Course title: Energy Efficient Buildings

Course code: MEU 112	**No. of credits:** 2	**L-T-P:** 22-0-16	**Learning hours:** 30
Pre-requisite course code and title (if any): None			
Department: Energy and Environment			
Course Coordinator(s): Dr Aviruch Bhatia		**Course Instructor(s)**: Dr Aviruch Bhatia	
Contact details: aviruch.bhatia@terisas.ac.in			
Course type: Elective		**Course offered in**: Semester 3	

Course Description

Course aims to impart requisite fundamental knowledge of building sciences for the development of high-performance buildings for taking effective decisions to ensure efficient building design conforming to national / international codes / standards. Low or net zero energy design is to design buildings such that their form, fabric and interior spaces respond to the local climate and utilise ambient energy to reduce/optimize load on building services. This course is an advanced version of this theme covered as part of first semester core course on Sustainable Provision and management of Urban Services. It will cover in detail passive building design strategies for providing natural lighting, cooling and heating in buildings. Principles of building physics that are required for understanding these have been introduced in earlier courses and in this course specific strategies will be explained.

Students will be familiarized with the key factors that need to be considered while designing daylighting and design parameters that affect daylight factor distribution in a space. An overview of the different techniques of enhancing daylighting in a building will be given to students. Second part of the course will cover the subject of passive/low energy solar heating and cooling systems. This will include an overview of the main design features of different types of systems, their advantages and disadvantages and their applicability to different building types and climatic regions

At the end of the course students will be able to develop an understanding of low or net zero energy building design to provide natural lighting, cooling and heating in buildings.

Course objectives

This course aims to provide an understanding of the concept of reduction in energy consumption through low or net zero energy building design. It will highlight strategies to integrate daylighting and low energy heating/cooling in buildings

Course content

Module	Topic	L	T	P
1	Introduction to energy efficient buildings; Building physics; heat gains in the building; Psychometric analysis; Weather analysis; Energy use in buildings; Energy Supply in Buildings: Heating, Ventilating, and Air Conditioning (HVAC) Systems; Heating and cooling loads;	3		
2	**Daylighting and artificial lighting** ▪ Daylighting and artificial lighting, relationship between daylight and human health and benefits of daylighting) ▪ Sky condition models and their characteristics ▪ Parameters for daylighting design (critical indoor illuminance, critical outdoor illuminance level, daylight factor distribution and glare) ▪ Parameters affecting daylighting factor (room depth, height of the window head, shading devices, glazing type, reflectance of room surfaces) ▪ Daylighting components (intermediate light spaces, interior light spaces, lateral pass-through components, zenithal pass-through components, global pass-through components)	7		

	▪ Control elements			
3	**Passive/low energy heating systems** ▪ Principle of passive heating ▪ Types of passive heating systems	2		
4	**Passive/low energy cooling systems** ▪ Building design strategies to reduce cooling demand ▪ Types of passive cooling systems (evaporative cooling, indirect evaporative cooling and earth cooling systems)	4		
5	**Building Performance analysis and Modelling:** ▪ Daylight analysis ▪ Thermal modelling, ventilation modelling, heat flow analysis ▪ Weather simulation and analysis tool (Climate Analysis, Solar Exposure analysis, Passive strategies through psychometric chart **Energy Codes, Guidelines and Standards.**	6		
	Total	22	0	16*

*Case study / field visits pertaining to energy efficient buildings

Evaluation criteria

- Case study 50%
- Design Problem 50%

Learning outcomes

- Have acquired an understanding of the concept and theoretical background of low energy building design.
- Be able to demonstrate their learning about use of simulation tools to achieve energy efficiency.

Pedagogical approach

The course will be delivered through a mix of classroom lectures and practical exercises.

Materials

Required text

Suggested readings

1. Crosbie, M.J., 1998. The Passive Solar Design and Construction Hand Book, John Wiley & Sons Inc., New York.
2. Ed. Baker, N., Fanchiotti, A. And Steemers, K., 1993. Daylighting in Architecture: A European Reference Book, James & James (Science Publishers) Ltd., London.
3. Givoni, B., 1994. Passive and Low Energy Cooling of Buildings, John Wiley & Sons Inc., New York.
4. Givoni, B., 1998. Climatic Consideration in Building and Urban Design, John Wiley & Sons, Inc., Canada.
5. Gregg D Ander, 2003. Daylighting Performance and Design Second Edition, John Wiley & Sons, Inc., New Jersey.
6. Guzowski, M., 2000. Daylighting for Sustainable Design, McGraw-Hill, New York.
7. Nayak ,J.K.andPrajapati, J.A., 2006. Handbook on Energy Conscious Buildings, Prepared under the interactive R & D Project No. % (03) 99 - SEC between Indian Institute of Technology, Bombay and Solar Energy Centre, Ministry of New and Renewable Energy, India.
8. Santamouris, M., 1996. Passive Cooling of Buildings, James & James (Science Publishers) Ltd., London.

Websites

1. http://www.wbdg.org/resources/daylighting.php
Additional information (if any): None
Student responsibilities Attendance, feedback, discipline: as per university rules.

Course reviewers

The course is reviewed by the following experts.

1. Ms Mili Majumdar, Director, Sustainable Habitat Division, TERI
2. Mr Pradeep Kumar, Associate Director, Centre for Research on Sustainable Building Sciences, TERI