Course Code JEE 674

Course Name: Waste to Energy and Its Sustainable Mitigation

(Thai): ขยะมูลฝอยเพื่อพลังงาน และการบรรเทาผลกระทบอย่างยั่งยืน

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 approaches such as integrated biorefinery, landfill mining, and sludge co-treatment are also addressed. Students will 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, 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, and feedstock preparation 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 (anaerobic digestion, LFG), thermal (incineration, gasification, pyrolysis), and hybrid technologies. Introduces principles of energy conversion, power plant systems, and energy efficiency in WtE applications.
  = **1 credit**
- **Session 3: Environmental and Economic Assessment of WtE Systems**
  Includes life cycle assessment (LCA), GHG accounting, and techno-economic analysis (TEA) to evaluate climate mitigation potential, carbon offsets, 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 (e.g., case-based exams, system design presentations, calculation exercises, policy critiques) are designed to 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) (8 August 2025)	Overview of WtE, sustainability context, circular economy, integrated system boundaries — Includes system interactions, case studies, flow diagrams, failure points, best practices, and critique of implementation in various contexts.	Define WtE in sustainability context;Illustrate system boundaries in WtE;Compare WtE with traditional waste treatment;Explain contributions to SDGs	CLO1
2	Waste Streams and Energy Potential (Awassada) (15 August 2025)	Composition and variability of MSW, wastewater sludge; energy-rich fractions; material auditing — Includes seasonal impact, contamination, sorting effects.	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) (22 August 2025)	Shredders, bag openers, trommels, disc screens, wind sifters — Includes system layout and equipment matching for diverse MSW.	Identify mechanical pre-treatment technologies;Construct process diagrams for pre-treatment;Assess efficiency trade-offs in different layouts;Design suitable MSW pre-treatment line	CLO2, CLO3
4	Biodrying of MSW for RDF Production (Abhisit) (29 August 2025)	Moisture control, biological heat, aeration, energy gain — Includes operational factors and quality of RDF.	Explain biodrying mechanisms and parameters;Evaluate factors affecting fuel output;Calculate drying curves and moisture loss;Compare RDF properties pre/post biodrying	CLO1, CLO2
5	Principles of Energy Conversion and Power Plant Systems (Part 1) (Boonrod) (5 September 2025)	Combustion theory, heat transfer, energy balance — Focus on thermodynamic foundations and conversion losses.	Explain combustion and thermal conversion;Illustrate energy flows in simple WtE system;Describe loss mechanisms in power generation	CLO1
6	Principles of Energy Conversion and Power Plant Systems (Part 2) (Boonrod) (12 September 2025)	Rankine cycle, CHP, ORC, efficiency benchmarks — Focus on integration with grid and process optimization.	Compare ORC, CHP, steam systems;Analyze conversion efficiency and losses;Recommend power systems based on waste type	CLO1, CLO2

Week	Topic	Content Focus	Lesson Learning Outcomes (LLOs)	Linked CLOs
7	Anaerobic Digestion for Solid Waste and Wastewater (Sumate) (19 September 2025)	Co-digestion, sludge digestion, gas yield, digester types — Case examples and design calculation.	Compare AD for solid vs liquid waste;Calculate potential biogas output;Design basic anaerobic digestion layout;Analyze retention time and pH effects	CLO2
8	Midterm Examination (26 September 2025)	Covers Weeks 1–7	Synthesize technical knowledge into written arguments;Solve conceptual and computational problems	All
9	Landfill Gas to Energy (LFGTE) and Landfill Mining (Komsilp) (3 October 2025)	Methane recovery systems, LFG control, legacy waste mining — Energy and material valorization from old sites.	Identify LFG collection and energy tech;Quantify methane recovery potential;Evaluate post-mining fuel and resource value	CLO2, CLO3, CLO4
10	Thermal WtE and Biorefinery Concepts (Sutham) (10 October 2025)	Incineration, gasification, pyrolysis — Value-added co-products and bio-oil integration.	Differentiate thermal WtE technologies;Analyze outputs from pyrolysis/gasification;Assess integration into biorefinery model;Compare energy vs material recovery priorities	CLO2, CLO4
11	Life Cycle Assessment (LCA) in WtE Systems (Ukrit) (17 October 2025)	Goal/scope definition, inventory, impact categories — Comparative scenarios for WtE vs landfill.	Define LCA structure and scope for WtE;Apply LCA software/tools;Interpret multi-scenario environmental trade-offs	CLO3
12	Techno-Economic Assessment (TEA) of WtE Technologies (Anupong) (24 October 2025)	CAPEX, OPEX, financial indicators — Scenario testing and investment logic.	Estimate costs for various WtE options;Calculate NPV and IRR;Conduct sensitivity analysis;Compare financial outcomes for technology choices	CLO3
13	Policy Instruments and Institutional Barriers (Komsilp) (31 October 2025)	Carbon credits, T-VER, FiT, PPA, zoning laws, permitting — Analysis of enabling or blocking factors.	Summarize key WtE policy tools in Thailand and globally;Identify institutional risks in WtE development;Propose mechanisms to support implementation	CLO1, CLO4
14	GHG Mitigation from WtE Systems (Sirintornthep) (7 November 2025)	Emission factor tools, baseline, project scenario design — Practical calculation of GHG reductions.	Estimate GHG emission reductions from WtE;Compare mitigation efficiency of WtE systems;Apply GHG accounting frameworks (IPCC/TGO)	CLO3, CLO4

Week	Topic	Content Focus	Lesson Learning Outcomes (LLOs)	Linked CLOs
15	Final Presentation: Integrated WtE Strategy (Komsilp) (14 November 2025)	Full-scope project presentation — Technical + policy + climate + economy in one system.	Develop a regional WtE system design;Justify design using LCA/TEA/GHG data;Communicate proposals to mixed audience	CLO4
16	Final Examination (21 November 2025)	Integration of concepts, applied reasoning, advanced WtE scenario	Solve multi-layered system design problems;Demonstrate synthesis of learning across all 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 insights
Exam	20%	Comprehensive understanding of issues, ability to initiate processes, conceptual depth, clarity of expression, and application of knowledge