The necessity of teaching renewable energy (RE) at engineering schools

Yuni Rahmawati, Ahmad Sonhadji, R. Machmud Sugandi & Arif N. Afandi

State University of Malang
Malang, Indonesia

ABSTRACT: The energy crisis has forced a search for renewable resources. As a consequence, the number of workers in renewable energy is increasing. However, engineering schools have not responded to the increased demand. The aim of this research was to explore the teaching of renewable energy (RE) at school. A pre-test survey was conducted for students, while information from school management and industry was collected through interviews. The results showed that it is necessary to teach RE in engineering schools. One integrated model also has been proposed, to reveal the use of various media in RE education.

INTRODUCTION

Energy is most important in modern society affecting all sectors by providing a source of power for households and workplaces, as well as for transportation and communication systems. Hence, it is necessary to consider how to preserve available energy, while providing sufficient energy for all sectors of society [1]. According to data from the Indonesian Ministry of Energy and Mineral Resources (ESDM), in 2015 Indonesia's oil reserves were only about 3.7 billion barrels [2]. Continuous use of petroleum without improved oil recovery will result in Indonesia's oil reserves being depleted by 2035 [3][4]. Therefore, there is an incentive for the country to develop renewable energy (RE) in order to fulfil the national energy needs [5-7].

An increase in the use of renewable energy, such as solar, wind, micro-hydro, geothermal and biofuel, fosters a reduction in the use of fossil fuels, such as coal, petroleum and natural gas. Accordingly, future generations may be less threatened by climate change [8]. As the fossil industry declines, renewable energy would create more employment. According to a recent report from the International Renewable Agency (IRENA) *Renewable Energy and Jobs - Annual Review 2016*, the renewable energy industry employed 8.1 million in 2015, an increase of 1.3 million jobs since 2014 [9]. The details are shown in Figure 1.

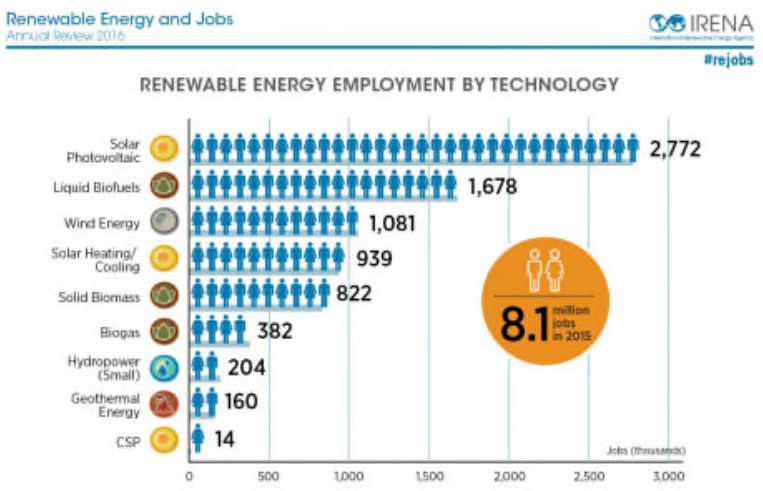

Figure 1: The number of workers in the renewable energy sector, 2016 [9].

There is both a new problem and an opportunity of how to supply labour for the renewable energy field. Thus, it is very important for educational institutions to take an active role in the provision of this workforce, both in terms of quality and quantity. By contrast, the number of unemployed engineering school graduates in Indonesia has increased, from 1,188,397 in 2010 to 1,332,521 in 2014 [10]. Year to year, the percentage of unemployed vocational graduates has increased, with a significant tendency for engineering school graduates to be unemployed.

Given the RE labour demand juxtaposed with the increasing number of unemployed vocational graduates in Indonesia, it seems appropriate to promote the teaching of RE in engineering school to serve as a supplier of qualified labour to industry and government. The aim of the research reported in this article was to produce a model programme to include renewable energy education in the engineering curriculum. Activities covered would include field lectures and the renewable energy business.

Renewable energy education should be most interesting for educators of engineering and science. The author emphasises the use of solar energy in Indonesia since geographically Indonesia is located close to the equator. The intensity of solar radiance in Indonesia is high at about 4.5 kWh/m^2 each day across Indonesia. This means that a 1 kW photovoltaic (PV) panel could generate 4.5 kWh of electricity each day. Thus, the abundance of solar energy in Indonesia suggests its use as an alternative power source [8].

METHOD

The research carried out was in two stages: a literature search (exploring the literature and previous research), and a field study. The literature search included the review of theories and concepts related to renewable energy education in engineering schools. The results of the literature search were used to support the field study. For the field study, documentation and observations were used to determine the requirements for including renewable energy education in an engineering school's curriculum.

Field study observations included focus group discussions with teachers in Malang, Indonesia. These examined schools' readiness to implement renewable energy learning, and teachers' perceptions regarding renewable energy education. The documentation study was directed to finding out the completeness of renewable energy learning documents, and the availability of guidelines for the preparation of renewable energy learning plans.

To identify the current state of renewable energy knowledge among vocational high school (VHS) students a pre-test survey was conducted. This consisted of two tests covering solar energy and energy awareness, given to 167 VHS students. The solar energy pre-test consisted of 20 items covering solar energy generation, solar energy generation components, installation and maintenance. The energy awareness pre-test was a questionnaire with 10 items covering electricity sources, electricity consumption, electricity price regulation and the results of wasting electricity.

RESULTS AND DISCUSSION

In the literature search, there were numerous references explaining how to incorporate RE learning into education by integrating renewable energy into the curricula. The curriculum should include renewable energy systems, electronics, the environmental and social impacts of power generation, power grids and integration of RE into the grid [1][11-14].

It is important that RE education is work-oriented notwithstanding that students will be used to conventional approaches to education. The resulting RE graduates should be adaptable to future environments and industries [5][15-17]. The results of this study indicate that project-based learning tends to be very effective in improving students' understanding of the practical implementation of RE in the community [18][19].

Interview Results

According to interview results from several engineering schools in Malang, the respondents mostly have not yet known of the presence and progress of the establishment of an engineering school with renewable energy engineering. Only one public school and one private school were aware of the opportunities provided by green energy. There were several obstacles to the establishment of a renewable energy engineering study programme. The results of interviews and survey of these two schools are summarised as follows:

- An electrical installation engineering programme in an engineering school has incorporated renewable energy into the learning material. The government syllabus only provides basic materials, such as basic electrical measurement and basic electromechanical work, as well as vocational materials, such as information installation, power installation, electric motor installation and control systems. There is sometimes a reference to RE, but without proper explanation.

- The form of learning only focuses on knowledge acquisition, which includes the delivery of material from the teacher and learning tasks, such as identifying solar cell images.

- The syllabus is limited to the introduction of renewable energy.

- The school interviewees opined that it would be helpful, if there was intensive learning of RE, given limited natural resources which eventually will be exhausted. Renewable energy education should eventually promote innovations in the field of electricity generation and the application of renewable energy. This, further, opens opportunities for engineering school graduates to meet the demand for a renewable energy workforce.

- Both schools considered there was a need for the establishment of an electrical installation engineering programme incorporated within renewable energy. There was a concern to strengthen the field of electric power installation. With the inclusion of renewable energy learning materials, students are expected to understand and to try to innovate in the use of renewable energy.

Current State of RE Education

The main obstacle to renewable energy learning is the lack of practicums. However, students can still follow the instruction regarding solar cell practice. As for other types of renewable energy, such as water, students must look for a micro hydro power plant. However, this is not always available.

The results of the pre-test on solar energy and energy awareness confirm that engineering school students' knowledge and understanding regarding RE is still insufficient. The average score obtained by students was 36.76 out of 100 for solar energy and 18.65 out of 100 for energy awareness. Students in the private school obtained 31.45 out of 100 for solar energy and 38.9 out of 100 for energy awareness. This clearly indicates that the current education requires additional and extended materials regarding RE and energy awareness.

The job opportunities in green energy should attract graduates of engineering schools that have improved the learning related to RE. The Directorate of Vocational Education, Indonesia, has made several attempts to prepare engineering school graduates in competing for green energy job opportunities. One of the newly established programmes, renewable energy engineering (TEBT), is divided into three: hydro energy engineering; solar energy engineering; and biomass energy engineering.

It takes much to implement a renewable energy engineering (TEBT) study programme. The more reluctant the engineering school in meeting the demands for a green workforce, the more there is a lack of opportunities for engineering schools in Indonesia to fulfil the demand for a green workforce.

There are many obstacles to the establishment of a renewable energy engineering (TEBT) study programme. Criteria that must be met by vocational education include adequate facilities and infrastructure [20]. The challenges for the current engineering school (see Figure 2) include the following:

- the number and quality of teachers;
- financial and infrastructure constraints;
- the concept of local excellence;
- changes in work patterns;
- technological developments;
- population growth;
- changes in the labour market;
- globalisation.

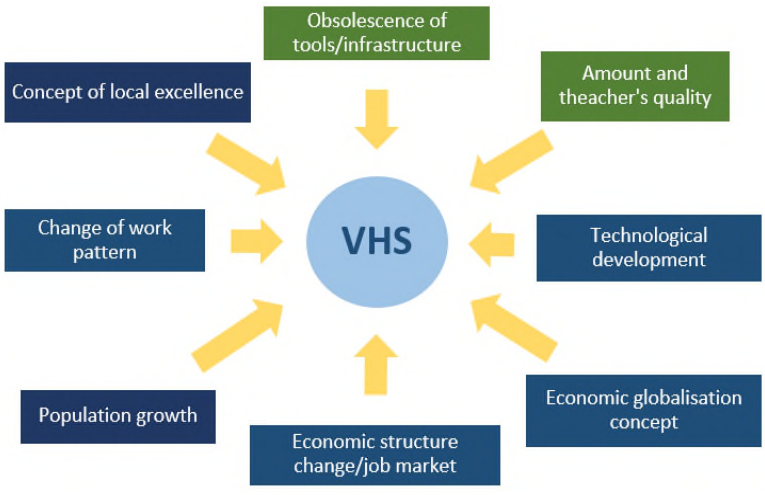

Figure 2: Challenges for engineering schools.

A Model for RE Education

Surveys of industry reveal many opportunities in RE. These include independent electrical energy generation to support people's lifestyles (telecommunications equipment, gadgets, etc), smart homes, smart devices and smart cities that are sustainable and energy efficient. These opportunities create the need for qualified engineering school graduates, who possess the knowledge to build, maintain and operate RE systems.

Renewable energy education should be developed. This model for renewable energy engineering includes energy awareness. Electricity installation was selected because this study can be related to an existing competency in electrical engineering. The model is shown in Figure 3. The notations X1, X2 and X3 are learning media, such as handouts, trainer and job sheets. The Y1 stands for RE engineering competency and Y2 is energy awareness.

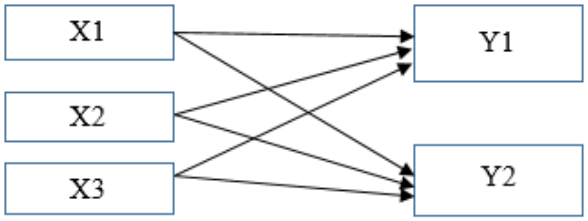

Figure 3: The relationship of research variables.

This model will underlie the development of new RE programmes in engineering schools to meet global energy demand for green energy. This model was implemented using learning software, learning modules and trainer material to improve competence in the field of renewable energy and energy awareness.

CONCLUSIONS

From the previous results and discussion, it can be concluded that there are problems in school and industry related to RE. Therefore, it is important to develop RE education programmes in engineering schools. Teaching RE using three different media is proposed. The use of those three could significantly improve the student's competence and awareness of RE.

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