Work in Progress - Integrating Energy Issues and Technologies into an Electrical or Computer Engineering Curriculum

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Abstract - **Most modern electrical engineering and computer engineering programs place emphasis on low power circuits and systems. The critical energy issues now facing the United States and the world, however, are concerned with the generation and distribution of large amounts of energy using high power generation facilities and networks. The Electrical and Computer Engineering Department at Lafayette College is exploring ways and means to integrate energy-related technical material, energy issues, and energy policy considerations into the existing Electrical and Computer Engineering degree program. This paper describes initial steps taken toward this goal, the projected curricular additions and changes, and the rationale for incorporating energy-related course material and laboratory exercises. The work in progress aims to provide an alternative to other approaches that either introduce one or two dedicated courses, or develop an entire energy course stem, to provide electrical or computer engineers with significant energy-related studies.**

Index Terms – Energy, ECE curriculum, Senior Design

INTRODUCTION

To seamlessly integrate energy technologies and issues into an existing EE/CE/ECE curriculum, significant constraints must be imposed. First, the curriculum must remain primarily an Electrical or Computer Engineering degree program. Core course requirements must therefore be preserved. Second, students must be provided with a significant academic experience related to energy in *each* of the four years of the BS degree program. A strategy must therefore be developed to integrate material on energy with existing courses. Third, students should become familiar with traditional — fossil fuels, hydro, and nuclear — means for providing energy, as well as the nontraditional, renewable — wind, solar, and biofuels — energy sources. Material on emerging energy technologies – hydrogen, geothermal, and wave – energy sources should be an option.

It is generally agreed that prospects for the "energy answer," at least for the foreseeable future, is not embodied by nuclear fusion breakthroughs. This being the case, the answer most likely will be a combination of energy sources and resources contributing in a complementary way to provide the more than one-hundred quadrillion Btu's of energy that represents the appetite of United States energy users. The urgency of curricular change to confront this "grand challenge" is the present reality that such a large fraction of our energy needs are provided by nonrenewable, fossil energy resources. This, coupled with the ultimate scarcity of fossil resources and the growing body of evidence linking climate change to carbon dioxide emissions, points to at least a strategic, if not moral and ethical obligation, to emphasize energy issues in engineering studies in all fields.

THE FIRST YEAR

Lafayette College faculty presently offer two first-year seminar courses related to energy in place that relate to technology, energy, and the environment. These are all-college courses and deal primarily with energy resources, energy use and policy issues. Incoming students with interests in energy issues would have the opportunity to enroll in a seminar that has an energy or environment focus. With enrollment caps of fifteen students in a seminar, there are obviously more seminars needed. A recent initiative to stress energy issues on a campus (like many others) seeking to go green should provide the initiative for more selection. For engineering majors there is a required Introduction to Engineering course that, because it has a significant design component, introduces concepts of power and energy as a matter of engineering principles basic to the design process.

THE SECOND YEAR

Engineering students would enter the second year of studies with some exposure (significant exposure if they have completed an energy-related first-year seminar) to the concepts and importance of energy at the system level, or the global level, or both.

There are ten second-year courses in Lafayette's Values and Science & Technology (VaST) program that consider technological development and societal issues that are related directly or indirectly to energy. These courses take a closer look at technologies associated with energy and the moral/ethical problems that arise. ECE majors would be encouraged to select one of these courses to satisfy their VaST requirement. In addition, a second year required course in digital circuits is planning to adopt a laboratory project related to the generation or distribution of energy.

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This could take the form of a practical application to data acquisition in a renewable energy system.

THIRD AND FOURTH YEAR

Ideas are presently being considered to introduce a photovoltaics project to a third-year required course in Solid-State Electronics. This would combine principles of solid state circuit design and solar energy.

In the fourth year, and more to the point of electrical energy generation, the current capstone course in the ECE program is the design and implementation of a rooftop solar array to provide a modest amount of green electrical power. This capstone design course could be altered in succeeding years to consider expansion of the solar system, wind turbine generation systems, or solar collectors for alternative applications. This would guarantee that ECE graduates have had a major design experience associated with energy technology. Figure 1 below illustrates the sequence of courses that would be involved in the integration process.

YR1	YR2	YR3	YR4
1st Yr Seminar	→ Values, Sci, Technology	→ Electronics Design	→ Sr Capstone Design
Intro to Engrg	→ Digital Design	↑	

Figure 1. Course Sequence with Embedded Energy Issues and Technologies.

PROJECT STATUS

The fulfillment of the objective of integrating energy issues and technologies into the ECE curriculum at Lafayette College has appropriate courseware in place at the second year and fourth year levels. In the second year, the presence of Values and Science & Technology courses offers options, and the digital laboratory is targeted for experimentation. Curriculum decisions will need to be agreed upon to guarantee that particular VaST selections are compulsory, and that the digital circuits lab incorporates appropriate experimentation. The fourth-year capstone design course has already been transformed.

For the first year, the students' selection of a first-year seminar is entirely their decision. However, course changes in the Introduction to Engineering course to further emphasize energy issues will likely require agreement across departmental boundaries. This is a challenge; ironically, the increasingly critical nature of energy production is an ally.

For the third year, a suitable laboratory-based design project related to energy is being considered and is subject only to departmental agreement.

IMPORTANCE TO THE EDUCATIONAL COMMUNITY

The long-term solution to the world's energy demands is one of the grand challenges that faces the scientific and engineering communities. It appears that there is not a "silver bullet" that will be the key to satisfying global energy demand while, at the same time, being of little or no risk to the environment. The challenge presented by the energy problem begs for engineering innovations that will lead to creative solutions to a problem that has environmental, economic, political, and societal dimensions. The introduction of energy-related courseware across the ECE curriculum and at many institutions would be a sensible and helpful change. It will be crucial to assess the effectiveness of the eventual implementation of the proposed integration. The Department's well-established assessment tools and metrics will be a part of this. In addition, the graduating seniors' exit interview will be enhanced to assess in particular the outcomes related to a four-year curricular thread emphasizing energy issues and technologies, and whether future plans include energy-related studies or employment.

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