The one-of-a-kind Ph. D. program in
Economic and Engineering Analysis of Biocomplex Systems

A Statement of Purpose

INTRODUCTION

A. PROGRAM RATIONALE

As stated by the National Science Foundation, "The key connector of [Biocomplexity in the Environment] activities is complexity-the idea that research on the individual components of environmental systems provides only limited information about the behavior of the systems themselves." [1] In this respect, the rationale for studying the biocomplexity of systems is to successfully merge understanding gained from the technological, economic, environmental and social aspects of the life cycle of industrial materials into a set of cohesive decision making tools, tools which could give rise to smarter use of limited resources and reduction of waste and harmful emissions in engineering systems and policy.

When I received the opportunity to join in the transportation fuels research conducted by Dr. Bakshi, Dr. Haab and Dr. Goel, I was immediately struck by the importance of this collaboration among the represented disciplines. Economists tend to describe an optimal solution in terms of social cost versus social benefit, market clearing conditions, consumption decisions and the provision of goods and services. Request the same of an engineer and the response will be about the best choices of material inputs, manufacturing processes and the amount of output yielded subject to government or industry standards, functional specifications and production costs. Traditional views frame solutions to the same problem with two differing criteria. In reality both insights are necessary considerations in the development of sustainable engineering practices and environmental policies.

I am currently engaged in research which focuses on the development of such a framework in the analysis of life cycle performance of transportation fuels. The Biocomplexity in the Environment/Material Use: Science Engineering and Society (BE/MUSES) grant has provided the opportunity to unite the insights of faculty and students from chemical engineering, environmental economics and statistics in assessing the life cycle performance of fossil and alternative transportation fuels. Government mandates are pushing for increased use of biofuels in order to stave off dependence on crude oil, and bring about reduction in greenhouse gas emissions. If crude oil conservation and reduction of greenhouse gases during end use are the only guidelines for selection of a fuel source, then renewable fuels such as corn ethanol excel; however, if consideration is given to the quantity of emissions in the upstream refining

processes, the land use requirements for crop feedstocks, and the tradeoffs between crops as fuel sources and crops food sources, then the push toward certain biofuels seems less attractive. The message is that a policy created only on the basis of traditional engineering or economic analysis is likely to shift the problem into another arena, rather than solve it in the present one.

In order to effectively model the biocomplexity of the fuel system, I require an understanding that can't be provided uniquely in one department. With the support of the faculty advisory committee and the approval of the graduate studies chairs in the departments involved, I have decided that the One-of-a-Kind Ph.D. program will be the best route to fulfill my educational and career objectives.

Reference

[1] "Biocomplexity in the Environment" National Science Foundation: Environmental Research and Education [Internet Resource] <http://www.nsf.gov/geo/ere/ereweb/fund-biocomplex.cfm>

B. EDUCATIONAL OBJECTIVES

The focus of the One-of-a-Kind program will be the development of statistical tools for the improvement of existing Life Cycle Assessment methods and to incorporate the results of these Life Cycle Assessments into effective economic policy. By adopting a framework which merges data available at multiple scales (process level, value scale, economic and even ecosystem level data), the assessments can be made comprehensive, rather than sensitive to the selection of an arbitrary boundary. Existing and proposed economic policies designed to curb emissions and resource consumption (for example, a carbon tax) can then be analyzed on the basis of life cycle environmental and social impact.

The proposed One-of-a-Kind program in Analysis of Biocomplex Systems will involve several aspects from the disciplines of engineering, environmental economics and statistics. The structure of the proposed program will emphasize the following methodological goals and applications:

Methodological Areas:

1. Statistics-multiscale modeling, survey methods, Bayesian analysis
2. Materials Life Cycle Assessment
3. Economic Modeling and Policy Design

Application Areas:

1. Development of deterministic and stochastic multiscale life cycle inventories and life cycle assessment models
2. Characterization of risk (variability) associated with stochastic hybrid life cycle inventories of transportation fuels
3. Use of traditional and thermodynamic LCA data to elicit social preferences among various fuel alternatives including gasoline, ethanol, and hydrogen
4. Evaluation of existing and proposed policies regarding fuel alternatives

C. CAREER OBJECTIVES

I have chosen the field of Analysis of Biocomplex Systems because it unites my quantitative interests with a broad spectrum of engineering and policy applications. The existing life cycle assessment measures, as outlined by the International Organization for Standardization (ISO 14000) environmental management standards, are evidence that firms and governments are seeking a better understanding of the long range impacts of human activity (both social and technological) on the environment. Though some standards are in place, the discussion surrounding the best metrics for identifying the most sustainable technologies and strategies is far from complete. I look forward to a career in which I can contribute to those discussions.

Upon graduation, I envision a career in consulting or as a research scientist. A number of agencies, firms and academic institutions have identified the need for the very interdisciplinary and comprehensive approaches that would make up the core of study in this unique degree program. The following is a list of just a few.

Government and International Agencies: Training acquired in the completion of the proposed degree program would be highly valued by government and international agencies.

- *USDA*-The United States Department of Agriculture has an instrumental role in assessing the viability of crop use for the production of alternative fuel sources and in supporting the improvement of these technologies. In particular, the USDA's Forest Products Laboratory identifies "five emerging areas of study: Advanced composites, advanced wood structures, biorefining and bioenergy, nanotechnology, and small-diameter timber utilization." [1]
- *DOE*-The Department of Energy has a considerable task of anticipating America's future energy needs and contributing research to inform government energy policy. In addition to famed national laboratories such as Fermi, Los Alamos, Ames, and Argonne, the DOE houses the Energy Information Administration which provides valuable energy statistics to the government. The National Renewable Energy Laboratory conducts research and development efforts in sources of renewable fuels and electricity. [2, 3]

- *United Nations-United Nations Environment Programme-Division of Technology, Industry and Economics*. The division's missions include "environmental monitoring, assessment, information and research including early warning; enhanced coordination of environmental conventions and development of environment policy instruments; freshwater; technology transfer and industry; and support to Africa." [4]

Private Sector: Several members of the private sector are actively pursuing the issues of responsible environmental management and sustainability through research and development, product design and marketing.

- *Goldman Sachs*-In 2005, Goldman Sachs adopted the Goldman Sachs Environmental Policy Framework, becoming the first global investment bank to develop such a framework for assessing investment opportunities in terms of environmental and social impact, as well as pledging the firm's resources to improving the environmental performance of their current holdings, especially in energy generation. [5]
- *BASF*-As a leading chemical manufacture, BASF has adopted its own Eco-Efficiency metric for assessing its success in sustainable development and "its ecological impact over the entire life cycle". [6]
- Other companies including *Proctor and Gamble, Tesla Motors, Electrolux, and Dell* have made concerted efforts to understand their role in the responsible development and management of their goods and services for the duration of their products' life cycles.

Academic: Several academic institutions have already realized the value of degree granting programs which can cut across traditional department boundaries to provide training useful in resolving technological, environmental and policy issues that arise from biocomplexity.

- *Arizona State University School of Sustainability*-ASU's School of Sustainability is a degree granting body offering both undergraduate and graduate degrees in Sustainability. "Academic-degree programs in sustainability not only build on the skills generated by discipline-based study, but make it possible to address the linkages between people in their social, natural, and built environment." It is the first of its kind in the United States. [7]

- *Leiden University, The Netherlands Institute for Environmental Science-Department of Industrial Ecology*-The faculty and researchers are among the most active in interdisciplinary approaches to sustainability and multi-scale modeling of industrial processes. They are also instrumental in the United Nations Environmental Programme Life Cycle Initiative. [8]

Beyond providing an intellectual challenge and academic rigor on par with other Ph.D. programs on campus, the proposed One-of-a-Kind degree program will provide skills that are already highly sought and that will certainly receive increasing attention in the future.

References

[1] Forest Products Laboratory <http://www.fpl.fs.fed.us/resources-products/fpl/fpl-our-research-works-for-you/fpl-our-research-works-for-you.html>

[2] Energy Information Administration <http://www.eia.doe.gov/>

[3] National Renewable Energy Laboratory <http://www.nrel.gov/>

[4] United Nations United Nations Environmental Programme Department of Technology, Industry and Economics <http://www.uneptie.org/en/about/index.htm>

[5] Goldman Sachs Environmental Policy Framework <http://www2.goldmansachs.com/citizenship/environment/policy-framework.pdf>

[6] BASF Sustainability <http://corporate.basf.com/en/sustainability/oekoeffizienz/?id=63tkoCL5Bbcp.gx>

[7] Arizona State University School of Sustainability <http://schoolofsustainability.asu.edu/degrees/program_PhD.php>

[8] Leiden University Department of Industrial Ecology <http://www.leidenuniv.nl/cml/ssp/index.html>