AC 2007-2028: ARIZONA-TEXAS CONSORTIUM FOR ALTERNATIVE AND RENEWABLE ENERGY TECHNOLOGIES

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Lakshmi Munukutla received her Ph.D. degree in Solid State Physics from Ohio University, Athens, Ohio and M.Sc and B.Sc degrees from Andhra University, India. She has been active in research and published several journal articles. She is the Chair of the Electronic Systems Department at Arizona State University at the Polytechnic campus.

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Richard L. Newman recently retired from the Arizona State University at the Polytechnic campus as Director of Training Operations for the Microelectronics Teaching Factory. Prior to joining Arizona State University, Richard served as an Associate Director at the NSF funded Maricopa Advanced Technology Education Center (MATEC) and twenty years as a faculty member and administrator within the Division of Technology and Applied Sciences at Arizona Western College and the University of Arizona.

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Dr. Kannan's areas of expertise and research interests include low temperature synthesis of meta stable nanoscale electrocatalysts, electrode active materials and structure-property relationships through physicochemical characterization. The focus is mainly on hydrogen and direct methanol fuel cells for stationary as well as automotive applications.

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Slobodan Petrovic is an associate professor at the Arizona State University at the Polytechnic Campus. He received B.Sc. in physical chemistry from the University of Belgrade, Serbia and Ph.D. in Chemistry from the Technical University of Dresden, Germany. He has over 20 years of experience in various areas of technology such as fuel cells, Si processing, catalysis, and sensors.

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Govindasamy Tamizhmani (Mani) is an associate professor of Department Electronic Systems and the director of Photovoltaic Testing Laboratory at Arizona State University. Dr. Mani has over 24 years of research experience and 7 years of teaching experience in the fields/subjects of photovoltaics, fuel cells and batteries with over 50 journal and conference publications/presentations.

Arizona -Texas Consortium for Alternative and Renewable Energy Technologies

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Abstract

The focus of the Arizona–Texas Consortium for Alternative and Renewable Energy Technologies is to meet the workforce needs of our national energy, transportation, and electronic industries. The project intends to establish an educational consortium through collaboration between high schools and community colleges in Arizona and Texas along with Arizona State University at the Polytechnic campus. This will be accomplished by leveraging existing teaching and research expertise and facilities in the field of alternative and renewable energy.

The strategy of the project is to meet the workforce needs by increasing the number of graduates, including underprivileged groups, with Associate of Applied Science degrees (AAS), certificate programs, and Bachelor of Science (BS) degrees by preparing them using world-class facilities. Furthermore, the project embarks on creating opportunities for industry internships for AAS and BS seeking students, providing training to improve the skills of the existing workforce, offering professional development educational activities to teachers in grades 9-16 (to include community college faculty), and also serving as a nationwide and statewide public awareness vehicle.

Introduction

One of the primary requirements of high quality human life in this world is abundant clean energy. The high demand for this precious resource is significantly increasing due to the industrialization of developing countries. In addition, the global effort in exploring alternate avenues to generate energy is also climbing in an exponential manner to meet this demand. As the global population depletes the existing natural resources at a faster rate, many energy-based industries are rapidly exploring alternative energy generation and distribution avenues. The consortium will focus its efforts on preparing the high technology alternative energy workforce by providing relevant education at the AAS, certificate program, and the BS degree levels both in the state of Arizona and Texas. The consortium partners of this project are currently serving a large percentage of underserved minorities and will further assist and nurture these minority groups by preparing them for STEM careers in high technology industries.

The energy field is becoming a major economic driving force in the State of Arizona, the nation, and the world. The Department of Electronic Systems has academic programs in this emerging field supported by a unique set of laboratories that facilitate hands-on learning and research. From solar cells to wind turbines, from biogas to fuel cells, the development of alternative energy sources has become not only the moral responsibility of the current generation, but also one of the fastest growing business

sectors. As conventional energy sources approach their ultimate limitations from the standpoint of reserves and environmental impact, the energy demand of civilization steadily increases and is expected to at least triple in the next few decades. The solar (photovoltaic)/fuel cell industry is growing at the extraordinary rate of 35% per year. Today, more than 25 states in the US require electric utility companies to generate a certain percentage of electricity from renewable energy sources such as solar, wind, and biomass. For graduates of these programs (AS, Certificate, and BS) this means JOBS.

The growth of alternative energy technologies is further stimulated by the legislative requirements; for example, the United States Renewable energy Portfolio Standard (RPS) requires 1% of the US electricity be generated from renewable energy sources by 2005 and 10% by 2020, and the Arizona Corporation Commission (ACC) requires the regulated utilities to generate 1.1% of the electricity from renewable energy sources by 2005. Every $100,000 investment in the production of photovoltaic or wind generators creates one job in Arizona. All three electric utility companies in Arizona (APS, SRP, and TEP) have created special branches related to solar and hydrogen activities. These three companies have already demonstrated their commitments by installing more than 10 MW of PV modules with the highest watts-per-capita installation in the nation. The fuel cell power sources are likely to replace electrical grid, traditional internal combustion engines and batteries in several applications including homes, cars, military, cell phones, laptops and lawnmowers. Currently, every photovoltaic and fuel cell company is recruiting workforce at a greater rate than ever before. Students who are qualified/trained in these technologies will have a definite recruiting advantage. The following quotes from nationally prominent persons/organizations demonstrate an underlying importance of alternative and distributed energy programs in the universities:

- *"First car driven by a child born today could be powered by hydrogen and pollution-free." George W. Bush, President, United States (2003)*[1]
- *"Arizona should become the Persian Gulf of Solar Power." Janet Napolitano, Governor, Arizona (2004)*[2]
- *"Cheap and clean energy generation is the most pressing problem in our EE world." David Lomet, Microsoft Research (IEEE Spectrum, 2004)*[3]
- *"The era of cheap oil is over." Shell Oil, Advertisement (Time Magazine, 2005)*[4]
- *"Workforce development begins with grade school and continues into professional life."*
- *"Building on plans developed for the other technology platforms, Arizona must have actions that explicitly address the sustainable systems career opportunities." Arizona Department of Commerce, Next Big Technology Wave, March 2004.*[5]

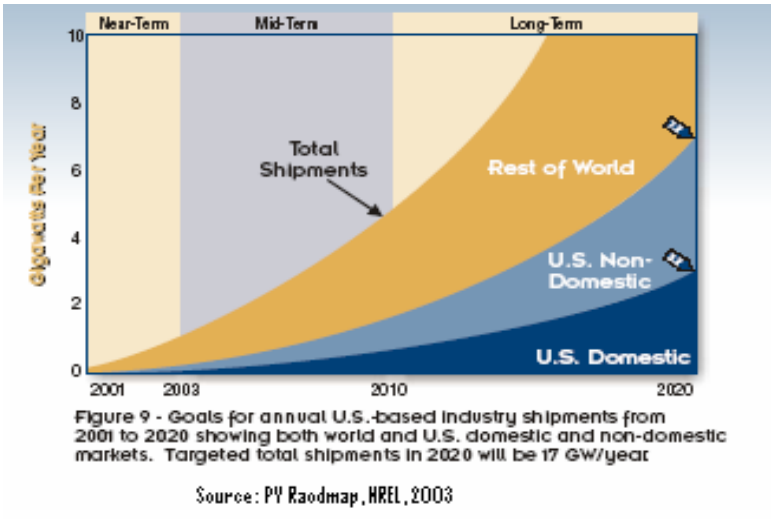

Figure 1: Projected growth rate (MW/Year) of photovoltaic module production in US and World.[6]

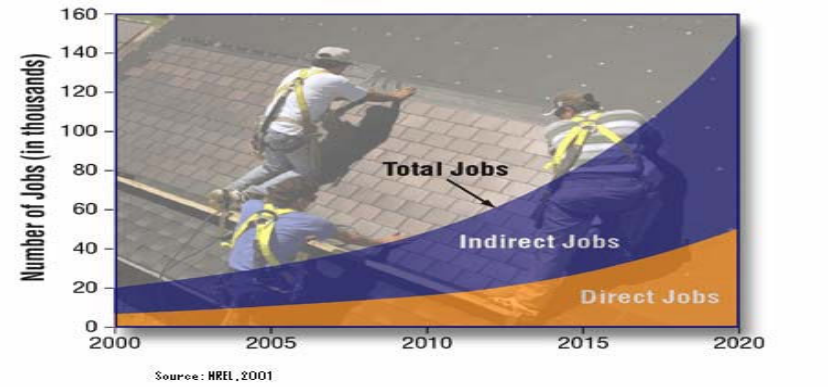

Figure 2: Projected job growth in photovoltaic industry in US[6]

The consortium partners of the project are as follows: Austin Community College (ACC), Mesa Community College (MCC), Pima Community College (PCC), Arizona State University's Polytechnic campus, the State of Arizona, Austin Energy, Arizona Public Service (APS), BP Solar, Georgetown Utility Systems, Global Solar Energy, Tucson Electric Power (TEP), Salt River Project (SRP), Southwest Gas, and Trico Electric Cooperative Inc. Our strategy is to create a regional workforce development consortium comprised of education, industry, and government organizations that foster the development and dissemination of a nationally recognized 2+2+2 bachelor's degree in Alternative and Renewable Energy Technologies. This strategy will be built in consultation with the National Renewable Energy Laboratory (NREL), and Sandia National Laboratory (SNL). Moreover, the consortium will serve as a nexus for alternative and renewable energy education, applied research, workforce development, and promotion of public awareness for renewable energy education. In addition, the

consortium will leverage the resources to create a world-class environment where technicians, technologists, and engineers of the future will gain the workplace knowledge, skills, and experience in alternative and renewable energy systems.

Curriculum Design

A curriculum development team has been established with members representing community college and university faculty, industry leaders and advisors. The curriculum team will assist in the development of curriculum based on business and industry needs, employability and transferability requirements. The team will select a team/project manger who will work directly with the Principle Investigator (PI) through each stage of the ATE development, implementation and assessment. This mutual effort by the consortium members will continue through to professional development, assessment, and articulation. Strengthening the relationships and partnerships between high schools, the community college, and university will ensure long-lasting 2+2+2 articulation agreements as well as the sustainability of the program for many years. Table 1 identifies the list of topics that are slated to be developed as courses or new modules for existing courses (highlighted courses) by the proposed consortium partners to carry out the new concentration requirements at the AAS and BS degree levels. *The best plan for introducing concepts of alternative and renewable energy will be injecting information into the existing courses.* For example, new concepts will be introduced in Information Systems Technology by adding courses on computer networking and programming for power grid management and Optical Systems Technology will develop courses on photovoltaic and solar energy and establish a laboratory with a solar panel array. A capstone course in alternative and renewable energy would incorporate the following: guest lecturers from industry; field trips to investigate operating solar, nuclear, wind and conventional power sources; laboratory instruction at ASU's Photovoltaic Testing Laboratory (PTL).

Proposed Course Titles and Development Schedules	Course #	Credit hours	Year 1	Year 2	Year 3
Introduction to Photovoltaics	XXX 100	3	X		
Introduction to Fuel Cells and Batteries	XXX 110	3	X		
Alternative Energy Sources	XXX 200	2		X	
Energy Conversion and Applications	XXX 220	3		X	
Capstone course for AAS students	XXX 240	2	X	X	
Electrical Power System Elements	XXX 200	3		X	
Industrial Safety	XXX 200	3	X		
Fuel Cells Applied Science and Engineering	XXX 300	3	X		
Solar Cells and Modules: Fabrication and Characterization	XXX 320	3	X		
Distributed Generation Systems: Design, Evaluation and Control	XXX 402	3		X	
Power Conditioning for Fuel Cell and Photovoltaic Systems (inverters and converters)	XXX 421	3		X	
Senior Project	XXX 415	3			X

Table 1: Course Development Schedule

The Instructional design process will incorporate and leverage the instructional design and development model developed as a deliverable during a prior NSF Grant titled; "The Teaching Factory", Award # DUE-0202444.

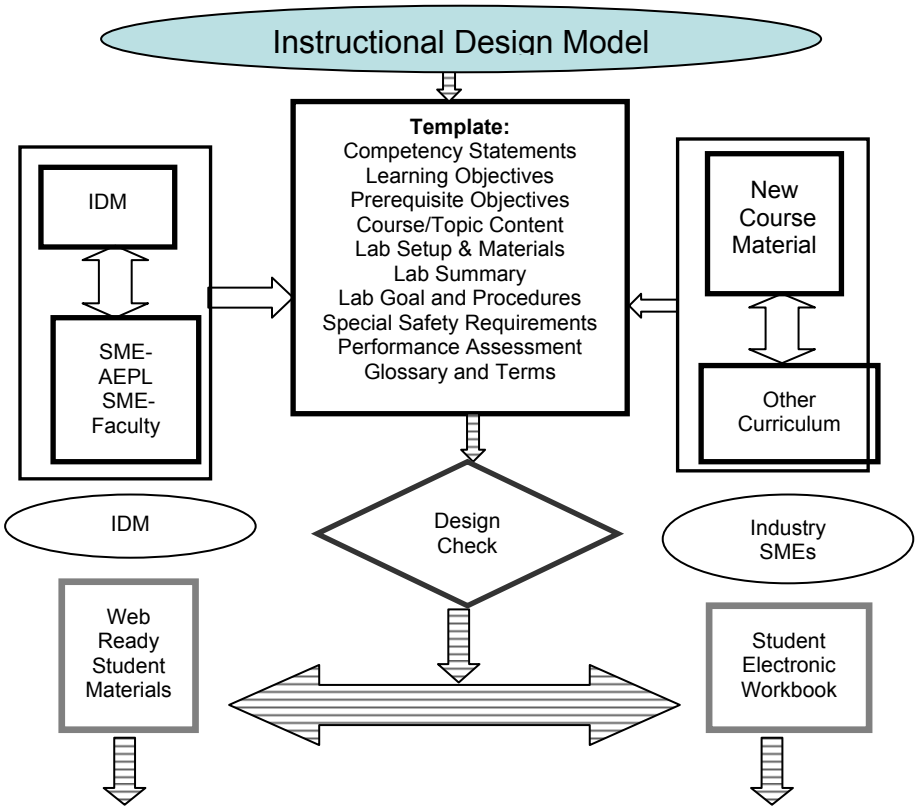

Figure 3: Instructional Curriculum and Development Process Flow[7]

Conclusion

The project team is currently working on the curriculum development; therefore, details of this work are not available at this time to include in the paper. However, the academic program concentration, ***Alternative Energy Technologies,*** received university approval to start from fall 2007 for the BS degree and also as a minor for BS degree seeking students from other programs at ASU. Existing laboratory facilities are available and adequate to accomplish the tasks outlined in the project. Because so few higher education institutions offer degree programs in alternative energy technologies, our team is working closely with those few that do. By working with those institutions who received NSF's ATE funding, we expect to leverage each others' strengths, to advance our educational agendas, and to minimize duplication of efforts.

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