

Center for Sustainable Energy

University of Massachusetts Lowell

Annual Report

August 18, 2006

1. Brief Overview of Center

In the abstract, the Center for Sustainable Energy exists to develop systems to provide energy for various end uses in an environmentally and economically sustainable manner. In the concrete, past and present projects in the center have focused on rural renewable energy systems for medical, educational, town, and agricultural use, solar/electric/fuel-cell systems, photovoltaic-assisted lighting, green building thermal efficiency test methods and case studies, solar crop drying, solar design tools, solar resource databases, and PV battery testing. The center is unique in the degree to which it combines undergraduate and graduate education, research, public service, service-learning, and public education into its projects.

Mission Statement

The Center for Sustainable Energy seeks to improve energy efficiency in end-use sectors and to increase the diversity of energy resources consistent with an economically and environmentally sustainable future. The center strives to combine undergraduate and graduate education, research, public service, service-learning, and public education into its projects.

2. Objectives

More specific objectives within this broad mission include:

- Be a leader in village renewable energy systems through research and education.
- Incorporate service-learning with sustainable energy projects into engineering courses at U Mass Lowell.
- Work with faculty to incorporate service-learning projects into mainstream courses throughout the College of Engineering in particular, but other colleges and other universities also.
- Design and install solar/hydro systems for vaccine refrigeration, transceiver radio communication, lighting, laptop PCs, water purification, and agriculture for remote medical clinics, schools, and towns in Peru and develop infrastructures for local people to take over development and maintenance of such systems.
- Develop solar electrolyzer-fuel cell systems for remote areas.

3. Focus Areas: Discovery/Learning/Engagement (Research/Teaching/Service)

Some of our focus areas that in general combine discovery, learning, and engagement (research, teaching, and service) include:

- The Village Empowerment Project involves the development of systems appropriate for use in developing countries: low cost; reliable; sustainable in terms of energy, environmental impact, and economics. Students, both graduate and undergraduate, develop such systems as parts of service-learning projects in courses and theses for graduate degrees. Trips have been made twice a year for two weeks since August of 1998, led and organized by the center.
- Service-Learning Integrated throughout a College of Engineering: SLICE. The goal here is integrate service-learning (S-L) projects into mainstream required courses in the engineering programs so that every student has at least one course every semester with S-L. One of the objectives, besides better learning of subject matter in the courses, is recruitment and retention of underrepresented groups in engineering. To date, over half the engineering faculty (along with a few others in other colleges) have incorporated S-L into at least one course. The center director is the faculty coordinator for this project.
- What appears to be the only academic program with a graduate degree explicitly in solar energy engineering is essentially run in collaboration with the center. The director of the center is the graduate coordinator of that program.

4. Faculty/Staff Members

The following faculty/staff are members of the center:

John Duffy, Director (as of May 1996), Mechanical Engineering Department (solar electrolyzer/fuel cell systems, electric vehicles, thermal testing of buildings, passive solar systems, PV systems, solar rural systems)

Raul Raudales, Principal of Mesoamerican Development Institute (solar crop drying, solar water purification)

Hong Wei Sun, Assistant Professor, Mechanical Engineering (MEMS micro systems, solar thermal concentrators).

Paul Soper, former University Chaplain, Catholic Center (developing countries)

Cheryl West, research associate, formerly with the Center for Work, Family, and Community, presently doctoral candidate Work Environment program (aquaculture and service-learning)

Alan Rux, Electrical Engineering Department (solar radios, assistive technology)

Bill Moeller, Professor Emeritus, Civil Engineering (sustainable development)

There are about 30 faculty members (including the dean and three department chairs) that have incorporated service-learning into their courses as part of the SLICE initiative in the college of engineering. The initiative is led by John Duffy of the Center.

5. New Faculty and Staff Affiliations

We have collaborated with the following new faculty and staff:

- Linda Barrington, Director of Service-Learning College of Engineering. Linda reports directly to John Duffy and is supported in part by the NSF SLICE grant and in part by the university.
- Hong Wei Sun, Assistant Prof., Mechanical Engineering. Collaborated on service-learning projects related to heat transfer and energy efficiency and will be working with a Fulbright Fellow coming from Nigeria for the next academic year to study solar thermal concentrators to produce heat and hydrogen.
- Yan Luo, Assistant Professor, Electrical and Computer Engineering. Worked on service-learning projects in his computer architecture courses involving remote sensors for monitoring and control of temperatures, purchased with SLICE funds.
- Chris Niezrecki, Assoc. Prof., M.E. Chris is the co-PI on the solar water purification project funded by the NCIIA. We also collaborate on some service-learning projects in his design of machine elements course.
- Joel Therrien, Assistant Prof., ECE. Joel is a former student in energy engineering, and we collaborated on a service-learning project in his circuits course for a hydro educational display system at the Tsongas History Center.

6. Students

The following graduate students have worked in/with the center since June of 2005:

Somchai Jiajitsawat, solar vaccine refrigerator development (D. Eng. in process)

George Nitschke, geothermal and solar ponds for hydrocarbon and water production (D.Eng. in process).

Nelly Vladmirsky, CPC photovoltaic roof shingles (MS thesis in process)

Peter Dubro, solar water purification indicator with TiO₂ catalyst (MS thesis in process)

Ujjwal Bhattacharjee, financial incentives for renewable energy (D. Eng. in process)

Nuchida Suwapeat, optimal design algorithm for reliability of solar remote communication systems (D.Eng. thesis completed)

Nto Diarra, stochastic systems approach to solar water pumping design with applications in Mali (D. Eng. in process).

Jesús Solis, biogas systems for farms in cold remote areas and service-learning.

Manuel Heredia, solar water purification with bottles coated with TiO₂ and service-learning.

Jorge Barrientos, green building case studies.

Tanya Martinez, indigenous peoples reservations green building designs.

Eric Morgan, service-learning in engineering.

Robert Williams, service-learning in engineering.

Several others supported by the SLICE grant on service-learning under the direction of other faculty.

In all, 12 graduate students were supported financially through the center.

In addition, 10 undergraduates worked on capstone design projects through the center.

- ◆ Degrees awarded by the university, with theses based on work at the center:
 - D.Eng., Mechanical Engineering, Nuchida Suwapaet, thesis: Optimal Reliability Design Method for Remote Solar Systems
 - M.S., Solar Energy Engineering, Sachin Jamadagni, thesis: Estimation of the Energy and the Associated Environmental Impacts of the Draft MA-CHPS Rating System.
 - M.S., Solar Energy Engineering, Christopher Lin, thesis: A Service-Learning Renewable Energy Project

7. Current Discovery/Learning/Engagement Projects

Major current projects include:

- Village Empowerment: Two more trips to Peruvian villages, in January and June 2006, with 12 and 17 students/volunteers, respectively. We now have over 70 systems in 29 different villages in the same region. The villages in general have no electricity, no telephone service, no space heating, biweekly bus transportation, and untreated water, in several cases only from open streams. The systems, which harvest energy with photovoltaic modules, solar thermal collectors, and microhydro turbines and in some cases from the grid, provide radio transceiver communication, lights, vaccine refrigerators and other medical devices, water supply and water purification, roads, aquaculture fish, laptop computers, and science experiments in schools, medical clinics, and municipalities. Some of the systems have dramatic impacts: In perhaps the most remote village of the group with no electricity and no telephone, in the six months prior to our installing a transceiver radio in the medical clinic in January 2006 there were seven deaths related to childbirth due to delays in getting medical help; from January 2006 to our return in June 2006 there were no deaths in childbirth. Technologies being developed with graduate and undergraduate students as well as volunteers during the past year include:
 - Sand filter water purification system
 - Solar water purification with recycled soda bottles coated with an emulsion of TiO₂ in collaboration with a team from Argentina.
 - File transfers with radio modems and wireless 802.11b internet access with parabolic antennas over long distances to remote villages
 - Inexpensive radio transceivers for medical clinics, most solar powered.
 - Solar water pumping systems
 - Microenterprise development for aquaculture, solar headlamps and lanterns, and water purification.
- Service-Learning Integrated throughout a College of Engineering: SLICE. The goal here is integrate service-learning (S-L) projects into mainstream required courses in the engineering programs so that every student has at least one course every semester with S-L. To date, over half the engineering faculty (along with a few others in other colleges) have incorporated S-L into at least one course. The center director is the faculty coordinator for this project.

There are many other current projects mentioned in various other sections under students, publications, grants, etc.

- Grants obtained:
 - Implementation of Service-Learning Integrated throughout a College of Engineering (SLICE); PI John Duffy, sponsor: NSF (\$1,005,000; 2005-08)
 - Solar Water Purification Bottles for Developing Countries; sponsor: National Collegiate Inventors and Innovators Alliance (\$12,500; 2005-2006)
 - Village Empowerment: Interdisciplinary Service-Learning, Healy public service endowment grant, UML (\$8000, 2005-2006).
 - Assessment of MTC Green Buildings; sponsor: Massachusetts Technology Collaborative Renewable Energy Trust (\$59,000; 2005-06)
 - Diversity in Engineering through the Village Empowerment Project; sponsor: UML Council on Diversity and Pluralism (\$3000; 2005-06)

8. Publications

Publications and presentations include:

- Bhattacharjee, U., and J. Duffy, 2005, “Renewable Energy Portfolio Standard: Impacts of financial incentives on residential owners of photovoltaic system,” *Proceedings of the 2005 Solar World Congress*, International Solar Energy Society, August.
- Duffy, J.J., 2005, “Village Empowerment : Sustainable Solar Solutions,” *Proceedings of the 2005 Solar World Congress*, International Solar Energy Society, August.
- Suwapaet, N., and J. Duffy, 2005, “Optimal Reliability Design Method for Remote Solar Systems,” *Proceedings of the 2005 Solar World Congress*, International Solar Energy Society, August.
- Diarra, N., and J. Duffy, 2005, “A New Design Method for PV Pump System Optimization,” *Proceedings of the 2005 Solar World Congress*, International Solar Energy Society, August.
- Tavaranan, S., and J. Duffy, 2005, “Solar Lanterns for Remote Areas,” *Proceedings of the 2005 Solar World Congress*, International Solar Energy Society, August.
- Aurora, P., and J. Duffy, 2005, “Solar Hydrogen Fuel Cell Modeling,” *Proceedings of the 2005 Solar World Congress*, International Solar Energy Society, August.
- Banzaert, A., J. Duffy, and D. Wallace, 2006, “Strategies for Integrating Service-Learning into the Engineering Core at the University of Massachusetts Lowell and the Massachusetts Institute of Technology,” *American Society of Engineering Education Annual Conference Proceedings*, June.
- Kazmer, D., J. Duffy, and B. Perna, 2006, “Learning through Service: Analysis of a First Semester, College-Wide, Service-Learning Course,” *American Society of Engineering Education Annual Conference Proceedings*, June.
- Bhattacharjee, U. and J. Duffy, 2006, “Effect of PV on Reducing Demand Charges: Case of a 26 kW PV System in MA,” *Proceedings Annual National Solar Conference*, American Solar Energy Society, July.

- Jamadagni, S., and J. Duffy, 2006, “Energy and Associated Environmental Impacts of the Draft High Performance School Rating System,” *Proceedings Annual National Solar Conference*, American Solar Energy Society, July.
- Jiajitsawat, S., and J. Duffy, 2006, “A Portable Direct-PV Thermoelectric Vaccine Refrigerator with Ice Storage through Heat Pipes,” *Proceedings of the 2006 National Solar Energy Conference*, American Solar Energy Society.
- Duffy, J., 2005, “Sustainability in International Service-Learning Projects,” “Village Empowerment: Peru Project,” invited presentations, Engineers for a Sustainable World national annual conference, U. Texas, Oct..
- Duffy, J., 2006, “Village Empowerment: Peru Project Service-Learning,” invited course presentation, Penn State, March.
- Duffy, J., 2006, “Service-Learning in Mainstream Required Courses in Engineering,” invited presentation, NSF Conference on Service-Learning in Engineering, National Academy of Engineering, DC, May.
- Duffy, J., 2006, “VILLAGE EMPOWERMENT: Sustainable International Service-Learning,” poster presentation, NSF Conference on Service-Learning in Engineering, National Academy of Engineering, DC, May.
- Duffy, J., 2006, “SLICE: Service-Learning Integrated throughout a College of Engineering,” poster presentation, NSF Conference on Service-Learning in Engineering, National Academy of Engineering, DC, May.
- Jiajitsawat, S., “A Solar Thermoelectric Vaccine Refrigerator with Ice Storage through Heat Pipes,” poster presentation, Ninth Annual UML Student Research Symposium, April 25, 2006.

9. Collaboration and Outreach

The center collaborates with approximately 35 faculty members through the SLICE project in developing S-L projects in undergraduate and graduate courses. It also collaborates with at least 12 local community partners in those S-L projects. Of course, we collaborate with various government bodies (Ministry of Health, Ministry of Education, and local town governments) in over 29 villages in Peru. Other collaborative endeavors with other universities are mentioned under the faculty and publication sections above.

Collaboration with industry includes:

- Stellaris Inc. used the center lab (E405) to help develop compound concentrating plastic roof tiles with photovoltaics. Stellaris received a first place award at the Ignite Clean Energy Competition of the Energy Special Interest Group (ESIG) of the MIT Enterprise Forum of Cambridge in May 2006.

10. Grants

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