ACADEMIC AFFAIRS OFFICE
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

No. Acd./ 1160 /IAPC-108 Dated: August 16 , 2021

Head, Hydro and Renewable Energy

The IAPC in its 108th meeting held on 11.08.2021 vide Item No. 108.2.4 considered and approved the following proposals:

1. Introduction of new PEC i.e., AHN-581: Energy-Water-Food-Nexus for M.Tech. programmes in HRED **(Appendix-A)**

2. To introduce following pre-Ph.D. courses: **(Appendix-B)**

   (i) AHN-901: Circular Economy for Renewable Energy
   (ii) AHN-902: Wastewater Resource Recovery
   (iii) AHN-903: Energy Recovery from Solid Waste

Assistant Registrar (Curriculum)

Encl: as above

Copy to (through e mail):-

1. All faculty
2. Head of all Departments / Centres
3. Dean, Academic Affairs
4. Associate Dean of Academic Affairs (Curriculum)
5. Channel i/ Acad portal/ Academic webpage of iitr.ac.in

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Hydro and Renewable Energy

1. **Subject Code:** AHN-581 **Course Title:** Energy-Water-Food Nexus
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** The course would provide basic knowledge and understanding of interrelationships and interdependencies of energy, water, and food, and their impact on agriculture, economy, and environment. Students would also understand systems approaches to the E-W-F nexus and develop the ability for interdisciplinary analysis of nexus issues and topics through the case studies.

10. Details of the Course

S.No.	Contents	Contact hours
1.	Energy, water, food (E-W-F) and Sustainable Development Goals (SDGs); Global and Indian energy, water, and food scenario; Transdisciplinary approach towards nexus; Need to understand the interdependencies and interrelationships between the three resources	6
2.	Energy market; Energy sources and applications; Energy policies; Energy-Water interactions; Energy-Food interactions; Role of Renewables; Challenges and opportunities	6
3.	Water sources and applications; Virtual water, and water footprint; Water-Food interactions; Water security and policies; Challenges and opportunities	6
4.	Food dependence on water and energy; Industrialization of the agri-food system; Challenges and opportunities in context of water and energy sectors; Case studies in food production and processing industry	5
5.	Methods and models for E-W-F nexus; Multi-criteria decision making and Sustainability analysis methods; Complexity and Uncertainty; Resource management; E-W-F nexus at local and regional levels; Sustainable practices for water and energy consumption	7
6.	Practical methodological implications of nexus; Role of technology in the nexus; Impact of nexus on economy, environment, policies, and community engagement	4
7.	Interdisciplinary case studies – Formulation and analysis (Exercise/Project activity); Climate change and nexus; Agriculture and nexus; Opportunities for business and innovation	8
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	A. Colucci, M. Magoni, S. Menoni / Peri-Urban Areas and Food-Energy-Water Nexus: Sustainability and Resilience Strategies in the Age of Climate Change / Springer International Publishing	2017
2.	M. D. Kumar, N. Bassi, A. Narayanamoorthy, M.V.K. Sivamohan/	2014

	The Water, Energy and Food Security Nexus: Lessons from India for Development / Routledge	
3.	P. A. Salam, S. Shrestha, V. P. Pandey, A. K. Anal / Water Energy-Food Nexus: Principles and Practices/ American Geophysical Union	2017
4.	Food and Agriculture Organization of the United Nations Rome / The Water-Energy-Food Nexus: A new approach in support of food security and sustainable agriculture	2014
5.	I.M. Mujtaba, R. Srinivasan, N. O. Elbashir / The Water-Food-Energy Nexus: Processes, Technologies, and Challenges / CRC Press	2017
6.	A. Stirling / Developing "nexus capabilities:" Towards transdisciplinary methodologies. The Nexus Network.	2015
7.	R. C. Brears / The Green Economy and the Water-Energy-Food Nexus / Palgrave Macmillan UK	2018
8.	D. Harford, J. O'Riordan, R. W. Sandford / The Climate Nexus: Water, Food, Energy and Biodiversity / RMB Rocky Mountain Books	2016
9.	J. Bartram, F. Dodds / The water, food, energy and climate nexus: challenges and an agenda for action / Routledge	2016

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Hydro and Renewable Energy

1. **Subject Code:** AHN-901 **Course Title:** Circular Economy for Renewable Energy
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To provide the advanced knowledge on principal of circular economy with respect to the renewable energy. The course will enable the scholars with the technical expertise in the area of renewable energy with focus on the resource recycling.

10. **Details of the Course**

S.No.	Contents	Contact hours
1.	**Circular economy fundamentals**: Introduction to the circular economy; principles, investment criteria, 4R Design; Reuse, Repair, Remanufacture, Recycle; closed loop supply chains, reversed logistics, Role in sustainable development	6
2.	**Circular system Engineering:** Systems thinking approach, engineering solutions, design criteria; linear to circular transition, Life cycle assessment, Agent based modelling, cost-benefit analysis (CBA)	6
3.	**Economics and policies in a circular economy:** Economic importance of the circular economy, driving factors selection, the precautionary approach, the irreversibility effect, Macro-economic framework and modeling, Renewable energy's economics and policies; mandates, price links and capping.	6
4.	**Circular economy directed renewable energy:** Renewable energy resources and technologies; Material and Energy assessment; Byproducts and waste streams; Recycling options for energy and other applications; Circular economy in solar, wind , and hydro sectors	8
5.	**Circular Bioeconomy approaches:** Biorefinery concept, Polygeneration; industrial and lignocellulosic waste recycling for renewable energy, microbial energy system, algal biomass for resource recycling; Role of stakeholders; Prospects in rural India	5
6.	**Global scenarios of circular economy: C**ircular economy at global stage, Technology transfer from bench to industry, current status, future prospects and challenges for transformation towards circular economy, global circular supply chain for circular economy, intellectual property rights in circular economy	6
7.	**Case studies:** Cases studies in circular economy directed renewable energy generation	5
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	The Circular Economy: A User's Guide (1st Edition) Authored by Walter R Stahel, Publisher: Routledge	2019
2.	The Circular Economy Handbook: Realizing the Circular Advantage (1st Edition) by Peter Lacy, Jessica Long and Wesley Spindler, Publisher: Palgrave Macmillan	2020
3.	The circular economy (1st Edition), Authored by Mika Sillanpää Chaker Ncibi, Publisher: Elsvier	2019
4.	Renewable Energy Engineering And Technology Principles and Practice, Edited by: V V N Kishore, Publisher: TERI Press.	2009
5.	Life Cycle Assessment: A Metric for the Circular Economy, Edited by: Aiduan Borrion, Mairi J Black, Onesmus Mwabonje Publisher: Royal Society of Chemistry	2021
6.	Circular Bioeconomy-Current Developments and Future Outlook (1st Edition) Edited by: Ashok Pandey , R. D. Tyagi , Sunita Varjani	2021

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Hydro and Renewable Energy

1. **Subject Code:** AHN-902 **Course Title:** Wastewater Resource Recovery
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To provide an overview of the technologies and recent development on resource recovery though integrated wastewater treatment

10. **Details of the Course**

S.No.	Contents	Contact hours
1.	**Overview of wastewater:** Types and sources, fundamentals of wastewater treatment, Environmental concerns wastewater management, generation and quantity estimation, point source and nonpoint source water pollution, physical and chemical properties, metallic and non-metallic pollutants in wastewater; wastewater as energy and nutrient resource	6
2.	**Conventional and advanced wastewater treatment processes:** Natural wastewater treatment processes, wastewater discharge to water bodies and water chemistry, objective and philosophy of wastewater treatment, wastewater treatment processes: primary, secondary and tertiary treatment, recent developments in wastewater treatment, concepts of wastewater based circular economy	8
3.	**Technologies for resource recovery from wastewater:** Concepts for wastewater mining, organic and metals recovery from wastewater, platform nutrient recovery from wastewater, Partition-Release-Recovery concept, re-engineering of conventional WWT for resource recovery, microbes-based bio-resource recovery, biopolymers	8
4.	**Integrated wastewater treatment for energy recovery:** Wastewater Recycling-Scope and demands; Types and stages of recycling, Recycling requirements, Designated reuse criteria, centralized vs decentralized recycling systems. Onsite energy generation- Combined heat and power systems, Bio-solids incineration, Effluent hydropower, Onsite wind and solar power, Heat pump, Biogas and hydrogen production from wastewater, Bio-electrochemical systems (microbial fuel cell (MFC) systems and microbial electrolysis cell (MEC) systems)	10
5.	**Algae for wastewater treatment and resource recovery:** Algae cultivation in wastewater for resource recovery, Different types of wastewater – composition and algal growth. Treatment - mechanism (nutrient uptake/metal adsorption), biotic/abiotic factors (biological or chemical contaminants/pH/light/temperature), advantages and challenges. Algal bioreactor configuration for wastewater treatment - suspended vs immobilized cells.	6
6.	Case studies on resource recovery from wastewater: global and Indian scenarios	4
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Metcalf and Eddy I AECOM, "Wastewater Engineering: Treatment and Resource Recovery", 5th edition, McGraw-Hill Education.	2014
2.	Resource Recovery from Water: Principles and Application, Edited by: Korneel Rabaey, Ilje Pikaar, Jeremy Guest, Olaf van der Kolk, Willy Verstraete, Céline Vaneeckhaute; Publisher: International Water Association.	2021
3.	The role of microalgae in wastewater treatment by: Sukla, L. B., Subudhi, E., & Pradhan, D. (Eds.). Publisher: Springer Nature Springapore Pte Limited.	2019
4.	Algal technologies for wastewater treatment and resource recovery by: Muñoz, R., Temmink, H., Verschoor, A. M., & Van Der Steen, P. Publisher: IWA publishing	2018
5.	Innovative wastewater treatment & resource recovery technologies: impacts on energy, economy and environment by: Lema, J. M., & Martinez, S. S. (Eds.). Publisher: IWA publishing.	2017

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Hydro and Renewable Energy

1. **Subject Code:** AHN-903 **Course Title:** Energy Recovery from Solid Waste
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To provide an overview of the technologies and recent development on energy recovery and sustainable solid waste management.

10. **Details of the Course**

S.No.	Contents	Contact hours
1.	Solid waste as energy resource; Indian and global SW generation and characteristics; Sources of solid waste; Introduction to solid waste management, technology, economics, policy and regulation on solid waste management, Current status, Global scenario, waste selection criteria for energy generation, Role of the Government in promoting 'Waste to Energy'	8
2.	Thermo-chemical Conversion Methods – Combustion, Incineration and heat recovery, Pyrolysis, Gasification, Hydrothermal liquefaction; Biochemical technologies – anaerobic digestion, waste fermentation for liquid and gaseous fuel production; Emerging technologies: Slurry Carb Process, Plasma Pyrolysis Vitrification (PPV) / Plasma Arc Process, Solid phase microbial fuel cell	10
3.	Landfill gas, collection and recovery. Refuse Derived Fuel (RDF) – fluff, briquettes, pellets. Alternate Fuel Resource (AFR) – production and use in Cement plants, Thermal power plants and Industrial boilers, Conversion of wastes to fuel resources for other useful energy applications. Energy from Plastic Wastes – Non-recyclable plastic wastes for energy recovery, concepts of co-generation, waste co-firing in boilers	7
4.	Basic Factors in Planning and Execution- Cost of Collection & Transportation of Wastes, Scale of Treatment, Local Conditions/ Existing Waste Management Practices, Seasonal Fluctuations in Wastes Quantity & Quality, Energy End-Use, Capital and Recurring Costs	7
5.	Environmental Impact, Scope of Feasibility Studies. Assessment models - Life Cycle Assessment (LCA), cost-effectiveness analysis (CEA) and cost benefit analysis (CBA); Environmental benefits and carbon credits	5
6.	**Case studies:** Global Best Practices and Indian Scenario on Waste to Energy production distribution and use (Urban and rural waste management). Indian Waste to Energy plants, anaerobic digestion of municipal and other waste for compressed biogas, bagasse Based Cogeneration Power Project, agricultures waste for energy recovery.	5
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Waste-to-Energy: Technologies and Project Implementation (3rd Edition), by: Marc Rogoff Francois Screve, Publisher: Elsevier	2019
2.	Waste to Resources: A Waste Management Handbook-TERI	2014
3.	Tchobanoglous G., Kreith F., "Handbook of Solid waste management", 2nd edition, McGraw-Hill Education	2017
4.	Sustainable Resource Recovery and Zero Waste Approaches Edited by: Mohammad J. Taherzadeh, Kim Bolton, Jonathan Wong, Ashok Pandey; Publisher: Elsevier	2019
5.	Resource Recovery from Wastes: Towards a Circular Economy, Edited by: Lynne E Macaskie, Devin J Sapsford, Will M Mayes; Publisher: The Royal Society of Chemistry	2019
6.	Resource Recovery from Waste: Business Models for Energy, Nutrient and Water Reuse in Low- and Middle-income Countries; Edited by: Miriam Otoo and Pay Drechsel; Publisher: Routledge	2018