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Jack Adams

Merrimack College, adamsj@merrimack.edu

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Renewable Energy Education at Merrimack College **John Adams, Merrimack College, North Andover, MA, 01845**

Session: Interdisciplinary programs, sustainability and alternative energy as related to engineering education

Abstract

This paper describes recent, ongoing and planned Renewable Energy (RE) education at Merrimack College. The primary RE education efforts have been through the department of Electrical Engineering (EE), with involvement from the department of Civil Engineering. In summer of 2009 the college installed a solar hot water (SHW) system in one of its student townhouses. The subjects of the advanced EE elective “Energy Measurement and Display” in summer 2009 were the selection of sensors to measure energy delivered by this SHW unit, and the uploading via Ethernet of real time data to a central server. The EE department requires all students to take “Embedded Controller Design”, and as a sequel a PIC based independent study focusing on sensing and evaluating energy consumption is presently under way. A number of Energy Savings and Power Quality independent studies have taken place over the past several years, with students developing embedded applications for measurement and assessment of donated Power Quality /Energy Savings systems.

A collaborative effort is underway between Biology and Electrical Engineering for summer, 2010, leading to a 4-credit “Renewable Energy and the Environment” course for non science majors. This cross disciplinary course is based in the EE department with significant input from the Biology department. A Kill-O-Watt meter serves as the “textbook” purchase, with required student real-world projects in energy usage assessment, and in evaluating effectiveness of remedial actions. This collaboration between EE and Biology is an initial effort towards greater collaboration between the two departments.

The Civil Engineering department piloted the senior elective “Environmental Design” in Fall 2009, with student teams running feasibility studies for renewable energy installations including Photovoltaic, SHW and Wind. The next iteration of this course will incorporate participation of EE and business students.

Background and Overview

The Merrimack College Department of Electrical Engineering is a unique EE department in that it sits in an undergraduate, Augustinian college. The department is the only ABET accredited EE Program to offer a part time evening program in New England, and in addition has a very active co-operative education program. A typical graduating class is on the order of 15 students, with most students going directly into industry.

Although the EE department differs markedly from many other EE programs, we believe that lessons learned here can provide value to others. This paper begins with a discussion of EE coursework pertinent to renewable energy/energy efficiency. The creation and early experiences with a Renewable Energy and Energy Efficiency (RE³) advisory board are reported. The role of the EE department in leading the campus efforts in the RE³ area and in helping to shift campus culture are discussed. The paper concludes with a summary and suggestions for future efforts.

Electrical Engineering Specific Coursework

The EE department has a hands-on approach from early on in the curriculum, which lends itself well to directed studies and special topics RE³ coursework. The course sequence in the freshman and sophomore years culminates in an “Embedded Controller Design” course in which the students learn to utilize the 8051 in a real world application including monitoring, timing, and signal generating applications. Students propose a topic, which they then design, write and debug the assembly code, interface, and troubleshoot. After taking this course, students are well prepared to go on in their junior and senior years with embedded controller based projects involving measurement and control. The figure below provides a flow chart of the pertinent coursework.

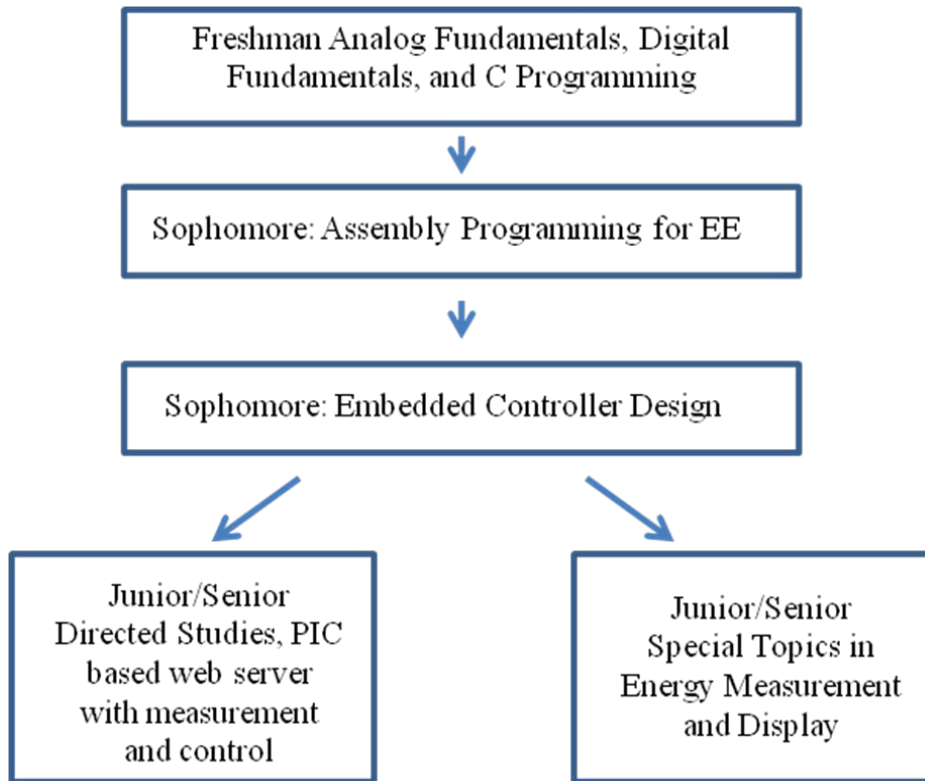


Figure 1: Coursework for EE majors pertinent to renewable energy.

The special topics course “Energy Measurement and Display” was held in summer 2009, with “Embedded Controller Design” as a prerequisite. The course focused on sensor choice and controller interfacing of a Solar Hot Water (SHW) system installed on one of the College’s townhouses during the same time period. Part of the intention was to monitor energy savings due to the SHW deployment, and then to stream the data to a web page. This approach is fairly common now in renewable energy installations – see for example [1] as one of many solutions. From an educational perspective, coverage of sensor choice, embedded and internet programming, as well as energy calculations and display, proved very interesting to the students. During this course, students learned quite a bit about sensors: however, the initial idea of utilizing an 8-bit controller with an embedded web server and Ethernet connectivity was not implementable using an 8051 controller. Going forward, the department is standardizing on PIC controllers that have on-chip Ethernet for cases where internet connectivity is key.

Two EE students are pursuing special topics courses in spring 2010 based on the PIC controller, with a Celeritous board at the heart of the project [2]. The Celeritous solution includes a TCP/IP stack and a “tiny” web server that includes all code needed for on board html pages including dynamic content. The PIC 18F67J60 [3] is utilized, a part featuring an embedded Ethernet controller, 11 10-bit A/D channels, 128k of flash, and over 3k of RAM. This is quite a bit more feature-laden than the vast majority of 8051s: however the EE department continues to use the 8051 for its sophomore course as the assembly instructions for an 8051 are much easier to teach and learn than the PIC instruction set – the PIC is much more oriented towards C programming. With lessons learned in this course and the “Energy Measurement and Display” course the department is building a knowledge base for further work in energy measurement, display, and control.

Other directed studies coursework in the RE³ area has focused on power quality and power factor monitoring. The EE department has received two donations of Power Quality units that utilize LC tank filtering. Significant energy savings have been measured and documented, and students have been involved throughout the process.

Ongoing and Completed Efforts

At the initiative of the EE department, the College has formed a Renewable Energy and Energy Efficiency Advisory Board – the Merrimack College RE³ Advisory Board. The membership includes key decision makers at the college, including the Dean of Science and Engineering, the VP of Finance, and the Director of Physical Plant. External members include experts from National Grid, BayState Gas, along with others bringing knowledge of HVAC, Co Heat and Power (CHP), and Demand Side Management to the table. The mission of the board is as follows:

“To further the adoption of renewable energy and energy efficiency technology at Merrimack College in order to reduce environmental impact, save money, create educational opportunities, and partner with external agencies.”

As of this writing, the board is still in its early stages, with development of a coherent overall strategy as the first order of business. A number of successful RE³ strategies have been adopted at the college in recent years, including the SHW installation mentioned above, an ice making installation incorporating state of the art heat reclamation, and more. Up to the present, these strategies have been pursued piecemeal rather than as part of a coherent strategy.

Role in Campus Sustainability Effort

The EE department is taking the lead in RE³ educational efforts within a general education context. This is happening via both coursework and involvement in the college's sustainability efforts.

A course entitled "Renewable Energy" for non-science majors is scheduled to be piloted during summer, 2010. This 4-credit course uses the existing 2-credit "analog fundamentals" course as its foundation, with the basic concepts of voltage, current, Ohm's law, power and energy all introduced. From there, students learn about renewable energy and energy efficiency options, and carry out their own "greening and saving" project by course completion. Students are required to purchase a Kill-O-Watt meter, and to obtain and analyze their family utility bills. A fundamental course intention is that the students use the "real world" and their lives as a key part of the learning experience. The College is actively considering and developing an Environmental Studies and Sustainability Program, and the "Renewable Energy" course would be part of the curriculum.

The college has an active sustainability committee, with college-wide recycling as one of a number of initiatives. The EE department leads the RE³ area of this "sustainability" effort. EE is involved in helping to shift the student culture through awareness, for example by human-powered electricity generation demonstrations. In these demonstrations the students can get a clear feeling of the difference between powering, for example, a 100 Watt incandescent bulb and its compact fluorescent equivalent.

Conclusions and Future Efforts

The EE department has made significant strides in recent years to expose majors to RE³ concepts. The early exposure to Embedded Controller Design in the EE curriculum lends itself well to coursework on monitoring and display of energy production and consumption, and power quality and power factor, among a number of related topics. Going forward, the intention is for the college to implement RE³ solutions on a much larger scale, with CHP and Photovoltaics in the mix. EE can play a significant role in monitoring and payback calculations. Other special topics/directed study work can involve building monitoring, with insulation efficiency monitored via IR cameras and temperature sensors.

The EE department has, with the support of the College's administration, created an RE³ advisory board. This board, while in its early stages, has extraordinary potential to positively influence the College's environmental impact via education, partnership with industry, and development of a coherent strategy.

The EE department has a significant role in general education and the College's sustainability effort. The "renewable energy" course is suitable for any non-EE major, and can serve as a nice component within an Environmental Studies and Sustainability Program. Going forward, the intention is to closely integrate this course with the Biology course "Ecology, Environment, and Society". All non-Science and Engineering majors at Merrimack are required to take two courses within the Science and Engineering division. The combination of "Renewable Energy" and "Ecology, Environment, and Society" can serve as a superb 1-2 punch for non-majors interested in sustainability. As a side benefit of the "Renewable Energy" offering, non-majors involved in the college's sustainability effort will be better informed in their decision making process and be better able to provide leadership in influencing the student culture of the college.

References

[1] Specs and fascinating example pages for the Web Energy Logger can be found at: <http://www.webenergylogger.com/>

[2] The overview, and related downloads can be found at www.Celeritous.com

[3] The product page for this part is available at: <http://www.microchip.com/wwwproducts/Devices.aspx?dDocName=en026445>

John Adams completed his PhDEE at the University of Massachusetts in 1990, after which he joined the Engineering and Public Policy Department of Carnegie Mellon University as Research Faculty. His research interests include biological effects of electromagnetic fields, visualization of electromagnetic fields, the use of experiential learning techniques in teaching Electromagnetics, and renewable energy education. He presently is Associate Professor and Chair of the Department of Electrical Engineering of Merrimack College, a position he has held since 2000. 978-837-5363, Jack.Adams@Merrimack.edu.