation of renewable energy investments	Lecture/ workshop	Cash flow prediction, project valuation, risk analysis (IRR, NPV).	LO4, LO9, LO11	Hürlimann, Christian (2019), Santosh Raikar and Seabron Adamson (2024)	Theory and practical case studies on renewable energy investments valuation
9	Energy Contracting and Business Models	Lecture / workshop / e-learning	PPA, ESCO, EPC, shared contracts, business model evaluation.	LO3, LO10, LO12	Andersen (2025), International Energy Agency (2023, 2024), North East & Yorkshire Net Zero Hub. (2024), RE-Source Platform (2025)	Lecture with guided case studies, Interactive seminar with guided discussion/project.
10	Emission allowances and their optimal management	Lecture / seminar / e- learning	Types of allowances, assignment methods, and risk decision models for companies.	LO05, LO13	Zapletal (2018), Zapletal et al. (2020), Abrell et al. (2022), Skjærseth & Wettestad (2016), Błażejowska et al. (2024)	Theory and practical case study of an industrial company in the EU based on the historical data.

6.4 Teaching & Learning Methods

▪ *Learning approach*

A hybrid learning approach will be adopted for this module, allowing sessions to be conducted either synchronously or asynchronously. Students will engage with interactive lectures, workshops, seminars, and guided discussions, as well as pre-recorded lectures, presentations, readings, case studies, and simulation exercises. This approach provides flexibility while ensuring active engagement and comprehensive understanding of the topics.

▪ *Key Teaching methods*

The module will use a variety of teaching methods, including interactive lectures with guided discussions to introduce foundational knowledge on energy systems, renewable energy, and energy management. Case studies, mini-case analyses, and role-playing simulations will allow students to apply theoretical knowledge to practical scenarios such as energy audits, energy sharing, and emission allowance management. Workshops and hands-on labs will develop skills in energy optimization, financial modeling, forecasting, and urban energy planning. Lectures/webinars, group projects, and seminars will enhance understanding of regulatory frameworks, innovative business models, and sustainability strategies. Assessments will include written or oral tasks to evaluate knowledge, analytical ability, and practical application.

▪ *Approaches and methods supporting active learning and practical application of knowledge.*

Practical-oriented methods, such as simulations, field interventions, and case studies, allow students to apply theoretical concepts to real-world energy challenges. Teamwork through workshops, group projects, and collaborative exercises enhances problem-solving, modeling, and decision-making skills. This combination equips students with the knowledge, skills, and competencies to effectively manage energy systems, implement sustainability solutions, and assess innovative strategies in industrial and urban contexts.

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6.5 Assessment Methods & Evidence

The module employs a mixed assessment strategy to evaluate both theoretical knowledge and practical skills across all topics. Students' understanding of energy systems, renewable sources, industrial energy flows, community energy, building energy efficiency, urban blue-green infrastructure, financial modeling, renewable energy valuation, energy contracting, and emission allowances management will be assessed through multiple methods. Assessments include active participation, applied exercises, project work, and written and oral exams. Both formative assessment (ongoing participation, exercises, and feedback) and summative assessment (final graded submissions) are integrated to support learning progression.

Assessment components & evidence of achievement of learning outcomes:

- *Participation & Engagement (Weight 10%).* Active participation in all teaching and learning activities, including lectures, workshops, seminars, e-learning exercises, case studies, simulations, and guided discussions. Engagement will be evaluated based on contribution to discussions, collaboration in group activities, and completion of interactive exercises.

- *Applied Exercises & Mini-Cases (Weight 20%).* Completion of practical exercises such as energy source sorting games, household energy audits, renewable energy simulations, building energy efficiency interventions, and blue-green infrastructure design tasks (testing LO6, LO7, LO8).
- *Group Project (Weight 40%).* A collaborative analytical project (approx. 3,000 words) focused on a real or simulated energy-related scenario, such as optimizing community energy sharing, designing energy efficiency measures for a building, or assessing emission allowances strategies. The report should include data analysis, decision-making, and practical recommendations (testing LO11 – LO14).
- *Final Written or Oral Exams (Weight 30%).* Exams will test theoretical knowledge and practical understanding across all module topics, including energy systems, renewable energy sources, industrial energy flows, financial modeling, valuation, energy contracting, and emissions management. Question formats may include open-ended questions, multiple choice, and scenario-based problems to evaluate LO1-LO5, LO9, LO10 comprehensively.

6.6 Bibliography & Tools

6.6.1 Required

Abrell, J., Cludius, J., Lehmann, S., Schleich, J., & Betz, R. (2022). Corporate emissions-trading behaviour during the first decade of the EU ETS. *Environmental and Resource Economics*, 83(1), 47–83.

Alam, M. S., Al-Ismaïl, F. S., Abido, M. A., & Salem, A. (2020). High-level penetration of renewable energy with grid: Challenges and opportunities. *arXiv*, 2006.04638. <https://doi.org/10.48550/arXiv.2006.04638>

Andersen. (2025, July 16). Energy Performance Contracts (EPCs): A pathway to sustainable energy solutions. <https://es.andersen.com/en/publications-and-news/energy-performance-contracts-epcs-a-pathway-to-sustainable-energy-solutions.html>

Beck, H. P., et al. (2025). A comprehensive review of sustainable energy systems in the context of the German energy transition—Part 2: Renewable energy and storage technologies. *Carbon Neutral Systems*, 3. <https://doi.org/10.1007/s44438-025-00013-z>

Błażejowska, M., Czarny, A., Kowalska, I., Michalczewski, A., & Stępień, P. (2024). The effectiveness of the EU ETS policy in changing the energy mix in selected European countries. *Energies*, 17(17), 4243.

Brázdová, K., & Kupka, J. (2023). The objectivization of the living green walls concept as a tool for urban greening (Case Study: LIKO-S a.s., Slavkov u Brna, Czech Republic). *Land*, 12(1), 229. <https://doi.org/10.3390/land12010229>

Bunn, D. (2004). *Modelling Prices in Competitive Electricity Markets*. London: Wiley. ISBN 978-0470848609

Chen, T., Anapyanova, A., Vandendriessche, F., & de Meer, H. (2025). Implementing energy sharing in energy communities: A comparative legal analysis of Austria and Flanders. *Utilities Policy*, 96. <https://doi.org/10.1016/j.jup.2025.101993>

Cleveland, C. J., & Morris, C. (2015). *Dictionary of Energy* (2nd ed.). Elsevier. <https://doi.org/10.1016/C2009-0-64490-1>

Energy Efficiency. (2024). Comparative analysis of residential building decarbonization policies in major economies: Insights from the EU, China, and India. *Energy Efficiency*, 17. <https://link.springer.com/article/10.1007/s12053-024-10225-w>

European Commission. (2017). Environmental baseline study for the development of renewable energy sources, energy storages and a meshed electricity grid in the North and Irish Seas. DG Energy. https://energy.ec.europa.eu/publications/environmental-baseline-study-development-renewable-energy-sources-energy-storages-and-meshed_en

European Community Power Coalition. (2021). Handbook on community energy. <https://communitypowercoalition.eu/2021/05/31/handbook-on-community-energy/>

Gartland, L. (2008). *Heat Islands: Understanding and Mitigating Heat in Urban Areas*. Earthscan / Taylor & Francis. <https://doi.org/10.4324/9781849771559>

Gkotsis, P., Papadopoulos, A., & Karagiannidis, A. (2024). Energy efficiency of buildings in Central and Eastern Europe: Room for improvement. *Energy Efficiency*, 17, Article 32. <https://link.springer.com/article/10.1007/s12053-024-10215-y>

Guo, J., Peng, J., Luo, Y., Zou, B., & Luo, Z. (2024). Study on the hybrid energy storage for industrial park energy systems: Advantages, current status, and challenges. *Nonlinear Systems and Optimization*, 3(1). <https://doi.org/10.1051/nso/20230051>

Hürlimann, C. (2019). *Valuation of Renewable Energy Investments*. Zurich: Springer Gabler. ISBN 978-3658274696

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Ionita, A., Kostopoulos, E., Almeida, A., Pires, A., & Ferreira, V. (2023). A systematic literature review on data-driven residential and industrial energy management systems. *Energies*, 16(4), 1688. <https://doi.org/10.3390/en16041688>

International Energy Agency. (n.d.). Energy Service Companies (ESCOs): ESCO Contracts. IEA Publications. <https://www.iea.org/reports/energy-service-companies-escos-2/escos-contracts>

International Energy Agency Efficient Energy Transition Programme (IEA EBC Annex 75 Deliverable 2). (2023, June 19). Business models for cost-effective building renovation at district level. https://annex75.iea-ebc.org/Data/publications/Annex75_D2_Report_BusinessModels_19_June_2023.pdf

Leghissa, G. (2024). A roadmap for a policy and legal framework for energy communities. Directorate-General for Energy, Energy Community Repository.

North East & Yorkshire Net Zero Hub. (2024, February). Power purchase agreement guide. <https://www.neynetzerohub.com/wp-content/uploads/2024/02/Power-Purchase-Agreement-Guide.pdf>

Nolzen, N., Leenders, L., & Bardow, A. (2023). Flexibility-expansion planning of multi-energy systems by energy storage for participating in balancing-power markets. *Frontiers in Energy Research*, 11, 1225564. <https://doi.org/10.3389/fenrg.2023.1225564>

Prossr, M. (2025). *Renewable Energy Financial Modelling* (1st ed.). Independently published. ISBN 979-8301944512

Randolph, J., & Masters, G. B. (2018). *Energy for Sustainability: Foundations for Technology, Planning, and Policy*. Island Press. ISBN 978-1-61091-820-6

Raikar, S., & Adamson, S. (2024). *Renewable Energy Finance: Theory and Practice* (2nd ed.). Boston: Academic Press. ISBN 978-0443159558

Rees, M. (2018). *Principles of Financial Modelling: Model Design and Best Practices Using Excel and VBA* (1st ed.). Hoboken: John Wiley. ISBN 9781118904015

RE-Source Platform. (n.d.). RE-Source's corporate PPA guide. <https://resource-platform.eu/corporate-ppa-guide/>

Rubino, A., Sapio, A., & La Scala, M. (2021). *Handbook of Energy Economics and Policy*. Academic Press. <https://doi.org/10.1016/C2017-0-01718-4>

SALUTE4CE-Handbook. (2022). *SALUTE4CE Handbook*. Interreg Central Europe. <https://programme2014-20.interreg-central.eu/Content.Node/SALUTE4CE/SALUTE4CE-Handbook.pdf>

Sebestyén, V. (2021). Environmental impact networks of renewable energy power plants. *Renewable and Sustainable Energy Reviews*, 151, 111626. <https://doi.org/10.1016/j.rser.2021.111626>

Skjærseth, J. B., & Wettestad, J. (2016). *EU emissions trading: Initiation, decision-making and implementation*. Routledge.

Widuto, A. (2022). *Energy saving and demand reduction*. European Parliamentary Research Service. [https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733666/EPRS_BRI\(2022\)73366_6_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733666/EPRS_BRI(2022)73366_6_EN.pdf)

Zapletal, F. (2018). *Optimization models for emissions management*. Series on advanced economic issues, Faculty of Economics, VŠB-TU Ostrava, vol. 53. Ostrava: VŠB-TU Ostrava. ISBN 978-80-248-4193-9

Zapletal, F., Šmíd, M., & Kopa, M. (2020). Multi-stage emissions management of a steel company. *Annals of Operations Research*, 292(2), 735–751.

6.6.2 Recommended

Boungou, W., & Dufau, B. (2024). EU ETS phase IV and industrial performance. *Economics Letters*, 236, 111596.

Ellerman, D. (2010). The EU emission trading scheme. In *Post-Kyoto International Climate Policy* (pp. 88).

Farid, M. (2021). *Introduction to Project Finance in Renewable Energy Infrastructure: Including Public-Private Investments and Non-Mature Markets* (1st ed.). Berlin: Springer. ISBN 978-3030687427

Fronda, S. (2025). *Renewable Energy Project Management: Strategy, Execution, and Sustainable Impact: A Comprehensive Guide to Developing, Managing, and Financing Sustainable Infrastructure Projects* (1st ed.). Independently published. ISBN 979-8288094965

Lynch, A. P. (2017). *Financial Modelling for Project Finance: Pre-financial close cashflow modelling in Excel* (3rd ed.). London: Lynch-Ayerst Publishing. ISBN 978-0995673007

SankeyMATIC Software tutorials. (n.d.). Available at: <https://sankeymatic.com/manual/>

Tang, L., Wang, H., Li, L., Yang, K., & Mi, Z. (2020). Quantitative models in emission trading system research: A literature review. *Renewable and Sustainable Energy Reviews*, 132, 110052.

Xue, X., Wang, S., Chun, T., Xin, H., Xue, R., Tian, X., & Zhang, R. (2023). An integrated framework for industrial symbiosis performance evaluation in an energy-intensive industrial park in China. *Environmental Science and Pollution Research*, 30, 42056–42074. <https://doi.org/10.1007/s11356-023-25232-0>

7. Concise Syllabus Template – HEI (EQF6)

Module Title: Environmental Management Systems (EMS)

EQF Level: 6

ECTS Credits: 4 ECTS

Total Workload (hours): 100 hours

- Contact hours (lectures, labs, seminars, workshops, etc.): 40 hours
- Guided self-study: 30 hours
- Project work: 30 hours

Delivering Institution: UNIVERSITY OF PATRAS (UPAT), Greece

7.1 Module Overview

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This Module provides an advanced introduction to Environmental Management Systems (EMS) and their role in supporting organisational sustainability, compliance, and continuous improvement. It focuses on the European EMAS Regulation as the primary EMS framework, supported by publicly available ISO 14001 fundamentals and the practical, step-by-step guidance of the U.S. EPA EMS model. Students develop an integrated understanding of how EMS frameworks are structured, how environmental aspects and impacts are identified and evaluated, how compliance obligations and performance indicators are set, and how audit, monitoring and review processes ensure continual improvement. This focus helps students see how EMS tools are applied in real-world settings to improve environmental performance. Through extensive hands-on use of official EMAS Tools—including the Environmental Aspects Tool, Data Collection Tool and Core Indicators—as well as EPA worksheets, students gain practical skills in analysing environmental performance and designing EMS components.

The Module is designed for HEI students and future professionals in sustainability, environmental management, industrial symbiosis facilitation, consulting, and compliance roles. It connects directly to the Industrial Symbiosis module by providing the operational and governance mechanisms required to embed symbiotic practices into organisational systems. Prior knowledge of environmental management, regulatory frameworks, or circular economy concepts is beneficial but not mandatory. By the end of the Module, students will be able to understand, compare and apply EMAS, ISO, and EPA EMS methodologies, and implement the core elements of a small-scale EMAS system, preparing them for real-world environmental management challenges.

7.2 Learning Outcomes (LOs)

The intended learning outcomes are divided into the three EQF domains:

▪ **Knowledge.** *Students will:*

1. demonstrate advanced understanding of EMS principles, structure and purpose, including EMAS requirements (Annexes I–IV) and publicly available ISO 14001 fundamentals (LO1),
2. critically evaluate the EMAS, ISO 14001, and EPA EMS frameworks, identifying their differences in requirements, transparency, auditing and performance (LO2).

▪ **Skills.** *Students can:*

3. identify and evaluate environmental aspects and impacts using EMAS methodologies and tools (Environmental Aspects Tool, Annex II criteria) (LO3),
4. develop EMS/EMAS core documentation, including environmental policy, objectives, KPIs, compliance registers, monitoring plans and operational controls (LO4),
5. apply EMAS Tools and EPA EMS worksheets to interpret environmental data, assess performance indicators and support EMS decision-making (LO5).

▪ **Competences (Autonomy & Responsibility).** *Students are able to:*

6. independently plan and coordinate key stages of EMAS implementation, including aspects evaluation, compliance assessment, KPI setting and monitoring (LO6),
7. perform internal EMS audits and contribute to management review processes, demonstrating accountability and continuous improvement orientation (LO7),
8. communicate effectively, formulate and defend evidence-based recommendations for EMS improvement to diverse stakeholders, including management and auditors (LO8),
9. propose adaptive solutions to common implementation challenges or non-conformities within an EMS, justifying choices based on EMAS, ISO, and EPA principles (LO9).

7.3 Indicative Learning Schedule / Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	What Are EMS? Understanding the Context	Lecture / workshop / e-learning	What EMS are, why they matter, EMS in EU sustainability and Industrial Symbiosis	LO1	EMAS User's Guide (Intro); EPA EMS Overview	Interactive lecture; context mapping; guided discussion
2	EMS Architecture & Core Components (EMAS/ISO/EPA)	Lecture	Structure of EMS (policy → planning → implementation → checking → review); PDCA	LO1	EMAS User's Guide – EMS Structure; EPA “Basic EMS Components” page	System mapping; component breakdown
3	EMAS Fundamentals (Part 1)	Lecture	What EMAS is; EMAS Registration; EMAS Annex I requirements; added value beyond ISO	LO1, LO2	EMAS Regulation (Annex I)	Guided reading
4	EMAS Fundamentals (Part 2): Aspects & Impacts	Workshop	EMAS Annex II methodology; significance assessment; environmental aspects mapping	LO3, LO6	EMAS Environmental Aspects Tool; EMAS Annex II	Hands-on use of EMAS Aspects Tool; significance scoring
5	EMAS Tools: Aspects, Indicators, Data (Hands-On Lab)	Hands-on Lab	Using EMAS Tools: Aspects Tool, Data Collection Tool, Core Indicators; preparing EMAS datasets	LO3, LO4, LO5, LO6	EMAS Data Collection Tool; EMAS Core Indicators Guidance	Template-based exercises; data interpretation

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
6	ISO 14001 Fundamentals	Lecture	ISO High Level Structure (public info); Clause overview; risk-based thinking; differences from EMAS	LO1, LO2	ISO 14001 Public Overview (iso.org); EPA “ISO-aligned EMS Guidance”	Conceptual comparison; mapping ISO structure
7	EPA EMS Step-by-Step Guide (Practical Module)	Workshop / Lab	EPA EMS Steps 1–9: Policy → Aspects → Legal → Objectives → Implementation → Monitoring → Audits → Review → Improvement	LO3, LO5, LO6	EPA EMS Implementation Guide; EPA Worksheet	Hands-on worksheet completion; scenario exercises
8	EMAS vs ISO 14001 vs EPA – Differences, Strengths, Tools	Workshop	Side-by-side comparison: requirements, transparency, indicators, audits, documentation	LO2, LO8, LO9	EMAS vs ISO comparison (EU); EPA “EMS Models” page	Venn diagram; structured comparison; group analysis
9	EMAS Implementation Step-by-Step (Advanced)	Workshop	Full EMAS workflow: Policy → Aspects → Compliance → KPIs → Controls → Monitoring → Audit → Statement (Annex IV)	LO4, LO7, LO9	EMAS Annex III (Audit) & Annex IV (Statement)	Group analysis
10	Final EMAS Project & Integration	Project / Assessment	Project / Assessment	LO4, LO5, LO6, LO8, LO9	All EMAS Tools; EPA EMS Worksheets	Documentation workshop

7.4 Teaching & Learning Methods

▪ *Learning approach*

A hybrid learning approach is adopted, combining synchronous and asynchronous modes. Synchronous sessions (lectures, seminars, workshops) facilitate direct interaction, guided discussions, and real-time problem-solving. Asynchronous learning provides flexibility by offering curated digital materials (EMAS User's Guide, EMAS Tools, EPA worksheets, ISO public summaries) on the learning platform, enabling self-paced study.

▪ *Key teaching methods*

- Interactive lectures introducing EMS concepts, EMAS structure, ISO 14001 fundamentals, and EPA step-by-step guidance.
- Case-based learning, applying EMAS tools to real or realistic organisational scenarios.
- Hands-on laboratory sessions using EMAS Environmental Aspects Tool, EMAS Data Collection Tool, EMAS Core Indicators, and EPA worksheets.
- Workshops and simulations, such as mock audits, management review simulations, and environmental statement drafting.
- Group work, supporting peer learning through tool-based tasks (aspects analysis, KPI setting, compliance mapping).
- Project-based learning, culminating in the development of a complete EMAS mini-system.

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These methods cultivate both conceptual understanding and practical competence in EMS/EMAS implementation.

▪ *Approaches and methods supporting active learning and practical application of knowledge*

Synchronous learning approach is well-suited to creating immediate engagement of trainers and students and faster exchanging of information, thus, helping to build a sense of community and clarify misconceptions. Moreover, asynchronous learning approach is more flexible. It allows more time for students to explore and engage with material and allows access to a wider range of students.

7.5 Assessment Methods & Evidence

Assessment components & evidence of achievement of learning outcomes

They consist of:

- *participation and engagement (Weight 10%),*
- *a practical group project (Weight 30%), and*
- *a final written examination (Weight 60%).*

Participation reflects students' active involvement in lectures, seminars, workshops, and tool-based exercises using official EMAS Tools and EPA EMS worksheets. The group project

requires students to collaboratively design a concise EMAS mini-system for a real or hypothetical organisation, applying key elements introduced across the 10 Units while retaining flexibility in structure and depth according to the specific organisational context they choose. The final written exam evaluates students' understanding of EMS and EMAS principles, ISO 14001 fundamentals (using publicly available sources), the distinctions between EMAS–ISO–EPA models, and their ability to analyse scenarios or interpret environmental aspects, indicators, or compliance data. Together, these components ensure that students demonstrate both theoretical knowledge and practical competence in implementing core EMS/EMAS processes.

7.6 Bibliography & Tools

7.6.1 Required

European Commission. (n.d.). *EMAS User's Guide*. https://green-forum.ec.europa.eu/publications/emas-users-guide-0_en

European Commission. (2009). *Regulation (EC) No 1221/2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS)*. <https://eur-lex.europa.eu/eli/reg/2009/1221/oj/eng>

European Commission. (2017). *EMAS Environmental Aspects Tool*. https://green-forum.ec.europa.eu/publications/environmental-aspects-tool_en

European Commission. (2017). *EMAS Data Collection Tool*. https://green-forum.ec.europa.eu/publications/data-collection-tool_en

European Commission. (2017). *EMAS Easy – Step-by-step Guidance for SMEs*. https://green-forum.ec.europa.eu/publications/emas-easy_en

U.S. Environmental Protection Agency. (2025). *EMS Implementation Guide*. <https://www.epa.gov/ems/plan-initial-development-ems>

International Organization for Standardization. (2015). *ISO 14001 — Environmental Management Systems (Public Overview)*. <https://www.iso.org/standard/60857.html>

Additionally, students are required to study all educational materials (lectures, presentations, notes, worksheets, and supplementary documents) uploaded by the instructor on the course platform, as they form an integral part of the module's core learning resources.

7.6.2 Recommended

European Commission. (2023). *EMAS – Tools*. *Green Forum: Green Business*. Retrieved November 18, 2025. https://green-forum.ec.europa.eu/green-business/emas/emas-resources/emas-tools_en

U.S. Environmental Protection Agency. (n.d.). *EMS Case Studies*. <https://www.epa.gov/sustainability/case-studies-and-best-practices>

Part B

7 Syllabuses for VET training modules

1. Concise Syllabus Template – VET (EQF5)

Module Title: The Industrial Symbiosis (IS) framework

EQF Level: 5

ECVET Credits: 2 to 3 ECVET

Total Workload (hours): 50-75

- Contact hours (inputs, seminars, workshops, etc.). 42- 56 hours
- Guided self-study: 4-9
- Project work: 4-10

Delivering Institution: MOGENSEN LENE (IDDK), Denmark.

1.1 Module Overview

This module introduces learners to the foundational concepts and practical applications of the **Circular Economy (CE)** and **Industrial Symbiosis (IS)** within the context of production and manufacturing.

It is designed specifically for managers, coordinators and facilitators in circular economy and industrial symbiosis initiatives, equipping them with essential managerial competencies.

This module introduces learners to Industrial Symbiosis (IS) from a practical and human-centered VET perspective. It looks at the competences needed for a CE/IS manager/facilitator. The module furthermore seeks to build understanding of IS in everyday terms, engaging stakeholders through dialogue, recognizing cultural enablers and barriers, and supporting innovation within teams and networks. The emphasis is on introductory facilitation skills grounded in real organizational contexts.

It serves as a foundational component of the SymbioTech training pathway, preparing participants for the next modules on Digital Industrial Symbiosis and Environmental Management Systems.

A general understanding of sustainability or industrial operations is helpful but not required. Basic analytical skills and an interest in collaborative problem-solving support effective engagement with the module's theoretical and practical components.

Upon completion, SymbioTech Managers and facilitators will be able to observe, document, and analyse material and energy flows within industrial facilities, as well as be able to facilitate innovation within diverse teams and network.

1.2 Learning Outcomes (LOs)

The intended learning outcomes are divided into the three EQF domains:

▪ **Knowledge.** *Students will:*

1. understand the principles of Industrial Symbioses (IS) and Circular Economy (CE) (LO1),
2. have an understanding of typical resource, energy, water and material flows in Small and medium sized enterprises (SMEs) (LO2),
3. have knowledge of enablers and barriers of IS (organizational, cultural, regulatory) (LO3),
4. know the role and core competences of IS facilitators, IS managers, team leaders etc (LO4),
5. have gained knowledge of facilitation of cross disciplinary teams with high levels of diversity as well as of innovative processes (LO5).

▪ **Skills.** *Students can:*

6. identify and document material/energy flows using simple tools (SankeyMATIC) (LO6),
7. identify cultural, organizational and regulatory enablers and barriers in their own context (LO7),
8. recognize the core competences needed for managing and/or facilitating IS (LO8),
9. build trust and understanding in cross-disciplinary and diverse teams (LO9),
10. facilitate simple innovative and idea-generating processes within teams and networks (LO10).

▪ **Competences (Autonomy & Responsibility).** *Students are able to:*

11. take responsibility for early-stage IS exploration tasks (LO11)
12. engage with enablers and barriers at an organizational level to support managers in decision-making (LO12),
13. continuously improve own competences as an IS manager/facilitator through reflective practice (LO13),
14. facilitate meaning-making processes internally and within IS networks characterized by high diversity (LO14),
15. balance diversity and psychological safety to ensure innovation and idea-generation (LO15).

1.3 Indicative Learning Schedule/ Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	Introduction to IS and CE, and its history. Introduction to mapping of flows of energy and materials	Input Workshop	Overview of Circular Economy & Industrial Symbiosis, IS definition. From the IS case of Kalundborg in the 1960s to Digital IS of the 2020s. Mapping energy and material flow with Sankey MATIC	LO1, LO2, LO6, LO11	Nolan (2020) SankeyMATIC Software tutorials QGIS Software tutorials	Interactive input with guided discussion on I, CE and sustainability studies. Case studies with success and failures of IS Interactive input on mapping flows of energy and materials Instruction on home assignment (SankeyMATIC mapping of flows of energy and material)
2	Enablers and barriers, understanding organisational and cultural context, EU policy and funding opportunities	Input Workshop	An initial look at the human factor that makes SI happen. Understanding organisational culture as well as national culture and how it interacts with the basic principles of SI. Knowledge of EU and national policy as well as funding opportunities	LO3, LO7, LO12	Mathews (2024) European Green Deal IS case studies	Presentation of home assignment Interactive input on organisational and national culture followed by group discussions of own cases Seminar-based introduction to EU legislation and funding opportunities Group work on own legislative and funding context. Presentation of group work.

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
3	IS manager and facilitator competences, role and responsibilities. Mapping internal and external stakeholders	Input Workshop	Further look into the human factor of SI. Identifying different organisational roles within SI as well competences needed for each role. Furthermore, initial mapping of potential partners. When to apply the different competences as salesperson, networker, manager, project-manager, fund-raiser, facilitator. Self-reflection: am I the right person in the right position, and what do I need to develop?	LO4, LO8, LO13	Lasthein et al. (2021) Mortensen & Kørnøv (2019)	Interactive input on IS roles and connected competences. Group work on mapping different positions within and outside of the organization in relation to IS, as well as impact on different parts of the organization. Group project presentation Self-reflection on own IS competences.

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
4	Inclusion, diversity and psychological safety. Facilitating interdisciplinary dialogue	Input Workshop	Facilitation of teams and groups in an IS context. Understanding the importance of diversity of professions, gender, age etc. as well as psychological safety. Practicing basic dialogue and facilitation skills, building understanding as well as enabling out-of-the box thinking	LO5, LO9, LO14	Edmonson & Roloff (2009) Gallo (2023) Kepinski & Nielsen (2022) Pentland (2014) Rock et al. (2016)	Interactive input on facilitation of teams and networks. Hands-on session (concrete exercises and role plays). Feedback from course leader. Instruction about oral exam.
5	Facilitating innovation Assessment	Input Workshop	Understanding incremental vs radical innovation Factors that enable innovation Facilitation of innovative processes internally within the organization and externally within the network	LO5, LO10, LO15	Darsø (2001) Høyrup (2010)	Interactive input on innovation and how to facilitate innovation in teams. Hands-on session (concrete exercises and role plays). Feedback from course leader. Oral exam.

1.4 Teaching & Learning Methods

■ *Learning approach*

The modules will primarily be based on face-to-face learning, supplementing with assignments to be carried out between the modules, primarily within their own organization. The face-to-face approach allows the students to develop competences needed in the workplace and get direct feedback on their performance from peers and the trainer.

The module will be supported by a digital platform for asynchronous learning, where the students can access materials which will be made available by the trainers. The material on the digital platform will primarily consist of literature and presentations describing theoretical issues.

■ *Key teaching methods*

Multiple key teaching methods will be used throughout the modules such as interactive inputs with guided discussions, case studies, group discussions, group project work, role-plays and simulations, individual reflection and assignments to be carried out in between of the modules within own organization.

■ *Approaches and methods supporting active learning and practical application of knowledge*

Face-to-face learning is well-suited for creating engagement between trainers and students and to ensure that the theory is seen as relevant in the every-day work practice. Despite the theoretical basis, the training will be highly practical. The course will consist of a mix of short theoretical inputs, concrete exercises, and group discussions. The inputs will provide theoretical knowledge for a comprehensive understanding of the IS principles, elements, and practices. It is believed that the only way to learn to facilitate SI processes is to relate the theory to the concrete realities in the different organizations, to try out the tools in real life and gain own experiences, reflect upon them. The starting point for input and discussions will thus be the work challenges and questions that the group bring to the room. Likewise, the modules will end with concrete assignments supporting the students to test out new ideas at home. Furthermore, face-to face learning combined with group discussions, role-plays and simulations allow the students to form a community in which peer-learning can take place. It will be the role of the facilitator to make sure that diverse voices and are brought into the room, showing the complexity of IS issues from the perspective of different genders, ages, professions, cultural backgrounds etc.

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1.5 Assessment Methods & Evidence

The Module employs a mixed assessment strategy that combines students' active participation and engagement, group project presentation and oral exam, to evaluate both the level of students' theoretical knowledge of the IS concept as well as their practical ability to develop sustainable IS frameworks as well as facilitate dialogue among a diverse range of stakeholders. The assessment will not only be summative (final graded submissions), but also formative (ongoing participation and feedback from peers and trainer during all the key teaching methods) to support learning progression.

Assessment components:

- *Participation & Engagement (Weight 40%).* Active participation in all teaching methods adopted such as inputs, discussions in plenary, role-plays and simulations
- *Group and individual project presentation (Weight 30%).* Presentation of groups work during modules as well presentation of individual assignments carried out in between of the modules.
- *Final oral exam (Weight 30%).* There will be a final oral exam to evaluate if the student has achieved the learning of the module, relating it to own organisational context, including a plan for own development as IS manager or facilitator. The exam tests theoretical knowledge, policy understanding, as well as practical competences.

1.6 Bibliography & Tools

1.6.1 Required

Darsø, L. (2001) *Innovation in the Making*. Samfundslitteratur

Edmonson, A. & Roloff, K. (2009). Leveraging diversity through Psychological Safety. *Rotman Magazine*, Fall 2009
https://scholar.harvard.edu/files/afriberg/files/leveraging_diversity_through_psychological_safety_hbs_article.pdf

European Green Deal. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Gallo, A. (2023) What is Psychological safety? *Havard Business Review*, February, 2023
<https://hbr.org/2023/02/what-is-psychological-safety>

Høyrup, S. (2010) Employee-driven innovation and workplace learning: Basic concepts, approaches and themes. In: *Transfer European Review of Labour and Research* 16(2):143-154

Kepinski, L. & Nielsen, T. C. *Inclusion Nudges. A short introduction to this change approach.*
<https://inclusion-nudges.org/wp-content/uploads/2022/08/Inclusion-Nudges-Free-Quick-Guide.pdf>

Lasthein, M.K.; Lingås, D.B.; Johansen, L.M. (eds) (2021). *Guide for Industrial Symbiosis Facilitators*. Transition Aps. Chrome extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.symbiosis.dk/wp-content/uploads/2021/03/Guide-for-IS-facilitators_online2.pdf

Mathews, S. (2024) Metaphors of Organizations: Beyond the Machine.
<https://www.leadingapiens.com/metaphors-of-organization/>

Mortensen, L. & Kørnøv, L. (2019) Critical factors for industrial symbiosis emergence process. In: *Journal of cleaner production*, 212, 56-69.
<https://www.sciencedirect.com/science/article/abs/pii/S0959652618336254>

Nolan, S (ed) (2020) *Quick Guides. Helping industries increase efficiency through resources sharing*. SCALER. [chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://circulareconomy.europa.eu/platform/sites/default/files/2025-09/SCALER-Quick-Guides.pdf](https://efaidnbmnnnibpcajpcglclefindmkaj/https://circulareconomy.europa.eu/platform/sites/default/files/2025-09/SCALER-Quick-Guides.pdf)

Pentland, S. (2012). The New Science of Building Great Teams. *Harvard Business Review*, April 2012 <https://hbr.org/2012/04/the-new-science-of-building-great-teams>

QGIS Software tutorials. Available at: https://docs.qgis.org/3.40/en/docs/training_manual/index.html

Rock, D., Halvorsen, H.G. & Grey, J. (2016) Diverse Teams Feel Less Comfortable – and That’s Why they perform better. *Harvard Business Review*, September 2016. <https://hbr.org/2016/09/diverse-teams-feel-less-comfortable-and-thats-why-they-perform-better>

SankeyMATIC Software tutorials. Available at: <https://sankeymatic.com/manual/>

Uzzi, B. (1997) Social Structure and Competition in Interfirm Networks: The Paradox of Embeddedness. In: *Administrative Science Quarterly*, 35-67

Vestergaard, B. (2012). Managing an unpopular change effort. In: *Harvard Business Review*, December 5, 2012

1.6.2 Recommended

Coleman, J. (2013) Six components of great corporate culture. In: *Harvard Business Review*, May 6, 2013

Fraccascia, L. & Giannoccaro, I. (2020). What, where, and how measuring industrial symbiosis: A reasoned taxonomy of relevant indicators. In: *Resources, conservation and recycling* 157, 104799.

McKinsey & Company: How to beat the transformation odds. https://www.mckinsey.com/mm/~media/mckinsey/business%20functions/people%20and%20organizational%20performance/our%20insights/how%20to%20beat%20the%20transformation%20odds/how_to_beat_the_transformation_odds.pdf

Neves, A., Godina, R., Azevedo, S. G., & Matias, J. C. O. (2020). A comprehensive review of industrial symbiosis. *Journal of Cleaner Production*, 247, 119113. <https://doi.org/10.1016/j.jclepro.2019.119113>

Placuzzi, V., Zanotti, G. (2019). *Towards an industrial symbiosis in the Emilia-Romagna region (Italy): A Study on the Main Barriers to Industrial Symbiosis in the Italian Context*. <https://research.cbs.dk/en/studentProjects/towards-an-industrial-symbiosis-in-the-emilia-romagna-region-ital/>

2. Concise Syllabus Template – VET (EQF5)

Module Title: Life Cycle Assessment principles for assessing the environmental benefits and drawbacks of sharing resources

EQF Level: 5

ECVET Credits: 2 to 3 ECVET

Total Workload (hours): 50-75

- Contact hours (inputs, seminars, workshops, etc.). 42- 56 hours
- Guided self-study: 4-9
- Project work: 4-10

Delivering Institution: CHAMBER OF COMMERCE AND INDUSTRY VRATSA SDRUZHENIE (CCI VRATSA), Bulgaria.

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2.1 Module Overview

This module equips learners with the essential knowledge and practical skills to apply Life Cycle Assessment (LCA) as a decision-support tool within circular economy (CE) and industrial symbiosis (IS) contexts. It introduces life-cycle thinking and the state of the art of LCA applications, followed by an overview of the ISO 14000 family of environmental management standards, and a focused introduction to the ISO 14040/14044 methodology and key sustainability indicators such as the Environmental Footprint (EF 3.1), Life Cycle Costing (LCC), and Social LCA.

Delivered in an intensive 4–5 week blended format, the module combines face-to-face workshops, online seminars, e-learning, and mentored project work. Participants learn to model and interpret environmental impacts using openLCA, assess trade-offs, and identify improvement opportunities across product systems. The module links life-cycle thinking with broader sustainability frameworks including the European Green Deal and the UN Sustainable Development Goals.

Learners develop systems thinking, ethical awareness, and communication skills. No prior module completion is required, though basic familiarity with sustainability or industrial processes is beneficial.

By the end of the module, participants can independently carry out a simplified LCA, support sustainability reporting, and contribute to informed decision-making in SME and CE/IS settings. Learning Outcomes align with ESCO and GreenComp competences.

2.2 Learning Outcomes (LOs)

The intended learning outcomes are divided into the three EQF domains of Knowledge, Skills, and Competence (Autonomy & Responsibility):

▪ **Knowledge.** *Students will:*

1. understand the four phases of an LCA according to ISO 14040/14044 (goal and scope definition, life cycle inventory, life cycle impact assessment, interpretation) (LO1),
2. understand the structure and purpose of key environmental indicators (e.g. EF 3.1 methodology) and their role in managerial decision-making and sustainability reporting (LO2),
3. recognize how LCA functions within broader sustainability strategies (e.g. circular economy models and the Sustainable Development Goals), and explain the interconnections between circular economy frameworks, the SDGs, and life-cycle thinking (LO3),
4. interpret environmental, economic, and social performance indicators using LCA-based tools to compare sustainability impacts of products or processes (LO4),
5. identify the policy relevance of LCA results, particularly in relation to the European Green Deal and the EU Circular Economy Action Plan (LO5).

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▪ **Skills.** *Students can:*

6. Gather and organize the necessary data (e.g. Bill of Materials and process data) for building an LCA model, ensuring data quality and completeness (LO6),
7. Operate the openLCA software to carry out life cycle assessments – including using the “Quick LCA” wizard for simplified cases – and model circular economy or industrial symbiosis scenarios to assess environmental impacts (LO7),
8. Analyze and interpret LCA results to support sustainable production and business decision-making, identifying hotspots and improvement opportunities (LO8),
9. Incorporate basic Life Cycle Costing (LCC) and Social LCA (S-LCA) approaches to evaluate economic and social dimensions alongside environmental impacts for a more holistic sustainability assessment (LO9),
10. Translate technical LCA findings into clear visual and verbal communications (reports, presentations) that are tailored to diverse stakeholders and decision-makers (LO10).

▪ **Competences (Autonomy & Responsibility).** *Students are able to:*

11. Work independently and methodically on LCA tasks, taking responsibility for data accuracy, proper methodology, and correct interpretation of results (LO11),
12. Take initiative to contextualize LCA findings within broader sustainability and business goals, and identify opportunities to use LCA in organizational improvement and compliance efforts (LO12),
13. Communicate LCA results in a responsible and transparent manner, clearly acknowledging uncertainties, limitations, and system boundaries of the analysis (LO13),
14. Demonstrate systems thinking and ethical awareness when evaluating environmental, economic, and social impacts, considering the interconnected nature of sustainability challenges (LO14),
15. Critically reflect on trade-offs, stakeholder perspectives, and value conflicts inherent in circular economy transitions, and balance these factors when making recommendations (LO15).

2.3 Indicative Learning Schedule / Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	Foundations of LCA & CE/IS	Face-to-face, Bootcamp	Life-cycle thinking and sustainability context; LCA in circular economy and industrial symbiosis; current policy and industry applications; ISO 14000 framework and ISO 14040/14044; LCA principles, functional unit, and system boundaries.	LO1, LO3, LO5, LO14	ISO 14000 family overview (selected excerpts); ISO 14040/44 extracts; EC Green Deal	Interactive lecture, guided discussion, software demo, hands-on exercise.
2	Data Collection & LCI Modelling	Online Seminar, E-learning, Mentoring	BoM & LCI data gathering; data quality; LCI databases; building product systems in openLCA; addressing data gaps	LO6, LO7, LO11	BoM template; LCI tutorials; dataset examples; openLCA Beginner Guide	Self-paced learning, workplace assignment, mentor check-ins.
3	LCIA & Interpretation	Live Webinar + Applied Practice	EF 3.1 method; midpoint/endpoint indicators; LCIA execution; hotspot analysis; circular vs. linear scenario comparison; intro to LCC and S-LCA	LO2, LO4, LO8, LO9, LO12, LO15	EF 3.1 method docs; Valdivia et al. (2021)	Software walkthrough; case study analysis; peer discussion.

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
4	LCA Project Development & Peer Review	Mentored Project Work + Online Workshop	Finalizing LCA model; interpreting results; improvement options; preparing 5-slide summary; peer review session	LO4, LO8, LO10, LO11, LO12, LO13, LO15	Interpretation template; presentation checklist	Independent project work; mentor meetings; structured peer feedback.
5	Final Assessment	Hybrid Assessment	Submission of model & report; final presentation; oral defense	LO10, LO11, LO12, LO13, LO14, LO15	LCA model file; slide deck; assessment rubric	Summative assessment; oral exam.

2.4 Teaching & Learning Methods

This module is delivered in a blended format that integrates an initial face-to-face bootcamp, online seminars, e-learning, and mentored project work. The pedagogical approach emphasises active, practice-oriented learning through interactive lectures, guided discussions, hands-on training in openLCA, and real-world case studies. Learners complete an applied LCA project and receive weekly mentor support.

This blended, applied approach builds the autonomy, problem-solving abilities, and analytical competences expected at EQF Level 5.

The module follows inclusive teaching principles and ensures accessibility of digital materials, assessments, and learning activities.

2.5 Assessment Methods & Evidence

Assessment in this module is integrated with the practical project work to authentically evaluate the achievement of learning outcomes. The assessment strategy includes both formative and summative components, with an emphasis on demonstrating real-world LCA competences:

Formative Assessment: Throughout the module, learners receive ongoing feedback on their progress. Mentors review draft work (such as LCA scope definitions, interim data sets, and preliminary results) and provide guidance. The peer feedback session in Week 9 is also a formative opportunity for learners to refine their presentations and deepen their understanding in a low-stakes setting. While formative activities are not graded, they are crucial for learning and preparation.

Summative Assessment: The formal evaluation occurs in Week 10 and consists of three parts:

- *LCA Project Submission (approximately 50% weighting):* Each student submits a complete LCA project dossier. This includes the openLCA **project file** (or exported package) with a fully defined model (documenting the functional unit, system boundary, inventory data, chosen impact assessment method, and any assumptions). A brief written report or annotated presentation slides summarizing the study's scope, methodology and key findings may accompany the model. This component assesses the learner's technical ability to conduct an LCA and produce the requisite documentation.
- *Presentation (approx. 20%):* Learners deliver a concise **presentation** (around 5 slides) that communicates the LCA project to an audience. This tests the ability to distill and present information clearly – covering the goal & scope, important results (e.g. top impact contributors), interpretation including any comparisons or improvement scenarios, and practical recommendations. Communication clarity, visual effectiveness, and focus on decision-relevant insights are evaluated here.
- *Oral Defense (approx. 30%):* Immediately following the presentation, learners engage in an **oral examination** (a structured Q&A or “viva voce”). The assessor probes the learner's understanding of their work: asking for justification of choices (e.g. why certain data, impact methods, or assumptions were used), interpretation of specific results (especially relating to EF 3.1 impact categories), and implications of findings. Learners may also be asked about

limitations of their study and how they managed uncertainties (addressing LO13). This component evaluates depth of understanding, critical thinking, and the ability to articulate and defend the work – key competences at EQF5.

If applicable, a peer feedback element (ungraded) may also be used wherein fellow learners fill out a feedback form or rubric for each presentation. This promotes a reflective practice but does not directly affect grades.

Assessment Evidence: To successfully pass the module, learners must produce **tangible evidence** of their competences. This includes:

- The *openLCA model file* (or exported archive) containing all model data, which demonstrates the correct setup and execution of an LCA study.
- A *presentation file* (PDF of slides or report) that succinctly communicates the LCA process and outcomes.
- A *recording or live observation* of the oral defense, providing evidence of the learner's explanation and reasoning abilities.
- A completed *assessment rubric* or evaluation form from the instructor, documenting performance against each criterion (e.g. technical accuracy, application of standards, communication quality, and analytical insight).
- (Optional) *Peer feedback forms* or the learner's self-reflection notes, which are used in the learning process and can be included as part of a portfolio.

Both the project artifact and the oral performance must meet minimum quality standards. The grading rubric is aligned with the learning outcomes to ensure fairness and transparency. Learners need to show competence in each major area (technical LCA skills, analysis/interpretation, and communication) to earn the full 3 ECVET credits and the SymbioTech “EcoFootprint Assessor” digital badge for this module.

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2.6 Bibliography & Tools

2.6.1 Peer-Reviewed Articles

Aissani, L., Lacassagne, A., Bahers, J., & Le Féon, S. (2019). Life cycle assessment of industrial symbiosis: A critical review of relevant reference scenarios. *Journal of Industrial Ecology*, 23(4), 972–985. <https://doi.org/10.1111/jiec.12887>

Daddi, T., Nucci, B., & Iraldo, F. (2017). Using life cycle assessment (LCA) to measure the environmental benefits of industrial symbiosis in an industrial cluster of SMEs. *Journal of Cleaner Production*, 147, 157–164. <https://doi.org/10.1016/j.jclepro.2017.01.090>

Kerdlap, P., Low, J. S. C., Tan, D. Z. L., Yeo, Z., & Ramakrishna, S. (2020). M³-IS-LCA: A methodology for multi-level life cycle environmental performance evaluation of industrial symbiosis networks. *Resources, Conservation & Recycling*, 162, 104963. <https://doi.org/10.1016/j.resconrec.2020.104963>

Valdivia, S., Backes, J. G., Traverso, M., Sonnemann, G., & Finkbeiner, M. (2021). Principles for the application of life cycle sustainability assessment. *The International Journal of Life Cycle Assessment*, 26(9), 1900–1905. <https://doi.org/10.1007/s11367-021-01993-4>

2.6.2 EU Policy & Institutional Reports

European Commission. (2019). *The European Green Deal* (COM/2019/640 final). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640>

European Commission. (2020). *Circular Economy Action Plan: For a cleaner and more competitive Europe* (COM/2020/98 final). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0098>

Joint Research Centre (European Commission). (2022). *Environmental Footprint 3.1 method*. <https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html>

2.6.3 International Standards (ISO)

International Organization for Standardization. (2006a). *Environmental management—Life cycle assessment—Principles and framework* (ISO 14040:2006). ISO.

International Organization for Standardization. (2006b). *Environmental management—Life cycle assessment—Requirements and guidelines* (ISO 14044:2006). ISO.

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2.6.4 Software & Databases

GreenDelta. (2023). *openLCA* (Version 1.11) [Software]. <https://www.openlca.org>

GreenDelta. (2023). *openLCA Nexus* [Database platform]. <https://nexus.openlca.org>

Ecoinvent Association. (2023). *Ecoinvent database* (Version 3.8) [Life cycle inventory database]. <https://www.ecoinvent.org>

SankeyMATIC. (2023). *SankeyMATIC* [Web-based software]. <https://sankeymatic.com>

2.6.5 Optional / Supplementary Resources

European Commission. (n.d.). *Environmental Footprint (EF) home page*. https://ec.europa.eu/environment/ecoap/initiatives/eu-environmental-footprint-home_en

European Platform on Life Cycle Assessment (EPLCA). (n.d.). *Life Cycle Initiative resources*. <https://eplca.jrc.ec.europa.eu>

3. Concise Syllabus Template – VET (EQF5)

Module Title: Inter-organisational relations

EQF Level: 5

ECVET Credits: 2 to 3 ECVET

Total Workload (hours): 65

- Contact hours (inputs, seminars, workshops, etc.). 45 hours
- Guided self-study: 20

Delivering Institution: EXEO LAB S.R.L. (Exeo Lab), Italy.

3.1 Module Overview

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This module provides learners with the practical skills needed to begin and facilitate inter-organizational collaborations within Industrial Symbiosis (IS) ecosystems. Its goal is to improve the skills of future SymbioTech Managers, VET students, and professionals working in the industrial, municipal, or environmental sectors to discover relevant partners, foster trust, and encourage early-stage resource-exchange collaboration.

The module covers important topics such as stakeholder profiling and mapping, communication and trust-building strategies, conflict and opposing management, key negotiation approaches, and the creation of simple cooperation papers (e.g., Memoranda of Understanding). The module is structured **over five weeks** and consists of ten concise learning units organised in a progressive and practice-oriented sequence. This design follows a competence-based VET approach, combining short theoretical inputs with continuous application, reflection, and skills practice. Each week focuses on a coherent thematic area and leads to tangible learning outputs that contribute to a final partner engagement project. The structure is aligned with experiential and microlearning principles, ensuring cognitive sustainability, effective skill acquisition, and strong learning transfer to professional contexts.

Practical seminars and role-play exercises allow students to practise communication, meeting facilitation, and persuasive techniques in real-life situations.

This module is primarily addressed to **VET students and professionals** working in the circular economy, environmental services, industrial operations, or local development. It focusses on the introductory knowledge presented in *Module 1: Industrial Symbiosis Framework*,

particularly on IS concepts and stakeholder relevance. It also prepares students for successful modules that cover digital technologies, environmental management, and advanced partnership coordination.

No formal qualifications are necessary, however prior experience with sustainability, basic communication skills, or organisational dynamics is suggested.

3.2 Learning Outcomes (LOs)

▪ *Knowledge. Students will:*

1. understand the dynamics of inter-organisational collaboration in Industrial Symbiosis (IS), including how to identify and profile typical partner types (SMEs, utilities, municipalities, waste operators). Develop an understanding of complex sustainability problems and their evolution, recognising that system components behave differently when analysed in isolation versus within the broader system (LO1),
2. know the principles of trust-building, interest alignment and collaborative behaviour in multi-stakeholder environments (LO2),
3. recognise common sources of resistance to change and understand behavioural strategies to address and mitigate resistance in early IS initiatives (LO3),
4. understand the structure, purpose and essential components of a basic Memorandum of Understanding (MoU) for outlining collaboration terms (LO4),
5. be familiar with the core principles of negotiation, persuasive communication and lobbying within business partnerships relevant to Industrial Symbiosis (LO5).

▪ *Skills. Students can:*

6. map and document stakeholders using simple tools (e.g., templates, matrices), identifying their interests, influence, potential contributions and barriers relevant to Industrial Symbiosis initiatives (LO6),
7. communicate professionally in written and verbal formats, including drafting outreach emails, developing meeting scripts, conducting discovery calls and preparing for site visits with potential partners (LO7),
8. facilitate early-stage collaboration activities by guiding introductory discussions, managing small-group interactions, and supporting dialogue between diverse organisational actors (LO8),
9. apply basic negotiation and persuasion techniques to address concerns, manage objections and foster shared understanding among potential IS partners (LO9),
10. draft a simple Memorandum of Understanding (MoU) that clearly outlines roles, expectations, potential resource exchanges, risks and mutual benefits (LO10),

11. use trust-building, active listening and reframing techniques to influence and engage hesitant or sceptical partners, strengthening early-stage collaboration dynamics (LO11).
- **Competences (Autonomy & Responsibility).** *Students are able to:*
12. take responsibility for planning and executing partner outreach activities, including preliminary research, meeting preparation and timely follow-up (LO12),
13. anticipate possible resistance or misunderstandings during inter-organisational exchanges and adapt communication strategies to maintain trust, clarity and constructive engagement (LO13).
14. represent their organisation professionally, ethically and diplomatically in interactions with external stakeholders, ensuring transparent and respectful communication (LO14),
15. escalate complex, sensitive or legal matters to supervisors or project leads while independently maintaining momentum in early collaboration processes (LO15).
16. engage proactively with partners by demonstrating initiative, persistence and reflective practice to strengthen collaboration effectiveness in IS contexts (LO16).

3.3 Indicative Learning Schedule / Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	U.1 Introduction to Inter-organisational relations in IS	Theory input + Workshop	Overview of IS partnerships; understanding partner types (SMEs, utilities, municipalities, waste operators); introduction to complex sustainability problems and system behaviour (“components behave differently in isolation vs. the system”)	LO1, LO3	Case studies (e.g., Eco-Industrial Parks, ECO3)	Interactive lecture; guided discussion; introductory scenario analysis.
	U.2 Stakeholder mapping and engagement theory	Theory input+Workshop	Stakeholder engagement theory (Freeman model, salience model, interest/influence grids); mapping actors’ interests, influence, motivations and barriers; identifying collaboration potential in IS ecosystems.	LO1, LO2, LO6, LO8	Stakeholder mapping templates; IS case studies	Interactive theory input; hands-on mapping lab; small-group exercises.
2	U.3 Trust-building and Communication strategies	Input + Role-play	Relationship-building in multi-stakeholder environments; communication styles; trust and reciprocity; framing and active listening. Application to early-stage IS interactions.	LO2, LO7, LO8, LO11	Communication toolkit: short readings on trust-building	Role-play simulations; peer feedback; guided discussion.
	U.4 Resistance to change and persuasion techniques	Workshop	Types of organisational and behavioural resistance; objection-handling; persuasion and influence strategies; reframing benefits for hesitant partners.	LO3, LO9, LO11	Resistance Scenario Deck	Case-based simulations; micro-exercises; trainer feedback.

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
3	U.5 Partner outreach and early engagement activities	Input + Workshop	Drafting outreach emails; planning introductory calls; preparing and facilitating site visits; managing early interactions with diverse actors.	LO7, LO8, LO12	Email and call script templates	Writing labs; pair simulations; practical communication drills.
	U.6 Basics of negotiation in IS contexts	Input + Simulation	Win-win negotiation principles; identifying interests vs. positions; framing proposals; negotiating early cooperation terms.	LO5, LO9, LO11	Negotiation cases examples	Structured negotiation simulations; group reflection.
4	U.7 Drafting a Memorandum of Understanding (MoU)	Workshop	Purpose and structure of MoUs; drafting clauses (roles, flows, risks, benefits, confidentiality, next steps); peer review of drafts.	K4, S5	MoU template	Group drafting session; peer-assessment workshop.
	U.8 Workplace-based partner engagement project	Mentored self-study	Learners select a real or hypothetical partner; prepare stakeholder profile, engagement plan, communication samples, and draft MoU terms.	LO6–LO11, LO12–LO16	Workplace data and context	Tutor mentoring; iterative feedback; autonomous project development.
5	Final Assessment Clinic	Assessment	Submission of partner engagement plan; recorded role-play simulating negotiation with a hesitant partner; short oral Q&A on trust-building and resistance management.	All LOs	Assessment rubric; video/recording guidelines	Oral debrief; performance review; reflective discussion.

3.4 Teaching & Learning Methods

The module adopts a practice-oriented and experiential VET learning approach designed to strengthen interpersonal, communication, and negotiation skills required for inter-organisational collaboration in Industrial Symbiosis. Teaching and learning methods combine short theoretical inputs with hands-on activities, reflection, and workplace application to support skill acquisition and behavioural competence.

1. Theory input: short, focused presentations (10–25 minutes) introducing key concepts such as stakeholder engagement theory, trust-building, resistance to change, persuasive communication, and negotiation principles. These inputs provide learners with essential frameworks necessary for informed participation in practical activities.

2. Workshops: learners analyse stakeholder scenarios, conduct stakeholder mapping, draft outreach messages, and discuss potential collaboration pathways. Workshops emphasise active participation, problem-solving, and learning-by-doing, enabling learners to apply theoretical concepts to realistic situations.

3. Role-plays and simulations: simulated partner meetings, negotiation exercises, and resistance-handling scenarios allow learners to practice communication, persuasion, and facilitation techniques in a safe environment. Role-plays include structured feedback from peers and trainers, enhancing self-awareness and behavioural competence.

4. Group work and peer learning: teams collaborate on mapping exercises, MoU drafting, outreach strategies, and case analysis. Peer learning promotes diverse perspectives and mirrors real inter-organisational collaboration dynamics while building soft skills such as listening, coordination, and conflict management.

5. Scenario-based learning: realistic case studies (industrial parks, local clusters, municipal partnerships) guide learners to explore barriers, opportunities, and relational dynamics in Industrial Symbiosis. Scenario-based learning supports decision-making, systems thinking, and practical problem-solving.

6. Micro-skills training: through short practical exercises (e.g., constructing email subject lines, rehearsing opening lines of calls, summarising a partner's position), learners refine specific communication and facilitation skills needed for effective outreach and engagement.

7. Reflective practice: learners review their performance after role-plays, examine strengths and weaknesses, and identify areas for personal improvement. Reflection supports continuous competence development, autonomy, and maturity in handling professional interactions.

8. Workplace-based learning: learners apply module concepts in their workplace or simulated professional environment by profiling a real or potential partner, preparing an engagement plan, and drafting MoU content. This bridges theory with authentic practice and supports relevance to job roles.

9. Mentoring and feedback: trainers provide personalised feedback on communication samples, engagement strategies, and MoU drafts. Mentoring enhances learning transfer and reinforces learners' confidence in managing real-life collaboration situations.

3.5 Assessment Methods & Evidence

The assessment strategy for this module combines formative and summative components to evaluate learners' ability to engage effectively in inter-organisational collaboration processes relevant to Industrial Symbiosis. Assessments measure not only theoretical understanding but also communication skills, behavioural competences, and the ability to apply tools and methods in realistic contexts.

- *Participation and engagement – 30% (formative +summative).* Learners are assessed on their active contribution to workshops, role-plays, discussions, stakeholder mapping activities, and micro-skills exercises.

Assessed competences: communication, collaboration, professional behaviour, reflective practice.

Evidence: trainer observation notes, peer feedback, participation log.

- *Partner engagement plan – 40% (summative).* Each learner develops a structured plan for engaging a real or hypothetical external partner aligned with an Industrial Symbiosis opportunity.

The plan includes: i) stakeholder profile and mapping; ii) identification of interests, concerns and influence; iii) outreach email/message; iv) outline of a discovery call or meeting; v) timeline for engagement steps; vi) draft MoU section (roles, benefits, risks, next steps).

Assessed competences: stakeholder analysis, communication strategy, structured planning, understanding of MoU components.

Evidence: written report (1.000–1. 500 words), communication samples, stakeholder maps, MoU draft.

- *Role-play simulation + oral reflection – 30% (summative).* Learners record or perform a simulated interaction with a hesitant partner (initial meeting, negotiation, objection-handling, or persuasive communication scenario).

This is followed by a short oral Q&A where the learner explains: the reasoning behind chosen communication strategies; how trust-building was approached; how resistance was handled; what they would improve

Assessed competences: negotiation, persuasion, active listening, behavioural adaptation, professional representation.

Evidence: video or live simulation (5–10 minutes); oral debrief (5 minutes); assessment rubric completed by the trainer.

3.6 Bibliography & Tools

Chertow, M. (2000). *Industrial Symbiosis: Literature and taxonomy*.

Paquin, R., & Howard-Grenville, J. (2012). *The evolution of facilitated industrial symbiosis*.

Lombardi, D., & Laybourn, P. (2012). *Redefining Industrial Symbiosis*.

Fraccascia, L., Giannoccaro, I., & Albino, V. (2017). *Industrial symbiosis: Uncovering the synergy potential*.

European Commission. *Circular Economy Action Plan* (policy context). Cropper, S., et al. (2008). *The Oxford Handbook of Inter-Organizational Relations*.

Huxham, C., & Vangen, S. (2005). *Managing to Collaborate: The Theory and Practice of Collaborative Advantage*.

Ring, P. S., & Van de Ven, A. (1994). *Developmental processes of cooperative interorganizational relationships*.

Freeman, R. E. (1984). *Strategic Management: A Stakeholder Approach*.

Mitchell, R., Agle, B., & Wood, D. (1997). *Toward a Theory of Stakeholder Identification and Salience*.

Bryson, J. (2018). *Strategic Planning for Public and Nonprofit Organizations* (stakeholder tools).

Gray, B. (1989). *Collaborating: Finding Common Ground for Multiparty Problems*.

Kaner, S. (2014). *Facilitator's Guide to Participatory Decision-Making*.

Dahlman, C., & Simkins, B. (2016). *Communication and Negotiation in a Global Context*.

4. Concise Syllabus Template – VET (EQF5)

Module Title: AI and machine learning to predict material flows and optimize supply chain/process

EQF Level: 5

ECVET Credits: 3 ECVET

Total Workload (hours): 75

- Contact hours (inputs, seminars, workshops, etc.). 45-50 hours
- Guided self-study: 10-15 hours
- Project work: 10-15 hours

Delivering Institution: PRIOS KOMPETANSE AS (PRIOS), Norway.

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4.1 Module Overview

This module introduces the fundamental concepts and practical applications of Artificial Intelligence (AI) and Machine Learning (ML) within Industrial Symbiosis (IS). It provides learners with a clear, operational understanding of predictive modelling, pattern recognition, clustering, and dashboard-based decision-support, with a strong focus on the types of industrial data typically available in SMEs. The module enables learners to interpret forecasts, identify trends and anomalies, and translate analytical insights into practical recommendations that support resource efficiency, supply–demand balancing, and optimisation of symbiotic exchanges.

Learners explore how AI-supported tools can enhance decision-making processes in industrial clusters, including how to handle uncertainty, avoid misinterpretation, and apply ethical and responsible data practices when working with sensitive or incomplete datasets. The module also strengthens communication and reporting skills through exercises requiring clear explanation of analytical outputs to non-expert stakeholders.

As part of the SymbioTech VET pathway, this module builds on foundational IS concepts introduced earlier in the curriculum and prepares learners for modules focused on digital tools, EMS implementation, and energy/resource optimisation. No prior experience with AI or coding is required; basic familiarity with IS data and industrial processes is beneficial.

4.2 Learning Outcomes (LOs)

▪ **Knowledge.** *Students will:*

1. Understand the basic principles of AI and ML relevant to Industrial Symbiosis, including supervised and unsupervised learning (forecasting, clustering) (LO1),
2. Know the main types of IS data used for predictive analysis, such as material flows, energy consumption, production variability and waste streams (LO2),
3. Be aware of how dashboards function as decision-support tools, including components, filters, variables and time-window logic (LO3),
4. Be aware of common model limitations and sources of bias (LO4),
5. Understand ethical and responsible data practices when using AI-supported tools, including transparency, uncertainty, and limitations of predictive models (LO5).

▪ **Skills.** *Students can:*

6. Validate input data, identify anomalies, and flag questionable patterns before analysis (LO6),
7. Interpret outputs of forecasting and clustering models applied to IS datasets, identifying trends, anomalies and hotspots (LO7),
8. Configure and use dashboard templates to examine industrial data, adjust parameters, and explore different analytical views (LO8),
9. Develop clear, evidence-based written and oral explanations of analytical results for SME managers and operational staff (LO9),
10. Produce actionable recommendations that link predictive insights to feasible IS decisions and optimisation measures (LO10).

▪ **Competences (Autonomy & Responsibility).** *Students can:*

11. Use AI-supported dashboards to inform and justify IS-related decisions independently within an operational context (LO11),
12. Evaluate the feasibility and implications of AI-generated recommendations, considering SME constraints, uncertainty, and ethical aspects (LO12),
13. Communicate analytical insights clearly and responsibly to non-experts, supporting collaborative decision-making (LO13),
14. Reflect on the limitations and risks associated with predictive tools and adjust recommendations accordingly (LO14).

4.3 Indicative Learning Schedule / Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	AI Context and Data Readiness	Input and Workshop	Overview: AI/ML in Industrial Symbiosis (IS); Supervised vs. Unsupervised learning. Data: Exploring IS datasets (material flows, energy logs); Identifying data quality issues (noise, missing values) in SME contexts.	LO1, LO2, LO6	Hyndman & Athanasopoulos (2021) Ch. 1-2; Yeo et al. (2020) tools section.	Interactive lecture; Case examples of data sources; Hands-on data review.
2	Predictive Modelling: Forecasting & Clustering	Input & Lab	Forecasting: Logic of regression and time-series; seasonality and uncertainty. Clustering: Detecting hotspots, segments, and anomalies in flows. Activity: Interpreting outputs of pre-built models (black-box approach) rather than coding from scratch.	LO1, LO5, LO7, LO10	Hyndman & Athanasopoulos (2021) Ch. 3; Patel & Dave (2019) clustering examples; Chandola et al. (2009) anomaly detection	Visual demonstration; "Interpretation Lab" using spreadsheet/visual tools.
3	Dashboard Configuration & Visual Analysis	Workshop	Structure: Dashboard variables, filters, time-windows. Configuration: Loading IS data into templates; adjusting parameters. Interpretation: Reading visualisations to diagnose trends and operational errors.	LO3, LO6, LO8	<i>Few (2006) Ch. 1-2; Few (2012) selected sections.</i>	Guided workshop (template configuration); Peer Q&A.

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
4	Decision Support, Ethics & Communication	Seminar & Writing Workshop	Decision Logic: Connecting predictions to supply-demand balancing and feasibility. Ethics: Data governance, responsible handling, and communicating uncertainty. Output: Drafting evidence-based recommendation briefs for non-experts.	LO4, LO5, LO9, LO12, LO13, LO14	<i>Mittelstadt (2019) AI Ethics; Knaflitz (2015) storytelling sections.</i>	Scenario walkthrough; Practical writing workshop; Reflective discussion.
5	Integrated Scenario Project & Final Assessment	Project Work & Assessment	Project: Applying dashboard insights to a realistic SME decision scenario. Assessment: Final presentation of dashboard interpretation, recommendations, and oral defense regarding feasibility and ethics.	LO9, LO10, LO11, LO12, LO14	Project brief; Assessment rubric.	Supervised project clinic; Formal presentation/Oral discussion.

4.4 Teaching & Learning Methods

▪ *Learning approach*

This module adopts a hybrid learning approach that combines synchronous activities (lectures, discussions, workshops, labs) with asynchronous materials that learners can explore independently. This format supports both immediate interaction during guided sessions and deeper reflection through self-paced study. The asynchronous elements—reading materials, data briefs, and structured analytical guides—ensure learners can revisit forecasting logic, clustering principles, and data interpretation techniques as needed to consolidate understanding.

▪ *Key teaching methods*

Teaching methods include interactive lectures for introducing core AI/ML concepts, seminars for discussing data ethics and uncertainty, and case studies to illustrate the use of predictive tools in industrial symbiosis settings. Workshops and hands-on labs provide structured opportunities to practice interpreting forecasts, identifying anomalies, and configuring dashboard templates. Scenario-based group tasks cultivate collaborative reasoning, while project-based work enables learners to apply analytical methods to realistic SME data contexts and develop evidence-based recommendations.

▪ *Approaches supporting active learning and practical application*

Learning activities are designed to support active engagement and progressive skill development. Workshops and labs allow learners to work directly with templates and datasets, translating abstract concepts into operational competence. Case-based discussions and scenario tasks encourage critical thinking and support the application of analytical results to real decision-making situations. The final project integrates knowledge, skills, and competences by requiring learners to independently interpret predictive outputs, justify decisions, address uncertainty, and communicate insights clearly reflecting the level of autonomy and responsibility expected at EQF level 5.

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4.5 Assessment Methods & Evidence

▪ **Assessment approach**

Assessment in this module combines **formative** and **summative** components to evaluate the development of knowledge, practical skills, and analytical competences aligned with the learning outcomes. Formative assessments are integrated throughout the module to provide continuous feedback, guide learners in interpreting predictive outputs, and support the progressive development of dashboard literacy, data interpretation, and communication skills. Summative assessment consists of a structured final project that requires learners to interpret industrial symbiosis datasets using a dashboard template, prepare a set of evidence-based recommendations, and demonstrate reflective understanding of uncertainty and ethical considerations.

▪ **Formative assessment**

Formative assessment tasks include short analytical exercises completed during workshops and labs, such as interpreting trends in dashboard views, identifying anomalies, validating data

quality issues, and drafting preliminary insight statements. Additional formative elements include participation in case discussions, contributions to group scenario work, and brief written reflections linked to uncertainty and ethical aspects of predictive tools. These activities are ungraded but provide essential feedback, allowing learners to consolidate understanding before the final assessment.

▪ Summative assessment

Summative assessment is based on an **individual project** that integrates all module components. Learners are required to populate a dashboard template using a provided dataset, interpret predictive outputs (e.g., trends, anomalies, hotspots), and prepare a short written recommendation brief addressed to an SME decision-maker. The assessment concludes with a **presentation and oral discussion**, during which learners justify their analytical reasoning, explain configuration choices, communicate uncertainty, and respond to questions on feasibility and ethical implications. A **structured rubric** is applied to ensure transparency and consistency in evaluating analytical accuracy, clarity of communication, justification of decisions, ethical awareness, and overall competence.

Weighting of components

The final grade is composed of:

- *Formative component: 30%*
 - workshop/ lab exercises (interpretation tasks)
 - short written reflections on uncertainty/ethics
 - contribution to scenario-based group work
- *Summative component: 70%*
 - dashboard interpretation and written recommendation brief (45%)
 - presentation and oral discussion (25%)

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Formative components contribute to the final grade to recognise the importance of continuous engagement and skill development, while the summative project ensures that learners can independently apply AI-supported analytical methods in an industrial symbiosis context. Evaluation criteria include accuracy and appropriateness of interpretation, correct identification of anomalies and limitations, clarity and relevance of recommendations, coherence of communication, ethical awareness, and reflective justification of decisions.

4.6 Bibliography & Tools

4.6.1 Required

The following materials support the core concepts and applied activities in this module. Selected chapters or excerpts may be assigned depending on learners' prior knowledge and the focus of specific units.

Few, S. (2006). Information dashboard design: The effective visual communication of data. O'Reilly Media.

Few, S. (2012). Show me the numbers: Designing tables and graphs to enlighten (2nd ed.). Analytics Press.

Knafllic, C. N. (2015). *Storytelling with data: A data visualization guide for business professionals*. Wiley.

Hyndman, R. J., & Athanasopoulos, G. (2021). *Forecasting: Principles and practice* (3rd ed.). OTexts.

Patel, H., & Dave, C. (2019). Applications of K-means clustering algorithm: A review. *International Journal of Computer Science and Mobile Computing*, 8(5), 182–191.

Järvenpää, A.-M. (2021). *Industrial symbiosis, circular economy and Industry 4.0*. Polish Academy of Sciences Publications, 69–76.

Yeo, Z., Low, J. S. C., & Tan, P. S. (2020). Tools for promoting industrial symbiosis: A systematic review. *Waste and Resources Action Programme (WRAP) / University of Warwick*.

Mittelstadt, B. (2019). *Principles of artificial intelligence ethics: A guide for practitioners*. Oxford Internet Institute.

4.6.2 Recommended

For deeper learning experience the following collection of materials can be also utilized:

Géron, A. (2019). *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow* (2nd ed.). O'Reilly Media.

Flach, P. (2012). *Machine learning: The art and science of algorithms that make sense of data*. Cambridge University Press.

Jain, A. K. (2010). Data clustering: 50 years beyond K-means. *Pattern Recognition Letters*, 31(8), 651–666.

Chandola, V., Banerjee, A., & Kumar, V. (2009). Anomaly detection: A survey. *ACM Computing Surveys*, 41(3), 1–58.

Machine learning-assisted industrial symbiosis: Testing the ability of word vectors to estimate similarity for material substitutions - Davis - 2022 - *Journal of Industrial Ecology*

Bin, S., Yeo, Z., Low, J. S. C., Koh, D., Kurle, D., Cerdas, F., & Herrmann, C. (2015). A big data analytics approach to develop industrial symbioses in large cities. *Procedia CIRP*, 29, 450–455.

5. Concise Syllabus Template – VET (EQF5)

Module Title: Blockchain technologies, to create transparent and secure tracking and certification systems for material and energy flows

EQF Level: 5

ECVET Credits: 3 ECVET

Total Workload (hours): 75

- Contact hours (inputs, seminars, workshops, etc.). 45-50 hours
- Guided self-study: 10-15 hours
- Project work: 10-15 hours

Delivering Institution: PRIOS KOMPETANSE AS (PRIOS), Norway.

5.1 Module Overview

This module introduces the practical use of blockchain technologies to support transparent traceability in circular and industrial symbiosis value chains. It provides learners with a clear, operational understanding of how permissioned blockchain systems record batch-level data, secure documentation, and provide verifiable evidence for audits, certification, and collaboration among multiple stakeholders.

The module focuses on the the blockchain-enabled traceability competencies required in digital IS practice: entering and updating batch information, attaching supporting documents, generating QR codes, verifying ledger entries, and explaining traceability outcomes to partners or auditors. Learners explore how blockchain increases trust in resource exchanges, supports Digital Product Passports (DPPs), and reduces information gaps in symbiotic networks. The module also addresses ethical and governance considerations, including responsible data handling and the limitations of blockchain when source data is unreliable or incomplete.

This module builds on earlier VET training in Industrial Symbiosis and digital tools, and prepares learners for subsequent modules involving environmental management systems and operational optimisation. No prior technical knowledge is required; basic familiarity with industrial processes or documentation practices is helpful but not mandatory.

5.2 Learning Outcomes (LOs)

▪ **Knowledge.** Students will:

1. Understand the basic principles of blockchain relevant to Industrial Symbiosis, including distributed ledgers, permissioned networks, blocks, transactions, hashes, and the role of immutability in data integrity (LO1),
2. Know how blockchain supports transparent traceability in circular and symbiotic value chains, including batch-level recording, digital certification, and linkage with Digital Product Passports (DPPs) and sustainability reporting (LO2),
3. Understand the structure and purpose of permissioned blockchain systems (e.g., Hyperledger), including participants, assets, transactions, and access rights (LO3),
4. Be aware of ethical, governance, and data-protection considerations when recording and sharing traceability data, including risks, limitations, and the operational meaning of “data integrity.” (*Canon: ethics, data governance, anti-greenwashing*) (LO4),
5. Know the types of documents and data typically attached to blockchain records (e.g., batch IDs, location, timestamps, certificates, delivery notes) and their role in supporting audits and stakeholder trust (LO5).

▪ **Skills.** Students can:

6. Create and update traceability records in a permissioned blockchain environment, correctly entering batch data, metadata, and supporting documents (LO6),
7. Generate and use QR codes linked to blockchain entries, ensuring correct functionality for retrieving traceability information (LO7),
8. Navigate a Hyperledger-based interface or low-code environment to deploy, test, and verify simple business networks, following defined procedures (LO8),
9. Verify the correctness of blockchain entries, including record completeness, hash confirmation, document attachment, and consistency with operational data (LO9),
10. Interpret blockchain-based traceability outputs, identify gaps or inconsistencies, and evaluate what the blockchain record does and does not confirm (LO10),
11. Prepare clear written or oral explanations of traceability workflows for SME stakeholders, demonstrating how blockchain supports transparency, certification, and trust (LO11),

▪ **Competences (Autonomy & Responsibility).** Students can:

12. Operate a blockchain traceability workflow independently within an SME or industrial symbiosis context, following established governance and data-management rules (LO12),
13. Take responsibility for data integrity when entering or modifying traceability information, ensuring accuracy, completeness, and proper documentation (LO13),

14. Apply ethical and responsible practices when handling sensitive or confidential data in traceability records, recognising boundaries and limitations (LO14),
15. Communicate blockchain-based evidence transparently to partners, auditors, or IS collaborators, supporting trust-building and preventing misinterpretation or greenwashing (LO15),
16. Evaluate when blockchain is an appropriate tool for a traceability need, based on transparency requirements, multi-stakeholder complexity, audit needs, and available alternatives (LO16).

5.3 Indicative Learning Schedule / Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	Fundamentals & Traceability Context	Input & Demonstration	Concept: Distributed ledgers, blocks, hashes, and the concept of "immutability." Context: How traceability supports Circular Economy (Digital Product Passports) and trust in symbiotic exchanges. Demo: Navigating a permissioned ledger interface (viewing participants and assets).	LO1, LO2, LO3, LO8	Antonopoulos & Wood (2018) – Basics; European Commission (2022) – ESPR context.	Interactive lecture; Case analysis (circular supply chains); Structured observation of interface.
2	Writing to the Ledger: Data Entry & Documentation	Workshop / Lab	Data Structure: Understanding batch metadata (IDs, timestamps) vs. attached evidence (PDFs, certs). Action: Hands-on practice entering new traceability records into a sandbox environment. Quality: Ensuring completeness before "sealing" the record.	LO5, LO6, LO12, LO13	GS1 (2022) – Traceability framework & Metadata; Hyperledger Sandbox tools.	Hands-on lab; Micro-exercises (filling fields); Instructor-supported practice.
3	Reading the Ledger: Verification & Retrieval	Workshop / Lab	Verification: Using checksums/hashes to verify data integrity; identifying gaps or manipulated records. Retrieval: Generating QR codes linked to ledger entries; testing the user experience (scanning to view provenance).	LO7, LO9, LO10	GS1 Digital Link (2020); Antonopoulos & Wood – Hashing/Integrity.	Practical workshop (QR generation); Peer verification (auditing each other's entries).

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
4	Governance, Ethics & Strategic Decisions	Seminar & Group Work	Strategy: "When to use Blockchain?" (Decision criteria: trust, complexity, audit needs). Ethics: Managing sensitive data, privacy, and avoiding "greenwashing" (overclaiming based on weak source data). Governance: Who has permission to write/read?	LO4, LO14, LO15, LO16	WEF (2018) Beyond the Hype; Francisco & Swanson (2018) – Transparency risks.	Decision mapping exercise (Blockchain vs. Database); Reflective discussion on greenwashing.
5	Integrated Traceability Project & Assessment	Project Work & Assessment	Project: Creating a full lifecycle record (Entry + Doc Attachment + QR Code) for a specific IS scenario. Assessment: Presentation of the workflow and oral defense regarding data integrity and system limitations.	LO6, LO9, LO11, LO13, LO16	Project brief; Assessment rubric.	Supervised project clinic; Final Presentation & Oral Exam.

5.4 Teaching & Learning Methods

This module adopts a blended learning approach that combines synchronous activities (lectures, workshops, labs, seminars, project clinics) with asynchronous materials that learners can explore independently. This combination supports both real-time guidance during practical sessions and self-paced consolidation of concepts, workflows, and interpretation skills.

Teaching methods include interactive lectures to introduce key blockchain and traceability concepts, seminars to explore ethical and governance questions, and case-based sessions to situate traceability within circular and industrial symbiosis value chains. Workshops and hands-on labs form the core of the module, providing structured opportunities to practice creating ledger entries, attaching documentation, generating QR codes, and verifying data integrity in a permissioned blockchain environment. Guided analysis and scenario-based exercises help learners interpret blockchain outputs and develop judgement about when blockchain is or is not appropriate for particular traceability needs.

Throughout the module, emphasis is placed on active learning, accuracy, and responsibility. Practical sessions require learners to work with real documentation formats, follow data-governance rules, and test their own outputs for consistency. Group discussions and oral explanations reinforce communication skills, while project-based work supports competence development in decision-making, documentation quality, and ethical use of traceability data. These methods collectively ensure that learners develop the operational capabilities expected of EQF5 SymbioTech Managers, with the confidence to apply traceability tools responsibly in industrial contexts.

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5.5 Assessment Methods & Evidence

Assessment in this module combines formative and summative components to evaluate learners' knowledge, applied skills, and competences in blockchain-enabled traceability. Formative assessments are embedded throughout the module to provide continuous feedback and support progression from conceptual understanding to independent operation of traceability workflows.

Formative assessment

- Short practical exercises during workshops and labs (creating entries, attaching documents, verifying data, navigating permission blockchain interface, locate record elements).
- Participation in seminars and group discussions on ethics, governance, and decision-making.
- Guided analysis tasks focused on interpreting blockchain outputs and identifying incomplete or inconsistent records.
- Brief reflective notes on limitations, data integrity, or ethical considerations.

These formative elements help learners consolidate procedural accuracy, strengthen interpretation skills, and prepare for the final project.

Summative assessment

The summative assessment is an individual project consisting of four components:

1. Traceability record task (ledger entry + documentation + QR)

Learners must create or update a complete traceability record in the permissioned blockchain environment, including accurate metadata, appropriate supporting documents, and a functioning QR link.

2. Verification & integrity check

Learners verify their own record, identify potential issues, and document corrections or limitations.

3. Short written brief (evidence interpretation)

A concise explanation of what the blockchain record confirms, what it does not confirm, and how it supports transparency for stakeholders.

4. Presentation & oral discussion

A short presentation of the final record, followed by an oral examination covering decisions made, constraints encountered, verification outcomes, and ethical considerations (e.g., data sensitivity, risk of overclaiming).

Weighting

- *Formative components:* 30% (workshops, labs, reflection tasks, participation)
- *Summative project:* 70%
 - Ledger task + documentation integrity: 40%
 - Written brief (interpretation and limitations): 10%
 - Presentation & oral discussion: 20%

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Assessment criteria

- Accuracy and completeness of ledger entry and metadata.
- Correct use of supporting documents and QR linkage.
- Quality of verification and integrity checking (identifying gaps or limitations).
- Clarity and correctness in interpreting what the blockchain record demonstrates.
- Ethical awareness and responsible handling of sensitive or incomplete data.
- Communication skills and ability to explain decisions to non-experts.
- Overall autonomy, reliability, and adherence to governance rules.

These assessment methods reflect the EQF5 emphasis on applied competence, responsible decision-making, and clear communication—ensuring learners can operate blockchain-enabled traceability workflows independently within industrial symbiosis contexts.

5.6 Bibliography & Tools

5.6.1 Bibliography

European Commission. (2022). Ecodesign for Sustainable Products Regulation (ESPR): Overview. https://single-market-economy.ec.europa.eu/sustainability/ecodesign-sustainable-products-regulation_en.

Antonopoulos, A. M., & Wood, G. (2018). *Mastering blockchain: Distributed ledger technology, decentralization, and smart contracts explained* (2nd ed.). O'Reilly Media. <https://learning.oreilly.com/library/view/mastering-blockchain-2nd/9781788839044/>

World Economic Forum. (2020). *Blockchain deployment toolkit: A guide for enterprise adoption*. <https://widgets.weforum.org/blockchain-toolkit/index.html>

Francisco, K., & Swanson, D. (2018). The supply chain has no clothes: Technology adoption of blockchain for supply chain transparency. *Logistics*, 2(1), 2. <https://doi.org/10.3390/logistics2010002>

GS1. (2022). *Global traceability standard: Overview*. <https://www.gs1.org/standards/traceability>

GS1. (2020). *GS1 Digital Link: Connecting physical products to digital information*. <https://www.gs1.org/standards/gsl-digital-link>

World Economic Forum. (2018). *Is blockchain the right tool for your business? Key questions to ask*. <https://www.weforum.org/stories/2018/04/questions-blockchain-toolkit-right-for-business>

World Economic Forum. (2018). *Blockchain beyond the hype: A practical framework for business leaders*. <https://www.weforum.org/publications/blockchain-beyond-the-hype/>

Deloitte. (n.d.). *Using blockchain to drive supply chain transparency and innovation*. <https://www.deloitte.com/us/en/services/consulting/articles/blockchain-supply-chain-innovation.html>

Hyperledger Foundation. (2022). *Hyperledger Fabric: Architecture, concepts, and components*. <https://hyperledger-fabric.readthedocs.io/en/latest/architecture.html>

5.6.2 Tools & Platforms

Hyperledger Foundation Labs (sandbox): <https://labs.hyperledger.org>

Hyperledger Fabric Test Network: https://hyperledger-fabric.readthedocs.io/en/latest/test_network.html

QR code generator (open source): <https://qrcode-monkey.com>

SHA-256 checksum calculator: https://emn178.github.io/online-tools/sha256_checksum.html

6. Concise Syllabus Template – VET (EQF5)

Module Title: Symbiotic energy efficiency/management technologies and models

EQF Level: 5

ECVET Credits: 3 ECVET

Total Workload (hours): 50-75 hours

- Contact hours (lectures, labs, seminars, workshops, etc.): 30-45 hours
- Guided self-study: 10-15 hours
- Project work: 10-15 hours

Delivering Institution: SLOVENSKA INOVACNA A ENERGETICKA AGENTURA (SIEA), (SIEA), Slovakia

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6.1 Module Overview

This module is designed specifically for SymbioTech Managers seeking comprehensive, practical expertise in managing symbiotic energy systems within industrial and manufacturing environments in line with the EU Energy Efficiency Directive (EED) 2023/1791 and National Energy and Climate Plans (NECP 2021-2030). It provides an in-depth examination of core EMS frameworks, with a particular emphasis on ISO 50001, which supports internationally recognized standards for energy performance and compliance in symbiotic industrial networks.

Participants will gain a robust understanding of the fundamental principles and requirements of these energy frameworks, enabling them to proficiently design, implement, and maintain effective energy management practices. The program thoroughly explores each component of symbiotic energy systems within EMS, such as energy policy formulation tailored to industrial symbiosis, energy-related regulatory compliance auditing, energy risk management, and mechanisms for continuous improvement. Special attention is given to ensuring these systems are not only compliant but also strategically aligned with the principles of circular economy and industrial symbiosis, encouraging resource efficiency, waste minimization, and symbiotic inter-industry collaborations. In addition, SymbioTech managers will learn to understand and implement waste management hierarchy in practice, focusing on prevention, reuse and recycling of industrial by-products, particularly energy-related waste. Managers will conduct energy balances and map raw material inputs and outputs through Material Flow Analysis (MFA), to identify energy waste that can serve as a resource for other processes within the framework of industrial symbiosis. Regarding the circular product design, SymbioTech

managers will understand how process redesigns, informed by energy tools, reduce the production of non-recyclable materials at the beginning of the production cycle.

Managers will engage with advanced practical tools and methodologies for energy impact assessment - such as Pinch Analysis, thermal imaging, and simple energy-related measurements – learning to interpret this data systematically for strategic decision-making to improve energy efficiency. SymbioTech managers will master Pinch Analysis fundamentals to design thermal integration networks across symbiotic companies - linking one firm's excess waste heat to another's process needs via shared exchanger cascades - enabling strategic leadership in industrial symbiosis. The training includes establishing energy objectives, setting performance indicators and developing reporting tools. The module also covers techniques for conducting internal and external energy management audits, ensuring organizations meet all ISO 50001 requirements.

The workshops, as interactive sessions, will deepen conceptual understanding, while simulations offer practical scenarios to apply energy auditing and implementation skills – like using thermal imaging data for team-based decisions. This provides support for SymbioTech managers to navigate the complexities of integrating symbiotic energy systems within existing organizational processes and drives tangible improvements in environmental performance.

Throughout the module, emphasis is placed on fostering leadership abilities in symbiotic energy management, empowering SymbioTech managers to promote continuous energy responsibility within their organizations. By the end of the course, participants will be equipped to lead energy efficiency projects that not only comply with international standards including ISO 50001 but also contribute meaningfully to sustainable industrial practices and collaborative energy management and EMS across industrial networks.

6.2 Learning Outcomes (LOs)

The intended learning outcomes are divided into the three EQF domains:

▪ **Knowledge.** *Students will:*

1. understand the core principles of energy efficiency and energy waste, including concepts such as waste heat recovery, system optimization, waste management hierarchy, Material Flow Analysis (MFA) for resource mapping within a company, and circular product design to enable product exchange between industrial partners (LO1),
2. become familiar with Pinch Analysis fundamentals (hot/cold streams, pinch point) as a method for improving thermal energy integration – applying it internally for process efficiency and externally across companies by linking one firm's excess waste heat as input for another's heating requirements (LO2),
3. recognize the key components of ISO 50001 standards that guide energy management systems in industrial settings (LO3).

▪ **Skills.** *Students can:*

4. perform simple energy-related measurements (temperature, power readings) on industrial machinery using basic tools (LO4),
5. utilize devices such as thermal imaging cameras to identify heat loss zones and collect supporting data. The use of Thermal Imaging Camera provides a hands-on experience necessary for SymbioTech managers to identify opportunities for cross-industry sharing (LO5),
6. apply checklists and introductory Pinch Analysis tools to assess energy use patterns, locate inefficiencies, and propose appropriate technical adjustments (e.g., insulation, recovery systems, process improvements) (LO6),
7. document findings clearly and structure recommendations in a corrective action plan (LO7).

▪ **Competences (Autonomy & Responsibility).** *Students can:*

8. work safely and attentively in industrial environments, adhering to established operational protocols, particularly when handling hot surfaces, working with electrical systems, or operating moving equipment (LO8),
9. take initiative in identifying energy loss points and drafting recommendations, while recognizing the importance of collaborating with engineering teams to justify implementation (LO9),
10. maintain clear and systematic records of energy observations, ensuring traceability and reliability for follow-up or auditing purposes (LO10).

6.3 Indicative Learning Schedule / Delivery Schedule

Week	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	On-site Bootcamp Training (Face to Face)	Lecture / workshop / e-learning	Energy efficiency fundamentals, real examples of energy savings.	LO1, LO2	Branca et al. (2022), Kemp et al. (2020), Energy Efficiency Directive 2023/1791	Using thermal cameras and sensors; learners practice identifying heat losses from selected equipment; Pinch Analysis exercises.
2	Mentored E-learning and Workplace Taks	Seminar / e-learning	Energy management, Energy balances, Waste management hierarchy, MFA, Circular Product Design, Waste reduction techniques, Calculating energy usage (case studies)	LO1, LO3, LO4, LO5, LO6, LO7	European Green Deal, Fit for 55, Energy Efficiency Directive 2023/1791, ISO 50001 (Energy Management Systems)	Simulated case studies, Self-paced quizzes, Conducting a mini energy audit.
3, 4	Final Assessment Clinic	Lecture / workshop / e-learning	Energy waste map on energy losses, Corrective action plan on improvement measures.	LO1, LO8, LO9, LO10	Cervo et al. (2020), Fraccascia et al. (2020)	Self-learning, Q&A sessions, Analysis defense.

6.4 Key Tools and Resources

- **Thermal Imaging Camera & Sensors** – Used during the on-site bootcamp training and other project work to detect and document heat losses in equipment or processes.
- **Energy Efficiency Checklists** – Based on **ISO 50001**, these tools help learners systematically inspect processes and identify common causes of energy inefficiency (e.g., idle machinery, lack of insulation).

6.5 Teaching & Learning Methods

- *Learning approach*

A hybrid learning approach will be adopted for this module. In other words, both synchronous and asynchronous learning will be used. Specifically, through synchronous learning, trainers and managers will gather virtually at the same time and place (in a digital classroom) and interact in real-time. On the other hand, based on asynchronous learning, managers can access materials which will be available on a digital platform (uploaded by trainers). These materials (e.g. pre-recorded lectures, presentations, word/pdf files, figures, videos, etc.) will describe theoretical issues and practical case studies. Thus, managers can interact with each material at their own pace over longer periods.

- *Key Teaching methods*

Multiple key teaching methods will be used throughout the module such as interactive lectures with guided discussion, case studies, seminars, expert webinars, workshops, hands-on labs. Issues related to Industrial Symbiosis (IS), Circular Economy (CE) and Sustainability will be reflected in the above-mentioned teaching methods. Key resources for the modules include a thermal imaging camera & sensors, which will be used during the on-site bootcamp training during Week 1 to detect and document heat losses in equipment or processes, and an energy efficiency checklist.

- *Approaches and methods supporting active learning and practical application of knowledge.*

Synchronous learning approach is well-suited to creating immediate engagement of trainers and managers with faster exchanging of information, thus, helping to build a sense of community and clarify misconceptions. Moreover, asynchronous learning approach is more flexible. It allows more time for managers to explore and engage with material.

Moreover, the key teaching methods (such as lectures) will provide theoretical knowledge of IS for a comprehensive understanding of the IS principles, elements and practices. This knowledge along with the many practical examples provided through the practical-oriented teaching methods (such as IS case-studies) set the foundations for a SymbioTech Manager.

Expert webinars and seminars will further contribute to enhance the theoretical and practical knowledge of IS. Teamworking, which is promoted through teaching methods such as Workshops, Group works and Projects, makes the SymbioTech manager able to successfully collaborate with stakeholders and develop effective IS networks.

6.6 Assessment Methods & Evidence

Assessment and evaluation for the SymbioTech Managers module are designed to measure both theoretical understanding and practical application of energy symbiosis concepts within industrial networks. Managers will be assessed through a combination of individual assignments, such as technical reports analyzing energy efficiency improvements using real-world data, and group projects that require the development and presentation of tailored energy management solutions. Participation in case study discussions, workshops, and problem-solving sessions will contribute to continuous assessment through structured team observation, evaluating critical thinking and soft skills such as leadership, collaboration communication and adaptability in group settings. Additionally, reflective essays on guest lectures and field visits or virtual tours will encourage students to connect industry insights with academic knowledge. This blended evaluation approach ensures that learners gain measurable competence in managing innovative, sustainable energy systems in real industrial contexts.

Participants have the opportunity to attend guest lectures and industry talks (sessions led by experts from the energy sector, highlighting cutting-edge technology policies and market trends) and field visits or virtual tours. Field visits are fully optional within the course and include visiting of industrial sites practicing energy symbiosis to observe technology applications and management practices firsthand.

Assessment Components:

Energy Audit Deliverables:

- Energy-waste map (e.g., diagram, table, or annotated thermal image) showing zones of energy loss.
- Corrective Action Plan outlining suggested improvements with justification (e.g., thermal insulation, heat exchanger, process shutdowns).

Oral Defence (Q&A):

- Learners explain their energy findings, describe the tools used, and respond to questions about energy efficiency strategies and auditing methods.

Evidence Submission:

- Complete a mini audit package including observation logs, diagrams, and action sheets.
- Evaluation against a 20-point rubric, with feedback provided on technical accuracy, safety awareness, and quality of recommendations.

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6.7 Bibliography & Tools

6.7.1 Required

Branca T., Colla V., Fornai B., Petrucciani A., Pistelli M., Faraci E., Cirilli F., Schröder A. (2022). Current state of Industrial Symbiosis and Energy Efficiency in the European energy intensive sectors, *Matériaux & Techniques* 109 (5-6).

Cervo H., Ferrasse J.-H., Descales B. (2020). Blueprint: A methodology facilitating data exchanges to enhance the detection of industrial symbiosis opportunities–Application to a refinery, *Chem. Eng. Sci.* 211.

Fraccascia L., Yazdanpanah V., van Capelleveen G. & Yazan D.M. (2020). Energy-based industrial symbiosis: a literature review for circular energy transition, *Volume 23*, 4791–4825.

He K., Wang L. (2017). A review of energy use and energy-efficient technologies for the iron and steel industry, *Renew. Sustain. Energy Rev.* 70, 1022-1039.

Malinauskaite J., Jouhara H., Ahmad L., Milani M., Montorsi L., Venturelli M. (2020). Optimizing the Efficiency of Resource Exchange in Industrial Symbiosis (IS). *Responsible Consumption and Production*, 1–12, *Energy*, Volume 172, 255–269.

Malinauskaite J., Jouhara H., Ahmad L. (2019). Energy efficiency in industry: EU and national policies in Italy and the UK, *Energy* 172, 255–269.

Curtin Joseph, Atanasiu, B., & Bowie Randall. (2014). *EU Energy Law. V. 7, energy efficiency in the European Union*. Claeys & Casteels.

Kemp, I. C., & Lim, J. S. (2020). *Pinch analysis for energy and Carbon Footprint Reduction: User guide to process integration for the efficient use of Energy*. Butterworth-Heinemann.

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6.7.2 Recommended

Capehart, B. L., Turner, W. C., & Kennedy, W. J. (2020). *Guide to Energy Management*. River Publishers.

Curtin Joseph, Atanasiu, B., & Bowie Randall. (2014). *EU Energy Law. V. 7, energy efficiency in the European Union*. Claeys & Casteels.

Sancho, Lasheras M. (2024). *Analysing the Determinants of Energy Efficiency Improvement in European Firms: The Role of Regulatory Landscapes and Organizational Capabilities*. Sciences Pro Paris.

Al-Shemmeri, T. (2013). *Energy audits: A workbook for energy management in buildings*. Wiley.

7. Concise Syllabus Template – VET (EQF5)

Module Title: Environmental Management Systems (EMS)

EQF Level: 5

ECVET Credits: 2-3 ECVET

Total Workload (hours): 50-75 hours

- Contact hours (lectures, labs, seminars, workshops, etc.): 30-45 hours
- Guided self-study: 10-15 hours
- Project work: 10-15 hours

Delivering Institution: VSB - TECHNICAL UNIVERSITY OF OSTRAVA (VSB - TUO), Czechia.

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7.1 Module Overview

This module introduces students to the structure, implementation, and evaluation of Environmental Management Systems (EMS), with a specific focus on the ISO 14001 and EMAS frameworks. Through hands-on activities, case analysis, and simulated audits, students will learn how to conduct environmental reviews, set objectives and indicators, implement operational controls, and ensure compliance with regulations.

Building upon the knowledge gained in Modules 1-6 of the SymbioTech pathway, this module aims to develop applied EMS capabilities for industrial symbiosis settings. It prepares students to guide SMEs or clusters toward improved environmental performance, regulatory alignment, and long-term sustainability strategies.

The module is designed for VET students, business managers, consultants, and facilitators engaged in resource-efficient innovation. A general understanding of sustainability is helpful but not required.

7.2 Learning Outcomes (LOs)

The intended learning outcomes are divided into the three EQF domains:

▪ **Knowledge.** *Students will:*

1. Understand the strategic role of EMS: Explain how environmental management balances economic, social, and environmental needs within an organization (LO1),
2. Distinguish EMS frameworks: Differentiate between key standards, specifically ISO 14001 and EMAS, and their implementation steps (LO2),
3. Connect EMS to broader goals: Recognize links between EMS, industrial symbiosis, circular economy, and EU climate neutrality policies (LO3).

▪ **Skills.** *Students can:*

4. Conduct environmental reviews: Perform an initial environmental analysis to identify significant aspects and impacts of an organization (LO4) ,
5. Develop EMS components: Draft environmental policies, set measurable objectives, and define key performance indicators (KPIs) (LO5),
6. Create environmental reports: Prepare transparent environmental statements in compliance with reporting standards (e.g., CSRD basics) (LO6).

▪ **Competences (Autonomy & Responsibility).** *Students are able to:*

7. Coordinate EMS implementation: Lead the planning and execution of EMS projects within SMEs or industrial clusters (LO7),
8. Manage compliance & audits: Ensure alignment with environmental regulations and prepare an organization for internal or external audits (LO8),
9. Facilitate stakeholder engagement: Communicate environmental performance effectively to regulators, partners, and the public (LO9).

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7.3 Indicative Learning Schedule / Delivery Schedule

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
1	Introduction to Environmental Management Systems (EMS) and to environmental certification	Lecture + seminar / e-learning	EMS as a tool for balancing environmental and economic needs. Benefits of certification (market, regulatory, operational).	LO1, LO3	Tinsley (2015), Watson M., Emery A. (2004), Dentch M.P. (2016), McKeiver C., Gadenne D. (2005), Hui et al. (2001); Ferenhof et al. (2014), Daddi T., Iraldo F., Testa F. (2015), Sheldon and Yoxon (2012).	Interactive lecture with guided discussion. Seminar using research based learning (RBL) scheme
2	EMAS: Eco-Management Audit Scheme - Planning phase	Lecture + seminar / e-learning	Introduction to EMAS structure and "Steps to EMAS". Management commitment and conducting the initial environmental review.	LO2, LO4	EMAS User Guide (2023) EMAS Regulation (2009) Sheldon C., Yoxon M. (2012)	Interactive lecture. Seminar-based introduction to planning.
3	EMAS: Defining environmental policy and programme (1) - Setting up and implementing EMAS	workshop / e-learning	Setting environmental objectives, targets, and measures. Resources, responsibilities, legal compliance review, and audit preparation.	LO4, LO5, LO7, LO8	EMAS User Guide (2023) EMAS Regulation (2009)	Group Project Part 1: Setting objectives and measures. Compliance review exercise.

A/A	Unit / Section Title	Session Type	Topic / Activity	Intended LOs	Required Readings / Materials	Recommended Methods
4	Environmental statement with EMAS	workshop / e-learning	Requirements for the environmental statement and core KPIs. Compliance with sustainability reporting regulations (ESRS, CSRD).	LO3, LO6, LO9	EMAS User Guide (2023) EMAS Regulation (2009) Campos et al. (2015) ESRS: E1 (climate change), E2 (pollution), E3 (water and marine resources), E4 (biodiversity and ecosystems), E5 (resource use and circular economy)	Group Project Part 2: Drafting and refining the report.
5	EMAS compliance with ISO 14001:2015 Project assessment	Seminar / e-learning Assessment	Comparison of EMAS and ISO 14001; identifying synergies. Presentation of the EMS Portfolio.	LO1 – LO9	ISO 14001:2015, ISO 14001 Key benefits, EMAS Regulation (2009), Dentch M.P. (2016) Salim H.K et al. (2018), Campos et al. (2015), Oliveira et al. (2016), Camilleri M.A. (2022)	Brainstorming: Compliance mapping. Presentation of Group Projects (Policy, Review, Report).

7.4 Teaching & Learning Methods

▪ *Learning approach*

A hybrid learning approach can be adopted for this module. In other words, both Synchronous and Asynchronous learning can be used. Specifically, through Synchronous learning, trainers and students will gather virtually at the same time and place (in a digital classroom) and interact in real-time. On the other hand, based on Asynchronous learning, the students can access materials which will be available on a digital platform (uploaded by trainers). These materials (e.g. pre-recorded lectures, presentations, word/pdf files, figures, videos, etc.) will describe theoretical issues and practical case studies. Thus, students can interact with each material at their own pace over longer periods.

▪ *Key Teaching methods*

Multiple key teaching methods will be used throughout the Module. For theoretical and conceptual insights, this course offers interactive lectures with guided discussions and seminars using elements of brainstorming or research-based learning. For practical aspects (such as EMAS implementation aspects) this module offers workshops to enable the participants collaboration on project development.

▪ *Approaches and methods supporting active learning and practical application of knowledge.*

Synchronous learning approach is well-suited to creating immediate engagement of trainers and students and faster exchanging of information, thus, helping to build a sense of community and clarify misconceptions. Moreover, asynchronous learning approach is more flexible. It allows more time for students to explore and engage with material and allows access to a wider range of students.

Moreover, the key teaching methods (such as lectures) will provide the theoretical knowledge of IS for a comprehensive understanding of the IS principles, elements and practices. This knowledge along with the many practical examples provided through the practical-oriented teaching methods (such as IS case-studies, hands-on labs) set the foundations for a HEI student and a business manager to be an IS manager. Expert webinars and seminars will further contribute to enhancing the theoretical and practical knowledge of IS. Teamworking, which is promoted through teaching methods such as Workshops, Group works and Projects, makes the IS manager able to successfully collaborate with stakeholders and develop effective IS networks.

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7.5 Assessment Methods & Evidence

The Module employs a mixed assessment strategy that combines students' active participation and engagement, group project results and written exam. These methods will be used evaluate the participants' general knowledge on environmental management systems, as well as skills and competences in practical implementation of EMS, based on the example of EMAS.

Assessment Components:

- *Participation & Engagement (Weight 20%):* Active contribution to discussions, seminars, and workshop activities.

- *EMS Practical Portfolio (Group Project) (Weight 80%):* Students will work in groups to develop a comprehensive EMS simulation for a chosen entity. The grade is distributed across four cumulative outputs to ensure continuous effort:
 - *Environmental Policy & Objectives (20%):* Drafting the strategic direction and measurable targets.
 - *Compliance & Review (20%):* Conducting the initial review and legal compliance check.
 - *Final Environmental Statement/Report (30%):* Synthesizing data into a final public report (including KPIs).
 - *Debrief and Reflection(10%):* Performance review and reflective discussion

7.6 Bibliography & Tools

7.6.1 Required

Dentch, M. P. (2016). The ISO 14001:2015 Implementation Handbook: Using the Process Approach to Build an Environmental Management System. Milwaukee: ASQ Quality Press.

Daddi, T., Iraldo, F., & Testa, F. (2015). Environmental Certification for Organisations and Products: Management approaches and operational tools. New York: Routledge.

European Commission. (2023). EMAS User's Guide. Commission Decision (EU) 2023/2463. [Online]. Available at: <https://eur-lex.europa.eu/eli/dec/2023/2463/oj/eng>

European Parliament and Council. (2009). Regulation (EC) No 1221/2009 (EMAS Regulation). [Online]. Available at: <https://eur-lex.europa.eu/eli/reg/2009/1221/oj/eng>

European Commission. (2023). European Sustainability Reporting Standards (ESRS). Delegated Regulation (EU) 2023/2772.

ISO. (2015). ISO 14001:2015 Environmental management systems – Requirements with guidance for use.

Sheldon, C., & Yoxon, M. (2012). Environmental Management Systems: A step-by-step guide to implementation and maintenance (3rd ed.). New York: Earthscan / Routledge.

Tinsley, S. (2014). Environmental Management in a Low Carbon Economy. New York: Routledge.

7.6.2 Recommended

Camilleri M.A. (2022) The rationale for ISO 14001 certification: A systematic review and a cost–benefit analysis, Corporate Social Responsibility and Environmental Management, 29(4): 1067-1083, <https://doi.org/10.1002/csr.2254>

Campos L., Heizen D.A., Verdinelli M.A., Miguel P.A. (2015) Environmental performance indicators: a study on ISO 14001 certified companies, Journal of Cleaner Production, 99: 286-296 <https://doi.org/10.1016/j.jclepro.2015.03.019>

Ferenhof H.A, Vignochi L., Selig P.M., Lezana A.G., Campos L. (2014) Environmental management systems in small and medium-sized enterprises: an analysis and systematic review, *Journal of Cleaner Production*, 74: 44-53, <https://doi.org/10.1016/j.jclepro.2014.03.027>

Hui I.K., Chan A.H.S., Pun K.F. (2001), A study of the Environmental Management System implementation practices, *Journal of Cleaner Production*, 9(3) 269-276, [https://doi.org/10.1016/S0959-6526\(00\)00061-5](https://doi.org/10.1016/S0959-6526(00)00061-5)

McKeiver C., Gadenne D. (2005) Environmental Management Systems in Small and Medium Businesses, *International Small Business Journal: Researching Entrepreneurship*, 23(5) <https://doi.org/10.1177/0266242605055910>

Oliveira J.A., Oliveira O.J, Ometto A.R., Ferraudo A.S. Salgado M.H. (2016), Environmental Management System ISO 14001 factors for promoting the adoption of Cleaner Production practices, *Journal of Cleaner Production*, 133: 1384-1394, <https://doi.org/10.1016/j.jclepro.2016.06.013>

Salim H.K, Padfield R., Hansen S.B., Mohamed S.E., Yuzir A., Syayuti K., Tham M.H., Papargyropoulou E. (2018), Global trends in environmental management system and ISO14001 research, *Journal of Cleaner Production*, 170: 645-653, <https://doi.org/10.1016/j.jclepro.2017.09.017>

Watson M., Emery A. (2004) Environmental management and auditing systems: The reality of environmental self-regulation, *Managerial Auditing Journal* 19 (7): 916–928, <https://doi.org/10.1108/02686900410549439>

Note: The translated versions of this deliverable in all project languages are available at the following link: <https://symbiotech-project.eu/symbiotech-d31-training-modules-for-hei-and-vet-students>