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Design of a new Egyptian/European double master degree in Clean Energy and Environmental Studies

Mohammed N. Anany[a,]*, Mohamed F. Shehadeh[a], Constantina Álvarez Peña[b]

[a] *Lecturer, College of Engineering & Tech,Arab Academy for Science & Tech, P.O.Box 1029 Alexandria, Egypt*
[b] *Lecturer, Electrical Engineering Department, University of Oviedo, Gijon, Spain*

Abstract

The introduction of a postgraduate course is a positive and a challenging task, it gets harder when the course is designed to be run between two or more different institutions, and even harder if the parties are located in different countries. In the field of renewable/clean energy, eighty two energy master's programs worldwide have been surveyed with special focus on Europe, MENA region and North America. The ECTS grading system has been adopted as a reference and other grading systems were translated into ECTS equivalents. The study reveals that master programs in Europe are in average longer than those offered in MENA and North America. Master programs in Europe are eight times as many as those offered in the MENA region. This study also confirmed that no master's programs, in the MENA region, in Energy integrating both of energy management, renewable/clean energy disciplines together. The study also recommends the integration of tidal and wave energy courses within the intended master's degree.

The CERES TEMPUS project is a collaboration program between four different academic institutions from Egypt, three European universities and two industrial partners who work together on designing and running a double European/Egyptian Master degree in Renewable/Clean energy technology as well as providing the local market with its training needs. This paper intends to provide some current practices worldwide on the master courses available in different countries, and the different approaches used.

Selection and/or peer-review under responsibility of the TerraGreen Academy

Keywords: multidisciplinary master program; Renewable/Clean Energy; low-emission power plants; environmental management; TEMPUS project

* Dr. Mohammed Anany. Tel.: +20-100-161-0427; fax: +203-562-2915.
E-mail address: mohamed.anany@aast.edu.

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1. Introduction

The load on the Egyptian power distribution grid is ever increasing to the extent that the production sector was not able to secure the peak load in the summer of 2012 to meet the demand needs. The only action taken by the distribution sector was to perform some electrical load shedding on some areas in the country. The Egyptian government is meanwhile trying to develop its energy sectors on many parallel horizons. One aspect is reviving their old nuclear power production plans, an approach which we consider contra-environmental. The other approach is by building new conventional fossil-fuel fired power plants. Furthermore, the Egyptian water supplies are liable to get reduced due to the political instability taking place in Sudan and due to the will of River-Nile countries to review the water distribution agreements between them from one side and Egypt from the other side. These have arisen the concern of sea water desalination using solar energy. Renewable energies are also considered as a very good alternative where they are participating in the ambitious EU program.

According to the annual report of the Egyptian National Renewable Energy Authority NREA for 2010/2011, the Ministry of Electricity and Energy is striving for doubling the renewable energy share of energy production to 20% by the year 2020 [1]. No direct transition from conventional methods to renewable energy resources is anticipated due to social and economical factors. Moreover, new technologies evolving for emission abatement are also conceived and investigated. Thus fossil fuel combustion will continue to be the dominant share through the following two decades.

The present work aims mainly to establish a new master's of science program leading to an engineering degree in the fields of energy and environmental management. This program is required globally and will support the labour and energy sectors of well qualified professional engineers in the renewable energy discipline [2-4]. Moreover, among the project's target, Egyptian/European partners are proposing the establishment of a center of excellence dealing with the energy sector under the title of Clean Energy and Environment. Accordingly, the project will establish a specially-tailored training programs for engineers working in this vital sector. The master/training program can be subdivided into three major modules namely renewable energy resources, low emission power plants and environmental management.

Finally, the vision of the CERES project is to put engineers, decision-maker and public awareness into its scope of interest. National awareness of the problem should be brought into the spot of light. Attitudes of public should be changed towards the conservation of the environment. The decision-maker should be tolerant about the idea of decentralized and private power production even on the house hold scale. Public should be also encouraged and aware of the benefits of house-hold energy producers.

2. Design of the Intended New Master's of Science

One of the outcomes of the collaborative work between the Arab Academy for Science and Technology and Maritime Transport AASTMT in Alexandria, Egypt, and partners from nine other institutions distributed among Egypt and Europe to design and run a joint European/Egyptian Master of science degree in renewable/clean technology. This collaborative work is done within the Clean Energy Research and Environmental Studies CERES granted by the Trans-European Mobility Scheme for University Studies TEMPUS. The project partnership is shown in Fig. 1.

The renewable energy resources module includes the studies of solar, wind, wave, and tidal as well as geothermal energy. The courses serving this module are to be prepared by mechanical as well as electrical engineers in order to assure a broader coverage of the subject under consideration. The low emission power plants module devotes itself towards the study of pollutant reduction technologies applied to conventional power plants. The courses cover the following areas: pre- and post-combustion treatment to fuel, the oxidizing medium and/or flue gases. Modifications to the combustion process to minimize

emissions are to be considered as well. The module includes different technologies for carbon capture and storage. The module targets to trigger the awareness of engineers (master students) and/or trainees of the international legislations/protocols concerning the environment and pollutant emissions. Topics concerning the use of biomass as an alternative fuel are covered in this module. The environmental studies module focuses on the mechanical and biological treatment of solid waste as well as design of solid waste treatment plants. The module covers waste water treatment of urban areas and industrial processes drainage. Air quality control is also covered within this module where air pollutant measurements and sampling are focused as well as flue gas treatments.

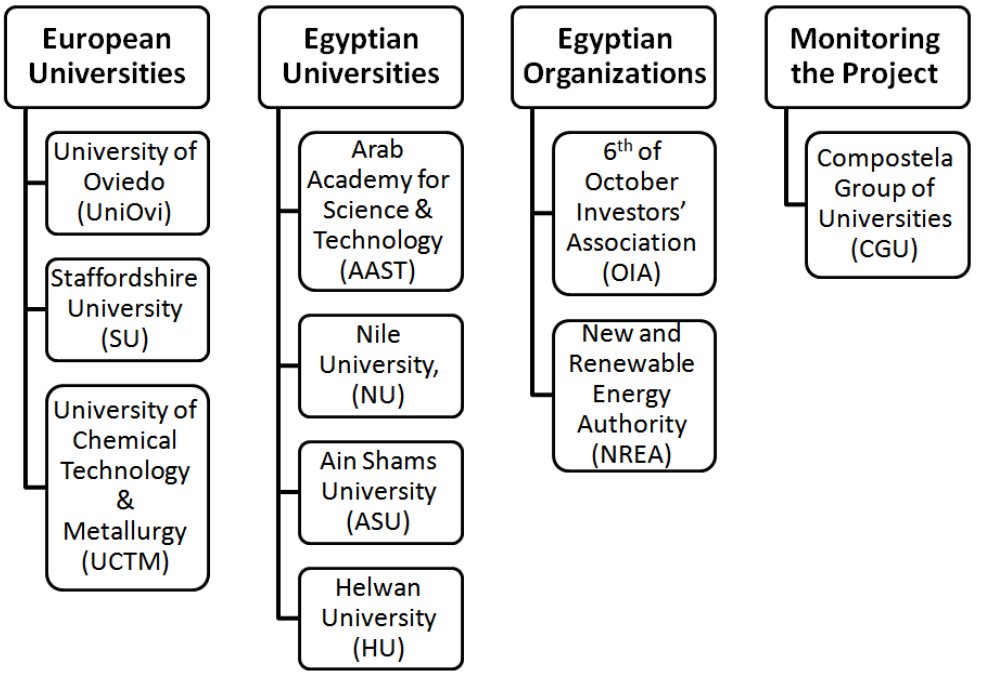

Fig. 1 CERES project partnership

3. Quality of Partnership

The partners within this project are selected on the basis that each partner is capable of contributing its specific expertise in the domains of energy and environment in a manner that fulfills the objectives of the project as a whole. Moreover, the majority of the partners has already cooperated together on similar EU projects, which makes the partners expect that synergy between partners already exists rather than building a new consortium lacking previous knowledge between partners who are newly-introduced to one another. This can be considered to be the optimum combination between expertise and mutual trust between different parties from Academia/Industry which has also been recommended by others [5]. The roles of partners can be summarized as follows:

1. EG universities where the master/training programs are going to take place, are going to participate in the local as well as international survey of similar master's/training programs given world-wide. They

will work with EU partners in developing as well as adapting the required courses to the local needs. EG universities are expected to co-finance the project as well.

2. EU universities are the main bodies where development of training and academic courses is going to take place.

3. EG Ministry of Environment and NREA are going to work as representatives of the EG decision-makers where they should provide necessary and sufficient data about the current and future plans about the energy sector in Egypt. They should also contribute their input to adapt the courses being developed at the EU universities to accord with the local needs of the energy and environmental sectors. Their role will be also important in dissemination and the sustainability of the master/training program on the local level during the funded interval and afterwards. They are expected to train their professionals at the EG partner universities.

4. The participation of the Sixth of October Investors Association helps to link the EG institutes with industry. Their participation will be in surveying the local training needs, dissemination of the training programs and publicity.

University of Oviedo (UNIOVI), for example, is recognized since 2009 as a campus of international excellence. They received mentioning as a campus of excellence due to their research and knowledge transfer in the field of energy, environment and climate change. University of Chemical Technology and Metallurgy (UCTM) is a specialized university in the fields of chemical engineering and metallurgy. They are accredited at the higher standards in Bulgaria and they offer master's degrees in Biotechnology, ecology and environmental protection as well as environmental protection and sustainable development which qualifies them as a very good contributor to the development of the master's program at the Egyptian Universities. Last but not least, the Staffordshire University (SU) has a reputation for excellence where they scored a rating of 90% by the UK Research Exercise Assessment (RAE) that they meet the international standards. SU are recognised of their expertise in the fields of solar, wind and wave energies.

Such collaboration works on strengthening and supporting the bilateral ties between the EU countries from one side and developing countries south of the Mediterranean on the other side. Moreover, it will strengthen the relationships between academic professionals from one side and the energy sector from the other side as it stimulates the mutual cooperation, understanding and building confidence between industry and academia. This multilateral collaboration will work on setting the participating universities as centres of excellence in the fields of energy production and environmental studies within the Egyptian boarders as well as boarders of MENA countries.

The presence of NREA as deputy of the Ministry of Electricity and Energy in Egypt, gives weight to the seriousness of the local partners to work on the success of this project. Since, this ministry will help to correctly and carefully tailor the master and training courses to the current and future needs of the local energy sector and their consequent environmental impacts.

4. General Approach

This work has been started with surveying Europe, North of America and MENA regions using mainly internet resources and by the aid of a multitude of lecturers and professors from different universities among partner Universities. The methodology applied needed some general approaches because of:

- The number of countries allocated all over the world;
- The number of universities in these countries.
- The various program structures and the credit transfer systems adopted.

Practically it was not possible to check all countries and all universities. That is why the survey was prepared for a number of countries in each region. Due to the large number of universities it was necessary to focus the study on the academic institutions that proved the quality of education provided.

Ranking websites [6-8] were used in order to focus on top university programs. The first brief look at the information provided by different universities showed that there is no common standard for describing the Master Degree courses. The module (course) content of many of the surveyed programs were either not available or having restricted access. On top of that, it is very often to find the description and content of courses were given only in the national language. Hence it was not possible to include these course contents in the survey. In spite of such difficulties, every effort was done to collect as much information as possible for every country, even if only one single program at a single university was available.

5. Program Analysis

This analysis is an attempt to spot the lights on the current situations of the Energy programs offered in Egypt, the MENA region, and the world wide institutions. No doubt that there are many Energy programs at different levels offered by different Universities and institutions locally and internationally. In addition, the intention of this survey is to reveal the competitive programs especially in well-established universities and institutions whether in Egypt, the regional area or worldwide. The report focused on:

1- The postgraduate programs in Energy relevant to our project.
2- The degree of competitiveness relative to our project.
3- The support given to the students enrolled to the programs.

The survey covered more than 29 countries, 149 universities, 83 master's programs constituting more than 6500 ECTS. The survey covered Europe, North America, MENA region and India. For convenience issues, the analysis has been conducted by dividing the scope of the Energy and Environment programs into three subject areas: Renewable energy resources, Energy management and Environmental management. The analysis was confined to graduate programs adopting either the ECTS, either the Credit Hour System or the Quarter Hours system.

Compiling the data needed the adoption of one grading system for the sake of comparison. Fulbright España [9] specifies that one credit ECTS is equivalent to 25-30 study hours per semester. Bearing in mind that one credit hour necessitates 15-16 contact hours per semester, i.e. 45-48 study hours. Hence the following scheme has been adopted

$$1 \text{ Cr. Hr.} = 1.667 \text{ ECTS} \quad (1)$$

The Adnoc scholarship program [10] specifies that three credit hours are equivalent to two quarter hours. Hence

$$1 \text{ Quarter Hours} = 1.11 \text{ ECTS} \quad (2)$$

The analysis shows that the Master programs are tailored on a 60 ECTS basis in the MENA region and USA, on average. Apart from the UK which has an average of 90 ECTS, Europe as well as India adopt 120 ECTS credits on average for a master's program.

Fig. 2 indicates that ten countries from the MENA region have been surveyed in comparison with 17 countries from the European side. This can be attributed to the partnership nature where countries of origin for 75% of the partners are European.

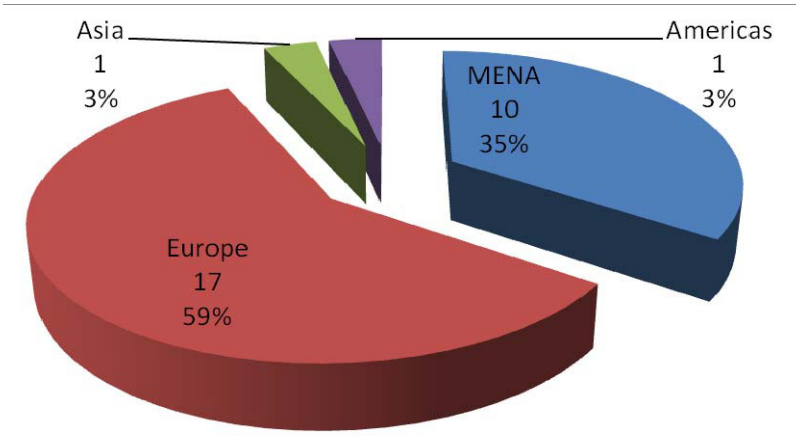

Fig. 2 Number of countries covered by the study distributed by region.

Fig. 3 and Fig. 4 reflect the need of the introduction of more than one master program in the MENA region. This can be justified by the fact that in spite of the number of universities surveyed in the MENA region is more than double those surveyed in Europe, Europe is offering more than 8 times as much programs as those offered in the MENA countries. Fig. 5 magnifies this dilemma as it shows that the ECTS of programs offered in Europe are in average double that offered in MENA countries. This can be explained by the fact that master's studies in the MENA region are studied on a part time basis rather than a full time scheme. The analysis also showed that similar programs in the region lack covering wave and tidal energy courses. Fig. 6 depicts the weight percent of each subject area among others within the programs covered by this survey. The analysis showed that an integral low-emission power plant module was not applied in the surveyed programs. Moreover, tidal and wave energy courses were not tackled by similar programs in the MENA region. Hence, the intended CERES master's program should cover such topics while being designed.

6. Discussion

Since today's perspective of energy has evolved with many technologies, it is wise when designing new energy programs to use the industry evolved and the international environmental constraints stated nationally and internationally including:

i) The synergistic integration of the required multidisciplinary engineering subjects.
ii) Intelligent control adopted in the energy field.
iii) The environment criteria topics into a unified framework that enhances the energy program.

When designing a program, the specific objectives of the energy degree are generally focused to provide engineering graduates who:

a) Understand the interdisciplinary fundamentals of mechanical engineering, electrical engineering, control systems, environmental engineering, and their integration.
b) Have strong knowledge of energy resources, energy systems, energy efficiency, and sustainable development relevant to the energy field.
c) Have team skills to solve complex problems that cross disciplinary boundaries.
d) Perform research, design, and implementation of intelligent energy efficient systems based on different engineering technologies.

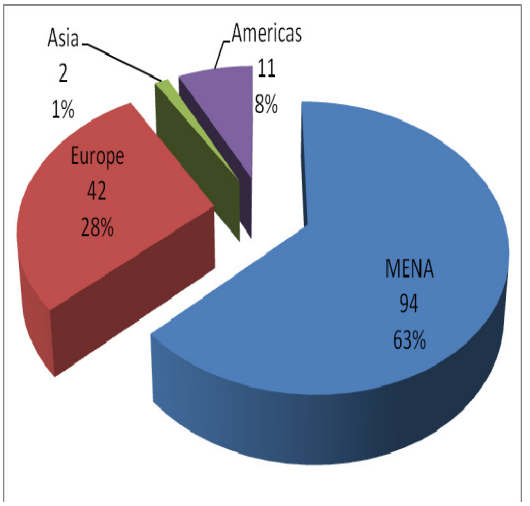

Fig. 3 Number of universities covered by the study grouped by region.

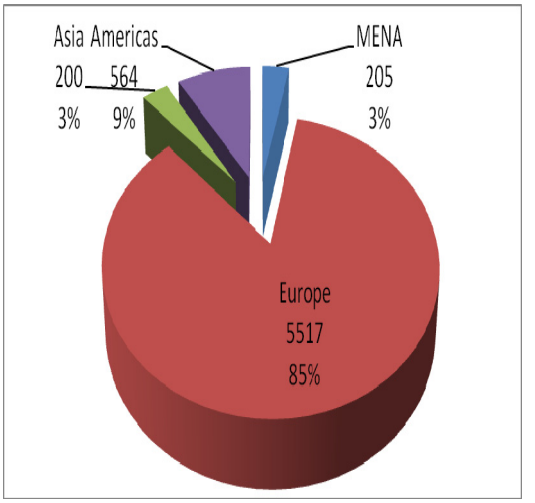

Fig. 5 Regional distribution of ECTS investigated by this study.

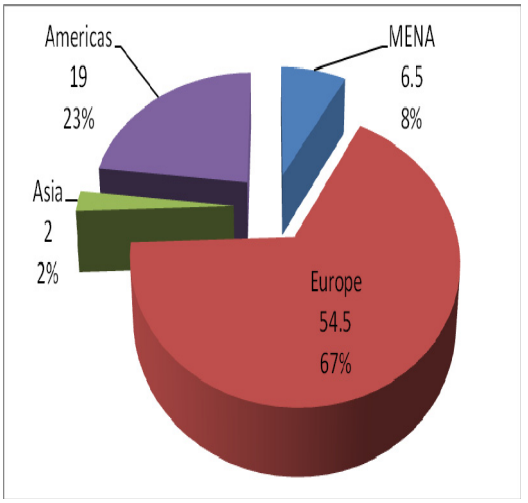

Fig. 4 Regional distribution of master's programs targeted by this study.

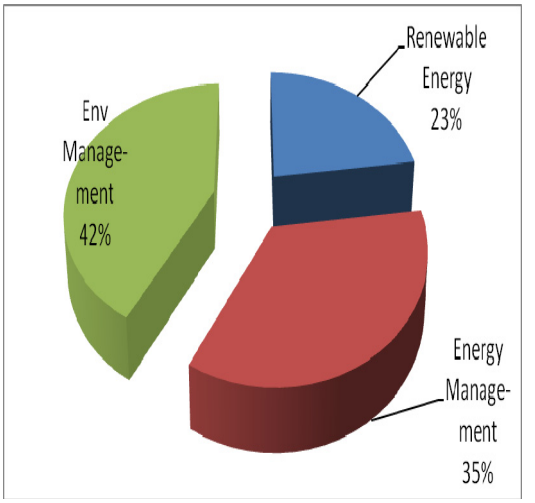

Fig. 6 Subject area percentages covered by the study

The survey confirms that there is no integral approach of a single Master Energy Program is provided at the universities of East of MENA. Only a few courses about solar energy are available for undergraduate studies. Also no courses covering the wave and tidal energy subjects are covered. Diploma and training studies in the different fields of environment management, renewable energy sources and low emission power plants are of limited spread at the universities of East of MENA. The other master's programs delivered in Algeria, three programs surveyed, are more devoted to science in ecology and environment and not effectively in energy engineering. Despite that there are large number of governmental

universities in Tunisia and Libya; none of these universities offer any master's programs for energy from the engineering perspective.

The current energy engineering master's program offered by Cairo University in collaboration with Kassel, Germany, is very modern, and very competitive to any other program offered elsewhere. The program is based on Bologna process and the standard ECTS modules scheme. The program has two compulsory modules, elective modules, and thesis module. Some of these modules are taught in Cairo, and others are taught in Kassel. This program is ideal and should be considered very well in marketing our program.

Master's degree studies in the field of environmental management and renewable energy resources are wide spread at the Universities of Central and Eastern Europe. Majority of these courses are provided in English most probably in order to be available for International academic exchange and studies. In the available internet information, issues concerning Renewable Energy Sources (RES) are mainly included as subjects in the curricula of Environmental Protection and Management. There are no Master courses that put together RES and Environmental subjects in the context of the environmental impact of RES.

Duration of courses in this survey varied from three to four semesters (more often 3) ranging from 90 to 120 ECTS credits. In general, the program credits designed and decided as required from higher education council or market demands [11]. No doubt that the Energy Engineering field is gaining much attention nowadays in many practical applications, but the capacity of the qualified energy engineers in the region is not fulfilling the requirements needed for industry. The survey confirms that the only Master Energy Program that is relatively in the field of energy in North West African Countries is: “The Master of Science in Sustainable Energy Management” offered by Morocco. It is not, however, an engineering energy program but it is rather science oriented educational courses and does not touch the typical engineering and technology of the energy programs spectrum.

7. Recommendations

The consortium agreed to divide the master's program into three subject areas; namely: Renewable energy resources, Low-emission combustion technologies and Environmental Management. A common semester for all fresh-enrolled students is expected. After the elapse of the first semester, students are entitled to choose one of the above subject areas. Table 1 lists the courses expected to be offered on each subject area.

8. Conclusions

A Master Degree course emphasizing on RES will be very useful. The proposed graduate program should include also courses concerning the tidal and wave energy resources which appeared to be overlooked by other equivalent programs offered in the MENA region. Environmental issues should be related to sustainability, efficiency and environmental impact of these energy sources. For a successful Master Energy Program, the consortium of the project should interlink the program with industry and direct the research topics to typical cases of industrial development in the region. Optimal duration of the course is 4 semesters (including the Diploma thesis) with 120 ECTS for obtaining the degree. A good professional training scheme should accompany our Master Energy program for continuous development and improvement of the target program.

Table 1 Courses to be offered on each subject area

Renewable Energy Resources	Environmental Management	Low emission combustion tech.
• Basics of Renewable Energy • Thermal Solar Power systems design • Photovoltaics I & II • Aerodynamic and mechanical design of wind turbines • Fluid Mechanics and conversion systems (wave & tidal energy) • Geothermal energy applications in cooling and heating systems • Wind power technology and development • Meteorology for wind power • Solar irradiation and energy data modeling • Meteorology for solar energy • Solar desalination technologies	• Basics of water quality control • Basics of Air quality control • Environmental Impact Assessment • Pollutant formation and air quality control • Chemistry and biology for environmental engineers • Measurement of air pollutant • Firing systems and flue gas treatment • Mechanical and biological waste • Design of thermal waste treatment plants • Industrial waste water • Disposal methods in industrial processes • Air quality management • Global atmospheric chemistry • Life cycle assessment • Advanced air noise and control	• Emission management and control • Power plants, combustion and emissions • Firing systems and flue gas treatment • Biomass as an alternative fuel • Carbon capture and storage • Internal combustion engines pollution control • Computational fluid dynamics • Control of power plants and distribution grids I • Control of power plants and distribution grids II • Steam generation • Engine combustion and emissions • Transport phenomena • Advanced zero emission power plant design • Magnetohydrodynamic power generation

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