

## **AC 2009-1380: ARIZONA-TEXAS CONSORTIUM FOR ALTERNATIVE AND RENEWABLE ENERGY TECHNOLOGIES**

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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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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**

## **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 (AAS, 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 10% of the US electricity be generated from renewable energy sources by 2020, and the Arizona Corporation Commission (ACC) requires the regulated utilities to generate measurable amount of the electricity from renewable energy sources starting from 2005. Every \$100,000 investment in the production of photovoltaic or wind generators creates one job in Arizona. Electric utility companies in Arizona and Texas have created special branches related to solar and hydrogen activities. The utility companies participating in the consortium companies have already demonstrated their commitments by investing heavily in renewable and sustainable forms of energy. 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. Furthermore, the Department of Labor forecast that 750,000 that jobs will be created by the year 2030 and various projected job categories are listed below. Students who are educated and trained in these technologies will have a definite recruiting advantage.

Projected job categories:

- Installation and maintenance of power generating systems including alternative & renewable
- Power plant systems operators
- Controls and instrumentation
- Field service and applications
- Hardware & software development
- Systems test and reliability
- Quality control.
- Environmental economics
- Energy analysis
- Power grid-distribution & management
- Power systems engineering (design and R&D)

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 manager 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 (Green Highlights Completed Courses)

## Batteries and Fuel Cell Course Development Process

Two courses (200 & 400 level) titled *Batteries and Fuel Cells* being developed by both ASU and Pima Community College are selected as an example for this paper. These examples highlight the salient features of the curriculum development process and approach utilized by the project team. At the onset of the project the faculty self selected his or her team assignments based on their content knowledge applicable to that module or area of interest. The consortium curriculum development team consists of six community college faculty and four university faculty, several industry subject matter experts (SME), and a grant project manager. The consortium team quickly adopted a standardized development process template that each member uses to produce the courses for their institution. The on-line templates and checklist provide a virtual authoring and development space that enables ease and consistency during each development phase. In the table1 a select list of course objectives are given for both 200 and 400 level courses as an example.

200 level course learning objectives	400 level course learning objectives
History of battery development	Principles of battery operation
Battery basics	Battery economics
Physics and chemistry of battery cells	Manufacturing and testing of batteries
Battery types	Batteries for portable electronics and other applications
Batteries impact on the environment	Batteries impact on the environment

**Table1: Course learning objectives**

A project management plan was put in place as the first order of business. Project management resources and software was used to coordinate and track the development activities and progress. Project planning tools such as Gantt charts, task assignments and deliverables were commonplace during all phases of development process. Each development team began their course development activity and assignments by identifying the competency statements, prerequisite objectives and learning objectives. A comprehensive set of prerequisite learning objectives were developed for all of the courses identified for development. Each faculty member selected the courses that best fit their subject matter knowledge or area of interest by partitioning themselves into multiple roles with associated task and capabilities in order to construct the components contained on the template. Regularly scheduled face-to-face meetings were held at each institution to compile drafts; share ideas, assume new assignments and try out the laboratory materials associated with a particular piece of equipment or infrastructure.

The developers have operated in a virtual authoring space throughout the project. The faculty and SMEs completed the bulk of the development work electronically by uploading downloading files through the on-line authoring system. The on-line authoring system minimized the need for face-to-face meetings, fostered a timely turn-around for materials submission, and overcame the constraints of developers located at geographically distributed campuses. The instructional design and project managers received the incoming drafts from all development teams; where they edited, formatted and uploaded the files to the on-line delivery system.

## **Challenges Confronted by the Curriculum Developers**

The development of body of courses related to Alternative and Renewable Energy Technologies presented a daunting task for the community college faculty teams involved in the project. The learning curve required for developing a quality Alternative and Renewable Energy Technology Curriculum was compounded by the lack of the community college curriculum developer's in-depth knowledge and work place competencies associated with the broad field of study related to Alternative and Renewable Energy Technologies. In order to overcome this challenge, several faculty development workshops were scheduled/conducted to familiarize the developers on the underlying concepts, build competency required to produce work-ready graduates and use laboratory equipment that provides practice and skill development related to a broad range of alternative and renewable energy fields.

A key goal of the project was to fully employ the expertise of Arizona State University faculty, state-of-the art applied research facilities and other university assets to develop and deliver a series of professional development workshops and internships for the community college faculty and students involved in the consortium.

Arizona State University at the Polytechnic Campus is home to a vanguard Alternative Energy and Photovoltaic Laboratory (AEPL). The AEPL exemplifies a public/private partnership; for example, its building and facilities infrastructure were constructed using \$2M in public and private monies with an annual operating budget of above \$2.5M. The AEPL is one of only three accredited laboratories in the world and the only laboratory in the U.S. to test and certify photovoltaic modules for design qualification. In addition to photovoltaic module testing for design qualification, R&D, the AEPL significantly contributes toward curriculum development and outreach program to assist the photovoltaic and fuel cell communities and the university. It maintains a strong emphasis on technology that distinguishes the curricula and out-of-class experiences of students, faculty, and staff.

Three professional all-day development workshops were hosted and taught by the ASU faculty. The university faculty provided several presentations each on various topics such as alternative and renewable energy sources, photovoltaics, fuel cells, batteries. Each lecture was coupled with a two to three hour laboratory assignment that highlighted critical sources of information such as equipment, infrastructure, testing procedures, and safety issues.

In addition industry subject matter experts provided by the companies as part of their commitment to the consortium played a key role in identifying the competencies and provided professional development and technical experiences for the community college and university faculty participating in the project. The role of the industry and universities' SME's has been invaluable to quality and currency and relevancy of the curricular resources produced thus far and has clearly impacted the overall success of the project. An example of such is the commitment by Austin Energy and Power to provide a full-time employee (Electrical Engineer) to assist Austin Community College with the development of their new Power and Energy AAS Degree Program.

### **The Role of SME's in the Development of Advanced Technology Curricula**

Ensuring currency of curricula requires that instructional materials are revised on a regular basis. The ideal would be to achieve a dynamic curricula base that evolves in parallel with technological advancement. This may be the only way to ensure that our hi-tech industries improve and maintain productivity, competence, and a competitive edge. In an attempt to meet this goal, colleges, technical training institutions, and training departments within hi-tech companies work closely with subject matter experts or SMEs (pronounced "smees") who possess the most current hi-tech knowledge and skills. These experts are familiar with the recent advances in technology, new processes, equipment, and industry "best practices." To maintain currency with technology and produce work-ready graduates, SMEs are needed to help create and maintain curriculum that addresses key technologies and emerging industry trends. To promote greater breadth of student learning, SMEs are needed to help integrate specific technical topics within core college curriculum—science, technology, engineering, and mathematics. Teaming SMEs with faculty developers, instructional designers/developers (IDs) produces an effective blend of unique abilities for scoping, structuring, and organizing technical information in a way that facilitates acquisition of technical knowledge and industry-relevant skills.

Developing curriculum for rapidly advancing fields makes it imperative to utilize SMEs who have up-to-date knowledge and are able to share this knowledge with IDs as described in the article by Gayeski, Wood, & Ford, 1992. Large companies and industry associations sometimes use their "workforce dollars" to enable some of their most knowledgeable employees (SMEs) to use company time to help develop training and education. This educational support is provided only to the degree that a significant number of graduating students master skills that make them valuable candidates for employment at contributing companies. The exchange works well for both parties, because educational organizations are historically poorer than industry, and industry loses money if sufficiently qualified graduates are not available for hire. Industry SMEs' contributions to educational programs have influenced the nature and scope of curricula. Knowledge and skills previously addressed by industry training are taught at community colleges and universities through industry's contribution of subject matter expertise. This helps educators keep the pace with rapidly advancing technology.

### **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 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. Austin and Pima Community Colleges have recently received approval to offer AAS Degrees in Power and Energy Technology. Mesa Community created a 12 credit hour certificate associated with their AAS Degree in Electronics Technology. The course material and curricular resources developed by the project is currently being integrated into the degree and certificate offerings listed above. By working with those institutions that have received NSF's ATE funding, we expect to leverage each others' strengths, to advance our educational agenda and to minimize duplication of efforts.

The outreach Programs designed to attract graduating high school students into the degree programs at both the two and four-year level is a critical component to the success of the project. Each participating educational institution in the consortium has developed outreach programs. Arizona State University has several graduate and undergraduates interning in wide range of energy related companies. Austin Community College has teamed up with their regional utility companies to successfully place 150 high school and community college student interns in energy and power related jobs. Pima Community is offering a two Summer Bridge Program for disadvantaged high school students who receive co-enrollment credit for their PCC Tech 100 Course. To date over nearly 500 students have applied for the Pima Community College Bridge Program.

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