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Renewable Energy Technology:
Engineering and Engineering Technology Educational Opportunities

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ABSTRACT

Renewable Energy Technologies (RET) have the potential to contribute significantly to the energy mix of Latin America and Caribbean counties. These regions have significant RET resources and there is increasing governmental emphasis on their development. It is forecasted that regional trends toward increased emphasis on these technologies will continue and accelerate in the short-, mid-, and long-term. The non-government organizations (NGO) and private sectors are also seeing increased involvement in commercial applications, investment, and research in the renewable energy technologies. This increase in focus from the private and public sectors along with changing political, social, security, economic, technical, and environmental conditions present short- to long-term challenges to educational institutions. These challenges presage an increasing risk that Engineering and Engineering Technology programs at four-year educational institutions could fall short of fulfilling their responsibilities toward important constituencies: students seeking a quality education relevant to today's issues and employment environments; employers of the university's graduates seeking qualified employees with specific knowledge and skill sets; and the citizens of the respective institution's state and country whom they serve.

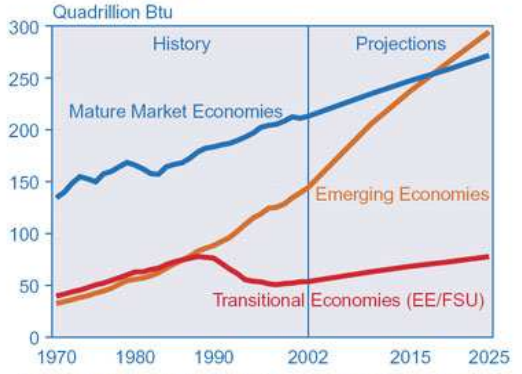
This risk conversely presents exciting and valuable opportunities for Engineering and Engineering Technology programs to develop curriculum in renewable energy topics, which would fulfill their responsibilities to their constituencies, as well as offer programs, which are attractive to today's student populations.

Keywords: Renewable Energy Technology (RET), Engineering and Engineering Technology, Educational Opportunities

Current Latin America and Caribbean Energy Situation

Similar to many other regions of the world, energy supplies in the Latin America and Caribbean region (LACR) are primarily dependent on fossil fuels - predominantly petroleum. Although some countries, including Brazil, Colombia, Mexico, and Venezuela have moderate to substantial oil resources to support their economies; the remainder of the region typically depend on imports that can have a significant effect on their economies and foreign currency reserves. In Argentina, Bolivia and Peru, sources of natural gas (another fossil fuel) are abundant yet, to some extent, under developed. Even so, many countries in the LACR have practically no accessible national sources of conventional fossil fuels. For example, countries of Central America and the Caribbean contain little in the way of conventional energy resources, with Guatemala being these regions' only producer of oil. Increasing development in the region tends to forecast increasing demands on energy sources (US Energy Information Administration 2003). The current reliance of fossil fuels for energy production has increasing environmental, social and political, security, technical, and economic risks. (Huacuz 2003; Energy Information Administration 2003, USA Today 2006)

Figure 8. World Marketed Energy Use by Region, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

In contract to this situation, according the US Energy Information Administration (EIA), all countries in the LACR have different levels of rich sources of renewable energy. Hydroelectric - both large but also the underutilized micro-hydro, biomass, solar, wind, and ocean related sources such as tidal, wave, and ocean thermal exist in significant quantities. Of course, these different sources that depend on different geographic variables of the countries of the region, offer crucial opportunities to mitigate the risks of reliance on fossil fuels for energy sources.

Growing Demand for RET

Global growth in the use of renewable and sustainable energy sources is impressive, not only in North America, Europe, and Japan, but also in developing countries. For example, Canadian and China wind capacity increased by over 50% in 2005 alone (Global Wind Energy Council 2005). Wind energy currently supplies almost 20% of the Danish total energy requirements. In Iceland, geothermal energy and hydroelectric provide virtually all its heating and electric needs. Iceland now is focusing on developing a hydrogen economy (BBC 2001). Germany and Japan have used strong tariff programs to become the two world leaders in the development of RETs. For grid-connected photovoltaic systems, there has been approximately 60% per annum increase and a 40% increase for wind in the years 2000-2004 (Eric Martinot 2005). As a single consequence, the European market has reached it's 2010 European Commission target of generating 40,000 MW of power from RET five years ahead of time. By 2010, the European Union is expected to save enough greenhouse gas emissions to meet one-third of its Kyoto[1] obligations through wind energy alone (Global Wind Energy Council 2005).

[1] The Kyoto treaty, which was signed by the members of the European Union, has a goal of reducing green house gas emissions to pre-1990 levels.

Although not as impressive as other regions such as the US and Europe, according to statistics provided by the EIA, news media, and the United Nations, usage of renewable energy technologies for energy production in the LACR is increasing and has developed some dramatic individual statistics. For example, Brazil has developed and used locally generated biofuels that has resulted in almost total energy independence for that country (USA TODAY 2006). An internet search of United Nations Development Programme Energy and Environment found on-going projects in most LACR countries ranging from hundreds of thousand of dollars to many millions of dollars($US).

Overall, according to a new report from Clean Edge, Inc. that was quoted in a newsletter from the US Department of Energy's (DOE) Energy Efficiency and Renewable Energy (EERE) Department "*Clean energy markets … are poised to expand fourfold ...by 2015*",.

Private Sector Growth

Public attention and interest in RET has begun to drive market forces as the private sector has elevated their commitment to RET. According to a National Renewable Energy Laboratory (NREL) 2005 news release, in the US alone, more than 600 utilities offer optional programs where customers can choose to have all or part of their household electric supply from renewable sources. An estimated 430,000 utility customers, which is up 20% from 2004 and represents 2.7 billion kilowatts (kWh) of energy - a 36% increase from 2004, have used these optional programs of selecting RET sources for their home energy use. This type of spontaneous public interest is providing a stimulus for growth of renewable energy. Large multi-national companies such as Shell, British Petroleum, Sanyo, Sharp, and Siemens have made major investments in RET with the obvious intent of profiting from this resource (Eric Martinot 2005) while regional small to medium-scaled companies are also developing infrastructure in this environment.

Private Citizens are profiting and investing in RETs. Again using the US as an example, a single wind project is providing $640,000 ($US) in annual payments to local farmers with some annual wind turbine revenues returning $2000-$5000 ($US) per turbine to farmers who are leasing land to utilities operating wind farms. Local governments where wind farms are located are reaping new revenues to their tax base from wind farm leases. In terms of local employment, it is estimated that construction of a typical 100MW wind farm can produce more than 419,000 man-hours of employment for local economies (Martin Pasqualetti 2005).

Issues

Technical issues such as the general lack of comprehensive centralized energy generation and countrywide distribution system, along with technical and environmental problems in the use of fossil fuels that exist in some countries with US styled energy systems, matched with a need for rural electricification, can be an incentive for distributed generation of energy at the local level. RET has an advantage that it can be used to supplement existing generation networks via grid-tied systems in the medium or large scale; or can be used in distributed stand-alone systems in the smaller to medium levels. A distributed system lends itself to RETs in many circumstances that have direct economic and environmental as well as less obvious indirect long-term benefits. A distributed system of RET energy generation can also create jobs as the local level, revitalize small and mid-size industries, solve or forestall environmental problems, remove the requirement for large transmission grids, provide opportunities for local human resources that may also mitigate population relocation issues, and provide national or international investment opportunities.

Additionally, social and civic issues such as pollution and climate change[2] from the effects of current energy production, and the application of RET toward solving these issues, are well documented through a plethora of movie and television documentaries, books, technical journal articles, journalistic reporting, as well as university and governmental research in this area (Report from the International Panel on Climate Change 2006). Nearly all LACR countries have signed and ratified the United Nations Framework Convention on Climate Change (Kyoto Treaty). Even though as non-Annex I countries, many regional countries are not legally obligated to reduce their emissions of greenhouse gases there is still a rising social consciousness which is driving a strong commitment to comply.

The accelerating growth of RET along with raising levels of public interest in these technologies are two of the driving interests in RET education.

Governmental Responses

The focus of the governments of many advanced nations such as the US and Europe, which are also dependent on foreign sources of energy, seems to be precipitated by social and political issues such as concern for the environment, security issues relating to their dependence on foreign sources of energy such as oil, and to a certain extent economics.

Latin American and Caribbean regional issues appear to be similar yet distinctive. Regional issues tend to be more directed toward economic issues such as energy independence and using local sources of energy to reduce foreign imports that lead to savings of scarce foreign currency. Many regional countries have a critical percentage of their economy that is dependent on tourism related industries. Tourism in the region is often directed toward natural environments that rely on clean air, water, and ecologically sensitive impacts on the environment. The use of RET gives direct benefit to maintaining these conditions as well as the understated byproduct of the goodwill and public perception of the use of these sources of energy.

The executive and legislative branches of many governments are increasingly directing a focus on renewable energy technologies (RET) for the production of energy. “Some 48 countries have introduced laws and regulations to support the development of renewable energies” – quoted by Arthouros Zervos Chairman of GWEC, 2005. This focus takes many forms such as legislative incentives for the use of RET, direct investment into RET development, and increased investment in research and development of these technologies particularly at universities. A brief purview of current energy policy of the countries Latin American region obviously finds different levels of structured commitment to RET; however, interest continues to grow (Dr. Jorge M Huacuz 2003, 1995; EIA 2003; Congressional Research Service Report 2005, Database of State (and Federal) Incentives for Renewables and Efficiencies (DSIRE) 2007)

NEEDS STATEMENT

Responding to all of these developments, some universities are increasing theoretical research into RET. However, still missing from this scenario is an educated and skilled workforce that will ***provide the bridge between the theory/research of energy technologies and the application of these technologies through the analysis, design, installation, testing, operation, and maintenance of these applied technologies*** which a college level curriculum of RET could address**.** A renewable energy program could serve more than just a particular nation or region by providing trained and civically responsible engineers and engineering technologists who can assist with this ever-increasing need to apply renewable energy education and skills to local, state, regional, national, and international arenas. "*With emerging energy technologies there will be a demand for qualified*

[2] A single web search of global warming found over 49 million hits. The book and movie “An Inconvenient Truth” by former Vice President Al Gore being the most compelling and visible in the mainstream media having won an Oscar.

technologists who can assist engineers in practical application of renewable energy," (Pecen 2004). An internet and literature search of Universities offering programs in RET education found few degree programs.

As interest toward RET in energy production increases in the region, additional indirect employment opportunities present themselves as work is required to promote policies and regulations supporting RETs, investment and financing developed and sustained, small- media- and large-scale infrastructure fostered, and of course the development of the human resources that is required to facilitate the introduction and maturation of renewable energy as part of the energy supply mixture. "*Increasing global competition for energy resources, growing concern over global climate change, questions about the long-term stability of the Middle Eastern energy supplies and the tremendous progress in new energy technologies all suggest a rapidly changing landscape of energy needs, vulnerabilities, and opportunities*"- National Commission on Energy Policy 2006

Finally, besides meeting this increased need of its constituents, curriculum in RET could be directly beneficial to the college that offers this type of curriculum. The National Science Board, in concert with the National Science Foundation (NSF), supervises the collection of a very broad set of data trends in technology. This is published as the *Science and Engineering Indicator.* In their published data, they say, "*we have observed a troubling decline in the number of U.S. citizens who are training to become scientists and engineers, whereas the number of jobs requiring science and engineering training continues to grow*". Indications are that without active intervention, these flat or downward trends can be expected to continue. Minorities and traditionally under-represented populations, especially women, provide a great pool of untapped potential students for engineering and engineering technology departments[3]. Evidence is beginning to develop that suggests that a RET program has the potential to attract socially conscience students especially female students to an engineering program. "*Young women are drawn to disciplines that have an obvious altruistic quality to them, such as environmental engineering*". A 2003 research study from the University of Michigan found that women place more value on fields that tend to improve society. This is demonstrated in that women were awarded 43% of environmental engineering degrees but represented only about 17% of total engineering enrollment. Although these statistics are only for the US, these trends are anticipated to be mirrored in engineering education in the LACR.

Conclusion

With large inequalities in terms of availability of conventional energy resources particularly fossil fuels, the Latin American and Caribbean countries have been gifted with abundant renewable energy resources, although at this point these sources are severely underutilized. Other than large-scale hydroelectric projects, few countries in the region are actively working to develop, utilize, and incorporate renewable energy technologies into their national energy portfolios at a significant level. However, it is predicted that development of RETs will increase as economic, security, technical, environmental and social/political issues dictate their inclusion in national energy mixes. Necessary to meet this required interest and development is a skilled workforce that local engineering or engineering technology educational institutions can best provide.

[3] The percentage of women receiving engineering degrees in the US is approx. 15% while the population of the country is 56% female.

References

BBC News - http://news.bbc.co.uk/1/hi/sci/tech/1727312.stm

Congressional Research Service Report for 109th Congress, 2005, Energy Efficiency and Renewable Energy Legislation http://shelby.senate.gov/legislation/EnergyEfficiency.pdf

Database of State (and Federal) Incentives for Renewables and Effeciencies (DSIRE) – http://www.dsireusa.org/library/includes/genericfederal.cfm?CurrentPageID=1&state=us&ee=0&re=1

Energy Information Administration (EIA, Short term energy outlook – http://www.eia.doe.gov/emeu/steo/pub/contents.html

Energy Information Administration (EIA) – official energy statistics from the U.S. Government concerning energy. http://www.eia.doe.gov/fuelrenewable.html

Goswami D, "*Present status of solar energy education.,* Proceedings of the 2001 ASEE Annual Conference & Exhibition, session 1433

Grose T., University of Michigan Institute for Research on Women and Gender 2003 study, J. Eccles – research scientist, Prism, The Journal of the ASEE, October 2006 article "*Trouble on the Horizon"*

GWEC - Global Wind Energy Council; press release on wind growth http://www.gwec.net/uploads/media/Statistics2005_170206.pdf

Huacuz J. M., 2003 "Overview of Renewable Energy Sources in Latin America", International Electrical Research Exchange. Central American Forum. San José Costa Rica,.

Huacuz J.M., 1995, "The Role of Comisión Federal de Electricidad in the Mexican Photovoltaic Rural Electrification Program". Proceedings of the IERE Workshop Photovoltaic Rural Electrification and the Electric Power Utility

Martinot E. "*Renewables 2005 – Global Status Report"*, – www.ren21.net

Mother Earth News – Aug/Sept. 2003 – "*Find a Solar School Near You"*

National Commission on Energy Policy http://www.energycommission.org/site/page.php?node=60

National Science Foundation; "*An Emerging and Critical Problem of the Science and Engineering Labor Force*" http://www.nsf.gov/statistics/nsb0407/

National Science Foundation report, May 2005 "*The Engineering Workforce: Current State, Issues, and Recommendations"*

Pecen R., Ph.D. Associate Professor and Program Coordinator, University of Northern Iowa http://www.uni.edu/~pecen/

Singh P., Dept. Chair ECE Dept., Villanova University "*The Power of Renewable Energy to Attract Female Students of Electrical Engineering", –*; proceedings of the International Conference on Engineering Education, 2006

US Department of Energy – Energy Efficiency and Renewable Energy; http://www.eere.energy.gov/

USA TODAY article "Brazil Hopes to Build on its Ethanol Success", http://www.usatoday.com/money/world/2006-03-28-brazil-ethanol-cover_x.htm

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