Revised February 19, 2019

Course Syllabus

University of New Hampshire

Department of Civil/Environmental Engineering

CEE 705 / CEE 805: Sustainable Engineering at SML

Instructors: Nancy Kinner (Coordinator), Martin Wosnik, Semra Aytur, Paul Kirshen, Weiwei Mo

3 credits hours – CEE 705/CEE 805

1 credit hour –CEE 796/CEE 896

Thursday, July 25 –Monday, July 29, 2019 at Shoals Marine Laboratory, Appledore Island (Co-requisite)

May 20 – July 22, 2019 (On-line)

Course Description

CEE 705/805 course begins with exploration of the precept that we live in, and must design engineering systems for, a world with a finite supply of natural resources and limited life support capacity. This is nowhere more true than on an island; life on an island provides a unique lens through which to view challenges of water supply, energy supply and use, transportation, wastewater and solid waste management, communications, and preservation of ecosystem services. The major focus of the course will be on how to quantitatively analyze attributes of sustainability in human systems (including engineered systems) using a life cycle, whole systems thinking approach. Topics such as life cycle management, social sustainability, climate change resilience, green building design, wind and solar energy, and societal metabolism will be presented. Students will be exposed to industry standard tools for assessing sustainability, including life cycle analysis (LCA). CEE 705/805 is entirely on-line and is divided into 9 modules (one/week). These will include video lectures, extensive readings and weekly assignments. On Thursday, July 25 at 9 AM, students and instructors will meet in Portsmouth, NH and take a boat to the Shoals Marine Laboratory where CEE 796/876 will be held for 5 days. The field component at the laboratory will involve hands on application of the principles learned during the on-line modules. Students will evaluate the sustainable infrastructure at the Shoals Marine Laboratory including the wind and solar energy systems, freshwater and saltwater supply systems, the wastewater treatment systems and the electrical distribution and demand. Data will be collected on each of these systems and analyzed with respect to efficiency, cost/benefit and life cycle analysis. Students will present their findings and recommendations to the Laboratory's staff.

Overall Learning Objectives

By the end of this course students should be able to:

- Properly define sustainability, list several current issues society faces by continuing in a "business-as-usual" trajectory, and explain the reasoning for incorporating sustainability aspects into engineering projects;
- Gather data for a life cycle, cradle-to-grave, inventory of a process and apply it within LCA to assess the environmental and social impacts while understanding the uncertainties, externalities, and trade-offs;
- Think critically using a life cycle, whole system mindset, with a meaningful awareness of industry-society-nature interactions, spatial and temporal scales, global change, generational and cultural inequities, and rebound effects;
- Explore the principles, perspectives and approaches learned during the on-line component of the course to the Shoals Marine Laboratory community during the field component of the course.

Grading

Assignments (72%)

Assignments

Assignments will consist of writing, traditional homework, and field/ laboratory exercises (the latter at the Shoals Marine Laboratory).

Portfolio

Student will keep an electronic course portfolio on-line. The purpose of the course portfolio is to provide a complete record of the learning, the work, and projects accomplished throughout the class for future use. The portfolio will contain all course materials including the following:

-Course readings

-Notes slide from lectures/Reflections on readings

-Completed assignments including those projects completed at the Shoals Marine Laboratory.

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Learning Topics and Objectives

Topic	Concepts to Cover	Learning Objectives
CEE 705/805 May 20-26 **Module 1:** Introduction to Sustainability **(Kinner)**	We face many challenges if we do not start planning and making decisions for a more sustainable future. The history of sustainability. The role of the engineer is sustainability. Life cycle, systems thinking is key to designing and manufacturing sustainable products, processes and societal systems.	• Meet other students in the class (on-line video) • Define sustainability and sustainable development
May 27-Jun 2 **Module 2:** Sustainability at SML **(Kinner)**	The Shoals Marine Laboratory, located on Appledore Island six mile off the coast of NH/ME, must maintain systems to support a community of 100+ people almost completely without support from mainland infrastructure. Since 2006, the Laboratory has supported 4-5 Sustainable Engineering Interns each field season who analyze and recommend improvements for the island. The interns' reports over the eight years are a microcosm of the challenges that must be addressed and the processes that are necessary when moving towards a sustainable community in an offshore environment.	• Develop an understanding of the mission and history of the Shoals Marine Laboratory and Appledore Island • Understand the process and work that the Laboratory staff and students have done to become a sustainable island community • Consider what further challenges/impediments exist for the Laboratory to address with respect to sustainability • Review the skills/protocols/principles needed to work with a client (i.e., the Laboratory staff) to help achieve its goals for a sustainable island community
June 3-9 **Module 3:** Energy and Sustainability I **(Wosnik)**	Overview of energy sources and usage, history and trends. Reading of Monthly Energy Reports (DOE/EIA).	• Understanding of our society's energy needs and how we have been meeting them.
June 10-16	Physical and engineering principles of wind and solar energy conversion.	• Gain a working knowledge of wind and solar energy

Module 4: Energy and Sustainability II **(Wosnik)**		• Learn how to calculate energy resource(s) and energy conversion system (e.g., wind turbine, photovoltaic solar panel) efficiency.
June 17-23 **Module 5:** Climate Change **(Kinner)**	Anthropogenic climate change impacts all human and natural systems and must be considered in planning present and future environmental, social, and economic/infrastructure systems. The causes of climate change must be understood as well as methods to carry out vulnerability assessments and adaptation plans to respond to the changes. The management of the emissions causing the changes in the climate must also be considered.	• Major gases and sources causing climate change • Methods for projecting climate changes • Magnitudes of possible climate changes • Impacts on natural and human systems • Scenario planning in vulnerability and adaptation planning • Mitigation of greenhouse gases • Knowledge of some of the climate change literature • Exposure to actual municipal adaptation plans
June 24-30 **Module 6:** Infrastructure to Address Rising Sea Level & Flooding **(Kirshen)**	Coastal urbanized areas are some of the most globally vulnerable areas to climate change because they are exposed to both inland and ocean changes. One of the major stressors is sea level rise and the associated increases in coastal flooding. Strategies to adapt to these threats consist of accommodating the threats, protecting systems from the threats, or retreating from them. The first two can utilize both green and grey infrastructure that are implemented over time as the climate changes.	• Economic, social, environmental impacts of increased coastal flooding in urbanized areas • Direct impacts • Indirect impacts • Management strategies • Flexible Infrastructure • Planning Process • Benefit-Cost and Multi-Criteria Analysis
July 1-7 **Module 7:**	Life cycle thinking & management are necessary to sustainable engineering of products and systems. Overview and learn the theoretical concepts and	• Define Life Cycle of a product or process

Life Cycle Assessment (LCA) **(Mo)**	methods behind LCA. Assessment of the economic and environmental impacts of products & processes embedded in their supply chains and end-of-life scenarios. Use of SimaPro and Economic Input-Output database to conduct simple LCA.	• Understand the process of LCA and be able to sketch the LCA framework • Define the goal and scope for an LCA study • Establish ability to collect and analyze inventory data • Name and describe the 4 steps of impact assessment • Identify sources of uncertainty in a published LCA study. • Apply LCA to solve simple problems and make recommendations
July 8-14 **Module 8:** Societal Aspects of Climate Change **(Aytur)**	Examples of social capital (e.g., health, well-being, civic engagement and prosperity, etc.), ways to measure and incorporate social factors into project design and implementation as well as some of the challenges of doing this, and future directions for this evolving area of study and practice.	• Know how and why engineers and scientists should incorporate social factors into project planning and implementation • Identify what the social factors are that engineers need to consider in their work
July 15-21 **Module 9:** Preparation of SML Component **(Kinner)**	Preparation of SML Component	• Examine applications of online modules to SML field component
CEE 796 /896 July 25-29 Field Component at Shoals Marine Laboratory **(Kinner, Wosnik)**	Application of the principles and practices learned during the on-line component to the Shoals Marine Laboratory and its human and ecological systems.	• Discussion groups • Field work with various infrastructure and social systems at SML (e.g., water supply, distribution and use; wastewater generation, collection and fate; solar and wind energy generation, distribution and use; solid waste management; food systems

		• Project with SML data (including oral presentation and written report) • Tour of Portsmouth, NH coastal flooding and adaptation