INTRODUCTION TO RENEWABLE ENERGY **Course Code : 315311**

Programme Name/s : Chemical Engineering
Programme Code : CH
Semester : Fifth
Course Title : INTRODUCTION TO RENEWABLE ENERGY
Course Code : 315311

I. RATIONALE

Today developing a environmental friendly energy technologies is need of the day. Many countries taking active parts for research in the area of renewable energy sources. Countries rich in natural potential plays greater role in future for the production of renewable energy. Due to limitation of conventional energy resources there is need of reforming environmental friendly energy policies for future. Wind energy, solar energy, tidal energy, geothermal energy, fuel cell, hydrogen cell plays important role in the area of renewable energy sources. These technologies plays greater to the abatement of the effect of climate change. This course will helpful to understand the basics of non-conventional energy sources.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Supervise the operation of different renewable energy equipment in order to preserve conventional energy

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Undertake the operation of wind mill for generation of electricity
- CO2 - Use solar system for different application
- CO3 - Differentiate sources of energy from biomass
- CO4 - Measure the amount of electricity produce using micro-hydro power plant
- CO5 - Compare tidal energy & geothermal energy

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical							
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315311	INTRODUCTION TO RENEWABLE ENERGY	IRE	DSE	4	-	2	-	6	2	03	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Identify major parts of wind turbine TLO 1.2 State wind turbine terminologies TLO 1.3 Describe types of wind turbine TLO 1.4 Explain rotation principle of wind turbine	**Unit - I Wind Energy** 1.1 Wind Turbine: Major parts of wind turbine, rotor blades, hub, nacelle, tower, yaw mechanism, shaft, brake, anemometer, vane 1.2 Wind turbine terminologies: cut-in speed, cut-out speed, survival speed, rated power, nominal power, wind power curve 1.3 Types of wind turbine: horizontal and vertical axis wind turbine, upwind and downwind turbine, one, two, three blades wind turbine, small and large wind turbine, constat and variable speed wind turbine 1.4 Rotation principle: Drag and Lift principle	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit
2	TLO 2.1 State function of PV cells TLO 2.2 Explain solar water heating system TLO 2.3 Describe rooftop home solar system TLO 2.4 Differentiate types of batteries used in solar PV system TLO 2.5 Explain hybrid wind solar system TLO 2.6 Give application of solar energy	**Unit - II Solar Energy** 2.1 Photovoltaic (PV): Function of PV cells, cell, module, array and panel 2.2 Solar water heating system 2.3 Rooftop home solar system 2.4 Types of batteries used in solar PV system 2.5 Hybrid wind solar system 2.6 Solar application: solar distillation and solar PV pumping	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 State applications of bioenergy TLO 3.2 Describe power generation from solid biomass TLO 3.3 Describe biodiesel production from oil TLO 3.4 Explain environmental benefits of bioenergy	**Unit - III Energy from Biomass** 3.1 Concept and application of bioenergy 3.2 Energy from solid biomass: Wood gasifier and biogas plant (floating drum and fixed dome) 3.3 Energy from liquid biomass: biodiesel, benefits of biodiesel, biodiesel from jatropha 3.4 Environmental benefits of bioenergy, advantages & disadvantages of bioenergy	Lecture Using Chalk-Board Presentations Video Demonstrations
4	TLO 4.1 State principle of micro-hydro power plant TLO 4.2 Describe high head micro-hydro power plant TLO 4.3 Explain medium head micro-hydro power plant TLO 4.4 Select the site for micro-hydro power plant TLO 4.5 Perform routine maintenance of micro-hydro power plant	**Unit - IV Micro-hydro Power Plant** 4.1 Concept and principle of micro-hydro power plant 4.2 High head micro-hydro power plant: construction and working 4.3 Medium head micro-hydro power plant: construction and working 4.4 Site selection of micro-hydro power plant 4.5 Routine maintenance of micro-hydro power plant	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit
5	TLO 5.1 Explain the concept of tidal energy TLO 5.2 Compare different types of turbines TLO 5.3 Write advantages & disadvantages of tidal energy TLO 5.4 Explain concept of geothermal energy	**Unit - V Tidal & Geothermal Energy** 5.1 Physical concepts of the tidal phenomena, principles of tidal power generation systems, semidiurnal tides with monthly variation 5.2 Types of turbines: bulb turbine, rim turbine, reciprocating device 5.3 Advantages & disadvantages of tidal energy 5.4 Geothermal energy, generating electricity from geothermal resources, types of geothermal plant, difference between conventional steam thermal power plant and geothermal power plant 5.5 Advantages & disadvantages of geothermal power plant, environmental issues of geothermal power plant	Lecture Using Chalk-Board Presentations Video Demonstrations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Calculate the efficiency of wind turbine for different load	1	Test the performance of wind turbine for different load	2	CO1
LLO 2.1 Simulate wind turbine using simulation software	2	*Estimation of energy from wind turbine using simulation software/simulator	2	CO1
LLO 3.1 Calculate the efficiency of PV cell for different intensity of light	3	*Test the performance of solar PV cell/panel for different intensity of light	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 4.1 Calculate the parameter using different flow rates	4	Determination of parameters of Flat Plate Collector for different mass flow rate	2	CO2
LLO 5.1 Measure the weight of given sample LLO 5.2 Calculate the percentage of carbon present in given sample	5	*Determination of carbon residue of biofuel/solid biomass using Conradson carbon residue apparatus	2	CO3
LLO 6.1 Measure weight of given sample using specific gravity bottle LLO 6.2 Calculate API gravity, it magnifies the specific gravity	6	*Determination of API gravity of bio-diesel at different temperature	2	CO3
LLO 7.1 Calculate the heat energy in the given sample	7	Determination of caloric value of biofuel/solid biomass	2	CO3
LLO 8.1 Calculate the percentage water content in the given sample to improve the burning quality of fuel	8	Determination of water content in biofuel using Dean and Stark apparatus	2	CO3
LLO 9.1 Simulate hydropower plant using simulation software	9	*Simulation study on hydropower plant	2	CO4
LLO 10.1 Estimate the energy by simulating geothermal energy source using Organic Rankine Cycle (ORC)	10	*Simulation study on geothermal energy using Organic Rankine Cycle (ORC)	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

-NA-

- -NA-

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Small wind turbine (laboratory scale of suitable capacity)	1
2	Open source software OpenFAST by National Renewable Energy Laboratory	2
3	Solar PV system (laboratory scale of suitable capacity)	3
4	Flat plate collector solar system (laboratory scale of suitable capacity)	4
5	Conradson Carbon Residue Apparatus ASTM D189 specifications	5
6	Digital weighing balance	5,6,8
7	Specific gravity bottle (10 ml capacity)	6
8	Bomb calorimeter with accessories	7
9	Dean and Stark apparatus	8
10	Open source software DWSIM	9,10

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Wind Energy	CO1	10	4	6	8	18
2	II	Solar Energy	CO1,CO2	10	4	6	8	18
3	III	Energy from Biomass	CO3	8	4	4	4	12
4	IV	Micro-hydro Power Plant	CO4	6	4	4	4	12
5	V	Tidal & Geothermal Energy	CO5	6	2	4	4	10
Grand Total				**40**	**18**	**24**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two Class Test of 30 marks

Term Work Assessment 25 Marks

Summative Assessment (Assessment of Learning)

- End Semester Exam of 70 Marks

End Semester Practical Exam of 25 Marks

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	2	2	2	3	2	3			
CO2	2	1	2	2	3	1	3			

CO3	2	2	2	2	3	2	3			
CO4	2	1	2	2	3	1	3			
CO5	2	1	2	2	3	1	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Tushar Ghosh and Mark Prelas	Energy Resources & Systems Volume 2: Renewable Resources	Springer, ISBN 9400714025
2	Earnest, Joshua, Rachel, Sthuthi	Wind Power Technology	PHI Learning, 9789388028509
3	D. P. Kothari, K. C. Singal, Rakesh Ranjan	Renewable Energy Resources & Emerging Technologies	Prentice Hall of India ISBN-9789389347890
4	S. C. Bhatia, R. K. Gupta	Textbook of Renewable Energy	Woodhead Publishing India Pvt Ltd, ISBN- 978-81-936446-0-7

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://archive.nptel.ac.in/courses/103/103/103103206/	Video Lectures
2	https://archive.nptel.ac.in/courses/121/106/121106014/	Video Lectures
3	https://nptel.ac.in/courses/103103206	Video Lectures
4	https://nptel.ac.in/courses/115105127	Video Lectures
5	https://www.iitr.ac.in/wfw/web_ua_water_for_welfare/education/proceeding_of_short-term_training/diploma/hydropower_dev_engg_elec/lecture_notes/LECTURE_ON_RENEWABLE_ENERGY_SOURCES.pdf	Presentation

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students