Subject Description Form

Subject Code	ISE1D02
Subject Title	Renewable Energy for A Sustainable World
Credit Value	3
Level	1
Pre-requisite / Co-requisite/ Exclusion	Nil
Objectives	This subject is designed for students by providing an introduction to the most important renewable energy resources and the technologies for harnessing these within a framework of a broad range of simple to state-of-the-art advanced energy systems. The subject helps students understand society's present needs and future energy demand by examining both conventional and renewable energy technologies including fossil fuels, nuclear power, solar energy, wind power, biomass energy, hydropower, geothermal energy, etc. and foster the ability to engage in lifelong learning on renewable energy (RE) issues. Unlike fossil fuels, renewable energy sources are sustainable. According to the World Commission on Environment and Development, sustainability is the concept of meeting "the needs of the present without compromising the ability of future generations to meet their own needs." That means start actions today to use renewable energy technologies will not only benefit society now, but will benefit many generations to come. The choices of energy supply are just one of the may scientific and technical issues our society faces now and in the future. Evaluating all these issues will be easier if students have a basic understanding of the scientific process and can consider scientific issues rationally. Through the ideas and methods presented in this subject, students are able to foster a new sense of wonder and curiosity about science and energy. The major goal of this course is to provide fundamental knowledge that will help students understand and analyze problems with various practices of renewable energy production and use, and to evaluate the feasibility of possible solutions to these problems. The objectives of the subject are to enable students to: 1. Understand the difference between renewable and non-renewable energy sources and identify and distinguish between different forms of renewable energy. 2. Understand the advantages and limitations of different renewable energy sources and identify a wide variety of applications for renewable energy.

	3. Understand the basic scientific and technical principles behind large-scale applications of renewable energy. 4. Identify selected political, social, and economic incentives that would accelerate the implementation of renewable energy.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Understand the fundamentals and main characteristics of renewable energy sources and their differences compared to fossil fuels; b. Understand the extent of environmental impact and resource depletion of each of the major non-renewable and renewable sources of energy; c. Identify the challenges and problems associated with the use of various energy sources, including fossil fuels, with regard to future supply and the environment; d. Be able to apply this knowledge to suggest the preferred combination of sustainable solutions/actions to minimize the emission of greenhouse gases and increase sustainability of the energy system in specific areas/regions
Subject Synopsis/ Indicative Syllabus	**Introduction** **S**tudents will learn about renewable energy sources and will distinguish them from non-renewable sources. They will be introduced with a definition of energy, then to think about the different sources of energy, divide those sources into renewable and nonrenewable categories, and to consider how renewables are currently used. • Understand the concept of energy; an overview of the forms of energy and the laws of energy that govern interactions between matter and energy. • Establish a base of knowledge about renewable energy; an overview of the use of different types of non-renewable and renewable sources of energy. • The current status, importance, future trends and potential for renewable energy technologies as a complement to, or replacement for, conventional technologies. **Conventional Energy Systems** • Standard conventional energy provision technologies based on fossil fuel energy, used for comparison, are defined and discussed. • Cost figures are provided allowing for a comparison with cost parameters assessed for the option of using renewable energy sources. **Solar Energy** • Review methods employed to obtain solar energy. • A brief review of the history and basic principles of solar thermal and photovoltaic energy conversion. • Various ways of reducing the currently high cost of energy are included in this section. • Discussion of environmental implications.

	Wind Energy • A description of the atmospheric processes that produces wind energy. • The fundamental principle of wind turbine operation. • Discussion of the environmental impact and economics of wind energy. • Examination of recent commercial developments in wind energy and its future potential. **Hydropower** • A discussion of this natural resource and its contribution to world energy. • Summary of the basic science together with a brief history of the development of water power. • Concerns, problems and potential of hydroelectricity. • Discussion of environmental implications. **Bio-Energy** • The features of bio-energy and other aspects such as the sustainability concern, economics and potential future for this renewable resource. • Discussion of environmental implications. **Geothermal Energy** • An overview of geothermal energy including sources of heat and its historical perspective. • Review various technologies for geothermal resource exploitation. • Discussion of environmental implications.
Teaching/Learning Methodology	Lectures to provide fundamental knowledge and information on various topics in this subject. Also, discussions, case studies, interesting and inspired seminars all engage student's in-depth analysis of renewable energy. The case studies, largely based on real experience, are designed to integrate the topics covered in the subject and to illustrate how selected techniques are inter-related and applied in real-life situations. The subject provides students with lifelong learning opportunities including seminars conducted by renewable energy experts, lectures and in class decision making exercises, cases studies, and science project which students will receive practical training in the use of world leading clean energy decision-making tool. The future development of renewable energy is significantly influenced by national energy policy, economy concern, sustainability issues, and technology roadmaps. The weightings of teaching and learning activities of interesting topics of renewable energy covered in this subject are based on market and industry trend, technology development, future prospect, national demand and sustainability issues, i.e., there is a continuing debate around the sustainability of biomass use for energy, particularly with respect to the carbon footprint, especially where linked with deforestation, and where land and water used for energy crop production competes with food and crops. Therefore, the teaching and learning

	activities of this subject will primarily focus on solar energy, wind energy, hydro power, and less concentration on bio-energy and geothermal energy. Periodically, based on the latest global energy demanding and national policy, the priorities of teaching and learning activities will be adjusted accordingly. Furthermore, the teacher will continue to monitor on students' learning activities closely for the purposes of diagnosing learning strengths and difficulties and making judgments about how to improve the learning process. *Reading Assignment* Each student will submit one assignment based on their weekly learning activities which will be part of the subject's evaluation. This assignment will deal with the main renewable energies and most important technological, economic and environmental aspects associated with them. Students will review and critique the literature with respect to a renewable energy source or a related technology. The assignment will be provided by the teacher and will be based on the published reports and papers from international organizations, professional institutions, governments, conferences, and related journals. *Group Decision Making Exercises* Two in-class decision-making exercises will be given. These provide an approach for assessing students' thinking skills, analyzing attitudes and values. Decision-making exercises are structured problem solving exercises that are presented to students as a series of tasks: • Identifying the problem • Finding solutions • Understanding the problem • Summing-up These decision-making exercises are based upon a set of prepared resources, including newspaper reports and statistical data. They are provided as background reading. Each group will submit short essay after the exercise. *Group Project* Science project is an effective way of teaching students about the world around them. Whether conducted in the classroom or field, projects can help students develop critical thinking and problem solving skills. In the classroom setting, projects offer a way for teacher to put "action" into the lessons. The students have fun while they're learning important knowledge and skills. Students will form into groups and throughout the subject. Each group will conduct a project addressing a renewable energy resource/topic by researching, developing, and preparing a renewable energy portfolio. A list of possible topics will be provided by the teacher. Group projects are intended to be an enjoyable learning experience in which students become familiar with *technical*, *economic*, *social*, *political*, and *environmental* issues associated with the topic they are exploring. The project preparation may involve following stages: (i) identifying possible causes and effects of a problem, (ii) identifying the underlying

problem, (iii) brainstorming potential solutions to the underlying problem, (iv) developing criteria for evaluating solutions, (v) evaluating all solutions to determine the best one, (vi) developing an action plan for the best solution. The RETScreen© International Clean Energy Project Analysis software will be used to help students to evaluate the energy production, life-cycle costs and greenhouse gas emission reductions for various types of proposed renewable energy technologies. It is the world's leading clean energy decision-making tool. It is provided completely free-of-charge by the Government of Canada (Minister of Natural Resources Canada). It is a Windows© Excel-based software tool that helps students to make decision and to estimate the viability of a potential clean energy project. The software is proven to be a quickest and easiest tool for students to learn and conduct the projects analysis.

Students complete the group projects at the end of the semester through the following learning activities:

1. The group project portfolio will include:
   (i) Presentation slides and report
   (ii) Individual reflection statement
2. Final project oral presentation.

Students will be evaluated based on the importance and relevance of the problem, quality of solution and its implementation, and clarity of the final report and presentation.

Seminar

Prominent experts from industry, professional institutions, academia and local government will be invited to share his/her experience and knowledge with students and this will give students to understand the latest development in renewable energy area. Through interactive, experiential learning, access to experts in the field, each student gains thorough knowledge in areas of interest to him or her as well as invaluable real world academic training.

Through above learning activities, students' ability to apply and synthesize acquired knowledge will be evaluated on the basis of their performance in group discussions, oral presentations, and the quality of their project reports on these case studies.

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed (Please tick as appropriate)					
		a	b	c	d		
1. Continuous	70						

• Group Decision Making Exercises	10	✓	✓	✓	✓		
• Mid-Term Evaluation	5	✓	✓				
• Research Essay (individual assignment)	20	✓	✓	✓			
• Project Oral Presentation	10	✓	✓				
• Reflection Statement	10	✓	✓	✓	✓		
• Group Project	15	✓	✓	✓	✓		
2. Examination	30	✓	✓	✓	✓		
Total	100 %						

Coursework of this subject involves students working in groups to study cases so that they are able to apply their knowledge to suggest the best combination of sustainable solutions to minimize emission of greenhouse gases and increase sustainability of an energy system in specific areas/regions. Through such exercises, students' ability to apply and synthesize acquired knowledge can be assessed on the basis of their performance in group discussion, oral presentations, and the quality of their written reports on these case studies. A written final examination is also designed to assess the intended learning outcomes.

The intended learning outcomes can be achieved through various learning activities:

Learning Activities	Intended Learning Outcomes (ILOs)
Group Decision Making Exercises	Traditional assessment methods are not usually useful for assessing thinking skills and the process of analyzing attitudes and values. Decision-making exercises are an excellent way of doing this. The objectives of the learning process being assessed by the decision-making exercise are: (a) to become aware of the seriousness of current energy issues as a problem, its causes and consequences, (b) to understand the different attitudes taken to the problem and why these differences arise, and (c) to describe and evaluate the effectiveness of solutions to the specific problems in potential areas. Decision-making exercises will be marked according to the following criteria: * conceptual knowledge/communication skills * organization/structure * the illustrations and examples used * the quality of the arguments that are used to support students' recommendation *(ILOs: a, b, c, d)*

	Research Essay	The assignments will be interesting and challenging. It considers how to focus students' thinking in ways that are creative, challenging, and motivating. The instructor gets students to exercise their imaginations while also accomplishing the learning objectives of the course. It can foster students' understanding of the relationship between theory and real world experience. Students will review and critique literature with respect to critical issues about sustainable development. *(ILOs: a, b, c)*
	Mid-Term Progress Evaluation	To ascertain whether the student has made progress and is on the right track, a mid-term evaluation will be scheduled. Students are requested to give a 10-15 minutes summary of their projects and an overview of what still needs to be done. The mid-term presentation assesses the progress of students' understand toward the final presentation. Students will receive the mid-term presentation evaluation sheet approximately one week after the mid-term presentation. Students are advised to refer to the evaluation sheet when they write their project reports and prepare for the project final presentation. Evaluation criteria include, but are not limited to: * Quality of the oral presentation * Quality and quantity of progress * Quality of answers to questions during presentation * Plans for completion *(ILOs: a, b)*
	Reflection Statement	Student will be reminded of the ILOs through the whole learning process to ensure that program activities are aligned with learning outcomes. Reflections allow students to see their own progress and encourage them to speak up if their needs are not being met. This practice also refocuses students on the intended learning outcomes of the course. *(ILOs: a, b, c, d)*
	Project Oral Presentation	Oral presentation is intended to: (1) test student's cognitive skills,(2) allow student to demonstrate the ability to generate and synthesize new ideas, (3) give student the opportunity to demonstrate what his/her have learnt in an analytical way, (4) give student a chance to learn from peers and to share his/her knowledge with them. This is important in building communication skills and can serve as a source of information about specific topics for other students. *(ILOs: a, b)*
	Group Project	The project usually reflects what the student has read or heard about an area of science. By creating displays or collections of scientific information or demonstrating certain phenomena, the student goes through a process similar to a library research report

			or meta-analysis in any other subject. Group projects can help students develop skills specific to collaborative efforts, allowing students to (1) tackle more complex problems than they could on their own, (2) delegate roles and responsibilities, (3) share diverse perspectives, (4) pool knowledge and skills, (5) develop new approaches to resolving differences, (6) find effective peers to emulate, and (7) develop their own voice and perspectives in relation to peers. *(ILOs: a, b, c, d)*
		Seminar	Seminar dealing with "special topics" and is a form of experiences and information exchanges. Seminar provides opportunity for students to have discussion and learning of specific techniques and topics with a keynote speaker. These prominent speakers are usually experts in their own fields, or topics. This inspired seminar will take an interdisciplinary approach to renewable energy to help students build a holistic understanding and develop competence in critical analysis of sustainability systems. The seminar aims to engage students intellectually in relevant renewable energy issues and give ample opportunity to exercise their knowledge with experts of related renewable energy field. *(ILOs: a, b, c, d)*
		Examination	The course objectives will be appropriately addressed by exam. The examination assesses students' fundamental knowledge and understanding of a specific topic and to apply the principles students have learned in the course. This helps students see how the components of the course align, reassures them about their ability to perform well (assuming they have done the required work), and activates relevant experiences and knowledge from earlier in the course. *(ILOs: a, b, c, d)*
Student Study Effort Expected	Class contact:		
	▪ Lecture		27 Hrs.
	▪ Case studies/Presentation/Seminar		12 Hrs.
	Other student study effort:		
	▪ Research and Preparation (Group/self-study)		55 Hrs.
	▪ Assignments/Report writing		25 Hrs.
	Total student study effort		119 Hrs.
Reading List and References	**Conventional Energy** 1. Boyle, Godfrey, 2012, Renewable Energy: Power for a Sustainable		

	Future, 3rd edit, Oxford University Press, *Chapter 1* 2. Renewables 2014 Global Status Report, www.ren21.net, *Chapter 2* 3. Jefferson W. Tester, et al, 2012, Sustainable Energy: Choosing Among Options , The MIT Press, , Cambridge MA, *Chapters 8-9* 4. Aldo V. da Rosa, 2012, Fundamentals of Renewable Energy Processes, Academic Press, *Chapters 2-3* *5.* V. Nelson, 2011, Introduction to Renewable Energy, CRC Press, *Chapter 2* 6. N. Armaroli and V. Balzani, 2011, Energy for a Sustainable World, Wiley-VCH, *Chapters 1-8* 7. Clean Energy Project Analysis: RETScreen© Engineering & Cases, 3rd ed., 2005, Minister of Natural Resources Canada, *Chapter: Introduction* **Solar Energy** 1. Renewables Information 2013, International Energy Agency (IEA), *pp. 187-197* 2. Boyle, Godfrey, 2012, Renewable Energy: Power for a Sustainable Future, 3rd edit, Oxford University Press, *Chapters 2-3* 3. Renewables 2014 Global Status Report, www.ren21.net, *Chapter 2* 4. Jefferson W. Tester, et al, 2012, Sustainable Energy: Choosing Among Options , The MIT Press, , Cambridge MA, *Chapter 13* 5. Aldo V. da Rosa, 2012, Fundamentals of Renewable Energy Processes, Academic Press, *Chapters 12 and 14* *6.* V. Nelson, 2011, Introduction to Renewable Energy, CRC Press, *Chapters 3 and 8* 7. N. Armaroli and V. Balzani, 2011, Energy for a Sustainable World, Wiley-VCH, *Chapters 9-10* 8. B. Sorensen, 2010, Renewable Energy - Engineering, Environmental Impacts, Economics & Planning, 4th ed., Academic Press, *Chapters 3-4* 9. Clean Energy Project Analysis: RETScreen© Engineering & Cases, 3rd ed., 2005, Minister of Natural Resources Canada, *Chapters of Photovoltaic, Solar Water and Air Heating* 10. http://www.renewableenergyworld.com/rea/home/solar-energy **Wind Energy** 1. Renewables Information 2013, International Energy Agency (IEA), *pp. 180-186* 2. Boyle, Godfrey, 2012, Renewable Energy: Power for a Sustainable Future, 3rd edit, Oxford University Press, *Chapter 7* 3. Renewables 2014 Global Status Report, www.ren21.net, *Chapter 2* 4. Jefferson W. Tester, et al, 2012, Sustainable Energy: Choosing Among Options , The MIT Press, , Cambridge MA, *Chapter 15* 5. Aldo V. da Rosa, 2012, Fundamentals of Renewable Energy Processes, Academic Press, *Chapter 15* *6.* V. Nelson, 2011, Introduction to Renewable Energy, CRC Press, *Chapter 9* 7. N. Armaroli and V. Balzani, 2011, Energy for a Sustainable World, Wiley-VCH, *Chapter 12* 8. B. Sorensen, 2010, Renewable Energy - Engineering, Environmental

	Impacts, Economics & Planning, 4th ed., Academic Press, *Chapters 3-4* 9. Clean Energy Project Analysis: RETScreen© Engineering & Cases, 3rd ed., 2005, Minister of Natural Resources Canada, *Chapter of Wind Energy* 10. http://www.renewableenergyworld.com/rea/home/wind-power **Hydropower** 1. Renewables Information 2013, International Energy Agency (IEA), *pp. 175-177* 2. Boyle, Godfrey, 2012, Renewable Energy: Power for a Sustainable Future, 3rd edit, Oxford University Press, *Chapter 5* 3. Renewables 2014 Global Status Report, www.ren21.net, *Chapter 2* 4. Jefferson W. Tester, et al, 2012, Sustainable Energy: Choosing Among Options , The MIT Press, , Cambridge MA, *Chapter 12* *5.* V. Nelson, 2011, Introduction to Renewable Energy, CRC Press, *Chapter 12* 6. N. Armaroli and V. Balzani, 2011, Energy for a Sustainable World, Wiley-VCH, *Chapter 12* 7. B. Sorensen, 2010, Renewable Energy - Engineering, Environmental Impacts, Economics & Planning, 4th ed., Academic Press, *Chapters 3-4* 8. Clean Energy Project Analysis: RETScreen© Engineering & Cases, 3rd ed., 2005, Minister of Natural Resources Canada, *Chapter of Hydro* 9. http://www.renewableenergyworld.com/rea/home/hydropower **Bioenergy** 1. Renewables Information 2013, International Energy Agency (IEA), *pp. 170-174* 2. Boyle, Godfrey, 2012, Renewable Energy: Power for a Sustainable Future, 3rd edit, Oxford University Press, *Chapter 4* 3. Renewables 2014 Global Status Report, www.ren21.net, *Chapter 2* 4. Jefferson W. Tester, et al, 2012, Sustainable Energy: Choosing Among Options , The MIT Press, , Cambridge MA, *Chapter 10* 5. Aldo V. da Rosa, 2012, Fundamentals of Renewable Energy Processes, Academic Press, *Chapter 13* *6.* V. Nelson, 2011, Introduction to Renewable Energy, CRC Press, *Chapter 10* 7. N. Armaroli and V. Balzani, 2011, Energy for a Sustainable World, Wiley-VCH, *Chapter 11* 8. B. Sorensen, 2010, Renewable Energy - Engineering, Environmental Impacts, Economics & Planning, 4th ed., Academic Press, *Chapters 3-4* 9. Clean Energy Project Analysis: RETScreen© Engineering & Cases, 3rd ed., 2005, Minister of Natural Resources Canada, *Chapter of Biomass Heating* 10. http://www.renewableenergyworld.com/rea/home/bioenergy **Geothermal** 1. Renewables Information 2013, International Energy Agency (IEA),

	pp. 173-174 2. Boyle, Godfrey, 2012, Renewable Energy: Power for a Sustainable Future, 3rd edit, Oxford University Press, *Chapter 9* 3. Renewables 2014 Global Status Report, www.ren21.net, *Chapter 2* 4. Jefferson W. Tester, et al, 2012, Sustainable Energy: Choosing Among Options , The MIT Press, , Cambridge MA, *Chapter 11* *5.* V. Nelson, 2011, Introduction to Renewable Energy, CRC Press, *Chapter 11* 6. N. Armaroli and V. Balzani, 2011, Energy for a Sustainable World, Wiley-VCH, *Chapter 12* 7. B. Sorensen, 2010, Renewable Energy - Engineering, Environmental Impacts, Economics & Planning, 4th ed., Academic Press, *Chapters 3-4* 8. Clean Energy Project Analysis: RETScreen© Engineering & Cases, 3rd ed., 2005, Minister of Natural Resources Canada, *Chapter of Ground-Source Heat* 9. http://www.renewableenergyworld.com/rea/home/geothermal-energy