AC 2011-1870: ALTERNATIVE ENERGY EDUCATION USING ALTERNATIVE DESIGN AND DELIVERY

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Alternative Energy Education Using Alternative Design and Delivery

Abstract

It is often said that a crisis is an opportunity in disguise. When faced with declining enrollments, the Electronic Engineering Technology (EET) faculty at Rock Valley College responded by tapping into two modern trends: the burgeoning field of sustainable energy systems, and the move towards online education. By adding a sustainable energy emphasis to the EET degree, the department prepares its students for the next generation of energy technology. By modifying its courses to be delivered in a hybrid format (lectures online, labs in person), the program offers a compatible option for students who have jobs and families that require more flexible course scheduling. There is a bold new mission for EET in the area of alternative energy. Sustainable Energy Systems (SES) professionals are needed to advance our nation's move toward freedom from fossil fuels. A curriculum has been designed based on the alternative energy job task analysis orchestrated by the Electronics Technicians Association, International. The resulting curriculum provides Alternative-Energy Integrator graduates and embeds a student learning outcomes assessment of that curriculum through industry-recognized, third-party certifications. The challenge to EET educators is to push the envelope of their comfort zones to tackle new interdisciplinary imperatives. Many students today are very comfortable learning from the internet. Hybrid educational experiences permit the lectures, and additional resources such as videos, to be delivered asynchronously, but paced to ensure timely completion. Laboratory activities are still conducted to provide students with hands-on experiences and direct interaction with their professors and other students. The design of alternative-format hybrid classes leads inherently to a detailed, concise, week-by-week course construction. This paper includes five sections: (1) Alternative Energy – A Comprehensive Overview, (2) Designing a Curriculum for Assessment, (3) The Pros and Cons of a Hybrid Course Design, (4) The Critical Issues of Enrollments and Employment, and (5) Conclusions and Future Development. The SES degree program curriculum at Rock Valley College finishes its first two years of delivery in June 2011.

1. Alternative energy - a comprehensive overview

Challenged by our administrators to increase the enrollments in our Electronic Engineering Technology (EET) program, the faculty proposed to tap into two modern trends: the burgeoning field of sustainable energy systems, and the move towards online education. Let us first address alternative energy¹.

The traditional EET curriculum establishes a marvelous underpinning for a degree program in Sustainable Energy Systems (SES). The essential elements of AC and DC circuit analysis, basic electronics, instrumentation, and controls needed to apply alternative energy sources are embodied within an EET curriculum. Further, those students who understand the somewhat invisible intricacies of electrical and electronic systems can be shown how to transfer that knowledge to analogous mechanical, hydraulic, and thermal systems. For example, a gear train is like an electrical transformer, pressure drop is like a voltage drop, and thermal resistance behaves like electrical resistance. These well-known analogies become basic concepts in a broad-based study of Sustainable Energy Systems.

Global warming predictions and a necessary independence from fossil fuels are important (but too-often political in the U.S.A.) arguments to the need for Sustainable Energy Systems.

Distributed energy generation, energy conservation, and energy efficiency are important overall goals to the operation of *any* energy system. A comprehensive approach to alternative energy must include those considerations, along with many more important aspects. Economics is always a major consideration of any real engineering solution, but in sustainable-energy systems incentives, rebates, and local taxing policies also force their way into the discussions and solution. They are temporal considerations.

At the onset, the faculty decided to constrain our program to the design and analysis of comprehensive residential and small-business alternative energy solutions. Specifically, the program does *not* target photovoltaic and wind farms or other large-scale systems, such as nuclear power plants and hydroelectric dams. Additionally, the faculty did *not* want to focus on the "boots on the roof" *installers*. Instead, it was decided to develop a curriculum for *Alternative-Energy Integrators* as the designers and consultants for sustainable energy solutions.

The SES program at Rock Valley College is therefore designed to prepare one to be an Alternative-Energy Integrator. This Integrator must understand how to analyze energy needs in residential and small-business settings.² (The associated systems will be less than 100 kW.) That analysis must lead to reduced energy consumption and incorporate appropriate distributed alternative energy generation. Recommendations must be based on a firm financial analysis that takes advantage of available incentives and rebates. It is vital the recommendation or design complies with national, state, and municipal codes and standards.

Specific areas of study include energy audits using blower doors and infrared cameras, electrical load audits, passive solar opportunities, photovoltaic systems, small wind turbines, microhydro, fuel cells as possibilities, solar hot water systems, heat pumps (air-to-air, ground source, and absorption), batteries, battery chargers, inverters, and DC to DC converters. The AC power control used for on-demand (tankless) water heaters, the control systems used for solar hot water heaters, and code-compliant AC power distribution systems must also be addressed. Electronics abounds; it serves as a solid metaphor to other nonelectrical systems. It is realized specifically through measurement needs, data acquisition, control, and interfacing. Even a seemly-simple topic such as light emitting diodes as luminaries requires an understanding of disparate topics such as buck converters, constant-current sources, power factor correction, thermal management, and electromagnetic control (EMC). All of those considerations are necessary to arrive at an energy efficient "light bulb".

The Rock Valley College 2011-2013 catalog SES program description follows:

"Graduates of the SES program have a broad understanding of energy efficiency and conservation, comprehensive energy and electrical-load audits, alternative electrical energy generation using photovoltaics, wind turbines, fuel cells, and microhydro. They also understand how active and passive solar technology (including geothermal systems) can be used to produce air conditioning via heat pumps and radiant floor heating. They comprehend solar hot water heating systems as well as well as tankless hot water heating. Graduates understand the importance of codes, standards, and permits as well as fees, financing, and payback. They also have the necessary skills to use electronic test equipment to make measurements, understand electrical schematics and blueprints, analyze electronic circuits and understand fundamental

design concepts. The graduates are ready to work in alternative energy product and service development, testing and alternative energy product certifications with an emphasis on the electrical and electronic systems. The SES program helps prepare you to take the Alternative-Energy Integrator Certification examinations offered by the Electronics Technicians Association, International."

The SES degree program sequence plan is provided in Table 1. The certification component of the program description is explained in the next section.

Fun-ume, 2-year Plan of Study											
Fall seme	ester – year 1		Spring semester – year 1								
Course	Title	Credit		Course	Title	Credit					
EET 141	DC/AC Circuits and Electronics I	4		EET 142	DC/AC Circuits and Electronics II	4					
EET 105	Intro to Sustainable Energy	3		EET 135	Digital Electronics	4					
MET 100	Intro CAD and Blueprint Reading	3		EET 190	Sustainable Electrical Energy Generation	3					
EET 107	Introduction to Codes and Standards	3		MET 162	Applied Physics	4					
MTH 125 MTH 132 MTH 100	Plane Trigonometry, <u>or</u> Pre-calculus Mathematics, <u>or</u> Technical Mathematics	3 (or 5)		ENG 101	Composition I	3					
			ETA Certification Exam Level I								
	TOTAL:	16 (or 18)	TOTAL: 15								
Fall seme	ester – year 2		Spring semester – year 2								
Course	Title	Credit		Course	Title	Credit					
EET 240	DC/AC Circuits and Electronics III	4		EET 282	EET Capstone Alternative Energy Project and Design Software	3					
EET 251	Microcontrollers and Interfacing	facing 4 EET		EET 298	EET Seminar – Alternative Energy Research and Presentations	3					
EET 277	Geothermal, Solar Heating and Lighting	3		EET 168	Internship in an Alternative Energy Company	2					
ENG 110	Technical Writing 3			EET	EET Elective	3					
CHM 105 or CHM 120	Foundations in Chemistry or General Chemistry I	4			Gen Ed Elective (SPH 131 is recommended)	3					
			ETA Certification Exam Level II								
	TOTAL:	18	TOTAL: 14								

Table 1. SES program sequence plan.

2. Designing a curriculum for assessment

The faculty agreed unanimously the new program should not be designed for installers, but rather designers who possess a great breadth of knowledge that embellishes their expertise in electronics. It was also decided that external outcomes assessment should be incorporated in the curriculum design. As part of our research, the Electronics Technicians Association, International (ETA-I ³) was contacted in January 2009. ETA-I was established in 1978. The not-for-profit trade organization provides technician-level certification examinations developed by industry-savvy subject matter experts. To our delight, alternative energy certifications were just beginning to be developed and we were invited to participate on the design committee. We leaped at the opportunity.

Initially, work was accomplished via phone calls and email. In May 2009 the committee met at the ETA-I headquarters in Greencastle, Indiana. The competencies for the Alternative-Energy Integrator were compiled and ranked. Members of the committee included representatives from California, Illinois, Indiana, Michigan, Minnesota, New York, Tennessee, and Texas. Not only did we walk away with the requisite competencies, but also with perspectives of the endeavors across the USA. A second meeting was held in February 2011 to review and revise the Alternative Energy Integrator competencies. Table 2 defines the major competency areas and provides a proficiency code key.

									-	
1.0	CODE	ES, STAND	ARDS AN	ND SAFE	TY					
2.0	ALTE	RNATIVE E	NERGY	OWER	NCENTI	ES, ECO	NOMICS	AND FE	ASIBILIT	Y ST
3.0	MAX	IMIZING E	NERGY I	FFICIEN	ICY					
4.0	PHOT	IOVOLTAI	CS							
5.0	WIN	D ENERGY								
6.0	MICR	O-HYDRO)							
7.0	PASS	IVE SOLAF	3							
8.0	SOLA	R THERM	4L							
9.0	GEOT	HERMAL	HEATING	AND C	OOLING					
10.0	ADDI	TIONAL T	ECHNOL	OGIES						
11.0	SYSTI	EMS INTEG	GRATION	1						
12.0	DEVE	LOPING T	HE SYST	EM DESI	GN AND	PROPOS	AL (HAN	IDS-ON)		
* Applie	ed Physica	al Science, Cl	hemistry a	nd Technic	al Mathem	atics are r	equired pr	erequisits	or success	in
** These	ng energ e compet	y questions. ency require	ments are	based on	residential	and small	husiness	ized applic	ations, ge	ner:
than 100	KW.							and als he have		
KEY:	U	Useful								1
1	1	Importar	nt							

Table 2. Alternative Energy Integrator Table of Contents -Draft. (Courtesy of ETA-I.) 2011 ALTERNATIVE ENERGY INTEGRATOR MAJOR CATEGORIES

Table 3 shows sample competencies and their corresponding ratings. Additional information is available at the ETA-I website.

While some educators prefer to avoid the adjective "training", it is folly to dismiss the extensive work that was accomplished collaboratively. There is certainly enough detail to begin to formulate the desired curriculum and the resulting individual courses. Our faculty used the ETA-I competencies further as a basis for our course and program objectives. At this early point we kept an eye on our need for outcomes assessment at the course and program level.

												Level 1	Level 2	Level 3
3.0	MAXI	MAXIMIZING ENERGY EFFICIENCY												
	3.1	Relate h	e how residential electrical loads are typically consumed (for example, lighting, space heating, etc.)									1.1	С	С
	3.2	Describ	e and/or co	I/or conduct a residential home energy audit										С
		3.2.1	Demons	trate ways to i	ncrease th	1	1	С						
			3.2.1.1	Suggest the	appropriat	te the U-	factor (ins	ulating va	ue) of wi	ndows		U	1.1	С
			3.2.1.2	Describe the	Describe the various ways windows are rated							U	1.1	С
			3.2.1.3	Suggest day	Suggest daylighting options to increase lighting within the home								1	С
			3.2.1.4	Suggest fixt	ure, bulb a	nd						U	1.1	С
		3.2.2	Demons	trate ways to increase the							1.1	1.1	С	
			3.2.2.1	Suggest ven	tilation cha	anges						U	1.1	С
			3.2.2.2	Describe va	rious beha	viors						U	1.1	С
			3.2.2.3	Suggest bui	lding desig	n and						U	1.1	С
			3.2.2.4	Describe the	e various ty	/pes of						U	1.1	С
			3.2.2.5	Define what	t is meant l	oy R-						U	1.1	С
		3.2.3	Demons	trate ways to i	e ways to increase the					1.1	1.1	С		
			3.2.3.1	Relate the a	dvantages	and						U	1.1	С
			3.2.3.2	Evaluate ho	w a solar tł	nermal						U	1.1	С
			3.2.3.3	Relate the a	dvantages	and						U	1.1	С
		3.2.4	Demons	trate ways to increase the							1.1	1.1	С	
			3.2.4.1	Describe the	e Energy St	ar rating	system					U	1.1	С
			3.2.4.2	Evaluate the	e performa	nce of						U	1.1	С
		3.2.5	Demons	trate ways to reduce the use of							U	1	С	
		3.2.6	List the v	various ways to inspect the							1.1	1	С	
			3.2.6.1	List the com	mon probl	em						U	1	С
	3.3	Researc	Research and understand the various energy efficiency								U	1	с	
		programs available to residential and small businesses.												

 Table 3. Alternative Energy Integrator Maximizing Energy Efficiency - Draft. (Courtesy of ETA-I.)

Competencies such those illustrated in Table 3 were reviewed by the RVC faculty and four new courses were designed. The first course (EET 105) provides an overview of alternativeenergy, hybrid-system integration. It was designed to require a minimal technical background. Strategically, this means that students can take it for general interest or as a first-semester course requirement. Of course there is a latent hope that some general-interest students will be motivated to pursue the entire SES program. The second course (EET 107) illustrates the importance of codes and standards and concentrates on the National Electric Code by illustrating wiring requirements and alternative energy generation compliance. The third course (EET 190) focuses on electrical generation using photovoltaics, wind turbines, fuel cells, and microhydro. The fourth course (EET 277) examines heat pumps, geothermal heating and cooling, tankless water heaters, solar thermal water heating, solid-state lighting systems (SLS) using LEDs, and the associated electronics for measurement and controls. These courses are indicated in the program sequence plan shown in Table 1.

The ETA-I examination questions map to the Integrator competencies. Our college course objectives are also mapped to the Integrator competencies. Our course (and program) outcomes assessment are mapped to our course and program objectives. Simply, our course objectives can be mapped to ETA-I competencies. The success of reaching those objectives effectively can be measured internally within our institution. The success of the program's first year and graduates of the two-year program can be measured using externally-developed measurements.

On further reflection and discussion, the faculty determined that several existing courses could be adjusted to serve SES goals as well as those of our traditional EET program. For example, the definition of a current source taught in our basic circuits and electronics course (EET 141) can include a photovoltaic module or a grid-tied inverter as practical examples to why the topic is necessary. Both our capstone project class (EET 282) and our seminar (independent student research) class (EET 298) can permit an SES emphasis.

The ETA-I Alternative-Energy Integrator Level I and Level II examinations can be taken after the first and second year of the SES program, respectively. The ETA-I provides institutional feedback regarding the examination results. This allows external assessments of the first year and the entire program. Table 1 illustrates the program and indicates the ETA-I certification examinations. By becoming an approved Certification Administrator, a faculty member can administer the examinations on campus. Further, the examination can be scheduled to meet the needs of the institution.

3. The pros and cons of a hybrid course design

The faculty decided to move into a hybrid course design. A hybrid course is a 50-50 split with half being internet based and half laboratory based ⁴. The flexibilities afforded by an on-line course are well-suited to many students as they can be made to fit with their work schedules and family commitments. It is important to point out this portion is asynchronous, but is paced on a week-by-week basis. Our college is trying to minimize student trips to campus. This hybrid approach fits well with that goal, and also reduces required carbon emissions inherently by design.

The faculty, however, felt that a hands-on approach is too important to abandon. They are not willing to relinquish personal contact, nor direct observations of the students and critical instructor-student interactions. Discussions about making "marathon" laboratory sessions once a month have occurred. However, many issues remain to be reconciled at this point.

The proper design of an on-line course is self documenting. That is both a huge advantage and requires a tremendous amount of work initially. Our first attempt at an alternative-energy course was taught by two faculty members. The team-teaching approach helped to keep the work load manageable. Even so, the challenge was formidable.

As hybrid courses are developed, it becomes easier to turn them over to colleagues and adjuncts. The choice of the learning management system (which in our case is Angel) controls the ease (or the difficulty) of taking advantage of features such as the generation of randomized examinations drawn from a test bank. By incorporating the course objectives linked to the course assessment questions, it becomes much easier to generate individual course outcomes assessments automatically.

4. The critical issues of enrollments and employment

Our EET enrollments have increased since the SES program was implemented in the Fall 2009 semester as indicated in Fig. 1 by the credit hours sold. Many of the students are younger, but all of them are eager and passionate. They are excited about making a difference in their world and employment prospects. Our SES student have a wild fresh enthusiasm, but face much larger challenges than have ever existed previously.

Figure 1 provides the EET student number of credits sold. Admittedly, student numbers increase during times of high unemployment, but the marked increase in the number of credits sold indicates that we are attracting more full-time students.



Figure 1. EET program enrollment data. (The SES program started in 2009.)

The SES degree program differs from our traditional EET program by 15 credits. Many students are interested in obtaining *both* Associate in Applied Science degrees. This has further increased the demand for our courses. That effect will be reflected in the 2011 enrollment data that is not yet available.

In spite of a sluggish economy, the number of "green" jobs is growing. Some would argue the rate of job creation remains low. The website <u>http://www.thegreenjobbank.com/</u>⁵ reports (3/11/2011) there are 10,390 green jobs with 1,979 green employers. Large wind and solar projects are proliferating. Consider these announcements also offered on the website:

• December 27, 2010: Siemens AG announced that it has closed a huge deal with the Iowa utility MidAmerican Energy for 258 wind turbines to be installed at three Iowa wind farms. The deal is the largest-ever onshore wind turbine order for Siemens.

- December 27, 2010: Illinois Governor Pat Quinn announced that long-term agreements have been executed to advance the state's ongoing efforts to expand renewable energy use, create green jobs and increase sustainability. The winning wind and solar energy vendors will supply Ameren and ComEd with renewable electricity to provide to consumers throughout the state. The 20-year agreements will help ensure long-term cost and rate stability for consumers across Illinois.
- December 22, 2010: Wind turbine manufacturer Nordic Windpower has chosen Kansas City, Missouri, to relocate its headquarters and operations, currently in California and Idaho. The company's move to facilities near Kansas City International Airport is expected to cost \$16 million, and create 200 jobs.
- January 5, 2011: At least 169 manufacturing companies are working to serve Ohio's clean-energy sector, according to an analysis by the Environmental Law and Policy Center. "What we're seeing is that old-line manufacturers are retooling to create the components for the growing renewable-energy market," said Howard Learner, the group's executive director.

An article "Job Study: Solar Workforce on the Rise" in the December 2010/January 2011 issue of Home Power magazine⁶ stated "A national survey of solar labor market conditions authored by The Solar Foundation (TSF), a solar research and education nonprofit organization in Washington, D.C., shows that more than 50% of all solar firms expect to add jobs over the next year, …" The article continues with "According to the study, solar firms – any company performing work related to PV, solar water heating (including pool heating), and solar space heating and cooling – expect to add jobs at a pace that is much faster than the general economy's growth. Solar companies anticipate their workforce to grow by 26% over the next year …This increase represents 50,000 new jobs spread across the solar-related industries, …".

Residences and small businesses are investing in photovoltaic power, solar hot water, and small wind turbines. These incremental investments do not make newspaper headlines. The weak economy has certainly limited the number of projects. Small businesses are being formed to supply design services and installation. Reporting of these small projects is usually provided by not-for-profit alternative energy associations. In our region we have the Illinois Renewable Energy Association, the Illinois Solar Energy Association, and the Midwest Renewable Energy Association. The memberships invariably include small businesses, and that can be a great source for jobs and internships. These organizations support and advocate for alternative energy small business development. Their messages are finally resonating beyond interested home owners.

We (at Rock Valley College) are also guiding our students to learn about entrepreneurship opportunities – make your own jobs and appreciate those provided by business owners. There are so many unfilled needs, the resulting opportunities are vast. We also counsel our students to remember that they are degreed electronics technicians. Alternative energy is driven by politics and the economy. They must be resourceful, flexible and adapt. This is precisely why our faculty did not choose to develop a photovoltaic or wind turbine installer program. The alternative-

energy need is certain, but may not be realized in the short term. We provide graduates with solid knowledge, hard skills, and many options. This should certainly be the capstone of all career education.

5. Conclusions and future development

Technical needs should always drive technical education. Response to current needs must be based on future *perceived* needs. Responsible technical curriculum design must draw on vast resources. The success of any endeavor must be established by careful measurements. External measurements reveal unbiased truths.

The Alternative Energy certification examinations are expected to be released by the ETA-I during summer 2011. At that time we will have a tool to apply to the outcomes assessment work for both the first and the second years of the Sustainable Energy Systems degree program at Rock Valley College. Part of our "routine" course assessment is being generated by our Angel Learning Management System. Each assessment activity is mapped to the objectives defined for each course. Our program also requires an internship. At present we have internship positions ten students this summer. We have also had inquiries from another company that is interested in two students. It is the internships that will speak to program assessment activity most strongly. Do the students perform well? What changes should be implemented?

Companies are exploring their roles and opportunities in alternative energy. A local heating ventilation and air-conditioning company is looking to two of our student interns to help them expand its operation to offer comprehensive energy services. Two Alternative Energy Integrators should be able render invaluable service.

Our EET role continues to be to responding to mandates in technology, adjusting to student learning needs, surviving within limited resources, designing in continual assessment, and embracing the necessary balance to guide our approach. Nothing is new here. People depend on us doing our job effectively. We repect that expectation.

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