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

1. Introduction

In a world rapidly facing the prospects of climate change and depletion of cheap fossil fuel resources, it becomes eminently clear that qualified professionals will be needed to rise to the challenges that will flow from these threats. Moreover, it is clear that these threats transcend the traditional disciplines that deal with the various pieces of the sustainability puzzle.

This is why the School of Natural Resources Engineering and Management is offering a Master program in Environmental and Renewable Energy Engineering. There are plenty of programs that teach renewable energy, environmental engineering and sustainable planning. These programs tend to have too narrow of foci to achieve the goals which set out herein.

We aim to create professionals who can take up the leadership positions that require both solid technical backgrounds as well as a broad scope of view, which will allow for visionary solutions for the challenges ahead. Thus, the integration of environmental and renewable energy under the heading of sustainability will allow for such an outcome.

Students will acquire a deep understanding of the issues of sustainability, discussing issues such as ecosystem approaches, collapse, efficiency traps, fossil fuel depletion and its implications. These will be the key to understanding the importance in building a world that is both robust and resilient. Obviously, a key component to this lies in alternative energy sources, of which the students will become acutely familiar with. Previous surveys of employers have shown keen interest in obtaining people with the competencies gained in this program.

The program is course based, with a total of 34 credit hours distributed between compulsory courses (25 CH), electives (9 CH) and a comprehensive exam at the end of the degree.

2. Program Objectives

The program objectives are as follows:

1) Understanding the limitations of ecosystem stability and the consequences of ignoring them.
2) Understanding system approaches and viewing future engineering challenges in a larger context.
3) The ability to find solutions merging renewable energy resources in place of conventional energy sources (fossil fuel) in various environmental engineering practices.

4) 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...
5) To raise the awareness among environmental engineers of the practices of the profession and its impact on the climate.
6) To be involved in a wide range of community concerns, such as regulatory, economic, ethical, and global issues.
7) The ability to pursue a Ph.D. Degree in Renewable energy and environmental engineering
8) Knowledge of regulatory considerations in pollution control related to model selection and use to avoid adverse effects on the environment.

3. Learning Outcomes

The program learning outcomes for our graduating students are:

1) Appreciation of the problems ahead and how best to tackle them on local and regional levels.
2) Ability to understand short and longer range implications of engineering solutions and the best ways to mitigate them.
3) Competency in using renewable energy solutions in place of fossil fuel energy sources.
4) Competency in environmental engineering and renewable energy research.
5) Ability to discuss and defend ideas constructively, effective oral communication, and to write technical reports skillfully.
6) Teamwork skills in multidisciplinary projects and identification of problems and proposal of solutions, including rigorous analysis and design of a process, component or system.
7) 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.
8) 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

During the course of study, students will be assessed through examinations, home works, reports and presentations. At graduation, the student will face a comprehensive exam which will be the basis for the graduation decision. 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.

4. Enrollment

A. All students having a BSC degree in any engineering discipline can be enrolled in this master program. This includes:

Civil engineers
Mechanical engineers
Architectural engineers
Electrical engineers
Renewable/energy engineers
Industrial Engineers
Chemical Engineers
Aeronautical Engineers
Nuclear Engineers

Basic knowledge in thermal and fluid science is required. Any student who did not have this knowledge will have to study prerequisites courses. The courses will be assigned by the department and informed to the applicant in his/her admission letter.

B. Passed the TOEFL Exam with a minimum score of 500 or equivalent.

C. A relevant working experience is preferable.

Students holding other degrees need to consult with the program director for application

5. Degree requirements

Students must complete the following requirements to obtain the Masters of Science Degree in Environmental and Renewable Energy Engineering – Non thesis option:

Classification	**Credit Hours**
Compulsory Requirements	25
Elective Requirements	9
Comprehensive examination, after completing all the core and elective courses successfully and obtaining the department approval.	0
Total	**34**

6. Curriculum

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

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

1. Compulsory Requirements

Course No.	Course Title	Cr. hrs.	Lecture	Lab*	Prerequisite
ERE 721	Applied Mathematics for Engineers	3	3	0	-
ERE 722	Modeling, Simulation and Optimization of Energy and Environmental Systems	3	3	0	-
ERE723	Advanced Numerical Methods	3	3	0	
ERE 731	Advanced Renewable Energy Systems	3	2	1	-
ERE 732	Advanced Energy Conversion	3	3	0	
ERE 734	Techno Economical Feasibility	3	3	0	
ERE 741	Meteorology and Climate Phenomenology	3	3	0	-
ERE742	Sustainability	3	3	0	
ERE 781	Seminar	1	1		
	Total	**25**			

2. Elective Requirements:

For the non-thesis track, 9 credit hours should be selected from the table below:

Course No.	Course Title	Cr. hrs.	Lecture	Lab*	Prerequisite
ERE 733	Energy Efficiency	3	3	0	-
ERE 735	PV – PhotoVoltaics	3	2	1	ERE 731
ERE 736	Wind Energy Systems	3	2	1	ERE 731
ERE 737	Concentrated Solar Power (CSP)	3	3	0	ERE 731
ERE743	Environmental Biotechnology and Bioenergy				
ERE 744	Climate change and Predictability	3	3	0	
ERE 751	Advanced water and Wastewater Treatment	3	3	0	
ERE 752	Water, Energy, and Environment Management	3	3	0	
ERE 761	Air pollution Control	3	3	0	-
ERE 771	Energy, Environmental and Water Laws and Policies	3	3	0	
ERE 791	Special topics in renewable energy	3	3	0	
ERE 792	Special topics in environmental engineering	3	3	0	
	Total Taken	**6**			

3. Non-thesis track comprehensive examination requirements:

Non- thesis track students must pass a comprehensive exam by the end of their degree.

Course No.	Course Title	Cr. hrs.	Lecture	Lab*	Prerequisite
ERE 799	Comprehensive Examination	0	0	0	Department Approval

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

Plan of Study for Non-Thesis Track:

First Year				
First Semester				
Course No.	**Course Title**	**Cr. hrs.**	**Prerequisite**	**Co-requisite**
ERE 721	Applied Mathematics for 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	Modeling, Simulation and Optimization of Energy and Environmental Systems	3	-	-
ERE 741	Meteorology and Climate Phenomenology	3		
ERE723	Advanced Numerical Methods	**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 742	Sustainability	3		
		10		
Second Semester				
Course No.	**Course Title**	**Cr. hrs.**	**Prerequisite**	**Co-requisite**
ERE 000	Elective (3)	3		
ERE 734	Techno Economical Feasibility	3		
ERE 799	Comprehensive Examination	0	Dept. approval	--
	Total	**6**		

8. Courses Description

ERE 721 Applied Mathematics for Engineers, 3 Crs.

Vector differential operators, computing multiple integrals and using integral theorems. Partial differential equations: Wave equation, Diffusion equation, Poisson Equation and Helmholtz equation. Special functions: Spherical harmonics, Bessel functions, and some more specialized functions. Greens functions and its use in solving partial Differential Equations. Complex Analysis and Residue theorem. Calculus of Variation.

ERE 722 Modeling, Simulation and Optimization of Energy and Environmental Systems, 3 Crs.

Modeling methodology including: system conceptualization. Model construction and validation (computational accuracy).Model evaluation and calibration. Simulation of energyand environmental systems. Optimization techniques; Classical direct search-for-optimum methods, Golden Mean, Conjugate Gradients, Modified Newton Method. Methods for constrained optimization such as Lagrange Multipliers, Search methods, Linear and Dynamic Programming. Use of software packages.

ERE723 Advanced Numerical Methods, 3Crs.

Overview of numerical errors, numerical solution of nonlinear equations and system of linear equations (matrix equation, eigenvalue problem). Curve fitting and interpolation, Numerical differentiation and integration. Discretization of Ordinary differential equation; Initial value problem and Boundary value problem. Consistency and convergence. Introduction to Partial Differential Equation; type and classification. Numerical solution of PDE.

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

Review of renewable energy resources. Wind energy: horizontal-axis and vertical-axis wind 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, and photovoltaic. Hydroelectric power and geothermal energy. Computer modeling and simulation using software packages. 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.

Forms of energy. Development of energy, sources and energy needs. Petroleum. Coal, oil shale and tar sand. Natural gas and hydrogen power. Principles of nuclear power. Methods of extracting energy from oil shale. Introduction to combustion process and combustion systems. Conversion of thermal energy into mechanical energy, including power, and heat engine cycles, internal and external combustion systems and turbines. Conversion of thermal energy into electrical energy including thermoelectric converters, thermoelectric systems. Electric generators and alternators, solar and fuel cells. Verification where possible.

ERE 733 Energy Efficiency, 3Crs.

Techniques and approaches adapted to improve the efficiency of energy generation, utilization, conversion, transport, storage and management. Energy audits. Energy conservation opportunities for efficiency improvements in different sectors: industrial, commercial, transportation and domestic. Economic regulatory and infrastructure issues affecting the implementation of energy efficiency measures as well as their potential for solving energy and environmental problems. Energy flow simulations in buildings. Best practices in building design. This course includes students performing real energy audits.

ERE 734 Techno Economic Feasibility, 3 Crs

Technological, cost, and environmental fundamentals of emerging renewable sources of energy and environmental systems; including solar, wind, biomass, geothermal, hydropower and fuel cell, water supply assessment and cost recovery options, water use efficiency measures, Pollution and remediation and treatment options assessments. The economics of source reduction, recycling, reuse, and recovery of wastes. Renewable energy sources commercialization and measurement. Economic and technical performance indicators of renewable energy and energy efficiency systems and environmental systems; LCOE and payback periods. This course include using softwares and projects to carry out real techno economic studies for real systems.

ERE 735 PV – PhotoVoltaics, 3Crs.

The characteristics of sunlight. Semiconductor and P-N junctions. The behavior of solar cells. Cell properties and design. PV cell interconnection and module fabrication. Stand-alone photovoltaic system components. Designing and simulation of stand-alone photovoltaic systems. Specific purpose photovoltaic applications. Remote area supply systems. Grid-connected photovoltaic systems. Photovoltaic water pumping system components. PV water pumping system design.

ERE 736 Wind Energy Systems, 3 Crs.

Basic characteristics of wind, site characterization, Statistical methods of wind analysis, wind resources assessment, fundamental principles of wind energy utilization, aerodynamics, mechanical and electrical design aspects. Wind machine technologies and wind turbines performance analysis. Wind power integration into the power systems, environmental impact of wind power utilization.

ERE 737 Concentrated Solar Power (CSP), 3Crs.

Introduction to the solar energy, Solar radiation; Review of the basics of thermodynamics and heat transfer, Power plant Technologies; Types of CSP systems including CSP parabolic trough systems, CSP dish technology, CSP Fresnel technology and Solar tower; Heat storage systems; Hybridization; Secondary use of CSP systems; Operation and maintenance of CSP systems; Power quality control and grid integration; CSP plant project planning: economical, social and environmental considerations and site assessment.

ERE741 Meteorology and Climate Phenomenology, 3 Crs.

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 Sustainability, 3 Crs.

Sustainability. Sustainable systems. 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 assessment of current and potential future energy needs, with emphasis on meeting regional and global energy needs in this and coming century.

ERE743 Environmental Biotechnology and Bioenergy, 3Crs.

Basic concepts of biotechnology: Biomass characterization, Biomass growth and kinetics. Bioconversion systems: types of biomass, which are currently considered for conversion into bioenergy conversion pathways available to turn biomass into bio-products. Identify energy potentials of biomass and biogas. Biofuels and Combustions Engines

ERE 744 Climate Change and Predictability, 3 Crs.

Fundamental aspects of the predictability of weather and climate. Basic theory of the divergence of trajectories in phase space and the periodic and chaotic properties of the flow are illustrated using simple nonlinear dynamical models. The dynamics of error growth, local and global predictability, and predictability of flows with many scales will be discussed. The predictability and error growth in large weather forecasting systems, predictability in mid-latitudes and tropics, and targeted observations will be studied. Predictability of time-mean quantities in large climate models, the role of ocean and land boundary forcings, and predictability of coupled models.

ERE751 Advanced Water and Wastewater Treatment, 3 Crs.

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. Waste water treatment Plant design: case study. Use of renewable energy in water and waste water treatment

ERE752 Water, Energy, and Environment Management, **3 Crs.**

This course addresses major topics such as water quantity, water quality, , and energy. It also addresses topics related to Middle East water/energy resources situation and management. Socioeconomic factors. 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 with emphasis on the MENA region.

ERE761 Air Pollution Control, 3Crs.

Air pollution control law and regulations .Air pollution measurement, Emission estimates. Meteorology for air pollution control engineers. Air pollution concentration models. Designing air pollution control systems and equipment. Combustion and control systems (Particulate pollutants, primary particulates, VOCs, SOx and NOx). Air pollutants and global climate.

ERE771 Environmental and Energy Laws and Policies, **3 Crs.**

An introduction into the environmental and energy justice system. An Introduction to environmental and energy 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 791 Special Topics in Renewable Energy Systems, 3Crs.
Covers specified cases with special interest for industry and modern technology in the areas of renewable energy technology

ERE 792 Special Topics in Environmental Systems, 3 Crs.
Covers specified cases with special interest for industry and modern technology in the areas of environmental technology.

ERE 781: Seminar, 1Cr.
This seminar is to work on issues related the environment directly or by using renewable energy engineering solutions.

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.

ERE 799: Comprehensive Examination, 0 Crs.
After the successful completion of all core and elective courses with a minimum cumulative average of 75%, students should be able to pass a comprehensive, four hours, exam. To pass, the student should have an overall grade of minimum 70%. The exam aims to measure the students' ability to understand and link the basic and advanced concepts they have learned throughout their study duration. Credit Hours: 0, Lecture Hours: 0, Lab Hours: 0

9. Tuition and fees

The following table gives a breakdown of tuition and fees at GJU:

Fees	Jordan Dinars
Credit hour fee	120
Other Fees	
Admission/Acceptance Fees	120
Refundable Collateral Fees	150
Registration Fees\ per semester	120
Computer Fees\ per semester	60
Medical Insurance Fee\ per semester	50

10. Contact information

For application and other enquiries, please contact:
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