Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

List of UG & PG courses submitted for approval by the SPGC.

SEE-211: Energy Climate Change and Sustainability (3-0-0-9)
SEE-601: Thermo-Fluid Engineering (3-0-0-9)
SEE-602: Physics of Energy Materials (3-0-0-9)
SEE-603: Electrical Power Engineering (3-0-0-9)
SEE-604: Thermodynamics of Energy Systems (3-0-0-9)
SEE-605: An Introduction to Sustainable Energy Technologies (2-0-3-9, with Laboratory)
SEE-606: Electrochemical Energy Systems (3-0-0-9)
SEE-607: Hydrogen Energy: Production, Storage and Utilization (3-0-0-9)
SEE-608: Introduction to Bioenergy and Biofuels (3-0-0-9)
SEE-609: Mathematical and Computational Tools for Engineering (3-0-0-9)
SEE-610: Introduction to Materials Modelling and Simulations (3-0-0-9)
SEE-611: Energy Systems: Modelling and Analysis (3-0-0-9)
SEE-612: Manufacturing of Energy Systems
SEE-613: Solar Photovoltaics (3-0-0-9)
SEE-614: Wind Energy (3-0-0-9)
SEE-615: Solar Thermal Engineering (3-0-0-9)
SEE-616: Renewables Integrated Smart Power System (3-0-0-9)
SEE-617: Introduction to Sustainable Energy Policy (3-0-0-9)
SEE-618A: Energy Efficient Building Design (3-0-0-9)
SEE-619: Finite Volume Methods for Engineers (3-0-0-9)
SEE-620: Heat Driven Cooling Systems (3-0-0-9)
SEE-621: Biomass Conversion and Biorefineries (3-0-0-9)
SEE-622A: Sustainable Energy- Enabling Net Zero Emissions (3-0-0-9)
SEE-623: Fuel Cell Electrical Energy Systems (3-0-0-9)
SEE-624A: Design Strategies for Net-Zero Energy Buildings (3-0-0-9)
SEE-625: Structural, Microstructural and Spectroscopic Characterization of Materials (3-0-0-9)
SEE-626M: Ecological Principles and Biodiversity for Sustainability (3-0-0-5)
SEE-627: Electric Mobility (3-0-0-9)
SEE-628: Policy Processes and Analytical Methods: Application to Climate Policies (3-0-0-9)
SEE-629M: Ecology, Equity and the Economy (3-0-0-5)
SEE-631- Sustainable Forest Management (3-0-0-5)
SEE-632: Heating, Ventilation, and Air-conditioning of Buildings (3-0-0-9)
SEE-633: Power Electronics for Electric Vehicles (3-0-0-9)
SEE-634: Critical Material Resources for Clean Energy Transition (3-0-0-9)
SEE-635: Carbon Capture, Utilization, and Storage (CCUS) (3-0-0-9)
SEE-888: Introduction to Profession & Communication (1-0-0-3)

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

First Course Handout

Course Title		Energy, Climate Change and Sustainability
Number		SEE-211
Credits (L-T-P [C])		3-0-0-9
Name of the Instructor	:	Ashish Garg Email: ashishg@iitk.ac.in; Phone: 0512-679-2200 Sachchida Nand Tripathi snt@iitk.ac.in Phone: 0512-679-7845 (use last four digits for internal phone)
Teaching assistants		Shailesh Kumar Sah shaileshks21@iitk.ac.in Sonam Dolkar Sonamd21@iitk.ac.in Neha Sinha nehasinha21@iitk.ac.in Siddharth Raj siddharthr23@iitk.ac.in Ambuja B. baambuja@iitk.ac.in
Prerequisite(s) for the course	:	None

Course Objectives

The objective of this course is to make students understand the importance of energy in the context of human development and its consequences. The course will cover the evolution and types of energy technologies, the role of materials, mining and manufacturing. It will also teach the issues created by the increasing energy demand coupled with increasing population and changing lifestyles, environmental issues caused by growing energy demand and global warming, carbon cycle, emissions, and sequestration and finally, the possible way forward for a sustainable future.

Expected Learning Outcomes

Students will be able to understand the evolution of energy technologies and their correlations with the broader issues of materials and manufacturing and their consequent impact on and correlations with the environment. They will also be able to correlate the energy demand, its generation, and our lifestyles with the environmental issues and how they affect us. They will be able to distinguish between natural and anthropogenic greenhouse gas emissions and resultant warming. Finally, they will be able to understand methods that are required for a sustainable future and put them into practice.

Course outline

Broad topic	Details
Historical perspective	Historical perspective on the need of Energy and Sources -Pre-industrial revolution era (before 1900) -Development of materials, human development, and quest for energy -Post-industrial revolution -Nexus of the materials-manufacturing -engineering - energy and population growth
Essentials of understanding Energy	Energy: definitions Simple calculations Basic thermodynamics Measuring efficiency of energy systems and units
Energy systems and utilization in modern era	Modern energy conversion systems Overview of conventional and renewable energy generation technologies Energy storage technologies Comparative assessment of energy generation technologies vis-à-vis present and future energy demand
Energy consumption	Major industrial sectors vs energy usage Mobility and Electric Vehicles Construction sector Manufacturing sector Energy efficiency Issues and challenges
Impact on climate and sustainable living	Global Energy Balance, Anthropogenic activities, and climate issues - Carbon emissions with sector wise distribution - Impact of mining and industrial manufacturing - Science of Carbon cycle and thermal analysis -Carbon Cycle - Radiative Thermal Equilibrium - Greenhouse Gases and their potential - Radiative Forcing, Natural Climate Variability - Natural carbon Sequestration

	- Natural vs anthropogenic impact - Impact of climate change on sustainability
Way forward for a sustainable future	Methods and practices needed for a sustainable future - Mitigation and adaptation strategies for Climate Change - Decarbonization - Carbon neutral/NetZero: concept and pathways - Reducing consumption - Need for carbon sequestration and methods - Social repercussions

Class schedule and venue

M (L19) W (L19) Th (L19) 12:00-13:00

Evaluation Policy

Two quizzes: 30%, Mid-Sem: 35%, End-Sem: 35%

Any absences in exams will be given consideration only for medical reasons upon production of a medical certificate and marks will be prorated appropriately. No makeup quiz will be provided. Absence due to any other reason will result in zero marks for the particular exam.

Attendance Policy

You are expected to attend all the classes for your own understanding and performance in the exams. Students with 90+% attendance will be awarded 10% bonus marks. Total will be normalized to 100.

Textbooks, reference books, suggested readings and any other references

- Sustainable Energy – Choosing Among Options. J.W. Tester, E.M. Drake, M.W. Golay, M.J. Driscoll, and W.A. Peters. MIT Press (2005)
- Energy and the Environment, James A. Fay & Dan S. Golomb
- Energy and Civilization: A History, Vaclav Smil, The MIT Press (2017)
- Atmospheric Science, Wallace and Hobbs
- Earth’s Climate Past and Future, William F Ruddiman
- Understanding Climate Change Feedbacks, National Research Council
- Climate change and technological options, Konrad and Hurtmud
- Human impacts on weather and climate, William R. Cotton

Please note that it is extremely important to supplement the class room instruction by appropriate reading from the books. Lectures and handouts alone will not be sufficient for good performance in exams.

Department of Sustainable Energy Engineering
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Proposal for a New Course

Course Title	Thermo-Fluid Engineering
Number	SEE-601 (proposed)
Credits (L-T-P [C])	3-0-0 [9]
Departments proposing the course	Sustainable Energy Engineering
Name of the Proposer	Ashoke De/ Laltu Chandra (I)
Offered for	PG Students of SEE and PG students of other departments
Status of the course	PG Elective
Prerequisite(s) for the course	Consent of Instructor
Faculty members interested in teaching	Ashoke De, Debopam Das, Malay K Das, Jishnu Bhattacharya, Sameer Khandekar, Vaibhav Arghode
Other Departments/Programmes of whose the students are expected to take up the course	ME, AE, CHE

Course Objectives:
The objective of this course is to train PG students with an overview of Fluid Mechanics and Heat Transfer. Fundamental knowledge of fluid mechanics and heat transfer required primarily for sustainable energy systems study will be covered in this course.

Course outline:
Fluid Mechanics: Basic concepts, fluid Statics, conservation of mass and momentum and energy in an inertial and non-inertial frame of reference, Dimensional Analysis, inviscid and viscous fluid flow: external and internal, boundary layer theory; Heat Transfer: Basic concepts of conduction, convection, and radiation; one-dimensional steady state and unsteady state conduction; Network circuit analysis; Convective heat transfer; Forced and free convection over flat plate and in pipes; Boiling and condensation; Radiation heat transfer, radiation properties, and shape factors; heat exchange between real surfaces; radiation network for an absorbing and transmitting medium; Basics of solar radiation; Applications: Heat exchanger design.

Lecture wise breakup:

Topic	No. of lectures
Introduction and Fundamental Concepts of Fluid Mechanics: Continuum hypothesis, kinematics	3

Fluid Statics • The Basic Equation of Fluid Statics • Pressure Variation in a Static Fluid • The Standard Atmosphere • Hydrostatic Force on Submerged Surfaces • Buoyancy and Stability	4
Basic equation • Governing equations in integral and differential form in inertial and non-inertial frame of references: Mass, Momentum, Energy, Angular Momentum	2
Incompressible Inviscid Flow • Control volume analysis • Bernoulli Equation • Flow Measurement • Potential Flow	5
Dimensional Analysis • Nondimensionalizing the Basic Differential Equations • Buckingham Pi Theorem • Significant Dimensionless Groups in Fluid Mechanics	2
Internal Incompressible Viscous Flows • Fully Developed Laminar Flow in Pipes and Ducts • Open channel flows	2
External Incompressible Viscous Flows • Boundary Layers • Fluid Flow about Immersed Bodies	3
Heat Transfer • Basics of Heat Transfer • Concepts of conduction, convection and radiation	1
Heat Conduction • Introduction • 1D heat conduction Equation • General Heat conduction equation • Steady Heat Conduction: Thermal Contact Resistance, Generalized Thermal Resistance Networks • Transient Heat Conduction: Lumped System Analysis, Transient Heat Conduction in Large Plane Walls, Long Cylinders, and Spheres with Spatial Effects, Transient Heat Conduction in Semi-Infinite Solids,	4
Heat Convection • Introduction and fundamentals • Velocity and Thermal Boundary Layer • Heat Transfer in Laminar and Turbulent Flows • Solution of Convection equations • External Force Convection • Internal Force Convection • Natural Convection	4
Boiling and Condensation • Boiling Heat Transfer • Pool Boiling	4

• Flow Boiling • Condensation Heat Transfer • Film Condensation • Dropwise condensation	
Fundamentals of Thermal Radiation • Introduction • Thermal Radiation • Blackbody Radiation • Radiation Intensity Radiation Heat Transfer • The View Factor • View Factor Relations • Radiation Heat Transfer: Black Surfaces, Diffuse, Grey Surfaces • Radiation Exchange with Emitting and absorbing Gases	4
Heat Exchangers • Types of Heat Exchangers • The Overall Heat Transfer Coefficient • Analysis of Heat Exchangers • The Log Mean Temperature Difference Method • The Effectiveness-NTU Method Selection of Heat Exchangers	2
Total number of lectures	40

Textbooks, reference books, suggested readings and any other references

(1) Introduction to Fluid Mechanics -Fox, McDonald, Pritchard
(2) Fluid Mechanics – F. M. White
(3) Fundamentals of Heat and Mass Transfer -Bergman, Lavine, Incropera, Dewitt
(4) Heat Transfer – Cengel

Course proposed by	Recommended/ ~~Not recommended~~	This course is approved/not approved
Ashoke De (Ashoke De)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	Physics of Energy Materials
Number	SEE-602 (proposed)
Credits (L-T-P [C])	3-0-0-9
Departments proposing the course	Sustainable Energy Engineering
Name of the Proposer	Ashish Garg / Sudarshan Narayanan(I)
Offered for	PG Students of SEE/other departments or programs 3/4th year UG students
Status of the course	PG Elective/ UG Elective
Prerequisite(s) for the course	Consent of Instructor Faculty
Faculty members interested in teaching	Kanwar Singh Nalwa Anandh Subramaniam Shobit Omar
Other Departments/Programmes of whose students are expected to take up the course	MSE, MSP, PHY, EE, ME, CHE, and CHM

Course Objectives:

The objectives of the course are to enable the students know the underlying concepts of physics of materials that are used for energy applications, primarily batteries, fuel cells solar cells, and solar thermal devices.

Expected Learning Outcomes:

The students will be able to understand the essential band theory, distinction between various types of semiconductors, transport in semiconductors and ionic materials, thermal properties and connect them to the required characteristics of devices based on these materials.

Course outline:

Semiconductors: Elements of basic quantum mechanics, reciprocal lattice, band theory, direct and indirect bandgap semiconductors, intrinsic and extrinsic semiconductors and their properties, optical absorption, generation, and recombination in semiconductors.

Ionic transport: ionic and electronic conductivity, Nernst equation, transport in ionic media. Thermal Properties: Phonons, Heat capacity, Thermal conductivity.

Phase transitions: Phase transitions, phase change materials- fundamentals & applications.

Applications: Solar photovoltaics, LEDs, Solar thermal materials , thermoelectrics, batteries.

Lecture wise breakup:

Topics	# of lectures (approximate)
Essential quantum mechanics and band theory	8
Basics of Semiconductors	5
Transport in semiconductors and distinction with metals	3
Absorption, generation, and recombination in semiconductors	4

Ionic transport: conductivity, Nernst equation	6
Thermal properties	8
Phase transitions, Phase change materials	4
Applications of the properties	2
	40

Text-books, reference books, suggested readings, and any other references

- Introduction to Solid State Physics by C. Kittel
- Electronic Properties of Materials by R.E. Hummel
- Solid State Physics by A.J. Dekker
- Semiconductor Device Fundamentals by R. F. Pierret

Course proposed by

Recommended/Not recommended

This course is approved/not approved

(Ashish Garg)

Convener, DPGC (SEE)

Chairman, SPGC

Department of Sustainable Energy Engineering
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Proposal for Revised Course

Course Title	:	Electrical Power Engineering
Course No.	:	SEE-603
Credits (L-T-P [C])	:	(3-0-0-0) 9 Credits
Department proposing the course	:	Sustainable Energy Engineering
Name of the Proposer	:	Prabodh Bajpai
Offered for	:	PG Students of SEE and other departments. 3/4th year UG students of other departments.
Status of the course	:	PG Elective/ UG Elective
Prerequisite for the course	:	Consent of the Instructor
Course objective and contents	:	Enclosed
Faculty members interested in teaching	:	Amarendra Edpuganti, Ankush Sharma
Other Departments/Programmes of whose the students are expected to take up the course	:	All Engineering Departments in Campus

Course Objectives

To familiarize the students with basics of electrical circuits, electrical machines, electric power system and power electronics.

Expected Learning Outcomes

This course will make the students to understand basics of DC, AC electrical circuits and electrical machines, such as transformer, DC and AC machines. Also basics of power electronics circuits, power system components and concept of smartgrid and micro grid will be important learnings from this course.

Course Outline

- Introduction
- DC Circuits- Circuit analysis
- Single-Phase AC Circuits, Power Calculations, Analysis of 3-Phase AC Circuits
- Transformers: Magnetic Circuits, Equivalent Circuit and Performance
- Rotating Machines: DC Machines, Induction Machines, Synchronous Machines
- Power System: Generation, Transmission, Distribution, Load demand, Restructuring,
- Smartgrid, Micro grid, Renewable energy systems and Grid integration, Electricity market

Lecture-wise break-up:

Topic	Lectures
Introduction	2
DC Circuits, KCL, KVL, Analyis	5
Single-Phase AC Circuits, Power Calculations, Analysis of 3-Phase AC Circuits	8
Transformers: Magnetic Circuits, Equivalent Circuit and Performance	6
Rotating Machines: DC Machines, Induction Machines, Synchronous Machines	3
Power System: Generation, Transmission, Distribution, Load demand, Restructuring,	8
Smartgrid, Micro grid, Renewable energy systems and Grid integration, Electricity market	6
TOTAL	**38**

Text-books, reference books, suggested readings and any other references –

1. Fundamentals of electric circuits, Alexander and Sadiku
2. Introductory Circuit Analysis, R. L. Boylestad
3. Electric Machinery Fundamentals, Stephen J Chapman
4. Electric Machinery, A. E. Fitzgerald, Charles Kingsley Jr., Stephen D. Umans
5. Power System Analysis, John J. Grainger and William D. Stevenson, Jr., Tata McGraw-Hill
6. Power System Analysis and Design, J. Duncan Glover, M. Sarma and T. J. Overbye, Thomson
7. Fundamentals of Power Electronics, Robert W. Erickson and Dragan Maksimovic, Springer.
8. Power Electronics: Converters, Applications and Design, Mohan, Undeland and Robbins, Wiley.
9. Smart Grids– Fundamentals and Technologies in Electricity Networks, Buchholz, Bernd M., Styczynski, Zbigniew, Springer
10. Renewable and efficient electric power systems, G.M. Masters, John Wiley & Sons

Course proposed by	Recommended / Not recommended	This course is approved / not approved
(Prabodh Bajpai)	Convener, DPGC (SEE)	Chairman, SPGC

Proposal for Course Modification

Course Title	Thermodynamics of Energy Systems
Number	SEE-604
Credits (L-T-P [C])	3-0-0-9
Departments proposing the course	Sustainable Energy Engineering
Name of the Proposer	Aakash Chand Rai
Offered for	UG/PG Students of SEE and other departments
Status of the course	UG/PG Elective
Prerequisite(s) for the course	Should not have taken ESO201 or an equivalent course at IITK.
Faculty members interested in teaching	Vaibhav Arghode, Sameer Khandekar
Other Departments/Programmes of whose students are expected to take up the course	ME, ChE, MSE

Course Objectives:
This course provides the necessary background of engineering thermodynamics to postgraduate students who did not get adequate exposure to the subject at the undergraduate level. The course will cover the basic principles of thermodynamics and prepare the student to effectively use thermodynamics in the field of sustainable energy engineering. The course will also lay the foundations for subsequent studies in fluid mechanics, heat transfer, and statistical thermodynamics.

Existing course outline
Course outline:
Open and closed systems, first and second laws, concept of characteristic potential and entropy, control volume analysis, properties of pure substance, chemical potential, phase equilibrium, binary solutions, chemical reaction, Air standard cycles, Rankine cycle, reheat and regenerative Rankine cycles, Vapour compression refrigeration cycle, Heat pump, vapour absorption cycle (qualitative analysis only), properties of moist air, Psychrometric chart, air- conditioning processes, Solar intensity on a tilted plane, flat plate collector, concentration limit, parabolic trough and parabolic dish collector, central receiver tower, thermal storage system, Basics of electrochemistry, equilibrium electrochemistry, kinetics, fundamental; of a battery, fundamentals of a fuel cell

Revised Course outline
1. Introduction and basic principles: Introduction, units and dimensions, thermodynamic systems, properties and states, process and cycle, energy, pressure, specific volume, temperature, and the zeroth law.
2. Pure substance behavior: Pure substance, phase equilibrium, independent properties, thermodynamic tables, thermodynamic surfaces, the ideal gas equation and deviation from the ideal-gas behavior, and other equations of state.
3. Energy transfers: Work and heat transfer processes.
4. Energy analysis for a control mass: The first law of thermodynamics and its applications for a control mass; internal energy, enthalpy, and specific heats; and the first law as a rate equation.
5. Mass and energy analysis for a control volume: Conservation of mass, the first law of thermodynamics for a control volume, and energy analysis of steady-state and transient process.
6. The second law of thermodynamics: Heat engines and refrigerators, the second law of thermodynamics, reversible and irreversible processes, Carnot cycle, and the thermodynamic and ideal-

gas temperature scales.
7. Entropy: The Clausis inequality; entropy- a system property; entropy of a pure substance; entropy change in reversible processes; the Gibbs equations; entropy changes of solids, liquids, and ideal gases; entropy generation and the increase of entropy principle; and entropy as a rate equation.
8. Entropy analysis for a control volume: The second law of thermodynamics for a control volume and its application to steady-state and transient processes, the steady-state single-flow process, and isentropic efficiencies.
9. Irreversibility and availability: Available energy, reversible work, and irreversibility; availability and second-law efficiency; and the exergy balance equation.
10. Thermodynamic property relations: The Maxwell relations and the Clapeyron equation.

Existing Lecture wise breakup:

S. N.	Broad Title	Topics	No. of Lectures
1.	Basics of thermodynamics	Open and closed systems, first and second laws, concept of characteristic potential and entropy, control volume analysis, properties of pure substance, chemical potential, phase equilibrium, binary solutions, chemical reaction	**15**
2.	Power and Refrigeration cycles, Air conditioning	Rankine cycles, Reverse Rankine refrigeration cycle, Heat pump, vapour absorption cycle (qualitative analysis only), properties of moist air, Psychrometric chart, air-conditioning processes	**7**
3.	Solar thermal conversion	Intensity on a tilted plane, flat plate collector, concentration limit, parabolic trough and parabolic dish collectors, central receiver tower, thermal storage system	**9**
4.	Electrochemical Conversion	Basics of electrochemistry, equilibrium electrochemistry, kinetics, fundamentals of battery, fundamentals of fuel cell	**9**

Revised Lecture wise breakup:

Topics	**Number of lectures (approximate)**
1. Introduction and basic principles	3
2. Pure substance behavior	6
3. Energy transfers	3
4. Energy analysis for a control mass	5
5. Mass and energy analysis for a control volume	4
6. The second law of thermodynamics	4
7. Entropy	6
8. Entropy analysis for a control volume	4
9. Irreversibility and availability	3
10. Thermodynamic property relations	2
Total	**40**

Textbooks, reference books, suggested readings and any other references

- Thermodynamics – an engineering approach by Yunus Cengel and Micheal Boles
- Fundamentals of thermodynamics by Claus Borgnakke and Richard Sonntag
- Engineering thermodynamics by P K Nag.

Course proposed by	**Recommended/Not recommended**	**This course is approved/not approved**
		
(Aakash Chand Rai)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	An Introduction to Sustainable Energy Technologies
Number	SEE-605 (proposed)
Credits (L-T-P [C])	2-0-3-9 (9 Credits)
Departments proposing the course	Sustainable Energy Engineering
Name of the Proposer	Kanwar Singh Nalwa and Ashish Garg
Offered for	PG Students of SEE and other departments
Status of the course	PG Elective
Prerequisite(s) for the course	Consent of Instructor Faculty
Faculty members interested in teaching	Jishnu Bhattacharya, Malay Das, Shobit Omar, Anandh Subramaniam, Debopam Das, Vaibhav Arghode, Raju Gupta
Other Departments/Programmes of whose students are expected to take up the course	MSE, CHE, ME

Course Objectives:

First objective of the course is to make students familiar with the basics of most clean and renewable energy technologies. Second objective is to give students hands-on exposure to energy systems and key instrumentation, operation of equipment, device fabrication and characterization, data acquisition and data analysis.

Expected Learning Outcomes:

The students will be able to know and differentiate between various types of clean energy systems. They will be able to conduct basic experiments related to efficiency calculations in energy systems.

Course outline:

Introduction to energy sustainability; Introduction to Sustainable Energy Systems including thermal (Rankine/Brayton cycle) conversion, photovoltaic technologies and their testing, solar thermal engineering including conversion and storage, fuel cells, wind energy systems, batteries, supercapacitors, hydrogen as fuel, its generation and storage, tidal energy.

There will be 12 laboratories on each of the above topics using judicious set of experiments.

Lecture and Lab wise breakup:

S.N.	Topic	Number of Lectures
1	Introduction	1
2	Conventional thermal energy conversion	2
3	Solar energy technologies	6
4	Wind energy	4
5	Batteries	6
6	Supercapacitors	2
7	Fuel cells	2
8	Tidal Energy	1
9	Thermal and vibrational energy harvesting	2

10	Water treatment and remediation	1
	Total	27

List of Experiments:

S.N.	Name of Laboratory	Details	No of labs
	Flow and temperature measurements	Digital Manometer, thermocouple with readout	1
	Basic electronics measurements	Thevenin Norton theorem, AC transformer	1
	Conventional energy lab	Small combustion experiment	1
	Photovoltaic assembly and testing	Device Fabrication and testing, Module testing	2
	Solar thermal (conversion and storage)	Solar Thermal experiment, Thermal Energy Storage	2
	Fuel cell and Hydrogen Lab	Hydrogen evolution, hydrogen storage, hydrogen usage in fuel cell	1
	Wind power experiment	Wind Energy Training System (horizontal axis), Vertical axis Turbine	1
	Battery storage	Zn-based battery fabrication, Charge-discharge, Battery demonstration	1
	Power Electronics or Smart grid	Smart grid	1
	Water remediation lab	Water remediation using Photocatalysis	1
	Total		12

Text-books, reference books, suggested readings and any other references:

- Energy storage, Robert A. Huggins, Springer Science & Business Media, 2010
- The Physics of Solar Cells, Jenny A. Nelson, World Scientific Publishing Company
- Fuel Cell Fundamentals, R. O'Hayre, S-W. Cha, W. Colella, F. B. Prinz, John Wiley and Sons, USA, 2005
- Advanced Batteries: Materials Science Aspects, Robert Huggins, Springer; 2009.
- Power System Analysis, John J. Grainger and William D. Stevenson, Jr., Tata McGraw- Hill, 2003.

A manual consisting of details pertaining to basic theory and experimental details of all the experiments will be provided to a.11 the students.

Course proposed by	Recommended/ ~~Not recommended~~	This course is approved/not approved
(Kanwar Singh Nalwa and Ashish Garg)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	Electrochemical Energy Systems
Number	SEE-606 (proposed)
Credits (L-T-P [C])	(3-0-0-0) 9 Credits
Departments proposing the course	Sustainable Energy Engineering
Name of the Proposer	Raju Kumar Gupta and Shobit Omar / Soumyabrata Roy (I)
Offered for	PG Students of SEE and other departments. 3/4th year UG students of other departments. PG Elective/ UG Elective
Status of the course	PG Elective/ UG Elective
Prerequisite(s) for the course	Consent of Instructor Faculty
Faculty members interested in teaching	Malay K. Das, Raja Angamuthu, Kanwar Singh Nalwa
Other Departments/Programmes of whose students are expected to take up the course	CHE, CHM, MSE, MSP, ME

Course Objectives:

This course intends to provide an understanding of the working mechanisms of different energy technologies e.g. batteries, supercapacitors, fuel cells, and identifying the limitations of these electrochemical systems. Students will study thermodynamics, and kinetics pertaining to the electrochemical reactions, electrodes, and electrolytes as well as experimental techniques to study their performance parameters. This course will give students a solid foundation upon which they will be able to use the modern electrochemistry, battery, fuel cells, and supercapacitor technologies in their research and career.

Course Outline:

Thermodynamics of electrochemical systems; equilibrium and non-equilibrium phenomena in electrochemical systems; chemical vs electrochemical kinetics; energy devices in electrochemistry: batteries, Supercapacitors, fuel cells, solid oxide fuel cells.

Lecture-wise break-up:

Topics	# of lectures (approximate)
Induction to Energy conversion and storage systems - Scope of energy systems, needs and opportunities, technology overview and applications	1
Introduction to Electrochemical Cells, Batteries, Primary and secondary Batteries, Battery Electrode Reactions, Important Parameters viz. Operation Voltage, Charge Capacity, Maximum Theoretical Specific Energy (MTSE), Coulombic Efficiency, Cycling Behavior, Transference Number. Types of Battery Electrode Reactions, Discharge Curves and the Gibbs Phase Rule, Binary and Ternary Electrodes, Phase Diagrams and Discharge Curves, Cases: Li-Bi, Li-h, Li-Sb, Li-Cu-Cl, Li-Transition Metal	5

Oxide Systems.	
Insertion and Convertible Electrode Reactions in Batteries, Positive Electrodes for Li-ion Batteries: (Olivine ($LiMPO_4$.), $LiMO_2$, Spinel ($LiMn_2O4$), Sulfur and Other Materials, Negative Electrodes for Li-ion Batteries Based on Insertion, Alloying, Conversion and Mixed Alloying-Conversion Reactions. Graphite, Sn, Si and Other Metal Oxides, Electrolytes for Li-ion Batteries: Requirements, Organic liquid Electrolyte, Dry Polymer Electrolyte, Gel Polymer Electrolyte, Solid Electrolytes Based on Sulfides and Oxides.	6
Battery Configuration & Fabrication: Conventional Batteries with Liquid Electrolyte, Passive Components, Redox Flow Batteries, All-Solid-State Batteries and other types, Batteries Based On Other Chemistries: Sodium-Ion, Zinc-Air, Pb- Acid, Ni-metal, Hydride Batteries, etc.	3
Supercapacitors and its working principle, types of supercapacitor, and criteria. of materials selection for electrodes, cycling, and performance characteristics, the difference between battery and supercapacitor, hybrid battery/supercapacitor energy storage system, future prospects and challenges	9
Introduction to Fuel Cells, Working Principle and Types of Fuel Cells, Thermodynamics and Kinetics of Fuel Cells, Charge-Voltage Characteristic Polarization Losses Proton Exchange Membrane Fuel Cells {PEMFCs), Structure, Bipolar Plates, Anode, Cathode, Cell Performance, Efficiencies, Challenges, PEMFCs for Electric Vehicles	4
Solid Oxide Fuel Cells (SOFCs), Requirements of Anode, Cathode, and Electrolyte, Defects in Oxide Based Ceramics, materials for Electrolyte of SOFCs: CeO_2, ZrO_2, LSGM, etc., materials for Anode of SOFCs: Ni/ZrO_2, Ni/CeO_2, Ni-free anode for direct hydrocarbon utilization, Materials for Cathode of SOFCs: LSCF, LSM, etc., Nanostructured Electrodes for SOFCs, Various Configurations & Fabrication of SOFCs: Planar, Tubular, Mixed, Electrolyte-Supported, Anode-Supported and others.	12
TOTAL	40

References:

1. Energy storage, Robert A. Huggins, Springer Science & Business Media, 2010.
2. Energy storage: A new approach, Ralph Zito, Wiley, 2010.
3. Electrochemical Engineering Principles, Prentice Hall Publications, 1990.
4. Electrochemical Systems, J. Newman and N. P. Balsara, Wiley Publications, 4th Edition, 2021.
5. Advanced Batteries: Materials Science Aspects, Robert Huggins, Springer; 2009.
6. Electrochemical Supercapacitors: Scientific Fundamentals and Technological, B. E. Conway, Springer; 1999.
7. Supercapacitors: Materials, Systems, and Applications, Ma.x Lu, Francois Beguin, Elzbieta Frackowiak, Wiley, 2013.
8. Fuel Cell Fundamentals, R. O'Hayre, S-W. Cha, W. Colella, F. B. Prinz, John Wiley and Sons, USA, 2005.
9. Fuel Cells: From Fundamental to Applications, S. Srinivasan, Springer, USA, 2006.
10. Principles of Fuel Cells, X. Li, CRC Press, USA, 2005.

11. Fuel Cells: Principles and Applications, B. Viswanathan and M. A. Scibioh, Universities Press, India, 2006.
12. Electrochemical methods, 2nd Ed., A.J. Bard and L.R. Faulkner, John Wiley & Sons, Inc., 2001
13. The CRC Handbook of Solid-State Electrochemistry, Edited by P.J. Gellings and H.J.M. Bouwmeester

Course proposed by	Recommended/~~Not recommended~~	This course is approved/not approved
(Raju Kumar Gupta and Shobit Omar)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	Hydrogen Energy: Production , Storage and Utilization
Number	SEE-607 (proposed)
Credits (L-T-P [C])	(3-0-0-9) 9 Credits
Departments proposing the course	Sustainable Energy Engineering
Name of the Proposer	Anandh Subramaniam
Offered for	PG Students of SEE and other departments. 3/4th year UG students of other departments. PG Elective/ UG Elective
Status of the course	PG Elective/ UG Elective
Prerequisite(s) for the course	Consent of Instructor Faculty
Faculty members interested in teaching	Anandh Subramaniam, Shobit Omar, Nishith Verma, Raju Kumar Gupta, Raja Angamuthu, Anand Singh, Vishal Agarwal.
Other Departments/Programmes of whose students are expected to take up the course	SEE, MSE, ChE, MSP

Course Objectives and Expected Learning Outcomes:

At the end of the course, the student should be able to have a grasp of the following aspects.

- Have an overview of the utilization of hydrogen energy.
- Understand hydrogen generation, storage and utilization methods.
- Comprehend the underlying science and the basis of technological devices for the use of hydrogen energy and hydrogen as a working fluid.

Course contents:

Overview of a hydrogen-based economy and hydrogen energy. Important components of the utilization of hydrogen energy: production, storage, transportation and conversion to thermal or electrical energy. Methods of hydrogen production: Reforming of Carbonaceous Sources, Pyrolysis of Biomass and reformation of bio-oil and gaseous products, Gasification of Renewable Biomass and its Reformation, Electrolysis of Water, Thermochemical splitting of water, Photo-catalytic and photo-electrochemical routes for hydrogen production and Biological Hydrogen Production. Methods of hydrogen storage and associated apparatus. Characterization of hydrogen storage materials. Applications based on hydrogen as a working fluid: Vehicular Applications, Purification, Thermal Energy Storage, back-up power, Compressor, Heating and Cooling system, and Reversible gettering. Conversion of hydrogen into thermal and electrical energy. Fuel cell for hydrogen.

Lecture Outline:

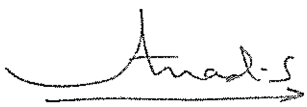
Topic	Lectures

Overview of a hydrogen-based economy and hydrogen energy. Important components of the utilization of hydrogen energy: production, storage, transportation and conversion to thermal or electrical energy.	3
Methods of hydrogen production: Reforming of Carbonaceous Sources, Pyrolysis of Biomass and reformation of bio-oil and gaseous products, Gasification of Renewable Biomass and its Reformation, Electrolysis of Water, Thermochemical splitting of water, Photo-catalytic and photo-electrochemical routes for hydrogen production and Biological Hydrogen Production.	11
Methods of hydrogen storage and associated apparahls. Characterization of hydrogen storage materials.	10
Applications based on hydrogen as a workingng fluid: Vehicular Applications, Purification, Thermal Energy Storage, Back-up Power, Compressor, Heating and Cooling system, and Reversible gettering.	6
Conversion of hydrogen into thermal and electrical energy. Fuel cells for hydrogen.	10
TOTAL	40

References

1. *Hydrogen Energy: Challenges and Solutions for a Cleaner Future,* Bahman Zohuri, Pergamon Press, Springer, 2019.
2. *Handbook of Hydrogen Energy,* Eds.: S.A. Sherif, D.YI. Goswami, E.K. Stefanakos, A. Steinfield, CRC Press, 2014.
3. Compendium of Hydrogen Energy: Hydrogen Production and Purification, edited by Velu Subramani, Angelo Basile, T. Nejat Veziroglu, Elsevier, 2015.

Course proposed by



(Anandh Subramaniam)

Recommended/~~Not recommended~~

Convener, DPGC (SEE)

This course is approved/not approved

Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	Introduction to Bioenergy and Biofuels
Number	SEE-608 (proposed)
Credits (L-T-P [C])	3-0-0-9 [9]
Departments proposing the course	Sustainable Energy Engineering
Name of the Proposer	Dr. Anand Singh/ Dr. Raja Angamuthu
Offered for	PG Students of SEE and other departments. 3/4th year UG students of other departments. PG Elective/ UG Elective
Status of the course	PG Elective/ UG Elective
Prerequisite(s) for the course	Consent of Instructor Faculty
Faculty members interested in teaching	Dr. Anand Singh Dr. Raja Angamuthu
Other Departments/Programmes of whose students are expected to take up the course	CHM, BSBE, ES

Course Objectives:
This course aims to provide an understanding about biofuels/bioenergy as related to the sustainable energy landscape. The course will provide knowledge of renewable feedstocks, conversion technologies, fuel characterization, environmental consequences, and resource utilization related to bioenergy. Insight into different bioenergy systems, including bioheat, biopower, biofuel, and biogas; will abo be provided.

Expected Learning Outcomes:
Students completing this course will develop an understanding of the existing and emerging biomass to energy technologies, biomass and fuel characterization, types of fuels and usage, and LCA. Additionally, students will develop critical thinking about energy sustainability and the environmental and economic parameters that govern the development and deployment of new technologies.

Course outline:
This course contents include renewable feedstocks, biomass to low-carbon energy systems including biopower, bioheat, and biofuels, including conversion technologies, end products, and their applications. The course encompasses thermochemical energy processes (gasification, pyrolysis, reforming), mechanical and chemical processes (oil extraction and trans-esterification), and biochemical processes (fermentation and anaerobic digestion). Characterization of biofuels. Concepts of sustainability, systems thinking, Life Cycle Analysis (LCA), environmental issues, prevailing energy policies, the economics of energy markets, and incorporation of these concepts into bioenergy systems.

Lecture Outline:

Topic	Lectures
Introduction to fundamental concepts of biofuels and bioenergy. Systems thinking, biopower, bioheat, biofuels, advanced liquid fuels, drop-in fuels.	3
Biomass Feedstocks: Harvested feedstocks for first, second and third-generation biofuels, residue Feedstocks from agricultural, forestry and farm waste, organic components of residential, commercial, institutional and industrial waste.	6
Biomass conversion technologies: Biorefineries and end products.	3
Biochemical conversion: hydrolysis and fermentation, anaerobic digestion, trans-esterification. Biofuel production, characterization and storage	8
Thermochemical conversion: combustion, gasification, pyrolysis, other technologies, scale-up, characterization,	8
Biohydrogen	3
Life Cycle Analysis: General understanding of LCA, cradle-to-grave, field-to-wheels concepts, goal and scope determination, defining LCA boundaries. Life cycle inventory, life cycle assessment	3
Sustainability: General principles, environmental sustainability, bioenergy &	3
Bioenergy & Environment: Criteria pollutants, carbon footprint, emissions of biomass to power generation applications, emissions from biofuels, indirect land use change (!LUC) issues, value-added processing of biofuel residues/wastes	3
Total lectures	40

Text-books, reference books, suggested readings and any other references:

1. Biofuels and Bioenergy, John Love, John A. Bryant, ISBN: 978-1-118-35056-0, Wiley-Blackwell (2017)
2. Biomass for renewable energy, fuels, and chemicals. D.L. Klass, Academic Press.
3. Biohydrogen, Ashok Pandey, S. Venkata Mohan, Jo-Shu Chang, Patrick C. Hallenbeck, Christian Larroche, ISBN 978-0-444-64203-5, second edition, Elsevier (2019)
4. Robert C. Brown, Biorenewablc Resources: Engineering New Products from Agriculture. Wiley-Blackwell Publishing (Second Edition)
5. Ycbo Li and Samir Kumar Khanal, Bioencrgy: Principles and Applications. Willey Blackwell, ISBN: 10-987-65-4321 (2016)
6. Sunggyu Lee and Y.T. Shah, Biofuels and Bioenergy Processes and Technologies. CRC Press (2013)

7. Sergio C. Capareda, Introduction to Biomass Energy Conversions, CRC Press, ISBN: 978-1-4665-1333-4 (2013)

Course proposed by	Recommended/ ~~Not recommended~~	This course is approved/not approved
Anand Singh Raja Angamuthu	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	Mathematical and Computational Tools for Engineering
Number	SEE-609 (proposed)
Credits (L-T-P [C])	3-0-0-[9]
Departments proposing the course	Sustainable Energy Engineering
Name of the Proposer	Dr. Lalit Pant
Offered for	PG Students of SEE and other departments. 3/4th year UG students of other departments. PG Elective/ UG Elective
Status of the course	PG Elective/ UG Elective
Prerequisite(s) for the course	Consent of Instructor Faculty
Faculty members interested in teaching	Dr. Lalit Pant, Dr. Ashoke De

Objectives :

The objective of this course is to equip students with the mathematical concepts: and computational tools required for solving common engineering problems and for analyzing engineering data especially those related to energy systems.

Learning Outcomes:

- At the end of the course, the student should be able to:
- Solve simple mathematical problems (system of equations, PDEs/ODEs, curve fittings, data analysis) using programming languages like MATLAB/Python.
- Analyze complex engineering systems (coupled multiphysics mathematical systems) using software tools like COMSOL/ANSYS.
- Formulate mathematical methods/models for energy engineering problems.
- Write codes in python/MATLAB and solve research problems in commercial tools.
- Perform data analytics on experimental/analytical/numerical data (statistics, processing, curve-fitting, correlation) and perform interpretations (interpolations/extrapolations)

Contents:

	Topic	**Detailed Contents**	**No. of Lectures**
1	**Introduction/ Overview**	• Course overview. • Role of mathematical methods in science/engineering. • Brief introduction to programming	**2**
2	**Data Analytics**	• Data statistics (mean, standard deviation, variance, • skewness, confidence interval, covariance, correlation)	**11**

		• Basics of hypothesis testing (p-value, t-test) • Statistical methods (Principal component analysis, factor analysis, Singular value decomposition) • Data fitting (Regression, SSE, fit quality, interpolation & extrapolation) Matrix and eigenvalue problems: o Solution of linear equations: Gaussian elimination, LU decomposition, conjugate gradient method o Solution of non-linear problems: Newton Raphson method, Secant method	**6**
3	**Numerical Methods**	• Solution of ODE:/PDE: • Discretization of equations • Overview of Finite difference, finite volume, and finite element methods (basic framework, differences, advantages/disadvantages, case-specific usage) • Linear and non-linear problems • Steady-state and time-dependent problems • Error, stability, convergence, relaxation & other concepts	**13**
4	**Software Tools for Numerical Analysis**	• Types of computational tools (in-house/commercial open-source), advantages, disadvantages, usage for various energy engineering-related problems • Workflow for performing numerical simulations using software, e.g., COMSOL Multiphysics o Geometry design, meshing, definitions, solver setting, coupling, solution, post-processing of results o Solution of single PDE system, e.g., heat transfer o Solution of coupled Multiphysics problems, eg, diffusion reaction/electrochemistry in battery fuel-cell	**7**

Books, Reading Material, and Resources:

1. S. C. Chapra and R. P. Canale, Numerical methods for engineers, 7th ed, (McGraw- Hill Education, 2015)
2. Mahendra K Verma. Practical Numerical Computing Using Python: Scientific & Engineering Applications. (Independently Published, 2021).
3. K.E. Atkinson, An Introduction to Numerical Analysis, (Wiley, 1978).
4. William H. Press, Saul A. Teukolaky, William T. Vetterling, Brian P. Flannery. Numerical recipes: the art of scientific computing, (Cambridge University Press, 2007)
5. Krevazig, Advanced Engineering mathematics, (Wiley, 2006)
6. RV. Hogg, A. T. Craig, Introduction to mathematical statistics, (Macmillan, 1970)
7. N. R. Draper, H. Smith, Applied regression analysis, (Wiley, 1966)

Course proposed by	**Forwarded by**	**This course is approved/not approved**
Lalit Pant (Faculty)	**Course convener**	

Department of Sustainable Energy Engineering Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	: Introduction to Materials Modeling and Simulations
Number	: SEE-610 (proposed)
Credits (L-T-P [C])	: (3-0-0-9)
Departments proposing the course	: Sustainable Energy Engineering
Name of the Proposer	: Vishal Agarwal
Offered for	PG Students of SEE and other departments 3/4th year UG students of other departments
Status of the course	PG Elective/ UG Elective
Prerequisite(s) for the course	: Consent of Instructor
Faculty members interested in teaching	Vishal Agarwal, Jayant Singh
Other Departments/Programmes of whose students are expected to take up the course	CHE, MSE, MSP, PHY, ME

Course Objectives

In the last couple of decades, the importance of atomic-Yeah simulations has exploded, largely because of the exponential growth in computational power. Chemical engineers, materials scientists, chemists, physicists etc. now all use atomic scale simulations of one type or another to advance their fields. The emphasis in this course would be to introduce some of the widely used techniques for atomic simulations along with hands-on experience with some of the commercial packages. The course will be covered in your modules with lab component associated with the last three. The emphasis would on Application rather than theory, but with the realization that it is impossible to be an intelligent practitioner without some understanding of' the underlying theory. The lectures will be designed without any assumptions of student's prior knowledge of atomistic simulations.

Learning Goals

1. Introduce the basic theoretical, mathematical, and numerical concepts.
2. Introduce the terminology and practical issues.
3. Get hands-on experience with these concepts using popular computational tools.
4. Learn how to interface the results of simulations with statistical mechanic theories to calculate thermodynamic and kinetic properties.
5. Execute a computational project on modeling and simulation.

Course outline and Lecture-wise break up

- **Module 1:** **Basic Theory**. Introduction to molecular modelling; Summary of classical mechanics: conservation laws, Hamiltonian and Lagrangian formulation; Failures of classical mechanics, Basic concepts in quantum mechanics: physical observables and operators, expectation values, Schrödinger's equation, Heisenberg's uncertainty principle; The many-holly Hamiltonian, Born-Oppenheimer approximation, variational principle, the concept of the potential energy surface. Ensembles arid statistical averaging. Simple numerical problems to illustrate some of these concepts. *(8 lectures + 2 computing sessions)*
- **Module 2:** **Quantum Chemical Calculations.** Hartree-Fock (HF), Post Hartree-Fock approaches and DFT; Basis-sets and Pseudo-potential. Applications and hands-on experience with commercial software like Gaussian, VASP or CP2K. *(8 lectures + 2 computing sessions)*
- **Module 3:** **Molecular Dynamics and Monte Carlo Simulations.** Introduction to Molecular Mechanics; Force-fields; Basics of Molecular Dynamics Simulation; Minimum image convention, Ewald summation, Thermostats and Barostats; Introduction to Monte Carlo Methods. Applications and hands-on experience with commercial software like Lammps or Gromacs. *(8 lectures + 2 computing sessions)*
- **Module 4:** **Meso-scale and Rare-Event Simulation methods.** Coarse-grained Modeling Methods; Rare-event simulation techniques like meta dynamics and umbrella sampling. Applications and hands-on-experience on commercial software. *(8 lectures + 2 computing sessions)*

Proposed Textbooks

While there are several excellent books covering these methods, there is no single book that covers all the topics mentioned in this course. The contents of this course will be drawn from several texts and research papers which will be distributed as handouts. Some o1 the texts which will be used are:

1. Jensen, Frank. Introduction to computational chemistry. John Wiley & sons, 2017.
2. Cramer, Christopher J. Essentials of computational chemistry: theories and models. John Wiley & Sons, 2013.
3. Frenkel, Daan, and Berend Smit. Understanding molecular simulation: from algorithms to applications. Vol. 1. Elsevier, 2001.
4. Allen, Michael P., and Dominic J. Tildesley. Computer simulation of liquids. Oxford university press, 2017.

Proposer's Name and Signature	This course is Recommended	This course is approved/not approved
Dr. Vishal Agarwal	**Convener, DPGC SEE ( )**	**Chairman. SPGC**

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

SEE611: Energy Systems: Modelling and Analysis

Course Objectives:
Application of fundamental physics principles for developing and solving; realistic steady state and dynamic models for renewable energy systems towards operating process performance prediction and robust process design.

Expected Learning Outcomes:
This course will enable the students to develop realistic non-linear models (steady state and dynamic) for energy systems such as heat exchange equipment (boilers, coolers, heat exchangers etc.), power cycles, PV systems, Wind energy system, fuel cells, energy economics and intend to develop the ability to numerically solve the models for meaningful performance and design simulations.

Prerequisite(s) for the course: Approval of Instructor

Schedule: **T, F: 15:30-16:45**

Venue: T206

Course outline:
Solar thermal systems- Power Generation (including ORC), heating and cooling applications; Class conservation, energy conservation, momentum conservation, equilibrium thermodynamics, mechanics. Heat exchanger (e.g. boiler, feed-water heater, condenser), thermal energy storage,

Wind energy systems: wind-turbine, generator, and system integration, wind turbine for power generation and irrigation

Solar PV systems: Energy economics- Cash flow models, Net present value, Solar PV modelling, I-V characteristics, maximum power point tracking, sizing of stand-alone and grid connected PV system, Discussion on practice problems on all topics

Topic-wise lecture schedule:

Topic	Instructor	Schedule	Number of lectures
Solar thermal systems	Laltu Chandra	January 7 – February 7	10
Wind Energy systems	Ashoke De	February 11 – February 20	3
	Ashoke De	March 4, 7, 18, 21	4
Project presentations	Laltu Chandra	March 25	1
Solar PV systems	Prabodh Bajpai	March 28 – April 23	8

Mid-semester Examination: February 21 – 28, 2025 (Friday – Friday)
Mid-semester Recess: March 8 – 16, 2025 (Saturday – Sunday)

Textbooks, reference books, suggested readings and any other references:

- Thermodynamics: An Engineering Approach by M. A. Boles and Y. A. Cengel
- Powerplant Technology: M. M. El-Wakil
- Wind Energy Explained: Theory, Design and Applications - J. F. Manwell, J. G. McGowan, A. L. Rogers, Wiley
- Handbook of Photovoltaics Science and Technology, Antonio Luque Steven Hegedus
- Renewable and efficient electric power systems, G.M. Masters, John Wiley & Sons
- Electrical Power System Essentials, Pieter Schavemaker and Lou van der Sluis, Wiley,

SEE612: Manufacturing of energy systems
Department of Sustainable Energy Engineering, IIT Kanpur

1. **Instructor: Dr. Sayan Kar, Vivek Verma**

2. **Objectives:**

Energy harvesting, conversion, and storage systems such as solar photovoltaics, fuel cells, batteries, and supercapacitors constitute an essential element for realizing the vision of reliable and economically sustainable energy. It is imperative to develop these systems, which will not only assist in the efficient utilization of renewable energy but also in the successful transition to electric vehicles. The proposed course intends to provide an understanding of the manufacturing of these aforementioned energy harvesting and storage solutions. Students will study the fundamentals of various fabrication processes that are commonly applied to manufacture these energy devices. The course will impart to students an in-depth perspective about the benefits, challenges, their possible solutions for the fabrication of these devices. This course will also explore the scalability of these processing techniques from lab-scale to pilot to commercial level.

3. **Course Contents**

Topic	**Lectures**
Introduction	4
Silicon Processing and refining	5
Solar cell manufacturing: Crystalline Si ingot growth, slicing of ingots, Wafer processing, Diffusion/Ion implantation, Screen printing of contacts, wiring of contacts, encapsulation, Glass cover, Al frame incorporation. Module Manufacturing process,	10
Battery manufacturing: *Batteries*: Types, working principle, basic concepts, components *Batteries* - Current Trends in Battery Manufacturing, Coin Cells, Pouch Cells and Cylindrical Cells, Conventional Rechargeable Batteries with Liquid Electrolyte, Active & Passive Electrode Components, Electrode Coating, Calendaring and Assembly of Prototype Coin Cell, Assembly of pouch cells, Solid-State Batteries and Metal-Air Batteries.	10
Fuel cell manufacturing: *Fuel cells*: Types, working principle, basic concepts, components *Proton exchange membrane Fuel Cells*- Configurations, Fabrication of Electrolyte-supported, Anode, cathode, membrane.	8
General semiconductor manufacturing techniques: Lithography, dry etching, wet etching, magnetron sputtering, electroplating, Oxide growth.	3
TOTAL	**40**

4. Books and references:

- *Handbook of Photovoltaic Science and Engineering,* Antonio Luque and Steven Hegedus, Wiley; 2003.
- *Solar Cells: Materials, Manufacture and Operation*, Augustin McEvoy, L. Castaner, Tom Markvart, Academic Press; 2012.
- *Semiconductor Materials for Solar Photovoltaic Cells*, M. Parans Paranthaman, Winnie Wong-Ng, Raghu N. Bhattacharya, Springer Nature; 2016
- *Ceramic Processing & Sintering,* M. N. Rahaman, CRC Press; 2nd Edition 2003.
- *Advanced Batteries: Materials Science Aspects,* Robert Huggins, Springer; 2009.
- *Lithium-ion Battery Materials and Engineering,* Malgorzata K. Gulbinska, Springer; 2014.
- *Lithium Batteries Science and Technology,* Christian Julien, Alain Mauger, Ashok Vijh, Karim Zaghib, Springer Cham; 2016

	Department of Sustainable Energy Engineering Indian Institute of Technology Kanpur

Proposal for Course Modification

Course Title	**Solar Photovoltaics**
Number	SEE-613
Credits (L-T-P [C])	3-0-0-9
Departments proposing the course	Sustainable Energy Engineering
Name of the Proposer(s)	Rajeev Jindal & Sudarshan Narayanan
Offered for	PG Students of SEE and other departments or programs 3/4'" year UG students.
Status of the course	: PG Elective/ UG Elective
Prerequisite(s) for the course	Consent of Instructor / SEE-602 / completion of any other course on introductory solid-state physics and semiconductors
Other faculty members interested in teaching	: Ashish Garg
Other Departments/Programmes of whose the students are expected to take up the course	: MSE, MSP, PHY, EE, ME, CHE, CHM

Course Objectives

The course aims to help students understand the physics and application of solar photovoltaics, which is the fastest growing source for renewable energy generation. The course reviews the basic semiconductor physics of photovoltaic materials and various structures in which these devices can function. It also covers the various generations of solar cells, including the device structure, manufacturing, and application aspects. Finally, it delves into the various stages of cell to module to system development, associated operational issues, and their potential solutions

Expected Learning Outcomes

The students will be able to understand the working principle of solar photovoltaics, its dependence on radiation, material processing, device fabrication, etc. The students will be able to learn how to characterize the solar cells and how to utilize them in the end application. They will also be able to understand the practical issues concerning degradation, and other field issues. The course should help the students who are willing to learn about this field, and guide them in appropriately identifying topics of interest for future research.

Course outline

Introduction to solar cells: Solar spectrum, concept of airmass, history of solar cells, economics, current status, emerging technologies and recent development.

P-N junction: Energy band diagram, Operation of p-n junction in forward and reverse bias, depletion width, drift-diffusion currents, I-V characteristics of P-N junction in dark and under illumination.

characterization of solar cell devices: Open circuit voltage, short circuit current, fill factor, efficiency, quantum efficiency, Equivalent circuit of solar cell, series anal shunt resistance, diffusion length, effect of recombination processes.

Brief overview of different types of solar cells: First generation technologies: Primarily Si based, Second generation *technologies* (low cost) thin films (a Si, CdTe, CIGS), Third generation (high efficiency and low cost) Organic solar cells, multi junction, Perovskite solar cells, Comparative Performance, PV Processing with emphasis on migration from solar cells to modules to systems, present status and future outlook.

Field Application: Enhancing capacity utilization factor (tracking), optical performance, effect of dust and possible mitigation strategies, system design, and related software. Module recycling and concept of material circularity.

Lecture wise breakup

Topics	No. of lectures (approximate)
Introduction to Solar cells / Introduction and motivation, including solar policy in India	2
Solar radiation and angles	2
Basics of Semiconductors, Recap of Semiconductors with emphasis on R-G Centers	4
Work-function and Junctions a) Metal–semiconductor interface b) Semiconductor i. P-N ii. P-i-N iii. P-N heterojunction	6
Characterization of solar cell devices	5
Brief overview of different types of solar cells a) First-generation technologies: Primarily Si-based and GaAs (Including Si cell manufacturing aspects and issues) b) Second-generation technologies: thin films (a-Si, CdTe, CIGS) c) Third generation: Organic solar cells, Perovskite solar cells d) Multi-junction and tandem solar cells	11
Enhancing solar cell / module performance: • Light management • Trackers	3
Solar Cells to modules to systems and related software	3
Field Issues, module recycling, material sustainability	3

Textbooks, reference books, suggested readings, and any other references:

• Robert F. Pierret, Semiconductor Device Fundamentals, Pearson
• Jenny A. Nelson, The Physics of Solar Cells, World Scientific Publishing Company
• Luque and Hegedus, Handbook of Photovoltaic Science and Engineering, John Wiley Publications
• S.M. Sze, Physics of Semiconductor Devices, Wiley
• Ben G. Streetman, Solid State Electronic Devices, Prentice Hall India
• Reviews and journal articles

Course Proposed By	Recommended/ Not recommended	This course is approved/ Not approved
(Rajeev Jindal) (Sudarshan Narayanan)	Convenor, DPGC (SEE)	Chairman, SPGC

Proposal for a New Course

Course Title	Wind Energy
Number	SEE-6I4 (proposed)
Credits (L-T-P [C])	3-0-0-9 [9]
Departments proposing the course	Sustainable Energy Engineering
Name of the Proposer	Debopam Das
Offered for	PG Students of SEE 3/4''' year UG students and PG students of other departments
Status of the course	PG Elective/ UG Elective
Prerequisite(s) for the course	Consent of Instructor
Faculty members interested in teaching	Debopam Dan, Ashoke De
Other Departments/Programmes of whose the students are expected to take up the course	ME, AE, CE

Course Objectives:
The objective *of this* course is to train PG students with an overview of wind Energy and its importance in green energy generation. The course will highlight the importance of wind energy through historical perspective and relevance in present days. Fundamental science and engineering aspects of harvesting wind energy is the focus of the course.

Course outline:
Review of basic concepts of fluid mechanics, Introduction to wind energy, Fundamentals of wind power-How wind is generated, overview of wind meteorology, Estimation of wind energy potential, History of wind energy harnessing methods, Wincl turbine technology, Fundamentals of Horizontal axis wind turbine and its design, Vertical axis wind turbine, Other wind harnessing methods.

Lecture wise breakup:

Topic	No. of lectures
Introduction and Review of basic concepts of fluid mechanics	5
Introduction to wind energy: Climate change anal need, Advantages of wind energy, Potential of Wind Energy worldwide	1
Fundamentals of wind power: *How* wind is generated, overview of wind meteorology, Wind power capture and efficiency in extracting wind power	2
Estimation of wind energy potential:—Estimating wind speed and power, wind resource estimation - Scope and methods	2
History of wind energy harnessing methods and applications: Historical developments, Applications	2
G1oba1 arid Indian Potential of Wind Energy: G1obal perspective, Indian perspective	2

Wind Turbine Technologies: Overview, Aerodynamics of wind turbines: general overview, Transmission and power generation systems, Controls and safety of wind turbines, Fixed speed and variable speed wind Turbines, Off-shore Wind Turbines: Dimensional Analysis anal Scaling laws	6
Horizontal Axis wind Turbine: Working principle, Aerodynamics of HAIVT: Momentum methods, Strip theory, Blade Element Momentum (BEM) method to model the aerodynamic forces on a rotor, Alternative aerodynamic models for rotors, Effects of atmospheric turbulence, Experimental methods for design and power estimations, Safety and Environmental impact	12
Vertical Axis Wind Turbine: Working principle: Lift Vs Drag based VAWT, Power coefficient, VAWT Design: Aerofoil choice, geometric, kinematic and dynamic design parameters, Experimental methods for power estimation, Safety and applicability	5
Small Scale Wind Turbines: Micro-Turbines, Building arid Pole mounted turbines	3
Total number of lectures	40

Text-books, reference books, suggested readings and any other references Text:

- Wind Turbine Technology — David A Spera, ASME Press
- Wind Energy Engineering — T M Letcher, Academic Press
- Wind Energy Explained: Theory, Design and Applications - J. F. Manwell, J. G. McGowan, A. L. Rogers, Wiley

Ref Books:

- Fluid Mechanics — F. M. White, Mcgraw-Hi11
- » Wind Tunnel Designs and Their Diverse Engineering Applications, N A Ahmed (Ed.) InTech
- Small-Scale Wind Power — John Abraham ñ Brian Plourde, Momentum Press

Course proposed by	**Recommended/** ~~Not recommended~~	This course is approved/not approved
(Debopam Das)	Convener, DPGC (SEE)	Chairman, SPEC

Department of Sustainable Energy Engineering Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	Solar Thermal Engineering
Course No.	SEE-615 (proposed)
Credits (L-T-P [C])	(3-0-0-9) 9 Credits
Department proposing the course	Sustainable Energy Engineering
Name of the Proposer	Jishnu Bhattacharya and Vaibhav Arghode
Offered for	PG Students of SEE and other departments. 3/4th year UG students of other departments.
Status of the course	PG Elective/ UG Elective
Prerequisite for the course	Consent of the Instructor Desirable: Undergraduate Thermodynamics (y ESO21A)
Faculty members interested in teaching	MK Das, S Khandekar
Other Departments/Programmes of whose the students are expected to take up the course	SEE, CIE, ChE, MSE

Course Objectives and Expected Learning Outcomes

This course focuses on the thermal conversion and storage routes for solar energy. In the first section, it will expose the students to the basics of solar radiation, its availability, estimation and the factors which affect them. In the next section, the major solar heat collection devices will be analyzed with the particular focus on the engineering design aspects. In the last section, the utilization of the collected heat in energy conversion, refrigeration etc. will be discussed along with the storage technologies.

Course Contents

Solar radiation, reckoning of time, extraterrestrial radiation, relevant angles, factors influencing intensity, estimation of intensity on a tilted phone, prediction of avai1abi1ity, solar thermal collectors, flat plate collectors, compound par‹tbo1ic concentrator, parabolic trough and parabolic dish, Fresnel lens based concentrators, central receiver tower, thermal analysis of collectors, effect of sum tracking, performance tests for collectors, thermal route to solar power, active and passive heating systems, absorption cooling devices, solar dryers, solar desalination systems, solar pond, sensible and latent thermal energy storage systems, economic analysis of solar thermal systems, sustainable habitat

Lecture Outline

S. No	Broad Title	Topics	No. of **Lectures**
1.	Solar radiation	Solar time and clock time, earth sun angles, observer specific angles, incidence angle on a general plane, sun path diagram, determination of shallow profile, wave spectrum of solar radiation, thermal and optical contribution, radiation exchange between surfaces, extraterrestrial radiation, atmospheric attenuation, data of measured and estimated solar radiation	9
2.	Solar thermal collectors	Flat plate collector, compound parabolic collector, evacuated tube collector S, Sun tracking concentrating collectors, parabolic trough, parabolic dish, Fresnel collectors, second-law analysis	9

3.	Performance analysis of collectors	Collector thermal efficiency. effect of flow rate, series and parallel configuration, Effect of sun tracking, collector *time* constant, performance testing, high temperature test, thermal shock test, rain penetration test	4
4.	Applications of solar thermal energy	Thermosiphon, solar-thermal power systems, pool heaters, space testing and cooling, passive heating systems, solar cooling based on absorption refrigeration, solar dryers, thermochemical applications, solar desalination systems, direct and indirect collection systems	10
5.	Thermal energy storage	Solar pond, latent. heat storage with phase change materials, sensible heat storage and recovery, thermal analysis of the storage, integration and optimization of storage with solar thermal power systems	4
6.	SpecaTTopics (one or more will be covered)	• Economy of solar thermal systems -f-chart method, utilizability method, life cycle analysis • Equipment sizing based on radiation availability — case study • Sustainable. habitat — thermal aspects of net-zero building design	4

Text-books, reference books, suggested readings and any other references:

Textbook:
Solar Energy — Principles of T1ierma.1 Collection and Storage, SP Sukhatme, JK Nayak, third edition, 2008, McGraw Hill

Reference Books:

- Solar Engineering of Thermal Processes, Duffie and Beckman, fourth edition, 2013, Wiley Publication
- Solar Energy Engineering — Processes and Systems, SA Kalogirou, first edition, 2009, Academic Press
- Solar Energy — Garg and Prakash, McGraw-Hill Education, 1st revised edition, 2019

Course proposed by	**Recommended/** ~~Not recommended~~	This course *is* approved/not approved
(Jishnu Bliattacharya and Va.i1›hav Arghode)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for Revised Course

Course Title	:	Renewables Integrated Smart Power Systems
Course No.	:	SEE-616
Credits (L-T-P [C])	:	(3-0-0-0) 9 Credits
Department proposing the course	:	Sustainable Energy Engineering
Name of the Proposer	:	Prabodh Bajpai
Offered for	:	PG Students of SEE and other departments. 3/4th year UG students of other departments.
Status of the course	:	PG Elective/ UG Elective
Prerequisite for the course	:	SEE603 or Consent of the Instructor
Course objective and contents	:	Enclosed
Faculty members interested in teaching	:	Amarendra Edpuganti, Abheejeet Mohapatra
Other Departments/Programmes of whose the students are expected to take up the course	:	All Engineering Departments in Campus

Course Objectives

This course intends to familiarize students with the concepts of power systems operation, application of power electronics interfaces, and operation of electricity markets in smartgrid that are essential for better understanding of challenges to integrate Renewable energy sources and operate the power system in smartgrid environment.

Expected Learning Outcomes

A student, after doing this course, will be able to appreciate the optimal operation of the power network and understand the challenges in the integration of Renewable energy sources. Further the transformation with the Electricity market and smartgrid technologies will be important learnings from this course.

Course outline and Lecture wise breakup

- Introduction to power system structure, smart grids, Global and Indian energy scenario, etc. (2 Lectures)
- Transmission line parameter and models (4 Lectures)
- Power flow analysis and optimal operation: per unit analysis, network model, power flow problem and methods, (8 Lectures)
- Unit commitment, scheduling, economic dispatch (8 Lectures)
- Issues in renewable integration to power system (8 lectures)
- Smartgrid: Ancillary services, Demand side management, Resiliency (6 lectures)
- The total number of lectures is 36 of One Hour.

Text-books, reference books, suggested readings and any other references

1. Power System Analysis, John J. Grainger and William D. Stevenson, Jr., Tata McGrawHill.
2. Power System Analysis and Design, J. Duncan Glover, M. Sarma and Thomas J. Overbye: Thomson.
3. Power Electronics, Ned Mohan & Tore M. Undeland & William P. Robbins, Wiley
4. Power Electronics: Converters, Applications and Design, Mohan, Undeland and Robbins, Wiley.
5. Smart Grids– Fundamentals and Technologies in Electricity Networks, Buchholz, Bernd M., Styczynski, Zbigniew, Springer
6. Electrical Power System Essentials, Pieter Schavemaker and Lou van der Sluis, Wiley,
7. Operation and Control of Restructured Power Systems, K. Bhattacharya, M. J .H. Bollen and J. E. Daalder, Kluwer Academic Publishers
8. Renewable and efficient electric power systems, G.M. Masters, John Wiley & Sons

Course proposed by	**Recommended/Not recommended**	**This course is approved/not approved**
(Prabodh Bajpai)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for Course Modification

Course Title		Introduction to Sustainable Energy Policy
Number		SEE-617
Credits (L-T-P [C])		3-0-0-9
Departments proposing the course	:	Sustainable Energy Engineering
Name of the Proposer	:	Deepika Swami, Rajeev Jindal
Offered for		PG Students of SEE and other departments 3/4th year UG students of other departments
Status of the course	:	PG Elective/ UG Elective
Prerequisite(s) for the course	:	Consent of Instructor
Faculty members interested in teaching	:	Deepika Swami, Rajeev Jindal, Sheo Shankar Rai, Indu Shekhar Chaturvedi, Anna Agarwal
Other Departments/Programmes of whose the students are expected to take up the course	:	ME, EE, CHE, MSE, AE, IME, ECO

Objective

The course will introduce different aspects of energy policy including energy resources, energy security, energy efficiency, energy justice, energy transition, integration of energy policy with climate governance, challenges and opportunities associated with coal and renewable energy. One of the major requirements is that energy policy should be aligned towards our development and rapid economic growth. Policymakers have predominately relied on policy instruments that utilize price mechanisms to deploy sustainable energy without giving much consideration to security and transition concerns and larger geopolitical questions of who owns the energy system, and how the energy needs to be generated and distributed.

Expected learning Outcomes

The students completing this course will be equipped with the theoretical and analytical abilities to examine the nuanced relationship between energy policy and climate change and how the transition towards sustainable energy systems will change the overall scenario of energy system. They will understand the role of various policy instruments and institutions in shaping India’s energy policy. The course will develop analytical and critical thinking and introduce new perspectives about energy, environmental and climate policies at global and national level and will give a new dimension to their innovative thinking, motivating them to come up with policy relevant technical solutions in the field of sustainable energy.

Course outline

The course begins with providing an overall context about the history of energy system and introduction of India’s energy landscape. Next, it focuses on understanding energy security, geopolitical factors important to achieve energy security for India. Following this, we will understand the production, generation and distribution of various energy resources and the instruments that can help in achieving smooth transition from fossil-based sources to renewable energy. Lastly, we will understand how global climate governance and commitments will shape India’s energy future.

Lecture wise breakup

S.No.	Topics	Lectures
1.	**Overview of the Indian Energy Scenario:** • Historical Development of India's and Global Energy Sector • Introduction to India's Energy Landscape: Energy Production, Demand, Supply, and Consumption Patterns • Linking energy and environment: Emissions, Emission factor, Role of energy, Kaya identity and need for energy transition	6
2.	**Energy security, and formulation of energy policy** • India's energy landscape: growth and challenges • Energy security: challenges and role of policies • Formulation of energy policy: Major stakeholders and process involved	6
3.	**Conventional energy sources and Indian energy portfolio** • Role of Fossil fuel sources: Role of coal, oil and gas in India's energy mix, including production, energy generation, environmental implication. Policy scenario and how is it evolving? • Indian economy and dependence on coal: Political economy of coal • India's energy management system – roles of GENCO, TRANSCO, DISCOM • Electricity act and its development	10
4.	**India's energy transition and various policy initiatives** • Drivers of energy transition: Environmental, Social, Economic, and Technological Factors • Growth of non-fossil based: Wind, Solar, Bioenergy, Tidal, Geothermal. Current status and policy support. • Driving demand and generation growth through policy framework: RPO, GEOA, roof top solar, PM-KUSUM Yojna, NBP, PMUY, CAFC, EBP, EV, • Regulatory institutions (MNRE, SERC, BEE, CEA etc.) • Economics of energy generation and distribution: Feed-in Tariffs, PPAs, Tax Incentives, Subsidies, Grants, Carbon Pricing, Cap-and-Trade Systems, and Emission Trading Schemes • Integration of renewables in grid: policy framework • India's energy policy for critical minerals for renewable energy	10
5.	**Indian energy policy and global climate governance** • National and international missions: UNFCCC, COPs, NPACC, NCAP • India's commitments and agreements (Kyoto, Paris, Glasgow) • India's efforts in integrating renewable energy policies with climate change mitigation strategies • Future of energy generation in context of climate change	8

References

Books

1. Gupta, J. (2014). Handbook of Climate Change and India: Development, Politics and Governance.

2. Laird, F. N. (2004). Power politics: equity and environment in electricity reform: Washington, DC: World Resources Institute, 2002. xv+ 175 pp. Paperback. $30.00. Utilities Policy, 12(1), 51-51.

Papers

Chapman, A.J., McLellan, B.C., Tezuka, T., 2018. Prioritizing mitigation efforts considering co-benefits, equity and energy justice: Fossil fuel to renewable energy transition pathways. Appl. Energy 219, 187–198. https://doi.org/10.1016/j.apenergy.2018.03.054

Dubash, N.K., Ghosh, S., 2019. National Climate Policies and Institutions. India a Warm. World 329–348. https://doi.org/10.1093/oso/9780199498734.003.0019

Dubash, N.K., Joseph, N.B., 2016. Evolution of Institutions for Climate Policy in India. Econ. Polit. Wkly. 51, 44–54.

Fischer, F., Miller, G.J., 2017. Handbook of public policy analysis: theory, politics, and methods. Routledge.

Hirth, L., 2013. The market value of variable renewables. The effect of solar wind power variability on their relative price. Energy Econ. 38, 218–236. https://doi.org/10.1016/j.eneco.2013.02.004

International Energy Agency, 2020. India 2020: Energy Policy Review, International Energy Agency. https://doi.org/10.1007/BF03404634

Keady, W., Panikkar, B., Nelson, I.L., Zia, A., 2021. Energy justice gaps in renewable energy transition policy initiatives in Vermont. Energy Policy 159, 112608. https://doi.org/10.1016/j.enpol.2021.112608

Kumar, G.S., 2017. Anatomy of Indian energy policy: A critical review. Energy Sources, Part B Econ. Plan. Policy 12, 976–985. https://doi.org/10.1080/15567249.2017.1336814 NITI Aayog, 2017. Draft National energy policy, NITI Aayog.

Patlitzianas, K.D., Doukas, H., Kagiannas, A.G., Psarras, J., 2008. Sustainable energy policy indicators: Review and recommendations. Renew. Energy 33, 966–973. https://doi.org/10.1016/j.renene.2007.05.003

Shukla, P.R., Chaturvedi, V., 2012. Low carbon and clean energy scenarios for India: Analysis of targets approach. Energy Econ. 34, S487–S495. https://doi.org/10.1016/j.eneco.2012.05.002 Tongia, R., Gross, S., 2019. Coal in India: Adjusting to Transition. Brookings Pap. 7

Course proposed by	**Recommended/ Not recommended**	**This course is approved/not approved**
(Deepika swami)	Convener, DPGC (SEE)	Chairman, SPGC
(Rajeev Jindal)		

Modidifed course vs. present course: Revised course looks at the energy policy in a more holistic manner, with consideration of various dimensions including, energy resources, their exploration, production, generation along with the broad range of policy initiatives related to both renewable and non-renewable energy, which were found to be missing in the earlier version of the course. Thereby, this course is more comprehensive in nature and focuses on integrating technological, environmental, economic and social aspects with energy policy.
The revision in course content is > 50%

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course title	:	Energy Efficient Building Design
Number	:	SEE-618A
Credits (L-T-P [C])	:	3-0-0-9
Departments proposing the course	:	Sustainable Energy Engineering
Name of the proposer	:	Aakash Chand Rai
Offered for	:	PG Students of SEE/other departments or programs 3/4th year UG students
Status of the course	:	PG Elective/ UG Elective
Prerequisite(s) for the course	:	Consent of instructor
Faculty members interested in teaching	:	Faculty members of ME and CE
Other departments/programmes of whose the students are expected to take up the course	:	ME and CE

Course objectives

The objective of this course is to equip the students with a fundamental understanding of buildings' thermal behaviour. The students will then be introduced to the design and analysis of air-conditioning systems for maintaining comfortable and healthy indoor environments. Finally, the course will focus on building energy simulation, climate impact assessment, and sustainable design practices.

Expected learning outcomes

The students will be able to understand the thermal behaviour of buildings and perform detailed design and analysis of air-conditioning systems. They will be able to conduct building energy simulations and climate impact analysis. They will also be able to appreciate green and sustainable building practices.

Course outline

Energy use in buildings: Building sector's energy usage and associated greenhouse gas emissions.

Air-conditioning systems and psychrometry of air-conditioning processes: Common air-conditioning systems, moist air processes and their combinations used for air-conditioning.

Thermal comfort, indoor air quality, and indoor infection transmission: Physiological considerations in comfort, environmental comfort indices, comfort conditions, indoor air quality concerns, common air pollutants and their control, airborne infection transmission: causes and mitigation techniques.

Heating load: Steady-state building heat transfer, indoor and outdoor design conditions, heating load calculation.

Solar radiation: Earth's motion about the sun, time, solar angles, solar irradiation, heat gain through fenestration.

Cooling load: Heat gain, cooling load, heat extraction rate, indoor and outdoor design conditions, cooling load calculation.

Energy calculations and building simulation: Degree day method, weather files, software tools for energy simulation.

Implications of climate change on building energy use: Emission trends and drivers, representative concentration pathways, future weather files, climate resilience.

Energy efficient and sustainable building practices: Green buildings, passive solar architecture, sustainable construction practices, case studies.

Lecture-wise breakup

Topics	# of lectures (approximate)
Energy use in buildings	2
Air-conditioning systems	2
Psychrometry of air-conditioning processes	4
Thermal comfort, indoor air quality, and indoor infection transmission	4
Heating load	3
Solar radiation	4
Cooling load	6
Energy calculations and building simulation	4
Implications of climate change on building energy use	4
Sustainable and energy-efficient building practices	8
	41

Text-books, reference books, suggested readings and any other references

- Heating Ventilating and Air Conditioning – Analysis and Design by McQuiston, Parker, and Spitler
- ASHRAE Handbook—Fundamentals
- Buildings. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
- Green Building – Guidebook for Sustainable Architecture by Bauer, Mösle and Schwarz
- Refrigeration and Air-conditioning by C P Arora

Course proposed by **Recommended/Not recommended** **This course is approved/not approved**

(Aakash Chand Rai) Convener, DPGC (SEE) Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course title	:	Finite Volume Methods for Engineers
Number	:	SEE-619
Credits (L-T-P [C])	:	3-0-0-9
Departments proposing the course	:	Sustainable Energy Engineering
Name of the proposer	:	Ashoke De
Offered for	:	PG Students of SEE/other departments or programs 3/4th year UG students
Status of the course	:	PG Elective/ UG Elective
Prerequisite(s) for the course	:	Consent of instructor
Faculty members interested in teaching	:	Faculty members
Other departments/programmes of whose the students are expected to take up the course	:	

Course objectives:

Introduction, Governing equations and general scalar transport equation, Mathematical classification of PDEs, Mesh terminology and types, Discretization methods; Solution of discretization equations, Accuracy, consistency, stability and convergence, 2D steady and unsteady problems, BC; Errors and stability analysis; Diffusion in orthogonal and non-orthogonal meshes, Gradient calculation and discussion, Direct Vs Iterative solvers; Data-structures, TDMA, Jacobi and gauss-seidel methods; General iterative solvers; Multigrid methods, 2D convection-diffusion problems: steady, unsteady, BC; Convection-diffusion in non-orthogonal meshes, Accuracy of discretization schemes Higher order schemes and Discussion, Discretization of governing equations; BC and solution methods; Staggered and collocated formulations, Pressure-velocity coupling: SIMPLE, SIMPLER, Pressure-velocity checker-boarding Solution algorithms, Turbulence modeling; Boundary conditions and applications

Course proposed by	**Recommended/Not recommended**	**This course is approved/not approved**
(Ashoke De)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

1. Course No: **SEE620**

2. Course Title: **Heat Driven Cooling Systems**

3. Per Week Lectures: **3** (L), Tutorial: **0** (T), Laboratory: **0** (P), Additional Hours[0-2]: **0** (A), Credits (3*L+2*T+P+A): **9** Duration of Course: **Full Semester**

4. Proposing Department/IDP : **Sustainable Energy Engineering**

   Other Departments/IDPs which may be interested in the proposed course: **ME, CHE**

   Other faculty members interested in teaching the proposed course: **Dr. Jishnu Bhattacharya**

5. Proposing Instructor(s): **Dr. Vaibhav Arghode**

6. Course Description:

A) Objectives:

Heat driven cooling systems obviate the use of mechanical compression of refrigerant vapor thus considerably saving the high-grade mechanical energy. The low-grade input heat, can be derived from non-concentrating solar collectors, industrial process waste heat or engine exhaust. In this course, we will discuss four such technologies, viz. Absorption, Adsorption, Desiccant-Evaporative and Ejector based systems. The fundamental concepts, and design, operation and performance of these systems will be covered.

B) **Contents: considering the duration of each lecture is 50 minutes** (*preferably in the form of 5 to 10 broad titles)*:

Sr. No.	Broad Title	Topics	No. of Lectures
1.	**Introduction**	• Conventional vapor compression refrigeration system • Introduction to heat driven cooling systems	2
2.	**Absorption cooling**	• Absorption cycle fundamentals • Properties of working fluids • Thermodynamic processes with mixtures • Water/Lithium Bromide system • Ammonia/Water system	18
3.	**Adsorption cooling**	• Fundamental principle of adsorption refrigeration • Mechanism and thermodynamics of adsorption • Adsorption working pairs • Adsorption refrigeration cycle and systems	12
4.	**Desiccant evaporative cooling**	• Operating principle of desiccant evaporative cooling • Solid and liquid desiccant technology	4
5.	**Ejector based cooling**	• Working principle and flow physics of ejectors • Ejectors as components of refrigeration systems	4
		Total lectures	**40**

C) Recommended pre-requisites, if any (*examples: a- PSO201A,or b- PSO201A or equivalent*):

Undergraduate thermodynamics, fluid mechanics, heat and mass transfer

D) Short summary for including in the Courses of Study Booklet:

Absorption refrigeration cycle, thermodynamic properties and processes with mixtures, water/lithium bromide system, ammonia/water system. Principle of adsorption cooling, adsorption phenomena, adsorption refrigeration systems. Operating principle of desiccant evaporative cooling. Solid and liquid desiccant technology. Working principle of ejectors. Ejectors as components of refrigeration systems.

7. Recommended text / reference books:

-Absorption Chillers and Heat Pumps, K. E. Herold, R. Radermacher, S. A. Klein, 2nd Edition, CRC Press, 2016.
-Adsorption Refrigeration Technology, R. Wang, L. Wang, J. Wu, Wiley, 2014.
-Desiccant Assisted Cooling, C. E. L. Nobrega, N. C. L. Brum, Springer, 2014.
-Ejectors for Efficient Refrigeration, G. Grazzini, A. Milazzo, F. Mazzelli, Springer, 2018.

8. Any other remarks: **NA**

Dated: **28/12/21**________ Proposer: **Dr. Vaibhav Arghode**________

Dated:________________ DPGC Convener:________________________

The course is approved / not approved

Chairman, SUGC/SPGC

Dated:

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	:	Biomass Conversion and Biorefineries
Number		SEE621
Credits (L-T-P-A)		3-0-0-0 [9]
Departments proposing the course	:	Sustainable Energy Engineering
Name of the Proposer	:	Dr. Anand Singh/ Dr. Raju Kumar Gupta
Offered for		PG Students of SEE and other departments 3/4th year UG students of other departments
Status of the course	:	PG Elective/ UG Elective
Prerequisite(s) for the course	:	Consent of Instructor
Faculty members interested in teaching	:	Dr. Anand Singh Dr. Raju Kumar Gupta
Other Departments/Programmes of whose the students are expected to take up the course	:	CHM, BSBE, CHE

Course Outline and Objectives

The overarching goal of this course is to focus on renewable feedstocks for the chemical industry. The transition from petroleum-based chemicals to a biomass-based production system will be the central theme with a special focus on carbohydrate based bio-feedstocks. Contents include introduction to biomass structure and classification, classical methods of carbohydrate chemical conversions and the evolution of such technologies during the rise (and fall) of oil as an inexpensive commodity. Biorefineries, biochemical and chemical conversions leading to bioethanol, biobutanol and other downstream products. Chemicals from ethanol and ethylene. Valorization of sucrose, oxidation, esterification, sucrose-derived urethanes, polymerizable sucrose derivatives, conversion to isomaltulose. Valorization of glucose, preparation of sorbitol, citric acid, lactic acid, acetic acid, alkylpolyglucosides (APG's). PLA preparation (methods, industrial production). Sugar derived polyamides and polyesters. LCA and TEA analysis.

Lecture wise breakup

Topics	***Lectures***
Introduction to fundamental concepts of biomass structure, sources, classification, feedstocks, applications towards the generation of energy and chemicals/commodities.	*4*
*Biomass conversion technologies, Biorefineries (*Classification, Products, and Processes) *and endproducts.* Biorefinery plant design, engineering and process optimisation (selected examples).	*6*
Platform chemicals, biochemical and chemical conversions, hydrolysis and fermentation, anaerobic digestion, trans-esterification.	*3*
Thermochemical conversion: combustion, gasification, pyrolysis, other technologies, scale-up, characterization, storage.	*5*
Bioethanol: Corn ethanol, lignocellulosic ethanol, microorganisms for fermentation, current industrial ethanol production technology, cellulases and their role in hydrolysis, concepts of SSF and CBP, pretreatment methods, advanced fermentation technologies, ABE fermentation pathway and kinetics, product	*7*

recovery technologies, fermentation technologies, LCA and TEA. Conversion to ethylene, propylene, butadiene, polyvinyl chloride and other products. Biobutanol.	
Conversion of biomass to furfural, Hydroxymethylfurfural (HMF), 2,5-Furandicarboxylic acid (FDCA), succinic acid, lactic acid, levulinic acid, 3-Hydroxypropionic acid (3-HP) and 3-hydroxypropionaldehyde (3-HPA), sorbitol, xylitol, isoprene, citric acid, lactic acid, acetic acid, alkylpolyglucosides (APG's) and other downstream chemicals and polymers. PLA preparation methods and industrial production. Process design for product separation and isolation.	*9*
Life Cycle Analysis: General understanding of LCA, cradle-to-grave, field to wheels concepts, goal and scope determination, defining LCA boundaries. Life cycle inventory, life cycle assessment as applicable to conversion of biomass to value-added commodities and associated challenges.	*3*
Sustainability: General principles, environmental sustainability, biorefineries & sustainability, economics of biorefineries, integrated biorefineries.	*3*
Total lectures	***40***

Text-books, reference books, suggested readings and any other references:

1) Valorization of Biomass to Value-Added Commodities: Current Trends, Challenges, and Future Prospects (Green Energy and Technology), Michael O. Daramola, Augustine O. Ayeni, Springer
2) Biomass for renewable energy, fuels, and chemicals. D.L. Klass, Academic Press.
3) Robert C. Brown, Biorenewable Resources: Engineering New Products from Agriculture. Wiley-Blackwell Publishing (Second Edition)
4) Industrial Microbiology by Prescott & Dunn
5) Shang-Tian Yang (Ed.), Bioprocessing for Value Added Products from Renewable Resources, Elsevier, 2007

Course proposed by	**Recommended/Not recommended**	**This course is approved/not approved**
Anand Singh/Raju K. Gupta	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	Sustainable Energy – Enabling Net Zero Emissions
Number	SEE-622A
Credits (L-T-P [C])	3-0-0-0 [9]
Department proposing the course	Sustainable Energy Engineering
Name of the Proposers	Anna Agarwal, Rajeev Jindal/ Deepika Swami (I)
Offered for	PG students, UG elective
Prerequisite(s) for the course	None
Faculty members interested in teaching	Faculty members of SEE, IME
Other Departments/Programmes of whose the students are expected to take up the course	ME, IME, CE, Eco

Objectives
This course aims to make students understand the importance of energy in achieving a carbon-neutral society, specifically in a country like India, where energy consumption is expected to increase drastically. The course will provide an overview of climate change: the underlying science, the threat posed by global temperature rise, the proposed policy solutions and international climate negotiations. The lectures will give students a detailed understanding of energy uses in different sectors and the urgent need for energy efficiency and low consumption patterns. Energy supply pathways and a comprehensive understanding of clean energy technologies will be taught. Important transition technology like CCUS is also covered in this course. This course will make students aware of the interventions which can eventually help in achieving Net Zero emissions.

Learning outcomes
Students will be able to understand the evolution of energy technologies and their correlations with broader climate change issues. They will become familiar with various aspects related to energy demand side management, including interventions needed in industries, transportation, and buildings. Students will also develop an understanding of supply-side interventions crucial for decarbonising the energy supply value chain. Finally, students will get hands-on experience in methods and tools commonly used to evaluate energy systems and climate change mitigation strategies.

Contents:

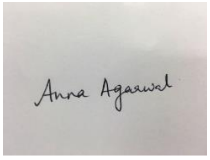
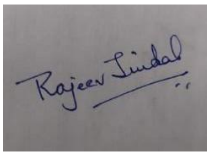
	Broad Topic	Detailed Contents	# Lectures (26 – 75 min. each)
1	Motivation& Introduction	Overview in Global and Indian context : • Evolution of humankind and the increase in Energy Demand • Rampant use of fossil fuels post-industrial revolution and Greenhouse gas emissions • Efforts on both the demand side and supply side – expected scenarios • Expected GHG trajectory linked to energy use	2
2	Climate Change	Understanding Climate Change: Science, Impacts and Mitigation Options • Historical evolution of global temperatures and greenhouse gas concentrations • Different GHG and their global warming potential • Regional distribution of CO2 and other GHG emissions: total and per capita • Sectoral contributions to GHG emissions • Natural sinks of GHG and Negative Emissions • Impacts of global temperature increase • Mitigation options and their economics	3 + 1
3	Energy Demand	• Importance of demand-side interventions to address climate change: Global and in India • Energy consumption trends: by region and by sector • Need for energy efficiency • Projections of energy demand under BAU and energy efficiency scenarios	1
	3.1 Industrial	• Role of industrial emissions • Major energy-consuming industrial sectors (Steel, cement etc.) • Emissions and fuel consumption • Energy efficiency interventions and BEE efforts • Demand projections, the role of technology and policies	1+1
	3.2 Transport	• Expected growth in the sector • Fossil fuel reliance and geo-political implications • GHG emissions and other pollutants • Mitigation plans for controlling emissions • Role of technologies and standards	1+1
	3.3 Buildings & Rural Demand	• Why focus on the built environment • Projected expansion in the built environment and appliance penetration: Urban and Rural • Rural demand projections and inefficiencies in energy use • The need for energy efficiency	3+1

		• Initiatives and Schemes by Government and Utilities: Opportunities and Barriers	
4	Supply	• Major sources of energy generation. • LCOE calculations • Carbon emissions from various sources • Expected scenarios – global and Indian • Role of growing renewables • Challenges	1
	4.1 Solar	• Solar as an energy source: various technologies and Relative Costs • Embedded carbon • Development over the years • Global Projections and India's potential • Expected challenges and barriers	2
	4.2 Wind	• Wind energy as an energy source: the potential and relative cost • Embedded carbon • Development over the years • Expected challenges and barriers	1
	4.3 Others	• Other major sources of renewable energy and their current status and expected movement: • Hydro • Nuclear • Geothermal • Biofuel • Hydrogen • Role of storage	2
5	Alternate Mitigation Strategies	The need for CCUS (carbon capture utilisation and storage) • The scale needed to achieve climate targets • Technology and storage options • Implementation examples • Bottlenecks to scale deployment	1
6	Net Zero and Global Climate Discussions	What do we mean by Net Zero? • Definition as per some standards • Relation of Net zero and COP commitments • Global Climate Negotiations • Social challenges	1+1+2

Books, Reading Material and Resources:

- Andrews, John, Nicholas Alfred Jelley, and Nick Jelley. Energy science: principles, technologies, and impacts. Oxford university press, 2022.
- Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change
- Dubash, Navroz K. An India in a Warming World: Integrating Climate Change and Development. Oxford University Press, 2019
- Emissions Gap Report 2022: The Closing Window — Climate crisis calls for rapid transformation of societies. United Nations Environment Programme, 2022.

- India Energy Outlook 2021, IEA, 2021.
- Net Zero by 2050, IEA, 2021.
- Tester, Jefferson W., Elisabeth M. Drake, Michael J. Driscoll, Michael W. Golay, and William A. Peters. Sustainable Energy: Choosing Among Options. 2nd edition. MIT Press, 2012
- World Energy Outlook 2022, IEA, 2022.
- More reference material will be prescribed during the course in various forms.

Course proposed by	Forwarded by	This course is approved/not approved
  (Anna Agarwal and Rajeev Jindal)	Convener, DUGC (SEE)	Chairman, SUGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course title	: Fuel Cell Electrical Energy Systems
Number	: SEE 623
Credits (L-T-P [C])	: 3-0-0-9
Departments proposing the course	: Sustainable Energy Engineering
Name of the proposer	: Amarendra Edpuganti
Offered for	: PG Students of SEE/other departments or 3/4th year UG students
Status of the course	: PG Elective/UG Elective
Prerequisite(s) for the course	: Consent of Instructor
Faculty members interested in teaching	: Prabodh Bajpai and Suvendu Samanta
Other departments/programmes whose students are expected to take up the course	: EE, ME, CHE, MSE

Course objectives

This course will equip students with the basics of fuel cells, models and controllers, fuel cell power system architectures, power converter design, and control for a wide variety of fuel cell applications.

Expected learning outcomes

On completing the course, the student will be able to:

- Understand the basics of fuel cell operation and their electrical characteristics.
- Modeling of fuel cells and design of controllers
- Identify the appropriate converter topology for the fuel cell application.
- Power converter design and control for the fuel cell in vehicles, utility and stand-alone power systems, locomotives, and aerospace applications.

Course outline

1. Basics of fuel cells: Introduction, operation, types of fuel cells, and modeling.
2. Electrical characteristics of fuel cells: Electrical characteristics and efficiency in steady operation, dynamic operations with and without battery/ultracapacitor.
3. Modeling and controllers for fuel cells: Linear and non-linear models, dynamic model, linear and non-linear controller design.
4. Fuel cell power system architectures: Modular stack architecture, two-stage architectures, three-stage architectures, high-voltage variable dc bus architecture, low-voltage variable dc bus architecture, and fixed low-voltage variable dc bus architecture,
5. Power converters for fuel cell applications: dc to dc, dc to ac, interleaved converters, current-fed converters, and resonant dc-dc converters.
6. Transportation applications: configurations of automotive fuel cell systems, power demand and

efficiency, hybrid fuel cell vehicles, passenger car drive configuration, heavy-duty vehicle drive configuration, and challenges in automotive fuel cell power systems.

7. Aerospace power applications: System performance requirements, operation, and various converter topologies.

8. Fuel cell locomotives: System description, converter topologies, and energy management.

9. Stationary power applications: Operation and converter topologies for smaller and larger power plants

10. State-of-the-art fuel cell electrical energy systems: Case studies, and technical challenges for mass deployment.

Lecture-wise breakup

Topics	Number of lectures (approximate)
1. Basics of fuel cells	2
2. Electrical characteristics of fuel cells	2
3. Modeling of fuel cells and controllers	4
4. Fuel cell power system architectures	5
5. Power converters for fuel cells	5
6. Transportation applications	8
7. Aerospace applications	4
8. Locomotive applications	5
9. Stationary power applications	4
10. State-of-the-art	1
	40

Textbooks, reference books, suggested readings and any other references

- Bei Gou, Woonki Na, and Bill Diong: Dynamic Modeling and Control with Power Electronics Applications, CRC Press, Second Edition, 2020.
- M Venkatesh Naik and Paulson Samuel - “Non-Isolated Power Converters for Fuel Cell Power Sources”, Lambert Academic Publishing, 2021.
- Frano Barbir - “PEM fuel cells – theory and practice”, Academic press. 2nd edition, 2013.
- Robert W. Erickson and Dragan Maksimovic - "Fundamentals of Power Electronics", Springer, Third Edition 2020.
- Iqbal Husain – “Electric and Hybrid Vehicles”, Design Fundamentals, CRC Press, 3rd editions, 2021.
- M. Ehsani, Y. Gao, S. Gay and A. Emadi – “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles”, CRC Press, 2005.

Course proposed by	Recommended/Not recommended	This course is approved/not approved
		
(Amarendra Edpuganti)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course title	: Design Strategies for Net-Zero Energy Buildings
Number	: SEE624A
Credits (L-T-P [C])	: 3-0-0-9
Departments proposing the course	: Sustainable Energy Engineering
Name of the proposer	: Aakash Chand Rai
Offered for	: PG Students of SEE/other departments or programs 3/4th year UG students
Status of the course	: PG Elective/UG Elective
Prerequisite(s) for the course	: Consent of instructor
Faculty members interested in teaching	: Faculty members of ME and CE
Other departments/programmes whose students are expected to take up the course	: ME and CE

Course objectives

This course will equip students with the knowledge and tools to design net-zero energy buildings. The students will learn basic building design principles, passive heating and cooling techniques, renewable energy integration, lighting principles, and retrofit techniques.

Expected learning outcomes

On completing the course, the student will be able to:

- Perform site and climate assessment and select proper building orientation, geometry, zoning, and massing strategies for net-zero energy buildings.
- Select suitable envelope components (walls, roofs, and windows) and design shading devices based on thermal principles.
- Design the building envelope and evaluate the suitability of different passive heating and cooling techniques.
- Select appropriate renewable energy systems for integration into net-zero energy buildings.
- Grasp basic concepts of lighting design.
- Propose solutions for improving the energy efficiency of existing buildings.

Course outline

1. Basic principles and overview of net-zero buildings: Introduction, vernacular architecture, measuring energy use in the built-environment (site versus source energy), energy source considerations, energy and carbon, energy use metrics, energy and climate, energy targets and baseline.
2. Thermal comfort and indoor air quality considerations: Physiological considerations in comfort, environmental comfort indices, comfort conditions, adaptive comfort, indoor air quality considerations.
3. Fundamentals design considerations: Climate and site assessment, building mass and geometry, building type and zone.

4. Solar geometry: Sun's motion around the earth, solar angles and time, sun-path diagrams, sunbeams, and solar heat gains.

5. Shading: Exterior shading devices, design of overhangs and fins, eggcrate shading devices, glazing as a shading element, interior shading devices, solar heat gain coefficient, roof and wall reflectivity.

6. Passive cooling: Ventilation cooling, radiant cooling, evaporative cooling, earth cooling, and desiccant-based cooling.

7. Building envelope: Envelope heat transfer, thermal planning, and envelope design considerations.

8. Passive solar heating: Design considerations, direct gain systems, Trombe walls, and sunspaces.

9. Renewable energy integration: Basic renewable energy systems and design guidelines for integrating photovoltaic systems in buildings.

10. Lighting: Basic concepts and design strategies.

11. Energy efficiency retrofits for existing buildings and case studies: Techniques for improving the energy efficiency of existing buildings and case studies of net-zero buildings.

Lecture-wise breakup

Topics	**Number of lectures (approximate)**
1. Basic principles and overview of net-zero buildings	4
2. Thermal comfort and indoor air quality considerations	3
3. Fundamentals design considerations	6
4. Solar geometry	4
5. Shading	6
6. Passive cooling	4
7. Building envelope	6
8. Passive solar heating	1
9. Renewable energy integration	3
10. Lighting	2
11. Energy efficiency retrofits for existing buildings and case studies.	2
	41

Textbooks, reference books, suggested readings and any other references

- Heating, Cooling, Lighting: Sustainable Design Strategies towards Net Zero Architecture by Norbert Lechner.
- Net Zero Energy Design by Thomas Hootman.
- Heating Ventilating and Air Conditioning – Analysis and Design by McQuiston, Parker, and Spitler.
- ASHRAE Handbook—Fundamentals.

Course proposed by | **Recommended/Not recommended** | **This course is approved/not approved**

(Aakash Chand Rai) | Convener, DPGC (SEE) | Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

<u>Proposal for a New Course</u>

Course Title		Structural Microstructural and Spectroscopic Characterization of Materials
Number		SEE-625
Credits (L-T-P [C])		3-0-0-[9]
Departments proposing the course	:	Department of Sustainable Energy Engineering
Name of the Proposer	:	Prof. Ashish Gar
Offered for		PG Students of SEE and other departments 3/4th year UG students of other departments UG and PG
Status of the course	:	
Prerequisite(s) for the course	:	Consent of Instructor
Faculty members interested in teaching	:	Srinivas Yadavalli (SEE), Sudarshan Narayan (SEE), Raju Kumar Gupta (CHE), Shikhar Misra (MSE)
Other Departments/Programmes (of whose the students are expected to take up the course)	:	CHE, MSE, MSP, PHY, ME, CHM

Course Objectives

One of the important aspects of understanding materials and their properties and establishing correlations with processing is the determination of their structure and composition at different length scales. The main objective of this course is to make the students learn different structural and compositional characterization methods, including fundamental principles, how to analyze the data and how to avoid making common mistakes that can lead to erroneous interpretations.

Expected Learning Outcomes

Students will be able to understand the principles of different structural and spectroscopic characterization methods, carry out the measurements and do data analysis. They will also be able to correlate the characterization results with the properties and processing.

Course content (# of lectures: 42)

Essentials of materials: Structure and composition (7)
- Crystal systems and Bravais lattices (1)
- Crystallographic directions and planes, Miller indices and Weiss zone law (1)
- Bonding in materials and materials classes (1)
- Defects in Materials (1)
- Phases and phase equilibrium (2)
- Single crystals and polycrystals (1)

Diffraction and Imaging (19)
- Phenomena of diffraction (1)
- Radiation-matter Interactions and response signals (2)
- X-ray diffraction: powder diffraction, phase identification, Scherrer formula, strain and grain

Size determination, texture determination (4)
- Fundamentals of Imaging: magnification, resolution, depth of field and depth of focus,

Aberration and Astigmatism (1)
- Optical microscopy, stereology basics and quantitative analysis (2)
- Fundamentals of SEM: imaging modes, image contrast, illustrative applications (2)
- Imaging with TEM: Contrast mechanisms, BF, DF, Weak beam DF images (2)
- TEM application in crystal defect analysis (1)
- Electron diffraction in TEM and applications (2)
- Synchrotron based diffraction methods (2)

Surface Characterization (2)

• Surface probe microscopy (AFM, STM and other modes) (2)

Surface Spectroscopic Techniques (10)

• X-ray spectroscopy (Energy and wavelength dispersive spectroscopy (EDS and WDS),
Electron probe microanalysis (EPMA), X-ray fluorescence spectroscopy (XRF) (3)

• Electron spectroscopy for surface analysis (electron energy loss spectroscopy (EELS), X-ray
Photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES)) (3)

• Secondary ion mass spectroscopy for surface analysis (SIMS) (1)

• Data Analysis (3)

Vibrational and Optical Spectroscopic Techniques (2)

• Vibrational Spectroscopy (Raman and FTIR spectroscopy) (1)

• Optical spectroscopy: UV-Vis-NIR and ellipsometer spectroscopy (1)

Thermal Analysis Techniques (2)

• Differential scanning calorimetry (DSC)

• Differential Thermal Analysis (DTA)

• Thermogravimetric Analysis

• Dilatometry

The lectures will include the necessary theoretical background, aided by the details of data acquisition, analysis and interpretations.

Reference Books:

- Marc de Graef and Michael E. Henry, Structure of Materials, Cambridge University Press
- David Brandon and Wayne D. Kaplan, Microstructural Characterization of Materials, Wiley
- B.D. Cullity, Elements of X-ray Diffraction, Prentice Hall
- Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods,
- Wiley-VCH

Course proposed by	**Recommended/Not recommended**	**This course is approved/not approved**
(Ashish Garg)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title		Ecological Principles and Biodiversity for Sustainability
Number		SEE626M
Credits (L-T-P [C])		3-0-0-[5]
Departments proposing the course	:	Department of Sustainable Energy Engineering
Name of the Proposer	:	Prof. Ashish Garg
Offered for		UG and PG
Status of the course	:	
Prerequisite(s) for the course	:	Having passed 10+2 with Science
Faculty members interested in teaching	:	Dr. Ankur Awadhiya, IFS
Other Departments/Programmes (of whose the students are expected to take up the course)	:	Biological Sciences and Bioengineering, Earth Sciences, Environmental Engineering, Civil Engineering

Course Objectives

Minimisation of adverse impacts on ecology and biodiversity are sine qua non for long-term sustainability of projects and welfare of human society. Concomitantly, numerous projects have been utilising ecological processes and biodiversity services as cost-effective, efficient, and carbon negative substitutes for anthropogenic constructions in the fields of water purification, waste treatment, and amelioration of local climatic conditions. To these ends, a knowledge and understanding of ecological processes and biodiversity is pivotal for the students of sustainability. This course intends to provide this knowledge and understanding using case studies from the field situations to build up on conceptual frameworks.

Expected Learning Outcomes

1. Conceptual and working knowledge of Ecology and ecological processes.
2. Conceptual and working knowledge of Biodiversity, its advantages, and threats to biodiversity.
3. Exemplar understanding of utilisation of ecological processes and biodiversity for sustainable works.

Course outline

1. Introduction to Ecology, Biodiversity, and Sustainability
2. Biodiversity – Organisation of the living world
3. Biodiversity – Economic valuation
4. Ecological interactions
5. Introduction to Behavioural Ecology
6. Ecological Energetics – Introduction, food chains, food webs, and trophic levels
7. Ecological Energetics – Biogeographical cycles
8. Population Ecology – Growth and regulation of populations
9. Community changes and ecological succession
10. Biogeography and geographical distributions
11. Biogeography – Push and pull factors
12. Human Ecology – Introduction and impacts in anthropocene
13. Human population growth and requirements
14. Threats to biodiversity and ecology
15. Case studies – Impacts of oil spills
16. Case study – Impact of plastics on Ecology and Biodiversity
17. Climate change and its impacts on Ecology and Biodiversity
18. Conservation of biodiversity – In situ conservation
19. Conservation of biodiversity – Ex situ conservation
20. Employing Ecology and Biodiversity for sustainable development

Reference Books:

1. Krebs, C. J. The experimental analysis of distribution and abundance. New York: Harper and Row.
2. Odum, E. P., & Barrett, G. W. Fundamentals of Ecology. Philadelphia: Saunders.
3. Awadhiya, A., Principles of Wildlife Conservation. Florida and Oxfordshire: CRC Press / Taylor & Francis
4. Selected articles / papers as referred to in the lectures

Course proposed by	**Recommended/Not recommended**	**This course is approved/not approved**
(Name of the Instructor)	Convener, DPGC (SEE)	Chairman, SPGC

Indian Institute of Technology, Kanpur

Department of Sustainable Energy

Engineering Proposal for a New Course

1. **Course Number:** SEE627
2. **Course Title:** Electric Mobility
3. **Per Week Lectures:** 3_(L), Tutorial: _(T), Laboratory: _(P), Additional Hours[0-2]: ____(A)
4. **Duration of Course:** Full Semester

5. **Proposing Department:** SEE

Other Departments/IDPs which may be interested: EE

Other faculty members interested in teaching: No

6. **Proposing Instructor**: Amarendra Edpuganti

7. **Course Description:**

Electric mobility includes all types of transportation that is fully or partly driven by electric motors. It has been gradually replacing the conventional transportation due to climate concerns, shortage of oil resources, and energy security. The aim of this course is to teach system level understanding of the electric mobility to benefit students from diverse backgrounds .

8. **Expected Learning Outcomes:** On completing the course, the student will be able to:

- Understand the basics of electric mobility, and power train configurations
- Learn about different battery storage technologies and charging algorithms
- Learn about different types of chargers for electric mobility
- Learn about different kinds of motors used in electric mobility

9. **Contents:**

I.Introduction: Need for replacing conventional transportation, comparison between electric vehicles (EV) and internal combustion engines (ICEV), types of EVs, vehicle fundamentals, plug- in hybrid electric vehicles (PHEV), Range extended EVs (REEVs), and configurations of EVs.

II. Energy storage system: Electrochemical cell, basics of batteries, types of batteries, battery modeling, charging algorithms, battery management system (BMS), cell balancing techniques, andSOC estimation techniques.

III. Battery charging: Classification of battery chargers, types of onboard chargers, fast charging stations, and v2x technologies.

IV. Motors for electric mobility: Induction motors, Brushless dc motors, permanent magnet synchronous motors, switched reluctance motors, and synchronous reluctance motors

10. **Lecture-wise breakup**

Topics	Topics Number of lectures
1. Introduction	10
2. Energy storage system	15
3. Battery charging	12
4. Motors for electric mobility	5
	42

11. **Pre-requisites:** consent of instructor

12. **Text books:**

1) Iqbal Husain, ELECTRIC and HYBRID VEHICLES, Design Fundamentals, CRC Press, 2003.

2) M. Ehsani, Y. Gao, S. Gay and A. Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press, 2005.

Dated: 13/10/2022 Proposer: Amarendra

Edpuganti Dated:_______DUGC/DPGC Convener:___________________

The course is approved / not approved

Chairman, SUGC/SPGC

Dated:______________________________

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title		Policy Processes and Analytical methods: Application to Climate Policies
Number		SEE-628
Credits (L-T-P [C])		3-0-0-[9]
Departments proposing the course	:	Department of Sustainable Energy Engineering
Name of the Proposer	:	Anna Agarwal, Rajeev Jindal
Offered for		PG students, UG elective
Status of the course	:	

Prerequisite(s) for the course	:	Understanding of Energy and Climate Change
Faculty members interested in teaching	:	Anna Agarwal, Rajeev Jindal, Deepika Swami, Mousami Prasad, Anoop Singh
Other Departments/Programmes (of whose the students are expected to take up the course)	:	DoMS, Eco, ME, ChE, CE, EE

Objectives
Will the global warming levels exceed 2C by 2100? What would be the global financial burden of climate impacts if warming were to exceed 1.5C? What would be the least cost pathway for India to meet its net zero targets?

All these questions involve considerable uncertainties about various aspects of the climate system, technologies,institutions, and societies. Along with the technology development, financial framework, social concepts etc, global and national policies become one of the major drivers. This course introduces students to analytical methods and theoretical frameworks commonly used in policymaking to address energy and climate issues. The course intents to also help students understand the linkages (and lack of the same) in between theoretical concepts and actual policies, through case studies.

Expected Learning Outcomes
Students will learn quantitative methods used in arriving at the right data points needed for informed policy making. It will also help students understand policy frameworks used as the basis of the policy formation. Students will be trained in creating linkages between these tools and frameworks and their use in creating various policy options in context of achieving global climate objectives. Throughout the course, concepts are illustrated with examples from energy and climate
policy.

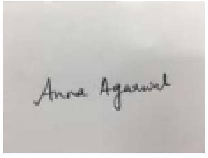
Course content (# of lectures: 42)

	Broad Topic	Detailed Contents	# Lectures (26 – 1.15 hrs each)
1	**Introduction and Context Setting**	• Climate challenge and uncertainty • Energy overview and transition to renewable, energy as enabler to net-zero	1
2	**Policy Frameworks**	• Basics of policy making - Process of policy formulation - Agenda setting - Options Making - Decision analysis • Implementation process • Policy structure • Social connect	3
3	**Probability and Statistics**	• Fundamentals of events, sample space and • introduction to probability • Conditional probability, Total probability, and • Bayes' theorem • Random variables • Probability distributions, Monte-Carlo Simulation • Covariance and Correlation • Regression: Singe variant and Multivariant	10
4	**Economic Theory and Decision Analysis**	• Basics of supply / demand • Marginal Abatement cost • Externalities/Social cost of carbon • Discounted Cash Flow • Cost benefit analysis • Decision trees or scenario analysis	9
5	**Case Studies**	Policy case studies and discussions on real world	3

		design and implementation challenges: India and Global	

Books, Reading Material and Resources:

1. Alessandro Rubino, Alessandro Sapio, and Massimo La Scala, Handbook of Energy Economics and Policy: Fundamentals and Applications for Engineers and Energy Planners, 2014.
2. Ang, Alfredo H-S., and Wilson H. Tang. Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering. 2nd ed. New York, NY: John Wiley & Sons, 2006.
3. Drake, Alvin W. Fundamentals of applied probability theory. Mcgraw-Hill College, 1967.
4. Frank Fischer, Gerald J. Miller, and Mara S. Sidney, Handbook of Public Policy Analysis: Theory, Politics, and Methods, 2007.
5. Michael Howlett and Ishani Mukherjee, Handbook of Policy Formulation, 2017.
6. Neufville, Richard de. Applied Systems Analysis: Engineering Planning and Technology Management. McGraw-Hill, Inc; New York, New York, USA, 1990.
7. Pindyck, Robert S. The social cost of carbon revisited, Journal of Environmental Economics and Management, Volume 94, 2019.
8. Webster, Mort. Communicating Climate Change Uncertainty to Policy-Makers and the Public. Climatic Change 6, 2003

Course proposed by		**Forwarded by**	**This course is approved/not approved**
 (Anna Agarwal)	 (Rajeev Jindal)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course (Modular)

Course Title	Ecology, Equity and the Economy
Number	SEE-629M
Credits (L-T-P [C])	3-0-0 [5]
Departments proposing the course	Department of Sustainable Energy Engineering
Name of the Proposer	Ashish Garg (SEE) Gurudas Nulkar, Visiting Professor, SEE
Offered for	UG and PG
Prerequisite(s) for the course	None
Other faculty members interested in teaching	
Other Departments/Programmes (who's students are expected to take up the course)	All departments

Course Objectives

Natural capital forms the foundation for economic activities. The real wealth of nations lies in the mineral and biological capital, social and human capital. The economic wealth is driven by how efficiently the nation is able to convert this into financial capital.

In the process of creating a 'medium of exchange' there is an inevitable decline in the stock of non-renewable resources and pollution of renewable resources. As the economy grows, the land use changes. Urban sprawls, infrastructure, mining, dams, are responsible for deforestation, loss of habitats and the degradation of natural ecosystems. Technological progress has pushed up economic growth. However, the distribution of income and wealth has hardly been equitable in society. The consequences of economic growth are showing up at a planetary level in climate change. The frequency and intensity of natural disasters has increased in the last decade, and has imposed a burden on the economy. Can we afford to continue such a form of economic growth?

In this course, participants will learn about sustainable development and why markets fail to address issues like resource depletion, pollution and income inequality. Participants will also understand why farmer poverty persists in India. The course will encourage discussions with brief cases.

Expected Learning Outcomes
In this course, participants will be able to:

1. Explain the evolution of trade and commerce from the perspective of natural capital
2. Correlate natural capital with economic growth
3. Critique the market failures of modern economy
4. Differentiate between growth, development, welfare and sustainable development

Course outline

	TOPICS	# of lectures (20)
1	Incredible earth – how did we get the natural capital?	1
2	Homo sapiens – how we made it to the top of the food chain	1
3	Resource use through human history	1
4	Forms of natural capital, Commons and Public Goods	1
4	Disequalizing growth – colonization and the industrial revolution	1
5	Premodern economics	1
6	Economic thoughts and the Modern economy	1
7	Market failures – externalized costs of economic growth	1
8	A critique on farmer poverty	1
9	Growth, development, welfare and sustainable development: SDGs	1
10	Valuation of Natural Capital, Ecosystem Services Measuring development – GDP, HDI, 5-Capital framework	1
11	Group exercise	2
12	Field visit – Study of a village market economy	5
13	Presentations of Group exercises	2

Reference Books:

This Fissured Land - Madhav Gadgil & Ramchandra Guha; Oxford University Press; 2nd Edition
Ecology, Equity and the Economy – Gurudas Nulkar; Ecological Society, 2nd Edition
Principles of Sustainability – Simon Dresner; Routledge; 2nd Edition
How the World Really Works - Valclav Smil; Penguin; 2022
Sapiens - Yuval Noah Harari; Random House; 3rd Edition
The Third Curve – Mansoor Khan; Mansoor Production, 1st Edition
Selected essays and articles

Course proposed by	Recommended/Not recommended	This course is approved/not approved
(Name of the Proposer)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	Sustainable Forest Management
Number	SEE-631
Credits (L-T-P [C])	3-0-0 [9]
Departments proposing the course	Department of Sustainable Energy Engineering
Name of the Proposer	Prof. Ashish Garg
Offered for	UG and PG
Prerequisite(s) for the course	Having passed 10+2 with Science
Faculty members interested in teaching	Dr. Ankur Awadhiya, IFS
Other Departments/Programmes (who's students are expected to take up the course)	Biological Sciences and Bioengineering, Earth Sciences, Environmental Engineering, Civil Engineering

Course Objectives

Management of forests is crucial not only because they provide us with resources, and because there are several fringe-forest communities dependent on them, but also because forests are one of the few effective measures for the sequestration of atmospheric carbon, so essential for climate change mitigation. Sustainable forest management aims to maximise the benefits of forests for the society - including major and minor forest produce, food and water security, ecosystem services, and tourism avenues - but in a manner that the benefits are continuously available to us for several generations. In this course, we shall discuss sustainable management of forest bio-resources using case studies and examples from India and abroad, in an attempt to understand how and why forests are planted, managed, and harvested in a continuous cycle.

Expected Learning Outcomes
In this course, participants will be able to:

- Conceptual and working knowledge of sustainable management of biological resources.
- Conceptual and working knowledge of silviculture and working of forests.
- Conceptual and working knowledge of ecosystem services emanating from forests.
- Exemplar understanding of utilisation of sustainable management principles to meet various objectives of management.

Course outline
Week 1: Introduction to forests
1. What is a forest?
2. Benefits from forests
3. Classification of forests

Week 2: Basics of forest management
1. What is forest management?
2. How do plants grow?

3. How do forests form?

Week 3: Understanding forest soils
1. Soil and soil profile
2. Types of soils
3. Biogeochemical cycles

Week 4: Measuring trees and forests
1. Describing trees and forests
2. Measurement of tree attributes - 1
3. Measurement of tree attributes – 2

Week 5: Surveying forests
1. Basics of forest surveying
2. Use of photogrammetry and satellite data 3. Use of LiDAR

Week 6: Protecting forests
1. Threats to forests
2. Forests and fires
3. Legal provisions

Week 7: Biological diversity and summing up 1. Biodiversity in forests
2. Summing up and discussion - 1
3. Summing up and discussion - 2

Mid Sem

Week 8: Silviculture – 1
1. Principles of forest regeneration
2. Silvicultural systems
3. Clear felling system

Week 9: Silviculture - 2
1. Shelterwood system
2. Selection system
3. Irregular shelterwood system

Week 10: Sustainably deriving bioresources
1. Logging and processing
2. Calculating growing stock and forest increment
3. Computing yield and sustained yield

Week 11: Sustainable practices
1. Collecting and treating forest seeds
2. Nursery techniques to produce seedlings
3. Planting and tending operations

Week 12: Recent developments in forestry 1. Non-timber forest produce
2. Social forestry
3. Ex-situ conservation

Week 13: Conservation of wild animals
1. National Parks and Wildlife Sanctuaries
2. Summing up and discussion - 1

3. Summing up and discussion - 2
End Sem

Reference Books:

- Forest soils by Wilde
- Principles and practices of silviculture by S.S. Bist
- Awadhiya, A., Principles of wildlife Conversation. Florida and Oxfordshire: CRC Press/Taylor & Francis
- Selected articles / papers as referred to in the lectures

Course proposed by	**Recommended/Not recommended**	**This course is approved/not approved**
(Name of the Proposer)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course title	: Heating, Ventilation, and Air-conditioning of Buildings
Number	: SEE-632
Credits (L-T-P [C])	: 3-0-0-9
Departments proposing the course	: Sustainable Energy Engineering
Name of the proposer	: Aakash Chand Rai
Offered for	: PG Students of SEE/other departments or programs 3/4th year UG students
Status of the course	: PG Elective/ UG Elective
Prerequisite(s) for the course	: Consent of instructor
Faculty members interested in teaching	: Faculty members of ME and CE
Other departments/programmes of whose the students are expected to take up the course	: ME and CE

Course objectives
This course aims to equip the students with a fundamental understanding of buildings' thermal behaviour. The students will then be introduced to the design and analysis of heating, ventilation, and air-conditioning (HVAC) systems for maintaining comfortable and healthy indoor environments. Finally, the course will focus on building energy simulation, climate impact assessment, and net-zero buildings.

Expected learning outcomes
The students will be able to understand the thermal behaviour of buildings and perform detailed design and analysis of HVAC systems. They will be able to conduct building energy simulations and climate impact analysis. They will also be able to appreciate net-zero building design practices.

Course outline
Energy use in buildings: Building sector's energy usage and associated greenhouse gas (GHG) emissions.
HVAC systems and psychrometry: Common HVAC systems (all-air, air-water, and all-water), moist air properties, and moist air processes for HVAC system design.
Thermal comfort, indoor air quality, and indoor infection transmission: Physiological considerations in comfort, environmental comfort indices, comfort conditions, adaptive thermal comfort, indoor air quality concerns, common air pollutants and their control, airborne infection transmission: causes and mitigation techniques.
Heating load: Steady-state building heat transfer, indoor and outdoor design conditions, and heating load calculation.
Solar radiation: Sun's motion as seen from the earth, solar time, solar angles, solar irradiation, and heat gain through fenestration.
Cooling load: Heat gain, cooling load, heat extraction rate, indoor and outdoor design conditions, and cooling load calculation procedures.

Energy calculations and building simulation: Degree day method, weather files, and software tools for energy simulation.
Climate change and net-zero buildings: GHG emission trends and drivers, representative concentration pathways, and net-zero buildings.

Lecture-wise breakup

Topics	**# of lectures (approximate)**
Energy use in buildings	3
HVAC systems	4
Psychrometry	6
Thermal comfort, indoor air quality, and indoor infection transmission	4
Heating load	4
Solar radiation	6
Cooling load	7
Energy calculations and building simulation	3
Climate change and net-zero buildings	3
	40

Text-books, reference books, suggested readings, and any other references

- Heating, Ventilating and Air Conditioning – Analysis and Design by McQuiston, Parker, and Spitler.
- ASHRAE Handbook—Fundamentals.
- Heating, Cooling, Lighting: Sustainable Design Strategies Towards Net Zero Architecture by Norbert M. Lechner and Patricia Andrasik.
- Refrigeration and Air-conditioning by C P Arora.

Course proposed by	**Recommended/Not recommended**	**This course is approved/not approved**
		
(Aakash Chand Rai)	Convener, DPGC (SEE)	Chairman, SPGC

Indian Institute of Technology, Kanpur
Department of Sustainable Energy Engineering

Proposal for a New Course

1. Course Number: **SEE633**

2. Course Title: **Power Electronics for Electric Vehicles**

3. Per Week Lectures: 3_(L), Tutorial: _(T), Laboratory: _(P), Additional Hours[0-2]: ___(A)

4. Duration of Course: Full Semester

5. Proposing Department: SEE

- Other Departments/IDPs which may be interested: EE
- Other faculty members interested in teaching: Dr. Suvendu Samanta

6. Proposing Instructor: Amarendra Edpuganti

7. Course Description:

Electric vehicles (EVs) are gradually replacing the conventional vehicles due to climate concerns, shortage of oil resources, and energy security. Power electronics plays an important role in EVs for charging battery from grid and/or renewables, power train, and powering the auxiliary loads. The aim of this course is to give students a deeper understanding of the state-of-the-art power converters used in electric vehicles in terms of operation, analysis, component design, and closed-loop control. Also, the course will cover some of the promising power converters for EVs from the ongoing research.

This course consists of four modules starting with the basics of EVs and the role of power electronics for EVs. The second module focuses on analysis, design, and control of power converters for on-board chargers. The third module focuses on different types of front-end converters including solid state transformers, and high power dc-dc converters for off-board charging. Also, this module covers analysis and design of conventional and multiport converters for renewables assisted EV charging and partial power processing converters for EV fast charging. The last module covers the design and control of dc-dc converters for interfacing the battery and control of dc-ac inverters for induction motor, brushless dc motor, and permanent magnet synchronous motor for EVs.

8. Learning Objective: At the end of this course, a student should be able to-
▪ Understand the role of power electronics in EVs.
▪ Analyze, design, and control of different types of power converters for EV charging, motor control, and dc-dc converters for interfacing the battery.
▪ Study and analyze the upcoming or promising converters for EVs

9. Contents:

S. No	Broad Title	Topics	No. of lectures
1	Introduction	Basics of EVs, and role of power electronics in EVs	3
2	On-board EV Chargers	CCM and DCM based power factor correction converters, dual active bridge converter, and integrated on-board chargers	14

3	Off-board EV Chargers	Front-end converters, solid-state transformers, multilevel converters, conventional and multiport converters for renewables assisted EV charging, and partial power processing converters	14
4	Power Train	Dc-dc converters for interfacing battery, control of dc motors, control of induction motors, permanent magnet synchronous motors, and brushless dc motors.	14
		Total lectures	42

10. Pre-requisites: EE360 (Power electronics) or EE660 (Basics of power electronic converters) or consent of instructor (only for EE/SEE students)

11. Textbooks:

1. "Fundamentals of Power Electronics", Robert W. Erickson and Dragan Maksimovic, Springer, Third Edition 2020.
2. K. T. Chau - Electric Vehicle Machines and Drives: Design, Analysis and Application. Wiley-IEEE Press (2015).
3. Iqbal Husain, ELECTRIC and HYBRID VEHICLES, Design Fundamentals, CRC Press, 2021.
4. "Power Converters for Electric Vehicles", L. Ashok Kumar and S. Albert Alexander, CRC Press, 2020.

Dated: 6/9/2024 Proposer: Amarendra Edpuganti

DPGC Convener : ___________________

The course is approved / not approved

Chairman, SPGC

Dated:___________________________

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title		**Critical Material Resources for Clean Energy Transition**
Number		SEE-634
Credits (L-T-P [C])		3-0-0-[9]
Departments proposing the course	:	Department of Sustainable Energy Engineering
Name of the Proposer	:	Sheo Shankar Rai
Offered for		PG students
Prerequisite(s) for the course	:	None
Faculty members interested in teaching	:	Sheo Shankar Rai, Ashish Garg
Other Departments/Programmes (of whose the students are expected to take up the course)	:	Geo-Sciences, ME, EE, CE, SPASE

Course Objectives

The course on "**Critical Material Resources for Clean Energy Transition**" aims to provide a comprehensive understanding of the **sustainable energy landscape**, with a specific focus on **critical materials that are needed for clean energy transition**. The program will cover topics such as the availability and production of critical minerals for making these materials, mineral and material processing techniques, and their applications in various sustainable energy technologies across various clean energy technologies. This postgraduate-level course will equip students with the essential knowledge and skills to assess the requirements of critical materials for energy transition, identify the sources as well as navigate the technical as well as commercial challenges posed by the requirement of **critical material resources**. These challenges include managing technological advancements, addressing environmental impacts, dealing with geopolitical pressures, and understanding the regulatory frameworks that govern the **sustainable energy sector**.

Expected Learning Outcomes

The course will provide a strong and holistic knowledge base and skills to the students on Critical Material Resources required for the development of Clean Energy Technologies. This includes an in-depth understanding of their source and availability, production processes, processing methods, applications in various Sustainable Energy Technologies, Supply Chain, Environmental and Social Impact, and Application of AI & ML. The course will provide students with the essential knowledge and skills to navigate the technical and management challenges, technological advancements, environmental issues, geopolitical pressures, and regulatory complexities specific to the Sustainable Energy Sector and Critical Material Resources.

Course outline

	Broad Title	Topics	No. of 1 h Lectures (Total: ~40)
1	An introduction to Sustainable Energy Value Chain	- Global Energy System and their Economics - Problem of conventional energy - Climate issues - Clean Energy Transition: Global and Indian perspective. - Defining the critical minerals and materials - Clean Energy Value Chain with emphasis on the use of critical materials and minerals - Achieving NetZero.	6
4	Mineral Requirements for Clean Energy Transition.	- Low Carbon Power Generation including photovoltaics (1G to 3G) - Energy Network. - Electric Vehicles and Battery Storage.	6

		- Hydrogen: Electrolysers and Fuel cells - Electro and photocatalysis for energy applications - CCUS	
2	Sustainable and Responsible Development of Critical Material Resources. **(Primary sources)**	- Role of Critical Mineral in Clean Energy Transition: - Global and Indian Perspective - Critical Mineral Value Chain. - Exploration - Planning and Extraction Technology of Critical Minerals - Availability of Critical Minerals • Lithium • Cobalt • Nickel • Mn • Copper • Rare Earth Minerals - Mineral Development and Climate Change. • Sustainable Development of Mineral Resources. - Critical Mineral Resources of Deep Sea. • Key Drivers • Deep-Sea Mineral Extraction Technology. • Challenges associated with the Extraction of Deep-Sea Mineral • Environmental Impacts of Deep-Sea Mining • Regulatory Framework of Deep-Sea Mining. - Critical Mineral Resources from Space. • Key Drivers • Potential Space Resources • Potential Resources of Asteroids • Advantages and Dis-advantages of Asteroid Resources • Discovery and Characterization of Asteroid Resources • Mineral Exploration and Extraction Technology for Asteroid Resources. • Challenges associated with the Extraction of Asteroid Resources • Regulatory Framework of Asteroid Mining	**12**
3	Processing of Critical Material Resources **(Primary sources).**	Introduction to Processing Technology for Critical Materials from the Minerals - Pyrometallurgy - Hydrometallurgy - Bio metallurgy	**4**
5	Secondary Sources of Materials: Metal Recycling Technology	- Need of secondary sources - India relevance - Circular Economic Model of Waste Management. - Technologies for Metal Recovery from Waste.	**3**
6	Environmental and Social Impact Assessments	- Assessment of Environmental Impact - Assessment of Social Impact	**2**
7	Supply Chain of Critical Material Resources	- Supply Prospects of Critical Materials. - Geo-political Scenarios. - Approaches to Ensure Reliable Supply of Critical material. - Prospects of Recycling in Critical Material Supply Chain.	**6**
8	Summary	Putting everything together	**1**

Textbooks, reference books, suggested readings and any other references

- Sustainable Energy Systems and Applications (Springer) : by Ibrahim Dincer, Calin Zamfirescu (Author).
- Asteroid Mining 101 – Wealth for New Space Economy by John S Lewis.
- R. Sharma, Deep-sea mining: Economic, technical, technological, and environmental considerations for sustainable development, Mar. Technol. Soc. J. 45 (2011) 28–41. doi:10.4031/MTSJ.45.5.2.
- Critical Minerals for India, Report of the Committee on Identification of Critical Minerals, Ministry of Mines, Govt. of India, June 2023.
- The Role of Critical Minerals in Clean Energy Transitions, World Energy Outlook Special Report, International Energy Agency (IEA), March 2022.
- Critical Minerals Market Review 2023, International Energy Agency (IEA).
- Net Zero by 2050 A Roadmap for the Global Energy Sector, International Energy Agency (IEA).
- Clean Energy Transitions Programme, Annual Report 2023, International Energy Agency (IEA).
- Greening the Renewable Value Chain: China Experience, Briefing Paper, June 2024, World Economic Forum in Collaboration with Boston Consulting Group.
- Latest Research Papers on relevant topics.

Course proposed by	Forwarded by	This course is approved/not approved
(Sheo Shankar Rai)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

Course Title	Carbon Capture, Utilization, and Storage (CCUS)
Course Number	SEE 635
Credits (L-T-P-C)	3-0-0-0 [9]
Department Proposing the Course	Sustainable Energy Engineering
Name of the Proposer	Soumyabrata Roy
Offered For	PG students
Prerequisite(s)	None
Faculty Members Interested in Teaching	Soumyabrata Roy, Sheo Shankar Rai, Raju Kumar Gupta
Other Departments/Programs who may be interested in the course	CHE, ES, KSS, CHM, MSE, CE, ME, CESE, DoMS

Course Objectives: This course will provide an in-depth understanding of Carbon Capture, Utilization, and Storage (CCUS) technologies as a critical pillar of sustainable energy transitions. It will address CO_2 emissions mitigation across sectors such as power generation, industry (hard- to-abate sectors), and transportation. The course will cover scientific principles, technological approaches, system integration, and policy/regulatory frameworks associated with the CCUS value-chain. Emphasis will be placed on emerging research directions, Indian and Global case studies, and techno-economic evaluations for large-scale deployment. The following will be the key objectives of this course:

1. Develop a strong foundational understanding of carbon emissions and the need for CCUS in achieving net-zero targets.
2. Explore fundamental principles of thermodynamics, reaction engineering, materials science, and system integration in CCUS technologies.
3. Provide a systematic overview of CO_2 capture techniques (solvent-based, solid sorbent, membrane-based, and cryogenic), transport logistics, and storage options (geological, mineral, and deep-sea)

4. Evaluate utilization technologies, including catalytic, electrochemical, biochemical, and mineralization routes for conversion to value-added products.
5. Assess techno-economic parameters, life-cycle assessments (LCA), and integration strategies with power plants, cement & steel industry, bioenergy systems, and other relevant industrial sectors.
6. Review current policy frameworks, carbon trading mechanisms, and regulatory aspects relevant to India and globally.
7. Encourage innovation and research thinking by connecting emerging trends such as AI/ML for CCUS system optimization and novel materials development.

Expected Learning Outcomes

On completion of this course, students are expected to develop the ability to analyze and compare various CO_2 capture technologies and understand their integration potential within relevant industrial systems. They will acquire a strong grasp of the underlying thermodynamics and kinetics of CO_2 capture and conversion processes, along with familiarity with a wide range of capture technologies, including solvent-based systems, solid sorbents, membranes, and cryogenic approaches. They will gain insights into CO_2 transport mechanisms and strategies for long-term geological storage, as well as understand the technical and economic potential of CO_2 utilization pathways such as fuels, chemicals, building materials, and biological fixation. The course will also prepare students to identify and navigate the regulatory, policy, and societal acceptance challenges surrounding CCUS deployment. They will develop understanding of the feasibility, cost, and environmental implications of implementing CCUS projects and will gain proficiency in designing conceptual flowsheets tailored to site or sector-specific applications. Lastly, students will be trained to critically assess current literature, evaluate emerging research trends and development efforts, and develop the necessary skills to design and optimize CCUS systems, particularly in the context of Indian industrial and energy sectors.

Course outline

S. No.	Broad Title	Topics	Lectures
1	**Introduction to CCUS and Global Context**	-Climate change and global carbon budget -Role of CCUS in Net Zero transitions and SDG goals - Global and Indian emissions scenario - Types of CO_2 sources and Sectoral emissions profiles (power, cement, steel, chemical, bioenergy) - Technology readiness and sectoral applicability - Life-cycle assessment of CCUS pathways - CCUS roadmap: Global and Indian perspective (IEA, NITI Aayog)	4
2	**Fundamentals of CO_2 Capture**	- Separation thermodynamics and driving forces -Post-combustion vs. pre-combustion vs. oxy-combustion - Mass transfer and reaction engineering basics - Energy penalties and process intensification strategies -Solvent-based capture (amine systems, challenges, regeneration) - Solid sorbents (zeolites, activated carbon, MOFs) - Membrane separations (types, transport mechanisms, limitations, permeability/selectivity trade-offs, energy penalties) - Cryogenic, Chemical looping and oxy-combustion approaches - Emerging materials: ionic liquids, phase-change solvents	8
5	**CO_2 Transport Systems**	- CO_2 compression, liquefaction, and conditioning - Pipeline design: codes, safety, monitoring - CO_2 shipping and logistics for remote storage - Infrastructure and cost assessment models	2
6	**CO_2 Storage Mechanisms**	- Geological storage: saline aquifers, depleted oil/gas fields - Well drilling and injection techniques - Geomechanics, Caprock integrity and leakage risks - Long-term monitoring and MRV (Measurement, Reporting, Verification) - Mineralization, in-situ reactions, solid-storage - Environmental and risk assessment frameworks	6
7	**CO_2 Utilization Pathways**	- Thermocatalytic, electrocatalytic and solar conversion: CO_2 to fuels, methanol, syngas - CO_2 to polymers, CO_2 mineralization to building materials (carbonates) - Biological conversion: algae, microbial fermentation - Techno-economic analysis of utilization pathways, Industrial symbiosis and circular carbon economy	6

8	**Integration with Industrial and Bioenergy Systems**	- CCUS in cement, steel, and refineries- BECCS (Bioenergy with Carbon Capture and Storage): scope, challenges, Indian context - Coupling CCUS with green hydrogen and waste-to-energy plants - Case studies: NTPC, Indian Oil, and global benchmarks	4
9	**Techno-Economics, LCA, and Evaluation**	- Cost of CO_2 avoided vs. captured vs. utilized - Key CAPEX and OPEX components - Life cycle assessment: GHG reduction potential - TEA tools and scenario analysis using open-source models	4
10	**Policy, Regulatory, and Public Engagement Dimensions**	- CCUS in national and international climate policies - Carbon markets, tax incentives, and subsidies - Indian regulatory landscape: MoEFCC, MNRE, NITI Aayog - Legal frameworks for liability and permanence - Social license to operate and community engagement	3
11	**Outlook and Emerging Frontiers**	- Emerging materials and digital tools (AI/ML) for CCUS optimization - Hybrid energy systems and CCUS coupling - Direct Air Capture (DAC) vs. Point Source Capture- - Role of CCUS in hard-to-abate sectors - Summary, project presentations, and open discussions	3

Textbooks, reference books, suggested readings and any other references

- *Carbon Capture, Storage and, Utilization: A Possible Climate Change Solution for Energy Industry" by Malti Goel*
- *Carbon Capture by Jennifer Wilcox*
- *Carbon Dioxide to Chemicals and Fuels by M. Aulice Scibioh and B. Viswanathan*
- *CO_2 Capture, Utilization, and Sequestration Strategies by Yatish T. Shah (https://doi.org/10.1201/9781003229575)*
- *Carbon Capture-Utilization and Storage: Climate Change Mitigation by Jayarama Reddy Puthalpet*
- *Carbon Capture: Sequestration and Storage: 29 (Issues in Environmental Science and Technology) by Vassilis Kitidis and Klaus Lackner*
- *Climate Change and Carbon Recycling: Surface Chemistry Applications* by K. S. Birdi
- Introduction to Carbon Capture and Sequestration (Berkeley Lectures on Energy) (The Berkeley Lectures on Energy) by Smit
- Carbon Capture, Utilization, and Storage (CCUS) Resources: CCUS Handbook for Policymakers
- Carbon Capture and Storage, IPCC Special Report, 2005
- IEA CCUS Reports (2020–2024), International Energy Agency

- Carbon Capture and Storage in Developing Countries: A Perspective from the Global South, Routledge
- CO_2 Utilization: From Fundamentals to Applications, Elsevier
- Government of India Reports: NTPC, MNRE, NITI Aayog – Reports on CCUS

Course proposed by	**Forwarded by**	**This course is approved/ not approved**
Soumyabrata Roy (Soumyabrata Roy)	Convener, DPGC (SEE)	Chairman, SPGC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for a New Course

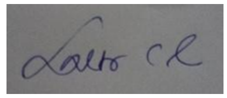
Course Title		Introduction to Profession & Communication
Number		SEE888
Credits (L-T-P [C])		1-0-0-0 [3]
Department proposing the course	:	Sustainable Energy Engineering
Name of the Proposers	:	All Faculty members
Offered for		PG students
Prerequisite(s) for the course	:	None
Faculty members interested in teaching	:	Dr. Sheo Rai /Faculty members of SEE
Other Departments/Programmes of whose the students are expected to take up the course	:	None

Contents:

Units	**Topic**	**Detailed Contents**	**# Lectures**
1	Introduction to Profession	The need for the sustainable energy engineering in the current context, key developments, research & development trends, career options	3
2	Professional Ethics	Workplace: perspective and best practices Collaboration: best practices	1
3	Mechanics of Publishing /Patenting & Bidding for Projects and other Resources	• Various stages of paper publishing in Journal • Dealing with rejection, reviewer' comments • Intellectual Property Rights; What can be patented? • Mechanics of project submission & approval • Developing laboratory and attracting students • Industrial teamwork, international collaboration	3
4	Technical Writing	• Basic principles of scientific/technical/report writing • Developing a pattern of organization • Common types of arguments • Scientific Journal papers writing • Editing for emphasis	2
5	Oral Presentation	• Presentation skills for conferences • Slide preparation and representation of data Mitigation plans for controlling emissions	2
6	Plagiarism	• What is it? • Author's responsibilities and rights • Plagiarism checking and avoidance aids	1

Textbooks/Reference materials:

1) T.N. Huckin and L.A. Olsen, Technical Writing and Professional Communication for nonnative speakers of English, second (international edition, McGraw Hill (1991)
2) Michael Alley, The craft of Scientific Writing, Springer Pub, 3rd Edition, (1996).

Course proposed by	**Forwarded by**	**This course is approved/not approved**
(All Faculty Members)	 Convener, DUGC (SEE)	Chairman, SUGC