LABORATORY DEVELOPMENT ON RENEWABLE ENERGY

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Abstract
The major aims of this multi-disciplinary paper are as follows: (1) to educate undergraduate students with a comprehensive understanding of renewable energy; (2) to organize a future workforce in academia and industries through development in professionalism and by rendering skills with practical experience; and (3) to prepare instructional modules and collaborative papers in the domains of (a) wind energy (b) solar energy (c) energy efficiency and procurement (d) biomass and geothermal (e) hydrogen and fuel cells (f) carbon reduction, and (g) application of lean manufacturing concepts for energy conservation, so as to support and modernize courses by integrating them with current engineering concepts after the establishment of an energy laboratory.

This multi-disciplinary paper focuses on sustainable energy, so as to innovatively tackle contemporary economic and environmental issues, such as application of renewable energy sources, global warming, and conservation of traditional energy sources. This paper will escalate knowledge, communication and teaming skills, and will enhance awareness regarding energy resources. It also will increase the confidence of students, educators, consumers, and entrepreneurs in relation to the future challenges imposed by energy problems. It will accomplish these goals by integrating pertinent key aspects of higher education with math and science courses through the development of instructional modules and projects. The instructional modules will be a one-of-a-kind design that will be provided to other colleges by means of developing and maintaining a cyber environment. In addition, instructional modules will spread awareness at all participating institutes and will benefit the nation to prepare itself for future challenges imposed by impending energy crises.

1. Introduction

The Department of Mechanical Engineering (ME) at the University of Louisiana at Lafayette is a part of the College of Engineering and plays a significant role in the university, community and industry. Its mission is to provide a quality education and meaningful career opportunities for ME graduates of UL Lafayette through its ABET accredited program. The ME Department program prepares students to meet the challenges of a global economy in an increasingly complex and competitive workplace, and to function as team members of an engineering group capable of designing and developing large, multidisciplinary projects.

UL Lafayette's goals are to teach its students in the most innovative way, as well as to help them conceive the concepts of each subject learned and to gain the specific knowledge that they will need, so as to enter the workforce successfully. In order to achieve this goal, the Mechanical

Engineering Department will introduce a new course into its curriculum—one that will help students to counteract competition in this contemporary world of hi-tech machines.

Uncertain and costly dependence[4] ($700B/yr. at the peak and about $200B/yr. currently) on imported oil, along with the emission of greenhouse gases, is threatening the U.S. economy and is making it difficult to imagine a future in which our country is secure and sustainable in terms of energy[5]. This is due to the fact that limited amounts of non-renewable sources are present within the earth's crust. They will end in the near future if consumption continues at the present rate. On the other hand, renewable energy sources present a potentially eternal supply[11]. The exploration of such competitive renewable energy resources can assist in resolving the overall problem and, in turn, can promote economic growth by exporting fundamentally advanced and modern energy technologies. In order to achieve this, it is imperative to make society, including future engineers, aware of the approaching problems regarding the rapid elimination of fossilized energy sources and the deployment of renewable energy sources and technologies. This is particularly critical for the State of Louisiana, which has gained a reputation as the second poorest state in the United States[3].

Particularly because of an ample amount of natural resources and related low energy prices, the State of Louisiana has many petroleum refining and petrochemical industries that consume considerable energy. In order to run these industries, the total amount of energy consumed in 2006 was 3,794.2 trillion BTUs, out of which 1291.5 trillion BTUs energy was imported from other states. The current status of the state's high industrial consumption is proven by its high ranking within the list of per capita energy consumption data. Table 1 shows the position of Louisiana in relation to various measuring aspects[7,15].

Category	Rank	TBTU	#1 State (TBTU)	Category	Rank	TBTU	#1 State (TBTU)
Residential	**24**	345.9	Texas (1,579.6)	Natural Gas	**3**	1,346.8	Texas (3,551.3)
Commercial	**23**	264.4	California (1,583.3)	Petroleum	**4**	1,702.2	Texas (5,871.4)
Industrial	**2**	2,419.8	Texas (5,926.1)	Electricity	**20**	264.3	Texas (1,169.4)
Transportation	**12**	772.4	California (3,343.0)	Total	**8**	3,802.5	Texas (11,558.3)
Coal	**29**	265.2	Texas (1,610.3)	Per Capita (MBTU)	**3**	896.1	Alaska (1,112.2)

Table 1 Position of the State of Louisiana in Relation to Various Measuring Aspects.

This table reveals only the minimum use of renewable sources in Louisiana. This state, however, has exceptional potential to engage in notable development and continuous growth because of its beneficial geography. Meanwhile, specifically with respect to solar and wind geothermal energy, Louisiana has emerged as a potential location, a fact evident from growing renewable companies. Solar power and small-scale wind systems run 70% of companies near the Gulf of Mexico. Homes and public boats are installed with solar systems in many areas in Louisiana, creating thousands of green jobs with a growing rate of 19.5%. The Department of Natural Resources (DNR) is encouraging incentive programs to enhance implementation of renewable energy sources.

From Table 1, it is evident that energy is an integral element that serves industry, transportation, commerce and housing. A huge amount of energy is wasted in every sector, and at the same time, a limited amount of conventional non-renewable energy resources is decreasing quite rapidly. This situation has caused a magnificent increment in energy prices. The good news is that efficient utilization of energy can pave the way for fiscal saving, a clean environment, and energy independence.

In this scenario, there is a strong demand to determine the potential methods needed in order to utilize energy properly with an ongoing eye to conservation. Lean Management is an established philosophy to eliminate wastes and already has proved its worth in various areas such as manufacturing, software, etc. This tool consists of a spectrum of practical strategies and techniques to assist organizations in reducing energy use and improving environmental performance. An extensive array of major methods offered in lean management include energy treasure hunts, value stream mapping, Six-Sigma, and kaizen events for achieving process excellence with less energy use and fewer environmental impacts. These methods aid in identification, elimination of non-value activities (waste), and improvement opportunities, with the aim of accomplishing continuous improvement in quality, reduction in waste and enhanced customer response. Therefore, it is imperative first to explore the relationship between lean and energy use, and then to provide background information for the implementation of lean concepts that can cut energy waste at least significantly, if not completely.

Not many universities have introduced courses of this sort in their engineering curriculums. The proposed curriculum will improve the learning environment and the ongoing quality of education. The planned course takes a creative and realistic approach that will encourage students of Mechanical Engineering and Industrial Technology. Students who take this course will gain new scientific and technological concepts relating to renewable energy. This program, moreover, seeks to broaden its attraction to minority and other under-represented groups who might not otherwise consider pursuing a Mechanical Engineering career.

An added advantage will be that the new equipment and laboratory set up will attract new research projects from Louisiana's industry. The course and laboratory not only will benefit undergraduates, but also graduates, by introducing them to the processes and technologies actually used by modern companies. This paper will provide a profound, positive impact on students that combine theory with real-time issues that will help them when such companies hire them.

Funding from this proposal would provide equipment that will add value to students' learning and projects. The requested equipment will lead to an extension of the already existing Industrial Assessment Center (please include few more names here). At the same time, society at large definitely also will benefit from the improved technology taught at the university. All of UL Lafayette's ME faculty members already have declared that the equipment proposed here also will benefit them in courses such as (please include two or three courses).

2. Paper's Goals and Objectives

The paper's objectives are as follows:

- To enhance student awareness of the current situation of traditional energy resources such as fossil fuels and to familiarize them with the lasting advantages of renewable energy sources and their combined impact on the environment;
- To provide resources and support students and teachers through the development of instruction modules and collaborative projects on renewable energy and lean manufacturing concepts in energy management;
- To attract students to face the future workforce shortage, and to equip them with related knowledge and information;
- To improve communication, leadership, teaming skills and practical experience of undergraduate students by engaging them to work on collaborative projects[13]; and
- To develop professionalism and to cultivate inquiry-based learning habits in students[19].

Students will be taught all the techniques of renewable energy, which involve the following: (a) wind energy, (b) solar energy, (c) energy efficiency and procurement, (d) biomass and geothermal, (e) hydrogen and fuel cells, (f) carbon reduction, and (g) application of lean manufacturing concepts for energy conservation. Finally, the successful implementation of this paper will help to encourage the professional development of undergraduate students, as well as the faculty within the entire state of Louisiana through online information sharing[19].

2.1 Curriculum and Educational Material Development

The main component of this paper involves the preparation of an instructional module on two topics. These topics are (1) renewable energy sources and (2) lean philosophy. During the first year, the targeted community college faculty will be trained in relation to the instructional modules with the help of graduate students and faculty from UL Lafayette[18]. These modules will be prepared collaboratively by people from industry with the help of faculty from UL Lafayette and will be evaluated for validation and effectiveness. The modules will adopt and integrate renewable energy concepts with STEM and will teach basic concepts, merits and demerits, various processes, information, implementation, and future works. They also will teach the implementation of lean concepts in relation to conserving traditional energy sources through the effective utilization of energy and the reduction of energy waste in industry and commercial use. This will enlighten future engineers, not only to the future challenges of energy, but also to their related solutions.

2.1.1 Sustainable Energy

Volatile fuel prices and continuously increasing utility rates are major concerns for future development[8]. On the other hand, renewable sources such as wind, solar, biomass, and energy-rich agricultural/municipal/industrial wastes have the potential to provide energy without compromising the needs of future generations. Some of these, such as biomass, even restore carbon dioxide and thus directly reduce greenhouse gases—all, by displacing fossilized energy sources that contribute to a net reduction in carbon dioxide emissions. Biomass, through the production of gas to liquid fuels, generates high energy-density fuels that form the backbone of

our transportation industry[10]. These raw materials also contribute to chemical intermediates that have the potential to enter the chemical and petrochemical industries, whose products are critical to our standard of living. These naturally-replenishing sources are environmentally friendly, affordable, and infinite. As such, the primary goals of the sustainable energy module are to provide a comprehensive understanding of the processes, based on renewable resources, and to generate innovative passion about sustainable energy and so evolve into an energy- sustainable world. A life-cycle analysis of daily use products also will be emphasized in the module[12].

2.1.2 Lean Manufacturing

Lean philosophy is the collection of practical strategies and techniques that accomplishes continuous improvement in quality, reduction in waste and enhanced customer response[9]. Lean is the philosophy of production that emphasizes the minimization of the amount of all resources (including time) used in various activities of a given enterprise[16]. It involves identifying and eliminating non-value-added activities in design, production, marketing, supply chain management and customer interactions. It also paves the way for concepts such as business process reengineering and enterprise resource planning. In general, lean is currently in favor with industries all around the world, so as to reduce waste and improve productivity. Lean concepts not only are used in manufacturing or production fields, but also in accounting, business process analysis, policy management, health care and the oil and gas industries[18]. And just as Lean Manufacturing is gaining importance in almost every business and industry, the demand for students with thorough knowledge on the concepts and practices of Lean Manufacturing is also increasing[6,16].

3. Strategy for Implementation of Curriculum

This paper is aimed at developing a program to equip engineering graduates with the necessary knowledge and skills that will make them ready to meet the challenges of renewable energy when they go to work for industry. In this way, society will get engineers with the latest knowledge, and they in turn will provide a better product to society with minimal utilization of its resources. This ultimately will lead our society toward new horizons. Virtual reality is one cutting-edge technology that will allow students to develop novel methods, innovative processes, and advanced software tools for next-generation virtual and rapid prototyping practices.

As an all-encompassing discipline, which includes the flexibility to accommodate widespread broad interests, ME seeks to broaden its allure to students, aiming especially at females and minority groups. By implementing this program, a novel innovation will rise up in ME education, which will be helpful not only to students, but also to companies located in Louisiana. Reasons for introducing this technology are as follows:

- To promote exposure to advanced technologies, interaction with industries, and expertise in developing ideas;
- To emphasize the need to convey to prospective students the breadth of opportunities, excitement and personal satisfaction within the ME profession;

- To create awareness and effective communication skills, and experience in system integration and in interdisciplinary teamwork, along with a strong sense of professionalism.

4. Work Plan of Proposed Paper

This course will teach students how to use the tools of product realization to develop a robust concept exploration method for configuring complex engineering systems. Students will be taught the use of software tools such as EON Reality to capture the data created by CAD tools such as Pro/ENGINEER or CATIA, by importing images and by adding behaviors and visualization of the products. Students will create advanced assembly features, managing the connectivity between images and learning to create high-level 3D simulation, which will give them a realistic experience.

4.1 Evidence of Potential

A new lab that includes the equipment mentioned in the Equipment section of this proposal is required, in order to provide an excellent learning environment for students of CE, ME and I-Tech. Such a state-of-the-art lab, backed by the commitment and expertise already noted, would put the university in a league with other prominent schools that have similar facilities. The lab will be extremely useful in a number of courses currently taught at UL Lafayette. In addition to serving the goals of the P.I. and his co-P.I.'s, the equipment also will be used by several other professors in various departments. Finally, the proposed laboratory will provide the means for faculty to do high quality research, thereby bringing further eminence to the university.

UL Lafayette's Industrial Assessment Center is one of 26 centers supported by the U.S. Department of Energy (DOE) at universities across the country. The Industrial Assessment Center (IAC) provides confidential energy, productivity, and waste assessments at no cost or obligation to eligible small and mid-sized manufacturers. This, in turn, enables them to become more efficient and competitive. Assessment teams are composed of a UL Lafayette faculty member and undergraduate (upper-level) and graduate engineering students. During a site visit, students take measurements to audit the manner in which a facility uses energy and resources. Then, with guidance from professors, students write a report that identifies opportunities to save energy, reduce waste, and improve productivity. An average annual savings of $55,000 is realized after implementation of IAC assessment recommendations.

The Energy Institute at UL Lafayette provides expert knowledge of the geology and geophysics of the Gulf of Mexico and the Gulf Coast region. The primary concern is the application of information for use by the petroleum industry, environmental concerns and government institutions. The Energy Institute provides research, education and collaborative opportunities with partner organizations and individuals. It also maintains several Unix-based workstations for research, training, and to serve individual company needs. In addition, our relationship with the NASA/UL Regional Application Center provides access to high-quality satellite data sets and hardware devices.

The Center for Ecology and Environmental Technology conducts research, education, and community outreach in ecology and environmental biology, with a strong emphasis on developing and using sustainable resources and energy.

These organizations, which include the Enterprise Center of Louisiana, the Doris B. Hawthorne Center (a multidisciplinary unit with components in research, academic and service), the Institute for Coastal Ecology and Engineering, and the Center for Plastics, Composites and Polymer Technology, have been helping to increase students' quality of education year after year. This organization will provide a collaborative industrial environment with the University of Louisiana at Lafayette, other universities, the State and other economic development agencies.

In terms of the ME Department's curricula, from the perspective of students, industry and the government, this paper will strengthen the program, which in turn will enhance the image of the institution. First, undergraduate students will gain real-life experience. Moreover, their pairing with graduate students and faculty mentors, as part of their projects, will prepare them for the scientific rigor and discipline needed to pursue research. These students will be encouraged to pursue their graduate degrees, thereby increasing the quality of our graduate program with their preparedness. Overall, the broadening of educational options will be done in a thoughtfully targeted manner that is cost effective for both givers and receivers. Equally important is that closer relations invariably will result on numerous successive levels: university-to-university, university-to-industry, and city-to-state. The widespread benefit to state industry will include a particularly gratifying boost to manufacturing, especially within the plastics, apparel, and petrochemical industries, all of which predominate in Louisiana[4].

4.2 Impact on Curriculum and Instruction

In order to serve the increasing number of students in the ME Department, the introduction of this course within their curriculum will provide an opportunity to introduce innovative teaching tools that will benefit students immensely. One of the new methods that will be utilized in the implementation of the new curriculum is to integrate practical aspects of renewable energy into the undergraduate program. The department already boasts a comprehensive course in ME. The aim now is to broaden the current curriculum in order to incorporate newer and more extensive practical applications to this course. The requested equipment will allow the department to incorporate actual elements of renewable energy.

4.3 Impact on Quality of Students

So far, students already have received hands-on experience in selective fields, as well as related perspective, but with the realization of this paper, they would have experience in the broad spectrum of renewable energy. They also will be able to learn practical approaches in the field of renewable energy[3]. When this university succeeds in establishing a fully equipped renewable energy laboratory, many training workshops will be offered. High school students also then will have the opportunity to utilize this laboratory and to engage in the broader learning it will facilitate. That certainly will have an immense influence on the possibility of understanding lasting advantages of renewable energy sources and their combined impact on the environment[24]. According to the proposal, the introduction of a new course on renewable energy will expose students to established trends that they will encounter when they enter the industry after their

graduation. Due to the practical aspects or exposure to the laboratory, more and more students will choose the field of ME and will enroll within UL Lafayette.

4.4 Impact on Faculty Development

A team of expert professors already has been selected to teach practical key aspects of renewable energy sources[1]. Should this proposal be funded and the advanced equipment laboratory established, it will act as a catalyst for the realization of teaching staff arrangements. Such an arrangement will be beneficial to all functions of CE, ME and ITEC departments, providing them the opportunity to learn from each other and to gain a greater appreciation for the knowledge and expertise of each individual. It will be especially beneficial to those students who will be taught by the able team of teachers / instructors[2].

The additional resource provided through this advanced equipment laboratory will greatly enhance the delivery of professional development programs, particularly in respect to practical/ technical training. Finally, it also should be noted that the practical training sessions or workshops in the laboratory will create an awareness of other related efforts and will plant a seed for additional collaborative endeavors[24].

5. Equipment Needed

Each piece of requested equipment relates specifically to the particular topics covered in courses that explain renewable energy in CE, ME and ITEC departments. The "Curriculum Development" section offers more details. All of this equipment will be integrated into other courses, based on relevancy. In addition, many industries, colleges and universities also will use the laboratory equipment requested in this proposal.

Item	Module	Description
1	**Wind-Powered Generator** 	This equipment has been designed to provide students with a basic understanding of how wind generators function as an alternate source of energy. This system consists of a wind source, DC generator, control panel and base assembly.
2	**Solar Heat System Trainer** 	Solar Heat System Trainer is an actual solar hot water heating system. Gauges, thermometers, and flow meters permit students to observe pressures, temperatures, and flow rate while the system is in operation. The trainer is mounted on a mobile frame and the collector panel is adjustable for easy positioning in direct sunlight.

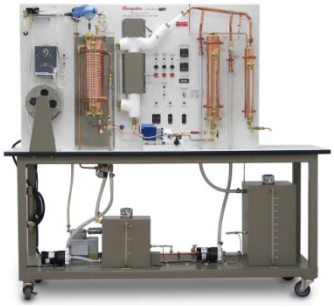
3	**Solar Photovoltaic Trainer** 	Solar Photovoltaic Trainer is a control system trainer that lets the student technician examine the electrical layout and operational features normally associated with a photovoltaic power source. The trainer demonstrates the electrical characteristics of the solar array, storage battery, AC-DC distribution, and AC-DC loading. The complete charging sequence can be observed.
4	**Solar Heat Service Trainer** 	Solar Heat Service Trainer is an actual solar hot water heating system. The trainer is mounted on a mobile frame and the collector panel is adjustable for easy positioning in direct sunlight.
5	**Geothermal Trainer** 	Geothermal Trainer provides hands-on training by allowing students to conduct tests and adjustments on a modern Geothermal Heat Pump.
6	**Fuel Cell Technology Trainer** 	Fuel Cell Technology Trainer allows students to create a grid independent power supply that uses only hydrogen as its fuel.
7	**Bio-Fuel/Bio-Mass Training System** 	The Ethanol Production Process System is designed to facilitate the instruction of students on the process required to produce ethanol for experimental purposes. Ethanol is quite a promising fuel alternative to oil since ethanol sources are widely available and clean-burning. The student will be able to observe and control the process of producing ethanol from corn, sugar, sorghum, fruits or several other sources. When using this unit's Liquid-to-Liquid Extraction Demonstrator option, it is possible to produce ethanol of high purity.

Table 2 Equipment Needed for Renewable Energy Laboratory Development.

6. Conclusion

This multi-disciplinary paper focuses on sustainable energy, so as to innovatively tackle contemporary economic and environmental issues such as the application of renewable energy sources, problems with global warming, and conservation of traditional energy sources. This paper will escalate knowledge, communication and teaming skills, and will enhance awareness regarding energy resources. It also will increase the confidence of students, educators, consumers, and entrepreneurs in relation to the future challenges imposed by energy problems. It

will accomplish these goals by integrating pertinent key aspects of higher education with two years and high school math and science courses through the development of instructional modules and projects. The effect of this project-based learning technique on students' knowledge will be testified through a meticulously prepared evaluation program. In addition, the two-day events and instructional modules will spread awareness at all participating institutes and will benefit the nation to prepare itself for future challenges imposed by impending energy crises. This paper will encourage underrepresented groups through various means to participate and will provide assistance in the future to organize a similar program on sustainable energy at participating institutions, so as to expand its impact.

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