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Implementation of renewable energy in education program at the State University of Jakarta

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Abstract. ***Due to serious air pollutants yielded from technology development in decades resulting remarkable climate change, it is the time to apply renewable energy for fuel production that is friendly environmental. Ongoing with this matter, there is a need to introduce a curriculum of renewable energy in education program to excel the skill of physics graduated students. Essentially, renewable energy education implicates various topics and issues related to renewable energy resources and technology as an object to be studied. The main objective of renewable energy education is to provide basic knowledge and understanding of facts, concepts, principles and technologies for harnessing renewable resources to produce energy. Based on that reason, the renewable energy education should be educative, informative, investigative and imaginative. Renewable energy such as solar, wind, micro-hydro or biomass energy is needed to be exposed in education program in order to make graduated student and researcher staff be able to master their knowledge on renewable energy for developing sustainable energy system. Therefore, this study has presented a new curriculum on renewable energy education in electrical engineering program in The State University of Jakarta. The case study applying solar and life cycle assessment is comprehensively discussed.***

Key words: **Renewable energy education, curriculum, field studies, project studies.**

I. INTRODUCTION

Renewable energy resources have become important in broad application because of heavy air pollutants resulting remarkable climate change, limited supply of fossil fuels and consequency of increasing oil cost. There are many renewable energy resources such as solar, wind, wave and micro-hydro energy. As earlier reported [1], the need and relevancy of imposing renewable energy education at all levels is globally recognized. During the last three decades many countries in the world have implemented renewable energy education in several higher institutions [2]. They involve renewable energy program in the curriculum of both engineering and applied science for teaching and training level, as well as for short course. In addition, some efforts have also been taken to introduce renewable energy program at preliminary stage in high schools. Even some other countries already implemented renewable energy education immediately after oil crises in1970s [3]. About two decades later, in the late 1990s some countries implicated renewable energy education in their academic programs ongoing with global climate concerns [4].

Since education is one of the most effective tasks to provide problem solving faced by societies, we are aware that renewable energy education is substantial pertaining to fundamental knowledge and understanding of facts, concepts, principles and technologies as the principal target of renewable energy education in most academic institutions. Renewable energy involving with topics and issues on its resources and technologies is needed to be implemented in education program as a curriculum in higher institutions and therefore, the renewable energy program should address to several factors, that is, educative, informative, investigative, and imaginative. In broader scale, renewable energy education should be exposed to entire population as its target audience and therefore, its planning should be integrated to the understanding of energy and environment relationship concerning with facts, concepts, units, activities, etc., in curriculum at different levels according to its importance [5]

In the last two decades, several academic institutions in developing countries have initiated some efforts to introduce knowledge of renewable energy resources and technologies, as well as courses on other relevant issues over than two thousand programmes. Most of these courses were presented at the university level either as independent postgraduate level on renewable energy technologies or as electives in both engineering and applied science. Some high schools have already exposed the concept of renewable energy in their curricula.

Objective of renewable energy education

The specific objectives of any desirable program of renewable energy education include:

i) To encourage serious awareness among students on cause and effect of current Energy crises.
ii) To make students understand various types of nonrenewable and renewable energy resources, potential resources, existing technologies related to both types of energy, economics aspect of that technologies, and socio culture, as well as its environmental condition.
(iii) To make students understand the consequences of various energy related to policy mitigations.
(iv) To enable students to suggest alternative strategies for solving energy crises and provide more energy for life quality improvement particularly in developing countries [6]

Regarding the target of renewable energy education, it is now almost globally accepted that the education on renewable energy resources and technologies should be provided
(i) at various levels in schools, colleges and universities.
(ii) For engineers so as to enable them to deal with needs and problems of relevant technologies.
(iii) For societies. [7]

II. RELEVANT CURRICULUM FOR RENEWABLE ENERGY EDUCATION

Any relevant programs within The Department of Electrical Engineering and the curriculum planning will be an essential step to reach the goal of renewable energy education. Thus, "electric" and "energy" programs, which are the major subjects of The Department of Electrical Engineering, should be structured equal and effective. In the context of this matter, renewable energy cource is established under The Department of Electrical Engineering, The State University of Jakarta. The structure of its curriculum is designed on the bases of "solar energy and its applications", "wind energy and its applications", "micro hydro and its applications" and "biomass energy source" by investigating the skilled labor-force requirement of the region. The support courses, namely, "Thermodynamic, Control and Automation, Vocational Foreign Language, Energy Management, Occupational Safety, Energy Economics e.t.c" are added next to the main components of the curriculum. The main objective of this article is to discuss about the main topics and sub topics in the area of solar energy , wind energy, micro hydro energy and biomas energy source that included in the science curriculum at university level. The syllabus for The Department of Electrical Engineering, The State University of Jakarta is as follows:

Solar energy

i) History of solar energy
ii) Solar collector (performance, model, measurement and application)
iii) Life Cycle Assessment of solar energy

The laboratory work includes measurements of solar radiation components (total and diffused), analysis of measurements and comparison with numerical calculations. Students are encouraged to perform repetitive calculations using personal computers. The experimental work is carried out using the various flat plate solar collectors. The experimental work on photovoltaic cell includes parallel and series connections of PV cells, The computer simulation work is carried out for estimating the energy behavior of greenhouses in several locations around the country[8]

Wind energy

i) Wind characteristic
ii) Wind energy conversion system
iii) Wind energy application
iv) Life Cycle Assessment of wind energy

The laboratory work on each topic includes a series of projects on wind data processing and measurement of forces on a wind rotor, and a complete design of a wind farm.

Micro hydro energy (MHE)

i) Principle working of MHE
ii) Turbine
iii) Power and efficiency

The laboratory work concerns with preliminary design of laboratory instrumentation for energy conversion. The design involves a drawing feature with analysis of MHE prototype and instrument demonstration of previous developed energy conversion.

Biomass energy

i) Biodiesel
ii) Bioethanol
iii) Biogas

The laboratory work is related to biodiesel production technologies, i.e. transesterification method, bioethanol production, i.e. raw material and fermentation, and biogas production, i.e. pyrolysis.

III. EDUCATION FIELD

Solar energy, biomass, and wind energy, micro hydro, geothermal are recognized as renewable energy source fields. When entire subjects are devoted to renewable energy, 25% of topics are primarily provided in solar energy and 20% of topics in wind energy, 30% of topics in micro hydro. While only part of classical subjects is devoted to renewable energy, 25% of topics are devoted to biomass energy.

Equipment used in teaching process is shown in Fig. 1. It can be seen that mainly computer databases, , and laboratories are used in renewable energy education. Also some pilot models are available for undergraduate education where biodiesel production, bioethanol production, installation solar energy, micro hydro energy and wind energy can be performed.

Instruction literature that is used in renewable energy education in Dept electric engineering is listed inside the reference section. In solar energy education, one books are used, In wind energy education, two books are used. In biomass energy education, four books are used of which two books are entirely devoted to biomass energy. In education on other types of renewable energy, one entire book is devoted to biogas and bioethanol, and two biodiesel.

Analysis of this literature revealed two facts. First, all books devoted entirely to one subject renewable energy are around 75% written in English. For instance, one of two books on solar energy are in Indonesian. One of two books on micro hydro is written in Indonesian. One of three books on biomass is in Indonesian. Books on biogas, bioethanol and biodiesel are in Indonesian. Second, universities offer literature to undergraduate students mainly in English and Indonesian language. Students at graduate levels are occasionally directed to foreign literature, international journals, and the Web.

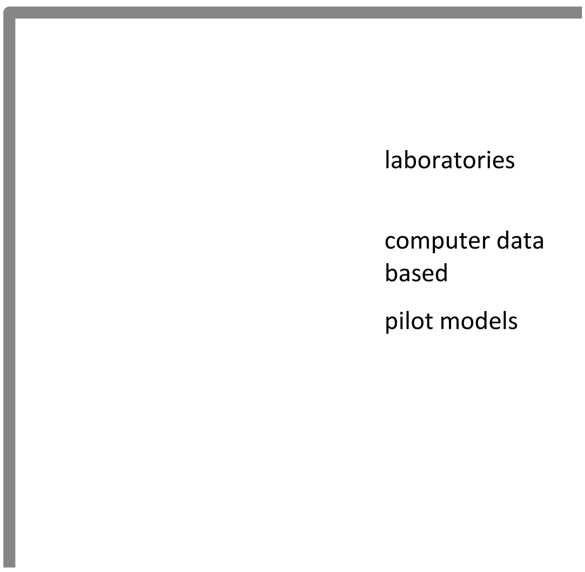

Fig 1. Equipment used in the teaching process

IV. PROJECT OF STUDY

The program consists of a number of projects that are involved in that program. A group of 3 - 5 students would jointly work on each project as a team. A report on the results attained is produced within a frame time of 4 weeks with 20 hours per week. The teamwork is established regardless the creativity and initiatives of the individual participant, however, the students are free to choose the project on which they prefer to work, based on their individual interest and capability.

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Case study on solar energy

In order to get further credit in one-month period, the students that spend their activities in building houses, i.e. hotels, restaurants, and hospitals, are saving for 1-credit. This project is entitled as "Application solar energy in building system", and it provides some tools for students need during their project work, which emphasizes on building tools especially related to systems concerned with heating, cooling, and lighting, as well as photovoltaic water pumping. In this project information is also given concerned with solar energy situation in the building system. Site visits to key establishments are made, such as heating building by solar air collectors, thermal cooling and PV water pumping system plants, and power stations.

The survey results showed a conclusion that for a heating system some features should be underlined concerned with solar air heaters on the roof, solar air heater using a packed bed of spherical capsules with the latent heat storage system and flat plate solar air collectors with the latent heat storage technique. Moreover, for a cooling system it should use solar flat-plate collector and PV hybrid system whereas for lighting system a PV array (1.5% of the roof area) and an APV in open field for shading are needed.

The economic study of solar thermal cooling systems which covered most climatic regions worldwide showed that solar thermal cooling is more viable in hot climates than that one in moderate European climates. The specific costs per kWh cooling in Germany vary between 0.25 and 1.01 €/kWh and in Spain between 0.13 and 0.30 €/kWh. [9].

In hot climates like Jakarta and Riyadh, the specific costs are as low as 0.09–0.15 €/kWh. Furthermore, the maximum investment costs were calculated and got a payback time of 10 years [10]. Fathoni *et al.* [11] studied the technical and economic potential of solar energy application in Indonesia and they reported that Makassar got the shortest payback period for 11 years and Banjarmasin got the longest payback period for 17.6 years. Furthermore, solar energy application can reduce the greenhouse gas effect by up to 243,252 tons per year in particular selected locations. In addition, a mixed mode solar greenhouse dryer with forced convection used to dry red pepper and sultana grape in Tunisia, the payback period was found to be 1.6 years, which was significantly less than the estimated life of the system (20 years) [12].

Case study on biomass energy

The case study on biomass energy was reported in June 2013. The title is "A Comparison of Life Cycle Assessment (LCA) on blending gasoline-bioethanol and gasoline for transportation fuel". The objective of this study is to perform and compare LCA on blending between gasoline and bioethanol.

Life cycle assessment is an important method used to minimize the environmental impact of products and processed by employing sustainable practice and environmental impact of the production and usage of three diesel fuels, i.e. Petroleum diesel, biodiesel from new vegetable oil, and biodiesel from waste vegetable oil. A typical example of a LCA flow sheet is presented at four stages. The first stage represents raw materials inouts, the second step is the manufacturing process and this includes an electrical energy input from a power station. Accordingly, the product is manufactured, filled and transported. In the transportation the used product can be either transported to a disposal site or recycled back to the manufacturing plant where they are used as a replacement for raw materials in the production of new product.

Fig. 2 shows the concept of life cycle analysis, which is simple to comprehend. For many students taking the subject of electrical engineering are able to develop models provided with simple answers in terms of energy consumption and carbon dioxide emissions.

Life cycle inventory analysis is performed on material and energy inputs, air emission, waterborne emission, and solid wastes involved in bioethanol and gasoline production. Each stage of analysis and calculations is carried out before and after plants yield. Transportation from gasoline plant to gasoline storage, bioethanol production to bioethanol storage, blending gasoline –bioethanol plant to E 1 storage and E 2 storage, use E1, E2 and gasoline are also considered in this study. The distance of transportation, the capacity and diesel fuel ratio of each path are as follow: i) from gasoline plant to gasoline storage: 127 km, 1: 5 (1 L for 5 km); ii) from bioethanol production to bioethanol storage: 20 km; and iii) from blending plant to E1 storage and E2 storage: 30 km.

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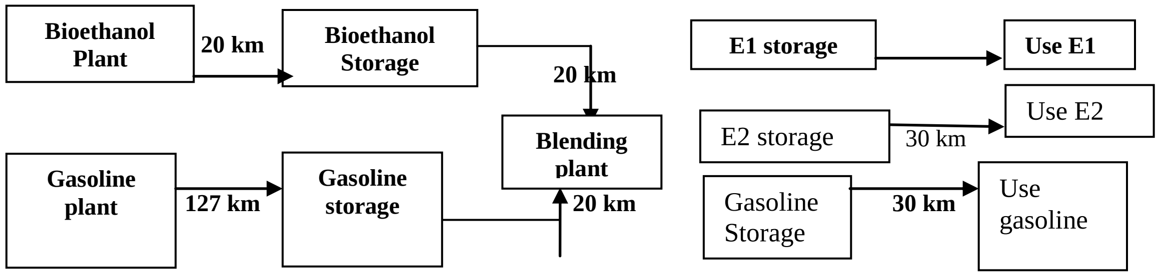

Fig 2 The analysis of LCI related to input-output energy.

The energy balance data of bioethanol plant is given in Table 1 whereas the energy balance data of gasoline plant is given in Table 2.

Table 1 The energy balance of bioethanol plant.

No	Process	Electricity (MJ/L)
1	Milling and washing	0.68
2	Steam pretreatment	0.73
3	SSCF	7.41
4	Distillation	0.66
5	WWTP	0.65
6	Total	10.15

Table 2 The energy balance of gasoline plant.

No	Energy	MJ/L
1	Fuel oil	0.02
2	Electricity	0.40
3	Liquefied natural gas	9.0
4	Total	9.42

Table 3 The estimate transport activities related to bioethanol, gasoline and blend bioethanol-gasoline.

No	Transportation activity	Average distance (km)
1	From gasoline plant to gasolin storage with pipe line	27
2	From bioethanol plant to bioethanol storage	
3	From bio ethanol storage to blending plant	20
4	From gasoline storage to blending plant	20
5	From distribution of blend, E1,E2 to regional storage area	30
6	From distribution of gasoline to regional storage area	30

Calculations (basis of 1 L .of bioethanol)

$$CO_2 \text{ manufacturing bioethanol} = 10.15 \text{ MJ x } \frac{1 \text{ kg } CO_2}{15 \text{ MJ}} = 0.67 \text{ kg } CO_2$$

$$CO_2 \text{ transportation for bioethanol} = 20 \text{ km x} \frac{3 \text{ kg}CO_2}{5 \text{ km}} + 30\text{km x } \frac{3 \text{ kg}CO_2}{5 \text{ km}}$$

$$= 12\text{kg} + 18\text{kg} = 30 \text{ kg } CO_2$$

$$CO_2 \text{ total} = 0,67 \; CO_2 + 30 \text{ kg } CO_2 = 30.67 \text{ kg } CO_2$$

$1 \text{ kg } CO_2$

CO_2 manufacturing gasoline = 9.42 MJ x -------------- = 0.62kg CO_2
15 MJ

$$CO_2 \text{ transportation for gasoline} = 20 \text{ km} \times \frac{3 \text{ kg}CO_2}{5} + 30 \text{ km} \times \frac{3 \text{ kg}CO_2}{5 \text{ km}}$$

$$= 12\text{kg} + 18\text{kg} = 30 \text{ kg } CO_2$$

CO_2 total = 0,62 CO_2 + 30 kg CO_2 = 30.62 kg CO_2

Gasoline has the lowest carbon dioxide emission The air emissions emitted during the life cycle of each fuel blend based on the travel distance oriented FU perspective is calculated by the GaBi 4 LCA software and given in Table 4.

Table 4 Air emissions over the life cycle of each fuel based on travel distance oriented FU perspective (1 km driving distance)

No	Fuel	CO_2(ppm)	NO_2(ppm)	SO_2(ppm)
1	Gasoline	0.273	198	420
2	Bioethanol	0.85	-	-
3	E1	0.259	224	411
4	E2	0.129	237	227

The results of the LCIA show that the levels of CO2 emissions which contribute to ozone layer depletion are considerably reduced when shifting from greenhouse gas to bioethanol blends. The standard operational of E1 and E2 fuel life cycles based on a-1 km travel driving distance yielded a 3.1% and 65.7% reduction, respectively, relative to the greenhouse gas fuel life cycle.

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