26CE802 Life Cycle Assessment and Sustainable Engineering 3-0-2-4

Year of Introduction: 2026-2027

Course Description:

This course establishes a trans-disciplinary framework for evaluating the interaction between industrial and ecological systems to address modern sustainability challenges. It equips researchers with rigorous quantitative environmental assessment tools, focusing on sustainable engineering principles, environmental risk frameworks, and comprehensive Life Cycle Assessment (LCA) methodologies compliant with ISO standards. The curriculum emphasizes practical application through hands-on software training for modeling complex material lifecycles.

Learning Objectives:

- Understand the fundamental interactions between industrial, environmental, and ecological systems.
- Formulate appropriate solutions to sustainability problems using scientific research and applied science.
- Master the complete ISO framework for Life Cycle Assessment, including goal definition, inventory analysis, impact assessment, and interpretation.
- Develop practical proficiency in LCA software tools to quantify the environmental footprints of engineering materials and structural systems.

Pedagogy:

Theoretical lectures integrated with intensive, hands-on software laboratory sessions. The course utilizes a project-based learning approach where doctoral candidates critically analyze and replicate published LCA case studies relevant to their specific engineering domains.

Syllabus:

Core sustainability concepts and the interaction of industrial and environmental/ecological systems. Material flow analysis and modern waste management paradigms. Design for sustainability: integrating economic, environmental, and social performance indicators. Sustainable engineering design principles and the application of green sustainable materials.
Introduction to risk and the life cycle framework for sustainability. Characterization of environmental problems, including chemical release, environmental fate, and transport. Environmental risk assessment methodologies and analyzing the health effects of example chemicals.
Historical development of Life Cycle Assessment and the standard LCA steps derived from the ISO framework. Defining the goal, setting system boundaries, and characterizing unit processes. Life Cycle Inventory (LCI) construction, resolving data collection issues, and evaluating data quality. Statistical analysis of environmental data, mass flow calculations, and addressing multi-functionality in complex industrial systems.
Procedures and methodologies for Life Cycle Impact Assessment. Evaluating impact categories and differentiating between mid-point and end-point indicators. Life cycle interpretation processes, emphasizing consistency checks and sensitivity analysis. Determining factors for a robust LCA study and applying specific ISO terminologies.

Overview of common analytical instruments and LCA software tools used in practice. Practical, hands-on execution of LCIA using software models. Detailed breakdown of LCA comparisons, assessing both the benefits and drawbacks of the methodology. Analysis of specific sustainability case studies: evaluating alternative construction materials (e.g., upcycled aggregates, self-curing matrices), bioplastics, and industrial waste treatment processes.

References:

1. Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. *Life Cycle Assessment: Theory and Practice*. Springer.
2. Allen, D. T., & Shonnard, D. R. *Sustainable Engineering: Concepts, Design and Case Studies*. Pearson.
3. Jolliet, O., Saade-Sbeih, M., Shaked, S., Jolliet, A., & Crettaz, P. *Environmental Life Cycle Assessment*. CRC Press.
4. Baumann, H., & Tillman, A.-M. *The Hitch Hiker's Guide to LCA*. Studentlitteratur AB.

Course Outcome:

CO1: Define and integrate fundamental sustainable engineering concepts and environmental risk frameworks into technical design processes.

CO2: Construct a rigorous Life Cycle Inventory (LCI) adhering to ISO standards, ensuring high data quality and correct boundary allocation.

CO3: Execute comprehensive Life Cycle Impact Assessments (LCIA) using appropriate midpoint and endpoint indicators.

CO4: Operate industry-standard LCA software to model environmental impacts and critically interpret the resulting data for engineering optimization.

Evaluation Pattern:

- Internal Assessment : 30 marks
  - *Mid-semester examination : 30 marks*
- External Assessment : 70 marks
  - *Project : 70 marks*

Employability:

Equips researchers and engineering professionals for high-level roles such as Sustainability Consultant, ESG (Environmental, Social, and Governance) Analyst, Life Cycle Assessment Specialist, and academic research positions focused on sustainable infrastructure, industrial ecology, and eco-friendly material development.