Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Fifth**

Course Title : **Renewable Energy Technologies (Elective)**

Course Code : **22514**

1. RATIONALE

Chemical technologists have to deal with various process and operations which deals with various sources of energy to be used to carried out the process. As there is limitations to non renewable energy sources in the universe the alternative is only renewable energy. This course will give knowledge of technologies related to renewable energy like wind, solar, biomass and fuel cell where chemical engineering principles and products will be applicable.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use renewable energy technologies as applicable in chemical industry.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Use wind power technologies wherever feasible
b. Use solar power technologies wherever feasible.
c. Use solid biomass power technologies wherever feasible.
d. Use liquid biomass power technologies wherever feasible
e. Use microhydro power technologies wherever feasible.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA; Out of 30 marks, 10 marks of theory PA are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

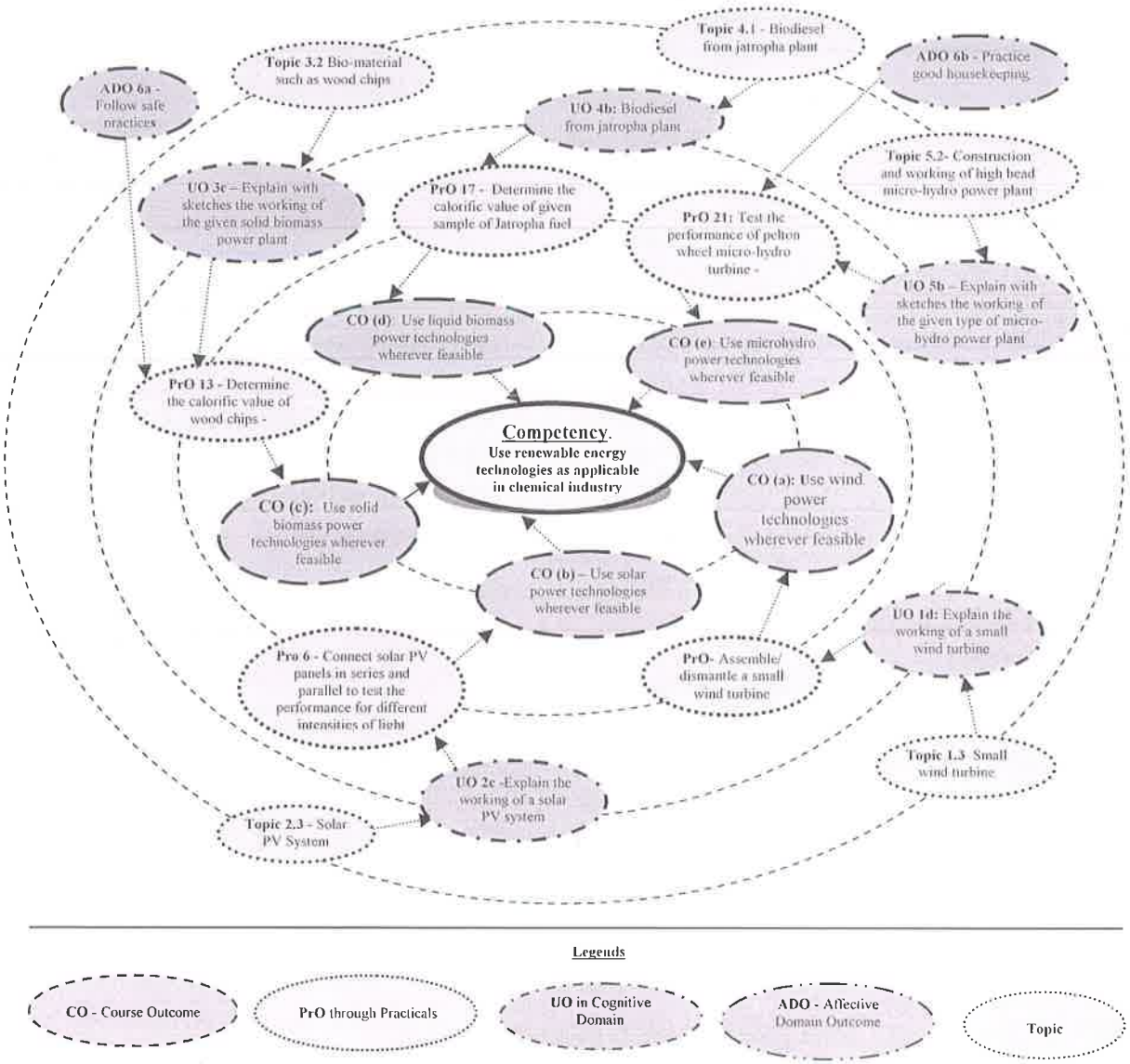

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Identify Components and sub Components of Wind turbine	I	02*
2.	Assemble/dismantle a small wind turbine	I	02
3.	Lubricate the various parts of wind turbine	I	02*
4.	Test the performance of the small wind turbine for different load.	I	02
5.	Identify the parts of the large wind turbine after viewing the relevant video	I	02*
6.	Connect solar PV panels in series and parallel to test the performance for different intensities of light	II	02
7.	Test the given Battery Charger used to charge the battery	II	02*
8.	Test the performance of given inverter of Solar PV power system	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9.	Perform preventive and scheduled maintenance of given Solar PV lighting system	II	02
10.	Measure current by grid connected solar PV system	II	02
11.	Measurement of temperature of water by using solar heater.	II	02*
12.	Determine the carbon content of solid biomass.	III	02
13.	Determine the calorific value of wood chips	IV	02*
14.	Determine the pour point of given sample of fuel.	IV	02
15.	Determine the cloud point of given sample of fuel.	IV	02
16.	Determine the viscosity of given sample of fuel.	IV	02*
17.	Determine the calorific value of given sample of Jatropha fuel	IV	02*
18.	Determine the acid value of given sample of fuel.	IV	02*
19.	Determine the aniline point of given sample of fuel.	IV	02*
20.	Determine the specific gravity of biofuel.	IV	02*
21.	Test the performance of pelton wheel micro-hydro turbine	V	02*
	Total		**42**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. All the above listed practical need to be performed compulsorily, so that the student reaches the 'Applying Level' of Blooms's 'Cognitive Domain Taxonomy' as generally required by the industry.

ii. The 'Process' and 'Product' related skills associated with each PrO are to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observation and recording	20
e.	Interpretation of results and conclusion	10
f.	Answer to sample questions	10
g.	Submission of report on time	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Work as a leader/a team member.
d. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year

- 'Organising Level' in 2nd year and
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	Pro. S. No.
1.1	Small wind turbine of 3 kW	1 to 5
1.2	Roof top solar PV system of of 3 kW	6 to 9
1.3	Microhydro turbine of 1 to 3 kW	V
1.4	Thermometer& stopwatch.	ALL
1.5	Cleveland open cup for fuel oil below 79 degree centigrade (boiling point)	I,II
1.6	Abels closed cup for fuel oil below 49degree centigrade (boiling point)	I,II
1.7	Flat bottomed tube (3cm diameter&20cm high)	III.IV
1.8	Water jaket	III,IV
1.9	Bomb calorimeter with accessories.	XI

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Construction and Working of Wind turbines	1a. Explain the given terms related to wind power. 1b. Describe the function(s) of the specified Wind turbine component(s). 1c. Explain with sketches the specified principle of the rotation of the wind turbine rotor. 1d. Distinguish the features of the given type of small wind turbine. 1e. Describe with sketches the functions of the given part(s) of the specified SWT.	1.1 **Wind Turbine Terminologies:** Cut-in, cut-out and survival wind speeds, Threshold wind speeds, rated power, nominal power, Wind Power Curve, 1.2 **Types of Wind Turbines**: Small and large wind turbines; Horizontal and Vertical axis; Upwind and Downwind, One, Two and Three blades; constant and variable Speed; Geared, Direct-Drive 1.3 **Major parts and Functions of Wind Turbines:** Rotor blades, hub, nacelle, tower, electric sub-station, nacelle layouts of Geared, Direct-Drive and Main shaft, gearbox, electric generator, electronic control panels 1.4 **Rotation principles**: Drag and Lift principle, thrust and torque of wind turbine rotor. 1.5 **Parts of SWTs:** Rotor, generator, gearbox, tower, electric control panel, tale vane, anemometer, wind vane, temperature and rpm sensors.
Unit– II Solar	2a. Describe the components and function of the given solar power	2.1 Features of roof top home solar system

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Power	plant. 2b. Describe the features of the given component solar power plant 2c. Interpret the specifications of the given type of battery 2d. Describe the features of a hybrid wind solar system 2e. Make the use of solar distillation and cooling in chemical industry.	2.2 Features hybrid wind solar system 2.3 Photo Voltaic(PV): Cell, module, array and panel 2.4 .Types of batteries used in solar PV system 2.5 Solar application: solar distillation, solar cooling.
Unit - III Bioenergy from solid biomass.	3a. Explain with sketches the formation of energy from the given type of solid biomass. 3b. Describe with sketches the construction of the given type of solid biomass power plant 3c. Explain with sketches the working of the given solid biomass power plant 3d. Compare the performance of the two types of solid biomass power plants	3.1 Concept and application of bio-energy. 3.2 Power from agri-based bio-material such as wood chips, animal excreta and others - construction and working. 3.3 Power from kitchen biomass - construction and working. 3.4 Power from municipal waste - construction and working.
Unit-IV Bioenergy from liquid biomass.	4a. Choose proper principle for preparation of bio-energy. 4b. Explain preparation of biodiesel from jatropha plant. 4c. Describe with sketches the construction of the given type of liquid biomass power plant 4d. Explain with sketches the working of the given Liquid biomass power plant 4e. Explain preparation of biodiesel from plastic waste. 4f. Identify merits and demerits of liquid biomass.	4.1 Biodiesel from jatropha plant. 4.2 Biodiesel from plastic waste plant. - construction and working 4.3 Power from liquid biomass power plant- construction and working 4.4 Merits and demerits bio energy from liquid biomass.
Unit –V Micro-hydro power plants	5a. Describe with sketches the construction of the given type of micro-hydro power plant. 5b. Explain with sketches the working of the given type of micro-hydro power plant. 5c. Select the micro-hydro power plant for the given situation with justification 5d. Describe the routing maintenance of given micro-hydro turbine.	5.1 Concept and principle of micro-hydro plant 5.2 Construction and working of high head micro-hydro power plant 5.3 Construction and working of medium head micro-hydro power plant 5.4 Site selection of micro-hydro power plant 5.5 Routine maintenance of microhydro power plant

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Construction and Working of Wind turbines	12	02	08	08	18
II	Solar Power	12	02	08	08	18
III	Bio-energy from solid biomass.	08	04	04	04	12
IV	Bio-energy from liquid biomass.	08	02	02	08	12
V	Micro-hydro power plants	08	02	04	04	10
Total		**48**	**12**	**26**	**32**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare journals based on practical performed in laboratory.
b) Give seminar on relevant topic.
c) Undertake micro-projects.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Demonstrate students thoroughly before they start doing the practice.
g) Encourage students to refer different websites to have deeper understanding of the subject.
h) Observe continuously and monitor the performance of students in Lab.
i) Demonstrate students thoroughly before they start doing the practice.

j) Encourage students to refer different websites to have deeper understanding of the subject.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be *individually* undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

Suggestive lists of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) Make working model of wind mill.
b) Develop a roof top solar PV system.
c) Develop a gobar gas system
d) Make a model for microhydro turbine.

13. SUGGESTED LEARNING RESOURCES :

S. No.	Title of Book	Author	Publication
1	Renewable Energy Sources and Emerging Technologies.	Kothari D.P., Singal K.C.	PrenticeHall of India PvtLtd-2008, ISBN-8120333578
2	Wind Power Technology	Earnest, Joshua	PHI Learning, New Delhi, 2016, ISBN:978-81-203-5166-0
3	Energy Resources and system	Tushar Ghosh	Mark prelas.ISBN-10-9400714017
4	Solar Electricity Handbook	Michael Boxwel	Greenstream Publishing; 2015 ISBN:9781907670459
5	Advanced Renewable energy sources		RSC Publications, , ISBN-978149733809

14. SOFTWARE/LEARNING WEBSITES

a) www.freesunpower.com
b) https://learn.adafruit.com/collins-lab-solar
c) www.tutorialspoint.com/power_electronics/
d) www.nptelvideos.in/2012/11/energy-resources-and-technology.htm
e) www.learnerstv.com/free-engineering
f) www.instructables.com
g) www.efxkits.com/blog/working-of-solar-wind-hybrid-system
h) https://4-h.org/parents/curriculum/wind-energy/
i) www.homepower.com
j) www.rpc.com.au/pdf/Solar%20PV%20Maintenance.pdf