PONDICHERRY UNIVERSITY

P.G. DIPLOMA PROGRAM IN GREEN ENERGY TECHNOLOGY
(Regular, One Year Programme)

Granted by University Grants Commission, New Delhi

Under Innovative Programme

BACKGROUND

The field of Green Energy Technology (GET) encompasses a continuously evolving group of methods, materials and processes from environmentally benign techniques for generating energy, to its minimal utilization for maximal production of end materials and utilization of waste products when generated. The goals of this rapidly growing highly interdisciplinary field include i) sustainability: meeting the needs of society in ways that without damaging or depleting natural resources, ii) innovation: developing alternatives to technologies to those that have been demonstrated to damage health and the environment and iii) reducing waste and pollution by changing patterns of production and consumption. Thus, Green Technology is a term used to describe production of knowledge-based products or provide services that improve operational performance, productivity or efficiency, while reducing consumption, waste and pollution.

Post Graduate Diploma in Green Energy Technology offered at Pondicherry University is designed to equip students with multi-disciplinary skills and knowledge in the areas of green energy generation technologies, energy management with environmental concern. The course will be taught by a team of specialists working in the fields of green energy technology, chemical science, biological science, project management, and environmental policy. This is program is designed for one year duration, comprised of two semesters. First semester comprises hard and soft core theory courses together with laboratory practical to enrich understanding of students in the areas of Green Energy Technologies. Each theory course is designed to have a project component to explore the technical understanding and skill development. Second semester is entirely dedicated for project work and dissertation. The entire course of study requires earning at least 36 credits to qualify for the P.G.Dip. in Green Energy Technology (PGD-GET). B.E/B.Tech in Mechanical, Electrical, Civil, Electronics, Chemical or Biotechnology specialization, or M.Sc in Physics, Chemistry, Material Science, Nanoscience or Photonics with Mathematics at B.Sc level and having at least 55% marks or equivalent grade in the qualifying examination are eligible to undergo this program.

The scope of the proposed PG-Diploma in Green energy Technology is to develop professional with an understanding about the overall energy scenario worldwide, various sources of energy and their merits and demerits, importance of renewable energy sources, various aspects of energy resources including the environmental and ecological impact, Overall understanding about the
solar photovoltaic, solar thermal, bio-energy, wind, ocean, hydro and other new means of energy generation, energy efficiency, utilization, storage and distribution methodologies.

Project work and Dissertation is specifically designed to inculcate professional skills to the student with practical experience in Green Energy technologies. Project work is research based that can be carried out at Pondicherry University or at an associated academic or industrial partner and thus receive practical training in chosen area from an expert. Dissertation will be evaluated as per academic practice followed.

In addition to above, course curriculum and syllabi will be updated time to time based on the developments. Teaching and Learning Methods includes lectures, tutorials and seminars as main methods and in addition course delivery will be enhanced by individual and group project work, laboratory work, computing workshops and industrial visits.

Assessment Methods Teaching and assessment will be by Choice Based Credit System (CBCS). Evaluation will be through session (laboratory reports, class tests, set assignments) or by continuous assessment (designing, computer practical, seminar papers, project reports etc.) and end-semester examinations.

Employment: It is envisaged that the P.G.D.GET holder will gain employment in the Engineering Industry with many companies now seeking to exploit the benefits of green energy technology products and processes.

Minimum credit requirement is fixed as 36. All teaching, learning and evaluations will follow Choice Based Credit System (CBCS) which is in vogue in Pondicherry University. Bridge courses are no credit courses. All students are expected to clear bridge courses, however, exemption to do the bridge course can be obtained on the basis of recommendation of a committee of experts consisting of the faculty advisor, concerned teacher, Head, Dean, and VC’s nominee in the PC.

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# P.G. Diploma in Green Energy Technology

## COURSE STRUCTURE **

### SEMESTER-I

<table>
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<tr>
<th>Course Code</th>
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#### SOFT-CORE COURSES# (Any Two to be taken)

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Minimum No. of Credits: 21

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No. of Credits: 15

*H – Hard-core Course; S - Soft-core Course

# Relevant soft core courses offered to MTech (Green energy technology) in III Semester may also be taken (list given in Annexure I).

**to be approved.
PROFILE OF THE COURSES

1. **Renewable Energy Resources & Sustainable Development:**
   This course exposes students the energy scenario, overview about the various sources of energy, difference between renewable and non-renewable energy sources and its impacts on the environment. It teaches the uses of clean energy technologies and its importance in sustainable development.

2. **Thermodynamics, Fuel & Combustion Technology:**
   Objective of this course is to lay foundation on science of energy conversion, study of fuel materials for harnessing energy.

3. **Energy Laboratory:**
   Laboratory training is aimed at imparting the concepts of energy conversion, energy utilization methodology, characterization and application. Student will acquire hand on training in the use of various characterization/energy conversion & utilization devices.

   The principle, material and device technology of photovoltaic devices, characterization techniques, SPV power system components, design and installation will be taught along.

5. **Solar Thermal Technology & Energy Conversion Systems:**
   The course aims to provide understanding of the solar thermal energy conversion processes, storage and the utilization of solar thermal energy. Student will acquire knowledge on the various types of collectors, concentrators, thermal power plants design and thermal energy storage concepts.

6. **Wind Energy & Small Hydropower Systems**
   Student will get the understanding on the source of energy in the wind, its characterization and various methods of harnessing the same. Detail theoretical understanding on design and characterization of wind energy conversion system with particular reference to electrical machines & turbines is emphasized. In the other part of the course, fundamentals of energy generation from hydro power and small hydro power plant concepts are discussed. Students will also get exposure in terms of case studies on wind and hydrothermal power plant.

7. **Bioenergy, Biodiesel Resource Development & Production**
   Bio-energy and conversion systems deal with biomass resource estimation and management, various energy conversion technologies and methods to generate energy from waste. Biodiesel from plants and algae represent renewable bioenergy resource. It has proven potential for large scale production, replacement biofuel and commercial exploitation. This course will cover various aspects of biodiesel resource development, production process and protocols & standards concerning its utilization in conventional energy sectors.
8. **Batteries and Fuel Cell Technologies:** From the basics to technologies on electrochemical energy conversion & storage will be taught which includes various types of batteries, supercapacitors and fuel cells.

9. **Project Work:** One full semester project work in Industrial and renewable energy technology development laboratories leading to dissertation.
GETD 516 Energy, Renewable Energy Resources and Sustainable Development
(Hard Core course)

Unit I
Introduction: Introduction to nexus between energy, 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:

Unit III

Unit IV

Unit V
Bioenergy: Biomass as energy resources; India’s bio –energy potential and challenges- Classification and estimation of biomass; Source and characteristics of biofuels: Biodiesel, Bioethanol, Biogas. Types of biomass energy conversion systems waste to energy conversions.

Text Books

References
GETD 511 Thermodynamics, Fuels & Combustion Technology
(Hard Core course)

Unit – I

Unit – II
Solid Fuels: Coal: Family, origin, classification of coal; Analysis and properties; Action of heat on coal; Gasification; Oxidation; Hydrogenation and liquefaction of coal- Efficient use of solid fuels- Manufactured fuels-Agro fuels- Solid fuel handling- Properties related to combustion - handling and storage

Unit – III
Liquid and Gaseous Fuels: Origin and classification of petroleum; Refining; Properties & testing of petroleum products; various petroleum products; Petroleum refining in India; Liquid fuels from other sources; Storage and handling of liquid fuels. Types of gaseous fuels: natural gases, methane from coal mines, manufactured gases, producer gas, water gas, biogas, refinery gas, LPG; Cleaning and purification of gaseous fuels.

Unit – IV
Combustion Process: Ignition: Concept, auto ignition, ignition temperature; Burners: Stoichiometry and thermodynamics; Combustion stoichiometry: Methods of combustion - Combustion thermodynamics. Fuel stoichiometry relations and stimation of combustion - Dew point of products; Flue gas analysis (O₂, C₂, CO, NOx, SOx).

Unit – V
Burners & Furnaces: Fluidized bed combustion process; Basic features and design of burners for solid, liquid, and gaseous fuels; Furnaces: Industrial furnaces, process furnaces, batch & continuous furnaces; Heat source; Distributions of heat source in furnaces; Blast furnace; Open hearth furnace, Kilns; Pot & crucible furnaces; Waste heat recovery in furnaces: Recuperates and regenerators; Furnace insulation; Furnace heat balance computations; Efficiency considerations.

Text Books

References
GETD 512 Solar Photovoltaic Devices & Energy Conversion Systems  
(Hard Core Course)

Unit-I Properties of Semiconductor:  

Unit-II Device fabrication and Characterization:  
Semiconductor junctions: Schottky barriers, MIS, P-N junction, p-i-n junction and its properties Homo & hetero junction solar cells, multijunction solar cells- Fabrication techniques: Diffusion, thin film technology- physical vapour deposition (PVD)- Electro-deposition- Molecular beam epitaxy (MBE)- Metal organic chemical vapour deposition (MOCVD)- Plasma enhanced chemical vapour deposition (PECVD)- Organic and Nano tech solar cells – contact & grid metallization- characterization techniques: I-V, C-V and L-I-V.

Unit-III Solar cell module materials and assembly  

Unit-IV: Solar PV system components & system design  

Unit-V Advanced SPV technologies  
Solar PV concentrators – Concentrator photovoltaic materials and devices – Hybrid SPV power systems – SPV power plant design tools and methodologies – SPV economics

Text Books

References
GETD 513  Solar Thermal Technology & Energy Conversion Systems  
(Hard Core Course)

Unit – I: [4]

Unit – II: [12]

Unit – III: [11]
Solar Thermal Energy Device:
Selective Surfaces: Ideal coating characteristics; Types and applications; Anti-reflective coating; Preparation and characterization. Performances of solar collectors. Flat-plate Collectors: Effective energy losses; Thermal analysis; Heat capacity effect; Testing methods; Evacuated tubular collectors; Air flat-plate Collectors: types; Thermal analysis; Thermal drying. Concentrating Collector: Performance parameters; Tracking systems; Compound parabolic concentrators; Parabolic trough concentrators; Concentrators with point focus; Heliostats; Comparison of various designs: Central receiver systems, parabolic trough systems; Solar power plant; Solar furnaces.

Unit – IV: Solar Cooling System: [8]
Liquid based solar heating system; Natural, forced and gravity flow, mathematical modeling, Vapour absorption refrigeration cycle; Water, ammonia & lithium bromide-water absorption refrigeration systems; Solar operated refrigeration systems; Solar desiccant cooling. Solar Thermal Energy Storage Systems: Sensible storage; Latent heat storage; Thermo-chemical storage.

Unit - IV: Design of Industrial Solar Systems: [10]
Modeling of solar thermal system components and simulation; Design and sizing of solar heating systems: f – chart method and utilizability methods of solar thermal system evaluation; Development of computer package for solar heating and cooling applications; Industrial process heat: Temperature requirements, consumption pattern; Applications of solar flat plate water heater & air heater for industrial process heat; Designing thermal storage; Transport of energy. Solar still; Solar cooker: Solar pond;

Text Books

References:
& Francis.
GETD 514: Biological Systems, Resources & Bioenergy Technologies
(Hard Core Course)

Unit I
Introduction to Biomolecules:
Classification of amino acids, carbohydrates and nucleotides; Structure and properties of carbohydrate polymers, proteins and nucleic acids; Classification and utility of lipids and fatty acids; Functional roles of biomolecules – energy carriers, enzyme cofactors and biochemical regulation. Biosynthesis and Metabolism.

Unit II
Biomass: Biomass resources; classification and characteristics; Techniques for biomass assessment; Application of remote sensing in forest assessment; Biomass estimation; Biomass to biofuel; Source and classification of biofuels and their characteristics.

Unit III
Biochemical Conversions:
Biocatalysis by enzymes and pathways - Fermentation and bioprocess engineering – Chemical kinetics – Mathematical modelling of biochemical reactions – Bioreactor designs; Biodegradation and biodegradability of substrate; anaerobic digestion - Bioconversion of lignocellulosic feedstock to sugars - Bioconversion of sugars and starches to fuels - Difference of the technologies of starch ethanol and cellulotic ethanol.

Unit IV
Thermochemical & Chemical Conversions:
Thermochemical Conversion: Direct combustion, incineration, pyrolysis, gasification and liquefaction; economics of thermochemical conversion. Biogasification: Biomethanation process, biogas digester types, biogas utilisation; Waste to energy.

Chemical Conversion: Hydrolysis & hydrogenation; solvent extraction of hydrocarbons; solvolysis of wood, biocrude, biodiesel production via chemical process; catalytic distillation; transesterification methods; Fischer-Tropsch diesel: chemicals from biomass.

Unit V
Biofuels Standards & Power Generation: Physical and chemical characteristics of biofuels – Biomass, wood gas, biomethane; ethanol, biodiesel, Wood oil; Bioblends - Indian and International standard specifications. Bioblends; Adaptation of biofuel in various applications – biomass integrated gasification/combined cycles systems - Sustainable co-firing of biomass with coal; Biofuel economy; Case studies.

Text Books

References:
[13] David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood, Chichester, 1984
GETD 510  Green Energy Laboratory
(Hard Core Course)

Course Outline:
A. Lectures:
- Basic concepts: Terminology used in experimental methods i.e. sensitivity, accuracy, uncertainty, calibration and standards; experimental system design and arrangement.
- Analysis of experimental data: Analysis of causes and types of experimental errors, uncertainty and statistical analysis of experimental data.
- Data acquisition and processing: Data acquisition methods, data storage and display, examples of application in typical energy system.
- Apparatus design and construction: Conceptual, substantive and detail designs of experiments; illustration of thermal energy equipment/devices and their accessories.
- Experiment plan and execution: Preparatory work for carrying out experiments; range of experimental study, choice of measuring instruments, measurement system calibration, data sheets and log books, experimental procedure, etc; applications.
- Technical Communication: Report preparation of experimental work, use of graphs, figures, tables, software and hardware aids for technical communication.

B. Laboratory:
Renewable Energy Technologies
1. Solar: Solar radiation analysis, Experimental study on thermal performance of solar water heater, solar dryers, solar PV cell characterization and its networking, solar cooker, Building duelling solar cells
2. Radiometry: Luxmeter circuit designing, Pyranometer circuit designing
3. Biomass: Experimental study on thermal performance and efficiency of biomass downdraft gasifier and sampling and analysis of air and flue gas from biomass energy systems i.e. gasifier, combustor and cook stoves using gas chromatography technique. Biogas production by anaerobic digestion and analysis.
5. Proximate and ultimate analysis, calorific value of solid fuels.
6. Storage: Programmable batteries

References:
GETD 515 Wind Energy Technologies
(Soft-core courses)

Unit I
**Wind Energy Potential:** Wind Velocity Distribution – Estimation of wind resource – Wind Indian and Global scenario

Unit II
**Wind Energy Conversion:** Aerodynamic design principles; Aerodynamic theories; Axial momentum, blade element and Strip theory; Maximum power coefficient; Prandlt’s tip loss correction; Rotor design and characteristics; Power, torque and speed characteristics – Wind turbine performance measurement – Loading analysis.

Unit III
**WECS design considerations:** Design of WECS components – Stall, pitch & yaw control mechanisms – Brake control mechanisms; Theoretical simulation of wind turbine characteristics; Test methods & SCADA.

Unit V

Unit V
**Wind Energy Application:** Wind forms – Stand-alone and Grid-connected systems - Hybrid systems. Wind pumps: Performance analysis, design concept and testing; Economics of wind energy utilization; Wind energy in India; Case studies.

Text Books

References
GETD 516  Biodiesel: Feedstock Development & Fuel Production
(Soft Core courses)

Unit I 10 hours

Unit – II 7 hours
Characterization of photosystems in microalgae – energy conversion efficiencies - optical characteristics of photoactive proteins in algae – recent development in artificial leaves and biosolar cells – Algal genetics.

Unit – III 8 hours
Cultivation of Algae for biodiesel and high value chemicals: Laboratory culture, Open raceways ponds, closed photobioreactors, design and illumination concepts - continuous culture and biomass recovery – Process engineering.

Unit – IV 8 hours

Unit – V 12 hours

Test Books

References
   ISBN 0–632–05953–2
GET617: Battery and Fuel Cell Technologies  
(Soft Core Course)

Unit I  Lead acid Battery  
[9 h]
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 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  
[9 h]
Advanced anodes and cathodes – theoretical capacity – merits and demerits - Nanomaterials for anodes: carbon nanotubes, graphene, Sn, Al, Si, SnO₂, NiO, TiO₂ & LiTiO₄. Nanomaterials for cathodes: LiCoO₂, LiMn₂O₄, LiFePO₄, and doped cathodes. Fabrication of nanostructured LiCoO₂, LiMn₂O₄, LiFePO₄, Si, Sn and CNTs. Battery fabrication technology and testing, batteries for electric vehicles, hybrid vehicles and solar photovoltaic applications.

Unit III  Metal-Air Batteries  
[9 h]

Unit IV  Fuel Cell Technology  
[9 h]

Unit V  Hybrid Energy Systems  
[9 h]
Concept of hybrid energy systems, development of battery and supercapacitors systems – Batteries and Fuel cells power systems – Recent developments and application areas.

Text Books

References
9. Energy conversion and storage scientific journals.
GETD 520 Green Technology Dissertations:  
(Hard Core Course)

Research Project and Dissertation specifically designed to give the student practical experience in technologies and principles appropriate to developing a green technology. Students under the supervision of Faculty Advisor, and with the due permission from the Chairperson / Coordinator will undertake a research based project for a duration of one full semester (four months) at Pondicherry University/ associated academic institution/ industrial partner/ any other industry /research organization outside Pondicherry University practicing green energy technologies. A thesis written for this project will be evaluated by an expert followed by viva-voce.

Green Energy Technology Dissertation: Duration – One full semester (four months)

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Annexure I

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GETY615: Nanotechnology for Energy Systems  3 0 0 3 45L
(Soft Core Course)

Unit 1  Nano-electronics  [9 h]
Atom by Atom arrangements, band structure formation, concept of wave, phase group velocities, electron state in solids, uncertainty principle, operators, wave properties of particle, quantum mechanical postulates, Schrödinger’s Wave Equation, free electron gas, spherical potential (hydrogen atom like problem), Hydrogen molecule like problem, electronic states of 2-D, 1-D, 0-D nanosystems.

Unit 2  Physical Properties of Nanosystems  [9 h]
Absorption, refraction, self electro optic effect, QCSE and Pockel effect in nanosystem, transport properties of nanosystems, partition function and thermodynamics of nanosystems.

Unit 3 Nanotechnology for Photovoltaic Energy Conversion  [9 h]

Unit 4 Nanotechnology for Photoelectrochemical and Photothermal Conversion Cells  [9 h]
Concept of photo-electro chemical cell. Conversion of solar energy to hydrogen, technology for storage, photo-thermal cells, nanotechnology in thermal conversion, nanosystems for heat storage.

Unit 5 Energy Efficient Nanodevices  [9 h]

Text books
[1] Physical principles of micro Micro-electronics, G.Yepifanov, Mir Publishers

Reference


UNIT I  Energy Auditing Techniques [9]
Energy Audit: Definition, need and objectives, types of Energy Audit, Energy audit strategies, Basic Components of Energy Audit, Energy Audit Instruments, Important survey items: Methodologies of conducting energy audit: Post audit analysis:

UNIT II  Furnaces and Boilers [9]
Furnaces: Classification, general fuel economy measures in furnaces, excess air and heat distribution losses, temperature control, draft control, case studies.
Boilers: Types, analysis of losses, performance evaluation, feed water treatment, blow down, energy conservation opportunities, FBC boilers, case studies.

UNIT III  Insulation and refractories [6]
Insulation type and application, economic thickness of insulation, heat savings and application criteria, refractory-types, selection and application of refractories, case studies.

UNIT IV  Steam system, Cogeneration, Cooling tower and Waste heat recovery [12]
Steam system
Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery systems, identifying opportunity for energy saving, case studies
Cogeneration
Need, applications, advantages, topping cycles, bottoming cycles, combined cycles, steam tracking mode, electricity tracking mode, saving potential, case studies.
Cooling Tower
Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities, case studies
Waste heat recovery
Availability and reversibility, first and second law efficiency, classification, advantages and applications, commercially viable heat recovery devices, saving potential, case studies
HVAC and refrigeration system, vapour compression refrigeration cycle, refrigerants, factors affecting refrigeration and air conditioning system performance and savings potential.
Vapour absorption refrigeration system, working principle, types and comparison with vapour compression system, saving potential, distribution system for conditioned air.

UNIT V  Energy Conservation (Electrical Systems) [9]
Electrical systems and bill analysis: Electricity billing, electrical load management, maximum demand control, Energy conservation opportunities in Lighting systems, Electric motors, Compressed air systems, HVAC & refrigeration system, Fans & blowers, Pumps, Cooling tower and DG system, case studies.

Text Books
2. Carig B. Saith, Energy Management Principles, applications, benefit and saving, Per n Presss, Newyork
3. F W Pyne, P gm Energy Conservation Manual, Fairmount Proem, INC. P.O. Box 14227 Atlanta, GA 30224

References
4. D Patrick and SW Fardo, Energy conservation, Prentice Hall, INC Englew eek Cliffs (NJ) 7632
5. Davida, Fuels of opportunity, characteristics and uses in combustion systems, Edition-2004, Publisher-Elsevier Ltd., UK
7. Savings electricity in utility systems of industrial plants by BG Desai, BS Vaidya, DP Patel and R Parman
8. Manual of variable speed drives by CII.
9. Electrical power distribution in industrial plants by MD Parmar
12 Energy Auditing, The Fairmont Press Inc. Published by Atlanta, Georgia.
GETY613: Algal Energy Technology 300345L
(Soft Core Course)

Unit I 9 h

Unit II 9 h
Characterization of photosystems in microalgae – energy conversion efficiencies - optical characteristics of photoactive proteins in algae – recent development in artificial leaves and biosolar cells.

Unit III 9 h
Cultivation of Algae for biodiesel and high value chemicals: Laboratory culture, Open raceways ponds, closed photobioreactors, design and illumination concepts - continuous culture and biomass recovery – Process engineering.

Unit IV 9 h

Unit V 9 h

Text Books

References
GETY 528: **Green Chemistry**  
(Soft-core Course)  

Green chemistry about chemical research and engineering that develops the design of chemicals and environmentally benign processes that minimize the use and generation of hazardous substances. In this course concepts of green chemistry will be exposed with real world applications in pharmaceutical industry and fine chemical industry. Apart from theory the course will have practical component where students are encouraged to do mini project involving principles of green chemistry.

**Unit 1:** Introduction to Organic Chemistry /Analytical Chemistry /Basic Chemical Engineering  
[8 h]

**Unit 2:** Introduction to Green Chemistry:  
[10 h]  
Principles of Green Chemistry, Reasons for Green Chemistry (resource minimisation, waste minimisation, concepts), Green reactions solvent free reactions, Catalyzed (heterogeneous/homogeneous) reactions, MW/ Ultrasound mediated reactions, Bio catalysts etc

**Unit 3:** Introduction to Pharmaceutical Process Chemistry:  
[12 h]  
Introduction to process chemistry, the difference between synthesis and process, Rote design, Route optimization, DOE,


**Unit 5:** Scale-up aspects including PE in Process Chemistry: Case Studies; New Initiatives : Micro reactors, Spinning Disc reactors  
[3 h]

Practical chemistry (Mini project):  
[24 h]

**Text Books**

**References**
[7] Green Chemistry in the Pharmaceutical Industry, Peter Dunn (Editor), Andrew Wells (Editor), Michael T. Williams (Editor), Wiley-VCH (2010)
[8] Handbook of Green Chemistry – Green Solvents (Hardcover), Walter Leitner (Editor), Philip G. Jessop (Editor), Chao-Jun Li (Editor), Peter Wasserscheid (Editor), Annegret Stark (Editor), Paul T. Anastas, Wiley-VCH (2010)
GETY 618: Green Concepts in Buildings
(Soft-core Course)

Pre-requisite (undergraduate degree in civil engineering)


Unit 5: Green Composites for buildings

TEXT BOOKS

REFERENCES
GETY 619: Carbon sequestration at landscape level
(Soft-core Course)

UNIT 1. Climate change and International agreements - 6 hours
The green-house effect. The United Nations Framework Convention on Climate Change (UNFCCC). The Intergovernmental Panel on climate change (IPCC), the Kyoto Protocol, the Clean Development Mechanism (CDM). Afforestation and Reforestation projects, Reduced Emissions from Deforestation and Degradation (REDD). CDM projects, finance, project development. Conservation of natural carbon sinks.

UNIT 2. Primary productivity: mechanisms and assessment - 12 hours
Photosynthesis, absorption and yield. C3, C4 and CAM pathways. Laboratory measurement of primary productivity: cell, plant, ecosystem. Direct field measurements of biomass and primary productivity: allometric models, harvest methods for forests, grasslands and ocean. Indirect measurements of biomass and primary productivity: remote sensing and other methods. The CDM methodologies for measurement of stocks and fluxes.

UNIT 3. Biogeochemistry - 11 hours

UNIT 4. Remote sensing and spatial analysis - 12 hours
Sensors. Reflectance of vegetation. Measuring biomass with remotely sensed data. Measuring primary productivity with remotely sensed data. High resolution satellites, use and limitations to measure biomass and primary productivity. Low resolution satellites use and limitations to measure biomass and primary productivity. Regional and global assessments of biomass and primary productivity. Introduction to Geographic Information Systems (GIS). Land-use and land-use changes assessment. The Clean Development Mechanism (CDM) methodologies for measurement of stocks and fluxes at the landscape level.

UNIT 5. Biomass as a major source of energy in India - 4 hours

Text Books

References