Course Code JEE 674
Course Name: Waste to Energy and Its Sustainable Mitigation
Semester: 1/2026

Number of Credits: .... 3(3-0-9) ....
Category: Elective Course
Prerequisite(s)/ Co-requisite(s): None

Course Description:

This course provides a comprehensive, process-based exploration of waste-to-energy (WtE) technologies with an emphasis on sustainability and climate mitigation. The course begins with the characterization and pre-treatment of solid waste and wastewater for energy recovery, including mechanical separation, biodrying, and resource preparation. Students examine biological and thermal energy conversion systems - such as anaerobic digestion, landfill gas recovery, incineration, gasification, and pyrolysis - and their integration with power generation processes. Key concepts include the fundamentals of energy conversion, combined heat and power (CHP), and the role of WtE in greenhouse gas (GHG) mitigation. Emerging and context-specific approaches such as advanced thermal conversion, landfill mining, and sludge co-treatment are also addressed. Students learn to assess environmental and economic performance through life cycle assessment (LCA) and techno-economic analysis (TEA), while critically evaluating trade-offs, carbon offset potential, and circular economy outcomes. The course cultivates advanced systems thinking, modeling, and policy literacy in the context of sustainable waste and energy transitions.

Course Learning Outcomes (CLOs):

CLO	Description	Bloom's Level
CLO1	Analyze interrelationships among waste characteristics, energy conversion processes, and system-level sustainability outcomes within integrated waste-to-energy (WtE) frameworks.	Analyze
CLO2	Evaluate biological, thermal, and hybrid WtE technologies - including anaerobic digestion, landfill gas recovery, biodrying, incineration, gasification, and pyrolysis - based on technical performance, environmental impact, and energy potential.	Evaluate
CLO3	Apply life cycle assessment (LCA), GHG accounting methods, and techno-economic analysis (TEA) to quantify emissions reduction and financial feasibility of WtE systems.	Apply
CLO4	Design integrated, context-sensitive WtE strategies that align with climate mitigation, resource recovery, and circular economy principles, and communicate outcomes effectively through technical and policy-oriented formats.	Create

Structure of Course

- Session 1: Waste Streams, Preparation, and Conversion Fundamentals

  Mechanical pre-treatment, biodrying, feedstock preparation, and energy-conversion fundamentals for energy recovery. Includes characterization of municipal solid waste (MSW) and wastewater as energy sources.

  = 1 credit

- Session 2: Energy Systems and Technology Pathways in Waste-to-Energy (WtE)

  Covers biological systems (anaerobic digestion and landfill gas recovery) and thermal systems (incineration, gasification, and pyrolysis). Introduces principles of energy conversion, power plant systems, operational performance, and energy efficiency in WtE applications.

  = 1 credit
- Session 3: Environmental and Economic Assessment of WtE Systems

  Includes two progressive LCA sessions, GHG accounting, and techno-economic analysis (TEA) to evaluate climate mitigation potential, carbon offsets, environmental trade-offs, and financial feasibility.

  = 1 credit

Mode of Learning

- Lecture, critical discussion, technical paper review, hands-on exercises, modeling workshops, and system-based problem-solving.
- Self-directed learning is emphasized, with students expected to complete assigned readings, preparatory tasks, and analytical exercises prior to class. Participants must be prepared to explain and defend their findings, engage in peer learning, and contribute to collective analysis during in-class sessions.
- Optional site visits or virtual case simulations may be included to reinforce the real-world application of waste-to-energy technologies and system assessment tools.

PLOs Development by Course Level: PLO 1 (Alignment with curriculum mapping)

OBEM Path:

This course follows the principles of Outcome-Based Education and Management (OBEM) through the following learning structure:

- Outcome-Oriented Design: Course Learning Outcomes (CLOs) are clearly defined and aligned with Program Learning Outcomes (PLOs), emphasizing technical, environmental, and policy competencies in waste-to-energy (WtE) systems.
- Progressive Weekly LLOs: Each week’s Lesson Learning Outcomes (LLOs) build upon prior knowledge, allowing students to progressively deepen their understanding from system thinking to techno-economic and climate-policy evaluation.
- Constructive Alignment: Teaching and learning activities (TLAs), including lectures, hands-on modeling, group discussions, and scenario-based workshops, are aligned with LLOs and CLOs to ensure students achieve measurable competencies.
- Authentic Assessment: Both formative and summative assessments, such as case-based exams, system-design presentations, calculation exercises, and policy critiques, evaluate students’ mastery of complex real-world WtE challenges.
- Learner-Centered Approach: Emphasis on self-directed study, peer interaction, and real-world problem solving encourages critical thinking, creativity, and evidence-based reasoning.

Weekly Topics, Expanded Focus, LLOs and CLO Mapping - JEE 674 (Full 16 Weeks)

Week	Topic	Content Focus	Lesson Learning Outcomes (LLOs)	Linked CLOs
1	Introduction to Waste-to-Energy (WtE) and System Thinking (Komsilp) (7 August 2026)	Overview of WtE, sustainability context, circular economy, and integrated system boundaries. Includes system interactions, case studies, flow diagrams, failure points, best practices, and critique of implementation in different contexts.	Define WtE in a sustainability context; illustrate system boundaries in WtE; compare WtE with conventional waste treatment; explain contributions to sustainable development goals.	CLO1
2	Waste Streams and Energy Potential (Panida) (14 August 2026)	Composition and variability of MSW and wastewater sludge; energy-rich fractions; material auditing. Includes seasonal effects, contamination, and sorting impacts.	Classify organic and high-energy waste types; evaluate waste-stream suitability for energy recovery; estimate calorific value using data; identify contaminants limiting conversion.	CLO1, CLO2, CLO3
3	Mechanical Pre-Treatment and Feedstock Preparation (Komsilp) (21 August 2026)	Shredders, bag openers, trommels, disc screens, and wind sifters. Includes system layout and equipment matching for diverse MSW.	Identify mechanical pre-treatment technologies; construct process diagrams; assess efficiency trade-offs in different layouts; design a suitable MSW pre-treatment line.	CLO2, CLO3
4	Biodrying of MSW for RDF Production (Abhisit) (28 August 2026)	Moisture control, biological heat, aeration, energy gain, operational factors, and RDF quality.	Explain biodrying mechanisms and parameters; evaluate factors affecting fuel output; calculate drying curves and moisture loss; compare RDF properties before and after biodrying.	CLO1, CLO2
5	Principles of Energy Conversion and Power Plant Systems (Boonrod) (4 September 2026)	Combustion theory, heat transfer, mass and energy balances, Rankine cycle, CHP, ORC, gross and net efficiency, conversion losses, and grid or heat-use integration.	Explain combustion and thermal conversion; construct basic energy-flow diagrams; compare steam, CHP, and ORC systems; analyze conversion efficiency and losses; recommend a power system based on waste type.	CLO1, CLO2, CLO3
6	Landfill Gas to Energy (LFGTE) and Landfill Mining (Komsilp) (11 September 2026)	Methane generation and recovery systems, LFG control, energy utilization, and legacy-waste mining for energy and material recovery.	Identify LFG collection and energy technologies; quantify methane recovery potential; assess collection and utilization performance; evaluate post-mining fuel and resource value.	CLO2, CLO3, CLO4

Week	Topic	Content Focus	Lesson Learning Outcomes (LLOs)	Linked CLOs
7	Anaerobic Digestion for Solid Waste and Wastewater (Panida) (18 September 2026)	Co-digestion, sludge digestion, gas yield, digester types, process controls, case examples, and design calculations.	Compare AD for solid and liquid waste; calculate potential biogas output; design a basic anaerobic-digestion layout; analyze retention time, pH, and process stability.	CLO2
8	Midterm Examination (25 September 2026)	Covers Weeks 1-7.	Synthesize technical knowledge into written arguments; solve conceptual and computational problems.	All
9	Thermal Waste-to-Energy (WtE) (Komsilp) (2 October 2026)	Incineration, gasification, and pyrolysis; feedstock requirements; process configurations; energy products; air pollution control; and solid residue management.	Differentiate major thermal WtE technologies; compare feedstock and operating requirements; analyze energy and material outputs; assess emission-control and residue-management needs; select a suitable thermal pathway.	CLO2, CLO4
10	Life Cycle Assessment I: Fundamentals and System Definition (Ukrit) (9 October 2026)	Goal and scope, functional unit, system boundary, reference flow, life cycle inventory, allocation, system expansion, avoided products, and data-quality requirements for WtE systems.	Explain the LCA framework; define a suitable functional unit; establish system boundaries; identify major material and energy flows; explain allocation and substitution approaches.	CLO1, CLO3
11	Life Cycle Assessment II: Comparative Assessment of WtE Systems (Ukrit) (16 October 2026)	Life cycle impact assessment, comparative WtE scenarios, climate and other impact categories, sensitivity analysis, uncertainty, and interpretation of environmental trade-offs.	Develop a simplified WtE inventory; compare environmental impacts across scenarios; conduct sensitivity and uncertainty analyses; interpret trade-offs; defend recommendations based on LCA evidence.	CLO2, CLO3, CLO4
	23 October 2026 - No Class			
12	Techno-Economic Assessment (TEA) of WtE Technologies (Anupong) (30 October 2026)	CAPEX, OPEX, financial indicators, scenario testing, sensitivity analysis, and investment logic.	Estimate costs for WtE options; calculate NPV and IRR; conduct sensitivity analysis; compare financial outcomes for technology choices.	CLO3
13	Policy Instruments and Institutional Barriers (Komsilp) (6 November 2026)	Carbon credits, T-VER, FiT, PPA, zoning, permitting, procurement, and institutional factors that support or obstruct WtE implementation.	Summarize key WtE policy instruments in Thailand and internationally; identify institutional risks; evaluate implementation barriers; propose mechanisms to support implementation.	CLO1, CLO4
14	GHG Mitigation from WtE Systems (Komsilp) (13 November 2026)	Emission-factor tools, baseline and project scenarios, direct and avoided emissions, methane mitigation, and practical calculation of GHG reductions.	Estimate GHG emission reductions from WtE; compare mitigation efficiency among WtE systems; apply IPCC and TGO accounting frameworks; interpret assumptions and calculation boundaries.	CLO3, CLO4

Week	Topic	Content Focus	Lesson Learning Outcomes (LLOs)	Linked CLOs
15	Final Presentation: Integrated WtE Strategy (Komsilp) (20 November 2026)	Full-scope project presentation integrating technical, policy, climate, environmental, and economic dimensions.	Develop a regional WtE system design; justify the design using LCA, TEA, and GHG data; communicate proposals to a mixed audience.	CLO4
16	Final Examination (27 November 2026)	Integration of concepts, applied reasoning, and advanced WtE scenarios.	Solve multi-layered system-design problems; demonstrate synthesis of learning across all course dimensions.	All

Grading System

Each Session Evaluation:

Contents	Score	Method of Evaluation
Active participation in class	10%	Attendance, enquiry, initiative and answering questions
Active participation in assignment	40%	Accomplishment and expression of assignment
Class presentation	20%	Performance of understanding assigned presentation topics and preparation quality
Evaluation of critical thinking in class	10%	Ability to identify key issues and participate in discussion with analytical reasoning
Exam	20%	Comprehensive understanding of issues, ability to initiate processes, conceptual depth, clarity of expression, and application of knowledge