Open Electives/CBCS Courses

November 2017

Department of Energy
Tezpur University
Tezpur, Assam, India

Open Electives/CBCS Course Structures w.e.f. from January 2018 Session
Academic Council Approval: AC.30/2017/3/2.3 dated 16th November, 2017

Open Elective I / CBCS course				
Course code	**Course name**	**L T P**	**CH**	**Credit**
EN 550	**Energy and Society**	**3 0 0**	**3**	**3**

Abstract

This course deals with the trend of energy use with respect to the development of the human society. The need and the applications of various alternative sources to reduce the gap between energy supply and demand are briefly discussed. The course also gives overview on energy conservation opportunities and approaches along with cost benefit analysis for renewable energy systems.

Objectives

(a) To present an overview of different energy sources, their environmental impact and the trend of energy tools and technologies with respect to development of human society.

(b) To give an overview on energy conversion principles of different renewable energy sources and linkage with the society.

(c) To give a brief idea of application of renewable energy systems for social benefit and energy conservation opportunities in different sectors.

Prerequisites of the course

Students having basic knowledge of physics, chemistry, biology and environmental science along with interest in the area of environmental issues and power generation system are preferred. This course is an interdisciplinary course and students from Departments apart from Department of Energy can register for this course.

Course contents

Introduction: Basics of energy and its various forms; energy resources, units and scales; Fuels, Energy content & basics of combustion; energy, work, and power; energy balance; Global energy scenario – Energy demand and supply; Fuel and energy substitution; Energetic theories: Historical vs. Contemporary versions

Energy economy and society: Overview of society and human energy need; Energy transitions and development; Pre-industrialization- Low energy societies, Industrialization- High energy societies; Energy consumption and economic development; Evolution of the modern energy economy

Fossil Energy: Energy from fossil fuels – Coal, Oil and Natural Gas; proven reserve; exploration and production; Nuclear energy

Renewable energy sources: Principles of energy conversions of various renewable energy sources, systems and components; Socio-technical aspects of renewable energy systems; Overview of centralized and distributed systems; Biomass, households, and gender

Energy issues and policy: Energy and public opinion; National energy policy; Energy related social impact assessment

Energy and Environment: Anthropogenic activities and environmental effects, Air pollution and health hazards, Green House Gas emissions and global warming, impacts and mitigation, Climate change issue and international policies and mechanisms for mitigation, Sustainable development.

Energy conservation and management: Energy conservation opportunities in household, transport and lighting sectors, Concept of energy management and audit, Load management practices, Performance analysis of conventional energy based systems

Text Books

[1] Hinrichs R. A. and Kleinbach M. H. (2012); *Energy: Its Use and the Environment*, Fifth Edition, Brooks Cole

[2] Masters G. (1991); *Introduction to Environmental Engineering and Science*, Prentice Hall

Reference Books

[1] Ristinen R. A. and Kraushaar J. P. (2006); *Energy and the Environment*, John Wiley

[2] Goldemberg J. (Ed.) (2009); *Interactions: Energy Environment*, Eolss Publishers

[3] Johansson T. B. (ed.) (1993); *Renewable energy: sources for fuels and electricity*, Earthscan

[4] Fowler J. M. (1984); *Energy and the Environment*, Second Edition, McGraw Hill

[5] Mathez E. A. (2009); *Climate Change: The Science of Global Warming and Our Energy Future*, First edition, Columbia University Press

Open Elective II / CBCS course				
Course code	**Course name**	**L T P**	**CH**	**Credit**
EN 516	**Advanced Solar Thermal Energy**	**3 0 0**	**3**	**3**

Abstract

This course discusses in details the theory and design aspects of various types of solar thermal collectors. Details of thermal performance of different thermal collector configurations are included. Emphasis has been given to the concentrating collector for power generation and the application of solar energy for industrial process heat. Solar thermal energy storage through different mechanics and processes and also discussed. The course is designed with objectives to make the students capable to analyze the performance of solar thermal systems.

Objectives

(a) To discuss different aspects and parameters of solar energy to enable learners to design solar thermal system

(b) To educate the learner for tackling different issues and challenges of various solar thermal collectors

(c) To understand the power generation aspects from solar thermal systems

Prerequisite of the course

Must have understanding on fundamentals of solar energy engineering and application.

Course contents

Basics for solar thermal system: Different design and components; Radiation transmission and absorption through glazing; Selective surfaces: Ideal coating characteristics, Anti reflection coating;

Flat plate collector: Theory and basic design aspects; Thermal analysis and effective heat loss; Performance analysis methods; Thermal analysis and effective energy loss of evacuated tube collector; Flat plate solar dryer: Issues and challenges.

Concentrating collector: Classification of concentrating collector; concentrating collector configurations; concentration ratio: optical, geometrical; Thermal performance of concentrating collector; Optical and thermal performance of different concentrating collector designs; Parabolic trough concentrators; Compound parabolic concentrator; Concentrators with point focus.

Solar thermal power plant: Central receiver systems; Heliostats; Comparison of various designs: Parabolic trough systems, Rankine cycle, Parabolic Dish - Stirling System, Combined cycle

Solar industrial process heat: Integration of solar thermal system with industrial processes; Mechanical design considerations; Economics of industrial process heat

Solar thermal energy storage: Sensible storage; Latent heat storage; Thermo-chemical storage; High temperature storage; Designing thermal storage systems

Text Books

[1] Duffie J. A. and Beckman W. A. (2013); *Solar Engineering of Thermal Processes*, John Wiley

[2] Garg H. P. and Prakash S. (2000); *Solar Energy: Fundamental and Application*, Tata McGraw Hill

Reference Books

[1] Twidell J, Weir T (2015); *Renewable Energy Resources*, Routledge

[2] Goswami D. Y. (2015); *Principles of Solar Eng*ineering, Taylor and Francis

[3] Tiwari G. N. (2002); *Solar Energy: Fundamentals, Design, Modeling and Applications*, Narosa

[4] Nayak J. K. and Sukhatme S. P. (2006); Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill

[5] Sorensen B. (2010); *Renewable Energy*, Fourth Edition, Academic press

Open Elective II / CBCS course				
Course code	**Course name**	**L T P**	**CH**	**Credit**
EN 517	**Advanced Solar Photovoltaic Energy**	**3 0 0**	**3**	**3**

Abstract

This course designed for a detail discussion on the topics related to principle of solar photovoltaic technology to system design. It includes the understanding of physical theories and phenomena of solar cell with inclusion of semiconductor physics. Moreover, fabrication processes of different solar cell technologies along with the PV module manufacturing techniques are included. The course also discusses different aspects of solar photovoltaic technologies for applications in building integrated PV, standalone system and power plant system. The course is designed with objectives to prepare students having capabilities of serving photovoltaic industry as well as to develop competency for research in photovoltaic system.

Objectives

(a) To discuss solar cell fundamentals to enable learners to model solar cell functioning using basic physical/chemical/electrical properties of a semiconductor material
(b) To discuss laboratory to industrial phase manufacturing techniques of solar cell
(c) To understand the design aspects of off-grid and grid-connected solar photovoltaic system

Prerequisite of the course

Must have understanding on fundamentals of solar energy engineering and application.

Course contents

Solar Cell Physics: Intrinsic, extrinsic and compound semiconductor; energy levels; electrical conductivity; Fermi energy level; Probability of occupation of allowed states; Dynamics of energy density of allowed states; Density of electrons and holes; Carrier transport: Drift, diffusion, continuity equations; Absorption of light, Recombination process, Basic equations of semiconductor devices physics, Dark and illumination characteristics of solar cell; Efficiency limits, Issues and challenges of solar cell, Factors affecting the efficiency of solar cell, Strategies to enhance the efficiency of solar cell
Solar cell fabrication: Wafer based solar cell fabrication: Czochralski Process, Multicrystalline Si ingot fabrication; PN Junction formation; Metal contacts; Thin film PV device fabrication; Thin film deposition techniques: LPCVD, APCVD, PECVD; Tandem Solar cell fabrication; Photovoltaic module fabrication and optimization

Solar photovoltaic system: PV system design and optimization; Array design; PV System installation, operation and maintenances; Balance of PV system (BOS); Issues and Challenges of PV system operation and maintenance; Factor affecting the PV system performance; Performance measurements and characterization of PV power plant.

Centralized and decentralized PV systems; Stand alone, hybrid and grid connected system; Grid connected PV system design and optimization, Rooftop PV systems, Net and Feed-in-Tariff mechanism, Energy generation analysis, Power control and management systems for grid integration, Issues and challenges of grid integrated PV system; BiPV systems, PV system simulation tools; PV market analysis and economics; National Solar Energy Mission.

Text Books

[1] Solanki C. S. (2009); *Solar Photovoltaics: Fundamentals, Technologies and Applications*, Prentice Hall India
[2] Mukerjee A. K. and Thakur N. (2011); *Photovoltaic Systems Analysis and Design*, PHI

Reference Books

[1] Luque A, Hegedus S (2011); *Handbook of Photovoltaic Science and Engineering*, Wiley
[2] Wenham S. R. Green M. A. Watt M. E. and Corkish R. (2007); *Applied Photovoltaics*, Earthscan.
[3] Partain L. D. (ed.) (1995); *Solar Cells and their Applications*, John Wiley
[4] Rauschenbach H. S. (1980); *Solar Cell Array Design Handbook*, Van Nostrand Reinfold
[5] Mertens K. (2013); *Photovoltaics: Fundamentals, Technology and Practice*, Wiley

Open Elective II / CBCS course				
Course code	**Course name**	**L T P**	**CH**	**Credit**
EN 526	**Energy Efficient Buildings**	**3 0 0**	**3**	**3**

Abstract

Buildings consume energy both in construction and operations. However, energy consumption in operation of buildings is approximately more than 80% of total energy consumption. Principles of building physics that are required for understanding the thermal performance of buildings will have specific focus for the design of the energy efficient buildings. This course includes an overview of the main design features of different types of buildings, advantages and disadvantages and their applicability to different building types and climatic regions. This course aims to provide an understanding on the concept of reduction in energy consumption through energy efficient building design.

Objectives

(a) To understand the principles of energy auditing, energy flow diagram, economics of energy conservation opportunities in buildings

(b) To understand thermal performance study, building performance simulation and thermal comfort

(c) To understand the energy conservation buildings codes, rating systems and case studies on energy efficient buildings in India.

Course contents

Energy management concept in building, Energy auditing in buildings, Bioclimatic classification of India; Climate Analysis for Nat-Vent Buildings, Mixed Mode Buildings and Conditioned building; Passive design concepts for various climatic zones; Case studies on typical design of selected buildings in various climatic zones

Vernacular architecture: Vernacular architecture in Indian Context, Factors which shape the architecture, building material and construction techniques; Case studies on vernacular architecture of Rajasthan, North-East India; Low cost buildings, climate responsive buildings, energy efficient buildings, green buildings, intelligent buildings, Building Integrated Photovoltaics (BIPV), Green Buildings in India; Case studies

Building codes and Rating systems: LEED, GRIHA, ECBC, Thermal properties and energy content of building materials; Building energy simulation, Simulation tool like TRANSYS, eQuest; Building management systems/automation, Artificial and daylighting in buildings

Thermal performance studies, concept of comfort and neutral temperatures, Thermal comfort, PMV-PPD models, Thermal comfort models, Adaptive thermal comfort models, case studies,

Heat flow calculations in buildings: Unsteady heat flows through walls, roof, windows etc. Concept of sol-air temperature and its significance; heat gain through building envelope; building orientation; shading and overhangs; Ventilation and Air-conditioning systems

Passive and low energy concepts and applications, Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain and sunspaces; Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth air-tunnel

Text Books

[1] Sodha M. S. Bansal N. K. Bansal P. K. Kumar A. and Malik M. A. S. (1986); *Solar Passive Building, Science and Design*, Pergamon Press

[2] Gallo C. Sala M. and Sayigh A. A. M. (1988); *Architecture: Comfort and Energy*, Elsevier Science

Reference Books

[1] Nayak J. K. and Prajapati J. A. (2006); *Handbook on Energy Conscious Buildings*; Solar Energy Centre, New Delhi

[2] Underwood C. P. and Yik F. W. H. (2004); *Modelling Methods for Energy in Buildings*, Blackwell Publishing

[3] Parsons K. C. (2003); *Human Thermal Environments*, Second edition, Taylor and Francis

[4] Majumder M. (2009); *Energy Efficient Buildings*, TERI, New Delhi

[5] Nicol F. (2007); *Comfort and Energy Use in Buildings- Getting Them Right*, Elsevier

Open Elective II / CBCS course				
Course code	**Course Name**	**L T P**	**CH**	**Credit**
EN 538	**Hybrid Renewable Energy System Design**	**3 0 0**	**3**	**3**

Abstract

Small-size hybrid wind-hydro-diesel-solar power generation systems are attractive to solve the power supply problem in rural areas where no grid connection is available. Optimal design models are necessary to design the hybrid generation systems including battery banks and to provide the optimum system configuration. It is to be ensured that the annual cost of the system is minimized while satisfying the required loss of power supply probability.

Objectives

(a) To develop computer models of hybrid wind, solar, and diesel generator to perform simulation and optimization.

(b) To use advanced system analysis, modeling and design tools like HOMER to design and develop hybrid power generation system.

(c) To validate the system design.

Course contents

This course will review technical characteristics of various renewable energy sources and develop the skills and knowledge for designing, sizing and specifying hybrid renewable energy systems. Renewable energy systems covered include biomass, electrical and wind energy systems. The course will present various hybrid system architectures and examine their advantages and disadvantages. System components, control strategies, and the use of storage (thermal and electrical) and other demand-side technologies will be analyzed and evaluated. Students will learn how to model energy sources and use simulation tools to design and optimize systems, and apply these techniques to develop a hybrid energy system to provide electricity to a small to medium rural village.

Text Books

[1] Fu Y., Yang J. and Zuo T. (2011); *Optimal sizing design for hybrid renewable energy systems in Rural Areas*, Springer

[2] Zerriffi H. (2011); *Rural Electrification: Strategies for Distributed Generation*, Springer

Suggested Reading

[1] Funabashi T. (Ed.) (2016); *Integration of Distributed Energy Resources in Power Systems: Implementation, Operation and Control*, Academic Press

[2] HOMER Simulation Tool; http://www.homerenergy.com/, HOMER Energy, NREL, USA

[3] Bhattacharyya S. (Ed.) (2013); *Rural electrification through decentralised Off-grid systems in Developing Countries*, Springer

[4] Mahmoud M. S. and AL-Sunni F. M. (2015); *Control and Optimization of Distributed Generation Systems*, Springer

[5] Tester J. W. (et al.) (2012); *Sustainable Energy: Choosing among Options*, Second Edition, The MIT Press

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