School of Natural Resources Engineering and Management

Master Program in Environmental and Renewable Energy Engineering

Study Plan

2013

Masters of Science Program in Environmental and Renewable Energy Engineering

Introduction

There are many master programs in environmental engineering and in renewable energies. However taking the impact of environmental engineering on climate change is a novelty at this time in history. Much of the greenhouse gases are manmade and it is very important to conduct research in finding ways that'll reduce the harmful effect of these gases. This Master program has this goal in its initiation.

The proposed program is designed to prepare well qualified environmental engineers, electrical engineers, mechanical engineers and renewable energy engineers who will be able to design and implement solutions to environmental challenges by providing students advanced knowledge in areas such as: Climate change, Pollution control technologies and alternate energy. The program was designed to comply with a market and universities study that was launched at the beginning of the TEMPUS project that funded this master program. Two questionnaires were designed by the partners in this TEMPUS project and was sent to around 600 stakeholders only around 48 replied with filled questionnaires. The analysis of the questionnaires were done by the University of Innsbruck in Austria, one of the partners in this project. The results are attached with this study plan to comply with the Council of Higher Educations decisions on establishing new graduate programs. Also attached are the names, positions and status of the faculty members involved directly or indirectly with this program. The program belongs to the School of Natural Resources Engineering and Management and is a joint program between the Department of

Energy Engineering and the Department of Water and Environmental Engineering. The applied aspect of the courses is reflected in practical or experimental student projects with a weight of one credit hour. This has been noted as a laboratory. These projects will need equipment and we have attached a comprehensive list of equipment for this program. Initially we may need half of these equipment but as the program grows and in order to diversify the projects then we need more equipment that are listed. We intend in the near future to search for a German University in order to collaborate with this program and as soon as we find such a university we shall go through the Ministry of Higher Education process in order to approve it. But for the moment it is purely a GJU graduate program.

Program Objectives

The program objectives are as follows:

1) The ability to find solutions merging renewable energy resources in place of conventional energy sources (fossil fuel) in various environmental engineering practices.
2) The ability of merging knowledge from multi-disciplinary fields to design, develop and assess new solutions that will have positive impact on climate change.
3) The ability to engage in environmental engineering research and careers in various areas such as sustainability, air quality engineering, wastewater treatment, impact on climate, etc...
4) To raise the awareness among environmental engineers of the practices of the profession and its impact on the climate.
5) To be involved in a wide range of community concerns, such as regulatory, economic, ethical, and global issues.
6) The ability to pursue a Ph.D. Degree in environmental engineering.
7) Knowledge of regulatory considerations in air pollution control related to model selection and use to avoid adverse effects on the environment.

Learning Outcomes

The program learning outcomes for our graduating students are:

1) Competency in using renewable energy solutions in place of fossil fuel energy sources.
2) Competency in environmental engineering research.
3) Looking for environmental engineering designs that have minimum negative impact on climate.
4) Ability to discuss and defend ideas constructively, effective oral communication, and to write technical reports skilfully.
5) Teamwork skills in multidisciplinary projects and identification of environmental engineering problems and proposal of solutions, including rigorous analysis and design of a process, component or system.
6) Appreciation of the ethical and societal responsibilities entailed in environmental engineering profession and the need for continuous education in the field and commitment to life-long learning.
7) Active participation in professional environmental organizations and involvement in NGOs for the benefit of the local community and the society at large.

Learning Outcomes Assessment

Competency is measured by the ability to use and apply fundamental principles and knowledge in solving problems in each of the mentioned areas. To measure the ability of the students and their perception of the program effectiveness the following will be done: In addition to students evaluation forms and the instructors evaluation forms which are done every semester, a continuous monitoring of the graduates whereabouts, professions they are involved in and their satisfaction and the employers' satisfaction, with what they learned will be checked against the above mentioned sources of evaluation, in order to determine the most probable positive or negative outcomes of the program. Research papers published in internationally refereed journals written by the students, which are the result of the master thesis projects, are the main indicators of the effectiveness of the program. The positive outcomes will be reaffirmed in the program and the negative outcomes will be avoided by redesigning the program.

Curriculum for Masters of Science Degree in Environmental and Renewable Energy Engineering

Classification	Credit Hours
Compulsory Requirements	**19**
Elective Requirements	**6**
Master's Thesis	**9**
Total	**34**

1. Compulsory Requirements (19 Credit Hours):

Course No.	Course Title	Cr. hrs.	Lecture	Lab*	Prerequisite
ERE 721	Applied math for environmental engineers	3	3	0	-
ERE 722	Quantitative environmental modeling	3	2	1	ERE 721
ERE 731	Advanced Renewable Energy Systems	3	2	1	-
ERE 732	Advanced Energy Conversion	3	2	1	
ERE 741	Introduction to Meteorology and Climate Phenomenology	3	3	0	-
ERE 761	Air pollution control and modeling	3	2	1	
ERE 781	Seminar	1	1		
	Total	**19**			

2. Elective Requirements (6 Credit Hours) to be chosen from:

Course No.	Course Title	Cr. hrs.	Lecture	Lab*	Prerequisite
ERE723	Numerical methods in environmental eng.	3	3	0	
ERE 733	Energy Efficiency in Buildings	3	3	0	-
ERE 734	Energy Systems and Energy Economics	3	2	1	
ERE 742	Environment and Sustainable Development	3	3	0	
ERE743	Environmental biotechnology	3	3	0	
ERE 751	Advanced Wastewater Treatment	3	2	1	
ERE 752	Water Management in Middle East	3	3	0	-
ERE 771	Environmental and Water Laws and Policies	3	3	0	
	Total Taken	**6**			

4. Thesis Requirements (9 Credit Hours):

Course No.	Course Title	Cr. hrs.	Lecture	Lab*	Prerequisite
ERE 799 A	Master Thesis	9	-	-	
ERE 799 B	Master Thesis	6	-	-	
ERE 799 C	Master Thesis	3	-	-	
ERE 799 D	Master Thesis	0	-	-	
	Total Taken	**9**			

Course Code

The digits have the following representation:

The left digit represents the course level.

The middle digit represents the specialized field of knowledge of the course as follows:

2. Mathematics and modeling

3. Energy/Renewable Energy/Energy Economics

4. Environment /Meteorology

5. Water and Wastewater

6. Air quality

7. Environmental and Water Laws and Policies

8. Seminar

9. Master Thesis

The right digit represents the sequence of the course within the field.

Study Plan Guide for the Masters of Science Degree in Environmental and Renewable Energy Engineering

First Year				
First Semester				
Course No.	**Course Title**	**Cr. hrs.**	**Prerequisite**	**Co-requisite**
ERE 721	Applied math for environmental engineers	3		
ERE 731	Advanced Renewable Energy Systems	3	-	-
ERE 000	Elective (1)	3	-	-
		9		
Second Semester				
Course No.	**Course Title**	**Cr. hrs.**	**Prerequisite**	**Co-requisite**
ERE 722	Quantitative environmental modeling	3	ERE 721	-
ERE 741	Introduction to Meteorology and Climate Phenomenology	3		
ERE 761	Air pollution control and modeling	3	-	-
	Total	**9**		

Second Year				
First Semester				
Course No.	**Course Title**	**Cr. hrs.**	**Prerequisite**	**Co-requisite**
ERE 732	Advanced Energy Conversion	3		
ERE781	Seminar	1		
ERE 000	Elective (2)	3		
ERE 799 C	Master Thesis	3	Dept.	

			Consent	
		10		
Second Semester				
Course No.	**Course Title**	**Cr. hrs.**	**Prerequisite**	**Co-requisite**
ERE 799 B	Master Thesis	6	Dept. Consent	-
	Total	**6**		

Courses Description

Masters of Science Program in Environmental and Renewable Energy Engineering

Courses Description

ERE 721 Applied math for environmental engineers, 3 Crs.

This subject introduces important mathematical methods required in engineering such as manipulating vector differential operators, computing multiple integrals and using integral theorems. A range of ordinary and partial differential equations are solved by a variety of methods and their solution behaviour is interpreted. The subject also introduces sequences and series including the concepts of convergence and divergence.

Topics include: Vector calculus, including Gauss' and Stokes' Theorems; sequences and series; Fourier series, Laplace transforms; systems of homogeneous ordinary differential equations, including phase plane and linearization for nonlinear systems; second order partial differential equations and separation of variables.

ERE 722 Quantitative environmental modeling 3 Crs.(2 lectures, 1 Lab*)

Environmental problems are highly complex and challenging to analyze. This subject focuses on environmental modeling methodology including the steps of model conceptualization, model construction, model evaluation and model application using a range of energy, water and waste models in different softwares. The relationship between theoretical and empirical understanding and their use in model conceptualization and construction will be explored. This subject introduces a range of environmental modeling techniques applicable to different environmental problems. Within the structure of this course the instructor will assign to the students experimental or practical projects related to the subject such as:

- System conceptualization
- Model construction and validation (computational accuracy)

- Model evaluation
- Calibration and optimization
- Model uncertainty assessment techniques
- Issues of appropriate model complexity

ERE 731 Advanced Renewable Energy Systems, 3 Crs. (2 cr lectures, 1 cr Lab*)

Review of renewable energy resources. Wind energy: horizontal-axis and vertical-axis machines, performance characteristics. Wave energy: principles of operation. Solar energy: solar flux and solar angles calculations, solar-thermal technologies. Biomass energy conversion: direct combustion and alcoholic fermentation. Applications include fuel reforming, hydrogen and synthetic fuel production, fuel cells and batteries, combustion, hybrids, catalysis, supercritical and combined cycles and photovoltaic. Matlab modelling and simulation. Experimental and practical verifications in the form of projects will be given to the students in the above areas.

ERE 732 Advanced Energy Conversion 3Crs. (2 cr lectures, 1 cr. Lab*)

The course covers the fundamentals of thermodynamics, flow and transport processes as applied to energy systems. Energy conversion in thermo mechanical , fusion , fuel-cells, photoelectric and hydroelectric processes in existing and future power and transportation systems, with the emphasis on efficiency and performance. Energy utilization , storage and transmission. Modelling and simulation of the different systems. Experimental verification where possible.

ERE 733 Energy Efficiency in Buildings, 3 Crs.

Energy requirements for buildings, industry and mobility. Physical principles needed to optimize the energy efficiency in the various fields. Building envelope and services. Energy simulations. Best practice building design.

ERE 734 Energy Systems and Energy Economics, 3 Crs.
This course covers the production, collection and storage of different types of renewable energy, including solar, wind, biological, geothermal, hydro, tide and wave, and fuel cells. Energy integration and energy economics are introduced. Transition to low carbon energy economy is emphasized.

ERE 741 Introduction to Meteorology and Climate Phenomenology, 3 Crs.

This course is intended to provide students with the tools and knowledge they need to develop their own well-informed view of climate change. The contents include an overview of atmospheric dynamics and thermodynamics structure. Atmospheric constituents and their change over time. Defining weather and climate; predicting weather and climate, deterministic vs. statistical forecast; periodicities in climate; solar forcing and its variation; glaciations. Weather and climate; natural causes of climate variation. The equivalent temperature and the radiative equilibrium climate model. Fundamental concepts of atmospheric physics. Introduction to atmospheric radiation; one layer greenhouse. The gray model for the radiative equilibrium temperature structure of the atmosphere; the greenhouse effect. Introduction to the radiative properties of clouds. Classification of clouds and the processes forming high and low clouds ; introduction to the microphysics of cloud formation. Precipitation processes; cloud condensation nuclei and ice nuclei and the collisional coalescence process. Introduction to dynamics. Explanation of fictitious forces and derivation of Coriolis force. Thermal wind and the hypsometric relation.

ERE 742 Environment and Sustainable Development, 3 Crs.

Sustainable systems in environmental engineering and their development are analysed and discussed. Sustainability is easily maintained when coupled with renewable energy resources. As an application we discuss the sustainable wastewater treatment by utilizing natural processes (aerobic digestion, photosynthesis, etc…), renewable sources of energy (e.g., sunlight, wind, geothermal, and biomass), etc... Sustainable wastewater treatment relies minimally on fossil fuel energy and the mechanical processes are operated through renewable energy resources, it is in general cost-effective. Sustainability and development of environmental systems involves assessment of current and potential future energy needs, with emphasis on meeting regional and global energy needs in this and coming century.

ERE 743 Environmental Biotechnology, 3 Crs.

This course covers fundamental aspects of microbial physiology and ecology. Specific areas of focus include energetics and yield, enzyme and growth kinetics, cell structure and physiology, metabolic and genetic regulation, microbial/environmental interactions, and biogeochemical cycles. The goal of this course is to provide a basic understanding and appreciation of microbial processes which may be applicable to environmental biotechnology.

ERE 751 Advanced Wastewater Treatment, 3 Crs.(2cr lectures,1 cr Lab*)

The course introduces Characteristics of wastewater. Principles of wastewater treatment process design, operation and economics. Unit operations. Biological treatment systems and oxidation kinetics. Advanced wastewater treatment and reuse. Sludge treatment processes, including public health engineering, wastewater disposal systems, and wastewater contamination indicators. Topics include wastewater quality parameters; unit operations in treatment of wastewater. Experimental and practical projects are given to the students in the above topics.

ERE 752 Water Management in Middle East, 3 Crs.

This course addresses major topics such as water quantity, water quality, human population, and energy. It also addresses topics related to Middle East water issues. Water sources. Main water uses. Recycling and conservation of water. Aquifers and its over-pumping. Discharge of human and industrial wastewater. National and international institutions. Militarization of water. Politics and research as part of the solution. Integrated water resource management. Principles and practice of water resources planning and management. Protocols employed at local, state, regional and international levels. Plan formulation, evaluation, and implementation. Stakeholder involvement in planning processes. Analytical tools. Case studies.

ERE 761 Air Pollution Control and modeling, 3Crs. (2 Crs, 1 cr Lab*)

Influence of greenhouse gases and air pollution on climate change. Relationship between air pollution and energy consumption. Air pollution control strategies: fossil fuel cleaning at refineries, renewable energy (wind, PV, biomass, etc.), and alternative energy sources (geothermal, hydrogen, etc). Industrial air pollution control. Control of particulate matter. Control of VOCs, SOx, and NOx. Adsorption and absorption of air pollutants. GHG emission control. Indoor air quality engineering. As an outcome of this course students should be able to design and critically evaluate pollution control methods for industrial and motor vehicle sources and suggest pollution prevention methods. This course includes also an overview of atmospheric motion to give students a sense of how air pollutant transport and transformation is modeled. Laboratory and/or field work projects are given to the students as explained below:

Laboratory procedures and principles include the nondispersive infrared method for CO; the coulometric, flame photometric, and UV fluorescent methods for sulfur compounds; the chemiluminescent method and UV calibrations procedure for O3; and the chemiluminescent method for NO2. Students also learn the use of dynamic calibration systems to calibrate continuous air monitoring equipment and to determine performance specifications of the various instruments. Carbon monoxide and hydrocarbons can be also measured in vehicle exhaust to quantify the contribution of combustion engines to air pollution. You will use the Air Quality Index to determine the health effects of carbon monoxide and ozone.

ERE 771 Environmental and Water Laws and Policies, 3 Crs.

An introduction into the environmental and water justice system. An Introduction to environmental and water values and policies. Economics and the environment. Overview of the structure of the environmental laws. Regulatory legislation, and the regulatory process. Air pollution problems and control. Contemporary climate litigation. Water pollution control. Statutory Authorities. Regulation from point sources. Effluent limitations. Water quality based controls. Environmental impact assessment. Environmental enforcement. Citizens law suits. Global climate change. Environmental and climate justice.

ERE 781 Seminar, 1Cr.

This seminar is to work on issues related the environment directly or by using renewable energy engineering solutions.

ERE 799A Master Thesis / Environmental Engineering and Climate Change, 9 Crs.

ERE 799B Master Thesis / Environmental Engineering and Climate Change, 6 Crs.

ERE 799C Master Thesis / Environmental Engineering and Climate Change, 3 Crs.

ERE 799D Master Thesis / Environmental Engineering and Climate Change, 0 Crs.

This course involves extensive research in environmental and renewable energy engineering and climate change. The Master's Thesis is based on field research and demonstrates student's background knowledge. A defense will be set to evaluate student's capabilities of carrying out research, with a focus on the analysis and interpretation of skills gained.

Further elective courses in the above fields will be added as deemed by the School of Natural Resources Engineering and Management.

*Wherever the word Lab appears in the courses headings we mean by that the projects carried out by the students in each course and evaluated by the instructor with a one credit weight.