M.Sc., ENERGY SCIENCE
REGULATIONS, SCHEME & SYLLABUS

CHOICE BASED CREDIT SYSTEM (CBCS) - CURRICULUM
(it is applicable from 2018-2019 onwards)

DEPARTMENT OF ENERGY SCIENCE
(University Department)

PERIYAR UNIVERSITY
(Reaccredited with "A" Grade by the NAAC)
PERIYAR PALKALAI NAGAR
SALEM – 636 011
TAMIL NADU

DEPARTMENT OF ENERGY SCEINCE

Vision

- To be a global knowledge hub in renewable energy education, research, entrepreneurship and industry outreach services.

Mission

- Impart quality education and training to the nurture globally competitive in renewable energy sector.
- Provide vital state of the art research facilities to create, interpret, apply and disseminate knowledge.
- Develop linkages with world class educational institutions and R&D organizations for excellence in teaching, research and consultancy services.

Graduate Attributes

The Graduate Attributes are the knowledge skills and attitudes which the students have at the time of graduation. These attributes are generic and are common to all programs. These Graduate Attributes are identified by National Board of Accreditation.

1. **Knowledge**: Apply the knowledge of mathematics, science, fundamentals, and an renewable energy specialization to the solution of complex problems.

2. **Problem analysis**: Identify, formulate, research literature, and analyze complex problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and energy sciences.

3. **Design/development of solutions**: Design solutions for complex problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern tools including prediction and modeling to complex activities with an understanding of the limitations.

6. **The post graduate and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the particular professional discipline practice.

7. **Environment and sustainability**: Understand the impact of the professional renewable energy solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the renewable energy sector practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex activities with the energy sector community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of renewable energy principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

ABOUT THE PROGRAMME:

The M.Sc., programme in energy science at periyar university is aimed at imparting advanced education in renewable energy, energy harvesting and and carry out research on science and technology to conduct studies in energy conservation and environmental protection by adopting villages and carryout pilot projects and sites. To bring out publications on energy science and technology and conduct international core group discussions on emerging tools and products and to evolve policy guidelines for the government for its considerations. In addition, the M.Sc. Programme is meant to develop professional skills for students to play a meaningful role in industrial or academic life and give students the experience of independent work and team spirit.

The M.Sc. programme includes a number of core courses, creative laboratory courses, various elective courses in the domain of energy, non-major elective courses and skill based value added courses relevant to the discipline and forward-looking with respect to recent developments, discoveries and state-of-the-art achievements.

The Department offers Ph.D in Energy science, Engneering science, materials science and nanotechnology with special focus to solar energy, wind energy, energy storage, bio energy conversion and thermal energy etc.

Eligibility for Admission

Candidate who has passed the B.Sc., degree in Physics/Chemistry/Geology/Electronics/Energy Science or B.E/B.Tech degree in Mechanical/Mechatronics/Electrical & Electronics/Electronics & Communication/Automobile/Chemical Engineering of the University or an Examination of any other University accepted by the Syndicate as equivalent thereto shall be eligible for admission to M.Sc., Degree of this University or any other University recognized by the Syndicate as equivalent thereto shall be eligible to register for the Degree of Master in Energy Science (M.Sc.,) and undergo the prescribed course of study in an approved department of this University.

Mode of Selection

The admission is subject to the prevailing rules and regulations for PG admission of this University and also as per the norms of Tamil Nadu Government.

Duration of the Course

The duration of the M.Sc., Degree shall be two years consist of four semesters under Choice Based Credit System.

Distribution of Credit Points

The minimum credit requirement for M.Sc., Degree shall be 90 Credits. The break-up of credits for the Programme is as follows;

- Core Courses : 68 credits
- Elective Courses : 16 credits
- Supportive Courses : 06 credits

Course of Study

The course of study for the M.Sc., Degree shall be in Energy Science (CBCS) with internal assessment according to syllabi prescribed from time to time.

PROGRAM EDUCATIONAL OBJECTIVES:

The Program Educational Objectives are the knowledge skills and attitudes which the students have at the time of post-graduation. At the end of the program, the student will be able to:

PEO 1. Understanding basic characteristics of renewable and non–renewable sources of energy and technologies for their utilisation

PEO 2. Identify, formulate, research literature, and analyze advanced scientific problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PEO 3. Plan, design, construct, maintain and improve renewable energy systems that are technically sound, economically feasible and socially acceptable to enhance quality of life.

PEO 4. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PEO 5. Communicate effectively using innovative tools and demonstrate leadership & entrepreneurial skills.

PEO 6. Exhibit professionalism, ethical attitude, team spirit and pursue lifelong learning to achieve career and organizational goals.

PROGRAM OUTCOMES:

At the end of the program the student will be able to:

PO 1. Understood and acquired fundamental knowledge on the science and renewable energy technologies and systems.

PO 2. Acquired the expertise and skills required for energy sector and gain a intelligible understanding of the subject.

PO 3. Design and conduct experiments using domain knowledge and analyze data to arrive at valid conclusions.

PO 4. Acquired skills in the scientific and technological communications, and project preparation, planning and implementation of projects.

PO 5. Exhibit responsibility in professional, ethical, legal, security and social issues in day-to-day life thereby attaining Cultural and Civilized personality.

PO 6. Communicate effectively in diverse groups and exhibit leadership qualities.

Mapping of PEO/PO

PO/PEO	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
PO1	H	M	H	M	M	H
PO2	M	H	M	H	H	M
PO3	M	M	H	H	H	M
PO4	M	H	M	H	M	H
PO5	M	M	H	H	H	H
PO6	M	M	H	M	H	H

PROGRAM SPECIFIC OUTCOMES:

At the end of the program, the student will be able to:

PSO 1. Acquire good knowledge in fundamentals and industrial need of renewable energy systems.

PSO 2. Provide good exposure in mathematical systems in energy and describing the techniques to solve the energy problems.

PSO 3. In-depth understanding the renewable energy utilisation like solar energy, Wind energy and thermal energy etc.

PSO 4. Understand and apply inter-disciplinary concepts and computational skills for understanding and describing the natural phenomenon.

PSO 5. Provide exposure to advanced experimental/theoretical methods for measurement, observation, and fundamental understanding of physical phenomenon/systems.

PSO 6. Engage in research and life-long learning to adapt to changing environment

Mapping of PO/PSO

PSO/PO	PO1	PO2	PO3	PO4	PO5	PO6
PSO1	H	M	H	M	L	M
PSO2	M	M	M	H	M	L
PSO3	H	H	H	H	M	M
PSO4	L	M	M	H	L	L
PSO5	M	M	H	H	M	H
PSO6	H	M	H	H	H	H

DEPARTMENT OF ENERGY SCIENCE

PERIYAR UNIVERSITY, SALEM – 11

Choice Based Credit System (CBCS) Regulation

M.Sc., Energy Science – Course Structure

(Applicable to the candidates admitted from the academic year 2019-2020 onwards)

SEMESTER - I

Paper Code	Subject	L	T	P	C
18UPESC1C01	APPLIED MATHEMATICS FOR ENERGY	4	1	0	4
18UPESC1C02	BASICS OF ENERGY SCIENCE	4	1	0	4
18UPESC1C03	ENERGY AUDIT AND MANAGEMENT	4	1	0	4
18UPESC1C04	ENERGY LABORATORY – I	0	0	3	4
-	ELECTIVE – I	4	1	0	4
	Total Credits				**20**

SEMESTER – II

Paper Code	Subject	L	T	P	C
18UPESC1C05	ENERGY ECONOMICS & POLICES	4	1	0	4
18UPESC1C06	BASICS OF THERMODYNAMICS	4	1	0	4
18UPESC1C07	FABRICATION OF SOLAR CELLS	4	1	0	4
18UPESC1C08	ENERGY LABORATORY –II	0	0	3	4
-	ELECTIVE –II	4	1	0	4
-	SUPPORTIVE-I	3	0	0	3
06PHR01	HUMAN RIGHTS				0
	Total Credits				**23**

SEMESTER – III

Paper Code	Subject	L	T	P	C
18UPESC1C09	FUEL CELLS	4	1	0	4
18UPESC1C10	WIND ENERGY	4	1	0	4
18UPESC1C11	INDUSTRIAL INSTRUMENTATION	4	1	0	4
-	ELECTIVE –III	4	1	0	4
-	SUPPORTIVE-II	3	0	0	3
18UPESC1C12	MINI PROJECT	0	0	8	8
	Total Credits				**27**

SEMESTER – IV

Paper Code	Subject	L	T	P	C
18UPESC1C13	ENERGY STORAGE SYSTEMS	4	1	0	4
-	ELECTIVE –IV	4	1	0	4
18UPESC1C14	PROJECT WORK	0	0	15	12
	Total Credits				**20**

Extra courses

Paper Code	Subject	L	T	P	C
-	MOOC - course – III/ SWAYAM/NPTEL/Coursera				2
-	Value added course - Extra credit				2

Total minimum credits required for completing M.Sc. Programme in Energy science is 90.

Course Code:

1st & 2nd Digits : Effective year of the syllabi (18)
3rd & 4th Digits : University Programme (UP)
5th, 6th & 7th : Department Code (ESC – Energy Science)
8th Digit : Degree code, M.Sc., Degree course number
9th Digit : C for core course, E for Elective course, S- Supportive.
10th & 11th Digit : Serial number of the course code (1 to 14).

Elective courses

18UPESC1E01 - Basics of solar cell
18UPESC1E02 - Basics of fluid Mechanics
18UPESC1E03 - Rural Electrification Technologies and Economics
18UPESC1E04 - Bio –Energy Conversion
18UPESC1E05 - Hydrogen and Fuel Cells
18UPESC1E06 - Energy Conservation, Energy Storage and Transportation
18UPESC1E07 - Green Concepts in Buildings

Supportive Courses

18UPESC1S01 - Basic Concepts in Energy Sciences
18UPESC1S02 - Energy and environmental impacts
18UPESC1S03 - Climate Change and CO_2 Emission Assessment
18UPESC1S04 - Erection and Maintenance of Refrigeration and Air-Conditioning

Industrial Course

Industrial course is offered in second or third semester with one or two credits.

Supportive Paper

Supportive paper is offered in second and third semesters. Students are expected to opt supportive course (Non major elective) offered by other departments. Students can earn three credit from supportive course.

Swayam Course

SWAYAM is a programme by government of India and designed to achieve the three cardinal principles of educational policy namely access, equity and quality. The objective of this effort is to take the best teaching learning resources to all, including the most disadvantaged. SWAYAM seeks to bridge the digital divide for students who have hitherto remained untouched by the digital revolution and have not been able to join the mainstream of the knowledge economy. The course hosted on SWAYAM are in 4 quardants – (1) video lecture, (2) specially prepared reading material that can be downloaded/printed (3) self assessment tests through tests and quizzes and (4) an online discussion forum for cleaning the doubts. Steps have been taken to enrich in the learning experience by using audio-video and multimedia and state of the art pedagogy /technology. In order to ensure best quality content are produced and delivered, nine National Coordinators have been appointed: They are AICTE for self-paced and international courses, NPTEL for engineering, UGC for non-technical post graduation education, CEC for under graduate education, NCERT and NIOS for school education, IGNOU for out-of-the school students, IIMB for management studies and NITTTR for teacher training programme. Course delivered through SWAYAM are available free of cost to the learners, however students wanting certifications if the register will be offered a certificate on successful completion of the course for a small fee. At the end of the each course, there will be an assessment of the student through proctored examination and the marks/grades secured in this exam could be transferred to the academic record of the students.

EXAMINATIONS

There shall be examinations at the end of each semester: for odd semester on October / November; and for even semesters in April/May.

Evaluation

The performance of a student in each course is evaluated in terms of percentage of marks with a provision for conversion to grade points. Evaluation for each course shall be done by a continuous internal assessment (CIA) by the course teacher concerned as well as by an end semester examination and will be consolidated at the end of the semester.

Distribution of Marks

A. THEORY

1. Continuous Internal Assessment : 25 Marks
   - Best 1 out of 2 Internal Test : 5 Marks
   - Model Examination : 5 Marks
   - Assignment, Seminar, attendance (each 5 marks) : 15 Marks
2. Theory Examination : 75 Marks

Total : 100 marks

The passing minimum shall be 50% out of 75 Marks (38 Marks)

Minimum Total Marks Required for Earning the Credits : 50 Marks

Marks allotment for attendance as follows,

% of attendance	Marks
91% - 100%	5
85%- 90%	4
81% - 84%	3
75% -80%	2
Below 75%	No marks

B. LABORATORY

1. Evaluation of Internal Assessment

Test (Best 1 out of 2 Test) : 20 Marks

Model Practical : 20 Marks

Total : 40 Marks

2. Final Comprehensive Examination

For the Experiment carried out during the Final Examination : 40 Marks

Viva-voce Examination : 20 Marks

Total : 60 Marks

Minimum Total Marks Required for Earning the Credits : 50 Marks

C. PROJECT

Mini Project

Test (Best 1 out of 2 Test) : 20 Marks

Model Practical		: 20 Marks
	Total	**: 40 Marks**
Evaluation of the Dissertation (External)		: 15 Marks
Viva-voce Examination (Supervisor, Internal & External)		: 45 Marks
	Total	: **60 Marks**
Minimum Total Marks Required for Earning the Credits		: 50 Marks

Main Project

Marks Awarded for 3 Reviews (20+20+40) (CIA)		: 80 Marks
Evaluation of the Dissertation (External)		: 30 Marks
Viva-voce Examination (Supervisor, Internal & External)		: 90 Marks
	Total	: **200 Marks**
Minimum Total Marks Required for Earning the Credits		: 100 Marks

Question Paper Pattern

Time: 3 Hrs **Maximum Marks: 75**

PART – A (20X1=20 Marks)
Objective Type Question filled in the OMR sheet (No choice)
PART – B (3X5=15 Marks)
Analytical Questions (One question from each UNIT)
PART – C (5X8=40 Marks)
Either or Type descriptive question (Two questions from each UNIT)

Passing Minimum

1. There shall be no Passing Minimum Marks for Internal.
2. For External Examination, Passing Minimum shall be of 50% (Fifty Percentage) of the maximum marks prescribed for the paper.
3. In the aggregate (External + Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-voce.
4. Grading shall be based on overall marks obtained (internal + external).

Classification of Successful Candidates

A candidate shall be declared to have passed in each course if he/she secures not less than 50% marks in the university examinations and not less than 50% in the aggregate, including CIA and university examintions marks.

Marks and Grades

Letter Grade & Description	Grade points	Range of Marks
`O' = Outstanding	9.0 – 10.0	**90 – 100**
`D+' = Excellent	8.0 – 8.9	**80-89**
`D' = Distinction	7.5 – 7.9	**75-79**
`A+' = Very Good	7.0 – 7.4	**70-74**
`A' = Good	6.0 – 6.9	**60-69**
`B' = Average	5.0 – 5.9	**50-59**
`U' = Re-Appear	0.0	**00-49**
'AAA'= Absent	**0.0**	**Absent**

C_i= Credits earned for course *i* in amy semester

G_i= Grade point obtained for course *i* in any semester

N= The semester in which such course are to be credited.

For a Semester:

GRADE POINT AVERAGE (GPA) = $\sum_i C_i G_i / \sum C_i$

GPA = Sum of the multiplication of grade points by the credits of the course/Sum of the credits of the courses in a semester.

For the Entire Programme:

CUMULATIVE GRADE POINT AVERAGE (CGPA) = $\sum_n \sum_i C_i G_{ni} / \sum_n \sum_i C_{ni}$

CGPA = Sum of the multiplication of grade points by te credits of the entire programme/ Sum of the credits of the courses of the entire programme.

Classification of Final Result

Grade Points	Letter Grade	Description
9.5-10.0	O+	First class with exemplary performance
9.0 and above but below 9.5	O	
8.5 and above but below 9.0	D++	First class with Distinction*
8.0 and above but below 8.5	D+	
7.5 and above but below 8.0	D	
7.0 and above but below 7.5	A++	First Class
6.5 and above but below 6.0	A+	
6.0 and above but below 6.5	A	
5.5 and above but below 6.0	B+	Second Class
5.0 and above but below 5.5	B	
0.0 and above but below 5.0	U	Re-Appear

*Only the candidates who have passed in the first appearance and within the prescribed semester of the PG program are eligible.

Industrial Visit

As a Part of M.Sc., Energy Science Degree, students shall go for industrial visit at different types of Energy based companies and institutes etc., under the guidance of faculty members.

Detailed Syllabus

L	T	P	C
4	1	0	4

18UPESC1C01 - Applied Mathematics for Energy

Objectives:

The course is designed to meet with the objectives of:

- Providing high quality education in pure and applied mathematics
- Imparting theoretical knowledge and to develop computing skill
- To make the students competent to their calculating ability, logical ability and decision making ability,
- Giving students theoretical knowledge of Calculus, Algebra and their practical applications in the various fields of Science and Engineering,
- Apply their knowledge in the field of quantitative/Mathematical finance, Mathematical computing, statistics and actuarial science.

UNIT-I EMPIRICAL LAWS AND CURVE FITTING

Introduction - Linear law –method of group averages – law containing three constants –Principle of Least Squares – Fitting a Straight line – Fitting a parabola – Fitting an exponential curve – Methods of moments

UNIT-II FINITE DIFFERENCES

Finite Differences – Interpolation – Newton forward Interpolation formula – Methods: Forward difference, backward difference, central difference- Gaussion forward and backword formula –Operators – Forward (Δ) , backward (∇)and central (δ) , shifting (E) Average (μ) and their interrelations

UNIT-III FOURIER TRANSFORM

Applications of Fourier Transform Fourier Transform methods – one-dimensional heat conduction problems in infinite and semi-infinite rod – Laplace Equation – Poisson Equation.

UNIT- IV CALCULUS OF VARIATIONS

Calculus of Variations Concept of variation and its properties – Euler's equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – Direct methods – Ritz and Kantorovich methods.

UNIT- V CONFORMAL MAPPING

Conformal mapping and applications The Schwarz- Christoffel transformation – Transformation of boundaries in parametric form – Physical applications: Fluid flow and heat flow problems.

Outcomes:

Students successfully completing this module will be able to:

- Students will become more confident about their computing skill, logical skill and decision making skill,
- Students will become more competent to analyze mathematical and reasonable conclusions,

- ❖ Students will be able to use mathematical and statistical techniques to solve well defined problems
- ❖ Students will be able to understand, electronic data-bases to locate information on mathematical problems,
- ❖ Students will be able to solve real life problems and provide the limitations of such techniques and the validity of the results,

TEXT BOOKS

1. Jain M K., Iyengar S R K., Jain R K (1993) ; Numerical Methods for Scientific and Engineering Computation, New Age International (P) Ltd. New Delhi.
2. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi (1997).
3. Spiegel, M.R., Theory and Problems of Complex Variables and its Application (Schaum's Outline Series), McGraw Hill Book Co., Singapore (1981).

REFERENCE BOOKS

1. Singaravelan, E (1999) NumericalMethods, Tata Mc Graw Hill , New Delhi.
2. Andrews, L.C. and Shivamoggi, B.K., Integral Transforms for Engineers, Prentice Hall of India Pvt. Ltd., New Delhi (2003)

Mapping of course outcomes with program specific outcomes

Course Outcome/Program specific outcomes	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	-	-	L	M
CO2	H	M	-	-	L	H
CO3	H	H	-	-	H	H
CO4	L	M	-	-	H	M
CO5	L	M	-	-	L	M

18UPESC1C02- BASICS OF ENERGY SCIENCE

L	T	P	C
4	1	0	4

OBJECTIVES

- ✓ To exposure the different types of energy
- ✓ To exposure other various types of Non- renewable energy
- ✓ Understand the renewable energy importance
- ✓ To learn the basics of energy productivity in Non- renewable and renewable energy.
- ✓ To provide the application knowledge in renewable energy.

UNIT-I THERMAL AND HYDRO ENERGY

Vapor power cycles - Boiler systems - Types of boilers; Fuel handling systems - Degasifies and Deaerators -Importance and potential of hydro-electric power - Hydropower - Merits and demerits - Types of hydroelectric power plants - Run-of-the-river power plants - Components of a hydroelectric power plant

UNIT-II NUCLEAR ENERGY

Nuclear energy – Potential, challenges and opportunities - Nuclear fuels - Nuclear fusion and fission technologies - Breeder technology - Nuclear fuel enrichment - Nuclear reaction control - Types of Nuclear Reactor - Recent developments in nuclear reactors - Reactor safety and safety measures.

UNIT-III SOLAR ENERGY AND WIND ENERGY

India's solar energy potential and challenges - Solar thermal energy conversions systems - Flat plate collectors - Solar concentrators and applications - Technology of wind energy conversion - Storage of wind energy - Developments of wind farms - Advantages and disadvantages of wind energy.

UNIT-IV BIOENERGY

Biomass as energy resources - Origins and use of biomass -India's bio-energy potential and challenges - Classification and estimation of biomass - Source and characteristics of biofuels – Biodiesel – Bioethanol – Biogas.

UNIT- V GEOTHERMAL AND TIDAL ENERGY

Introduction - Classifications and energy extractions - Advantages and disadvantages of geothermal energy over other energy forms - Geothermal energy in India - Prospects- Applications of Geothermal energy - Tidal energy

-Introduction - Main types - Tidal power plant - Advantages and limitations of tidal power generation.

OUTCOME

Students will have

- Awareness on the existence of various mechanisms for basics energy, their merits, constraints and drawbacks
- Ideas of thermal and hydro energy usage
- Knowledge in nuclear energy utilizations
- Conversion process of solar energy and wind energy
- General ideas of geothermal and tidal energy

TEXT BOOKS

1. Non-conventional energy sources, GD Rai, Khanna Publishers, Delhi, 1998.

2. Wakil M, Power Plant Engineering, McGraw Hill, 2004.

REFERENCES BOOK

1. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.

Mapping of course outcomes with program specific outcomes

Course outcome/ Program specific outcomes	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H		M		M	
CO2	M		H		M	
CO3	M	L	M	L		M
CO4	L	L	H		M	M
CO5	M		H		L	L

18UPESC1C03- ENERGY AUDIT AND MANAGEMENT

L	T	P	C
4	1	0	4

OBJECTIVES

- ✓ Students able be understand the basic knowledge of energy auditing role in industry
- ✓ Students will be able to use the energy audit methods learnt to identify the areas deserving tighter control to save energy expenditure
- ✓ To understand the energy utilization pattern including wastage and its management.
- ✓ Students will be able to apply the knowledge of the subject to calculate the efficiency of various thermal utilities.
- ✓ Students will be able to understand complete study of Electrical Energy Management

UNIT- I INTRODUCTION TO ROLE OF ENERGY AUDITING IN IDUSTRY

Basic elements and measurements - Mass and energy balances - Scope of energy auditing industries - Evaluation of energy conserving opportunities.

UNIT- II ENERGY AUDIT

Need of Energy audit - Types of energy audit - Energy management (audit) approach - understanding energy costs - Bench marking - Energy performance - Matching energy use to requirements - Maximizing system efficiencies - Optimizing the input energy requirements –

UNIT- III ENERGY MANAGEMENT

Design of Energy Management Programmes - Development of energy management systems – Importance - Indian need of Energy Management - Duties of Energy Manager - Preparation and presentation of energy audit reports - Some case study and potential energy savings.

UNIT- IV THERMAL ENERGY MANAGEMENT

Energy conservation in boilers - steam turbines and industrial heating systems - Application of FBC - Cogeneration and waste heat recovery - Thermal insulation - Heat exchangers and heat pumps - Building Energy Management.

UNIT- V ELECTRICAL ENERGY MANAGEMENT

Supply side Methods to minimize supply-demand gap - Renovation and modernization of power plants - Reactive power management - HVDC - FACTS - Demand side - Conservation in motors - Pumps and fan systems - Energy efficient motors.

OUTCOME

After successful completion of the course, the students should be able to

- perform energy auditing tasks in different fields & development of energy efficient systems,
- design and develop consumer products for the betterment of human kind
- Understand various aspects of energy audit such as planning, monitoring and implementation
- Manage electric and thermal energy in the industry.
- Suggest the renewable energy systems for the buildings

TEXT BOOKS

1. Energy Management: W.R.Murphy, G.Mckay, (2019)

2. Energy Economics A.V.Desai, Wieley Eastern, (1991)

REFERENCE BOOKS

1. Hamies, Energy Auditing and Conservation; Methods Measurements, Management and Case study, Hemisphere, Washington, 1980.

Mapping of course outcomes with program outcomes

Course Outcome/Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	-	H	L	-	M
CO2	H	-	M	M	-	H
CO3	L	-	L	H	-	H
CO4	L	-	M	H	-	L
CO5	L	-	H	L	-	M

L	T	P	C
0	0	3	4

18UPESC1C04 - Energy Laboratory–I

Objectives

- ✓ To develop experimental skills for energy related measurements and experiments.
- ✓ To understand the techniques to investigate the uncertainties in experiments.
- ✓ To develop the skill for using different parameter analysis for energy system performance
- ✓ To develop practical skill in solar based experiments
- ✓ To create a group involved practical discussion in the experiments

S. No.	List of Experiments
1	I-V and P-V characteristics of PV module with various radiation and temperature
2	I-V and P-V characteristics of series and parallel combination of PV module
3	Effect of variation in tilt angle on PV module power
4	Effect of shading on solar module
5	Demonstration the working of diode as bypass and blocking diode
6	Charging period analysis of system containing PCM-1 (Organic Fatty Acid)
7	Discharging period analysis of system containing PCM-1 (Organic Fatty Acid)
8	Charging period analysis of system containing PCM-2 (Paraffin Wax)
9	Discharging period analysis of system containing PCM-2 (Paraffin Wax)
10	Charging period analysis of the system containing PCM-1 and PCM-2 in cascading

Outcome

Students will

- acquire hands-on knowledge of photovoltaic cell
- The students will learn the design and working of photovoltaic cell and thermal storage systems
- understand piecewise linear circuit elements of photovoltaic cell connections
- work independantly on analog and digital circuits
- Learn the concepts of thermal storage system prtactically

Mapping of course outcomes with program outcomes

Course Outcome/Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	L	H	L	M	M
CO2	H	M	M	M	M	H
CO3	M		L	H		H
CO4	L	H	M	H	M	L
CO5	L		H	L	M	M

18UPESC1C05 - Energy Economics & Polices

L	T	P	C
4	1	0	4

OBJECTIVE

- ✓ To explain the energy conservation Laws using a different laws
- ✓ To understand Indian energy scenario in different aspects
- ✓ To understand world energy scenario with different aspects
- ✓ To understand Indian energy policy systems through in different aspects.
- ✓ To understand world energy policy systems through in different aspects.

UNIT- I ENERGY CONSERVATION

Energy Conservation Act-2001 and its features - Electricity Act – 2003 and its features - Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)-Role of MoP(Ministry of Power)-BEE (Bureau of Energy Efficiency).

UNIT-II INDIAN ENERGY SCENARIO

Energy resources & Consumption-Commercial and noncommercial forms of energy- Fossil fuels- Renewable sources in India- Sector wise energy Consumption - Impact of energy on economy – Need for use of new and renewable energy sources-present status and future of nuclear and renewable energy-Energy Policy Issues related Fossil Fuels-Renewable Energy-Power sector reforms-restructuring of energy supply sector-energy strategy for future

UNIT-III GLOBAL ENERGY SCENARIO

Role of energy in economic development and social transformation - Energy and GDP - GNP and its dynamics - Energy sources, overall Energy demand and availability - Energy consumption in various sectors and its changing pattern - Depletion of energy sources and impact economics on international relations.

UNIT-IV INDIAN ENERGY POLICY

Global Energy Issues-National & State Level Energy Issues-National & State Energy Policy-Industrial Energy Policy- Energy Security-Energy Vision-Energy Pricing and Impact of Global Variations-Energy Productivity (National & Sector wise productivity).

UNIT-V GLOBAL ENERGY POLICY

International Energy Polices of G-8 Countries - G-20 Countries - OPEC Countries - EU Countries - International Energy Treaties (Rio, Montreal and Kyoto) - INDO-US Nuclear Deal- Future Energy Options-Sustainable Development-Energy Crisis-Role of International Energy Agency.

OUTCOMES

Students will have

- An exposure energy conservation with different policies and laws
- Understand the Indian Policy Issues
- Describe the key policies that will facilitate the transition and explain the economics of how the policies will introduce incentives that will support the transition
- Describe and explain the effects of TAE resources and technologies on economic growth and economic development including transition effects and those associated with moving the economy along the sustainable path
- Identify the key economic development consequences of the development of local indigenous alternative energy resources

TEXT BOOKS

1. P. Meier and M. Munasinghe: Energy Policy Analysis & Modeling, Cambridge University Press, (1993).
2. Charles E. Brown, World Energy Resources, Springer 2002.
3. Resources, Charles E. Brown, 'International Energy Outlook' - EIA annual Publication.

REFRENCE BOOKS

1. Principles of Energy Conversion: A.W. Culp (McGraw Hill International edition) BEE Reference book: no. 1/2/3/4
2. S Rao, Energy Technology, Khanna Publishers

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	-	H	-	-	L
CO2	H	-	M	-	-	M
CO3	L	-	L	-	-	H
CO4	M	-	M	-	-	L
CO5	L	-	L	-	-	M

L	T	P	C
4	1	0	4

18UPESC1C06 - BASICS OF THERMODYNAMICS

OBJECTIVE

- ✓ To apply concepts of TD and Zeroth Law in solving numerical problems with relevant units.
- ✓ To analyze and evaluate different forms work, heat and other properties by applying 2nd Law of TD.
- ✓ To evaluate COP, EER, Efficiency and entropy by applying second law of TD and its corollaries.
- ✓ To explain pure substance with various diagrams, explain with sketches different calorimeters and to solve numerical problems using steam tables or fundamental equations.
- ✓ To apply ideal and real gases laws in solving related numerical problems for various conditions.

UNIT -I BASIC CONCEPTS AND FIRST LAWS THERMODYNAMICS

Basic concepts of Thermodynamics - Thermodynamics and Energy - Closed and open systems - Properties of a system - State and equilibrium - Processes and cycles - Forms of energy - Work and heat transfer - Temperature and Zeroth law of thermodynamics - First law of thermodynamics - Energy balance for closed systems

UNIT -II SECOND LAW OF THERMODYNAMICS

Limitations of the first law of Thermodynamics - Thermal energy reservoirs - Kelvin-Planck statement of the second law of thermodynamics - Clausius statement - Equivalence of Kelvin-Planck and Clausius statements - Refrigerators, Heat Pump and Air-Conditioners –COP - Perpetual Motion Machines - Reversible and Irreversible process - Carnot cycle –

UNIT -III VAPOUR AND GAS POWER CYCLES

Properties of pure substance-Property diagram for phase - change processes - Carnot vapour cycle - Rankine cycle - Methods for improving the efficiency of Rankine cycle - Ideal Reheat and Regenerative cycles - Binary vapour cycles - Combined gas - vapour power cycles - Analysis of power cycles - Carnot cycle -

UNIT- IV IDEAL GAS MIXTURES IDEAL

Vander Waals equation - Principle of corresponding states - Ideal gas equation of state - Other equations of state - Compressibility factor - Compressibility charts - Composition of gas mixtures - Mass and mole fractions - Dalton's law of additive pressures - Amagat's law of additive volumes.

UNIT-V THERMODYNAMIC PROPERTIES OF FLUIDS

Properties of pure substances, Concept of phase change, Graphical representation of Pressure, Volume and Temperature, (PVT)– T and H diagrams, Properties of steam, Use of steam Tables and Mollier diagram, Thermodynamic relations involving Entropy, Enthalpy, Internal Energy, Maxwell relations and Clapeyron equation.

OUTCOMES

- Understand thermodynamics laws and their applications
- Apply concepts of TD and Zeroth Law in solving numerical problems with relevant units.
- Analyze and evaluate different forms work, heat and other properties by applying 1st Law of TD. Evaluate COP, EER,Efficiency, temperature and entropy by applying second law of TD and its corollaries.
- Illustrate problem solving procedure related to pure substances using PT, PV, TH diagrams.
- Apply ideal and real gases laws in solving related numerical problems for various conditions.

TEXT BOOKS

1. Sachdeva R C, "Fundamentals of Engineering Heat and Mass Transfer" New Age International, (1995).
2. Holman.J.P., "Thermodynamics", 3d Ed. McGraw-Hill, (1995).
3. Arora C.P, "Thermodynamics", Tata McGraw-Hill, New Delhi,(2003).
4. Kothandaraman C.P "Fundamentals of Heat and Mass Transfer" New Age International, New Delhi, (1998).

REFRENCE BOOKS

1. Smith JM, van Ness H and Abbott M, Introduction to Chemical Engineering Thermodynamics, McGraw-Hill (2001)
2. Holman JP, Heat Transfer, McGraw-Hill (2004).

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	-	-	-	L	M
CO2	H	-	-	-	L	H
CO3	H	-	-	-	H	H
CO4	L	-	-	-	H	M
CO5	L	-	-	-	L	M

18UPESC1C07 – FABRICATION OF SOLAR CELL

L	T	P	C
4	1	0	4

OBJECTIVE

- ✓ To understand Basics of Solar radiation
- ✓ To understand detailed understanding of PV systems
- ✓ To equip the students with knowledge of different solar cell technology
- ✓ To provide general views of solar cell fabrication in the field of silicon technology.
- ✓ To explore the knowledge upto end usage of solar cells

UNIT-I INTRODUTION OF SILICON

Solar PV industry and Silicon requirement-steps in producing Silicon wafers-production of metallurgical grade Silicon (MGS)-production of electronics grade silicon (EGS)-production of silicon wafers-Mono crystalline silicon ingots-multi crystalline silicon ingots-wafer dicing-silicon feedstock for solar industry.

UNIT-II SILICON WAFER BASED SOLAR CELL TECHNOLOGY

Commercial silicon solar cells-Process Flow of Commercial Silicon Cell Technology-Processes Used In Solar Cell Technologies-High Efficiency Silicon Solar Cells-Passivated Emitter Solar Cells (PESC)-buried contact solar cells-rear point contact solar cells-passivated emitter and rear contact.

UNIT-III THIN FILM SOLAR CELL TECHNOLOGIES

Thin film deposition techniques-common features of thin film technologies-amorphous silicon solar cell technologies-cadmium telluride solar cell technology-chalcopyrite (CIGS) solar cell technology-thin film crystalline silicon solar cell technologies.

UNIT-IV EMERGING SOLAR CELL TECHNOLOGIES

Need of emerging cell technologies-organic solar cells-dye sensitized solar cell (DSC) –GaAs solar cells- Thermo photovoltaic (TPV)- Crystalline Silicon Multifunction Solar Cells-Quantum Well Solar Cells-Hot Carrier Solar Cells

UNIT-V BATTERIES AND CONVERTERS

Definition-types of batteries-parameters of batteries-batteries for photovoltaic systems-liquid vented and sealed-AC to DC converters-DC to AC converters (inverters)-DC to DC power converters-charge controllers-PWM charge controller-maximum power point tracking (MPPT)

OUTCOMES

Students will have

- ✓ Understanding the solar cell theory to improve and optimize its performance of Solar cell device
- ✓ Performance of silicon material in market production
- ✓ Brief ideas about the silicon wafer based technology
- ✓ Deep knowledge in thin film technologies
- ✓ Understand the concepts of battery and convertor process

TEXT BOOKS

1. Chetan Singh Solanki , Solar Photovoltaic Technology And Systems PHI Learning Private limited (2013)

2. Richard A.Dunlap, Sustainable energy, Cengage (2018)

REFERENCE BOOK

1. Boxwell Michael, Solar Electricity Handbook, Green stream publishing LTD (2017)

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	L	H	L		L
CO2	M	L	M	M	L	M
CO3	L	L	M		H	M
CO4	H	L	M		H	H
CO5	M		H		M	L

L	T	P	C
0	0	3	4

18UPESC1C08 - Energy Laboratory–II

Objectives

- ✓ To develop experimental skills for energy related measurements and experiments.
- ✓ To understand the practical utilities of the different theories of energy component and system.
- ✓ To develop the skill for using different software for energy system performance analysis
- ✓ To conduct experiments on various Energy devices to study the performance and its applications
- ✓ To understand theory concepts by learning the practical parameters

S.No.	List of Experiments
1	Power flow calculation of PV system of DC load with battery
2	Power flow calculation of PV system of AC load with battery
3	Power flow calculations of PV system of AC&DC load with battery
4	Power flow calculations of PV system of DC load in series connection
5	Power flow calculations of PV system with AC load in series connection
6	Charging analysis of fatty acid as PCM by varying mass flow rate
7	Discharging analysis of fatty acid as PCM by varying mass flow rate
8	Charging analysis of paraffin wax as PCM by different mass flow rate
9	Discharging analysis of paraffin wax as PCM for different mass flow rate
10	Charging analysis of both fatty acid and paraffin wax cascading method by varying mass flow rate

Outcome

Upon completion of the course, the students will be able to:

- Understand the working principle of different energy sources.
- Measure the properties of different storage systems.
- Procedure to be adopted for performance analysis and optimization of energy utilities
- Work predominantly in the solar cell analysis and its efficient on solar radiation

- Understand the practical skills of doing the experiments with precision.

Mapping of course outcomes with program outcomes

Course Outcome/Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	L	H	L	M	M
CO2	H	M	M	M	M	H
CO3	M		L	H		H
CO4	L	H	M	H	M	L
CO5	L		H	L	M	M

L	T	P	C
4	1	0	4

18UPESC1C09 – FUEL CELLS

OBJECTIVE

- ✓ To understand about fuel cells, their working principle, Types, Design and performance analysis.
- ✓ To provide fundamental views of fuel cells.
- ✓ To give depth of understanding in fuel cell kinetics
- ✓ To provide an understanding on fuel cell applications and problems.
- ✓ To skill for solving simple systems is educated

UNIT-I OVERVIEW OF FUEL CELLS

Low and high temperature fuel cells - Fuel cell thermodynamics – Heat - Work potentials - Prediction of reversible voltage - Fuel cell efficiency.

UNIT-II FUEL CELL REACTION KINETICS

Electrode kinetics – Overvoltage - Tafel equation - Charge transfer reaction - Exchange currents - Electro catalysis – Design - Activation kinetics - Fuel cell charge and mass transport - Flow field - Transport in electrode and electrolyte.

UNIT-III FUEL CELL CHARACTERIZATION

In-situ and ex-situ characterization techniques -I-V curve - Frequency response analysis - Fuel cell modelling and system integration - 1D model – Analytical solution and CFD models.

UNIT-IV BALANCE OF PLANT

Hydrogen production from renewable sources and storage - Safety issues - Cost expectation and life cycle analysis of fuel cells.

UNIT-V FUEL CELL POWER PLANTS

Fuel processor - Fuel cell power section (fuel cell stack) - Power conditioner - Automotive applications - Portable applications.

OUTCOME

After completing the course, student should have learnt

- ✓ Basics and working principles of the Fuel cell technology.
- ✓ Selection the suitable materials for electrode, catalyst, membrane for the fuel cells
- ✓ General kinetics of fuel cells
- ✓ Discription of Fuel cell characterization
- ✓ Management of safety issues

- ✓ Application of fuel cell in industries

TEXT BOOKS:

1. Liu, H.,Principles of fuel cells, Taylor & Francis, N.Y., (2006)

REFERENCE BOOK

1. Fuel cell technology handbook, edited by GregorHoogers, CRC Press (2003).
2. Shripad Revankar, Pradip Majumdar, Fuel Cells: Principles, Design, and Analysis, CRC Press, (2014).

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	L	M	L	M	L
CO2	M	L	M	L	M	H
CO3	L	M	M		L	M
CO4	M	L	M		M	H
CO5	H		H	L	L	L

18UPESC1C10 – WIND ENERGY

L	T	P	C
4	1	0	4

OBJECTIVES

- ✓ To understand the working principles of the conversion devices, limitations, cost of energy generation
- ✓ Understand the processes of generation of wind, its potential and energy extraction
- ✓ Understand the aerodynamic principles of turbine blade design
- ✓ To understand wind energy resource assessment techniques.
- ✓ To understand the principles of conversion to useful form of energy from these resources.

UNIT-I INTRODUCTION OF WIND ENERGY

Historical and recent development of Wind Energy - Wind Turbine Technology – Onshore and Offshore - Components of wind turbines - Design aspects of wind turbines - Electrical and mechanical aspects of wind turbines - Aerodynamic aspects of wind turbine - Characteristics of wind - Wind resource Assessment and techniques.

UNIT-II WIND ENERGY INSTRUMENTS & MEASUREMENTS

The Nature of the Wind - Site Selection, Wind measurements - Monitoring Stations - Wind Resource Mapping, Installation -Instrumentation and Commissioning of WMS - Met Mast and Modern Measurement Techniques - Measurement using remote sensing instruments (SODAR & LiDAR).

UNIT-III WIND RESOURCE ASSESSMENT

Latest trends in Wind Resource Assessment - Data collection - Data processing, Data Analysis Processing - Software tools for Wind data Analysis - Design and Layout - Micro siting - Wind Atlas: A Case Study - Forecasting and Wind Energy Production.

UNIT-IV WIND TURBINE TECHNOLOGY

Latest wind turbine technology - Constant / Variable Speed wind turbines – Transformers - Power electronics - Power converters – Blades - Drive train – Nacelle - Rotor hub - Control strategies (Pitch and Stall Regulation) – Gearbox – Generator – Brake - Yaw drive - Tower and foundation.

UNIT- V WIND FARMS

Wind Farm development - Pre-feasibility studies -Installation & Commissioning of wind farms - Grid Integration of wind turbines - Wind

Power Evacuation - Operation and Maintenance - SCADA & Condition monitoring - Power quality characteristic - Energy Storage - Testing and Certification of wind turbines - Small wind turbines and Hybrid systems.

OUTCOMES

Students will have

- ✓ Prepare and evaluate detailed project reports for establishing a wind farm
- ✓ Understand the operation of a wind farm and economics of power generation
- ✓ Analysis concepts of wind energy measurements
- ✓ Innovative knowledge in wind turbine design and technology
- ✓ Real fields application of wind energy farms

TEXT BOOKS

1. Thomas Ackermann, (2005), Wind Power in Power System, John Wiles & Son Ltd.
2. Ray Hunter, (19970, Wind Energy Conversion: From Theory to Practice, John Wiley and Son Ltd.

REFERENCE BOOKS

1. Gary L.Johnson, (1985), Wind Energy Systems, Prentice-Hall Inc., New Jersey.
2. Desire Le Gouriers, (1982), Wind Power Plants: Theory and Design, Pergamon Press.

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	L	M		M	L
CO2	L	M	M		L	L
CO3	M	L	M	L	H	M
CO4	M		H	M	L	L
CO5	M		M		M	M

18UPESC1C11 - INDUSTRIAL INSTRUMENTATION

L	T	P	C
4	1	0	4

OBJECTIVE

- ✓ To familiarize with the characteristics of instruments.
- ✓ To familiarize with the thermal and pressure flow measurements systems.
- ✓ To understand the flow visualization techniques.
- ✓ To understand the pollution and energy measurement.
- ✓ To understand the applications of electrical energy measurement.

UNIT-I GENERALIZED INSTRUMENTATION SYSTEM

Error theory – Calibration of instruments – Range – resolution – Span – Linearity, Sensitivity- Signal conditioning systems.

UNIT-II PRESSURE AND TEMPERATURE MEASUREMENT

Bimaterials, Pressure thermometers, Thermocouples, RTD, Thermisters, and Pyrometry, pyrometers- Calibration of Pressure measuring equipment, principles and operation of various vacuum pumps and gauges.

UNIT-III FLOW MEASUREMENT

Variable head flow meters- Rota meters, Electromagnetic flow meters, Hot wire anemometers, Hot film transducers, Ultrasonic flow meters, impellers turbine system, corollas meters, vortex-shed meters

UNIT-IV AIR POLLUTION AND ENERGY MEASUREMENTS

Particulate sampling techniques, SO2, Combustion Products, Opacity , odour measurements - Measurement of liquid level, Humidity, O2, CO2 in flue gases- pH measurement, moisture analyzer.

UNIT-V ELECTRICAL ENERGY MEASUREMENT and ADVANCE MEASURMENT TECHNIQUES

Power factor, load factor, harmonic analyzer, lighting: Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Hot wire, Anemometer, heat flux sensors, Telemetry in measurement.

OUTCOMES

After successful completion of this course, the students will be able to

- ✓ Illustrate the various types of transducers and measurement systems
- ✓ Demonstrate the temperature measuring devices
- ✓ Understand the operation of pressure and level measuring devices
- ✓ Summarize the various parameter measuring devices
- ✓ Distinguish various measurement devices in different application

- ✓ Apply basic knowledge of measuring devices in various real time applications

TEXT BOOKS

1. Sawhney A K and PuneetSawney, "A course in Mechanical Measurements and instrumentation" DhanpatRai & Co 2002.

2. Doebelin E O, "Measurement Systems - Application and Design", McGraw-Hill, 2004.

REFERENCE BOOKS

1. Bechwith, Marangoni and Lienhard, "Mechanical Measurements" Addison-Wesley, 2000.

2. Holman J P, "Experimental methods for engineer's", McGraw-Hill, 1994.

3. Rangan C S, Sharma G R and Mani V S V, "Instrumentation Devices and Systems", Tata McGraw-Hill, 1983.

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	M	H	-	L	M
CO2	H	M	H	-	L	H
CO3	M	H	H	-	H	H
CO4	L	M	L	-	H	M
CO5	H	M	L	-	L	M

18UPESC1C12 **MINI PROJECT**

L	T	P	C
0	0	8	8

OBJECTIVES

- ✓ A research project topic may be selected either from published lists or from the creative ideas of the students themselves in consultation with their project supervisor.

EVALUATION

- ✓ Project work evaluation is based on Regulations of Credit system University Departments - Post graduate programmes of Periyar University

OUTCOME

- ✓ The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated in their main project work phase.

18UPESC1C13- ENERGY STORAGE SYSTEMS

L	T	P	C
4	1	0	4

OBJECTIVES

- ✓ To understand the concept of understand / analyses the various types of energy storage.
- ✓ To study the various applications of energy storage systems
- ✓ To acquire the knowledge of various types of energy storage materials
- ✓ To understand the fundamental theories that explain design of energy storage systems
- ✓ To comprehend the concepts of energy storage applications.

UNIT-I LEAD ACID BATTERY

Advantages and disadvantages of lead acid batteries - Electrochemical reactions - Physical and chemical properties of active materials - Characteristics and properties of sulphuric acid - Constructional features - Materials and manufacturing methods - SLI (Automotive) batteries - Charge and discharge properties ties of lead acid batteries - Sealed lead acid or maintenance free batteries fabrication technology and testing - Lead acid battery for PV and automotive applications.

UNIT-II LITHIUM-ION BATTERY

Advanced anodes and cathodes – Theoretical capacity – Merits and demerits - Nanomaterials for anodes - Carbon nanotubes - SnO_2 – NiO - TiO_2 & $LiTiO_4$ - Battery fabrication technology and testing - Batteries for electric vehicles - Hybrid vehicles and solar photovoltaic applications.

UNIT-III METAL-AIR BATTERIES

Lithium-Air - Sodium-Air – Zinc - Air batteries - Principle – Components – anodes – Cathodes - Fabrication – Evaluation – Merits - Demerits and Applications.

UNIT-IV FUEL CELLS

Membrane electrode assemblies – Fabrication - Catalyst layer - Fuel cell supports – GDL - Bipolar plates - Fuel cell catalysts – Precious and non-precious metal catalysts - Bi-functional catalysts – Nanomaterials for low temperature fuel cells – Reversible fuel cells - Fuel cell stacks and systems - Fuel cells for vehicles and grid connected applications.

UNIT-V HYBRID ENERGY SYSTEMS

Concept of hybrid energy systems - Supercapacitors – Fundamentals and types - Battery/supercapacitors hybrid systems – Example – Applications - Hybrid fuel cell/battery systems – Example – Applications.

OUTCOME

Students will have

- ✓ Students will be Able to analyses various types of energy storage devices and perform the selection based on techno economic view point
- ✓ Knowledge in Industrial and usage of lead acid batteries
- ✓ Advance technologies used in lithium ion batteries
- ✓ Recent trends of technology used metal air batteries.
- ✓ Advancement of hybrid storage systems

TEXT BOOKS

1. Subramanian Srinivasan, Fuel Cells from fundamentals to applications, Springer, (2006).
2. Modern Batteries, Colin A Vincent and Bruno Scrosati, (1997) Pub Arnold ISBN 0-340-66278-6.
3. Electric Vehicle Battery Systems Sandeep Dhameja, October (2001), Pub Newnes, ISBN 0750699167.

REFERENCE BOOKS

1. T. R. Crompton, Battery Reference Book, SAE International, (1996). Edition: 2EV/Hybrid Batteries & Battery Material Suppliers: An Automotive Market Review.

2. David Linden, Hand Book of Batteries, McGraw-Hill, Inc), 4th edition, (2010) New York.

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	M	H	M	L	M
CO2	H	L	H	L		M
CO3	M	L	H	L	L	H
CO4	H	L	H	M	L	H
CO5	H		H	L		H

18UPESC1C14 **PROJECT WORK**

L	T	P	C
0	0	15	12

OBJECTIVES

- ✓ The objective of the research project work is to produce factual results of their applied research idea in the area of renewable energy, from mini project.

EVALUATION

✓ Project work evaluation is based on Regulations of Credit system University Departments - Post graduate programmes of Periyar University

OUTCOME

✓ The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated project outcome of the aimed work.

ELECTIVE COURSES

L	T	P	C
4	1	0	4

18UPESC1E01- BASICS OF SOLAR CELL

OBJECTIVE

- ✓ To learn and study the basics of basics of electricity
- ✓ To study the various solar photovoltaic energy and their applications
- ✓ To learn about various solar pv cell materials and conversion techniques
- ✓ To learn various and designs solar pv cell and requirement
- ✓ To know about various solar pv modules and arrays applications

UNIT-I BASICS OF ELECTRICITY

Introduction to Electricity-Voltage-Current-Resistance-Electric Power-Electrical Energy-Types of Power-Measurement of Electrical Quantities-Millimeter-Measurement of DC Voltage-AC Voltage-DC Current-AC Current-Resistance- Electrical Power and Energy

UNIT-II INTRODUCTION TO SOLAR PHOTOVOLTAIC ENERGY

Photovoltaic effect- Solar Cell-Parameters of Solar Cells -Solar Cell Technology -Effect of Conversion Efficiency-Input Light- Solar Cell Area-Angle of Light Falling on Solar Cell-Solar Cell Operating Temperature.

UNIT-III SOLAR CELL MATERIALS

Semiconductors-Intrinsic Semiconductor-Extrinsic Semiconductor-P Type and N Type Semiconductors-Generation of Carriers-Recombination of Carriers- P-N Junction-Energy Band Diagram of P-N Junction-Carrier Movements and Current Densities.

UNIT-IV CONCENTRATED PV CELLS

Light concentration-Concentration Ratio Optics for Concentrator PV- 'V' Trough Concentrator –Compound Parabolic Concentrator-Parabolic Trough Concentrator-Parabolic Reflector-Fresnel's Lenses Concentrator-Tracking Requirement of CPV-Cooling Requirements.

UNIT-V PV MODULES AND ARRAYS

Definition of PV module-Module Ratings-PV Module Parameters -IV and PV characteristics of PV module- Number of cells in a module-designing wattage of PV module-Definition of array-connection of modules in series-parallel and mixed combination-mismatch effect

OUTCOMES

students will have

- ✓ Learn and study the solar radiation and various solar Cells
- ✓ Know the various solar energy technologies and their applications
- ✓ Aware about various solar PV cell materials and conversion techniques
- ✓ Learn various Solar SPV systems designs and their applications
- ✓ Understanding the solar cell theory to improve and optimize its performance of Solar cell device

TEXT BOOKS

1. Chetan singh Solanki, solar photovoltaic technology and systems PHI learning private limited (2015)

2. H.P.Garg Solar Energy: Fundamentals And Applications , McGraw Higher Ed Publication (2000)

REFERENCE BOOK

1. Suneel Deambi, From Sunlight to Electricity: A practical handbook on solar photovoltaic applications, The Energy And Resources Institute (2009).

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	L	-	H	-	M
CO2	-	-	M	L	-	H
CO3	-	L	-	H	-	M
CO4	L	-	M	M	-	L
CO5	L	L	M	L	M	M

18UPESC1E02- BASICS OF FLUID MECHANICS

L	T	P	C
4	1	0	4

OBJECTIVES

- ✓ To familiarize with the properties of fluids and the applications of fluid mechanics.
- ✓ To make students familiarize with the application of conservation equations
- ✓ To explain the incompressible and compressible fluid flow concepts
- ✓ To provide the details of turbulent forced convective heat transfer
- ✓ To understand the concept of fluid measurement, types of flows and dimensional analysis.

UNIT-I PROPERTIES OF FLUIDS

Introduction –Density-Specific Weight-Specific Volume-Specific Gravity-Viscosity-Kinematic Viscosity-Dynamic Viscosity-Compressibility and Bulk Modulus-Surface Tension and Capillarity

UNIT-II PRESSURE MEASURING DEVICES

Pascal's law – Absolute gauge – Atmospheric and vacuum pressures – manometers – simple manometer – piezometer –U tube manometer- single column manometer-differential manometer- U tube differential manometer – inverted U tube differential manometer.

UNIT – III FLUID FLOW AND LOSSES

Types of flows- Rate of Flow (Or) Discharge- Continuity Equation- Euler's Equation of Motion-Bernoulli's Equation from Euler's Equation -Application Of Bernoulli's Equation- Venture- Orifice Meter-Pitot-Tube.

UNIT-IV DIMENSIONAL AND MODEL ANALYSIS

Introduction-Derived Quantities- Buckinghams Π Theorem Method of Selecting Repeating Variables-Procedure for Solving Buckinghams Π Theorem- Dimensionless Number

UNIT-V HYDRAULIC MACHINES & APPLICATION

Centrifugal pump- Construction-Working-Reciprocating Pump-Construction- Working –Hydraulic Press –Hydraulic Accumulator-Hydraulic Intensifier – Hydraulic Ram-Hydraulic-Lift-Hydraulic Crane.

Outcomes:

Upon completion of this course, the students will be able to:

- Identify and obtain the values of fluid properties and relationship between them and understand the principles of continuity, momentum, and energy as applied to fluid motions
- Learn the flow concepts of fluid flow and losses
- Solve the conduction and gas radiation heat transfer problems.
- Understand the dimensional and model analysis
- Design a hydraulic machines & application

TEXT BOOK

1. Fang, Chung, An Introduction to Fluid Mechanics, Springer Publications (2018)

REFERENCE BOOKS

1. Fluid Mechanics, Spurk, Joseph, Aksel, Nuri, Springer Publications (2008).
2. Fluid Mechanics And Hydraulic Machines – Dr. R.K.Bansal, Laxmi Publications (2010).

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	L	-	M	L	-
CO2	-	-	M	H	-	L
CO3	-	L	-	M	-	-
CO4	L	-	M	L	M	-
CO5	L	L	M	M	-	M

L	T	P	C
4	1	0	4

18UPESC1E03 - Rural Electrification Technologies and Economics

OBJECTIVES

- ✓ To provide knowledge about urban and rural environment and its energy demand
- ✓ To understand financial analysis for Electrification Technologies
- ✓ To learn about various power generation
- ✓ To provide information about bio gas in rural electrification
- ✓ To introduce the concept of smart grid

UNIT –I GENERATION TECHNOLOGIES

Decentralized generation technologies; Costs and choice of technology, Demand and benefits forecasting and program development, Principles of cost-benefit calculations

UNIT- II Financial Analysis

Economic and financial analysis of stand-alone electrification projects, Decentralized versus central station generation, Traditional power systems, Load curves and load curve analysis

UNIT- III GAS TURBINE GENERATOR

Basic gas turbine generator concepts; Utility system turbine generators; Mini and micro gas turbine generators; Solar thermal power generation, utility scale photovoltaic (USPV) generation; Wind powered generation

UNIT –IV BIOMASS BASED GENERATION

Biomass based generation; DG Evaluation: Cost from past, present, and future, basic DG cost analysis, cost Evaluation and schedule of demand.

UNIT- V POWER GRID

The power grid; DG-Grid interconnection issues, Mini and Micro Grids – Economics – Environmental Factors – Transmission and Regulations

OUTCOMES

Students will have

- The principle of direct technologies used in rural areas
- The structure, materials and operation of bio gas process in rural areas
- knowledge about socio-economic and environmental merits of rural electrification
- The prospects of rural technology for sustainable power generation
- knowledge in concept of smart grids, environmental factor and economic issues

TEXT BOOKS

1. H. Lee Willis and W.G. Scott: Distributed Power Generation: Planning and Evaluation, Marcel Dekker, (2000).
2. J. J. Burke: Power Distribution Engineering, Fundamentals and Applications, Marcel Dekker, (1994).
3. T. Gonen: Electric Power Distribution System Engineering, McGraw Hill (1986).
4. M Mohan: Rural electrification for development: policy analysis and applications. Boulder: Westview Press, (1987).

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	-	H	L	-	M
CO2	H	-	M	M	-	H
CO3	L	M	L	H	L	H
CO4	L	-	M	H	-	L
CO5	L	-	H	L	L	M

18UPESC1E04 - Bio –Energy Conversion

L	T	P	C
4	1	0	4

OBJECTIVE

- ✓ Acquiring the knowledge of biomethanation
- ✓ Understanding Biomass through combustion and its importance with respect to environment protection
- ✓ To design gasification systems.
- ✓ Analyze the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications.
- ✓ To provide general features of geothermal energy

UNIT-I BIOMETHANATION

Microbial Systems – Phases in Biogas production – Parameters affecting gas production – Effect of additives on Biogas yield – Possible feed stocks. Biogas plants – Types – Design – Constructional details & comparison – Biogas appliances – Burner, Illumination & Power Generation – Effect on Engine Performance.

UNIT-II COMBUSTION

Perfect, Complete & Incomplete – Equivalence ratio – Fixed Bed, Fluid Bed – Fuel & Ash handling – Steam Cost comparison with conventional fuels. Briquetting: Types of Briquetting – Merits & Demerits – Feed requirements & Preprocessing – Advantages - Drawbacks

UNIT-III GASIFICATION

Types – Comparison – Application – Performance Evaluation – Economics – Dual fuel engines –100 % Gas Engines – Engine characteristics on gas mode – Gas Cooling & cleaning train.

UNIT-IV IMPORTANT ASPECTS OF GEOTHERMAL ENERGY

Important aspects of Geothermal Energy (GTE), Applications, Geothermal Energy Resources, Origin of Geothermal Thermal Resources, Geothermal Thermal Gradients, Non-uniform Geothermal Thermal Gradients, Hydro-Geothermal Resources

UNIT- V GEOTHERMAL ELECTRIC POWER (GTEP) PLANTS

Introduction, Classification and Types, Historical Background, Vapor dominated GTEP Plant (Steam), Liquid dominated GTEP Plant (Hot Water), Liquid dominated Flashed Steam GTEP Plant, Scope for Geothermal Energy systems in India.

OUTCOMES

After successful completion of this course, the students will be able to

- ✓ Acquiring the knowledge of biomass energy.

- ✓ Understanding Biomass as an renewable energy and its importance with respect to environment protection
- ✓ To design bio-energy systems
- ✓ Discuss the organic compounds will provide a strong platform to understandthe concepts on Bio Gas these subjects for further learning.
- ✓ Develop knowledge on historical background and scope of geothermal

TEXT BOOKS

1. G D Rai, Non Conventional Energy Sources, Khanna Publishers, New Delhi (1988)

2. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood, Chichester, (1984)

REFERENCE BOOKS

1. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, (1986)

2. R.C. Mahaeswari, Bio Energy for Rural Energisation, Concepts Publication, (1997)

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	-	-	-	H	L
CO2	H	-	-	-	M	L
CO3	H	M	-	-	M	H
CO4	H	L	-	-	M	M
CO5	H	L	-	-	M	M

L	T	P	C
4	1	0	4

18UPESC1E05- HYDROGEN AND FUEL CELLS

OBJECTIVE

- ✓ To introduce to emerging technologies like production and storage of Hydrogen
- ✓ To discuss the fundamentals of various types of fuel cell system, its components and characterization
- ✓ To discuss comprehensive background in fuel cell base systems and hydrogen technologies
- ✓ To understand hydrogen generation techniques and hydrogen economy.
- ✓ To provide application concepts of hydrogen and fuel cells.

UNIT-I HYDROGEN ENERGY ECONOMY

Hydrogen Energy Economy – Conception - Present status and a vision – Applications of Hydrogen - Transport application - cars, light trucks, buses -

Stationary and Portable - Electronic gadgets.

UNIT-II HYDROGEN AND PRODUCTION TECHNIQUES

Hydrogen – Physical and chemical properties - Salient characteristics - Production of hydrogen – Steam reforming – Water electrolysis – Gasification and woody biomass conversion – Biological hydrogen production – Photo dissociation – Direct thermal or catalytic splitting of water.

UNIT-III HYDROGEN STORAGE & TRANSPORT

Hydrogen storage options – Compressed gas – Liquid hydrogen – Hydride – Chemical Storage – Comparisons - Transport of Hydrogen -

Pipelines, Gaseous, Liquid and Compound materials.

UNIT-IV FUEL CELLS

History – Principle - Working - Thermodynamics and kinetics of fuel cell process – Performance evaluation of fuel cell – Comparison on battery Vs fuel cell - Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – Relative merits and demerits.

UNIT- V APPLICATION OF FUEL CELL

Fuel cell usage for domestic power systems - Large scale power generation – Automobile - Space - Environmental analysis of usage of Hydrogen in Fuel cell - Future trends in fuel cells.

OUTCOME

Students will have

- ✓ Exposure to different fuel cells in particularly Hydrogen fuel cells
- ✓ Current status of hydrogen energy economy
- ✓ General ideas of hydrogen production techniques
- ✓ Deep understanding of hydrogen storage & transport issues
- ✓ Concepts learning and facts of usage in fuel cells
- ✓ Application knowledge in fuel cells

TEXT BOOKS

1. Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn Well Corporation, Oklahoma , (2005).
2. Hydrogen and Fuel Cells: Emerging Technologies and Applications, Bent Sorensen (Sorensen), Elsevier, UK ,(2005).

REFERENCE BOOKS

1. Fuel Cell and Their Applications, Kordesch, K and G.Simader, Wiley-Vch, Germany ,(1996).
2. Fuel Cells: Theory and Application, Hart, A.B and G.J.Womack, Prentice Hall, NewYork Ltd., London, (1989).

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H		M		L	L
CO2	M	L	M			L
CO3	H		H		M	M
CO4	H	L	M		L	M
CO5	L		L		L	H

18UPESC1E06- ENERGY CONSERVATION, ENERGY STORAGE AND TRANSPORTATION

L	T	P	C
4	1	0	4

OBJECTIVE

- ✓ To Introduce to emerging technologies like production and storage of Energy
- ✓ To determine conservation of basic techniques and available technologies
- ✓ To provide a comprehensive understanding on industrial waste heat recovery and storage systems
- ✓ To understand the basic necesseties of energy transportation
- ✓ The course covers the physical understanding of application of batteries and hydrogen fuel cells

UNIT –I ENERGY CONSERVATION

Introduction- approaches to energy conservation-energy conservation in the united states- energy conservation in India- cogeneration- smart grid-energy conservation in the community-LED street lights.

UNIT-II HOME HEATING COOLING AND TRANSPORTATION

Furnace efficiency-heat pumps- air conditioning-integrated HVAC systems-minimizing heat loss-insulation, windows, and air leaks-residential lighting-transportation-FUEL Economy-hybrid vehicles.

UNIT-III ENERGY STORAGE

Introduction-pumped hydroelectric power-bath country pumped hydroelectric facility-compressed air energy storage-implementation of compressed air energy storage-fly wheels-superconducting magnetic energy storage (SMES).

UNIT-IV BATTERY ELECTRIC VEHICLES (BEVs)

Introduction-battery types-the cost of electricity-BEV requirements and design-flow batteries-history of BEVs-rechargeable sodium batteries-super capacitors.

UNIT-V HYDROGEN FUELS

Introduction-properties of hydrogen-hydrogen production methods – electrolysis-Thermal Decomposition of Water-Chemical Reactions-Storage And Transportation of Hydrogen-Hydrogen Internal Combustion Vehicles-Fuel Cells-Fuel Vehicles-Hydrogen Present And Future-Efficiency of Different Transportation Technologies.

OUTCOME

Students will have

- ✓ Exposure Students will be Able to analyses various types of energy storage devices and perform the selection based on techno economic view point
- ✓ Ideas in energy conservation
- ✓ Conception of home heating and transportation
- ✓ Detail practical knowledge in energy storage systems
- ✓ Conversion process of battery electric vehicles
- ✓ Types and usage of hydrogen fuel cells

TEXT BOOK

1. Richard a. Dunlap sustainable energy, Cengage Learning; 1 edition (2014)

REFERENCE BOOK

1. Jochen Fricke, Walter L. Borst , Essentials of Energy Technology: Sources, Transport, Storage, Conservation 1st Edition, Wiley, (2014)

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	L	L			
CO2	H		M	M	L	M
CO3	H	M	H	L		
CO4	M	M	M		M	L
CO5	L		L			H

18UPESC1E07- GREEN CONCEPTS IN BUILDINGS

L	T	P	C
4	1	0	4

OBJECTIVES

- ✓ To understand and apply the concept of availability and to calculate the behaviour of real gases
- ✓ To predict the condition of systems and analyze them by the criteria of equilibrium
- ✓ impart knowledge on different ways of energy building
- ✓ to develop capability in the students to design solar energy building systems and make students aware with the challenges of the field,
- ✓ to give students in depth understanding of green composite builidng, related technical and environmental challenges

UNIT –I ENVIRONMENTAL IMPLICATIONS OF BUILDINGS

Environmental implications of buildings energy, carbon emissions, water use, waste disposal; Building materials: sources, methods of production and environmental Implications. Embodied Energy in Building Materials: Transporation Energy for Building Materials; Maintenance Energy for Buildings.

UNIT- II IMPLICATIONS OF BUILDING TECHNOLOGIES

Implications of Building Technologies Embodied Energy of Buildings: Framed Construction, Masonry Construction. Resources for Building Materials, Alternative concepts. Recycling of Industrial and Buildings Wastes. Biomass Resources for buildings.

UNIT –III COMFORTS IN BUILDING

Comforts in Building: Thermal Comfort in Buildings- Issues; Heat Transfer Characteristic of Building Materials and Building Techniques. Incidence of Solar Heat on Buildings-Implications of Geographical Locations.

UNIT- IV UTILITY OF SOLAR ENERGY IN BUILDINGS

Utility of Solar energy in buildings concepts of Solar Passive Cooling and Heating of Buildings. Low Energy Cooling. Case studies of Solar Passive Cooled and Heated Buildings.

UNIT- V GREEN COMPOSITES FOR BUILDINGS

Green Composites for buildings: Concepts of Green Composites. Water Utilisation in Buildings, Low Energy Approaches to Water Management.

Management of Solid Wastes. Management of Sullage Water and Sewage. Urban Environment and Green Buildings. Green Cover and Built Environment.

OUTCOMES

Students will have

- ✓ To calculate the availability of the systems and cycles
- ✓ Analyze the engineering systems to improve and optimize its performance
- ✓ Elaborate knowledge on the building technologies
- ✓ Able to apply solar energy in green buildings.
- ✓ Familiar in the concept of green composites for buildings.

TEXT BOOKS

1. K.S.Jagadish, B. U. Venkataramareddy and K. S. Nanjundarao. Alternative Building Materials and Technologies. New Age International, (2007).
2. Low Energy Cooling For Sustainable Buildings. John Wiley and Sons Ltd, (2009).

REFRENCE BOOKS

1. Green My Home: 10 Steps to Lowering Energy Costs and Reducing Your Carbon Footprint, by Dennis C. (2008).
2. Brewer, ISBN: 9781427798411, Publisher: Kaplan Publishing, Publication (2008).
3. B. Givoni, Man, Climate and Architecture Elsevier, (1969).
4. T. A. Markus and E. N. Morris Buildings Climate and Energy. Pitman, London, (1980).

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	L	-	-	-	M
CO2	-	-	-	-	M	H
CO3	-	L	-	-	-	M
CO4	L	-	-	-	M	L
CO5	L	L	-	-	M	M

SUPPORTIVE COURSES (For other Departments)

L	T	P	C
3	1	0	3

18UPESC1S01- BASIC CONCEPTS IN ENERGY SCIENCES

OBJECTIVES

- various renewable energy resources available in the country, their potential, exploitation/achievements etc.,
- solar energy radiation on the earth surface and outside earth atmosphere, solar radiation measurement and estimation etc.,
- wind resource assessment, site selection for wind turbines, wind systems, physics of wind and wind measurements and instruments
- bio-energy resource assessment, physical and chemical properties, composition.
- Geothermal, wave, tidal and OTEC resources assessment, estimation of power potential, site selection

UNIT –I ENERGY SOURCES

Environment and sustainable development - Energy sources - sun as the source of energy – photosynthesis - classification of energy sources - fossil fuel reserves and resources - overview of global/ India's energy scenario.

UNIT- II SOLAR ENERGY

Solar radiation: measurements and prediction - Solar thermal energy conversions systems: flat plate collectors - solar concentrators and other applications - Solar Photovoltaic: Principle of photovoltaic conversion of solar energy.

UNIT – III WIND ENERGY

Wind Resource: Meteorology of wind, India's wind energy potential and challenges -distribution across the world - Eolian features - Biological indicators - Wind measurement systems - Wind Energy Conversion Systems.

UNIT- IV BIOENERGY

Biomass as energy resources - Classification and estimation of biomass - Source and characteristics of biofuels – Biodiesel – Bioethanol – Biogas - Waste to energy conversions.

UNIT- V GEOTHERMAL ENERGY

Introduction - Geothermal sources - advantages and disadvantages of geothermal energy over other energy forms - Geothermal energy in India: Prospects - Applications of Geothermal energy - Material selection for geothermal power plants

Outcomes:
Students successfully completing this module will be able to:

- skilled both theoretically and practically to address the issue of energy crisis with emerging technologies of energy generation
- work on research topics of different sources of non-conventional energy systems,
- analyse the energy scenario of our country,
- impart knowledge on different ways of energy generation.
- Awareness on the existence of various mechanisms for conversion and storage of energy, their merits, constraints and drawbacks

TEXT BOOKS

1. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press (1994).
2. S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).

REFERENCE BOOKS

1. Loulou, Richard, Waaub, Jean-Philippe; Zaccour, Georges, Energy and Environment Set: Mathematics of Decision Making, (Eds.), (2005), XVIII, 282 p. ISBN: 978-0-387-25351-0.
2. Ristinen, Robert A. Kraushaar, Jack J. AKraushaar, Jack P. Ristinen, Robert A, Energy and the Environment, 2nd Edition, John Wiley, 2006, ISBN:9780471172482, Pub Wiley, New York, (2006).

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	M	H		M	L
CO2			M			H
CO3	M	M	M	L		
CO4	H	L	M		M	M
CO5	M		H	L		

18UPESC1S02- ENERGY AND ENVIRONMENTAL IMPACTS

L	T	P	C
3	1	0	3

OBJECTIVES

- ✓ To teach the principal of energy and environmental issues
- ✓ To explore the environmental impact of various energy sources and also the effects of different types of pollutants.
- ✓ To create an understanding on bio-refinery concept for conversion of biomass to modern biofuels.
- ✓ To aware the environmental impact of pollutants
- ✓ To generate knowledge on green chemical technologies and pollution control

UNIT-I ENERGY SOURCES

Present Energy resources in India and its sustainability - Different type of conventional Power Plant - Energy Demand Scenario in India - Advantage and Disadvantage of conventional Power Plants – Conventional vs Non-conventional power generation

UNIT-II SOLAR ENERGY

Basics of Solar Energy - Solar Thermal Energy - Solar Photovoltaic - Advantages and disadvantages - Environmental impacts and safety.

UNIT-III BIOMASS AND GEO THERMAL ENERGY

Biomass resources - Biomass conversion Technologies - Feedstock preprocessing and treatment methods - Bioenergy program in India- Environmental benefits and impacts - Geothermal Energy resources – Ocean Thermal Energy Conversion – Tidal.

UNIT-IV POLLUTION CONTROL

Air pollution - Sources – Effects – control - Air quality standards - Air pollution act - Air pollution measurement - Water pollution - Sources and impacts - Soil pollution - Sources and impacts - Disposal of solid waste.

UNIT- V ENVIRONMENTAL AFFECT FACTORS

Greenhouse gases – Effect - Acid rain - Noise pollution - Pollution aspects of various power plants - Fossil fuels and impacts -Industrial and transport emissions -Impacts.

OUTCOME

Students will have

- ✓ Learn about challenges and opportunities related to energy use and conversion. Learn how to evaluate the sustainability of energy systems.
- ✓ Basics of energy resources and current energy scenario
- ✓ Impact of solar energy importance
- ✓ Significance of bio and geothermal energy
- ✓ Importance of pollution control and their damage
- ✓ Environmental factors influence the atmosphere

TEXT BOOKS

1. Boyle, G..' Renewable energy: Power for a sustainable future'. Oxford University press, (2004).
2. B H Khan, 'Non Conventional Energy Resources'-The McGraw –Hill Second edition (2009).

REFERENCE BOOKS

1. G. D. Rai, 'Non conventional energy sources', Khanna Publishers, New Delhi, (2006).
2. Gilbert M. Masters, 'Introduction to Environmental Engineering and Science', 2nd Edition, Prentice Hall, (2003).

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H		M		L	
CO2	M	L	M	M	L	
CO3	M		H		M	M
CO4	H		H		M	L
CO5	M		M	M	L	L

18UPESC1S03- CLIMATE CHANGE AND CO2 EMISSION ASSESSMENT

L	T	P	C
3	1	0	3

OBJECTIVES

- ✓ Will explain evidence for human-caused climate change, in the context of historical climate change, as well as the relevant scientific uncertainties and possible evidence to the contrary.
- ✓ Explain the impacts of climate change on human well-being and the natural world, and evaluate means by which these impacts can be reduced
- ✓ Explain the human causes of climate change, including the sources of greenhouse gas emissions.
- ✓ Learn about carbon assessment and food print
- ✓ Knowledge about carbon credit

UNIT-I INTRODUCTION TO ENERGY

Introduction to Energy: Overview of energy sources and technologies - energy consumption Pattern - social and economic implications of energy uses - equity and disparity.

UNIT-II INTRODUCTION TO GLOBAL CLIMATE CHANGE

Introduction to global climate change: theory of global climate change - mechanism of Greenhouse Gases Emission - theory and proof of climate change impacts - global overview - International concern on Climate change and mitigation efforts.

UNIT-III CARBON DIOXIDE (CO2) EMISSIONS AND CONVERSION/CONSUMPTION

Carbon dioxide (CO2) emissions in relation to energy conversion/consumption: theory of CO2 emission in relation to energy conversion processes.

UNIT- IV METHODOLOGY FOR CO2 ASSESSMENT/CARBON FOOT PRIN

Methodology for CO2 assessment/carbon foot print: estimation of emission from fossil fuel combustion (Fuels and their composition - fuel to energy conversion - concept of emission factor) - emission from major sectors (industry – transport – agriculture – domestic - service)

UNIT-V CARBON CREDIT

Carbon credit: Definition - concept and examples - Carbon credit - national policies *vis-à-vis* international market scenario - Current efforts and future prospect/limitation of carbon trading mechanism.

OUTCOMES :

After successful completion of this course, the students will be able to

- ✓ Demonstrate knowledge of the conceptual designs of key climate models and their efficiency in climate projections
- ✓ Show awareness of innovative theories and scientific methods to carbon dioxide management
- ✓ Demonstrate knowledge of chemical analyses and ecotoxicology methods used in detecting pollutants in coastal and marine zones; Climate Modeling and Carbon Management
- ✓ Apply scientific methods in the evaluation of weather trends and climate change projections
- ✓ Produce critical and analytical essays on issues of geoengineering and carbon management

TEXT BOOKS

1. Mathez E. A., Climate Change: The Science of Global Warming and Our Energy Future, First edition, Columbia University Press (2009).
2. Dessler A.; Introduction to Modern Climate Change, Cambridge University Press (2011).
3. Yamin F. (ed.); Climate Change and Carbon Markets: A Handbook of Emissions Reduction Mechanisms, Earthscan (2005).

REFERENCE BOOKS

1. Franchetti M. J. and Apul D. S. (2013); Carbon Footprint Analysis: concepts, methods, implementation and case studies, CRC Press.
2. Clean Development Mechanism, UNFCC Website; http://cdm.unfccc.int/
3. Stern N. (2007); The Economics of Climate Change. The Stern Review. Cambridge University Press.
4. Barrett S. (2007). Why Cooperate? The Incentive to Supply Global Public Goods. Oxford University Press.

Mapping of course outcomes with program outcomes

Course Outcome/ Program Specific outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	L	L	-	H	M
CO2	H	L	H	-	H	M
CO3	M	H	M	-	H	M
CO4	M	H	M	-	H	L
CO5	L	M	L	-	H	L

18UPESC1S04 - ERECTION AND MAINTENANCE OF REFRIGERATION AND AIR-CONDITIONING EQUIPMENTS

L	T	P	C
3	1	0	3

OBJECTIVES

- ✓ To understand and apply the concept of availability and to calculate the behavior of real gases
- ✓ To predict the condition of systems and analyze them by the criteria of equilibrium
- ✓ To analyze the working principle, pros and cons of Conventional energy conversion techniques
- ✓ To apply the concepts of advanced thermodynamics to combustion systems and refrigeration systems.
- ✓ To know about energy based measurement & maintenance system

UNIT-I INTRODUCTION

Refrigeration and air-conditioning plant layout, parameters affecting the location.

UNIT-II ERECTION OF R&AC SYSTEMS

Erection methodology, foundation, padding, network analysis, critical path, interconnections; safety precautions, air handling equipment's. Maintenance procedures.

UNIT-III TESTING OF EQUIPMENTS

Testing of compressors, condensers, evaporators, cooling towers, motors, controls, test rings, ISI standards. Testing of control systems, circuitry and trouble shooting, condition monitoring.

UNIT-IV TOTAL PREVENTIVE MAINTENANCE

TPM Principles, Corrective and preventive measures and Reliability analysis.

UNIT-V MAINTENANCE SCHEDULES

Studies on different maintenance schedules followed by various industries

OUTCOMES:

After successful completion of this course,
the students will be able to

- ✓ Students will able to calculate the availability of the systems and cycles
- ✓ Analyze the engineering systems to improve and optimize its performance
- ✓ Understand the working and the design principles of combustion systems and refrigeration systems.
- ✓ To make, design modifications and cost reduction methods.
- ✓ An exposure on Solar refrigeration or A/C.

TEXT BOOKS

1. Arora C.P., Refrigeration and Air conditioning II Ed. McGraw-Hill, Pub., 2000.
2. ASHRAE Hand book on Refrigeration & Air conditioning, Published by ISHRAE, Bangalore, 1998.

REFERENCE BOOKS

1. Althouse A.D. and Turnquist C.H., Modern refrigeration and air-conditioning, Good HeartWilcoz Co Inc., 1980.
2. Nelson C.W., Commercial and Industrial refrigeration, McGraw-Hill,1982.

Mapping of course outcomes with program outcomes

Course Outcome/Program specific Outcome	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	L	-	M	H	H
CO2	H	L	-	M	H	L
CO3	M	L	-	H	L	M
CO4	M	L	-	H	L	L
CO5	M	M	-	H	H	M