The Development of an Alternative Energy Minor at Robert Morris University

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The Development of an Alternative Energy and Sustainability Minor at Robert Morris University

Abstract

Energy experts have identified seven energy sectors as strategically important for the economy of the Unites States. These energy sectors are: coal, natural gas, nuclear, solar, wind, transmission & distribution and intelligent building. Along with Chicago and Detroit, Pittsburgh is among the only three cities in the nation with high employment across all of these seven energy sectors. Additionally, Pittsburgh is the only city that also resides on a natural resource base of coal and shale gas fields. In consideration of the existing energy activities in the Pittsburgh region, these energy sectors are addressed in the School of Engineering Mathematics and Science (SEMS) energy curriculum. In the fall semester of the 2010 school year at Robert Morris University, SEMS began laying the groundwork for what is now an alternative energy minor. This is an interdisciplinary minor that was developed through the combined efforts of engineering and science faculty. The curriculum was based on the currently available expertise in environmental science and engineering. The initiative began as a collaborative effort and after multiple meetings and the consent of the university registrar; the minor was offered to the students and has achieved a very promising enrollment in the first semester of its offering. The alternative energy minor is comprised of three capstone courses and two elective courses, totaling 15 credits. The minor also has two tracks, one tailored to SEMS students and another which has a background in business sustainability. These two tracks open this minor to the entire student population at RMU. This paper discusses the steps taken to enact the minor, as well as the lessons learned in the course development process. In particular, the classes currently offered as part of the minor are discussed and the reasons for developing these courses are detailed.

I. Introduction

The School of Engineering, Mathematics and Science (SEMS) was founded in 1999 by building on the existing Department of Quantitative and Natural Sciences. Undergraduate offerings from the Engineering Department currently include an ABET accredited B.S. in Engineering (tracks in Software, Industrial, Mechanical and Biomedical Engineering) and a B.S. in Manufacturing Engineering. The department also offers an M.S. in Engineering Management. Mathematics offerings currently include B.A. and B.S. programs in Applied Mathematics including a very successful Mathematics Education program, Finite Mathematics and a B.S. in Actuarial Science, which is an advanced and rigorous program. The Actuarial Science degree is accredited by the Society of Actuaries and RMU is among 10 institutions in the nation that is recognized as a Center for Actuarial Excellence. Science offerings include a B.S. in Biology, both B.S. and B.A. programs in Environmental Science, a Biology Teacher Certification program and a Pre-Medicine program.

Two minors are also offered. One in forensics and our new interdisciplinary minor in Alternative Energy and Sustainability that is the subject of this article. Industrial and

educational outreach is accomplished through the SEMS Research and Outreach Center (ROC) which has an extensive outreach program to middle and high school communities.

To emphasize the endeavors and desire for excellence within our school, we include our school's mission statement:

“The School of Engineering, Mathematics and Science will prepare engineers, mathematicians and scientists for leadership roles in a rapidly changing world. Our graduates will benefit from a professionally focused, applied education, derived through active classroom learning, laboratory experiences and cooperative education alliances with industry.”

The school offers graduate and undergraduate degrees showcasing the best of Robert Morris University’s practical, real-world philosophy of engaged and applied learning. In biology, environmental science, pre-medical, mechanical engineering, and mathematics, our faculty are experts in their fields.

Close ties to the business world allow our students to tackle real problems under the guidance of their professors. Internships and research are key to our curriculum, helping our graduates gain subsequent employment. Students work with sophisticated lab equipment, such as our 7,500-square-foot Engineering Learning Factory and dedicated science laboratories in physics, chemistry, biology and environmental science. RMU's focus on communication and business skills gives graduates an advantage in the job market. All of our students enjoy small class sizes and personal attention that make RMU a special place to learn.

It is this interdisciplinary background and strong vocational emphasis, along with Pittsburgh's status as a future energy capital that makes RMU the ideal environment for training our future workforce for careers in the alternative energy sectors, and providing local employees with science and business graduates with a strong background in environmental issues and sustainability.

On a recent visit to Pittsburgh, President Obama outlined the importance of energy [1]:

“The time has come, once and for all, for this nation to fully embrace a clean energy future. Now, that means continuing our unprecedented effort to make everything from our homes and businesses to our cars and trucks more energy-efficient. It means tapping into our natural gas reserves, and moving ahead with our plan to expand our nation’s fleet of nuclear power plants. It means rolling back billions of dollars of tax breaks to oil companies so we can prioritize investments in clean energy research and development.”

Obama’s words ring loud and clear in the Pittsburgh area. There has been an economic boom in the Pittsburgh area that is directly related to the Marcellus Shale natural gas wells.

In a recent study done by researchers at Penn State University, Marcellus Shale drilling has lead to 44,000 jobs in the Pittsburgh region and has generated about $3.9 billion dollars in economic activity in 2009 [2]. The increased emphasis in energy has lead to substantial industry activity and an emphasis on green jobs in the region. According to the 2010 Milken Institute Best-Performing Cities Index, which ranks U.S. metropolitan areas by how well they are creating and sustaining jobs and economic growth, Pittsburgh was ranked 32nd in 2010, up 77 spots from 2009 [3]. Pittsburgh's emphasis is not only on creating jobs, but creating green communities and cleaning up the city. Pittsburgh is the home of the first green Leadership in Energy and Environmental Design (LEED) certified convention center (David Lawrence Convention Center) and conservatory (Phipps Conservatory) in the world, as certified by the U.S. Green Building Council [4]. In fact, as of 2010, there were 54 green buildings throughout the city, making Pittsburgh the 4th ranked city in the nation in the number of green buildings [5].

With a city-wide emphasis on sustainability, RMU has decided to do its part in educating our future workforce to increase their environmental knowledge and awareness. Through the development of a new minor in Alternative Energy and Sustainability and in addition to existing educational and outreach programs, RMU is doing its part to meet the objectives of the students and their future employers. The purpose of this paper is to detail the structure and design decisions in developing our new minor. In addition, a breakdown of the courses taught within this minor and the reasons for choosing these particular courses for inclusion are provided. The emphasis throughout this process, as reflected in the resultant minor, is the interdisciplinary collaboration between science and engineering faculty to create a broad program capable of addressing our future societal needs.

II. Structure of Alternative Energy and Sustainability Minor

The Alternative Energy and Sustainability minor is comprised of a total of 15 credits. The first 9 credits of the minor consist of three core courses which are required by all students pursuing this minor. Two of the core classes offer an introduction to the issues of energy generation and our future sustainability, while discussing the role of technology in addressing these issues. The final core class is a capstone class in which expert speakers are invited from the campus community and the Pittsburgh region to address topics following a particular alternative energy course theme. The students are required to complete an undergraduate research project that is related to this theme.

The remaining 6 credits that students are required to complete as part of the minor are chosen from a number of upper-level courses focusing on specific areas of expertise in both science and business disciplines. This increases the accessibility of the minor to the wider RMU community and introduces alternative energy and sustainability to non-science students.

The courses which constitute our minor are included in Table 1.

Core Courses	
ENVS/ENGR 1022	Energy Fundamentals and Sustainability
PHYS/ENGR 1023	Alternative Energy Technologies
ENVS/ENGR 4112	Energy Research Seminar
SEMS Elective Courses	
ENVS/ENGR 2012	Renewable Resources
ENVS/ENGR 3022	Energy Storage, Conversion and Transportation
GEOL/ENGR 4022	Conventional Energy: Fossil Fuels
Business Elective Courses	
MGMT 3850	Business Governance and Corporate Social Responsibility
ECON 3060	Environmental Economics
MGMT 3750	The Sustainable Organization
MARK 4700	Sustainable Marketing

Table 1. A list of the interdisciplinary courses which comprise the Alternative Energy and Sustainability minor.

The precise choice of courses was considered, after much deliberation and discussion, to be the optimum structure to meet the goals and objectives of the minor for students that are not only science or engineering majors, but for the entire student body The details of these courses are listed below.

III. Course Details

Included is a detailed description of the topics covered in each of the courses that comprise the core of the Alternative Energy Minor as well as the elective courses offered by SEMS.

III.1. Energy Fundamentals and Sustainability

The Energy Fundamentals and Sustainability course is an introductory course that focuses on energy production and use throughout the residential, commercial and industrial sectors. The course educates the students on the different types of energy streams and the current energy sector breakdown on a local, national and international level. Students are also introduced to sustainable energy production, including photovoltaic, solar thermal, wind powered, hydro powered and geothermal energy generation. This course includes

discussions about the potential environmental, political and socioeconomic ramifications of continued conventional energy generation as well.

III.2. Alternative Energy Technologies

This course endeavors to elucidate recent and future developments in alternative energy technologies. In particular, this course covers recent scientific developments and the latest technological advances in areas of science and engineering associated with power generation. Students develop the necessary skills to quantitatively decipher scientific articles and to qualitatively interpret the scope and conclusions of recent scientific research. Subjects covered in the course are drawn from recent scientific breakthroughs, aimed at improving the cost-effectiveness and practicality of renewable energies. The strength of this course as part of the minor lies in its ability to motivate students about the contemporary science and research behind alternative energy, and to emphasize to students that new scientific breakthroughs are always occurring within the research community.

III.3. Energy Research Seminar

The Energy Research Seminar is the capstone course for the Alternative Energy Minor and is taken by juniors or seniors. The course focuses on current issues of importance in the Alternative Energy field. Expert speakers from the campus community and the Pittsburgh region address topics following a particular course theme selected by the instructor. Students are expected to review and critically discuss selected articles and have the opportunity to serve as discussion leaders during the semester. Each student prepares a research paper or conducts undergraduate research on a specific topic, either of their own choosing or assigned by the instructor, which is aligned with the Alternative Energy theme of the course.

III.4. Renewable Resources

This course provides a comprehensive overview of renewable energy technologies including: biofuels, geothermal energy, hydroelectric power, hydrogen fuel cells, solar energy (active and passive), tidal power, and wind energy. The types of energy and potential uses from each energy source are covered. The energy budget and overall efficiency of a wide variety of renewable energy sources are calculated. The economic, social, and environmental impacts of each technology are also considered.

III.5. Energy Storage, Conversion and Transportation

This course introduces conventional and renewable mechanisms for the transfer and storage of electrical energy. The course beneficially integrates class presentations and hands-on demonstration activities. The topics include: electrochemical storage systems and related power densities; super capacitors, lithium batteries, fuel cell systems, proton exchange membranes, fuel cell stacks; basic principles of operation and future development needs; materials for energy storage and conversion; conventional lead-acid,

zinc-air, nickel-cadmium and nickel-metal hydride batteries; fuel cell architectures and electrode life times; purely ionic conductors; mixed ionic / electronic conductors; ionic transport, conductivity in polymers; AC to DC and DC to AC transformers and electrical circuits; economics of energy storage and conversion.

III.6. Conventional Energy: Fossil Fuels

This course is a review of the three major fossil fuels: coal, oil and natural gas. It includes an in-depth review of the geological processes responsible for the formation of conventional fuels, including the national and international distribution of these fuels. The combustion process as related to fossil fuels is discussed, as are the techniques and technologies utilized in the exploration, use and environmental remediation of the fuels. The history of the industry devoted to exploration and use of these fuels is discussed. The effects of these fuels on climate change is also included in the course review. Non-conventional fossil fuels are also discussed including Marcellus Shale exploration.

Development of the Alternative Energy and Sustainability Minor

In a political climate where national news channels openly attack the scientific community, and leading political figures read excerpts from the bible in congress to "disprove" the scientific consensus on global warming, science education is crucial if the United States are to lead the world in both developing alternative energy technologies and reducing greenhouse gas emissions [6]. However, not only is alternative energy and sustainability important from a national perspective, but Pittsburgh as an energy capital will play a large role in the development and application of renewable energies (as well the uses of conventional energy sources, such as the large reservoir of natural gas within the Marcellus Shale). Therefore, in addition to existing educational and outreach programs at RMU, a new minor in alternative energy and sustainability was proposed to better prepare our students for a future workforce in clean energy and green jobs.

It is worth noting that RMU in particular is well suited to the development of such interdisciplinary programs. The Science Department within the School of Engineering Mathematics and Science (SEMS) houses a diverse range of faculty including a chemist, a geologist, an environmental scientist, three biologists and a physicist. Furthermore, the Science Department within RMU is also closely associated with the Engineering Department, which also includes a diverse range of expertise within the engineering disciplines including manufacturing, nanotechnology, renewable energy sources, and energy storage technologies. The close relations between the Science and Engineering Departments within SEMS led to this new interdisciplinary minor and remain its largest strength. Many of these courses were developed with input from a number of different faculty from both the Engineering and Science departments, and the minor continues to draw from this diverse pool of expertise.

The six courses that are currently part of the minor were chosen for multiple reasons. The first reason, is that the courses should encompass a broad spectrum of topics from life cycle assessment and sustainable design to specific renewable resources. One of the purposes for

introducing the students to a full spectrum of alternative energy topics is to broaden their fundamental knowledge in the area, and to make the students more attractive to a wide range of future employers. Another important reason for the exposure is to foster interest in more specific area of the students' choosing which could lead to future graduate level research projects. Although RMU does not currently have a graduate level alternative energy program, preliminary discussions seem promising and the inclusion of a graduate program is in the near term goals for SEMS. A broad spectrum of courses was an important aspect of the development process, but another aspect that was equally important was the expertise of our faculty. Because the development process included the input of the faculty in the engineering, mathematics and science departments, we were able to take into account the views and expert opinions of faculty from a multitude of backgrounds. This diversity lead to a course selection that was tailored toward the faculty knowledge and strengths.

The exact structure of the minor was established, along with the detailed course contents at a SEMS retreat held on October 8th 2010. In particular, 18 members of faculty from the Engineering, Mathematics and Science departments were all present at the retreat. The retreat consisted of two components. The first part consisted of a discussion on the overall structure and design of the minor, at which point the 6 courses which constitute the minor were decided upon. Not only do these 6 courses provide an excellent balance between science education in alternative energy and sustainability in the core classes, but the upper-level electives provide a comprehensive overview of our energy requirements in the 21st century.

The second component of the retreat consisted of the faculty splitting into 6 groups, each group tasked with developing one of the above courses. The groups were asked to develop a course description, syllabus and describe how they saw the course fitting into the minor. The courses were then finalized and put into the RMU course catalog. In order to spread the word about the newly established Alternative Energy and Sustainability Minor on campus, flyers and brochures were printed (the brochure can be viewed in Appendix 1 and 2). Along with the distribution of the printed materials, emails were sent out to the faculty and students, and the SEMS faculty were encouraged to announce the minor in their classes.

Conclusions

The development of the RMU Alternative Energy and Sustainability Minor was an experience that involved a great deal of collaboration between the engineering, mathematics and science departments. The minor, which consists of a total of 15 credits, was first offered in the fall semester of 2011 and has had a significant amount of interest among the students. RMU currently has a total of 10 courses that will be offered for the minor and there is a distinct possibility of the minor expanding into a graduate level program in the near future. In an effort to prepare students for the ever-increasing emphasis on the environment in the current workforce, RMU has successfully developed an

Alternative Energy and Sustainability Minor that will give RMU students an advantage in the job market.

References

1. Bill Schackner, Katie Falloon, "Obama touts economic, energy policies in CMU speech," Pittsburgh Post-Gazette (June 02, 2010)

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3. Milken Institute, "2010 Milken Institute Best-Performing Cities Index ranks," http://www.milkeninstitute.org/

4. Leadership in Environmental Sustainability, CMU-BCA Executive Development Program 2011," http://www.bcaa.edu.sg/enews/201101/pdf/CMU_draft6.pdf

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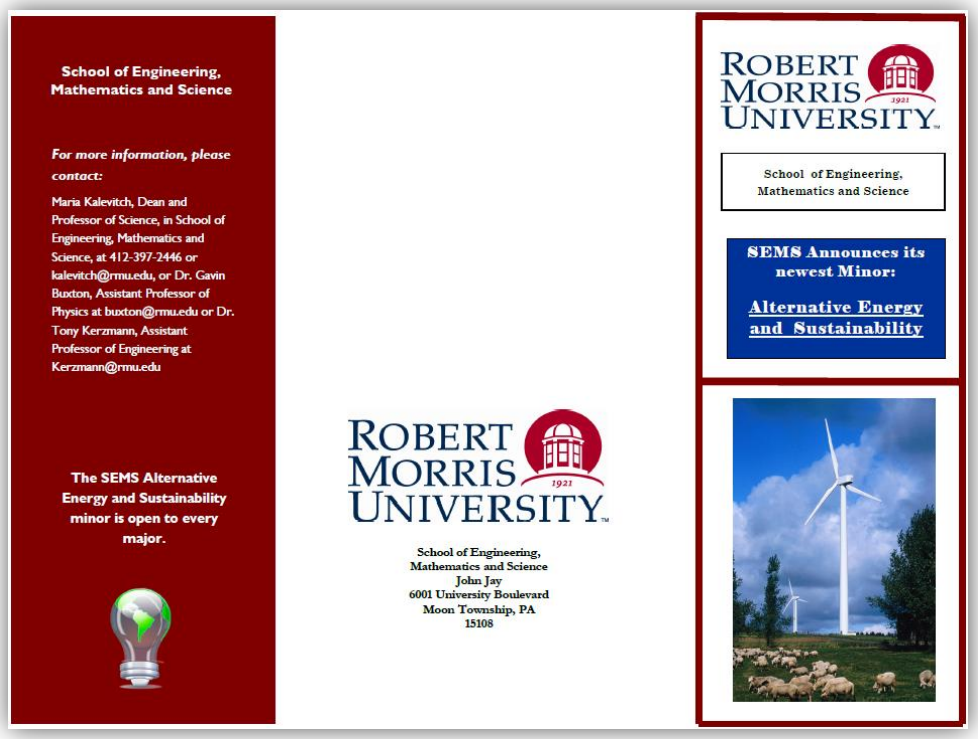
6. "Science scorned" Nature 467, 133 (2010)

Appendix 1: Cover of the Alternative Energy Minor Brochure



School of Engineering, Mathematics and Science

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The SEMS Alternative Energy and Sustainability minor is open to every major.

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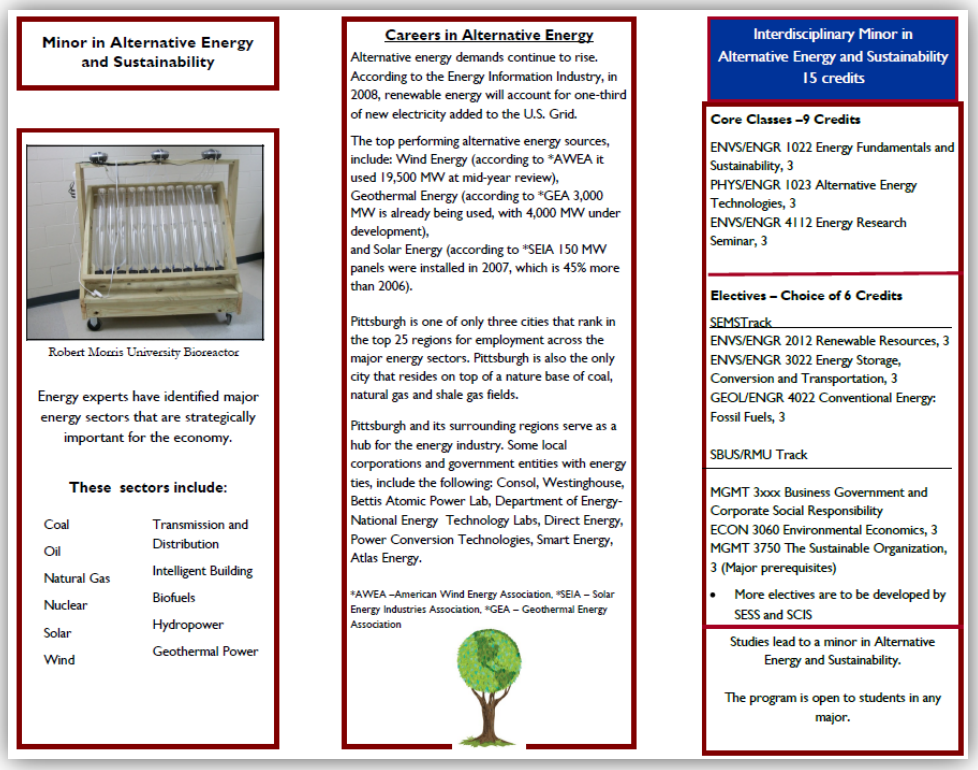
ROBERT MORRIS UNIVERSITY

School of Engineering, Mathematics and Science

SEMS Announces its newest Minor:

Alternative Energy and Sustainability

Appendix 2: Inside of the Alternative Energy Minor Brochure



Minor in Alternative Energy and Sustainability

Robert Morris University Bioreactor

Energy experts have identified major energy sectors that are strategically important for the economy.

These sectors include:

- Coal
- Oil
- Natural Gas
- Nuclear
- Solar
- Wind
- Transmission and Distribution
- Intelligent Building
- Biofuels
- Hydropower
- Geothermal Power

Careers in Alternative Energy

Alternative energy demands continue to rise. According to the Energy Information Industry, in 2008, renewable energy will account for one-third of new electricity added to the U.S. Grid.

The top performing alternative energy sources, include: Wind Energy (according to *AWEA it used 19,500 MW at mid-year review), Geothermal Energy (according to *GEA 3,000 MW is already being used, with 4,000 MW under development), and Solar Energy (according to *SEIA 150 MW panels were installed in 2007, which is 45% more than 2006).

Pittsburgh is one of only three cities that rank in the top 25 regions for employment across the major energy sectors. Pittsburgh is also the only city that resides on top of a nature base of coal, natural gas and shale gas fields.

Pittsburgh and its surrounding regions serve as a hub for the energy industry. Some local corporations and government entities with energy ties, include the following: Consol, Westinghouse, Bettis Atomic Power Lab, Department of Energy-National Energy Technology Labs, Direct Energy, Power Conversion Technologies, Smart Energy, Atlas Energy.

*AWEA –American Wind Energy Association, *SEIA – Solar Energy Industries Association, *GEA – Geothermal Energy Association

Interdisciplinary Minor in Alternative Energy and Sustainability 15 credits

Core Classes –9 Credits

ENVS/ENGR 1022 Energy Fundamentals and Sustainability, 3
PHYS/ENGR 1023 Alternative Energy Technologies, 3
ENVS/ENGR 4112 Energy Research Seminar, 3

Electives – Choice of 6 Credits

SEMSTrack

ENVS/ENGR 2012 Renewable Resources, 3
ENVS/ENGR 3022 Energy Storage, Conversion and Transportation, 3
GEOL/ENGR 4022 Conventional Energy: Fossil Fuels, 3

SBUS/RMU Track

MGMT 3xxx Business Government and Corporate Social Responsibility
ECON 3060 Environmental Economics, 3
MGMT 3750 The Sustainable Organization, 3 (Major prerequisites)

- More electives are to be developed by SESS and SCIS

Studies lead to a minor in Alternative Energy and Sustainability.

The program is open to students in any major.