Joint mAster of Mediterranean Initiatives on renewabLe and sustainAble energy

MASTER of RENEWABLE ENERGY & SUSTAINABILITY

الماجستير في الطاقة المتجددة وإستدامتها

(MRES)

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College of Engineering	College of Engineering
Palestine Polytechnic University	Al-Quds University
(PPU)	(AQU)

Hebron

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Contents

JOINT MASTER OF RENEWABLE ENERGY AND SUSTAINABILITY

(MRES)

1. INTRODUCTION

The Electrical Engineering Sector in its both tracks Power Engineering and Renewable Energy (RE) Engineering plays an extremely important role in the development of communities on an international scale, and carefully considered in short and long terms strategic plans. In Palestine due to occupation since 1967 until Oslo agreement energy sector was totally under the Israeli control resulting in classifying Palestine as one of the poorest countries in energy production and consumption. This status in turn resulting in lack of skillful and experienced electrical power engineers. Meanwhile in the past decade and now a day RE sector is significantly developing and has promising future.

The energy sector in general received much more interest since the arrival of Palestinian National Authority in 1993 by establishing Palestinian Energy Authority (PEA) as a body responsible for management and development the energy sector.

Establishing PEA resulting in massive development of energy sector in form of:

Firstly, establishing local electrical companies such as Northern Electrical Power Company, Southern Electrical Company, Hebron Electrical Companies, and Tubas Electrical Power Company whose are responsible for management the electrical distrusting and purchasing process of electrical energy;

Secondly, establishing new electrical networks mainly medium and low voltage networks where the most of Palestinian villages and communities are now supplied by the electrical grid instead of being supplied by diesel generators that have a lot of disadvantages including high cost of energy, reliability, and air pollutions.

Thirdly, starting national initiatives for increasing the awareness for using RE sources such as solar energy as a friendly electrical alternative source, in addition to establishing local solar power stations in Jericho and Tubas.

The need of the Master degree in Renewable Energy Engineering stems from the fact that:

1. All Palestinian Universities have been graduating electrical engineering holding bachelor degree since 20 years while none of them yet has a master degree program in Renewable Energy Engineering that is capable for offering highly distinctive competencies to meet the future challenges in this sector. An-Najah university has similar program entitled "Clean Energy" but it differs from what partner universities (PPU and AQU) offering in both program content & strategic objectives.
2. Development of existing power networks and improving their reliability to an international level requires preparing highly educated engineers with solid knowledge in energy and renewable energy sector.
3. Existing of solid infrastructure for establishing such programs in form of academic staff, advances educational & research laboratories, and a libraries with textbooks and specialized journals.

Finally, as a leader universities in engineering education in Palestine, and proceeding from our believe, vision and mission as a universities serving community, offering advanced theoretical and practical education, and sharing knowledge , the partner universities are applying to lunch Master degree in Renewable Energy & Sustainability (MRES) as a result of collaborative efforts between eight national and international universities form Palestine , Egypt, Italy, Spain & UK according to TEMPUS Project code (544339-TEMPUS-1-2013-1-IT-TEMPUS-JPCR). The mentioned Joint master program should be started in 2015-2016 academic year after being officially accredited and should be *established by completely support of European Union (EU) under the*

umbrella of TEMPUS Project where a memorandum of understanding was assigned between EU & partner universities toward establishing joint master of renewable & sustainable energy engineering (Annex 4).

2. : Program Justifications

The proposed MRES program has been designed to satisfy the current and the future market needs from highly qualified Engineers to lead the advancement in renewable energy in Palestine. To determine these needs, it was of great significance to carry out a survey with a distinguish goals that are aimed at knowing the current market of the renewable energy experts and M.Sc. engineers, knowing the working scope and type of companies/ institutions and whether they being adopted to renewable energy, estimating the future need by determining the growth rate of their employment, sending distinguished engineers to join the M.Sc. program, taking part in the events of M.Sc. program as conference days, workshops, carrier days, etc., Proposing and co-supervising topics for the M.Sc. thesis, and support program sustainability throughout partially funding and working together for fundraising etc. The stakeholders of the survey include companies of the renewable energies and vendors, companies that deal with energy production in its two forms: conventional and renewable energy, the renewable energy authority, the electrical supply authority, the environmental authorities, research centers, universities and higher education institutions, trading &consulting companies, and renewable energies associations and NGOs.

According to the conducted Labor-Market survey (Annex 5)[1] and the status of energy sector the program justifications can be summarized as follows:

1. The objectives and justification of this program stems from the reality of energy engineering and the need of those working in this field to deal with advanced analysis of power sources, power systems, power management , environmental issues, and developing mathematical models to solve complicated problems that the undergraduate engineers are not able to do such as :

For Renewable Energy Sector:

Conventional power generation and distribution systems; control & management of power systems; power quality; energy auditing & efficiency; stability of energy systems; and conducting research tasks with energy aspects.

For Environmental Sector:

Green buildings; treatment bio waste; energy & environmental sustainability; the impacts of energy sources on surrounding environment; environmental policies and regulations; quality control of surrounding environment; and conducting research tasks with environmental aspects.

The advances in these fields needs qualified specialists are able to accommodate with the evolution in the design and best practice of the RE system & their sustainability , and are able to innovate practical solutions for the complicated problems based on theoretical analysis and study.

2. Having a master program in RE engineering in a leading partner universities in engineering education like PPU and AQU will give a great opportunity to the Palestinian undergraduate students to obtain such degree locally without the need to travelling outside borders that will save money, efforts and will help increasing the national economic income, taking into account that there is no Palestinian universities offering such program at least in the middle and southern parts in Palestine, where 60% of populations.

3. Existing of bachelor programs in more than 12 engineering programs since 1997 in three departments at PPU :

- *Electrical Engineering Programs*
    - Industrial Automation Engineering; Electrical Engineering Technology; Telecommunication Engineering and Biomedical Engineering.
- *Mechanical Engineering Programs*
    - Vehicle Engineering; Mechatronics Engineering; and Refrigeration & Air conditioning; and Production Engineering.
- *Civil and Environmental Engineering Programs*
    - Building Engineering; Architectural Engineering; Survey Engineering; and Environmental Engineering Technology.

4. Existing of bachelor programs in more than (3) engineering programs in departments of electrical and mechanical engineering at AQU :

- *Electrical Engineering Programs*
    - Computer Engineering , Electronics engineering
- *Mechanical Engineering Program*
    - Material engineering
- *Master programs*
    - Master in electronics & Master in Computer Engineering

- In addition to similar engineering programs in other National & International Universities.
- Given the demand, a large number of students graduated with Bachelor degrees in various programs where more than 790 students were graduated from PPU as mentioned in table (1-a) and 263 students from AQU undoubtedly those students want to raise their academic and professional qualifications, and acquire new skills and knowledge in the field of renewable energy, to keep up with scientific and technological progress in the areas of renewable energy engineering & electric power systems engineering. Which in turn improve their chances of employment and preparation to compete on the regional and global levels, through enrollment in the proposed Master in Renewable Energy program?

Table (1-a): PPU_ Number of graduates of programs related to the proposed Master in Electrical Engineering program during the academic years 2011 to 2014.

Field	Program	2011-2012	2012-2013	2013-2014
Electrical Engineering	Industrial Automation	14	14	9
	Electrical Energy	0	0	19
	Biomedical Eng	19	9	17
	Telecommunication	60	53	41
Mechanical Engineering	Mechatronics	11	31	21
	Heat & Air-conditioning	10	10	8
	Vehicle Engineering	18	12	19
Civil Engineering & Environmental Engineering	Building l Engineering	51	60	101
	Survey Engineering	40	32	36
	Architectural Engineering	35	27	34
	Environmental Engineering	0	0	30
Total		258	248	286

Source: Data base of the university registration department.

Table (1-b): AQU_ Number of graduates of programs related to the proposed Master in Electrical Engineering program during the academic years 2011 to 2014.

Field	program	2011-2012	2012-2013	2013-2014
Electrical Engineering	Electronics Engineering	28	31	26
	Computer Engineering	40	37	41
Mechanical Eng.	Material Engineering	22	20	18
Masters	EE & CE	5	4	6
Total		90	88	85

Source: Data base of the university registration department.

5. Taking into account the partner universities reputation among local and nearest universities beside the good ranking of both college of engineering at PPU and AQU , it is fair to say that the number, quality and experience of the staff of these colleges in addition to the labs and infrastructure in related engineering departments is capable even exceptional to offer such program that benefiting from the advances of both partner universities.

6. The proposed program will provide the electrical companies working in power and RE sectors, industry and the public sector with educated, skillful and experienced engineers in advanced topics in electrical power, RE and environmental sustainability. These market needs are extracted from the conducted survey according ***to Annex (5)*** where Fig.1 illustrates the most weaknesses in finding RE professionals. It is important to mention that the described topics in this program are beyond the knowledge of the undergraduate engineer (Electrical, mechanical and civil).

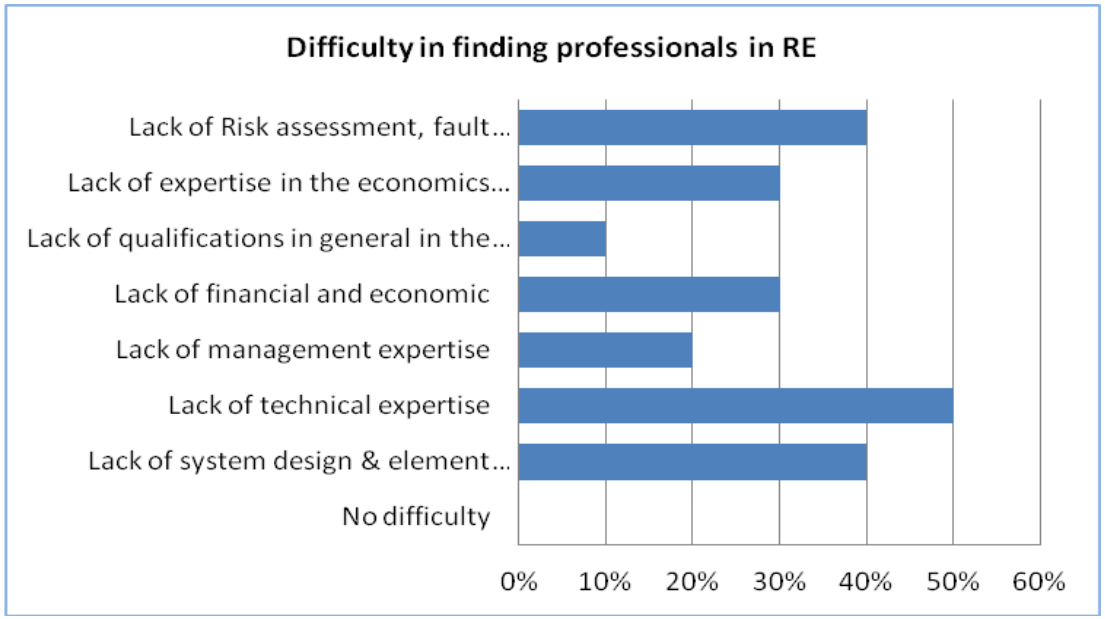

Fig.1: Difficulty in finding professionals in RE.

7. As well known, Palestine is a poor country with conventional energy sources such as fossil oil, coal, natural gas and water power, it is rich with solar energy. Hence, preparing highly qualified engineers will help applying best practice for generating and managing this energy source with respect to consumption and generation.

8. The fast development of energy conversion technologies dictates academic institutions to develop their academic programs to be in harmony with market needs; therefore offering master degree in RE will fulfill these needs and increase the employability of university graduates as shown in fig.2.

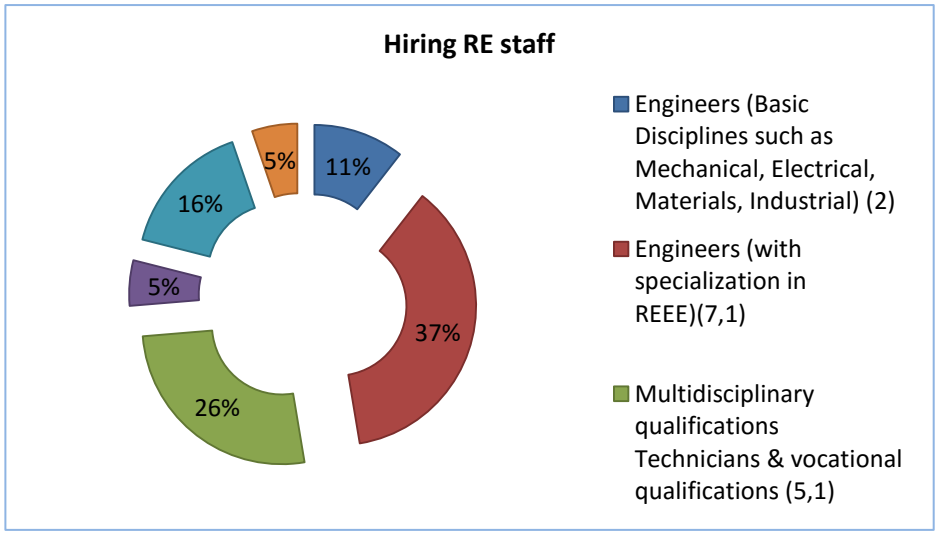

Fig.2: Hiring RE professionals

9. The existing electrical utilities (networks) in Palestine are still suffering from problems such as sudden and repeated interrupt of the power supply especially in winter time, in addition to the unsymmetrical load distribution, high rate of electrical losses in the networks, overloaded networks at daily peak consumption hours, and lack of knowledge related to applying smart grids and smart energy solutions. Therefore, having the proposed program will provide high qualified experience and skilful engineers able to solve these problems and to improve networks efficiency, and reliability of electrical networks to meet those of developed countries.
10. It is obvious that the all areas of the Palestinian territories need more focus to be developed in the area of Renewable Energies.
11. Most of the companies specialized in RE are small ones and their business and market are carried out locally or regionally.
12. The number of domestic experts specialized in RE technologies including software tools and equipment are modest.
13. The willingness and readiness of the private sector in the field of RE is insubstantial for acquiring Master graduates in RE or supporting their Bachelor engineers to attend the Master program.

14. Furthermore partner universities are characterized as an educational institution with solid and up to date infrastructure related to educational and research laboratories in the field of electrical, electronics, mechanical, civil engineering and environment, therefore establishing master program in the field of RE has good and advanced technical-scientific infrastructure for future successes (Annex 6).

15. The Deanship of Graduate Studies & Scientific Research at PPU offers annually grants for master students to conduct their thesis toward solving research task and to release the achieved results in international forums, journals and conferences. The offered grants are offered based on competitive bases. This strategy help support solving realistic issues extracted from the community needs on one side, on the other improve the quality of the graduated students (Annex 8). Applying this strategy for students enrolled in this program (master of RE) will support the development of energy and RE sector,

16. Someday, Palestinian energy sector will be independent of Israeli energy sector, therefore Palestinian engineers should carry the responsibilities for power generation, transmission and distribution. This full energy cycle requires highly qualified engineers at master and doctoral levels.

Since the enrollment in the Master program is conditioned that students should obtain a Bachelor degree in one of the disciplines associated with electrical , mechanical & civil engineering programs; it is possible to estimate the level of demand for the program by looking at the number of enrolled and graduate students of these programs at the Palestinian universities.

It is clear after reviewing the latest statistical manual for higher education institutions for the year 2012-2013, that the number of students, specialized in programs awarding Bachelor degrees in the disciplines can proceed to enroll in the proposed Master program. Those enrolled in the academic year 2012-2013 in Palestinian universities in the West Bank have reached 3,216 students, and 1,167 students in universities in the Gaza Strip, who will graduate in the next few years. In the 2012-2013 year alone about 540 students graduated from these programs from Palestinian universities**.**

Table 2: Distribution of enrolled and graduate students for a Bachelor degree in the academic year 2012-2013 in disciplines related to the Master degree program in electrical engineering**.**

	Electrical Eng		Mechatronics Eng		Computer Systems Eng/ Computer Eng		Communications Eng		Total	
	Enrolled	Graduates	Enrolled	Graduates	Enrolled	Graduates	Enrolled	Graduates	Enrolled	Graduates
Traditional Universities in West Bank	1,418	247	495	16	844	80	459	-	**3,216**	**343**
Traditional Universities in Gaza Strip	228	47	103	17	836	133	-	-	**1,167**	**197**
TOTAL	**1,646**	**294**	**598**	**33**	**1,680**	**213**	**459**	**0**	**4,383**	**540**

Source: *These figures were collected from the annual statistical manual for institutions of higher education for the year 2012-2013 issued by the Palestinian Ministry of Education and Higher Education.*

Therefore, we can expect the demand for the proposed program to be in the limit of 80-90 applications per year (this demand will rise in the coming years, starting with the graduation of students from the newly established undergraduate programs). The figure will even rise further if one takes into account the number of workers in the Renewable Energy companies, the electricity local companies and public and private institutions and those willing to develop their knowledge, skills and abilities in the field of renewable energy and electrical engineering, which is 8-10% of graduates from traditional universities in the West Bank and the Gaza Strip, in disciplines eligible for admission to the proposed Master program. It is therefore concluded that the demand for the program would be enough, and that the number of applicants will enable those in charge of the program to choose the top of up to 20 students per year;

and acceptance rate of 20-25% of the total applicants which can ensure an appropriate geographical distribution, at least in the West Bank and Jerusalem, until students of the Gaza Strip are able to join too. Table 2 shows the distribution of students over related disciplines in both traditional universities in the West Bank and the Gaza Strip, as well as the distribution of graduates from these disciplines.

The proposed program, in additional to the physical and human capabilities available at partner universities PPU & AQU, together with the distinctive scientific and practical experiences that the academic staff have, will give the program an added advantage. Such capabilities will enable the program to achieve its objectives, which will impact the quality of graduates from this program and will contribute to filling in part of the demand which will be reflected also on their ability to compete. The graduates will be able to apply for jobs both in the private and public companies in the field of renewable energy and power companies in the relevant non-governmental and international organizations, or in the academic and educational field in the industrial and technical schools and research centers in the fields of energy and renewable energy.

3: Market Study

The conducted market study concerning the status of the local sectors (private & public sector) with respect to good qualified graduate students, utilizing new state of the art technologies are in annex(1).

4: Program Mission, Goals, and Overall Objectives

Program Description:

The proposed master's program is a Master in Renewable Energy (JAMILA) offered by Palestine Polytechnic University and Al-Quds University and another three MENA universities such that the program is funded by the European Union through TEMPUS program for a period of three years with effect from 12/2013 to 12/2016. The program will be developed in collaboration with European partner universities.

TEMPUS European project includes supporting the laboratories in the two partner universities through purchasing laboratory equipment for the use by students enrolled in the program. The project also enables some students enrolled in the program conducting research, related to their Master's Theses, in one of the participating European universities under a joint supervision between Palestinian and European partners, where the period of the research visit lasts three months for each student with full support for the expenses of their trips.

There will be a possibility for faculty members in the European partner universities to participate in teaching some of the program courses through Video Conferencing, as well as participating in the supervision of theses according to their specialty.

This program will be characterized by the diversity of experiences of the teaching staff participating in it. Besides, it would be an opportunity for a tighter relationship between the Palestinian and European universities, which will increase the opportunities for scientific research collaboration. Furthermore, the program aims to meet the industry requirements, throughout tight collaboration with University Industrial Synergy which has solid relationships with local industrial & energy sectors in Palestine.

The program partners are:

- **European Universities that will provide financial & technical support and advisory to the partner universities.**
  - Sapienza University of Rome, Italy, project leader
  - Northumbria University, UK
  - University of Cadiz, Spain
- **Partner Universities that will offer the M.Sc in Renewable Energy & Sustainability (MRES)**
  - Palestine Polytechnic University -Palestine
  - Al-Quds University / Jerusalem -Abu Deis -Palestine
  - Ain-Shams University – Egypt
  - Alexandria University- Egypt
  - Suez University- Egypt

Program Mission

The program's mission is to teach students in current and future technologies of renewable energy systems to integrate energy-related technologies with the economics and financial considerations required to implement them, and to develop leadership and decision-making skills to implement energy systems in the private or public sectors of the local, regional as well as the global market. The

MRES program will expose students to a combination of local and European academic and corporate experience in energy-related systems.

Integration between the Partner Universities and the Program Mission

The program mission is in harmony with the mission of the Polytechnic University and Al-Quds University , where both universities encourager excellence in engineering & scientific education, stimulation of innovation, creativity and experimentation, through applied research and knowledge of contemporary technologies and advances in engineering & science. The program also contributes to providing scientists (engineers & non engineers with outstanding scores) with the necessary knowledge and skills for the development of the related sciences and engineering work for the prosperity of their society.

Joint Master in Renewable Energy & Sustainability

Program Objectives

To graduate students with master's degrees in renewable and sustainable energy engineering by:

1) Contributing the local market with skilled and professional engineers & scientists specialized in the areas of power engineering (electrical, mechanical,), renewable energy, smart grid systems, power converters, energy , policies, energy management & economics, and related material sciences.
2) Providing the students with the necessary scientific, engineering, business and economic expertise and knowledge in renewable energies for being able to conceptualize, design and operate of existing technical/business systems as well as to invent new solutions and techniques.

3) Supplying the industry, research institutions, colleges and universities, nationally and internationally, with engineers and experts with a high level of in-depth knowledge and expertise in a selected range of advanced topics in renewable energies.

4) Equipping the students with the necessary knowledge and self-confidence coupled to an understanding of the process of technological and economical innovation and of the key factors in the strategic and operational management to establish a start-up enterprise.

5) Networking and partnership with those working in related areas from public and private sectors and international institutions,
6) Developing and capacity building of local engineers, and administrators working in this field,
7) Formulating and developing scientific research in the field of renewable energy & electrical energy,
8) Contributing to the dissemination of awareness, among students and community, of the role and importance of renewable energy,
9) Giving the opportunity for students to implement projects related to domestic or global industries, through the development of a system or finding a solution to a particular problem in order to contribute to the development of local and global industries.
10) Enhancing the live rate of graduated from this program students by offering them highly paid salaries and incentives.

Rational for Offering the Program

1) Keeping abreast of scientific and technological progress in the areas of renewable energy such as Photovoltaic technologies, Energy savings, smart grids and their role in development of the electrical energy sector in general.
2) The rapid development in the Power electronics converters sector and the inevitability of upgrading the capabilities of the graduates to keep pace with this development,

3) The growing interest in alternative and renewable energy sector and the need to build the capacity of graduates to familiarize themselves with the requirements of such sectors,
4) The remarkable and the significant development in the performance of local electricity companies (such as Jerusalem District Electricity Company, North Electricity Distribution Company, Tubas Electric Company, Southern Electricity Company, Hebron Electricity Company...) and the need to hire highly qualified engineers in both fields renewable energy & electrical energy fields,
5) The remarkable increase in the interest of electrical ,mechanical and civil engineering graduates to complete their master's study to improve their chances of finding jobs inside and outside Palestine, or to increase their abilities within their specific jobs,
6) The high demand of a master program in Renewable Energy by public and private companies in order to develop the skills of their engineers, and to provide them with the scientific and academic developments in their specialties, which will impact positively on their performance within their institutions,
7) The urgent need of the Palestinian universities to hire PhD holders, as the program will enable students to obtain a master's degree and enable them getting involved in research, which will facilitate their application and competition to pursue the doctoral degree in prestigious international universities,
8) Seizing the opportunity and taking advantage of European and foreign expertise involved in establishing the program (through the TEMPUS project), including the structure of the program and the development of its courses.
9) Raising the level of scientific research and enhancing the collaboration between the local and European universities,
10) Increasing the Palestinian contribution in the global scientific research by increasing the number of publications of researchers in the Palestinian universities, which is contributed strongly by the program students and their research projects,
11) Providing opportunities for employees associated in the local market to complete their studies in the Palestinian universities,
12) The harsh economic conditions make finding a sufficient financial support a barrier against studying abroad,
13) The difficulty of obtaining scholarships to complete the master's degree abroad is an obstacle for a lot of graduates,

14) The master's program helps in supporting the concentrations, courses and graduation projects of undergraduate programs, and enables interested students joining smoothly the new program.

Graduate Characteristics

1) Thorough and expanded knowledge and understanding of the principles of theoretical, applied sciences, and advances in renewable energy and electrical power to be utilized in the design and analysis of engineering systems,
2) Understand the appropriate methods in finding solutions to typical renewable energy , electrical engineering and power conversion problems within specific engineering and economic frameworks,
3) Planning and designing renewable and electrical power systems including their protection, management, operation, and safety, in line with the forecast of future needs,
4) Planning, designing, operating, managing the most important for Palestine energy Source " Photovoltaic Solar source", in line with the forecast of future needs, and addressing the health and environmental impacts,
5) Designing and analyzing renewable energy systems, and integrating them with the conventional power systems through smart grids,
6) Design Solar collector system in their integration with thermal power station and air-conditioning systems
7) Applied state of the art software packages in all stages of building the energy system starting with power generation, distribution, load forecasting, management the resources, planning and up keeping the system efficiency.
8) Analysis, criticism, and preparation of technical reports and conducting scientific research in the areas of advances in renewable energy and electrical engineering,
9) Commitment to professional and research ethics and responsibility in the professional life,
10) Optimal time management of available resources, with necessary fault diagnostic & system maintenance.

11) Communicate effectively.
12) Leadership, good administration and ability to deal with risk and risk management,

Graduate Expected Career

Taking into account the importance of development of renewable energy sector, the graduated from this program student should have the following career character:

- Follow-up on academic achievement and pursue a PhD degree in renewable energy and power engineering or related fields,
- Engineering offices and contracting companies dealing with conventional power and renewable energy sources..,
- Companies for generation and distribution of electric power,
- Design, analysis and construction of smart grid systems in electricity distribution companies,
- The Ministry of Public Works and Housing, and the Palestinian Energy and Natural Resources Authority, and others,
- Housing and urban cities projects,
- Factories and related companies,
- Non-governmental and international organizations,
- The academic field in the industrial and vocational schools,
- Academic and educational fields,
- Research centers in the fields of power, renewable energy and control.
- Research centers and entities
- Material Sciences & related chemicals in the field of RE
- Start up their own business (spin of companies..))….

5: Intended Learning Outcomes/ILO's

Graduates' Specifications and Intended Learning Outcomes (ILOs) of the MRES Program

The various attributes and specifications of the MRES program's graduates after successfully completing the program are tabulated inn Table and Table . It is worth noting that the proposed MRES program is a multidisciplinary one and designed to be offered to students coming from different engineering fields including Electrical, Electronics, Communications, Computer, Mechanical ,Industrial and even Civil* Engineering. The various ILOs of the proposed MRES program are as follow:

Table 3: The graduate attributes (Knowledge, Understanding, Skills, Abilities and Attitudes) and their corresponding ILOs after successfully completing the MRES program

Graduate Attributes	Intended Learning Outcomes (ILOs)
Know/ledge, Understanding, Skills, Abilities & Attitudes	1. A graduate-level understanding of basic disciplinary concepts as well as identifying the different aspects of renewable energies with regard to management and finance.
	2. Designing, developing and implementing renewable energy systems belonging to a diverse range of energy resources such as solar, thermal, electrical, wind, tidal, wave, hydroelectricity, geothermal, biomass and waste technology, hydrogen, bio-processing and bio-based materials.
	3. Identifying, analyzing and solving technical problems of renewable energies related to computer engineering, for example, computational techniques and system modeling, knowledge-based systems and artificial intelligence, computer simulations for engineering design.

	4. Having a minimum computer programming knowledge, understanding and skills to solve practical engineering problems related to renewable energies.
	5. Applying mathematical techniques to model and solve engineering, business, and finance problems related to renewable energies.
	6. Appreciating and identifying all kind of issues of renewable energies related to product design, management and finance, as well as generating and evaluating design management and finance solutions to solve a specific problem.

Table 4: All-roundedness attributes (intellectual skills, professional practical skills, transferable/key skills) and corresponding ILOs after successfully completing the MRES program

Graduate Attributes	Intended Learning Outcomes (ILOs)
All-roundedness attributes such as Intellectual Professional Practical and Transferable Key Skills	1. Analyzing, modeling and simulating systems at various levels.
	2. Applying fundamental principles, advanced knowledge and methods of engineering, business and finance successfully to solve different kind of problems of renewable energy systems.
	3. Utilizing relevant engineering design tools such as Microsoft .NET, NetBeans, MATLAB, LabVIEW, PSCADE, ETAP, HOMER, RETSCREEN, POWERSYS etc.
	4. Planning, controlling and executing of renewable energy projects.
	5. Communicating effectively and presenting ideas and findings clearly in oral and written forms acquired through semester activities, projects and research theses.
	6. Thinking critically and creatively.

	7. Demonstrating self-learning and collaborating effectively with other members in a team.
	8. Recognizing social and national responsibility, regulations and ethics.
	9. Planning, designing, carrying out, evaluating and reporting research, engineering, business and finance projects of systems of renewable energies.

*- Civil & Architectural Engineering

**- Students are able to attend this program after giving them 1-2 alignment courses

6: Program Structure (List of course titles):

I. Admission Requirements

Admission to the program is based on the following conditions:

a. Applicants should have BSc from a university recognized by the PPU and AQU with a good standing in one of the following areas; Electrical Engineering, Mechanical Engineering, Computer Engineering, Materials Engineering, Civil & Architectural Engineering, Industrial Engineering, Chemical Engineering, Geothermal Engineering, Petroleum Engineering, Renewable Energy Engineering, and other related engineering programs.
b. Outstanding students from non-engineering programs (Math and Physics) can be conditionally accepted with (1-2) alignment courses.
c. Provide two ceiled recommendation letters from professors or work supervisors,
d. Passing certain exam may be required.
e. Personal interview with the program committee is required.
f. Good English with min TOFEL of 500.

II. Graduation Requirements

a. Complete any alignment or remedial course requested from the student when accepted into the program.
b. Successfully Completing 36 credit hours distributed as illustrated in the next paragraph.

III. The main program topics

The proposed MRES program is a multidisciplinary program that must cover the latest trends in the field of Renewable Energies including the following major components:

1) Renewable Technologies technicalities that includes:

a) Renewable energies technologies, Policy & Markets: Solar Thermal & electricity systems, Wind, Hydrogen, Tidal, Wave, Geothermal, Hydroelectricity, Biomass and waste technology, bio-processing and bio-based Materials.

b) Grid Systems, Renewable Heating & Cooling; Energy Storage, Structural Integrity of Renewable Energy Systems;

c) Energy Conversion Technologies, thermodynamics machines and their application to energy conversion and management in buildings (refrigeration plant, energy conversion plant and energy management, etc.)

d) Energy system analysis and optimization: Energy use in buildings/Zero emission buildings; Sustainable Heat Pumping Processes and Systems; Gas technology

2) Technical Support Topics that includes:

a) Advanced Topics in Power Electronics and Machines;

b) Control Systems, Optimization, Decision-Making, business models and operations; Energy management and Audit;

c) Fault diagnostic and system maintenance .

3) Management, finance and Environment that includes:

a) Environment and sustainability that includes:

b) Management/Finance: Principles, regulation, economic procedures, Computational methods, emissions trading, and operation of energy systems;

c) Renewable Energies for Built Environment: Environmental Legislation (Energy and Environmental Review and Audit, environmental regulations, hands-on environmental review and audit, environmental management systems, establishing a monitoring and targeting scheme;

d) Energy Sustainability that includes Energy Consumptions, Sustainable Development Applications and corporate environmental management.

4) Applied Computations that includes:

a) Computational Techniques and system Modeling;

b) Knowledge-based Systems & Artificial Intelligence: Basics of Knowledge-based Systems, Representing design process as a space of states, Relating design artifact, designing intent & designing rationale and building ontology & applying an agent-based architecture as a solution of a problem.

c) Computer Simulations for Engineering Design.

IV. Proposed program Structure

The program structure is shown on figure 3, where there are **12** credit hours for compulsory (core) courses, **18** credit hours for elective courses, and **6** hours for the master thesis. The elective courses are clustered into three groups of courses where student should select few courses from these groups as follow:

- ✓ ***Group "A":*** Combines courses related to renewable energy, and conventional energy topics, where student be able to study (9-12) credit hours from this group, which means (3-4) courses.

- ✓ ***Group "B":*** Combines courses related to system management, energy auditing, economics, energy market forecasting, where student be able to study (3-9) credit hours from this group, which means (1-3) courses .

- ✓ . ***Group "C":*** Combines multidisciplinary courses that are proposed for enriching the research skills, knowledge skills, soft skills, and in additional to discovering new alternating energy sources, where student be able to study (3-9) credit hours from this group, which means (1-3) courses.

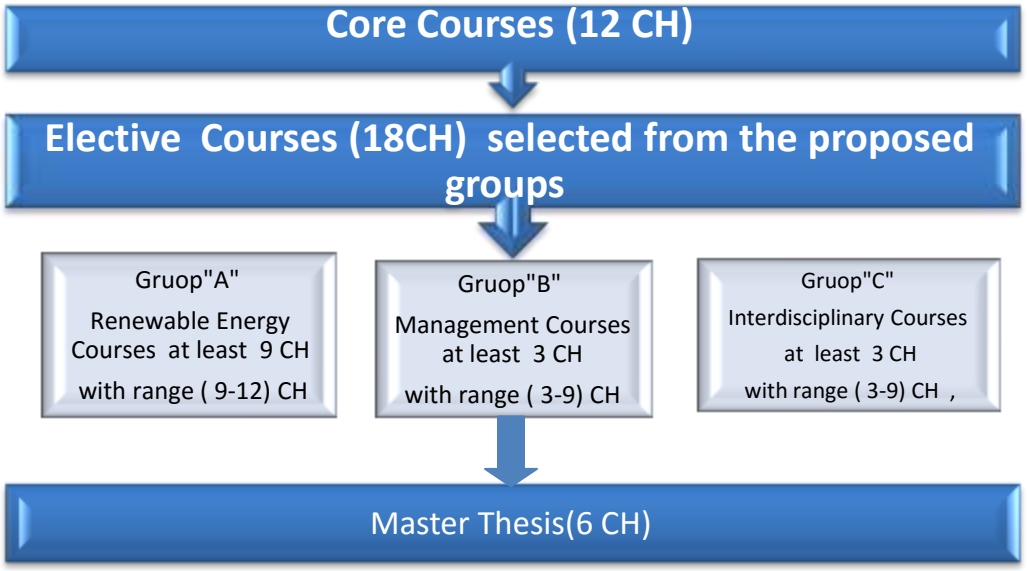

Figure 3: Program Structure

V. Program Content

The proposed courses are distributed in table (5)-table (6):

A) Compulsory Courses (12) Credit Hours:

Table (5): Compulsory courses

Title	CH
Renewable Energy Resources	3
Electrical & Electronics Systems for RE	3
Engineering Mathematics & Applied Programming	3
Energy Conversion	3
Research & Academic Activities**	0
Total	12

** This course gives students the opportunity to conduct solid research in the field of energy & renewable energy and it could be an introductory course for Master thesis..

B) Elective Courses (18) Credit Hours

Students are able to select (18 hrs) in term of courses from three groups/ areas as illustrated in Table (6):

Table (6) Elective courses.

Total CH.	Group/ Area		Title	CH
18 CH	Group A (at least 9 CH) With range (9-15) CH	Renewable Energy Courses	Photovoltaic & Thermal Solar Systems	3
			Wind Energy Systems	3
			Fuel Cells Systems	3
			Biomass & Waste Energy	3
			Energy Generation & Distribution	3
			Smart Grids	3
			Energy & Environmental Sustainability	3
			Power System Planning & Stability	3
	Group B (at least 3 CH) with range (3-9) CH	Energy Management Courses	Project Management	3
			Management & Economics Aspects in RE	3
			Energy Market & Policies	3
			Potential of RE in ME & EUROPE	3

			Energy Efficiency & Auditing	3
	Group C (at least 3 CH) with range (3-9) CH	**Interdisciplinary Courses**	Research Methods & Innovation	3
			Special Topics in RE	3
			Energy – Efficient Building Systems	3
			Geothermal Energy	3
			Fault Diagnostics & System maintenance	3
			Information Security Management	3
			Sustainable Materials	3
			Power Electronics for RE	3
			Architectural Aspects	3

B) Track Master Thesis (6) Credit Hours:

Table (7): Master thesis track

Title	CH
Thesis I, II : Considering Renewable Energy Topic	6

C) Track Comprehensive Exam (6) Credit Hours:

Table 7.1: MRES Compulsory courses for the track "Comprehensive Exam and Project"

Title	CH
Tack Comprehensive Exam & Project Compulsory Courses Course Project = 3 CH Elective Course = 3 CH from the elective courses listed in table (13)	6

D) Program Coding:

Coding Key: MRESXYZ

M- Joint Master of Science, M.Sc.

RES- Renewable Energy & Sustainability

X- Course's level = (6 for 1st year; 7 for 2nd year; 8 for the thesis) .

Y- Course cluster=2 (start coding for Master Degree)

Z- Course's sequence when being offered= 1,2,3,4,5…

E) Course Coding:

Table (8) & table (9) describes the course coding as follows:

E-1) Compulsory Courses

Table (8) Compulsory courses coding with (12 CH)

Course Code	Course title	Pr-requisites	Co-requisites
MRES6201	Renewable Energy Resources		
MRES6202	Engineering Mathematics & Applied Programming		
MRES6203	Electrical & Electronics Systems for RE		
MRES6204	Energy Conversion		
MRES6200	Research & Academic Activities**		

E-2) Elective Courses

Table (9) Elective courses coding with (18 CH)

Course Code	Course title	Pre-requisites	Co-requisites
MRES6205	Power Electronics for RE		
MRES6206	Photovoltaic & Thermal Solar Systems	MRES6201, MRES6205	
MRES6207	Wind Energy Systems	MRES6201, MRES6205	
MRES6208	Fuel Cells Systems		
MRES6209	Biomass & Waste Energy		
MRES6210	Energy Generation & Distribution		
MRES6211	Smart Grids	MRES6201, MRES6205, MRES 6210	
MRES7201	Energy & Environmental Sustainability		
MRES7202	Power System Planning & Stability		

MRES7203	Project Management		
MRES7204	Management & Economics Aspects in RE	MRES6201, MRES 6210	
MRES7205	Energy Market & Policies		
MRES7206	Potential of RE in ME & EUROPE		
MRSEE7207	Energy Efficiency & Auditing		
MRES7208	Research Methods & Innovation		
MRES7209	Special Topics in RE	MRES6206	
MRES7210	Energy – Efficient Building Systems		
MRES7211	Geothermal Energy	MRES6207, MRES7202	
MRES7212	Information Security Management		
MRES7213	Sustainable Materials		
MRES7214	Fault Diagnostic & System Maintenance		
MRES7215	Architectural Aspects	MRES6201	

E-3) Comprehensive Exam & project

Course Code	Course title	Pre-requisites	Co-requisites
MRES828	Course project	After successfully completing **30** credit hours	
MRES829	Comprehensive Exam		

E-4) Master Thesis

Course Code	Course title	Pre-requisites	Co-requisites
MRES830	Master Thesis	After successfully completing **21** credit hours	

7: Course Descriptions & ILO's of MRES Program

a) Offered Courses in the Program and their ILOs

The various attributes and specifications of the MRES program's graduates after successfully completing the program are tabulated in Table and Table .

Table 10: The graduate attributes (Knowledge, Understanding, Skills, Abilities and Attitudes) and their corresponding ILOs after successfully completing the MRES program

Graduate Attributes	Intended Learning Outcomes (ILOs)
Knowledge, Understanding, Skills, Abilities & Attitudes	1. A graduate-level understanding of basic disciplinary concepts as well as identifying the different aspects of renewable energies with regard to management and finance.
	2. Designing, developing and implementing renewable energy systems belonging to a diverse range of energy resources such as solar, thermal, electrical, wind, tidal, wave, hydroelectricity, geothermal, biomass and waste technology, hydrogen, bio-processing and bio-based materials.
	3. Identifying, analyzing and solving technical problems of renewable energies related to computer engineering, for example, computational techniques and system modeling, knowledge-based systems and artificial intelligence, computer simulations for engineering design.
	4. Having a minimum computer programming knowledge, understanding and skills to solve practical engineering problems related to renewable energies.
	5. Applying mathematical techniques to model and solve engineering, business, and finance problems related to renewable energies.

	6. Appreciating and identifying all kind of issues of renewable energies related to product design, management and finance, as well as generating and evaluating design management and finance solutions to solve a specific problem.

Table 11*:* All-roundedness attributes (intellectual skills, professional practical skills, transferable/key skills) and corresponding ILOs after successfully completing the MRES program:

Graduate Attributes	Intended Learning Outcomes (ILOs)
All-roundedness attributes such as Intellectual Professional Practical and Transferable Key Skills	1. Analyzing, modeling and simulating systems at various levels.
	2. Applying fundamental principles, advanced knowledge and methods of engineering, business and finance successfully to solve different kind of problems of renewable energy systems.
	3. Utilizing relevant engineering design tools such as Microsoft .NET, NetBeans, MATLAB, LabVIEW, PSCADE, ETAP, HOMER, RETSCREEN, POWERSYS etc.
	4. Planning, controlling and executing of renewable energy projects.
	5. Communicating effectively and presenting ideas and findings clearly in oral and written forms acquired through semester activities, projects and research theses.
	6. Thinking critically and creatively.
	7. Demonstrating self-learning and collaborating effectively with other members in a team.
	8. Recognizing social and national responsibility, regulations and ethics.
	9. Planning, designing, carrying out, evaluating and reporting research, engineering, business and finance projects of systems of renewable energies.
	10. Ability to conduct system maintenance and fault discovering, and proposing suitable solutions…

b) Courses Description- Summary description

Core Course : MRES6200 Research & Academic Activities (0 CH) / Student pay fees for 1CH .

The main aim of this course is to increase the level of involvement of master students in different organized academic and research activities. Student responsibility is to attend a number of academic and research activities during each semester, either inside or outside the university. Activity attendance must be documented and reported. Furthermore students are invited to participate in conducting research tasks under the guidance of academic instructors. The conducted research task may be able to realize an introduction to formulate master thesis task.

Core Course : MRES6201 Renewable Energy Resources (3 CH)

Introduction to Renewable Energy Sources, wind energy, solar energy, water, biomass, and geo-energy. Wind Energy Conversion Systems (WECS), assessment of wind energy potential, wind turbine aerodynamics, types of WECS, wind turbines modeling and control strategies, isolated and grid connected WECS systems, hybrid energy systems. Solar energy systems, photovoltaic cells, module and array concepts, PV system engineering, Solar energy collection systems, PV modeling and performances, parallel & series connected PV modules.

Core Course : MRES6202 Engineering Mathematics & Applied Programming (3 CH)

Linear Algebra using Eigen expansions, Sturm-Lowville problems and orthogonal functions in orthogonal coordinate systems, separation of variables, Fourier series, solution of boundary value problems for Laplace's equations, the heat diffusion equation and the wave equation in different coordinate systems, the Fourier integral, Bessel functions and Fourier-Bessel series, Legendre polynomials and Fourier-Legendre series. Regression and classification, time series prediction, Newton's method for non-linear equations, convex optimization, and model predictive control. Application areas include electricity demand and renewable resource prediction, modeling energy consumption in buildings, electrical power systems, power flow, and power markets, control of distributed storage. Several Software packages & simulation examples should be applied describing RE case studies..

Core Course : MRES6203 Electrical & Electronics Systems for RE (3 CH)

Fundamental definitions in electric circuits; basic loads; DC and AC circuit analysis; power electronics: DC/DC and DC/AC topologies; measurements; energy conversion; rotating machines; laboratories and exercises.

Basic concept of electronic circuits, transistor operation modes, amplifiers, regulators, analogue to digital converters, digital to analogue converters, Flip flops, comparators. Introduction to digital controllers. Applications of electronic circuits in renewable energy systems. Conducting Experimental handouts in the field of electronics, digital electronics, and power electronics.

Core Course : MRES6204 Energy Conversion (3 CH)

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 content: Forms of energy; Energy needs and available sources of energy, Conversion of thermal energy into mechanical energy and electrical power using heat engines (internal and external combustion engines and turbines) and electrical generators; (1st law and 2nd law of thermodynamics with concentration on power cycles). The second 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.

- ***Elective Courses - Group "A"***

Elective Course : MRES6205 Power Electronics for RE (3 CH)

An introduction to Power (Industrial) electronic devices and converters; characteristics and operational principles. DC-DC choppers; topologies and principle of operation. Fundamentals of loss-less switching techniques. Modeling and analysis of Resonant Converters. DC-

AC inverters and Multilevel inverters. Characteristics and principles of Modulation Techniques. Applications: Switch mode power supplies, Space vector pulse width modulation, power utility related applications. Harmonic processing & treatment, Power factor correction. Simulation of Power Electronics modules in RE, Sizing Industrial electronic Converters for renewable energy systems .

Pre-requisite : MRES6202

Elective Course : MRES6206 Photovoltaic & Thermal Solar Systems (3 CH)

Photovoltaic (PV): Decentralized and stand-alone PV hybrid systems: modular PV systems technology for decentralized AC-power supply; large decentralized PV systems (fixed mounted and tracking systems, power condition units and grid integration); PV stand-alone and hybrid systems configurations and components performance; supervisory control and energy management strategies for PV decentralized systems; storage technology for PV stand-alone systems (super-capacitors, batteries, electrolysis and fuel cells); power conditioning units for decentralized and stand-alone PV-Systems and components (battery charger, bidirectional converters, fuel cell inverters); PV economics and specific energy cost calculation; techno-economic performance criteria of stand-alone PV and hybrid systems; methodologies for sizing PV hybrid systems; design of stand-alone PV hybrid system (load demand synthesis, component sizing, evaluation of performance criteria); implementing simulation tools for designing PV stand-alone systems; case study via project work (design of stand-alone PV system).

Thermal Solar Systems: Fundamentals of the solar thermal heating systems including technologies, components, and applications. Solar Thermal Heating, concentrated solar thermal devices, solar thermal cooling, and solar thermal storage (Heating and Cooling). The application of various computational Simulations related to solar thermal energy analysis and optimization. Technologies related to solar thermal devices including solar collectors, solar thermal plants, and air conditioning. Design of thermal storage system for both heating and cooling systems.

Pre-requisite : MRES6201, MRES6205

Elective Course : MRES6207 Wind Energy Systems (3 CH)

Wind energy review, Power curve, overall efficiency, Betz limit, stall and pitch regulation; energy yield of a wind turbine from a site, calculating energy yield of a wind turbine using actual wind speed measurements or approximate data., Construction and functional structures of Wind energy converter ; main components of wind energy converters: rotor blade with pitch drive, input torque, generator, mechanical drive train; grid integration: different electrical networks, grid influences, grid control; control concepts and operational results: island grid operation of WECs, grid operation, interconnection operation; control system design and plant simulation: plant components characteristics, development of mathematical models for control and simulation, dimensioning of the controllers. The impact of the wind turbines & wind power on environment. Describing different economical support schemes for wind power. Simulation of wind system with grid integration using various simulation tools & software packages such as Matlab/Simulink, RETSCREEN, HOMER..

Pre-requisite : MRES6201, MRES6205

Elective Course : MRES6208 Fuel Cells Systems (3 CH)

This course introduces students to aspects of fuel cell engineering, with emphasis fuel cell systems, stacks, and single cells. The materials will be presented in the context of polymer exchange membrane fuel cells (PEMFC) and solid oxide fuel cells (SOFC). Students will learn the principles of fuel cell system design, fuel cell stack engineering, and safety.

Hydrogen Technologies. State of the art (generation, transport and storage). Power Storing & Batteries. Ultra capacitors based energy storage systems; Flywheel, Electric Vehicles (EV) interests. Random generation forecast corrections; EV needs according to users and grid exigencies/ - Dimension and security according to EV needs; Batteries and chargers.

Elective Course : MRES6209 Biomass & Waste Energy (3 CH)

This course will deal with technologies involved in the treatment and use of bio-wastes, particularly from animal manure and from plant

and food municipal organic wastes. The main purpose will be to expose students to environmentally friendly technological and whole system solutions for organic bio-waste utilization, recycling, and control of pollution agents from the agricultural and municipal's wastes. It will include odor control, biological digestion, flocculants, and bio-gas production. Students will also gain the ability to analyze and presenting data and processes in bio-wastes management. Specific themes that will be dealt with in this course include:

- Processes involved in the separation of bio-waste slurries into liquid and solid phases through the application of mechanical separation with or without additions of flocculants.
- Reactor and bio-fermentation technologies for biogas production from bio-wastes.
- Processes involved in the reduction of odor emissions, ammonia and greenhouse gases from stored bio-waste.
- Organic bio-waste material composting.
- Bio-waste management options with the use of mathematical models.

Elective Course : MRES6210 Energy Generation & Distribution (3 CH)

This course describes the power system components starting with introduction to the system components, elements, operations, and the how these systems being integrated together, the distributed generation advantages and needs. Modeling and simulation of electric systems introduction. Electric systems modeling for permanent regime operation, Steady state simulation. Load flow, line, cable, transformer, generator and load models. Sequence grids, three phase short-circuit. Transient regime electric systems modeling. Line modeling. Transient regime electric systems modeling. Transformer substation structure. Generation systems modeling & micro grid modeling. Electric supply quality with respect to frequency variations, slow voltage variations, flicker voltage fluctuations, voltage gaps and brief voltage cuts, and boosts, harmonic distortion and voltage unbalances. Various simulation tools for system modeling are applied.

Elective Course : MRES6211 Smart Grids (3 CH)

Cross-disciplinary subjects on smart grids that relate to energy generation, transmission, distribution, and delivery as well as theories, technologies, design, policies, and implementation of smart grids. Smart sensing, communication, and control in energy systems; advanced metering infrastructure; energy management in buildings and home automation; smart grid applications to plug-in vehicles and low-carbon transportation alternatives; cyber and physical security systems; microgrids and distributed energy resources; demand response and real time pricing and intelligent and outage management systems.

Pre-requisite : MRES6201, MRES6205, MRES6210

Elective Course : MRES7201 Energy & Environmental Sustainability (3 CH)

The course discusses energy in terms of fundamental concepts such as the physical/scientific and the technological, as well as societal properties of energy systems. In addition, the course covers the relation between energy and major global issues, energy and social issues, energy and the environment, energy and security, as well as energy and the economy.

Furthermore, opportunities in energy demand, energy efficiency and materials efficiency, energy end-use technology status and potential, economic viability, energy end-use analysis,

and energy scenarios are examined. Energy Policies for renewable energy sources & energy support. Environmental consequences of energy use and production. Environmental impacts, technology status and potential, economic viability, cost calculations etc. Also, old and new actors in the electric power market, from monopoly to de-regulation, are covered. The final issue covered is making it happen - from policy making to implementation.

Elective Course : MRES7202 **Power System Planning & Stability** **(3CH)**

Mathematical methods and modern approaches to power system planning. Demand forecasting. Generation, Transmission & Distribution planning: deterministic and probabilistic methods, heuristic and stochastic methods, system layout, and choice of components. Route selection: environmental and economic considerations. Quantitative methods of long and short term planning.

Introduction to the power system stability, power system types and elements, different states of power systems. Security control, and power system optimization and its economic importance . Power systems control , relay control ,automatic emergency control, generation and frequency control (Single machine model, Multi machine model), voltage stability and automatic voltage regulator , stability of power systems (Static stability, Dynamic Stability) . Power systems optimization, emergency state optimization , economic dispatch problem , unit commitment , optimal power flow, and long-term optimization of power systems. Simulation examples by using various software packages ETAP, Simulink, and *SCADA* for processing the occurred behaviors, in addition to conducting practical experiments regarding system stability.

- ***Elective Courses - Group "B"***

Elective Course : MRES7203 **Project Management** **(3 CH)**

Introduction to project management, definition the project management components with respect to planning, implementing, controlling the tasks to achieve an organization's schedule, budget, and performance objectives. Project lifecycle vs solution Development lifecycle, the project manager role, and project leadership and team building. Initiating project charter development and scope statement development. Plan for creating a work breakdown structure, schedule development, resource planning, communications planning, and risk planning. Execution, control and close the project stages, scope control, the triple constraint and

project control, and project communications. Applying various Microsoft Project software such as Microsoft project and Primavera . Course project regarding certain production process in RE systems are going to be conducted.

Elective Course : MRES7204 Management & Economics Aspects in RE (3 CH)

Introduction to methods and strategies for operation and management of renewable energy systems and theirs integration aspects with the electrical power system, mathematical methods and tools applied to power system operation. Characteristics of power generation units combining both RE and conventional power units . Economic dispatch of generating units and methods of solution. Power interchange production cost models. Generation control. Reactive power dispatch and allocation, Optimal power flow using intelligence algorithms. Conducting concrete projects concerning these issues. Using various simulation software packages such as Smart Grid Modular with SCADA training Software, Matlab/Simulink software and Power World simulator for managing & optimization the integration procedure.

Pre-requisite : MRES6201, MRES6210

Elective Course : MRES7205 Energy Market & Policies (3 CH)

Energy Market policies are analyzed in a perspective and in relation to changes in different agendas for example growth, environment and development. How are energy policies& energy market policies designed nationally and globally? Which are the consequences on the environment and society of certain energy policies? How can energy policies be utilized to promote growth and fight poverty?. Invited speakers from the local society should take part in conducting this courser in order to put students in real status of the conducted policies toward development the energy sector and promoting it's sustainability.

Elective Course : MRES7206 Potential of RE in ME & EUROPE (3 CH)

Introduction to EU & MENA countries locations and energy potential, actual energy situation, in particular in EU and MENA countries and in student's home country with presentation, definitions of potentials, researching specific information sources, actual state and potentials of renewable energies in the different countries, presentation/discussion of actual projects for renewable energies. Determination of economic and calculation of technical potentials of RE in the MENA region.

Environmental consequences of energy use and production: climate change/global warming, air pollution, water use and pollution, natural disasters, sea level rise, migration and climate change; mitigation: political framework, Kyoto protocol, technologies for mitigation such as renewable energies, energy efficiency, clean coal; adaptation: risk management, land use change;

Elective Course : MRES7207 Energy Efficiency & Auditing (3 CH)

This course describes topics related to energy Efficiency in Industrial processes and buildings , where the energy management systems, high efficiency motors and generators, variable speed drives, combustion control and monitoring, waste heat recovery exchangers, building management system, design of thermal storage (cooling/heating), demand controlled ventilation, steam systems, compressed air use are described. Understanding the power flow in buildings, applied technologies, determine the heat gain, heat losses ,cooling demands, life cycle cost , and life cycle assessment of environmental impacts in the building sector .

Then introduction to energy audit , defining the energy audit, developing an audit Plan, audit resources, audit methodology. Energy Analysis Methods: Condition Survey, Establish the Audit Mandate, Establish Audit Scope, Analyze Energy Consumption and Costs, Comparative Analysis, Profile Energy Use Patterns, Inventory Energy Use, Identify Energy Management Opportunities, Assess the Costs and Benefits.

Technical Supplement: Energy Fundamentals, Energy- Consuming Systems, Instrumentation for Energy Auditing, Electrical Inventory Method.

- ***Elective Courses - Group "C"***

Elective Course : MRES7208 Research Methods & Innovation (3 CH)

Fundamental concepts of scientific research; an introduction to concepts underlying peer-reviewed research, evaluating the relevance and impact of sources, conducting literature reviews, evaluating published findings, using research productivity tools, using statistical methods, designing research studies and writing scholarly articles; an introduction to intellectual property (IP), development, evaluation and strategy; strategy and innovation concepts with a focus on technology commercialization.

Elective Course : MRES7209 Special Topics in RE (3 CH)

Study of a particular subject related to advances in Power Engineering depending on students' needs and instructor's interests such as Entrepreneurship in RE, Urban Energy Systems, sustainable Transport, etc.

Pre-requisite : MRES6206, & Program Committee Approval .

Elective Course : MRES7210 Energy – Efficient Building Systems (3 CH)

Basics of building physics: heat transfer adapted to building elements like walls and windows, shading devices, humidity and condensation effects, thermal comfort, ventilation, global radiation on building, boilers, cogeneration of heat and electricity, heat pumps. Passive houses. Costs

and savings of energy efficiency measures. Principles of integrated, energy-efficient building design. Interpretation / application of codes, standards. Use of software tools for modeling and simulation of building energy systems. Discussion of different conditions in the MENA countries.

Elective Course : MRES7211 Geothermal Energy (3 CH)

Heat pump design and operation, heat pump cycles, refrigerant selection, ground-loop design, heat transfer issues pertaining to geothermal energy, system design and integration, temperature and materials issues unique to geothermal heat pumps, classification of geothermal resources.

Pre-requisite: MRES6207, MRES7202

Elective Course : MRES7212 Information Security Management (3 CH)

The course aims at providing enrolled students with an understanding of the principles of information security management that are commonly used in business. It includes an introduction to the commonly used frameworks and methods and critically exploring the suitability and appropriateness of these for addressing today's organizational security needs. The course covers comprises several topics including: Governance and Security Policy, Threat and Vulnerability Management, Incident Management, Risk Management, Information Leakage, Crisis Management and Business Continuity, Legal and Compliance, Security awareness and security implementation considerations and ISO 27000 series.

Elective Course : MRES7213 Sustainable Materials (3 CH)

Wind: Passive Cooling (Natural and Cross Ventilation and Energy Production: Wind Power including Wind Turbines. Water Systems: Grey Water Systems: Evapotranspiration Systems, Green Roofs, Fixtures and Appliances, Solar: Active and Passive, Solar Collectors, Solar Water

Heaters, Solar Pool Pumps, Solar Heating Walls, Certified Products: Wood, Flooring (Wood Alternatives), Chemicals (Paints and Coatings, Adhesive and Sealants) and Appliances & Lighting.

Elective Course : MRES7214 Fault Diagnostic & System Maintenance (3 CH)

Introduction and types: Preventive maintenance, its objectives, benefits and economics, inspection and implementation. Routine maintenance and monitoring of fault indicators, main concepts and implementation. In additional to that this course should cover certain topics concerning basic maintenance techniques and the applications of troubleshooting in fault diagnosis, inspection, disassembly, keeping record, repair and reassembly of different electromechanical and electronics equipments such as electrical motors, pumps, hoisting systems, elevators, escalators, cutting machines, home appliances, electrical generators & transformers, Renewable energy systems , air conditioning and cooling system, production lines, hydraulic and pneumatic systems and power electronics equipments and devices. The course is supported by practical training and software packages for virtual fault production, training and simulation….

Elective Course : MRES7215 Architectural Aspects (3 CH)

This course describes the architectural aspects in order to minimize energy consumption and to keep sustained energy efficiency, the main topics are: the roots of sustainable architecture, the environmental impact of buildings (ecological footprint), principles of the environmental design, energy, ventilation and lighting in sustainable architecture, the major steps to create sustainable architecture. Indoor Environmental Quality, monitoring and modeling of environmental performance. Advanced Construction and sustainable Building Analysis.

Pre-requisite: MRES6201

Comprehensive Exam Track

Core Course : MRES828 Project (3 CH)

During the project, which extends over one semester, the student will be assigned a specialized renewable energy application problem of limited scope under the supervision of a faculty member. The problem definition spans from gathering all pertinent information and data, through studying, analyzing and recording of the problem, followed by designing and implementing of an application, which can be an executable program, a simulation or real system realization including mechanics, hardware, software etc. At the end of the project, the result of the student's findings must be provided informs of a report, a system demo, and an oral presentation.

Pre-requisite: First Program committee approval; Then Graduate Studies committee approval.

Core Course : MRESE829 Comprehensive Exam (3 CH)

Student is required to prepare for comprehensive exam in few courses from the master program courses. These courses are selected by the program committee. The exam schedule is announced by the program committee and lunched one time each semester.

Pre-requisite: First Program committee approval; Then Graduate Studies committee approval.

Thesis Track

Core Course : MRES830 Master Thesis (6 CH)

The MRES thesis represented in the two courses Thesis I and Thesis II must be done under the supervision of a professor from PPU or AQU or other university and can be done in cooperation with other national or international organization specialized in renewable energies. The thesis may be a design project, an analytical paper, or experimental work etc.

The associated work is an individual effort that demands initiative, creativity and individual responsibility. The MRES thesis is to be completed in two semesters. In Thesis I, which represents the first stage of the MRES thesis, the student will be also examined for his ability to continue with Thesis II. During Thesis I, the student gathers all pertinent information and data acquired through literature reviews, and then, studies, experiments, analyzes, solves etc. At the end of the Thesis I, the student is required to make a representation of his findings that must be approved by the MRES's program committee before the student may enroll in Thesis II. In Thesis II, the research must be completed and copies of the thesis are to be deposited at the university`s library.

Pre-requisite: First Program committee approval; Then Graduate Studies committee approval .

C)-2 **Detailed ILO's with their matching courses and methods for measures**

Table (12) shows a matrix of the Intended Learning Outcomes and their relations with the program courses and methods for measuring these ILOs.

Table (12): Intended Learning Outcomes/ILO's Matrix

	Methods to measure ILOs																													
	MRES6200	MRES6201	MRES6202	MRES6203	MRES6204	MRES6205	MRES6206	MRES6207	MRES6208	MRES6209	MRES6210	MRES6211	MRES7201	MRES7202	MRES7203	MRES7204	MRES7205	MRES7206	MRES7207	MRES7208	MRES7209	MRES7210	MRES7211	MRES712	MRES7213	MRES7214	MRES7215	MRES8830**	
A. Knowledge and understanding																													
A.1. Have and develop a thorough knowledge and understanding of the theoretical and applied principles of renewable energy and electrical engineering,	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Exams, Engineering Simulation and Experiments, Research Papers, Presentations, Hosting Specialists and Experts
A.2. Have and develop a comprehensive understanding of the requirements for designing, analyzing and evaluating renewable energy projects	X	X			X		X	X						X							X	X						X	Research Papers, Presentations
A.3. Have a comprehensive and accurate knowledge of renewable energy sources and related systems applications,	X	X		X					X	X	X	X		X														X	Exams, Engineering Simulation and Experiments, Hosting Specialists and Experts

						Methods to measure ILOs																									
		MRES6200	MRES6201	MRES6202	MRES6203	MRES6204	MRES6205	MRES6206	MRES6207	MRES6208	MRES6209	MRES6210	MRES6211	MRES7201	MRES7202	MRES7203	MRES7204	MRES7205	MRES7206	MRES7207	MRES7208	MRES7209	MRES7210	MRES7211	MRES712	MRES7213	MRES7214	MRES7215	MRES830**	
A.4.	Have a comprehensive and accurate knowledge about electrical power systems and the related applications,				X	X		X	X										X	X	X		X							Exams, Engineering Simulation and Experiments, Hosting Specialists and Experts
A.5.	Be able to select and apply an appropriate methods to solve engineering problems within specific framework,	X		X													X								X		X			Exams, Engineering Simulation and Experiments
A.6.	Develop critical awareness about the implications of the renewable and sustainable energy & electrical engineering systems with their applications on the Palestinian Society, economically and socially.	X			X					X	X					X	X								X	X				Presentations, report, exams.
A.7.	Have a comprehensive and accurate knowledge about renewable energy management, economics & system cost,.	X	X							X	X					X	X							X		X			X	Exams, presentations, case studies
A.8.	Have a comprehensive and accurate knowledge about renewable energy and											X	X					X	X					X					X	Exams, presentations Experiments, Hosting

					Methods to measure ILOs																								
	MRES6200	MRES6201	MRES6202	MRES6203	MRES6204	MRES6205	MRES6206	MRES6207	MRES6208	MRES6209	MRES6210	MRES6211	MRES7201	MRES7202	MRES7203	MRES7204	MRES7205	MRES7206	MRES7207	MRES7208	MRES7209	MRES7210	MRES7211	MRES712	MRES7213	MRES7214	MRES7215	MRES830**	
environmental sustainability.																													Specialists and Experts
B. Subject specific and practical skills																													
B.1. Be able to explain and discuss the characteristics of renewable energy systems, and to design practical solutions for an optimal and safe usage,			X	X	X		X	X					X			X	X		X						*			X	Exams, Engineering Simulation and Experiments, Hosting Specialists and Experts
B.2. Be able to design and analyze electric power conversion systems and their applications,		X	X											X				X				X							Exams, Engineering Simulation and Experiments, Hosting Specialists and Experts
B.3. Be able to estimate future energy needs and to plan and suggest appropriate solutions,		X								X						X							X						Exams, Engineering Simulation and Experiments
B.4. Be able to automate renewable and electrical systems through the use of computer programming and optimal control,													X							X		X			X				, Engineering Simulation and Experiments, case studies, and projects
B.5. Be able to design and operate electrical generation & distribution		X																	X	X		X						X	Exams, Engineering Simulation and Experiments,

									Methods to measure ILOs																									
	MRES6200	MRES6201	MRES6202	MRES6203	MRES6204	MRES6205	MRES6206	MRES6207	MRES6208	MRES6209	MRES6210	MRES6211	MRES7201	MRES7202	MRES7203	MRES7204	MRES7205	MRES7206	MRES7207	MRES7208	MRES7209	MRES7210	MRES7211	MRES712	MRES7213	MRES7214	MRES7215	MRES830**	
unit ,																													Hosting Specialists and Experts
B.6. Be able to design and analyze smart electrical networks and systems and to identify their components and characteristics,		X	X																			X						X	Exams, project, and Experiments, Hosting Specialists and Experts
B.7. Be able to plan and manage renewable energy production processes and their economics ,			X						X	X					X			X	X		X		X		X				Exams, Engineering Simulation , project, and Experiments,
B.8. Be apple to conduct fault inspection and maintenance ,	X	X	X		X		X	X					X	X											X	X	X		Exams, reports , assignments and presentations
B.9. Be able to design and analyze different power electronics converters,	X	X	X				X																		X				Exams, Engineering Simulation and Experiments, Hosting Specialists and Experts
B.10. Be able to conduct energy auditing and losses reduction ,	X								X												X								Exams, Engineering Simulation and Experiments

					Methods to measure ILOs																								
	MRES6200	MRES6201	MRES6202	MRES6203	MRES6204	MRES6205	MRES6206	MRES6207	MRES6208	MRES6209	MRES6210	MRES6211	MRES7201	MRES7202	MRES7203	MRES7204	MRES7205	MRES7206	MRES7207	MRES7208	MRES7209	MRES7210	MRES7211	MRES712	MRES7213	MRES7214	MRES7215	MRES830**	
B.11. Be able to conduct scientific research in advanced areas of renewable. Energy, electrical engineering, including power conversion, management and efficient use,	X	X	X		X	X		X			X		X				X					X		X		X		X	Exams, Engineering Simulation , reports, presentations
B.12. Be able to use various means of technology,	X	X			X	X	X	X			X	X	X	X				X	X	X		X		X	X			X	Research Papers, Presentations, projects
B.13. Be able to prepare, analyze, and critique electrical technical reports,		X															X				X			X			X	X	Reports, presentations, exams.
C. Intellectual/Cognitive skills																													
C.1. Be able to provide innovative and creative solutions supported by scientific evidence within specific framework,	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Exams, Engineering Simulation and Experiments, Research Papers, Presentations
C.2. Be able to manage time and resources effectively,	X	X		X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X			X	X	Research Papers, Presentations

													Methods to measure ILOs																					
		MRES6200	MRES6201	MRES6202	MRES6203	MRES6204	MRES6205	MRES6206	MRES6207	MRES6208	MRES6209	MRES6210	MRES6211	MRES7201	MRES7202	MRES7203	MRES7204	MRES7205	MRES7206	MRES7207	MRES7208	MRES7209	MRES7210	MRES7211	MRES712	MRES7213	MRES7214	MRES7215	MRES830**	
C.3.	Be able to deal with emerging and contemporary renewable energy and electrical engineering issues,		X							X		X				X		X		X		X	X						X	Exams, Engineering Simulation and Experiments, Research Papers, Presentations, Hosting Specialists and Experts.
C.4.	Be able to critique and evaluate renewable energy systems , electrical engineering systems and networks,		X							X												X	X	X	X				X	Exams, Engineering Simulation and Experiments, Research Papers, Presentations
C.5.	Be able to analyze the requirements of renewable energy systems, electrical engineering applications and to build appropriate system model,	X	X	X						X				X	X						X		X	X					X	Engineering Simulation and Experiments, Research Papers, Presentations
C.6.	Be able to critically analyze complex scientific concepts in electrical engineering. Be able to critically analyze complex scientific concepts in renewable emery and electrical engineering.	X	X					X								X							X	X		X			X	Engineering Simulation and Experiments, Research Papers, Presentations

					Methods to measure ILOs																									
	MRES6200	MRES6201	MRES6202	MRES6203	MRES6204	MRES6205	MRES6206	MRES6207	MRES6208	MRES6209	MRES6210	MRES6211	MRES7201	MRES7202	MRES7203	MRES7204	MRES7205	MRES7206	MRES7207	MRES7208	MRES7209	MRES7210	MRES7211	MRES712	MRES7213	MRES7214	MRES7215	MRES830**	
D. General and transferable skills																													
D.1. Be able to communicate technical issues effectively,		X		X						X							X					X	X	X			X		Research Papers, Presentations
D.2. Be able to write, review and present project proposals, scientific papers and patents,		X																			X	X	X			x		X	Research Papers, Presentations
D.3. Be able to use computer software to design and implement renewable energy electrical engineering projects,	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	Engineering Simulation and Experiments
D.4. Be able to choose and apply experimental measurement techniques and to study and process extracted data,	X	X			X		X	X			X		X							X		X		X			X		X	Engineering Simulation and Experiments, Research Papers, Presentations
D.5. Be able to conduct scientific research and to design experiments and process their results,		X	X		X		X	X						X					X	X		X			X	v	X		X	Experiments, Research Papers, Presentations,
D.6. Committed to professional ethics ….		X																												Research Papers, PPT

**- The ILOs of Comprehensive Exam track is similar to these of master track.

8. Program Study Plan

The proposed program is a two-year master program with four semesters, and in line with the University regulations and AQAC instructions. Graduate students be able register no more than 9 credit hours per semester as shown in Table (13) and Table (14) for both "Thesis" and "Comprehensive exam" :

Table 13: A recommended two-year study course distribution for completing the "Thesis" track within two years

	Fall Semester			**Spring Semester**		
First Year	**Course Number**	**Course Name**	**Credits**	**Course Number**	**Course Name**	**Credits**
		CORE I	3		CORE IV	3
		CORE II	3		ELECTIVE I	3
		CORE III	3		ELECTIVE II	3
		CORE V	0		CORE V	0
			9			9
	Fall Semester			**Spring Semester**		
Second Year	**Course Number**	**Course Name**	**Credits**	**Course Number**	**Course Name**	**Credits**
		ELECTIVE III	3		ELECTIVE V	3
		ELECTIVE IV	3		ELECTIVE VI	3

		CORE V	0		CORE V	0
	MRES830	Thesis I*	3	MRES830	Thesis II	3
			9			9

Table 14: A recommended two-year study course distribution for completing the "Comprehensive Exam & Project" track within two years

	Fall Semester			**Spring Semester**		
First Year	**Course Number**	**Course Name**	**Credits**	**Course Number**	**Course Name**	**Credits**
		CORE I	3		CORE IV	3
		CORE II	3		ELECTIVE I	3
		CORE III	3		ELECTIVE II	3
		CORE V	0		CORE V	0
			9			9
	Fall Semester			**Spring Semester**		
Second Year	**Course Number**	**Course Name**	**Credits**	**Course Number**	**Course Name**	**Credits**
		ELECTIVE III	3		ELECTIVE V	3

		ELECTIVE IV	3		ELECTIVE VI	3
		CORE V	0		CORE V	0
	MRES828	Course project	3	MRES829	Comprehensive Exam	3
			9			9

*- Officially registered with 6 hrs in third semester and continues to fourth semester.

9. Educational System adopted in the Program

The program will follow the procedures and instructions related to assuring healthy and dynamic educational process, in terms of the admission requirements, credit hours study system, exams and assessment procedures applied in both partner universities. Furthermore, the joint master program will have its specific laws and instructions that should be applied in both partner universities. As mentioned in annex (2).

The major points of these regulations are:

a. Targeted programs

Graduates with a Bachelor of Science, B.Sc. / B.Eng. degree in one of related Engineering disciplines Electrical, Electronics, Communications, Computer, Mechanical Industrial Engineering, Civil Engineering fields awarded by an locally and internationally recognized academic institution, is eligible to apply for the MRES program. Also outstanding graduates **form Non-engineering programs (Mathematics, Physics, Chemistry,..) are eligible to apply.**

b. Transcripts and References

All applicants who wish to apply for the MRES program should provide original transcripts and two faculty references from the most recent academic institution.

c. Grade Point Standing

Applicant's record should exhibit adequate achievement as indicated both by accumulative average and quality of courses covered during her/his entire academic record. Normally, applicants should have a good grade in her/his Engineering B.Sc. /B.Eng. degree.

d. Graduate Record Examination (GRE) (counts as extra credit for the applicant)

Applicants to the MRES program are recommended to submit their GRE scores which increase the applicant acceptance chances.

e. TOFEL Scores (counts as extra credit for the applicant)

Applicants to the MRES program must have a score higher than 500 in their Test of English as Foreign Language (TOFEL) scores as a requirement for graduation.

f. Provisional Admittance

Provisional admittance may be granted on a case-by-case basis, and indicates that although an applicant shows adequate potential, the applicant does not meet all the requirements. The required collateral work as well as completion dates shall be indicated in the letter of admission issued by both partner universities.

g. Admission Process

A complete application consists of the following:

- Partner Universities University Graduate Application Form with two universities logos
- Faculty of Engineering Supplemental Application Form/ Faculty of Science for non-engineering programs
- Application Fee
- Two official Transcript of all Academic Institution work (undergraduate and graduate)
- TOFEL scores (recommended)
- GRE Scores (recommended)
- Three letters of recommendation
- A statement of purpose for graduate study
- An interview.

End.

Annexes