ENGS 44 Sustainable Design

Term projects for Spring 2015

Seven different types of term-long team projects are proposed for this edition of ENGS 44.

The design project has three objectives:

1. Practice of the sustainable design process,
2. First-hand experience with the complexities of design under multiple constraints, and
3. Gain experience with presentation and defense of a sustainable design in front of an audience.

Each project will follow the steps outlined below and will culminate by the end of the term in an oral presentation in front of a review board and the entire class. A 20-to-30 page report is also required.

The seven project types are:

1. Building low-cost housing with local materials and simple tools
2. Energy-efficient retrofit of a house at the Dartmouth Organic Farm
3. Design of a sustainable warehouse for Amazon.com or a data center for Google
4. Floating infrastructure for low-lying island nations threatened by sea level rise
5. Design of a biomimetic building
6. Design of a building component that incites its users toward environmentally conscious behavior
7. Cooling with liquid desiccant technology.
TEAMS & PROJECT SELECTION

Students will group themselves in teams of 4 to 5 students, and each team will be assigned one of the project types.

Students will be allowed to voice their preference before being assigned a type of project. They will then proceed with the corresponding sustainable design project under the supervision of one TA, the professor, and possibly an external client or faculty advisor.

While it is expected that different teams will work on different project types to make the course more enriching, it is not excluded that different teams can select the same project type as long as they set different parameters (such as location or purpose) and objectives.

Restriction: There can be only one Project #2 (Dartmouth Organic Farm building retrofit) and one Project #7 (Cooling with liquid desiccant technology).

Project Type #1
Building Low-Cost Housing with Local Materials and Simple Tools

Need: In many areas of the world, people need better housing, but financial resources, transportation of materials, and technological know-how are severely limited.

Approach: Combine local vernacular architecture with newer technologies to design low-cost housing that use local and sustainable materials, simple tools, and a mix of traditional and newer technologies. New tools may have to be designed. Consider passive technologies. For this project, sustainability means both sustainably harvested materials and a durable structure.

Expected deliverables:
- Paper design with 3D color rendition of a standard structure
- Bill of materials
- List and drawings of tools needed
- Cost estimation
- A few variations on the standard structure (such as a larger one and a smaller one)
Project Type #2
Energy-Efficient Retrofit of House at Dartmouth's Organic Farm

Need: The Dartmouth Organic Farm (about 2 miles north of campus) has an unused house that the Sustainability Office would like to put to use, but first it must be made much more energy efficient.

Approach: Talk with Rosi Kerr (Dartmouth' Sustainability Director), who will serve as the client, to establish a list of objectives (type of use, degree of energy efficiency, etc.), then get to work on a design of all the necessary retrofits, such as better windows, better wall and roof insulation, passive and active energy technologies, and new interior layout for anticipated uses.

Expected deliverables:
- Paper re-design of the structure with targeted R-values for windows, walls, and roof
- Diagrams of wall and roof sections
- Design and analysis of passive and active energy technologies (e.g. PV panel size)
- A year-round analysis of the energy needs of the house
- 3D color renderings of the outside and inside of the remodeled building, using architectural software

Project Type #3
Design of a Sustainable Warehouse for Amazon.com or Data Center for Google

Need: A special purpose building such as a warehouse or data center comes with its special needs for space, lighting, energy, etc. As the likes of Amazon.com and Google grow seemingly without limits, the need to design sustainable dedicated buildings becomes paramount.

Approach: Select a growing company and a building type (warehouse, data center, other) that it needs. Define what sustainability means in this context and design accordingly. Attention must be paid to energy consumption, energy source, indoor air quality, and materials.

Expected deliverables:
- Statement of company need and building specifications
- Definition of sustainability in this context
- Paper design of the facility and 3D computer rendition
- Energy analysis – Materials analysis – Other analysis as necessary (e.g. water)
- Sizing of the equipment generating the necessary energy
- Comparison with state of the art
- Estimation of cost per square foot (construction and annual operation)
Project Type #4
Floating Infrastructure for Low-Lying Island Nations Threatened by Sea-Level Rise

**Need:** Climate-related sea level rise is seriously threatening several low-level island nations, such as Kiribati and Tuvalu. To avoid the relocate of the inhabitants, floating infrastructure may be a solution.

**Approach:** Study what people have already designed and accomplished in the West, particularly in The Netherlands and find ways of adapting some of these technologies to one specific island country. Consider the following: residential buildings, commercial buildings, transportation, procurement of freshwater, food, solid waste, and treatment of wastewater.

**Expected deliverables:**
- Analysis of the population and needs of one specific small island country
- Set of objectives for a new mode of living once sea level has risen 2 meters or so
- Proposed layout of one prototypical city, incl. designs for several types of buildings
- Systems design for freshwater, food, solid waste, and wastewater treatment
- Technical numbers for all the above
- Elementary economic analysis

Project Type #5
Biomimetic Building

**Need:** Sustainability is best achieved when symbiosis with the environment is maximized, and nature’s solutions serve as ideal suggestions.

**Approach:** Select of geographical location and a building type for this location (ex. residence, apartment building, commercial building, factory). Then, from the study of vegetation and animals in that location, identify nature's ways of adaptation to the location and design the structure that incorporates several of these adaptive ways.

**Expected deliverables:**
- Climatological description of the selected location
- List of ways by which flora and fauna have adapted to this location (ex. cactus, camel)
- Paper design of a structure that incorporates as many of these adaptations as possible
- 3D CAD rendering of the designed structure + a physical scaled model in surroundings
- Energy analysis – Materials analysis – Other analysis as necessary (ex. water)
- Sizing of the equipment generating the necessary energy, if applicable
- Comparison with state of the art
- Estimation of environmental benefits
- Estimation of cost per square foot (construction and annual operation)
Project Type #6
Design of a Building Component to Promote Environmentally Conscious Behavior

Need: A “green” building can’t be maximally green unless its users also behave in environmentally conscious ways. Thus there is a need to design some technologies that promote “green behavior” on the part of building users. Ideally, sustainable behavior should become the default choice of behaving.

Approach: Start with a wasteful manner of behaving in a certain type of building and then brainstorm about a technology to incite occupants to behave in a less wasteful manner. Avoid negative pressure and think of positive, rewarding ways to engage in the better behavior. Design the system or product and, if possible, build a prototype and test it.

Expected deliverables:
- Identification of a wasteful behavior and its better alternative
- Technical solution that creates a positive incentive
- List of specifications and constraints
- Paper design of the technology, with 3D CAD renderings
- Engineering analysis of the system or product
- Projected environmental savings
- Estimate of system cost and return on investment

Electrical switch next to the door knob to incite people to turn lights off when leaving the room.

Project Type #7
Cooling with Liquid Desiccant Technology

Need: Air conditioning in building aims for a sweet spot on a temperature-humidity diagram, but in many applications, targeting humidity alone is sufficient, and a liquid desiccant technology offers hope for a low-cost solution. The need consists in optimizing the technology in a specific building.

Approach: Get familiarized with liquid desiccant technology. Identify a geographical location and building for which humidity control is important. Integrate the technology in the design the building. Estimate the benefit over a more traditional approach.

Expected deliverables:
- Evaluation of the technology, with its advantages and disadvantages
- Selection of a location where humidity is an issue, and of a building in that location
- Design a liquid desiccant system for that building (paper design)
- Sizing of the equipment (humidity transfer rates, desiccant flowrate, controls, etc.)
- Estimation of energy savings compared to a traditional air-conditioning system
- Estimation of cost (construction and annual operation)
Timeline – up to middle of term

Week 1
* Students form teams and voice their preferences.

Week 2
* Each team is assigned a project type and a TA.
* Teams establish contact with their external client, if any.
* If the site is not pre-determined, the students select a hypothetical location.
* Teams characterize the geographical, environmental, historical, and legal aspects of their sites.
* Students engage in brainstorming.

Weeks 3-5
* Teams set down their objectives for the infrastructure (or building component in case of Projects # 6-7).
* Teams enunciate all specifications and constraints.
* Teams elaborate a first design in broad lines, making decisions concerning the main aspects of the infrastructure (or component) such as overall shape, energy features, construction materials, and human use. Depending on the type of project, they may also consider orientation, access, water supply, and wastewater treatment.
* Some consideration is given to how the infrastructure will be symbiotic with its surroundings.
* Teams decide on key numbers such as basic dimensions, heating/cooling load, electrical consumption, and water usage.

Week 6
* Teams report on their project in class.
* Professor provides formal feedback and grades performance to date (see grading below).
* Professor, TAs and teams outline the remaining tasks.

Timeline – from middle of term to end of course

Weeks 7-10
* The design is gradually refined with the possible alteration of specifications.
* Teams perform the relevant engineering analyses, including but not limited to energy calculations.
* Teams estimate the projected environmental benefits and impacts.
* Teams develop a convincing narrative of how the structure is symbiotic with its surroundings.
  (Very important for Project #5. In the case of Project #6, how the component is human friendly.)
* A basic cost analysis is performed.

Week 11
* Teams give their final report in front of the entire class and a review board.
* Teams submit their written report.

Not required but a nice complement to the design: A 3D scaled model.
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<th>Grading</th>
<th>1st report</th>
<th>2nd report</th>
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<tr>
<td>Characterization of site (or need)</td>
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<td>Enunciation of objectives</td>
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<td>Specifications &amp; constraints</td>
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<td>Siting of structure</td>
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<td>amount of water)</td>
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<td>Refined design</td>
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<td>Estimation of environmental impacts &amp; benefits</td>
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<td>Symbiosis with surroundings</td>
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<td>(first, in broad terms / second, developed narrative)</td>
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<td>Aesthetics</td>
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<td>Economic analysis (major aspects only)</td>
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<td>Measure of success (Have the objectives been met?)</td>
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<td>Quality of oral presentation (including ability to answer</td>
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