ACS Environmental Programs: CFD Alliance Application
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Developing Multidisciplinary Curricula through Green Energy Initiative

1. Introduction

Centenary Professors from multiple disciplines (English, Chemistry, Biology, Physics, Mathematics) seek to install a 720-watt solar array on one building on campus for the purposes of energy sustainability, but also for purposes of curriculum development. Professors from each discipline will develop teaching modules around the solar array to be used in relevant courses. The installation of a solar array marks a first step toward sustainable technologies in use and on display at Centenary. Finally, this project will significantly impact the college's Environment and Society minor as multiple courses in that minor will benefit, and will help Centenary's Chemistry Club meet the qualifications of the Student Affiliates of the American Chemical Society (SAACS) to become a Green Chemistry Club.

The selected location for the solar array is the Library roof, which provides space for 4 panels and additional area for expansion. We propose to install a 720-watt System which will produce 1117 kilowatts per year (93.1 kw/month, 3.1 kw/day). According to a solar pathfinder analysis of the site, and taking into account the photovoltaic watts rating of the panels and the efficiency loss from the inverter, the solar array will produce enough energy production each day to power:

- 16 20-watt fluorescent lights (120 watt incandescent equivalent) for 10 hours
- 5.5 Desktop computers with printers for 10 hours

An example classroom that could be powered from the solar array, with energy to spare:

- 8-20 watt fluorescent lights
- 3 ceiling fans
- laptop computer with wall display monitor
- 2 misc. small appliances

The solar energy generated from a 720-watt solar array prevents 1,469 pounds of coal from being burned each year, prevents 2,592 pounds of CO_2 from being released into the atmosphere each year, and conserves 924 gallons of water each year.

a. Goals

- To foster collaboration between departments through developing a comprehensive pedagogy anchored by common interest in sustainability and conservation.
- To incorporate environmental themes into a range of courses.
- To expose students, in concrete ways, to the promise of sustainable technologies.
- To teach students the physics, chemistry, and mathematics of solar energy.
- To provoke student explorations of the social consequences of our current energy crisis and the politics of alternative energies.
- To allow students to explore issues of energy production and consumption, which provide a gateway to discussions about pressing social and environmental issues such as sustainability, pollution, global warming, global politics.
- To model sustainable living practices for campus and community.

b. Justification

The solar array will provide a working laboratory for students to study issues of sustainability and green initiatives from multiple disciplinary perspectives. Rather than study these issues through hypothetical examples, a level of distance that, perhaps, reinforces the sense that real change is impossible, students will able to see and touch and study this technology.

c. Match with listed priorities

By installing a solar array to be used as a teaching aid, our faculty will be able to:

A. refine existing courses to incorporate environmental themes.

B. expand the rubric of institution's environmental studies minor.

D.1. add to the curriculum of courses in mathematics, social science, or humanities through the incorporation of an environmental module. Such modules will address:

- environmental mathematics/statistics
- sustainable development
- environmental policy & practice
- environmental ethics
- environmental philosophy (not listed)
- photovoltaic physics (not listed)
- technology studies (not listed)

It should also be noted that Joshua Lawrence, the originator of this proposal, has not previously received funding from the CFD alliance

2. Project Description

a. Activities

1. Raise funds.
2. Purchase the solar array.
3. Install solar array and grid tie.
4. Develop curricula.
5. Integrate curricula.
6. Evaluate the project and publish results.

b. Timetable

Implementation of this project, from fund-raising to installation, to teaching and evaluation, should take one school-year. Our projected timetable is as follows:

Jan-May 2008	Summer 2008	Fall 2008	Spring 2008
Raise Funds for Solar Array, develop plans for installation and curricula.	Purchase and Install Solar Array.	Begin teaching with Solar Array, collect teaching assessment data.	Cont. teaching with Solar Array, collect teaching assessment data, write and submit final report.

c. Budget and justification for each line item

1. 4-180 Watt Panels: $800 each=$3,200
2. Racking for panels (necessary to secure panels to flat roofs): $250
3. Grid-Tie Inverter (converts DC electricity from solar panels to AC electricity): $1000
4. DC & AC Disconnect Boxes (Safety devices turn off DC & AC current for maintenance to solar system and utility company power lines): $160

5. Wireless Data Monitoring: donated by One Planet Solar
6. Labor for Utility Meter: $50
7. Labor for installation: donated by One Planet Solar)
8. Building Permit: $90
9. Wire, conduit, & electrician hookup: provided by school

Total Cost: $4740.00

Total Request from the ACS: $3000.00

d. Syllabi

Listed here are some of the courses that will incorporate solar array modules, as well as module descriptions.

1. **Chemistry 105: Chemistry and Society. Part of Environment and Society (ENST) minor. Enrollment: 35.** Students will perform an experiment that demonstrates the increased capacity of CO_2 to absorb heat over CO_2-free air. They will assemble and test a solar cell based on TiO_2 and anthocyanine dye, and discuss the structural features of the dye that allow light to be absorbed. They will calculate the volume of CO_2 produced by the gasoline consumption of each student and the volume of CO_2 not produced each year because of the solar panel.
2. **Chemistry 121-122: General Chemistry I-II. Part of Chemistry, Biology, Physics, Biochemistry, and Neuroscience majors. Enrollment: 80.** Students will discuss the composition of the solar cells when studying periodic properties and metalloids. They will use Gibbs free energy and stoichiometry calculations to predict the *minimum* amount of CO_2 emissions prevented by the use of the solar panel.
3. **Chemistry 401: Advanced Inorganic Chemistry: Part of Chemistry major. Enrollment: 5.** Students will discuss types and properties of p- and n-type semi-conductors, and learn how these materials are used in the construction of solar panels.
4. **English 290: Ecology, Technology, Culture. Part of ENST minor. Enrollment: 20.** Students will keep an "energy journal" in which they record their energy consumption habits for one week. They will then frame that data in terms of CO_2 emissions. They will then tour the solar array and collect data from the solar array's wireless data monitoring device and will compare this data to their energy consumption habits in order to gain a critical understanding of energy consumption practices and how they contribute to global warming, pollution, and economic dependency.
5. **Environment and Society 302: Special Topics. Capstone course for ENST minor. Enrollment: 20.** Students will explore the political, economic, and ideological impediments to sustainability by investigating alternative energy technologies such as solar. In addition to hands-on engagement with solar technologies via the array, students will study the history of solar research in relation to energy lobbies (i.e. oil and gas).
6. **Physics 317: Electronics. Enrollment: 20.** A solar panel array would provide students with an excellent "real life" application of an exploratory laboratory that would be incorporated into Centenary's electronics physics course. The exploratory laboratory would follow the procedural protocols established by the Chemistry Department at the University of California, Los Angeles, [1] where students create small-scale solar panels using chemistry and physics. Combining the laboratory experience with observations made using the full-scale solar array provide a unique opportunity for students explore the science behind the devices and connect that science to the social and environmental

impacts associated with smaller ecological footprints.

[1] May Leung Chiu, Amar Flood, Steve Joiner, Alshakim Nelson, and Rob Ramirez, Solar Cell Experiement, The California NanoSystems Institute, University of California, Los Angeles Science Outreach Program, (March 2006), http://voh.chem.ucla.edu/classes/Solar_cells/

7. **Mathematics 115: Analytical Geometry and Calculus I. Enrollment 30; Mathematics 303: Multivariable Calculus: Enrollment: 15.** The array will serve as an example of flux and will help create optimization problems.

3. Evaluation and Dissemination

a. Evaluation

The project will be evaluated in two ways. First, we will collect syllabi and assignments to determine how well faculty are able to incorporate the solar array into their courses. Secondly, we will administer an assessment tool at the end of relevant courses to measure student learning and engagement. Because the solar array will be used differently in each course, assessment will likely vary.

b. Dissemination

The project will be publicized through a report to the ACS that will serve as a model for other schools hoping to implement a similar project. This report will consist of a project description as well as sample syllabi or teaching modules. We also hope to highlight the project on Centenary's website and through the Ecology, Technology, Culture wiki (http://www.centenary.edu/etc)

4. Institutional Approval: forthcoming from Provost Darrel Colson

5. Disclosure Statement

We are seeking an additional $1000.00 from Centenary's student government, and another $1000.00 through on-campus fund-raising. The college will contribute an in-kind donation of electrical installation, labor, and materials necessary to tie the array into the electrical grid.

6. Curriculum vitae: For Hamming and Lawrence. See attached.