Brief Description of Energy Systems Courses

Workload for the courses is displayed in an A-B-C-D- E format where:

A – No. of lecture hours per week
B – No. of tutorial hours per week
C – No. of laboratory hours per week
D – No. of project/assignment hours per week
E – No. of hours for preparatory work per week

Elective Courses in Energy Technologies

CN5190 Hydrogen Energy and Technology
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Familiar with general chemistry, materials science, thermodynamics, chemical kinetics and chemical engineering
Preclusion(s): Nil
Cross-listing(s): Nil
This course gives a comprehensive overview of the fundamental knowledge of hydrogen, and introduction to the development of hydrogen technologies, including hydrogen production, storage and transportation, hydrogen utilization in industry, and as a clean fuel. Opinions and perspectives on future hydrogen economy will also be introduced. Students will learn various types of hydrogen related research and technologies, their significance, advantages, challenges and opportunities ahead. Guest lectures from academic and industrial experts, literatures from key areas will also be introduced to reinforce classroom learning. This course is meant for students with some chemical engineering, chemistry, materials science, or related background.

CN5192 Future Fuel Options: Prospects and Technologies
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Familiar with general chemistry, chemical kinetics and chemical engineering thermodynamics
Preclusion(s): Nil
Cross-listing(s): Nil
This course introduces fuel options for mankind beyond coal, conventional natural gas and petroleum. It is a multidisciplinary course integrating cutting edge technologies for the utilization of future fossil fuels (such as shale gas, coal bed methane and methane hydrates), biofuels and hydrogen fuel. Students will learn various types of alternative fuels, their advantages, significance, current practice, production strategies, and challenges ahead. A term project along with several real and literature case studies from key areas will be used to illustrate and reinforce the learning. This course is meant for graduate students having chemical engineering background.

CN5194 Carbon Capture Sequestration and Utilization
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): Familiar with general knowledge of chemistry and chemical engineering.
Preclusion(s): Nil
Cross-listing(s): Nil
The link between global warming and rising anthropogenic CO_2 in the atmosphere is now well recognized. The urgency to address this existential threat requires a multi-pronged approach where carbon capture, concentration, sequestration and utilization are among the leading mitigation options. This course provides a broad introduction to global warming and an overview of various intervention strategies. Various carbon capture and concentration technologies, and sequestration options are discussed in detail. The challenges and opportunities of CO_2 utilization for chemicals production are addressed. Renewable and low CO_2 emission alternative energy technology options are also discussed.

CN5195 Biomass and Energy
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This course provides a comprehensive and interdisciplinary examination of biomass as a renewable energy source. The main focuses of this course include types of biomass, main conversion technologies, quality and characterization of biofuels, and process evaluation metrics. In this course, students will learn about the science of biomass and its use as a sustainable feedstock for the production of fuels in lieu of finite fossil fuels. Further, the merits, demerits, barriers, and way forward solutions of energy exploitation will also be delivered upon the completion of the entire course.

CN5216 Electronic Materials and Energy Technologies
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Familiar with general chemistry and materials science.
Preclusion(s): Nil
Cross-listing(s): Nil
Electronic materials have become essential for modern society, and new breakthroughs in electronic materials promise to offer next generation technologies. This course explores the fundamental mechanisms for understanding existing and emerging electronic materials for green energy devices in the modern world. This survey course will enable students to learn the fundamental properties in order to understand the operation and development of materials for applications such as organic electronics, hybrid semiconductors, photovoltaics, photocatalysts, and optoelectronic devices. This course is also intended to introduce contemporary research to students through discussion and analysis of research manuscripts as case studies.

EE5713 Modern Power Systems and Smart Grid
Units: 4
Workload: 3-0-0-1-6
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This course will provide a comprehensive overview of modern electrical grids. The topics covered will be useful in planning and operating a modern power system with increasing penetrations of demand side management (DSM) programs, renewable resources and distributed generation. This course will explain how today's power systems are evolving to interact with an emerging future with distributed energy resources for peak load management and energy efficiency improvement. Several case studies will be discussed to highlight best practices for design and implementation of these programs to work in conjunction with the changing grid.

ME5207 Solar Energy Systems
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The aim of this course is to develop awareness among students on the use of solar energy for low temperature applications. They will acquire expertise on several aspects of solar thermal system design including meteorological conditions, solar systems and components, potential applications, and economic evaluation. Students will be expected to undertake 2 to 4 projects to gain hands-on design experience. The topics included are: analysis of solar radiation, heat transfer in solar systems, solar energy collection devices, energy storage systems, economics, system simulation and optimization, photovoltaic applications

ME5209 Energy Technologies and Systems
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): Nil
Preclusion(s): ME5205
Cross-listing(s): Nil
The course is designed to give an overview and selected deep-dives of different energy conversion systems. It comprises three main parts – (is) renewable technologies and conventional energy/power systems, (ii) different fuel uses for reduction of carbon emission, (iii) energy/power distribution systems and (iv) life cycle cost analysis. Firstly, the course introduces renewable systems including solar, wind, geothermal, hydropower, biomass, and fossil-fuel driven energy conversion systems. In addition to electric energy systems, different thermal energy generation systems will be introduced. Secondly, electric energy systems with different fuel uses for current and future will be analysed. Thirdly, students will learn about energy distribution systems (both electric and thermal) and the changes that arise from distributed generation of renewable energies. Finally, the long-term economic viability will be discussed.

MLE5212 Energy Conversion and Storage
Units: 4
Workload: 3-0.5-0-0-6.5
Prerequisite(s): Nil
Preclusion(s): MLE4210
Cross-listing(s): Nil
The course provides a foundation for students interested in doing research into materials related to energy storage and conversion. It will start by introducing the basics of designing and processing materials for energy storage and conversion, their integration into batteries, supercapacitors, and fuel cells as well as methods for the performance characterisation and optimisation of these devices. The course will finish with aspects of current research on materials for energy storage and conversion.

MLE5222 Nano and 2D Materials for Energy Applications
Units: 4
Workload: 2-1-0-2-5
Prerequisite(s): Nil
Preclusion(s): MLE4206 & MLE5211
Cross-listing(s): Nil
This course will cover selected key nanomaterials for green energy harvesting, energy storage, conversion and catalysis, including their design, nanomaterials fabrication, energy performance, and applications. They include: introduction to energy nanomaterials; design principles; selected key energy nanomaterials in different dimensions (0D, 1D, 2D and 3D); processing and synthesis, and relationships among key variables at both nanomaterials and energy device levels.

MLE5226 Problem Solving for Future Sustainability Challenges
Units: 4
Workload: 1-2-0-4-3
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The course challenges students to apply knowledge towards problem solving in a series of challenging weekly scenarios. These scenarios will be set in the future, and these scenarios will share the common theme of applying knowledge towards developing practical and workable solutions to sustainability challenges in group settings. This course will consist of both lecture introduction to relevant topics in sustainability and the context in the discipline of MSE. Students will be pushed to think creatively to develop submit workable solutions towards resolving the weekly scenario under time constraints.

SH5407 Sustainable Energy and Environment
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This course is designed to provide students with: (a) an understanding of the effect of climate change and energy on sustainable development, as the world transit from fossil fuels to low carbon energy and renewable energy; (b) insights on the challenges and opportunities in achieving affordable, reliable and clean energy in major industry and transportation sectors; and (c) strategic thinking and skill-set to explore and evaluate the environmental impacts, hazards and risks associated with energy, across its value chain,from production to consumption.

Elective Courses in Innovation and Management

CN5191 Project Engineering
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Nil
Preclusion(s): CN4225
Cross-listing(s): Nil
The objective of this course is to provide a step-by-step description and illustration of a project's lifecycle in the chemical industry. Beginning with an overview of the chemical process industry (CPI) and project terminology, the course will discuss in detail the organization of projects, team composition and roles of various personnel, planning and scheduling of activities, project management tools, and plant operations. It will involve guest speakers from various industries and real-life cases studies. This course is targeted at students with a potential career interest in engineering and construction field.

IE5003 Cost Analysis and Engineering Economy
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
Cost and engineering economic analysis with special emphasis on a unified approach based upon cost accounting, operations research, economics and other quantitative methods. Topics include cost accounting and cost analysis, cost estimation, methods of engineering economic analysis, analyses for government projects and public utilities, effects of income taxes in economy studies, depreciation methods, risk and uncertainty in engineering economy studies, replacement studies and models, capital budgeting and computer applications.

IE5203 Decision Analysis
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): IE4243
Cross-listing(s): Nil
This course teaches the necessary analytical knowledge and practical skills for improving decision-making processes in engineering and business environments. This is achieved by providing a paradigm based on normative decision theory and a set of prescriptive tools and computational techniques using state-of-the art software with which a stake holder can systematically analyze a complex and uncertain decision situation leading to clarity of action. Topics from utility theory and influence diagrams modeling to multi-attribute utility theory and analytic hierarchy process are covered.

IE5206 Energy and Sustainability: A Systems Approach
Units: 4
Workload: 3-0-0-1-6
Prerequisite(s): Nil
Preclusion(s): IE4244
Cross-listing(s): Nil
The course deals with energy and sustainability at the policy and strategic levels. Fundamentals of energy and carbon emission accounting, global and national energy systems, drivers of energy consumption and related emissions, and climate change are introduced. The latest developments in global and Singapore's energy scene, actions to reduce energy use and carbon emissions, and future outlook are discussed. The issues are analyzed at different levels: international, national, sector and corporate. Cases with a focus on the application of systems engineering and management concept and tools to problem formulation, analysis and solving form an integral part of the course.

IE5207 Energy Systems Modelling and Market Mechanisms
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): IE5206
Preclusion(s): Nil
Cross-listing(s): Nil
This course examines energy and climate issues from the system modelling and market-based mechanisms perspectives. Topics covered include energy system modelling principles and their applications, energyeconomic system flows, energy demand modelling and related policy issues, interactions of market-based mechanisms with the national energy-economic systems, scenario analysis and strategies for net zero emissions. The course will help students to understand the challenges and opportunities in energy transitions and deep decarbonisation in the coming decades. Relevant examples and cases based on the latest global developments will be presented.

MT5007 Management of Technological Innovation
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): MT5007A & MT5007B
Cross-listing(s): Nil
The aim of this course is to help students develop a strong conceptual foundation for managing technological innovation. It introduces concepts and frameworks for how firms can create, commercialize and capture value from technology-based products and services. The course is designed for business managers and engineers who are involved in the research and development, marketing, acquisitions, and strategic assessments of new technologies. Topics covered include (i) the evolution of industries; (ii) technological discontinuities and vertical disintegration; (iii) network effects and standards; (iv) profiting from innovation and intellectual property (IP); (v) R&D management; and (vi) managing knowledge and learning.

MT5010 Technology Forecasting, Intelligence & Foresighting
Units: 4
Workload: 3-0-0-5-2
Prerequisite(s): Nil
Preclusion(s): MT5010A & MT5010B
Cross-listing(s): Nil
Successful R&D engineers and managers should have the foresight to anticipate and drive technological changes and convert them into strategic assets to organizations. This course will equip students with technology forecasting, intelligence and foresighting skills, make use of the foresight to generate strategic intellectual assets and realize value from them to succeed in competitive environment. Effective collection and transformation of information into intelligence requires awareness of enterprise niches and alternatives, as well as the search and analytical skills of data and information. The course will emphasize these skills and impart a thorough understanding business & technology related strategic frameworks.

MT5020 Managing the Human Elements of Technology Management
Units: 4
Workload: 3-1-0-3-3
Prerequisite(s): Nil
Preclusion(s): MT5020A
Cross-listing(s): Nil
The successful management of the human aspects of technological innovation has been increasingly recognised as an essential element for project success. Building on engineering, psychology and management literatures, the aim of this course is to provide students with a theoretical understanding and a foundation for developing skills related to motivations, team work, role transition, conflict management and productivity management. As such, this course is a valuable complement to traditional engineering courses that focus much on the technical developments.

SH5409 Sustainability and Environmental Analysis
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The course is designed to explore the roles of Occupational Health and Safety professionals in driving organisation's sustainability and ESG performance. The course focuses on the transition to interpreting workplace and industrial settings in social well-being and ecological sense, considering biophysical, social, cultural, economic, human rights human health regarding industrial proposals, projects and regulatory requirements. It provides students with various reporting and environmental management tools to gain practical and theoretical knowledge. The course focuses on three toolkits to help students' capacity building on sustainability:
a) ESG and sustainability disclosure;
b) Environmental Impact Assessment;
Product Life Cycle Assessment;

General Elective Courses

CN5202 Selected Topics in Energy Systems
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): Familiar with general knowledge of energy technologies.
Preclusion(s): Nil
Cross-listing(s): Nil
As the world moves into a greener future, new technologies and solutions are emerging rapidly. This course will introduce new concepts and development in energy technologies and systems.

CN5246 Catalysis Science and Engineering
Units: 4
Workload: 3-0.5-0-3-3.5
Prerequisite(s): Nil
Preclusion(s): CN4246R
Cross-listing(s): Nil
Students will learn the concepts of heterogeneous catalysis with increasing complexities, starting from those involving polymeric phases, enzyme pockets, up to those involving zeolite cages and complex oxide surfaces. To achieve these, students will learn steady state approximation, catalytic cycles, catalyst structures, reaction mechanisms & kinetics, transport phenomena (diffusion, mass and heat transfer), and reaction engineering. Many reactions and catalysts of industrial importance will be emphasised throughout the course to illustrate these principles. Students will then learn how to apply their knowledge of these principles to the design of catalysts, reaction mechanism, and reaction kinetics rate laws for reactor design.

CN5550 Energy Systems Project
Units: 8
Workload: 0-0-0-7-3
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The aim of this course is to allow students to acquire knowledge in a selected field of energy systems through experiential learning. This will be done through a basic or applied research project hosted by a research lab or centre. The student will be guided by a professor in the domain chosen but is expected to work independently mostly. The project will be graded through a report and presentation.