PROPOSAL TO ESTABLISH AN INTERDISCIPLINARY MINOR IN ENERGY AND WATER SUSTAINABILITY

Introduction. We propose an interdisciplinary minor devoted to studying the supply of energy and water for our modern society and the sustainability of related alternatives and urban infrastructure, all critical, interconnected factors limiting economic and urban development. Specifically, this minor in Energy and Water Sustainability will address how increasing demands for energy and water will be met while balancing environmental, social and economic interests.

Given the fundamentally interdisciplinary nature of these challenges, such a minor must not only address technological considerations, but also foster in students an appreciation for the economic and social implications of their work. Given the constraints inherent in a minor curriculum, this program of study concentrates on engineering and science considerations, such as design of urban systems; however, all students are required to take an Environmental Economics or Engineering Economics course, and are able to select courses from Architecture, Humanities and Social Sciences as electives. While this minor will likely attract Engineering and Science majors, we hope it will also appeal to other quantitatively savvy students from across the campus. We would welcome a proposal for a complementary minor, perhaps in “Energy and Sustainability Policy”, that would be focus primarily in the Social Sciences and Humanities, while still providing some exposure to science and engineering considerations.

The minor in Energy and Water Sustainability will be closely linked to the Departments of Civil & Environmental Engineering, Chemical & Biomolecular Engineering, Economics, Earth Science, Ecology & Evolutionary Biology, Political Sciences, the Baker Institute, the Energy & Environmental Systems Institute, the Center for Severe Storm Prediction, Education, and Evacuation from Disasters (SSPEED), and the China Center for Environmental Remediation and Sustainable Development. Prof. Pedro Alvarez (CEE) agreed to coordinate efforts to establish this minor, and to serve as primary advisor. A steering committee will be established from representatives from the Schools of Engineering, Natural Sciences, and Social Sciences, such as:

- Phil Bedient (CEE): Surface water hydrology and groundwater recharge/subsidence
- Jim Blackburn (CEE): Environmental law, sustainability
- Walter Chapman (ChBE): Energy, policy and sustainability
- Dan Cohan (CEE): Air quality modeling and environmental policy
- Ken Cox (CHBE): Sustainability of energy sources
- Leonardo Duenas-Osorio (CEE): Network analysis to optimize siting of new facilities
- Peter Hartley (ECON, Shell center for Sustainability): Energy and environmental economics
- George Hirasaki (CHBE): Enhanced oil recovery, multimedia fluid flow, carbon capture
- Qilin Li (CEE): Nanotechnology for point of use water treatment systems
- Carrie Masiello (ESCI): Carbon management
- Kai-Yiu San (BIOE): Metabolic engineering
- Ed Segner (CEE): Engineering economics and ethics
- William Symes (CAAM): Partial differential equations, inversion of seismic data
- Evan Siemann (EEB): Population and community ecology and biodiversity
- Bob Stein (POLI): Institutional Architecture and equitable decision-making
- Mason Tomson (CEE): Brine chemistry, sorption processes and aquatic chemistry
- Ken Whitney (EEB): Plant ecology and evolutionary biology
- Richard Wilson (POLI): Policy adoption and implementation
- Kyriacos Zygourakis (ChBE): Energy, technology and sustainability
Background. Sustainability encompasses an approach to design and decision-making that takes into account the economic, social and environmental implications of human activities. Often described as a meta-discipline, sustainability aims to foster human activities that “meet the needs of the present without compromising the ability of future generations to meet their own needs”. This implies a long-term perspective where environmental and social capital is valued highly in addition to economic feasibility. This also implies a commitment to improve environmental, material, and social conditions without exceeding the ecological capabilities that support them. Therefore, it is very important that we educate future leaders that will design, build, retrofit and manage our infrastructure for energy and water production and distribution (and supporting industries), and create and implement new technologies that consider the economic, social and environmental implications — termed the “triple bottom line” (Figure 1).

General Vision and Educational Objectives. Future business and technology leaders and entrepreneurs will need more than technical training to navigate the emergent social and environmental implications of their field, to excel at public communication, risk assessment, ethics and regulatory policy. Thus, we propose to educate our students (mainly those in engineering, natural science, social sciences, business and economics) so that they are sophisticated about the environmental and social context within which their work (including innovation and commercialization) occurs. The overall approach is based on course work (and research opportunities when applicable) that integrates pertinent science and engineering disciplines with social and environmental implications. These efforts will equip our students with a social and ethical context for their more specialized training, will develop problem-solving skills by analogy, and will provide wide-ranging analytical and communication skills invaluable to the program’s goals. In this way, the students would be able to address the that “triple bottom line”.

We will teach our students how to assess, communicate and affect the broader implications of their work, and equip them with life cycle assessment (LCA), green engineering, eco-responsible design, risk assessment and contingent valuation tools. Ultimately our students will engage with stakeholders in identifying and judging tradeoffs inherent in developing and applying a wide variety of initiatives and technologies as tools for sustainable development. Our educational efforts will contribute to the development of new paradigms, including:

- Designing ecologically sustainable energy and/or water infrastructure to minimize negative impacts of external drivers (e.g., climate change) on urban environmental quality & public health.
Achieving water, air and energy security
Understanding, forecasting, and controlling hydrologic cycle processes, including the effects of climate change on droughts/floods and the incidence on water-borne communicable diseases, to ensure a safe, economically and reliable water supply.
Developing sensors, models and early warning systems to identify emerging energy or water quality problems that compromise the sustainability of urban systems.
Life cycle engineering (LCE) of materials and systems.

**Proposed Course Requirements.** The minor in Energy and Water Sustainability will require seven courses, comprising three core courses, a design practicum, and three electives that can focus on energy, water, or sustainability. To promote educational breadth, no more than two of these electives can be used to also fulfill Major requirements, and at least one elective course must be taken from a different school than the one hosting the student’s Major.

Core courses:
- ENGI 2xx Sustainable Design (2 credits; course to be developed; see Appendix A)
- CEVE 307 Energy and the Environment
- CEVE 322/ENGI 303 Engineering Economics
- or ECON 480 Environmental Economics (requires ECON 211 or 370 or permission)

Electives: three courses from the list below, with no more than two drawn from any one area.

*Energy elective courses (choose up to two):*
- ECON 437 Energy Economics (pre-requisite: ECON 370)
- ESCI 415 Economic Geology – Petroleum
- ESCI 417 Petroleum Industry Economics and Management
- ESCI 420 Modern Exploration Technology (pre-requisite: ESCI 442)

*Water elective courses (choose up to two):*
- CEVE 203 Principles of Environmental Engineering
- CEVE 314 Sustainable Water Purification for Developing World
- CEVE 412 Hydrology and Watershed Analysis
- CEVE 415 Water Resources Planning
- CEVE 418 Groundwater Hydrology and Contamination

*Sustainability elective courses (choose up to two):*
- ARCH 313 Case Studies in Sustainable Design
- BIOE/CEVE 409 Integrated Approaches to Sustainable Development
- BIOS 323 Conservation Biology
- BIOS 325 Ecology
- CHBE 281 Engineering Sustainable Communities
- CEVE 306 Global Environmental Law and Sustainable Development.
- CEVE 315 Sustainable Technologies for Developing Countries
- CEVE 406 Intro to Environmental Law
- CEVE 492 Reliability of Complex Urban Systems
- ENST 302 Sustainability: Rice Into the Future
- ESCI 513 Soil Science and Sustainability
- STAT 485 Quantitative Environmental Decision Making (requires STAT 305 & 385)
- POLI 441 Common Property Resources
- POLI 331 Environmental Politics and Policy
- POLI 432 Urban Politics
- SOCI 367 Environmental Sociology
Design Practicum (1 credit)
Students are required to enroll in a 1-credit (integrative) independent study for one semester, typically fall of the senior year. Students in Engineering and Architecture that must take a senior design course will typically fulfill this requirement by preparing a report that describes the incorporation of sustainability concepts into their design effort, in consultation with the senior (capstone) design course instructor. Students not engaged in a suitable design project will either consult with an extant design group, or pursue a project related to their own area of study in consultation with the advisors for this interdisciplinary minor.

APPENDIX A

Proposal for New Course
ENGI: 2XX Sustainable Design:

The objective of this team-taught course is to develop skills in formulating problems arising from emerging technologies for the energy and water industries, such as green construction or renewable energy technologies, in the context of sustainable design. Students will be challenged to examine the economic, social, and environmental dimensions of problems by identifying the relevant objectives, constraints, and decision variables as viewed by various stakeholders. No pre-requisites.

Instructors: Alvarez, and Invited speakers

<table>
<thead>
<tr>
<th>Week</th>
<th>Tentative Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to Sustainability (Definitions, sustainability metrics, economic, social, environmental, what's not sustainable?)</td>
</tr>
<tr>
<td>2</td>
<td>Chemical fate in the environment, Green Chemistry</td>
</tr>
<tr>
<td>3</td>
<td>Water and Balances, P³ Pollution Prevention, Process Flowschemes, Reduce/Recycle/Reuse</td>
</tr>
<tr>
<td>5</td>
<td>Systems Analysis – System boundaries, decision variables, constraints, objectives</td>
</tr>
<tr>
<td>6</td>
<td>Multi-objective Decision Making,</td>
</tr>
<tr>
<td>7</td>
<td>Engineering and environmental economics, Micro economics and resource allocation</td>
</tr>
<tr>
<td>8</td>
<td>Cost-Benefit Analyses, Green Accounting, Natural Capital, Valuing ecosystem services</td>
</tr>
<tr>
<td>9</td>
<td>Risk Assessment and management, Impact Assessments, Ecological footprints (air and water)</td>
</tr>
<tr>
<td>10</td>
<td>Life Cycle Assessment (Goals, Scope, Inventory Analysis, case studies)</td>
</tr>
<tr>
<td>11</td>
<td>Environmental Management Systems, ISO 14,000, Responsible Care, Laws &amp; Regulations</td>
</tr>
<tr>
<td>12</td>
<td>Industrial Ecology, Green Design, Design for the Environment, Biomimicry, Biotechnology</td>
</tr>
<tr>
<td>13</td>
<td>Renewable Energy Systems: biomass, wind, solar PV, geothermal, microturbines</td>
</tr>
<tr>
<td>14</td>
<td>Sustainable Resource Management and Community Development</td>
</tr>
<tr>
<td>15</td>
<td>FINAL PROJECT PRESENTATION</td>
</tr>
</tbody>
</table>
Report to the CUC on the Energy and Water Sustainability Minor, proposed by Dr. Pedro Alvarez of the Civil and Environmental Engineering Department.

The committee found that all required supporting documents are present. Mary Ellen Lane solicited comments from the CUC and from the subcommittee. A summary of these comments was sent to Dr. Alvarez, who changed the proposal accordingly. I have highlighted the additions in the revised versions. There were no other deletions or changes.

Our comments (regular type) and actions taken by Dr. Alvarez (italics) are summarized below. Note also the addition of new members of the steering committee (names highlighted in the revised proposal).

1. It was noticed that it would be possible for students to fulfill the requirements for the minor without taking electives from outside the Engineering division. We asked Dr. Alvarez to consider requiring that minors take at least one non-ENGI elective, and he changed the proposal as indicated to introduce this requirement.

2. Dr. Richard Boylan of the Economics Department pointed out that Econ 448 is also listed as a substitute for ENGI 303 in Managerial Studies (see [http://www.ruf.rice.edu/~mana/requirements.htm](http://www.ruf.rice.edu/~mana/requirements.htm)). While ECON 480 seems the appropriate substitution course for ENGI 303 in this minor, this may cause some confusion. Dr. Alvarez consulted Dr. Ed Segner, instructor for ENGI 303 for advice. Dr. Segner recommended that ENGI 303 be allowed as well as ECON 448 and ECON 480.

3. Dr. Susan McIntosh suggested that SOCI 367 (Environmental Sociology) be added to the list of electives. Dr. Alvarez added this elective.

4. We asked that a member of the Political Science Department to the steering Committee, given the number of POLI classes on the elective list. Drs. Rick Wilson and Robert Stein were added.

5. The absence of the Shell Center for Sustainability (SCS) in the proposal was noted. Dr. Alvarez indicated that SCS was subsidizing the development of the core course, and that Dr. Peter Hartley is a member of SCS. He added this affiliation to Dr. Hartley’s information.

6. Finally, a number of minor points on the wording of the proposal:
   - p. 5: "three courses FROM the list below". This was not changed but I think we can let it go.
   - p. 5: We asked that the phrases "no more than" and "up to", be reworded to say that the electives must be taken from at least two of the three groups. See above.
   - We asked for clarification regarding the relationship between the "capstone design course", "design practicum" and the "senior design course". Dr. Alvarez changed the text as indicated.