AC 2012-3025: AN APPROACH TO DEVELOPING INTERDISCIPLINARY ENERGY AND ENVIRONMENTAL PROGRAMS

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An Approach to Developing Interdisciplinary Energy and Environmental Undergraduate Programs

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The need to develop student skills in the areas of energy and environment is an important undertaking as we advance into the future. As the price and availability of fossil fuel goes in opposite directions, new graduates need to understand how to produce and efficiently utilize sustainable energy, as well as how to economically use current energy. In addition, changes in the environment have many effects on the population, and thus, there needs to be a magnified knowledge of how we as engineers and technologists deal with the environmental needs and regulations, both in the United States and abroad. At Northern Illinois University (NIU), a select group of senior faculty members from such disciplines of Engineering, Technology, Biology, Anthropology, Geology, Geography, Economics, Political Sciences, and Law, have developed a multi-faceted, interdisciplinary approach to the education in energy, environment, and sustainability. The NIU Institute for the Study of the Environment, Sustainability, and Energy (ESE) was developed to deal with interconnected education and research needs in these fields from various points of view, including engineering and technology, as well as legal, government relations, and geological, to name just a few. The technology program which was developed has a strong engagement and industry interaction component as a desired outcome. Students on the NIU campus now have the ability to select educational programs in energy and environmental studies from several different directions; as well as four new minors in these new areas. Students can also choose to take individual courses of interest in various energy and environmental areas or they can even take energy and environmentally related courses as part of the university’s general education core. The new ESE will touch many of the 17,500 undergraduate students on campus and allow them to choose their appropriate level of involvement in this important and timely education.

This paper will provide the details behind the degrees developed and the goals and outcomes involved in the development of the interdisciplinary programs. In addition, the formation of the ESE, its interdisciplinary nature, and the filling of a major educational void on campus will be discussed.

Introduction
Northern Illinois University is a diverse research university of 25,000 graduate and undergraduate students, located in a rural area about sixty miles east of Chicago. To adhere to its mission, NIU offers vast array of educational programs and a multitude of different courses, to both an on-campus and off-campus population. In 2007, the University commenced a broad
based strategic planning initiative which sought to identify new areas and strengthen existing areas of education, as well as delete vastly underperforming areas of education. As part of this initiative, the University administration made funding available which would foster new curricular developments in areas which the university was underrepresented. In support of this initiative, the authors, along with several other faculty from across the university, identified the fact that there was no unified delivery of the topics of Energy and Environmental issues. Topics related to energy and the environment have been taught within the colleges of Liberal Arts, Engineering and Technology, Law, and Health and Human Services, and through courses located in departments like Mechanical and Industrial Engineering, Technology, Geology, Geography, Biology, Anthropology, Economics, and Chemistry, just to name a few of the departments.

As part of the strategic planning initiative, the authors and several other faculty teaching in energy and environmental areas from across the university proposed a new university institute which would encompass areas of energy, environment, and sustainability. The proposal received very high regard among the administration, and thus, the NIU Institute for Environment, Energy, and Sustainability was officially developed. The goals of the institute were to develop new majors in a cross-disciplinary structure. In addition, the center also sought to create a cross-disciplinary structure for the faculty too. Faculty from across the university with teaching and scholarship interests in areas covered by the institute now have a place in which to develop collaborative funding initiatives and new courses. In addition, the university has made funding available to hire approximately six new faculty members into this cross-disciplinary model. Universities and state and national government offices have been developing programs in energy and the environment for many years [1,2,3]. NIU has had a presence in these important areas for many years, however, this was the faculty’s opportunity to create an entity which would tie together all of these areas under one umbrella, and thus, provide a platform for new research and curricular development.

The development of the institute was underway, and many new hurdles which were related to the cross-disciplinary approach had to be resolved. In addition, once programs were developed and approved both locally and at the state level, it was up to the institute to promote the curriculum and obtain a student body.

**Initial Institute Development**

As was stated, in 2008, the University started an academic strategic planning initiative which looked at academic offerings and departments from across the university. One of the outcomes of this undertaking was the ability of groups of faculty and/or administrators to propose new areas which represented new of underrepresented areas of study that need to be strengthened. As such, an interdisciplinary group of faculty members suggested that NIU needs to strengthen its course offerings and degree structure in the areas of energy and the environment. In these areas, the university had some courses in place, however, no real structure.

From the university standpoint, it was widely agreed that environmental issues, from climate change to land and water usage, to alternative energy, represent critical challenges for society. Thus, through the strategic planning initiative, the NIU administration agreed with the group of faculty, and set up the NIU Institute for the Study of the Environment, Sustainability, and Energy – the ESE Institute. In addition, the University administration made funding available for
development, hiring faculty members and supporting students. The academic programs developed through the ESE Institute, at both graduate and undergraduate level, address societal and scientific needs for a greater understanding of environmental issues. Recognizing the complexity of environmental issues, a holistic approach was taken which connects energy (particularly alternative energy for Illinois), foundational and applied environmental science, with societal and policy issues. The strategies are twofold:

1. to train people in a broad-based environmental studies curriculum that complements our existing focused programs
2. to strengthen our research in environmental and alternative energy issues

The program will produce graduates prepared to meet these challenges via careers in industry, small business, federal, state and local governments, non-governmental organizations (NGO), and academic research.

The starting point for the newly developed ESE Institute was to determine a contributing membership and leadership. The leadership was critical in that this being a new site on campus, forethought knew that there would be many fights on campus for issues like space, funding, and other resources. In addition, since inter-disciplinary and cross-disciplinary ventures were fairly unique on the NIU campus, and this was a new paradigm on campus, there would most likely be issues in the implementation! Based upon what has transpired in the past three years, the initial assumptions were totally correct!

As part of the Institute leadership, it was decided to set up a governing board from individuals that were leaders at the university in the areas of energy and the environment. The board consisted of the following faculty members,

- Mark Cordes - College of Law
- Carl von Ende - Biological Sciences
- David Goldblum – Geography
- Jason Hanna – Philosophy
- Rich King - Biological Sciences
- Melissa Lenczewski, Interim Director - Geology & Environmental Geosciences
- Cliff Mirman - Engineering Technology
- Eric Mogren – History
- David Murphy - Environmental Studies and Geography
- Nicholas A. Pohlman - Mechanical Engineering
- Reed Scherer, Director - Geology & Environmental Geosciences
- Tomoyuki Shibata - Public Health and Health Education Programs
- Diana Swanson - Women's Studies
- Brendon Swedlow - Political Science
- Kendall Thu – Anthropology

It should be noted that the governing board was as cross-disciplinary as the programs which were being developed. It should be noted that the selection of the ESE governing board was done in steps, where an initial core was developed to represent the program areas which would be
developed. As such, the Departments of Geology, Political, Law, History, Technology, and Anthropology were initially represented. This was expanded to include others after initial discussions. This board was provided with a budget and 5 funded faculty positions based upon the initial strategic planning proposal which was submitted. This document was the governing document as to the interaction of the committee members and the programs which were developed. The faculty members who initially populate the governing board and the others added, worked well from the start, each area developed new courses and some areas created programs. The developed courses were interdisciplinary and used in several different programs. Once the board was developed, the members held meetings and started finding areas of support and mutual interest, and thus funding proposals were developed and conference and journal papers were initiated. Overall this has been and continues to be a very impressive and profitable undertaking for all of the parties involved and all of the constituent groups served.

Developmental Issues Encountered
The most important issue encountered in this project to date is the mode in which team taught courses are treated in the loading of a faculty member. To the faculty member, this is not a major issue, however, to the departments, it is a major concern. At the start of the project, it was discussed at a high level, and the governing board was told that it will be no problem. At this point in time, several courses have been offered using interdisciplinary faculty teams, typically two-three faculty members. Again, at this point, the departments have been loading these individuals at full course load. This mode of loading will be modified, and a solution will be determined. At this point in time, no solution has been found, and it is an issue that definitely needed to be solved at the start of the project!

Undergraduate Program Development
The Initial work that awaited the ESE Institute leadership was the development of a world-class comprehensive and competitive undergraduate program in Environmental Studies and Energy and Environmental Technology, as well as several minors. The newly created cross-disciplinary undergraduate degrees consist of both BA and BS tracks. Both tracks include core courses that cover topics from the environmental sciences, environmental law and policy, green technologies, and the human experience. This foundation will allow students to learn about the breadth of knowledge in Environmental Studies. Students then will pick from one of six emphases: Biodiversity and Environmental Restoration, Energy Studies, Environment and the Human Experience, Environmental Policy, Non-Governmental Organizations, and Water. The overall goal of the undergraduate programs are to train students in the causes, scales, and remediation and mitigation approaches to major local, regional and global environmental problems.

In addition to interdisciplinary environmentally based programs which have been created, several technology based programs and minors have also been developed. The technical programs were developed out of the College of Engineering and Engineering Technology and gives the students a more technical program using applications in an energy and environmental curriculum. In this program, the students are instructed in applications used in industry, be it forms of energy savings approaches, new materials and processes, or new sources and needs in the production of energy. The Energy and Environmental Systems Technology program will provide undergraduate students with an understanding of the application and needs in areas as well as new advances which better the environment and new technologies that utilize green principles,
and green transportation topics. The program includes new areas of green manufacturing and materials used today and in the future, including the operation and manufacture of solar cells, the production of wind, thermal, and hydro-electric power. In addition, the curriculum will introduce students to basic and advanced topics in HVAC, bio-based fuels and alternative energy, as well as the ability of our graduates to examine the carbon footprint and develop solutions in the reduction of energy consumption.

The following listings detail the undergraduate programs that were developed as part of the ESE Institute.

1). Major in Environmental Studies (B.S. degree)
   - CHEM 210 – General Chemistry I and CHEM 212 – General Chemistry Laboratory I
   - CHEM 211 – General Chemistry II and CHEM 213 – General Chemistry Laboratory II
   - MATH 211 – Calculus for Business and Social Science
     OR MATH 229 – Calculus I and MATH 230 –Calculus II
   - STAT 301 – Elementary Statistics
   - ENVS 301- Environmental Science I: Physical Systems
   - ENVS 302 - Environmental Science II: Biological Systems
   - ENVS 303 - Environment in the Social Sciences and Humanities
   - ENVS 304 - Environmental Law, Policy and Economics
   - ENVS 305 - Green Technologies
   - ENVS 490 – ENVS Research OR ENVS 492 Internship in ENVS OR ENVS 498 Senior Thesis

2). Major in Environmental Studies (B.A. degree)
   - Fulfillment of foreign language requirement
   - CHEM 100 Chemistry in Everyday Life OR PHYS 140 Physics and Society
   - MATH 155 – Trigonometry  OR MATH 211 – Calculus for Business and Social Science
   - STAT 208 – Basic Statistics
   - ENVS 301- Environmental Science I: Physical Systems (3)
   - ENVS 302 - Environmental Science II: Biological Systems (3)
   - ENVS 303 - Environment in the Social Sciences and Humanities (3)
   - ENVS 304 - Environmental Law, Policy and Economics (3)
   - ENVS 305 - Green Technologies (3)
   - ENVS 490 – ENVS Research OR ENVS 492 Internship in ENVS OR ENVS 498 Senior Thesis

In either Environmental Studies majors, students are required to take one emphasis group which includes approximately eleven courses from areas which are germane to the given emphasis. In most cases the course work covers study areas from five or six different departments within the university.

Emphasis 1 - Biodiversity and Environmental Restoration
The diversity of life on earth (Biodiversity) represents a resource of unknown potential for improving human welfare that is increasingly put at risk by human activities. Perhaps the most significant challenge of the 21st century is to resolve how to best utilize this resource while providing effective stewardship such that biodiversity resources are maintained for future generations. Meeting this challenge requires a detailed understanding of the processes that promote, maintain, and diminish biodiversity at all levels of biological organization, from molecules to ecosystems, a theme that unites the many subdisciplines within biology.

Emphasis 2 - Energy Studies
This emphasis combines courses which are designed to introduce students to the world of green technology and energy related issues. The focus of the emphasis includes, but is not limited to, green concepts in power production, processing, manufacturing, ecologically friendly materials, and transportation. Students also take courses in the humanities and social sciences to better understand the role that energy plays in society and how these concerns are regulated and legislated.

Emphasis 3 - Human Experience
This emphasis is designed to give students broad exposure to how the environment is represented and researched in the social sciences and humanities. This includes a wide-ranging examination of environmental issues through time and from diverse perspectives in order to provide students the ability to better understand and critically assess contemporary environmental challenges. An underlying theme is the critical examination of the notion of sustainability as a potential principle underlying and guiding human interaction with the environment.

Emphasis 4 - Environmental Policy
This emphasis is designed to give students an understanding of how American law and policy have responded to environmental problems. This includes how environmental law operates and the goals of specific laws, equipping students to evaluate and better understand environmental legal issues they might encounter in their subsequent studies and professional lives.

Emphasis 5 - Non-Government Organization
This emphasis is linked with the new major in community leadership and civic engagement (CLCE). This emphasis is designed for students who are interested in seeking a career in public affairs in government, voluntary social agencies, and public interest groups that focus on environmental or energy issues. This area also examines land use planning and utilizing current population data and maps to better understand the demographic needs in environmental usage.

Emphasis 6 - Water
Whether it is for agriculture, industry, or personal consumption, current use of fresh water by humans is unsustainable. In many parts of the world, access to clean, safe drinking water is lacking. With the human population predicted to expand for the next 40-50 years demand for water will increase dramatically in the coming decades. It is
essential that students pursuing environmental studies are well grounded in the economic, legal, physical, and biological facets of water resources.

3). Major in Energy and Environmental Systems Technology (B.S. degree)

Foundations courses
- CHEM 110 – Chemistry and CHEM 111 - Chemistry Laboratory
- ENGL 308 - Technical Writing
- MATH 155 - Trigonometry and Elementary Functions
- MATH 229 - Calculus I
- PHYS 210 - General Physics I
- STAT 208 - Basic Statistics or STAT 301 - Elementary Statistics
- CSCI 215 or TECH 295 – Visual Basic Programming
- Geog 256 – Maps and Mapping
- Geog 359 - Introduction to GIS
- ENVS 304 – Environmental Law, Policy, and Economics

Required Technology core courses
- TECH 175 - Electricity and Electronics Fundamentals
- TECH 211 – Computer-Aided-Modeling
- TECH 245 - Pollution, Prevention, Pestilence, & Cost of Doing Business
- TECH 262 – Machine Production Processes
- TECH 265 – Basic Manufacturing
- TECH 305 – Green Technologies
- TECH 391 - Industrial Quality Control
- TECH 406 – Facilities Management Technology
- TECH 415 – Heating, Ventilating and Air Conditioning
- TECH 416 – Design for energy efficiency and Green Materials
- TECH 417 – Bio-Based Fuels and Alternative Energy Applications
- TECH 418 – Energy auditing
- TECH 432 - Disaster Preparedness
- TECH 443 - Engineering Economy
- TECH 484 – Energy Management
- TECH 496 - Industrial Project Management (Capstone experience)
- Three Technical Electives related to energy and the environment

It should be noted that the Technology degree was not developed with the intent of obtaining either ATMAE or ABET accreditation, however, in the future this may be an option with minor alterations to the program. In addition to the three major curricular paths that were developed, the group also developed two undergraduate minors; however, other minors are planned or in current process. The goals of the minors are introduce students from various unrelated majors to the area of energy and the environment or “green your major”. In addition, the Department of Industrial Engineering added a minor of sustainable engineering, which is concerned with the integration of social, environmental, and economic considerations into product, process and energy systems design methods. The objective is to minimize the total of the negative
environmental impacts across the entire lifecycle and maximize the positive social and economic impacts. The Sustainable Engineering minor was developed for the engineering majors, due to the match and foundations requirements; other majors can take this minor, however, it is not expected. The minor in Energy Technology seeks to educate students, typically from liberal arts majors, in new environmentally friendly materials and processes, as well as energy reduction techniques in industry. The Technology minor is more accessible to students in non-engineering or technology program due to the prerequisite needs. The following listings detail the undergraduate minors that were developed through the ESE Institute.

1. Minor in Sustainable Engineering

   Core Courses
   - ISYE 420- Introduction to Energy Management Systems
   - ISYE 421- Introduction to Green Engineering
   - ISYE 453- Integrated Product and Process Design

   Two Technical Elective Courses (Select 2 courses)
   - ISYE 100- Fundamental of Manufacturing Systems
   - ISYE 250- Introduction to Lean Systems Engineering
   - ISYE 439- Six Sigma Performance Excellence and Modern Problem Solving
   - ISYE 490-Systems Engineering Management
   - MEE 101- Energy and the Environment
   - TECH 245- Pollution, Pestilence, Prevention, and the cost of doing business
   - TECH 484- Energy Management

   Interdisciplinary Elective Courses (Select 2 courses)
   - ENVS 301- Environmental Science I: Physical Systems
   - ENVS 302- Environmental Science II: Biological Systems
   - ENVS 303- Environment in the Social Sciences and Humanities
   - ENVS 304- Environmental Law, Policy and Economics
   - POLS 324-Environmental Law and Policy

2. Minor in Energy Technology

   - TECH 245 - Pollution, Prevention, Pestilence, and the Cost of Doing Business
   - TECH 305 – Green Technologies
   - TECH 406 – Facilities Management Technology
   - TECH 415 – Heating, Ventilating and Air Conditioning
   - TECH 416 – Design for energy efficiency and Green Materials
   - TECH 417 – Bio-Based Fuels and Alternative Energy Applications
   - TECH 418 – Energy auditing
   - TECH 484 – Energy Management

Student Recruitment
Due to the State of Illinois rules, all new programs must receive Board of Education approval, and as such, the two new Liberal Arts programs which were created have just received approval to be offered. The new Technology program received approval last year, as is in its first year of being offered. Recruiting for these programs is relatively simple; they are selling themselves! The Institute leadership and staff routinely attends new student fairs and new majors
presentations on campus, as well as some events off campus. In addition, due to the cross-disciplinary nature of the programs and the instructors, there is a constant promotion of the new programs in the courses which the Institute faculty teach. Since it is known that the majors will officially start in the fall of 2012, many students have already indicated that they will be transferring into these majors, and they have started to take the foundations courses. At this point, there are over 40 students that have indicated that they would like one of the Liberal Arts majors and there are currently about 20 students in the Technology major. It is anticipated that this number will grow in the very near future.

Future Development
At the present time, the Institute leadership and governing board is looking at three new developments; Community College transfer programs, undergraduate/graduate and faculty research opportunities, and graduate programs. Each of these areas represents a new opportunity and challenge for the Institute board and faculty.

- **Community College transfer programs:** The Community College system within the State of Illinois is very aggressive in the mode in which they adapt to the changing education landscape and offer new programs and courses. Within the Institute programs, there needs to be a concerted effort to work with the regional Community Colleges to find modes in which their 2-year programs can merge with the NIU programs.

- **Development of a research program:** The concept of the Institute was originally proposed as a graduate research initiative. Through multidisciplinary and integrative research the ESE Institute seeks to: (1) evaluate the nature and magnitude of environmental and climatic change at local, regional and global scales, (2) understand and explore solutions to our energy challenges, and (3) assess the impact of environmental, climatic, and energy challenges on society and contribute toward the development of a public policy that promotes sustainability. The multidisciplinary research at the core of the program will directly enhance NIU’s research into climate, the environment and energy issues by encouraging communication among different research groups on campus and fostering shared analytical facilities between Departments and Colleges.

- **Energy and environmental graduate programs:** Through the foundations that were developed for the cross-disciplinary undergraduate programs, the Institute board will develop a similar graduate program. Due to the resource needs for the graduate program, it is anticipated that the offering will not be as broad based as the undergraduate programs. It is also anticipated that the graduate portion will be housed in both the College of Liberal Arts and Engineering and Engineering Technology. Courses will be offered out of both colleges and many departments from across campus will be involved.

Conclusion
Four years ago, Northern Illinois University entered into a strategic planning initiative, and the administration and faculty examined the entire catalog of course offerings and programs. It was the goal of this exercise to determine new areas and programs which could be strengthened or eliminated. As part of the planning, a funding was made available to develop new programs in
unique areas which would attract both new students and new research opportunities. The authors, along with other faculty from across the university, proposed that a new Institute of Environment, Sustainability, and Energy be created. This institute would be cross-disciplinary and would house several new undergraduate and graduate degree programs, as well as foster new collaborative research initiatives in the areas. The institute developed a leadership structure and an oversight board which point the directions and approve new undertakings. After two years of work, the Institute faculty have developed three new undergraduate majors and two undergraduate minors. We are in the process of developing new cross-disciplinary masters programs, and while several grant proposals have been submitted by Institute faculty, this will be a priority moving into the future. In the short amount of time that the undergraduate programs have been in place, a total of about 60 new students have entered the program or will be entering the program at the start of the fall 2012 semester. The work on the Institute of Environment, Sustainability, and Energy continues, and new objectives continue to be developed and implemented.

References

