Building Energy on Campus: Evaluating Efficiency and Conservation Measures at Duke
ENVIRON/ENERGY 830

Duke University | Nicholas School of the Environment
Spring 2017

Tuesday and Thursday, 3:05 to 4:20
Environment Hall 2102

Instructors
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Office hours: Wednesday 1:30 to 3:30, or by appointment

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Grader
Eleanor Johnstone, Energy and Environment MEM candidate (May 2017)
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Course Description and Objectives
Buildings use more than 40% of the energy consumed in the US and are a natural target of energy efficiency and conservation measures. While the Green Building movement is associated with new construction, a significant part of the built environment in 2050 will consist of structures existing today. Building owners and facility managers, as well as the policy community, are therefore interested in identifying means of reducing energy consumption in the current building stock and taking advantage of the embodied energy already sunk into its construction. Such efficiency and conservation measures range from technical changes to lighting and HVAC (heating, ventilation, and air conditioning) systems, to reduction in plug loads, retrofits to building envelopes, use of building-scale renewables, and changes in occupant behavior. Aiding this process is the increasing availability of data—from utility sources, as well as from sensors and building energy management systems—used in
conjunction with building energy models to evaluate energy efficiency alternatives. Furthermore, the rise of building rating systems such as LEED, Green Globes, and Energy Star (which cover existing as well as new buildings) is focusing public attention on the connection between energy use and the built environment.

This course is designed to increase students’ understanding of the linkage between building design and energy consumption by providing hands-on experience evaluating energy use in existing campus buildings, as well as familiarity with related building science concepts and the work of building industry professionals. Most of Duke’s buildings are tied into a larger campus utility system, and we will therefore focus on those aspects of building energy consumption that can be isolated and addressed through building-specific recommendations. In particular, the course will provide students with:

- An understanding of how building design and operation, as well as occupant behavior, affect energy needs, as well as a working knowledge of building science fundamentals and related energy reduction strategies;
- An awareness of trends in building energy use, the forces motivating building energy efficiency improvements, and best practices for green design;
- Exposure to a variety of building industry professionals and an opportunity to learn how they approach problems related to their work;
- Hands-on experience collecting and analyzing energy usage and utility data, reading architectural and other technical drawings, conducting basic energy audits, and evaluating building energy reduction measures for campus buildings;
- Experience working in teams on a “real world” project; and
- Practice developing recommendations for presentation to an actual client.

This course will take advantage of a unique opportunity. Duke is in the rare position of having a dedicated Energy Manager and is fortunate that its Facilities Management Division (FMD) sees education as part of its mission. The campus will therefore provide a laboratory for student learning. Steve Palumbo (Director, Facility Operations), Casey Collins (Duke’s Energy Manager), and Abhishek Bathula (Staff Engineer) have helped organize the class, and will lead occasional class discussions, conduct “back of the house” campus tours, facilitate access to campus buildings and energy data, and serve as a client for student projects.

**Course Format**
The course will consist of discussions based on the readings and material presented in class, campus building tours, and talks by invited industry speakers.

**Prerequisites**
This course does not have formal prerequisites. All students interested in the connection between energy use and the built environment are welcome.

**Coursework and Grading**
Your grade will be based on the following:
Assignments: 35% (7 assignments)
Group Project: 50%
Reading Summaries: 5%
Class Participation: 10%

Assignments will consist of a mix of quantitative problem solving and reflective writing, and must be uploaded to Sakai by 3:00pm on the posted due date (see below for policy on late assignments). You may discuss the assignment questions with your colleagues, but the work you submit must be completed on your own (per the Duke Honor Code).

The Group Project will be an evaluation of specific measures to reduce energy use in an existing campus building, and will involve: data collection and analysis, energy auditing, spreadsheet-based energy modeling, consideration of occupant behavior, identification of alternative measures, calculation of financial savings, and presentation of final recommendations (written and oral) to Duke’s Facilities Management Division.

To encourage your preparation, I will occasionally ask you to submit a reading summary—typically a paragraph reaction to the day’s readings—via Sakai prior to the start of class. These submissions will not be graded or returned, though we will use your thoughts to structure our discussions.

Class participation will be based on attendance, contribution to class discussions, and evidence of having prepared for class. The more interactive the class is, the more we will all get out of it.

I will use the following rubric to translate cumulative scores into final grades:

- [99 to 100] A+
- [93 to 99) A
- [90 to 93) A-
- [87 to 90) B+
- [83 to 87) B
- [80 to 83) B-
- [77 to 80) C+
- [73 to 77) C
- [70 to 73) C-
- Below 70 F

Policy on late assignments
All assignments must be uploaded to Sakai by 3:00pm on the posted due date. Assignments handed in after 3:00pm on the posted due date will incur a 25 percent penalty for each 24 hour period they are late (i.e. from 3:00pm to 3:00pm the next day). Assignments submitted more than 3 days after the posted due date will not receive credit.

If you know of conflicts with the course schedule that will affect a majority of the students, please let me know as soon as possible. I will make exceptions only for serious illnesses and personal emergencies.

If you are sick and cannot complete assigned work, you must complete a Short-Term Illness Notification Form (STINF) at: http://trinity.duke.edu/undergraduate/academic-policies/illness.
The website provides instructions, but note the following text: “Definition of Incapacitation: An incapacitating illness or injury is one in which you are hospitalized, under medical care for a short-term condition, or otherwise sufficiently debilitated as to be unable to perform basic academic tasks. Colds, headaches, or other such mild complaints that result in your feeling less than 100% are not considered incapacitating, and you should not use the STINF in such instances. Appropriate uses of the STINF might include such conditions as influenza, migraine, sinus infection, and strep throat.” In the event of something even more serious, of course, I will make every effort to accommodate your situation.

Readings
Readings are available on Sakai or via web links to public documents and information resources (we will not use a separate textbook). The schedule below lists reading assignments, which you must complete prior to each day’s class. I may also assign additional readings based on your interest in related topics. Your job is to read critically and use the factual basis we develop in class to reach your own conclusions about the issues we discuss.

Sakai
If you are registered for the class, you should have access to our Sakai website. All course materials, including the syllabus, assignments and readings, are available on the site.

Classroom Etiquette
Please arrive on time and refrain from checking email and social media, texting, and websurfing while we are together. These activities are more obvious than you might think, and I will not hesitate to cold call anyone who appears to be using their device for anything other than notetaking or researching the occasional discussion question. If I feel that electronic media are becoming too much of a distraction, I will ask you to turn off and store all phones, tablets, and laptops during class.

My Expectations of You
This is your course. At minimum, I expect you to attend class and be an active participant, which, in turn, requires that you prepare for each class in advance, having completed the readings and other assignments. I also expect you to have an open mind, but to think critically and use what we learn in making your own judgments.

In addition, if you have suggestions on how to improve the course, please let me know. Feedback received midstream can be more useful (to you and me) than end-of-term evaluations, and I am happy to make reasonable changes if a majority concurs.

What You Can Expect from Me
I’m here to help you learn. I understand and appreciate the diversity in your backgrounds, interests, and analytical strengths, and have tried to design the course to accommodate these differences while providing opportunities to help you develop in new areas. Again, I appreciate feedback. I’m available during my office hours if you have questions about the class (or
anything related), and am happy to find mutually agreeable times outside of these windows to meet. Just let me know what works best for you.

**Nicholas School Honor Code and the Duke Community Standard**

All activities of Nicholas School students, including those in this course, are governed by the Duke Community Standard ([http://integrity.duke.edu/standard.html](http://integrity.duke.edu/standard.html)), which states:

“Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and nonacademic endeavors, and to protect and promote a culture of integrity. To uphold the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised.”

Please add the following affirmation to the end of all assignments and your project, and sign your name beside it: “I have adhered to the Duke Community Standard in completing this assignment.”

**Schedule**

This schedule below is subject to change, and I may modify it as we go along if extra time is needed (or desired!) for particular topics. I’ll provide updates to the schedule in class and via email. See the assignment and project handouts for due dates. (The bibliography below provides full reading citations.)

<table>
<thead>
<tr>
<th>CLASS</th>
<th>DATE</th>
<th>TOPIC</th>
<th>READINGS</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>12-Jan (Th)</td>
<td>Introduction to the class; Energy supply and use at Duke</td>
<td>Duke Climate Action Plan</td>
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<td>Duke Sustainability Strategic Plan 2016 Progress Report</td>
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<td>2</td>
<td>17-Jan (Tu)</td>
<td>Building tour: Duke Chiller Plant #2</td>
<td>Chilled Water Brochure</td>
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<td>3</td>
<td>19-Jan (Th)</td>
<td>Trends in building energy efficiency, design, and policy; Assignment 1 discussion</td>
<td>Green Building and Sustainability Reexamining Priorities in Green Building</td>
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<td>4</td>
<td>24-Jan (Tu)</td>
<td>What energy data does FMD collect, how do they manage it, and how do they use it?; Overview of campus energy forecasting</td>
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<td>Real-Time Energy Management Still a Major Priority</td>
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<td>Making the Case for Energy Metering</td>
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<td>5</td>
<td>26-Jan (Th)</td>
<td>Building science fundamentals: Energy codes and standards, green building standards and rating systems</td>
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<td>Building Energy Codes 101: An Introduction</td>
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<td>Beyond LEED: Chris Bentley explores the latest horizons in sustainable design metrics</td>
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<td>LEED v4 for Building Design and Construction</td>
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<td>Building Energy Performance Metrics</td>
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<td>6</td>
<td>31-Jan (Tu)</td>
<td>Introduce projects; Building science fundamentals: Lighting</td>
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<td>Mechanical and Electrical Equipment for Buildings, Chapters 13 (selections only) and 14</td>
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<td>7</td>
<td>2-Feb (Th)</td>
<td>Overview of campus lighting projects; Overview of building drawings</td>
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<td>Building Information Modeling</td>
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<td>8</td>
<td>7-Feb (Tu)</td>
<td>Building tour: Rubenstein and Sanford</td>
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<td>74 Mount Auburn Street Energy Audit Report</td>
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<td>9</td>
<td>9-Feb (Th)</td>
<td>Building science fundamentals: Thermal comfort</td>
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<td>Mechanical and Electrical Equipment for Buildings, Sections 4.2 and 4.3</td>
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<td>Thermal Comfort</td>
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<td>10</td>
<td>14-Feb (Tu)</td>
<td>Building science fundamentals: Heating and cooling load calculations, building enclosure (envelope) design</td>
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<td>Energy for Sustainability, selections from Chapter 6</td>
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<td>Thermal Control in Buildings</td>
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<td>11</td>
<td>16-Feb (Th)</td>
<td>Building science fundamentals: Continued</td>
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<td>The Building Enclosure</td>
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<td>The Future of Window Technology... Is Here</td>
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<td>12</td>
<td>21-Feb (Tu)</td>
<td>Green building from an engineer’s perspective; HVAC system design; Guest speaker: Jose Torres, RMF Engineering</td>
<td>Building Upgrade Manual, Chapters 8 and 9</td>
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<td>13</td>
<td>23-Feb (Th)</td>
<td>Building science fundamentals: Continued</td>
<td>See 21 February</td>
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<td>14</td>
<td>28-Feb (Tu)</td>
<td>Building Commissioning; Guest speaker: Michael Mantai, System Worcx</td>
<td>Building Commissioning</td>
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<td>15</td>
<td>2-Mar (Th)</td>
<td>LEED at Duke; Where green fits in the design/construction process</td>
<td>Beyond LEED: The Future of Energy Management &amp; Sustainable Development at Duke University</td>
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<td>Net Zero Energy Design, Chapter 3</td>
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<td>16</td>
<td>7-Mar (Tu)</td>
<td>Financial calculations; Building audits</td>
<td>Building Upgrade Manual, Chapters 3 and 4</td>
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<td>ASHRAE Updated Procedures for Commercial Building Energy Audits</td>
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<td>74 Mount Auburn Street Energy Audit Report</td>
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<td>17</td>
<td>9-Mar (Th)</td>
<td>Energy generation on campus: CHP plant overview, regulatory and other policy-related complexities</td>
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<td>18</td>
<td>21-Mar (Tu)</td>
<td>Sanford and Rubenstein on-site Q&amp;A</td>
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<td>19</td>
<td>23-Mar (Th)</td>
<td>Green Building from an Architect’s Perspective; Guest speakers: Jeff Paine and Sanjeev Patel, Duda</td>
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<td>21</td>
<td>30-Mar (Th)</td>
<td>Solar at Duke: Why don’t we see PV?; Environmental Hall tour</td>
<td>Net Zero Energy Design, selections from Chapter 8</td>
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<td>22</td>
<td>4-Apr (Tu)</td>
<td>Master planning on campus: Guest speaker: Adem Gusa, Assistant Director of Planning and Design, Duke FMD</td>
<td>Duke Illustrative MP 2024 Plan</td>
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<td>Duke Master Planning Principles</td>
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<td>23</td>
<td>6-Apr (Th)</td>
<td>What Duke is doing in the realm of energy that you don't know about; Water; Energy market overview: Natural gas purchasing</td>
<td>Net-Zero Water and More: Moving Beyond “Low Flow”</td>
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<td>24</td>
<td>11-Apr (Tu)</td>
<td>Project presentations</td>
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<tr>
<td>25</td>
<td>18-Apr (Tu)</td>
<td>Project presentations</td>
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**CLASS DATE TOPIC READINGS**

ENVIRON 830—Building Energy on Campus, Spring 2017 (updated 10 January 2017)
Bibliography


Eastman, Chuck (2009). Building Information Modeling. Atlanta: Georgia Institute of Technology, Digital Building Laboratory.


http://www.energycodes.gov/sites/default/files/becu/BECU_Codes_101_Intro.pdf


https://www.wbdg.org/project/buildingcomm.php

https://www2.buildinggreen.com/article/reexamining-priorities-green-building-0

Other useful readings
https://placesjournal.org/article/how-much-does-your-household-weigh/

https://www2.buildinggreen.com/article/what-makes-product-green

http://www.planning.org/tuesdaysatapa/2012/chicago/oct.htm


https://www2.buildinggreen.com/article/driving-green-buildings-transportation-energy-intensity-buildings