AC 2011-1038: DEVELOPMENT OF A RENEWABLE ENERGY COURSE IN ELECTRONIC ENGINEERING TECHNOLOGY (EET) PROGRAM

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Antonio Soares was born in Luanda, Angola, in 1972. He received a Bachelor of Science degree in Electrical Engineering from Florida Agricultural and Mechanical University in Tallahassee, Florida in December 1998. He continued his education by obtaining a Master of Science degree in Electrical Engineering from Florida Agricultural and Mechanical University in December of 2000 with focus on semiconductor devices, semiconductor physics, Optoelectronics and Integrated Circuit Design. Antonio then worked for Medtronic as a full-time Integrated Circuit Designer until November 2003. Antonio started his pursuit of the Doctor of Philosophy degree at the Florida Agricultural and Mechanical University in January 2004 under the supervision of Dr. Reginald Perry. Upon completion of his PhD, Dr. Soares was immediately hired as an assistant professor (Tenure Track) in the Electronic Engineering Technology department at FAMU. Dr. Soares has made many contributions to the department, from curriculum improvements, to ABET accreditation, and more recently by securing a grant with the department of education for more than half a million dollars.

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Introduction

Energy plays an indispensable role in modern society. We all depend on a constant and reliable supply of energy - for our homes, businesses and for transport. But have you ever thought about the source of the energy you use? The majority of the US's electricity comes from burning fossil fuels (e.g. coal, oil and gas). With limited resource of fossil fuel on earth and thus prospect of depletion, the world has to turn to other alternative sources to provide our energy needs in a sustainable way. It is also of a great concern that fossil fuels are a major contributor to climate change. [1]

In tackling these issues, President Obama came up with a strategy for US to harness the power of clean, renewable energy to lead 21st century. He has a comprehensive plan to chart a new energy future by embracing alternative and renewable energy, ending our addiction to foreign oil, addressing the global climate crisis and creating millions of new jobs that can't be shipped overseas. He sets an ambitious goal of generating 25 percent of our energy from renewable sources by 2025. [2]

Renewable energy

Then what is renewable energy? Renewable energy is any source of energy that can be used without depleting its reserves. These sources include sun, wind, biomass and hydro energy. Each of these energy sources can be harnessed to varying degrees and at varying costs. They can be used to produce electricity, generate heat and transport goods and people. It comes from sources that are essentially inexhaustible.

Until the industrial revolution, renewable energy sources were virtually the only form of energy used by humans – we burned biomass (wood) and made use of windmills, watermills and sailing ships. But during the last 150 years, modern civilization has become increasingly reliant on fossil fuels: oil, coal and natural gas. Fossil fuels form so slowly in comparison with the rate of energy use that they are considered finite or limited resources. In addition, the burning of fossil fuels produces greenhouse gases and other pollutants. Greenhouse gases are believed to be responsible for trapping heat in the earth's atmosphere, heat that would normally be radiated back into space. This effect is being linked to changes in the earth's climate. Renewable energy generally produces few or no greenhouse gases. The exception, however, is biomass. The carbon dioxide emitted is balanced by the amount of carbon absorbed from the atmosphere while the organic material is produced. If biomass is being used sustainably, there are no net carbon emissions over the time frame of a cycle of biomass production. Biomass is therefore generally considered to be carbon neutral. Using renewable energy can provide many benefits, including:

- Making use of secure, local and replenishable resources.
- Reducing dependence on non-renewable energy.
- Helping to keep the air clean.
- Helping to reduce the production of carbon dioxide and other greenhouse gases.
- Creating new jobs in renewable energy industries.

Table 1 Different Types of Renewable Energy [3]

Renewable energy source	Technology/Application
Solar	1. Photovoltaic (PV) cells to produce electricity 2. Solar thermal system for heating water
Wind	1. Wind turbine: single turbines or a number of turbines in a wind farm 2. Conventional windmill to pump water
Water	Hydro electric, wave and tidal systems to produce electricity
Biomass	Direct combustion of gas produced from biomass, or biogas, to generate electricity and/or heat - e.g. wood stoves or larger commercial operations
Goethermal	Using the temperature of the earth to produce electricity and/or heat, e.g. ground source heat pumps

Despite its nickname, Florida, 'the Sunshine State' hasn't been at the forefront of solar power or other renewable energy sources. Less than 4 percent of Florida's energy has come from renewable sources in recent years, which places it at 40th place across US. Unlike California and many other states, Florida lawmakers haven't agreed to setting clean energy quotas for electric companies to reach in the years ahead. Overall, the United States still trails other nations, such as Spain and Germany in building photovoltaic plants. In December 2009, Florida Power & Light (FPL) built a Solar Plant in Acadia, FL. It is called Desoto project, which serves as a pilot renewable energy project for FPL. It is the world's largest solar plant when it was built [4]. The investment isn't cheap: The Desoto project costs $150 million to build and the power it supplies to some 3,000 homes and businesses will represent just a slice of the 4 million-plus accounts

served by the state's largest electric utility. But definitely as President Obama said in the opening ceremony, "we need to shift our focus and move toward the right direction."

Overview of renewable energy programs in US

As business and industry are taking more interest in renewable energy, academia should not lag far behind. Anticipating increased demand for new technical and design skills in renewable energy, colleges and universities across the nation start offering degree programs in the field. [5]

The Oregon Institute of Technology has developed the country's first four-year undergraduate degree program in renewable-energy systems. This year (2010) the program is training 50 students and will graduate its first class.

The degree requires basic knowledge in engineering, electrical circuits, motors and generators, thermodynamics, heat transfer and the language of computers. Then there come specialized courses in photovoltaics (solar energy research and technology), wind, biomass (the recycling of biological material), hydropower and geothermal energy development. After graduation, students would be applying their new Bachelor of Science degrees in a range of design, engineering, installation, auditing and programming careers in the region's expanding green-power sector.

In 2006, the State University of New York (SUNY) at Canton started a four-year degree program in alternative and renewable energy. Illinois State University in Normal has established a four-year degree program in renewable energy. Appalachian State University in Boone, N.C., offers an undergraduate degree in appropriate technology, an environmentally and socially responsible approach to engineering, with coursework in the design and construction of solar-powered buildings, drafting, design, woodworking, metalworking, computer literacy, architecture and green construction.

More community colleges are offering one-year certificate and two-year associate degrees in building and installing clean-energy systems. Lane Community College, in Eugene, Ore., trains renewable-energy technicians in a two-year program that teaches students how to improve the energy efficiency of homes and businesses and install solar-power and wind-power systems.

San Juan College, in Farmington, N.M., which has a program that specializes in designing and installing solar-energy systems, awards one-year certificates and two-year degrees. Bronx Community College, part of the City University of New York also offers solar-electric training.

Students view these programs as gateways to good jobs. Starting salaries nationally, typically range between $35,000 to $45,000 for graduates of two-year programs and $45,000 to $60,000 for graduates of four-year programs. But nationwide, renewable energy programs are still far and few in between.

While in Florida, Florida Solar Energy Center, which is located in central Florida and has affiliation with University of Central Florida serves as hub for research, education and outreach

in renewable energy, especially in solar energy. The authors haven't found any other renewable energy programs in Florida. Even renewable energy courses are rarely offered in Florida's four year college/university.

One introductory course in renewable energy

As the only ABET accredited four year Electronic Engineering Technology (EET) program in Florida public universities, the EET program at Florida A&M University has been continuously accredited since 1973. The authors think that our EET program is well poised to take the initiative to create a renewable energy option for our graduates in the next few years. As the first step toward this direction, we are proposing to offer one course in renewable energy. Since currently we don't have coursed dedicated to energy system, we propose to develop a course on energy system with emphasis on renewable energy.

This course will be offered to senior students as an elective course first. Our goal will be to make it a required course after a few years. By offering an introduction to renewable energy course to our senior students, who should have already built a foundation in electrical fundamentals, physics, and chemistry, the students will obtain the basic knowledge and understanding in this crucial area. In this course, we will put renewable energy in the perspective of energy system. Topics included are energy generation, energy transportation, energy storage, energy efficiency, etc. Each renewable energy source will be studied in this course. Pros and cons will be discussed. Challenges facing each renewable source will also be discussed. For example, in discussing wind energy, "Windmills can be used to harness the energy available from moving air. The rotating blades of a windmill turn a generator to produce electricity. The challenges for engineers in using wind energy include location, efficiently capturing the kinetic energy of the wind, environmental concerns, and conversion efficiency. Location is a significant challenge since windmills must be placed in a windy space where there is enough room for multiple structures. Public acceptance of their present is also necessary."[6] The students taking this course will also perform hands on labs since we are training engineering technologist. They will install solar panel, wind turbines. They will learn how to test and maintain these equipments. By taking this course, they will have an advantage when they look for jobs after graduation. They can go into energy auditing, solar design, energy modeling. They can also go to photovoltaic manufacturers or wind turbine manufactures. It is our understanding that one course is far from enough to equip the students with all the knowledge needed to work in the renewable energy industry, thus it is our goal to offer more courses in this field to make it an option in EET program in the near future. But since there are few graduates who have the education and qualification to work in this field, a lot of employers are willing to train the new hires. Then one renewable energy course may make students stand out to get the opportunity.

In solar energy part, this course will train students on the various and most common solar thermal system installations. The course will review the different components and the respective functions of a solar thermal system. The course also covers the financial aspects of installing

different solar thermal system such as cost, energy savings, and return of investments. The course will involve the inspection and installation of various types of solar thermal system. Individual components are discussed and several labs will be performed. Emphasis will be placed on hands-on training. This course explores the design and installation of solar photovoltaic systems and their applications both off-grid and on-grid. Both centralized solar power plants and distributed topologies will be considered.

In wind energy part, in-depth study of the components of the input and output electrical power delivery system for wind generation. This course will include blades, rotors, generators, controllers, brakes, wind vanes, gear drives and anemometers. This course will also include a geothermal power discussion to provide information on bottom hole temperatures, water injection, binary cycles, heat exchanges and energy converters.

The following are some sample projects which will be included in this course. [7]

(1) Juice from juice *Make your own blackberry juice solar cell*

With iodine, blackberry juice, and a few simple materials, the students can create a working solar cell that mimics the process of photosynthesis. This type of cell is called a *Grätzel cell*. Grätzel cells are in commercial operation and cost half as much as silicon solar cells.

(2) Nanocrystalline Solar Cell

In this activity, the student will explore photogeneration of electricity using dye-sensitized nanocrystalline titanium dioxide.

(3) Converting Photons to Electrons: Build your own Solar Cell

Solar cells, also known as photovoltaic cells, covert the sun's energy directly into electricity. The students will build their own solar cells using common household items to produce up to 50 mA of current.

(4) Classroom Turbines/Turbine Project

The students will build their own wind turbines from scratch. They first need to make a list of the parts and materials that go into making a wind turbine. Many of these materials are available at the Kidwind shop, but creative, unique designs are always encouraged! [8]

- Electrical Materials:

One might need to do some basic soldering to connect wires to motors. The multimeters and alligator clips are used to hook up the measuring devices. Understanding the electrical output can be confusing, but you can learn more about it

- Building Materials:

- A hub to attach blades to generator
- Balsa wood PVC pipe and fittings, dowels, plastic cardboard, building "junk"
- Gears, pulleys, tinker toys, k'nex, legos
- Construction tools hammers, small saws, scissors, exacto knifes, glue guns, PVC cutters
- Safety goggles

➢ Other testing materials:

- Handheld wind speed meter
- Computers for graphing, simulations, etc.
- Tachometer to measure blade rotational speeds

In writing this paper, it came to our attention that there are few textbooks available on this important topic. We have been continuously doing research on how to combine and compile materials for our course. Right now internet seems to be the only place where we can find some educational material, but its validity needs to be verified. In this paper, the rationale of developing a renewable energy course in EET program is explained. Overview is given on available renewable energy programs. Some course materials are outlined as examples.

Bibliography

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