



The University of Jordan
Faculty of Engineering and Technology
Mechanical Engineering Department

A Masters Program Proposal
in Renewable Energy

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1. Introduction

The Master of Science in **Sustainable Development and Renewable Energy** program offers advanced training in the area of renewable energy systems and sustainable development. This program is designed to provide engineers and scientists with specific training in advanced areas of renewable energy technology. The emphasis is on the design, analysis and implementation of energy systems, with particular emphasis on renewable energy systems. Furthermore, the program is designed to provide environmental scientists and policy analysts with training in advanced areas of renewable energy technology and policy. The emphasis is on policy analysis, environmental monitoring and resource assessment related to renewable energy systems.

The sustainable development of the renewable energy sector in Jordan has been rapidly increasing over the past decade. A need has emerged for qualified engineers to deal with the project in all filed related to renewable energy

2. Program Objectives

The main goal of the program is to provide a high quality education for Jordanian students in the key aspects of Renewable Energy and Energy Efficiency (REEE), therefore enabling them to take responsible, creative, challenging and stimulating posts in industry or research in this exciting field. The additional specific objectives of the program are to promote and publicize new REEE technologies in the country and considerably increase the scale of REEE technologies application in public and private buildings in accordance with the Jordanian National Energy Plan. Moreover, the program aims to address the social, economic and environmental issues involved with renewable energy systems.

1. To provide a thorough training in the principles of renewable energy systems
2. To enable students to develop novel engineering solutions to important regional and global energy problems in order to meet the region's needs for renewable energy through carrying out fundamental and applied research using appropriate design methods and analysis tools.
3. To broaden and enhance student's skills on efficient problem solving, critical-thinking, team working and professional communication.
4. To provide students with extensive knowledge on social and ethical codes, energy regulations, energy efficiency, international agreements, conventions and standards which they can actively use in their professional activities.
5. To train engineers, scientists, environmental scientists and policy analysts to participate in the development of the renewable energy industry in Jordan and the region.
6. To provide students with a capacity of self-learning in familiar and unfamiliar situations and for efficient time and resource management.
7. To develop in students leadership skills so they can play principal roles in academic and industrial organizations in the engineering areas.

8. To enable students to pursue PhD and other advanced postgraduate studies

3. Needs for the program

- 1) Increase in the demand on energy in all sectors i.e., residential, governmental, and industrial sector.
- 2) Emerging technologies in energy and energy efficiency.
- 3) Globalization and market interactions, national and international energy business.
- 4) Proficiently qualified energy managers are not available locally or in the region.
- 5) The program will contribute to the university progress in academic research and community service.
- 6) Energy is the driving engine of economy. 10-20% of the national GDP is the share of Energy in Jordan.

4. Human Resources

4.1. Faculty members

The current faculty members at the department of Mechanical Engineering and respective departments are more than enough to run the program

4.2 Lab Technicians

To the current Lab Technicians at the department of Mechanical Engineering and respective departments are more than enough to run the program

4.3 Expected numbers of students applying to the proposed program

The information of the following table is based on the market needs analysis carried out by MANSUR team.

	First Year	Second Year	Third Year	Fourth Year	Fifth Year
Masters Program	10	20	30	35	35

5. Facilities: Libraries, computer labs, and software

Engineering library is available. The program requires the establishment of a renewable energy Lab supplied with at least 6 computer stations loaded with suitable software.

6. Similar Programs at other Universities and Numbers of Registering Students

Currently, there is no similar programs are available at other universities in Jordan

1. Cooperation and Partnering with other Universities and Programs

The program is intended to be an efficient environment for university-community outreach activities, training, and R&D. Courses offered through the program will connect students to real projects, problems, and case studies. Professionals from different governmental agencies and industry are expected to participate in the educational and research activities of the program. The program will seek cooperation with established graduate programs at Sapienza University (Italy), Northumbria University (UK), Lund University (Sweden) and other programs to extend skills and exchange experience.

2. Recommendations

The Graduate Committee recommends the establishment of the program at the College of Engineering and to dwell the program of **Sustainable Development and Renewable Energy** at the Department of Mechanical Engineering.

Study Plan for Master Degree in Sustainable Development and Renewable Energy

A. General Rules and Conditions:

1. This plan conforms to the regulations of the general framework of the programs in graduate studies on the University of Jordan.

2. Areas of specialty for admission to the M.Sc. Program:

- Holders of the bachelor's degree in:

- Mechanical Engineering,
- Chemical Engineering,
- Electrical Engineering.
- Architecture Engineering
- Civil Engineering
- Industrial Engineering
- Mechatronics Engineering

B. Special Conditions: : Students with other disciplines may be admitted to the program with certain courses the student has to pass, which will be determined case by case

C. This Study Plan consists of 33 credit hours as follows:

1. Obligatory Courses (18 credit hours)

	Course No.	Course Title	Credit Hours	Pre-req.
2	0904751	Renewable Energy Systems	3	-
3	0904761	Energy efficiency	3	-
4	0904762	Energy Conversion	3	-
5	0904771	Energy Management	3	-
6	0904772	Economic aspects of renewable energy and energy efficiency (REEE)	3	-

2. Elective Courses (6 credit hours to be selected)

	Course No.	Course Title	Credit Hours	Pre-req.
1	0904742	Modeling, simulation and optimization	3	-
2	0904743	Market Communication, Strategies and Tools	3	-
3	0904752	CSP – Concentrated Solar Power	3	-
4	0904753	Wind energy	3	-
5	0904754	Photovoltaic Energy	3	-
6	0904755	Solar Desalination	3	-
7	0904763	Environment and sustainable development	3	-
8	0904764	Bio-fuels	3	-
9	0904765	Low Carbon Buildings	3	-
10	0904773	Energy regulations	3	-
11	0904774	Sepcial Topics	3	-

3. (0904799) Thesis (9 Credit hours)

Courses Description

(0904751) Renewable Energy Systems (3 credit hours)

The main types of renewable energy and the concept of distributed power generation will be illustrated in this course. In particular the usefulness of various types of energy systems as they relate to the future of this planet will be demonstrated. Topics will include: passive and active solar systems (high, medium and low temperature thermal solar collectors; photovoltaic systems of the first, second and third generations); wind energy and integration of wind and solar power systems into the electricity grid; biomass and bio-energy; waste management; hydrogen (fuel cells and other uses); hydroelectric power; geothermal heat transfer. Students will be introduced to the practical aspects of renewable energy systems design development, exploitation and monitoring.

Information on each technology will be presented using the same training approach: general presentation; main characteristics, operational principles, application, technical aspects of installation and maintenance; basic introduction to the relevant market and financial management, policies, regulations and incentives; dissemination of both positive and negative national and international practice and experience.

In conclusion, there will be an introduction to social, legal and market challenges to assist students to identify prospective of RE technologies at early stages and a range of factors affecting the deployment of RE systems.

(0904761) Energy Efficiency (3 credit hours)

The objective of this course is introduction to the definition of energy efficiency and to teach student how to analyze energy production and consumption processes and relevant technical systems from the energy efficiency point of view.

The first part of the course will deal with introduction to the different thermal systems and to integration of processes and the energy saving techniques. The most relevant energy systems (conventional and renewable) and the current methods used for the improvement and the optimization of thermal equipment will be described. These include: steam generators and auxiliary equipment; industrial furnaces; heat exchangers; heat exchanger networks. Efficient energy systems such as co- and tri-generation systems and ORC systems, also combined with solar plants, will be analyzed.

The second part of the course is concentrated on efficient management of energy plants. Students will develop skills on planning and carrying out modifications in technological plants in order to improve the energy efficiency, selecting the Best Available Technologies (BAT). Main methods of energy diagnosis will aim at evaluating processes' criticalities in terms of thermal and electrical consumption.

A final part of the course will be dedicated to the sociology and behavioral economics of energy efficiency, dealing with the hypothesis of why, despite economic and technical feasibility of EE, we do not see spread adoption of EE solutions: barriers to EE spreading and diffusion in industrial processes.

(0904762) Energy Conversion (3 credit hours)

Course content: Forms of energy; Energy needs and available sources of energy; Petroleum, coal, oil shale and tar sand; Natural gas and hydrogen, hydropower and biomass; Principles of nuclear power; Solar energy, geothermal energy, wind, tidal and wave power; Conversion of chemical energy into thermal

energy using gas, liquid and solid fuel combustion systems; Conversion of thermal energy into mechanical energy and electrical power using heat engines (internal and external combustion engines and turbines) and electrical generators; Conversion of thermal energy into electrical power using thermoelectric converters and fuel cells.

(0904771) Energy Management (3 credit hours)

Short and long term planning. Restructuring and Privatization: Models of electricity industry. contracts issues, markets and transmission pricing. De-regulation of the energy market around the world. Costing techniques. Financial appraisal and profitability. Cost optimization. Energy auditing and monitoring. Saving of energy for heating, ventilation, air conditioning, refrigeration, lighting. Electrical demand control and power factor correction. Load forecast and generation side management. Characteristics and economic dispatch of power generating units. Transmission losses. Unit commitment. Interchange evaluation and power pools.

(0904772) Economic Aspects of REEE (3 credit hours)

This course covers: basics of energy supply and demand; the national energy balance (who produces what type of energy, where, and from which source, who consumes it, where, and for what purpose), energy related units, conversions and formulas; criteria and indicators of the concept of sustainable energy supply, trade, and security, role of market, role of private sector, decentralization, standardization, policy options and mix, laws, law enforcement, distribution of labor among organizations, feed-in-tariffs, economic and social functions of tariffs; functions and structure of public and private organizations in the energy sector on the national, regional and international level

Basic market barriers will be introduced related to transaction cost of EE implementation, sunk costs, split incentives hypothesis, etc.

(0904742) Modeling, Simulation, and Optimization (3 credit hours)

The aim of the course is to introduce to students fundamentals of mathematical modeling and simulation of Renewable Energy Systems and Energy Efficiency Systems, including optimization techniques. Students will learn to develop conceptual design of a renewable energy system, implement such the design, simulate and optimize the system. Emphasis will be on classical direct search-for-optimum methods, such as Golden Mean, Conjugate Gradients, Modified Newton Method, methods for constrained optimization such as Linear and Quadratic Programming. Many of these concepts will be reinforced through the use of non-commercial software packages such as SoPlex for Linear Programming, MUSCOD-II for Nonlinear Programming and Dynamic Optimization, and Parfit++ for Parameter Estimation.

Additionally, thermal modeling of buildings will be introduced and applied during the work group activities.

(0904743) Market Communication, Strategies and Tools (3 credit hours)

This course facilitates understanding how advertising, sales promotion, public relations, personal selling, word of mouth, social media, website content and presence, internal marketing and in some cases design and packaging decisions form a coordinated marketing communications strategy. The course will provide the theoretical underpinning of a set of concepts, approaches and tools in integrated marketing communications. Tools and methods for setting promotional budgets and the factors that affect the design of the promotion mix.

The course will describe REEE marketing and promotion challenges, including awareness raising strategies, overcoming consumer resistance, facilitating supply chain transactions, political rhetoric and the different views in REEE in political debates; Life Cycle views; risks.

(0904752) CSP – Concentrated Solar Power (3 credit hours)

Course content: 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.

(0904753) Wind Energy (3 credit hours)

The purpose of this course is to introduce students to wind energy systems. The following topics will be covered in the course: Statistical methods of wind analysis, Wind Resources Assessment and Site Selection, Wind Machine Technologies and wind turbines performance analysis. The course deals with the basic characteristics of wind energy, site characterization, fundamental principles of wind energy utilization, and discusses the design of basic parts including aerodynamics, mechanical and electrical design aspects. Special emphasis will be given to the theory of design of turbine blades. Off-shore and on-shore wind plants. integration into the power systems will also be addressed in this course. Furthermore, environmental impacts of wind power utilization will be discussed along with national regulations and authorizations and modern international experience in this area.

(0904754) PV – Photovoltaic (3 credit hours)

History of PV technology; Markets for PV; Types of PV Systems, Principles of operation of photovoltaic systems; PV systems performance characteristics as a function of environmental conditions; Site assessment for PV systems installation, selection of an appropriate system design; Installation of basic subsystems; Inspection and maintenance of PV Systems; Safety considerations during installation and exploitation of PV systems. PV systems: standard PV systems, PV concentrator, innovative systems (PV + Thermal collectors). Use of desert area, small and large plants.

(0904755) Solar Desalination (3 credit hours)

This course is to familiarize students with water desalination processes, with focus on the solar desalination process. The main topics include: physical and chemical properties of sea water, scale formation and control, the various desalination technologies based on thermal and non-thermal processes: Multi Stage Flash Evaporation and Multi Effect Distillation, Membrane Process (Electrolysis and Reverse Osmosis), Freezing and Solar Humidification. Emphasis will be on the combination of thermal and solar energy as the energy source for water distillation. Students will be engaged in active learning with the development of team work skills. Development of students ability on critical analysis and evaluation together with synthesis through case-based, problem-solving approaches will be the aims of this course.

(0904763) Environmental and Sustainable Development (3 credit hours)

This course introduces students to theory and practice of environment and sustainable development at the international, national and urban levels in a variety of contexts. Also it covers environmental degradation by deforestation, loss of biodiversity, pollution, soil erosion, decreasing quality and quantity of water, poor

sanitation services and poor urban conditions; CO₂ emissions and global warming, interactions among society, development and environment, and their implications for sustainable development; technical, economic, ethical and philosophical aspects of sustainable development.

(0904764) Biofuels (3 credit hours)

The objective of the course is to give the students experience to apply their Engineering knowledge and skills to biofuel production technologies. It will introduce them to various types of biofuels; their feedstocks, production processes, differences, advantages, and challenges. Fundamentals of thermochemical and biochemical conversions of biomass to biofuel/bioenergy will be discussed. The course will also focus on economic trend, environmental, ethical, social, and technical innovation and technological issues associated with the use and management of biofuels. The course will emphasize practical with little of theoretical learning. It will involve lectures, discussions, student projects and student presentations and guest speakers.

(0904765) Low Carbon Buildings (3 credit hours)

Low carbon buildings design will be introduced in this course.

The content of the course: The fundamentals of conventional energy sources used in buildings; renewable energy technology; policies and drivers that are leading to the more widespread uptake of low carbon building technologies; low carbon building codes, policies and planning from the past, present and future from around the globe; Integrated design: urban micro-climate design, passive architectural interventions, active interventions (energy plants).

(0904773) Energy Regulation (3 credit hours)

Course content: Overview of developments in Energy Regulation; Technical and economical characteristics of the Energy sector; Regulation and competition in energy supply; Energy generation and wholesale markets for energy; Energy networks: Pricing and investments, supply and distribution of energy, benchmarking and comparative competition; Regulatory governance and Institutions for energy regulation; Energy production competition and retail markets; Jordan Forum: Energy regulation and welfare; Assessment of effects of reforms on the energy sector; Implications of climate change for Energy regulation. The regulatory effect on technological innovations and transition management: how regulation can stimulate innovation and market feasibility of REEE.

Faculty Members for Master Program in Sustainable Development and Renewable Energy

Member	Specialty field	Department	Faculty
Prof. Mohamed Ahmad Hamdan	Thermals	Mechanical Engineering	Engineering and Technology
Prof. Ahmed Al-Salaymeh	Thermals	Mechanical Engineering	Engineering and Technology
Prof. Mahmoud Hammad	Thermals	Mechanical Engineering	Engineering and Technology
Prof. Ali Badran	Thermals	Mechanical Engineering	Engineering and Technology
Prof. Hamzeh Dewiri	Thermals	Mechanical Engineering	Engineering and Technology
Dr. Ahmad Sakhrieh	Thermals	Mechanical Engineering	Engineering and Technology
Dr. Jamil Asfar	Thermals	Mechanical Engineering	Engineering and Technology
Dr. Jihad Yameen	Thermals	Mechanical Engineering	Engineering and Technology