Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Third**

Course Title : **Plant Economics and Energy Management**

Course Code : **22312**

1. RATIONALE

In the development of any country, Energy management and economics plays a very important role. The depletion of fossil fuel, problem of global warming, environmental issues related to energy and effect of all these on business climate are critically faced by chemical industries. Efficient utilization of available resources and development of upgraded technologies for energy conversion are the significant responsibility of a diploma chemical engineer. This will lead the diploma chemical engineers to plant economics. Economics where technology meet business.This course is designed to provide basic understanding about theenergy resources, environmental impact, different renewable energy resources, technologies for energy conservation, management, money and market, capital investment, cost estimation, taxes, depreciation, budgeting and business plans.

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 the principles of energy management and economics inchemical process 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. Identify forms of energy and its impact on plant environment.
b. Select the energy source and method for energy conservation.
c. Perform energy conservation audit for chemical process industry.
d. Calculate the cost, taxes and insurance liability for chemical process industry.
e. Estimate the depreciation for chemical process industry.

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	
4	-	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20	

(*): Under the theory PA, out of 30 marks, 10 marks 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 cognitive domain 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 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.

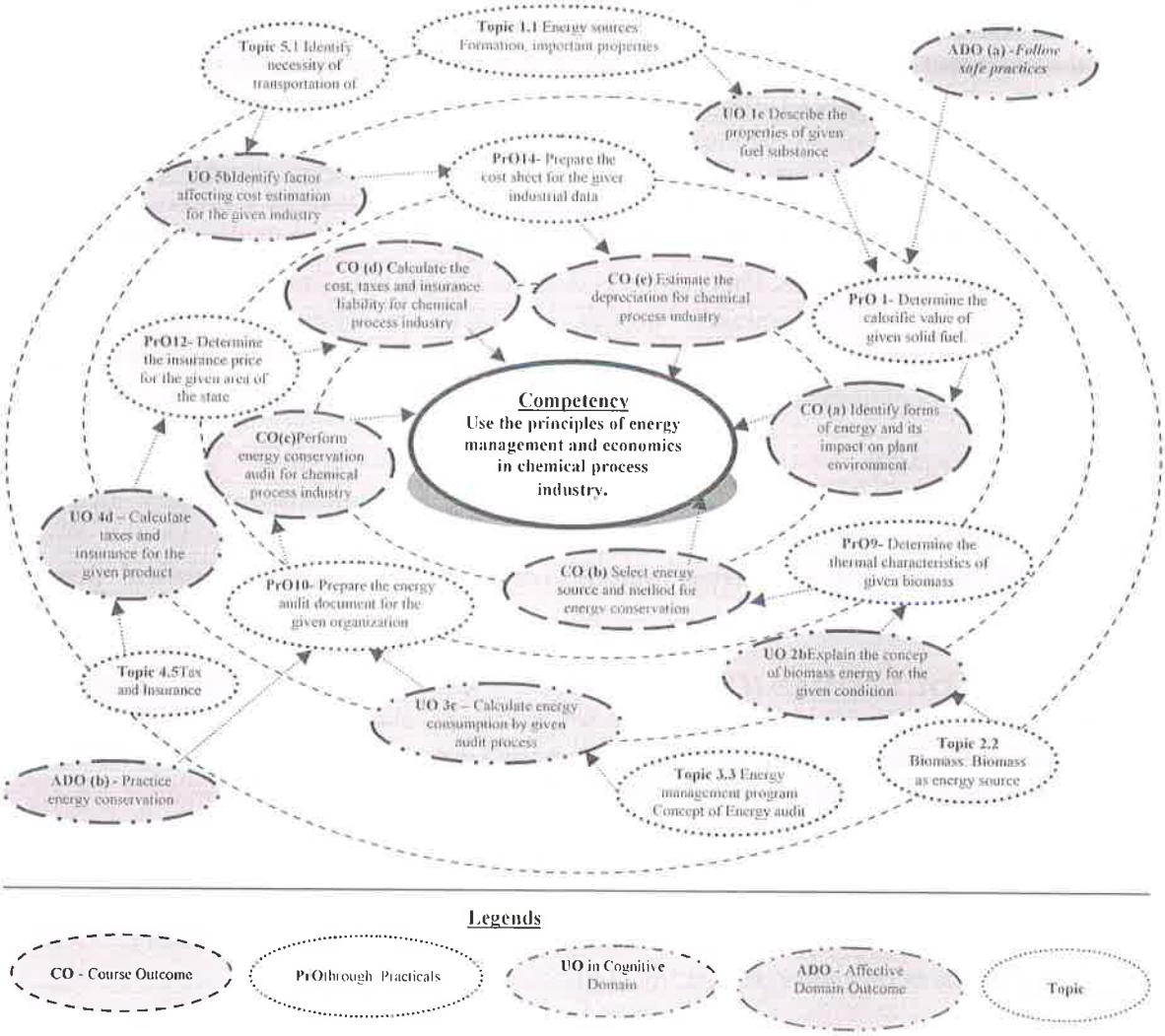

Figure 1 - Course Map

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	Determine the calorific value of given solid fuel.	I	2*
2	Determine the calorific value of given liquid fuel.	I	2*
3	Determine the calorific value of given Gaseous fuel.	I	2
4	Determine the moisture content in given coal sampl	I	2*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
5	Determine the volatile content in given coal sample.	I	2
6	Determine the ash content in given solid fuel sample.	I	2*
7	Determine the efficiency of sample solar plate.	II	2*
8	Determine the fuel components from kitchen waste	II	2
9	Determine the thermal characteristics of given biomass.	II	2*
10	Prepare the energy audit document for the given organization.	III	2*
11	Estimate the simple and compound Interest on given project cost in specific conditions.	IV	2
12	Determine the insurance price for the given area of the state.	IV	2*
13	Measure the impact of net profit and sales on stock prices of given company through the implementation of regression equation.	IV	2*
14	Prepare the cost sheet for the given industrial data.	V	2*
15	Prepare the balance sheet for the given company account.	V	2*
16	Measure the profitability of given project using development of cases and virtual situations for the given economic conditions.	V	2*
	Total		**32**

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. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

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

S. No.	Performance Indicators	Weightage in %
a.	Selection of suitable component, apparatus/instrument	20
b.	Preparation of experimental set up	10
c.	Setting and operation	10
d.	Safety measures	10
e.	Physical presence during practical	10
f.	Observation and recording	10
g.	Interpretation of result and conclusion	10
h.	Answer to sample question	10
i.	Submission of report in 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. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. 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
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

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	Bomb's calorimeter	1, 2
2	Junker's calorimeter	3
3	Hot air oven Up to 250°C temperature, gas ventilator and current protection	4, 5
4	Muffel Furnace with 800°C to 1400°C temperature range.	6
5	Digital multimeter : 3 1/2 digit display, 9999 counts digital multimeter measures: V_{ac}, V_{dc} (1000V max) , A_{dc}, A_{ac}(10 amp max) , Hz , Resistance (0 - 100 MΩ) , capacitance and Temperature	7
6	Solar panel with installation kit	7
7	Thermometer with the range of 0-120°C.	9

8. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught 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 – IEnergy and Energy Policy	1a. Explain the energy policy for the given chemical plant. 1b. Identify different energy sources for the givenapplications with justification. 1c. Describe the properties of the given fuel substance. 1d. Identify the future energy system in the given situation with justification.	1.1 Energy and development:National and International energy policy. Energy sources. Classification of energy sources. Quality and concentration of energy sources. 1.2 Energy Sources: Units of various energy, conversion, calorific value. Formation, important properties, conversion and uses of Coal, Petroleum and Natural Gas. 1.3 Future Energy system. Clean energy technologies.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– II Renewable . and Non-renewable Sources of Energy	2a. Describewith sketches concept of solar energy for the given application. 2b. Explain the concept of biomass energy for the given condition. 2c. Identify importance of wind energy for the given condition with justification. 2d. Select the type of clean energy for the givenapplication with justification.	2.1 Solar Energy:Concept, Flat plate collector (Liquid & Air). Theory of flat plate collector. Importance of coating. Advanced collector. Solar pond. Solar water heater, solar dryer. Solar stills. 2.2 Biomass: Biomass as energy source. Classification and production. Physicochemical and Thermal characteristics of biomass as fuel. Anaerobic digestion. Biogas production mechanism. Types, installation, operation and maintenance of digesters. Utilization and storage of biogas. 2.3 Wind energy: History, current status and future prospects of wind energy. Wind energy in India. Environmental benefits and problem of wind energy. Economics of wind energy. Introduction, classification, advantages and disadvantages of Hydropower. 2.4 New Energy Sources: Need and types. Hydrogen energy: Production method, storage, transportation and applications. Ocean energy resources. Tidal energy conversion. Geothermal energy concept, origin and power plants.
Unit– III Energy Management and Audit.	3a. Describewith sketches thetype of energy that can be used for the given application. 3b. Explain energy conservation for the given industrial application. 3c. Calculate energy consumption by the data from the given audit process. 3d. Identify the energy management duties of chemical technologist for the given industry.	3.1 Energy: Commercial and Noncommercial energy. Primary energy resources. 3.2 Energy security. Energy conservation and its importance. 3.3 Energy management program. Concept of Energy audit. Types and procedure of energy audit, energy losses & control. 3.4 Energy conservation act. Duties and responsibilities of Energy manager and auditor.
Unit-IVIntroduction to Plant Economics	4a. Describe the concept of market for the given area of plant economics. 4b. Calculate different types of cost for the giventype of chemical industry. 4c. Apply thelaw's of demand	4.1 Economics: Definitions and concept. Different types of market. 4.2 Concept of Cost, Total cost, fixed cost, variable cost, direct and indirect cost. 4.3 Demand and supply: Law of demand and supply. Demand and supply schedule. Methods of measurement.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	and supply for the givenchemical engineering commodity. 4d. Calculate taxes and insurance for the givenchemical engineering product.	4.4 Cost accounting: Basics and procedure of accounting. Methods of accounting. Balance sheet. 4.5 Tax and Insurance: Concept and types. income tax, excise tax, property tax,benefits of insurance.
Unit –V Cost Estimation and Interest.	5a. Calculate the interest onthe given amount and condition with respect to chemical engineering application. 5b. Identifyfactor affecting cost estimationfor the given type of chemical engineering industry. 5c. Calculate depreciation by the given method in the given given chemical engineering industry. 5d. Describe concept of profitability and calculation by the given method with respect to chemical engineering industry.	5.1 Interest: Concept and types of interest.(simple, compound and continuous) 5.2 Cost Estimation: Factor affecting on cost estimation. Total cost, fixed, variable cost. 5.3 Depreciation: Meaning and definition. Purpose of charging and factor affecting on depreciation. Methods of calculation of depreciation. Straight line method, Sinking fund method, Sum of the digit method, Annuity method, Written down value method. 5.4 Profitability: Concept of profitability. Evaluation of profitability by Rate of return on investment method, Net present worth method, Pay out period method. Advantages and disadvantages of above methods.

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

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Energy and Environment	14	02	06	08	16
II	Renewable and nonrenewable sources of energy.	12	02	04	04	10
III	Energy management and audit	14	02	04	08	14
IV	Introduction to Plant Economics	12	02	04	08	14
V	Cost estimation and interest.	12	02	04	10	16
Total		**64**	**10**	**22**	**38**	**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. Visit nearby industry to study energy consumption.
b. Prepare report on energy consumption in your institute.
c. Visit nearby energy auditor to understand auditing process.
d. Prepare list of equipment from nearby industry which conserve energy.
e. Prepare report on different laboratories from institute where energy can be conserved..
f. Suggest method to save energy in institute during practical hour.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various 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 LOs/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.

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.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. **Visit to plant**: visit nearby industry and prepare report on technologies adopted for energy conservation.
b. **Visit of chemical process plant**: Prepare flow chart for Energy conservation process.
c. **Prepare the report**: prepare the report for energy conservation of the institute.
d. **Preparation of model**: Prepare model of energy conservation in practical lab.

e. **Collection of different account samples**: Collect the accounting data from different organization/process industries/Laboratory.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Principles of Energy Conversions	Culp, A. W.	Mc Graw Hill, New York, 1991,ISBN 0-07-100991-4
2	Industrial Energy Conservation	Reay, D. A.	Pergammon Press, London, 1979, ISBN: 9780080232744
3	Energy Management Handbook	Turner Wayne C. , Doty Steve Turner, W. C.	The Fairmont Press, Inc.,Georgia, 2007, ISBN: 978-1466578289
4	Management of Energy Environment Systems	Foell, W. K.	John Wiley and Sons, London, 1979, ISBN 13: 9780471997214
5	Chemical Engineering Economics	Garrett, D. E.	Springer, Netherland, 1989, ISBN978-94-011-6544-0
6	Plant design and economics for Chemical Engineers	Max,P.S, Timmerhaus Klaus D, West Ronald E.	Mc Graw Hill Publication, New York, 2003, ISBN: 9781259002113

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://en.wikipedia.org/wiki/Energy_management
b. http://www.energylens.com/articles/energy-management
c. http://www.capterra.com/energy-management-software/
d. http://guides.lib.utexas.edu/c.php?g=494197&p=3381912