Renewable Energy Education for Engineering Freshman Students

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ABSTRACT— ***The importance of renewable energy has been increasingly recognized. This paper discusses the significance of offering a renewable energy course in the undergraduate freshman level. It is proposed to adopt the inquiry-based concept in the offered course, where students seek knowledge, rather than been delivered to them. Surveys are provided to three groups of students; one group of graduate students who completed a course on renewable energy and two groups were of undergraduate students, one who have taken a course on renewable energy and the other did not. The objective of the survey is to assess the participants' opinion on the importance of having a course on renewable energy in the undergraduate engineering curriculum. The different questions in the survey were modeled to challenge the attitude towards renewable energy sources and the knowledge of renewable energy system and sustainable development. This is important to identify and reveal the attitude toward acceptance of renewable energy system. The results of the survey clearly show that most participants believe that renewable energy course and/or related activities should be included. It is also found that most participants thought that solar energy is the most suitable for UAE and will be a major source of income by 2020.***

Keywords— Renewable energy; freshman year; graduation projects; career prospectus

1. INTRODUCTION

Renewable energy (RE) is the energy that comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable and naturally replenished. In the last decade, RE sources have gained considerable attention by the academia, industry and policy making organizations. This interest has been driven by environmental reasons, such as greenhouse abatement and ozone layer protection and economic and strategic ones, such as the limited fossil fuel and its increasing price. The global warming is strongly related to the vast consumption of fossil fuels which contribute to the emission of greenhouse gases. New policies are now in place in many countries to encourage the use of renewable energy sources such as solar, wind, tidal waves, geothermal, and biofuels. Climate change concerns, coupled with high oil prices, and increasing government support, are driving increasing RE legislation, incentives and commercialization [1].

Large investments in alternative energy sources are expected to change the UAE's energy mix in the coming years. Abu Dhabi's Economic Vision - 2030 aims at generating 7 % of Abu Dhabi energy requirements from renewable resources [2]. To achieve this objective many RE projects are currently going on in UAE, which are related to all engineering disciplines. The most significant project is the Masdar initiative, which is a multi-billion dollar investment in renewable and alternative energy and clean technology. The main objective of this initiative is to explore, develop and commercialize RE sources. In Dubai, the Mohammed bin Rashid Al-Maktoum Solar Park was established in early 2012 as part of a strategy to diversify Dubai's energy sources so that 1% of its power will be from renewable sources by 2020 and 5% by 2030. The Solar Park led by the Dubai Electricity and Water Authority (DEWA) aims at installing 1000 MW of solar power by 2030. Shams 1 is another initiative by Masdar, Abu Dhabi to generate 100 MW of solar power by early 2013 using solar concentration. Shams 1 power plant will be the largest in the world and spans on area of 2.5 square kilometer, enough to power 20 thousands homes. Another PV solar project announced last year by Masdar called

NOOR1 with a planned capacity of 100 MW. The new PV power plant, which uses PV solar cells to convert sunlight directly into electricity, will be located in Al-Ain city in Abu Dhabi Emirate and expected to be ready for power generation by end of this year.

In parallel to these efforts, the UAE utility companies are running energy saving campaigns to raise awareness among consumers of the consequences of prodigal energy consumption on global warming. UAE has also initiated The Estidama program. Estidama, which is the Arabic word for sustainability, is an initiative aimed to develop and promote development of sustainable communities and buildings to improve quality of life. The initiative encourages water, energy and waste minimization, local material use and aims to comply as much as possible with the green building codes.

Because of this overwhelming attention to RE, almost all high school and new college students have heard the term "renewable energy" and other terms such as "green energy", "alternative energy resources" in one form or another. This huge investment in RE means jobs for new graduates. However, in most UAE universities, many students are not introduced to RE basics until their senior year projects. This makes the students waste significant amount of their graduate projects time learning the basics rather than working on the actual project. Other students, due to lack of basic information, may choose not to work on a project related to RE, even though it has market interest and of importance to the environment.

Renewable energy education at undergraduate level is a relatively new field in general education. Although there are many studies conducted in this field worldwide [3-8], however most of these studies focus on the theoretical aspect and have little emphasis on practical and inquiry based education.

In this paper, the implementation and basic material for an inquiry-based college freshman course on RE is presented. Inquiry implies involvement that leads to understanding, and therefore, the philosophy of this inquiry based course is to get the students involved through exploring the importance of energy and its applications by raising questions [9]. In such a course, the students seek the knowledge by questioning and exploring while instructors play the role of facilitator versus traditional teaching techniques. It is very much believed that learning in best described by the following famous statement: "Tell me and I forget, show me and I remember, involve me and I understand". The last part of this statement is the essence of inquiry-based learning.

2. INTRODUCING RE AT FRESHMAN LEVEL

The course is proposed to be taken by students in their first year of their tertiary education, i.e., freshman year. The introduction at freshman year is suitable because education at high school level meets the prerequisite knowledge required for students to understand the basic concepts of RE. In addition, introducing engineering students, at an early stage, to the concepts and applications of RE have several advantages, which include and not limited to:

a. Better prepare students to modern technology needs.

b. Enhance students' awareness to environmental issues.

c. Assist students to choose their discipline along current market needs.

d. Provide basic knowledge that would allow students to work on RE projects in advanced years.

3. IMPLEMENTATION

The course is planned to be an interdisciplinary in nature and will involve instructors from different disciplines. The course will cover the following RE fields

3.1 Biofuels

Biofuels, derived from biomass conversion, are gaining increased public and scientific attention, due to the increases in petroleum oil prices and the concern over greenhouse gas emissions from fossil fuels [10]. There are many types of biofuels; however, the course will concentrate on one type, which is biodiesel. This type of biofuels has seen most of the attention in the recent years in the UAE. A project on mass production of algae-based biofuels in Dubai has begun in 2012 [11].

In the proposed freshman course, students are asked to make simple experiment to produce biodiesel from vegetable oil. The students will use simple experimental setup and lab glassware to examine the effect of different parameters such as reactants concentrations and catalysts on the production of biodiesel. They will also see the effect of the process on reducing the viscosity of the raw material.

3.2 Solar

Solar energy technologies include solar heating, solar photovoltaics (PV), solar thermal electricity and solar architecture, which can make considerable contributions to solving some of the most urgent problems the world now faces [12].

In the proposed course, students are asked to use basic experiments on solar arrays using basic measurement equipment that is typically available in high school or freshman university labs. Students will be using voltmeters and ammeters to measure basic Photovoltaic I-V characteristic. electrical load (e.g., lamps) is interfaced with PV panels. How many lamps can be turned on and what is the wattage. They will, through experiment's observation, figure out the limitations and capabilities of solar power. In addition, students are asked to do the same experiments in open space to understand the effect of temperature on the PV capability

3.3 Wind

Wind energy has been utilized for centuries to pump water. In the US, power generated from wind is expected to exceed 15% by 2015. Even though UAE does not have a lot of wind power, specific places like coastal areas (Abu-Dhabi) and northern emirates have the capability to produce power from wind [13].

In the proposed course, students will be asked to research history of wind power and how it can be used in UAE environment. For a typical day in the Emirates, students will be asked to experimentally approximate power that can be generated from wind and come up with applications for it. In addition, students will be assigned to map wind speed throughout the UAE using historical data from local weather stations.

3.4 Fuel Cell

Fuel cell technology provides electrical energy through series of chemical reactions. Low power Proton exchange membrane fuel cells (PEM FC) are made available to students to explore the voltage current characteristics of fuel cell. Also, students are expected to evaluate the fuel cell output power as function of load and temperature in a similar manner to the PV experiments.

4. NATURE OF THE COURSE

As mentioned earlier, engineering students register for this course at their freshman year. The duration of the course is fourteen weeks and will be self centered, projects based in nature. At early stage of the course, the students will explore basic principles of the different RE sources mentioned in Section 3, through a set of experiments. Midway through the semester, the class will be divided into groups of three-to-four students. Each group will design and assemble a lab-scale prototype on one (or more) RE source for an application. Each group will have to prepare a poster and submit a report on their respective projects. All projects will be presented in a competition day, where a judging panel will evaluate the projects and prizes will be awarded to the top three winners.

5. ASSESSMENT PROCEDURE

The significance of taking an undergraduate course on RE is assessed using surveys given to three groups of students at the Heriot-Watt University, Dubai Campus. One group of graduate students who completed or undertaking a course on RE and two groups are of undergraduate students, one who has already taken a course on RE and the other did not. The different questions in the survey were modeled to challenge the attitude towards renewable energy sources and the knowledge of RES and sustainable development. This is important to identify and relate the attitude toward acceptance of renewable energy system. The questions in the surveys are divided into two categories; the undergraduate course and the RE concept. Tables 1 and 2 show samples of the surveys given to undergraduate students and the graduate groups.

Table 1: Undergraduate student survey

A) The undergraduate course

1. A Renewable Energy course should be made compulsory in the undergraduate curriculum
   a) Strongly agree b) Agree c) Partially agree d) Disagree

2. Undergraduate students who completed a course on Renewable Energy fully understand the general concept of Renewable Energy
   a) Strongly agree b) Agree c) Partially agree d) Disagree

3. Taking an undergraduate course on Renewable Energy is useful for undergraduate project work.
   a) Strongly agree b) Agree c) Partially agree d) Disagree

4. The knowledge about Renewable Energy motivates students to learn more about the topic
   a) Strongly agree b) Agree c) Partially agree d) Disagree

5. Various activities on Renewable Energy applications, such as awareness campaigns, symposiums,… etc, should be included in the undergraduate curriculum.
   a) Strongly agree b) Agree c) Partially agree d) Disagree

B) Renewable Energy concept

6. Reducing the dependency on non-Renewable Energy sources is a good idea.
   a) Strongly agree b) Agree c) Partially agree d) Disagree

7. Industries based on Renewable Energy are booming and will be a major income source by 2020
   a) Strongly agree b) Agree c) Partially agree d) Disagree

8. The type of Renewable Energy that will see the largest applications in the near future:
   a) Wind b) Solar c) Biomass d) Geothermal

9. The most suitable type of Renewable Energy for UAE:
   a) Wind b) Solar c) Biomass d) Geothermal

10. Are you aware of disadvantages of using various Renewable Energy technologies?
    a) Yes b) No

Table 2: Graduate student survey

A) The undergraduate course

1. A Renewable Energy course should be made compulsory in the undergraduate curriculum
   a) Strongly agree b) Agree c) Partially agree d) Disagree e)
2. Undergraduate students who completed a course on Renewable Energy fully understand the general concept of Renewable Energy
   a) Strongly agree b) Agree c) Partially agree d) Disagree
3. Students who took an undergraduate course in Renewable Energy are more likely to end up working, or perusing a postgraduate study, in a field related to this topic
   a) Strongly agree b) Agree c) Partially agree d) Disagree
4. Taking a course in Renewable Energy is an added advantage in job finding
   a) Strongly agree b) Agree c) Partially agree d) Disagree
5. Taking an undergraduate course in Renewable Energy allows graduates to develop new ideas related to the topic
   a) Strongly agree b) Agree c) Partially agree d) Disagree

B) Renewable Energy concept

6. Reducing the dependency on non-Renewable Energy sources is a good idea.
   a) Strongly agree b) Agree c) Partially agree d) Disagree
7. Industries based on Renewable Energy are booming and will be a major income source by 2020
   a) Strongly agree b) Agree c) Partially agree d) Disagree
8. The type of Renewable Energy that will see the largest applications in the near future:
   a) Wind b) Solar c) Biomass d) Geothermal
9. The most suitable type of Renewable Energy for UAE:
   a) Wind b) Solar c) Biomass d) Geothermal
10. Are you aware of disadvantages of using various Renewable Energy technologies?
    a) Yes b) No

6. RESULTS AND DISCUSSION

A total number of 44 undergraduate students have participated in the survey; 8 of which took a course on RE and 36 did not. In addition, 43 graduates who took the course have also participated in this survey. The survey was conducted in November 2013. The results are presented and evaluated in terms of students' attitude towards RES and students' concept knowledge of RES and sustainable development

6.1 Students' attitude towards RES

6.1.1 Should a RE course be made compulsory in the undergraduate engineering curriculum?

As shown in Fig. 1, the undergraduate students who took a course on RE (UG1) unanimously found that the course should be made compulsory, with 50% strongly agree. Similar result was also found by the undergraduate students who did not take the course (UG2). However, the percentage of students strongly agrees dropped to 42%, with the rest 8% partially agreed. Surprisingly, 7% of the graduate students (PG) did not think that a course on RE should be included in the undergraduate engineering curriculum. This could be explained by the MSc Energy RE programme they are currently undertaking which assumes students have little RE background. Having said so, still 72% of the graduate students agreed on the inclusion of this course.

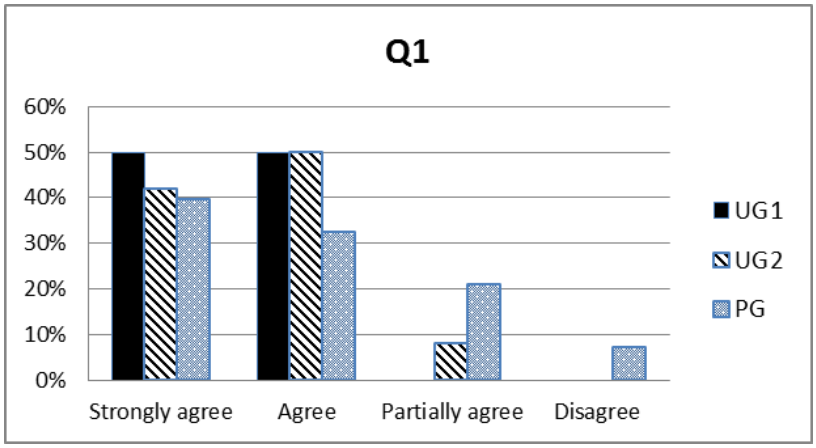

Figure 1: Students responses of Q1 (Should a RE course be made compulsory in the undergraduate engineering curriculum?)

6.1.2 Undergraduate students who completed a course on RE fully understand the general concept of RE

Figure 2 shows the results of the second question given to the undergraduate and postgraduate groups. Majority of the participants agreed that taking a course on RE have actually enhanced their understanding of the concept. None of the undergraduate students who took the course disagreed, and only 6% and 2% of the undergraduate students who did not take the course and postgraduates, respectively, believed that taking the course would not enhance their understanding of the RE concept. Having said so, still majority of the participants believed that taking the course had a positive effect on their understanding of the concept.

6.1.3 Importance of taking a RE course on motivating student to learn more about the RES and its effect on undergraduate project selection and job interest

The student's responses to question 3 to 5 for UG1 and UG2 are presented in in Fig 3 and Fig 4 respectively. In response to question 3, the students who took a course on RE unanimously found that the course was useful, with 37% strongly agree. Majority of the students who did not take the course also agreed on that with 17% strongly agreed and only 3% of them did not agree. The results of Q4 presented in Figures 3 and 4 for both UG1 and UG2 show that 75% of the students who took the course agreed that a knowledge about RE motivates them to learn more, with 25% strongly agree. A larger percentage 89% of the students who did not take the course also agreed on that with 39% strongly agreed.

The results of Q5 given only to the undergraduate groups show that 75% of the students who took the course agreed on the idea that various activities on RE, such as workshops, seminar and labs, should be included in the undergraduate curriculum, with 50% strongly agree. Almost the same percentage 78% of the students who did not take the course also agreed on that with 39% strongly agreed. However, in the group of students who did not take the course 5% disagreed, which was not witnessed in the group that took the course.

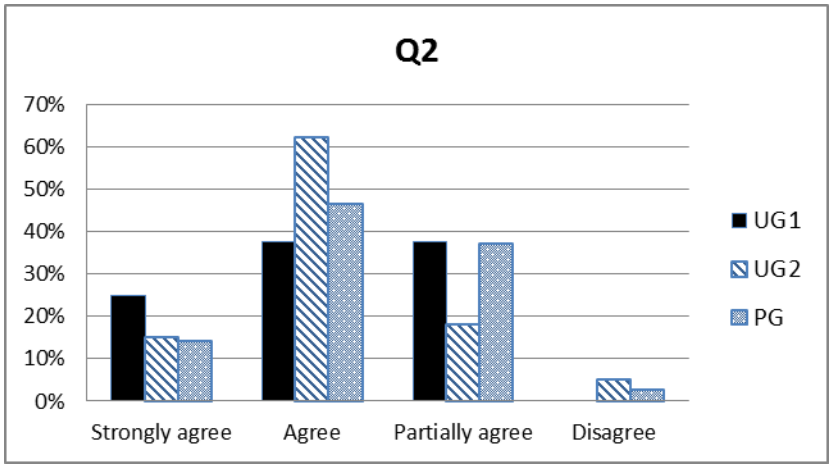

Figure 2: Students responses of Q2 (Undergraduate students who completed a course on RE fully understand the general concept of RE)

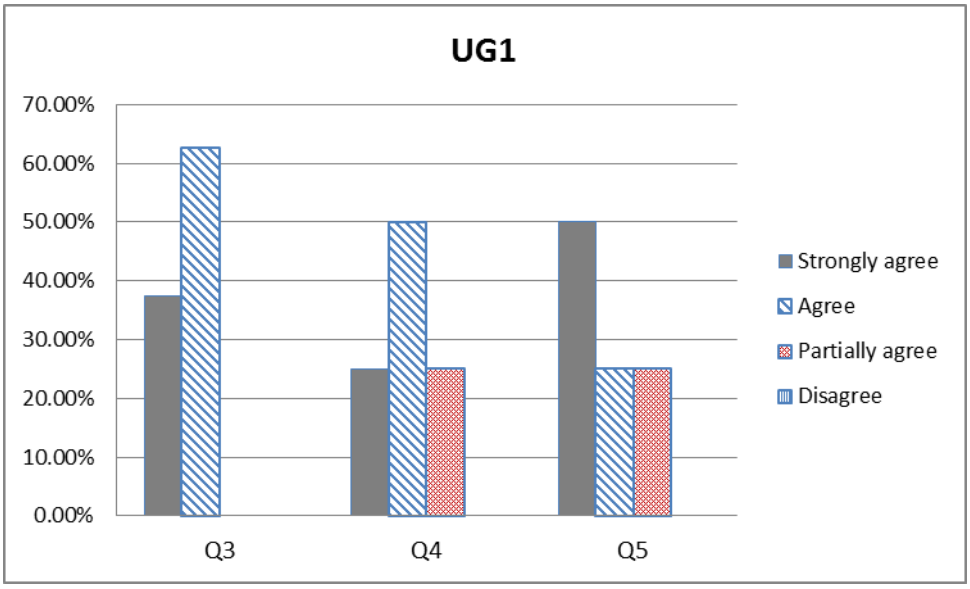

Figure 3: UG1 students group responses to Q3 - Q5.

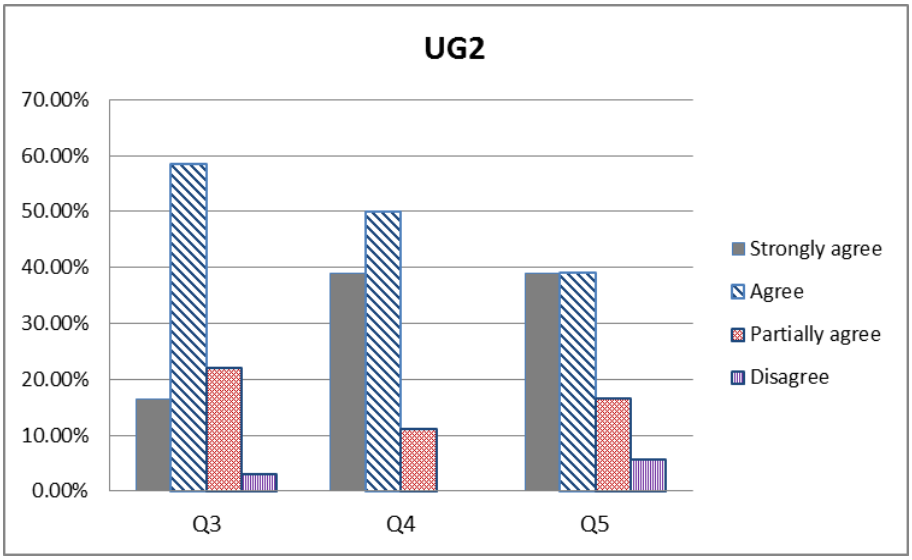

Figure 4: UG2 students group responses to Q3 - Q5.

Figure 5 shows the results of the question 3 to 5 given only to the graduate group. In response to Q3 74% of the participants agreed that taking a course on RE made them work or pursue a postgraduate study in RE, with 16% strongly agreed. 5% of the participants did not see the course they have taken in RE affecting their future career. The results of Q4 presented in Figure 5 show that 70% of the participants agreed that the course on RE added advantage in job finding, with 28% strongly agreed. 7% of the participants found that taking this course in the undergraduate level did not add advantage in job finding.

In graduate students responses to Q5, 91% of the participants agreed on the idea that an undergraduate course on RE allows graduates to develop new ideas on the topic, with 33% strongly agreed. Only 2% of the participants did not believe that the course may allow students to develop new ideas on RE.

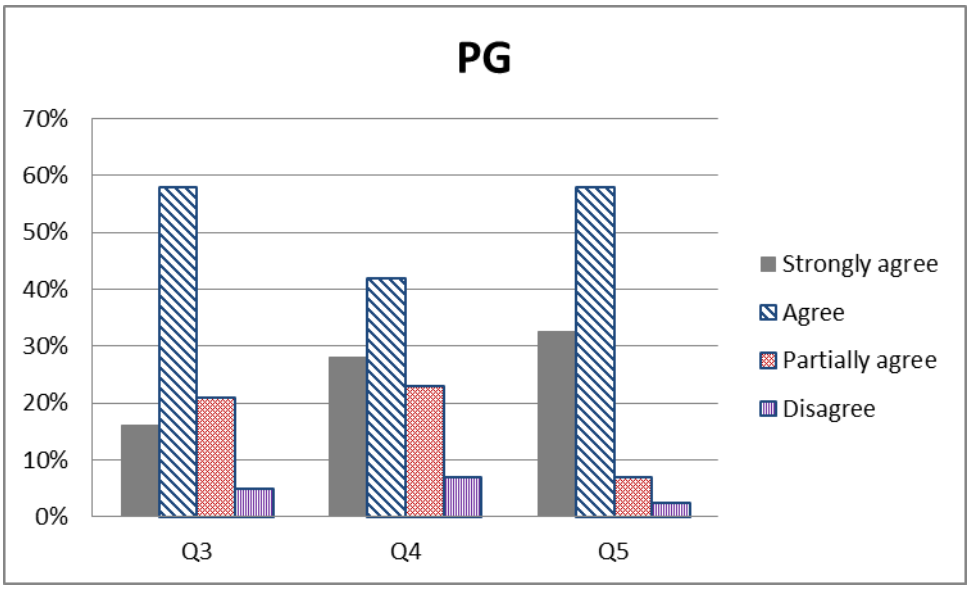

Figure 5: PG students group responses to Q3 - Q5.

6.2 Students' concept knowledge of RES and sustainable development

6.2.1 Reducing the dependency on non-Renewable Energy sources is a good idea

Figure 6 shows the results of the first question in the RE concept given to the undergraduate and postgraduate groups. Majority of the participants agreed that it is a good idea to reduce the dependency on non-renewable energy sources. None of the undergraduate students who took the course disagreed, and only 3% and 5% of the undergraduate students who did not take the course and postgraduates, respectively, believed that we should still keep the dependency on non-renewable energy sources.

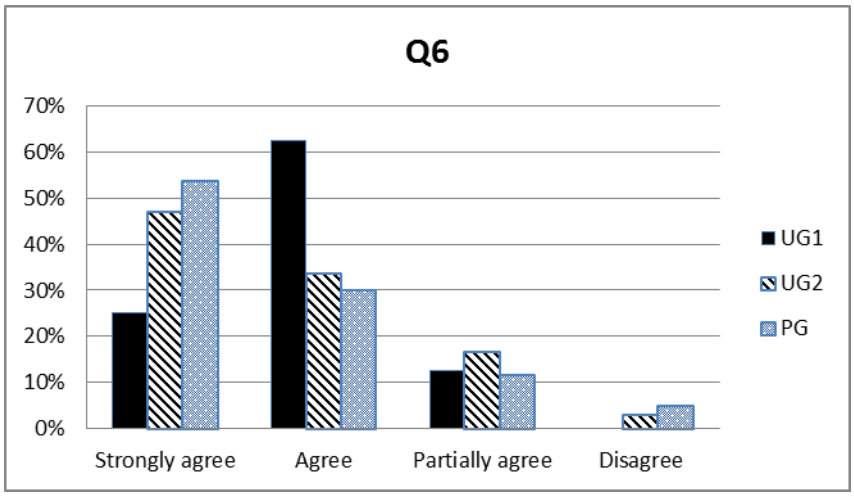

Figure 6: Reducing the dependency on non-Renewable Energy sources is a good idea

6.2.2 Industries based on RE are booming and will be a major income source by 2020

Figure 7 shows the results of the second question in the RE concept given to the undergraduate and postgraduate groups. Majority of the participants agreed that industries based on RE are booming and will be a major source of income by 2020. The undergraduate students who took the course unanimously agreed with impressive 62% strongly agreed. None of the undergraduate students, who did not take the course, and only 5% of the graduates did not believe that RE industries are booming.

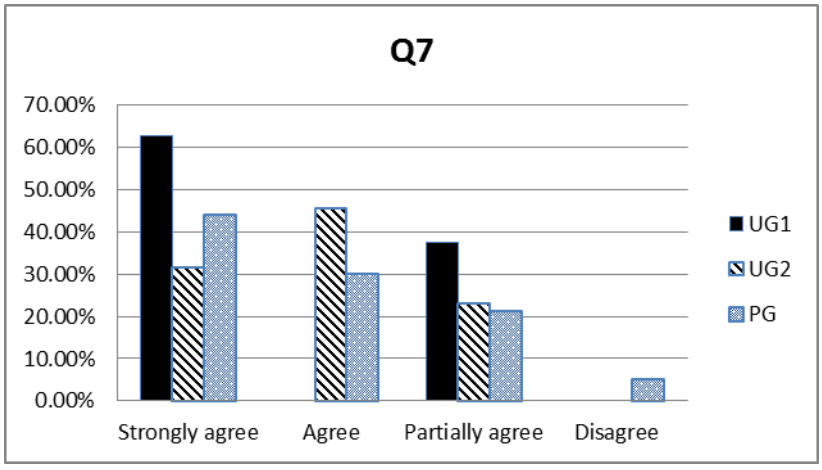

Figure 7: Industries based on RE are booming and will be a major income source by 2020

6.2.3 The type of RE that will see the largest applications in the near future

Figure 8 shows the results of the third question in the RE concept given to the undergraduate and postgraduate groups. Majority of the participants thought that solar energy will see the largest applications in the near future. 88%, 78% and 74% of the undergraduate students who took the course, the undergraduate who did not take it and graduates, respectively have chosen solar energy. The undergraduate who took the course found that the second RE will be wind, with biomass and geothermal not seeing any future in their opinion. The undergraduate who did not take the course found that the second RE will be biomass (14%) followed by wind (5%) then geothermal (3%). Similar order was also seen in the results of the graduates, with 14% have chosen biomass, followed by wind (10%) then geothermal (2%).

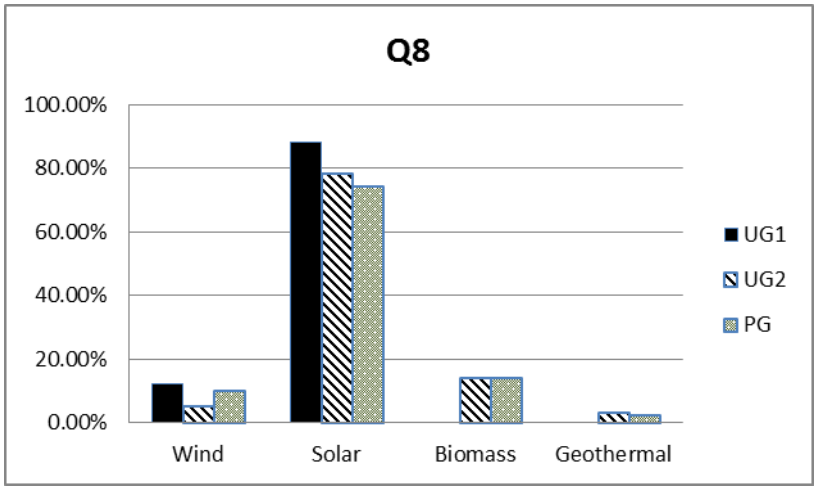

Figure 8: The type of RE that will see the largest applications in the near future

6.2.4 The most suitable type of RE for UAE

Figure 9 shows the results of the fourth question in the RE concept given to the undergraduate and postgraduate groups. Similar to the previous question, majority of the participants thought that solar energy is the most suitable RE for UAE. 100%, 81% and 86% of the undergraduate students who took the course, the undergraduate who did not take it and graduates, respectively have chosen the solar energy as the most suitable. None of the undergraduate students who took the course have chosen any other source of RE beside solar. The undergraduate who did not take the course found that the second RE is both wind and geothermal (7%) followed by biomass (5%). The graduates on the other hand thought that biomass is the second most suitable (12%), followed by geothermal (2%). None of them however, thought that wind is suitable for UAE.

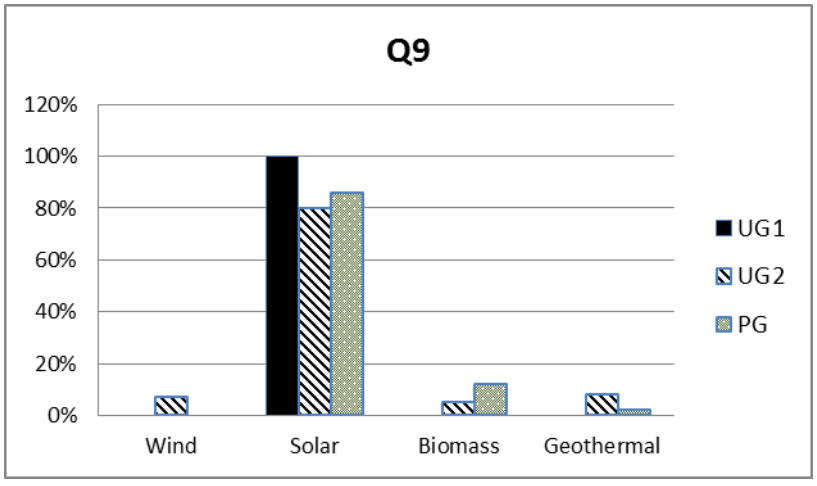

Figure 9: The most suitable type of Renewable Energy for UAE

6.2.5 Are you aware of disadvantages of using various RE technologies?

Figure 10 shows the results of the fifth question in the RE concept given to the undergraduate and postgraduate groups. The effect on taking the course in RE is evident in the results, where 74% and 74% of the undergraduate and graduate students, respectively, have mentioned that they are aware of the disadvantages of RE. Whereas, 69% of the undergraduate students who did not take a course in RE clarified that they do not know.

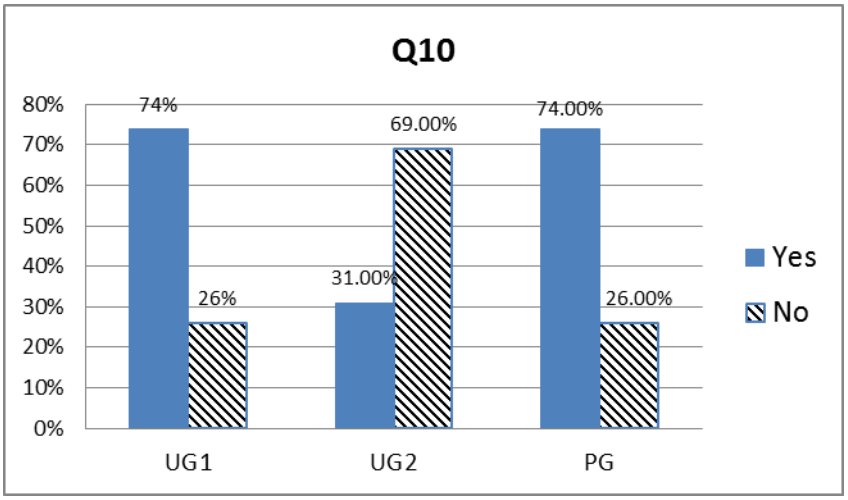

Figure 10: Results of students' awareness of disadvantages of using various RE Technologies

7. CONCLUSION

Most of the engineering graduates in the UAE are not trained to use renewable energy technologies and most are not aware of the principles of sustainability. Therefore there is an urgent need to develop and implement new courses that prepare engineers to work with renewables to produce sustainable energy generation systems.

Introducing such a renewable energy course in the undergraduate level and possibly starting the awareness in the secondary school should also be in the agenda of decision makers in UAE to make it possible to achieve their targeted renewable energy mix. This is will contribute favorably to produce the required expertise and personal to accomplish and maintain the renewable energy projects at the long run.

In this paper, the significance of offering a RE course, for undergraduate engineering students in their freshman year, has been evaluated for UAE market. The evaluation has been made through designed survey questions which examine students' attitude towards renewable energy sources and the knowledge of renewable energy system for three different groups of students. It has been found that such a RE course is of genuine interest for the UAE student community. Basic components of this inquiry-based course have been discussed in the paper.

It is expected that the adoption of the proposed RE course will favorably contribute to meet the renewable energy generations targets of UAE and successfully implement the RE projects, various education programs should meet the needs for qualified personnel to implement and maintain these projects. The introduction of an enquiry based renewable energy course, for engineering freshman students, plays a role in providing basic knowledge, and motivation to work, on RE projects in advanced years and hence lead to producing trained and qualified technical personnel. Conversely, the lack of qualified personnel may compromise the quality of the RE systems and unfavorably affect the demand for renewables.

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