Course title: Waste to Energy			
Course code: ENR 187	**No. of credits:** 2	**L-T-P:** 26-04-00	**Learning hours:** 30
Pre-requisite course code and title (if any): NA			
Department: Department of Energy and Environment			
Course coordinator: Dr. Som Mondal	**Course instructor:** Dr. Lakshmi Raghupathy		
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Course type: Elective	**Course offered in:** Semester 3		

Course description

The objective of the course is to provide insights into waste management options by reducing the waste destined for disposal and encouraging the use of waste as a resource for alternate energy production. This course is designed to provide an understanding of the various aspects of Waste to Energy. The various sources of waste generation is analysed with a focus on its potential for energy production. The need for characterization of wastes will be discussed along with the existing norms for waste utilization for alternate energy source. Various Technological options available for the production of energy form waste will delineated along with economics of using alternate sources. Case studies will be discussed to provide a better understanding of the concepts of "**Waste to Energy"** in
the Indian context.

Course objectives

- To enable students to understand of the concept of Waste to Energy.
- To link legal, technical and management principles for production of energy form waste.
- To learn about the best available technologies for waste to energy.
- To analyze of case studies for understanding success and failures.
- To facilitate the students in developing skills in the decision making process.

Course contents

Module	Topic	L	T	P
1	**Introduction** The Principles of Waste Management and Waste Utilization. Waste Management Hierarchy and 3R Principle of Reduce, Reuse and Recycle. Waste as a Resource andAlternate Energy source.	2		
2	**Waste Sources & Characterization** Waste production in different sectors such as domestic, industrial, agriculture, post- consumer, waste etc. Classification of waste – agro based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous). Characterization of waste forenergy utilization. Waste Selection criteria.	2		
3	**Technologies for Waste to Energy** Biochemical Conversion – Energy production from organic waste through anaerobicdigestion and fermentation. Thermo-chemical Conversion – Combustion, Incineration and heat recovery, Pyrolysis, Gasification; Plasma Arc Technology and other newer technologies.	4		
4	**Waste to Energy Options** Landfill gas, collection and recovery. Refuse Derived Fuel (RDF) – fluff, briquettes, pellets. Alternate Fuel Resource (AFR) – production and use in Cement plants, Thermalpower plants and Industrial boilers. Conversion of wastes to fuel resources for other useful energy applications.	4	2	

	Energy from Plastic Wastes – Non-recyclable plastic wastes for energy recovery.Energy Recovery from wastes and optimization of its use, benchmarking and standardization. Energy Analysis			
5	**Case Studies** – Success/failures of waste to energy Global Best Practices in Waste to energy production distribution and use. Indian Scenario on Waste to Energy production distribution and use in India.Success and Failures of Indian Waste to Energy plants. Role of the Government in promoting 'Waste to Energy' Sectoral Policies, Programmes, tariff & subsidy schemes	6		
6	**Centralized and Decentralized Waste to Energy Plants** Waste activities – collection, segregation, transportation and storage requirements.Location and Siting of 'Waste to Energy' plants. Industry Specific Applications – In-house use – sugar, distillery, pharmaceuticals,Pulp and paper, refinery and petrochemical industry and any other industry. Centralized and Decentralized Energy production, distribution and use. Comparison of Centralized and decentralized systems and its operations.	4	2	
7	**Waste To Energy** & Environmental Implications Environmental standards for Waste to Energy Plant operations and gas clean-up. Savings on non-renewable fuel resources. Carbon Credits: Carbon foot calculations and carbon credits transfer mechanisms.	4		
	Total	26	4	

Evaluation criteria:

Test 1: Assignment (after completion of modules 1, 2 and 3) - 20%Test 2: Case Studies (after completion of module 5) - 20%

Test 3: Written test (after completion of module 4) - 20%

Test 4: Written test (after completion of modules 6 and 7) - 40%

Learning outcomes:

On successful completion of this course the students will be able to:

- Apply the knowledge about the operations of Waste to Energy Plants. (Test 1 and 3)
- Analyse the various aspects of Waste to Energy Management Systems. (Test 3)
- Carry out Techno-economic feasibility for Waste to Energy Plants. (Test 2)
- Apply the knowledge in planning and operations of Waste to Energy plants. (Test 3 and 4)

Pedagogical approach:

A combination of class-room interactions, group discussion and presentations, tutorials and assignments

Materials:

Recommended readings

Industrial and Urban Waste Management in India, TERI Press.
Wealth from Waste: Trends and Technologies by Banwari Lal and Patwardhan, TERI Press.
Fundamentals of waste and Environmental Engineering, S.N Mukhopadhyay, TERI Press. Gazette Notification on Waste Management Rules 2016.
CPCB Guidelines for Co-processing in Cement/Power/Steel Industry
Waste-to-Energy in Austria – White Book – Figures, Data Facts, 2nd edition, May 2010
Report of the task Force on Waste to Energy, Niti Ayog (Formerly Planning Commission) 2014.Municipal Solid Waste Management Manual, CPHEEO, 2016

Reference Books/Journals:

Environmental and Resource Economics Environmental Monitoring and Assessment
Journal of Environmental Assessment Policy and ManagementReference papers and journals will also be given in class.

Websites:

www.envfor.nic.inwww.cpcb.nic.in www.mnre.gov.in
www.eai.in/ref/ae/wte/typ/clas/india_industrial_wastes.html
www.teriin.org/projects/green/pdf/National-Waste.pdf

Additional information (if any): There will be interactive sessions during the course.

Student responsibilities:

Attendance, timely feedback, discipline: as per university rules, adopt peer learning and knowledge sharingwithin the class

Reviewers

1. Dr Suneel Pande, Senior Fellow & Director Environment TERI, IHC, New Delhi
2. Dr Dinesh Pant, Fellow, Division Energy – Environment Technology, TERI, IHC, New Delhi
3. Mr Ulhas Parlikar, Dy Head Geocycle India –ACC Limited, Mumbai