Duke | NICHOLAS SCHOOL of the ENVIRONMENT

Building Energy on Campus

ENVIRON/ENERGY 830—Fall 2021

Tuesday and Thursday, 1:45 to 3:00
Grainger Hall 2102

Instructors

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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. The rise of building rating systems such as LEED, WELL, and the Living Building Challenge; the increasing prominence of demand-side energy management programs; and municipal-level energy and greenhouse gas emission reduction efforts are focusing public attention on the connection between energy use and the built environment. While new construction draws much of this attention, a significant part of the built environment in 2050 will consist of structures existing today. Building owners and facility managers, members of the policy community, and electric utility planners are therefore interested in identifying means of reducing energy consumption in the current building stock and taking advantage of the embodied energy already sunk in its construction. Such efficiency and conservation measures range from lighting and HVAC (heating, ventilation, and air conditioning) system upgrades, to plug load reductions, building envelope retrofits, building-scale renewable integration, and occupant behavior changes. 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.

This course is designed to increase students' understanding of the linkage between building design and energy consumption *plus* institutional decision making regarding energy and

sustainability priorities. The class provides hands-on experience evaluating energy use in existing campus buildings, as well as a grounding in related building science concepts and exposure to 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. After taking this class, students will be able to:

- Explain trends in building energy use, the forces motivating building energy efficiency improvements, and best practices for green design
- Apply building science fundamentals to predict energy needs and develop energy savings recommendations
- Collect and analyze energy utility data, read architectural and related technical drawings, conduct basic energy audits, evaluate energy reduction measures, and present audit findings and recommendations to an actual client
- Explain how an institution like Duke manages energy supply and use and prioritizes energy conservation measures in its decision making
- Communicate with a variety of building industry professionals and appreciate how they approach problems related to their work

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 Department (FMD) sees education as part of its mission. The campus will therefore provide a laboratory for student learning. Casey Collins (Duke's Energy Manager) and Abhishek Bathula (staff Energy 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 clients 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	40% (7 assignments)
Group Project	50%
Class Participation	10%

Assignments will consist of quantitative problem solving and short-answer reflective questions. **You must complete each assignment individually; though you may discuss assignment questions with your colleagues, the work you submit must be your own (per the Duke Honor Code).** Due dates follow, though note that *these dates are subject to change*.

Assignment	Due Date
1	30 Aug
2	07 Sep
3	16 Sep
4	23 Sep
5	12 Oct
6	26 Oct
7	04 Nov

The ***Group Project*** will provide an opportunity to apply everything you will learn this semester in an evaluation of measures to reduce energy use in an existing campus building. In particular, the project 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. See the project handout on Sakai for details.

Your ***class participation*** score will depend 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 your cumulate weighted score (percentage) into a final grade:

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

Policy on late assignments

All assignments must be uploaded to Sakai by 1:00pm on the posted due date. Assignments handed in after 1:00pm on the posted due date will incur a 25 point penalty for each 24 hour period they are late (i.e. from 1:00pm to 1:00pm the next day). **Assignments submitted more than 3 days (72 hours) 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.

Undergraduates: If you are sick and cannot complete assigned work, please contact me and submit a Short-Term Illness Notification Form (STINF) at: https://trinity.duke.edu/undergraduate/academic-policies/illness. The website provides instructions, but note the following text: **"**Definition of Incapacitation: An incapacitating health issue 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 Incapacitation Form in such instances." In the event of something even more serious, of course, I will make every effort to accommodate your situation.

Graduate students: If you are sick and cannot complete assigned work, please contact me. If your illness will affect multiple classes and you are a Nicholas School MEM or MF, you should also notify Cynthia Peters, Nicholas School Assistant Dean Student Services, at petersca@duke.edu or 919-613-8071.

Readings

Readings are available on Sakai or via web links to Duke Library holdings and 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

All registered students will have access to our Sakai website. 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 that 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 and arrive 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 life in general), and am happy to find mutually agreeable times outside of these windows to meet. Just let me know what works best for you.

Respect for Diversity and Honest Analysis

Energy supply and use are inseparable from our daily lives and lifestyle choices. Hence, some of the topics we will cover have a political and even personal subtext, and some of you may arrive with strong opinions about the past, present, and future of energy and all that it affects. My goal is to help you reason through the complexities of how we might balance conflicting societal goals that require more than technical problem solving or idealistic visions of how cultural change occurs. While I will respect the individual conclusions you reach, I ask that you *lead with evidence and analysis rather than opinion* and I will try to model this behavior in class. In short, let's strive to be honest brokers and respect differences in personal and cultural preferences. The fact that we come from many different places and backgrounds is an asset and I will draw on the diversity of your experiences as a valued resource.

Beyond that, I teach because I like spending time with students. If you all looked, felt, and thought like me it wouldn't be nearly as interesting and I wouldn't learn nearly as much as I continue to learn after many years in the classroom. I enjoy getting to know you as individuals and will do whatever I can to create a comfortable environment in which we can all be challenged and learn together.

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), 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. The bibliography below provides full reading citations.

CLASS	DATE	TOPIC	READING
1	24-Aug (Tu)	Introduction to the class; Energy supply and use at Duke	--
2	26-Aug (Th)	Building tour: Duke Chiller Plant #2	2019 Duke University Climate Action Plan Update (pages 1 to 32)
3	31-Aug (Tu)	Trends in building energy efficiency, design, and policy; Assignment 1 discussion	Sustainable Campus Development; Towards a Zero Emission Efficient and Resilient Buildings and Construction Sector (pages 1 to 36)
4	2-Sep (Th)	Energy data management at Duke	Real-Time Energy Management Still a Major Priority; Designing a Metering System
5	7-Sep (Tu)	Building science fundamentals: Energy codes and standards, green building standards and rating systems; Overview of building drawings	ASHRAE GreenGuide, Chapter 2 "Green Rating Systems"; Green Building Certification; for history see Energy for Sustainability, Chapter 8 "Whole Building to Zero Net Energy"
6	9-Sep (Th)	Building science fundamentals: Lighting	Energy Audits and Improvements for Commercial Buildings, Chapter 5 "Lighting"
7	14-Sep (Tu)	Overview of campus lighting projects; Introduce project	Daylight and Electric Illumination
8	16-Sep (Th)	Building tour: Project buildings	74 Mount Auburn Street Energy Audit Report
9	21-Sep (Tu)	Building science fundamentals: Thermal comfort	Mechanical and Electrical Equipment for Buildings, Sections 4.2 and 4.3; Thermal Comfort; Relative Humidity

CLASS	DATE	TOPIC	READING
10	23-Sep (Th)	Building science fundamentals: Heating and cooling load calculations; psychometrics	Energy for Sustainability, Chapter 6 "Energy Efficiency for Buildings" and Chapter 7 "Solar Energy for Buildings Approach"; Thermal Control in Buildings
11	28-Sep (Tu)	Building science fundamentals: Heating and cooling load calculations, building enclosure (envelope) design	The Building Enclosure; High Performance Glass
12	30-Sep (Th)	Building science fundamentals: Humidity removal, vapor compression cycles; Passive House	Passive House
--	5-Oct (Tu)	*Fall Break*	--
13	7-Oct (Th)	Green building from an engineering perspective; Guest speaker: Jose Torres and Jessica Allen, RMF Engineering	Building Upgrade Manual, Chapters 8 and 9
14	12-Oct (Tu)	Building Commissioning; Guest speaker: Michael Mantai, System Worcx	Building Commissioning
15	14-Oct (Th)	Building audits; Energy Savings Performance Contracting	ASHRAE Updated Procedures for Commercial Building Energy Audits; 74 Mount Auburn Street Energy Audit Report
16	19-Oct (Tu)	Financial calculations	Energy Audit of Building Systems, Chapter 3 "Economic Analysis"
17	21-Oct (Th)	Building science fundamentals: Energy modeling class exercise	An Architect's Guide to Integrating Energy Modeling in the Design Process (especially pp. 39-41 and Section 5); Understanding Building Energy Models
18	26-Oct (Tu)	Project on-site Q&A	--

CLASS	DATE	TOPIC	READING
19	28-Oct (Th)	Where green fits in the design/construction process; High Performance Building Framework	Net Zero Energy Design, Chapter 3 "Integrated Process"; Duke University High Performance Building Framework
20	2-Nov (Tu)	Grainger Hall tour	--
21	4-Nov (Th)	Green Building from an Architect's Perspective; Guest speakers: Sanjeev Patel and Scott Baltimore, Duda | Paine	View Duda | Paine project portfolio at http://www.dudapaine.com/
22	9-Nov (Tu)	Energy generation on campus: Energy Needs Analysis, CHP plant and biogas overview, regulatory and other policy-related complexities of campus renewables	Duke University Energy Needs Analysis
23	11-Nov (Th)	Master planning on campus: Guest speaker: Adem Gusa, Assistant Director of Planning and Design, Duke FMD	Duke Illustrative MP 2024 Plan; Duke Master Planning Principles; Duke University Architectural Design Guidelines 2018
24	16-Nov (Tu)	Wrap-up: Assorted topics and discussion (e.g., mass timber construction, LCA, water, other Duke)	Carbon Crackdown; Building Electrification; Building Industry Gets Serious About Its Embodied Carbon Problem; Getting Building Height Right for the Climate
25	18-Nov (Th)	Project presentations	--
26	23-Nov (Tu)	Project presentations	--

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