SUMAK5119: Building Energy Workshop
Prof. Lynnette Widder

Fulfills Graduation Requirement Area 3: Physical Dimensions of Sustainability Management

The built environment offers us the ability to determine our surroundings: temperature, light, spatial qualities. This ability is in constant dialogue with the environmental forces which constantly act on a building, from gravity and weather to urban stresses. No less important is the way we humans interact in the spaces we make for ourselves. Understanding our built environment as part of a system in *constant flux* is the first step to understanding the myriad ways in which building performance can be approached.

Building energy depends upon a host of complex relationships that includes people, behaviors, cultural norms, construction and tradition. Looking only at efficiency or large-scale metrics does not do justice to this complexity. In this course, we will consider the many integral aspects of building energy:

- **Looking back:** Assessment and benchmarking is central to understanding the legacy buildings we have. Working directly with Columbia's Offices of Facilities Management and Environmental Stewardship, we will study a campus building using tool kits that include digital data trackers (temperature, humidity and light sensors), remote surface temperature sensors and instruments to track building insolation (the amount of sunlight that a building receives). We will also develop occupant surveys and forensic techniques for deciphering legacy construction in the building envelope and building systems; and use technical instruments for assessment.
- **Looking ahead:** Building energy is intimately dependent on materials and building systems; the relationship between the two at the design phase is essential to building energy. Recent years have seen enormous advances in this area which we will consider through case studies, a guest lecture and a field trip.
- **People and policy:** The landscape of energy has to include the people and their cultural contexts relative to thermal comfort. This has deep history and significant consequences for the present. Through readings and a guest lecture, we will learn about that cultural history and the impact, especially on vulnerable populations, of energy economies and politics.

You will also complete an individual research project on a strand of built environment technology over time that can point a way forward, both technologically and societally. You will be able to choose your topic in consultation with the professor. A separate assignment will offer details.

Your assignments in this course will be both research-based and project based, comprising a report done individually; and an analytic study, for which you will be expected to work with your colleagues to assess and benchmark a campus building. In addition to the projects, there will be assigned readings for in-class discussion. Lectures and in-class exercises will provide you with the specialized knowledge you will need to complete the projects, but you will be asked to learn actively through interpolation, research and visual representation.

By the end of this course, you should be able to:

- Describe conventional and emerging systems for servicing building resource demands;
- Describe current protocols for resource benchmarking and improvement;
- Use energy tracking equipment to assess specifically the energy flows to which a building is subject;
- Understand historical and contemporary developments in the relationship between energy, buildings and people;
- Understand methods to assess and impact human interaction with the built environment;
- Learn the basics of building construction, especially façade construction;
- Use visual communication methods to define and address problems, and to convey complex proposals.

Required Course Work and Evaluation:

- You **must** keep a dossier or file of your work for the entire semester, including notes on readings, class notes, in-class workshops, annotated research, brainstorming, diagrams, etc. Co-authored work must be accurately attributed. In addition with the other requirements noted below, this dossier will be submitted and used to judge your individual effort in the course. *individual 20% of grade*.
- Class attendance and participation in discussions and lecture q/a is expected. You are also expected to complete readings and discuss them actively in class, when prompted by the professor. You must submit all workshop assignments, completing them after class if needed. Legitimate reasons for missing class must be sent via email to the professor and TA no less than 24 hours before class. *individual 10% of grade*.
- Individual research project: You will select a particular built environment/energy nexus– thermal comfort, light, materials, feedback loops, behavior– to study across three historical moments that address it, from traditional to cutting edge technologies. Use examples from vernacular "architecture without architects" as well as emergent techniques. Each research project will be developed in close consultation with the professor and TA. You will present your three case studies in class immediately after spring break. Using feedback from your presentation, you will develop a 10 page illustrated research paper for submission at the end of the semester. *individual 35% of grade*
- Campus Building Analysis: Working in groups during and outside of class, you will record the thermal behavior of a small building on Columbia campus. We will work with Facilities and the Office of Environmental Stewardship, as well as building users, to understand the building's history, construction, use, comfort and resource demands. You will use the tools we introduce in class to track sun, temperature, light and electrical usage. You will conduct interviews with users, maintenance crews and facilities officers. You will study legacy information (drawings, diagrams, etc) on the building's tempering systems and compare them with as-built conditions, noting discrepancies. In the end, you will have a detailed thermal portrait of the building in its present state. Your group work will be presented together in the last class of the semester to a panel for discussion. *group 35% of grade*
- For an additional 3% extra credit (about half a letter), you may write a 1,500 word response to any of the readings assigned this semester, except for those from textbook.

Group Work and Individual Grading:

Effective group work is the only way to accomplish the full scope of work this semester. So that I understand group dynamics and input, I will also be working directly with the groups during workshop times. The required **dossier**, which will be submitted at the end of the class, is your opportunity to offer cumulative evidence of your work's quality and breadth.

Below is a rubric of qualities I expect to see in your work. I expect active class participation, evidence of solid preparation and willingness to invest your own expertise in group work. Do not be afraid to try out unlikely ideas! I appreciate risk-taking and creativity.

The work submitted should be graphically clear and free of careless errors. Projects should evidence:

- research – offer technological context, describe appropriate case studies
- analysis – develop a clear methodology as you work that you believe could be replicated, but do not be afraid to learn from your process and to iterate as the research develops
- presentation – verbal and visual presentation including original diagrams
- creativity/integrative thinking – qualitative evaluation of the framing and resolution of the problems and ideas you identify

Evaluations for each project will include both comments and letter grades so that students can improve their performance over the semester. However, work may not be redone and resubmitted for a new grade. Requests for extensions will only be granted if made in advance and warranted by documented extenuating circumstances (sickness, personal or family matters, etc).

Failure to submit an assignment will result in an F for that portion of the grade. Plagiarism (using text written by others without proper citation) is an academic offense that will result in automatic failure for the course.

Course Format and Assignments:
This course will be run as a hybrid lecture/workshop. For the first portion of the semester, we will use this time for a lecture lasting about an hour, and spend the rest of the course time discussing readings and running workshops that will teach you how to use assessment equipment.

In the latter portion of the semester, we will devote more time to consultation, presentation and discussion about your individual research studies and group building assessment projects. The last classes of the semester and two intermediary classes along the way will consist of student presentations; at the end of the course, I will assemble a panel of guests to review and discuss your findings.

Book for Purchase at bookculture, 112th Street between Broadway and Amsterdam:
Alisdair McGregor, Cole Roberts and Fiona Cousins, *Two Degrees. The Built Environment and Our Changing Climate* (Routledge, 2013) (required)

We will also use a book that is difficult to find and very expensive using on-demand printing: Baruch Givoni, *Climate Considerations in Building and Urban Design* (Wiley, 1998). Scanned excerpts will be posted on Canvas in accordance with copyright regulations. All other readings and guides to those texts listed below are available to you on Canvas. Please be sure that you have a paper or digital copy for reference during class.

Schedule:

Part I: Building Energy Basics

Week 1	January 17
Lecture:	Energy and the Built Environment – People, Buildings, Cities
Reference:	*Climate Considerations,* 'The Urban Wind Field' p.256-266 (10 pages)
	Weather in the City, p. 37-50, 'Mapping the Microclimate' p.82-103 (45 pages)
Workshop:	Microclimatic wind and aerodynamics (compass and anemometer)

Week 2	January 24
Lecture:	What is Thermal Comfort?
Workshop:	Temperature and humidity tracking (Hobo data tracker)
Reference:	*Climate Considerations,* Chapter 1: Comfort Issues and Climate Analysis for Building Design p.3-45 (42 pages)
	Two Degrees Chapters 6 and 17 (16 pages)

	Lisa Heschong, *The Architecture of Thermal Delight,* (MIT Press: Cambridge, 1979) 'Affection' p. 31-49 (18 pages)
Assignment:	Resource Scavenger Hunt Student Research Project (see separate assignment sheet)

Week 3	January 31
Lecture:	Solar Energy Interactions: Tempering and Daylighting
Workshop:	Solar orientation/Light (light meter)
Reference:	*Two Degrees,* Chapter 7 (18 pages) *Climate Considerations,* Chapter 4: Passive Solar Heating Systems p.149-182 and 'Urban Radiation and Sunshine', p. 266-74 (41 pages) Marilyne Andersen, 'Unweaving the Human Response in Daylight Design' (Building and Environment 91 (2015))(13 pages)
Assignment:	Research Project – Meet with professor and TA during week, develop initial annotated bibliography and proposed case studies

Week 4	February 7
Lecture:	The Anatomy of a Building and its Envelope
Workshop:	Reading historic and contemporary construction drawings
Reference:	*Two Degrees* Chapters 9, 10 and 11 (41 pages) *Introduction to Architectural Technology* p.78-100 (22 pages) John Straube, 'The Building Enclosure' (Building Science Digest 018, 8/2006) (15 pages) Due:
Due:	Resource Scavenger Hunt – tracking of resources and selection of resource for research project

Week 5	February 14
Workshop:	Introduction to campus building assessment project, site visit with Columbia Facilities Management and Columbia Office of Environmental Stewardship
Assignment:	Campus Building Assessment (9 week group project using instruments, interview and calculation to understand building comfort and resource usage)
Due:	Research Project – Finalized choice of case studies and research plan; annotated bibliography

Week 6	February 21
Lecture:	Building load worksheet and Occupant Interface
Reference:	Julia Day and William O'Brien, 'Oh Behave! Survey Stories and Lessons Learned from Building Occupants in High Performance Buildings', in: 'Energy Research & Social Science' v. 31, September 2017, 11-20 (9 pages) *Climate Considerations,* Chapter 3: Material Properties and Thermal Performance of Buildings p. 107-147 (40 pages)
Workshop:	Campus Building Assessment project consultations – tracking methods and protocols, collection plan
Due:	Research Project – analytical diagram design

Part II: Cultural Frameworks

Week 7	February 28
Guest Lecture	Prof. Diana Hernandez, CU Mailman School of Public Health
Readings:	TBA
Ongoing:	Research Project – Ongoing research and analytical diagrams, second draft; schedule meeting with professor and/or TA for consultation Campus Building Energy Assessment – design and start interviews, balance point calculation, design and start data collection, initiate historic research

Week 8	March 7
Readings and Discussion:	Cecil D. Elliot, *Technics and Architecture: The Development of Materials and Systems for Buildings* (MIT Press: Cambridge, Ma, 1992) Chapter 11 'Heating and Ventilation' excerpts, p.270-285, 291-305 (29 pages) Vladimir Jankovic, *Confronting the Climate: British Airs and the Making of Environmental Medicine* (Palgrave Macmillian: New York, 2010) Chapter 2 'Cursed by Comfort' (25 pages) James Marston Fitch, *American Buildings: The Environmental Forces that Shape It* (Oxford University Press: Oxford/New York, 1999) Chapter 9 'The Integration of Environmental Control Systems' (21 pages)
Due:	Research Project – Storyboards and presentation texts (comments will be returned over the break for revisions)

SPRING BREAK

Part III: Presentations and Field Reports

Week 9	March 21 Class Cancelled
Ongoing:	Campus Building Assessment – Interview and data collection, historic research
Week 10	March 28
Presentation/ Lecture:	Student research presentations
Workshop:	Campus Building Assessment – Data collation and gap analysis/filling
Week 11	April 4
Field Report:	Prof. Franca Trubiano, University of Pennsylvania School of Architecture Energy/Material Interactions
Readings:	Franca Trubiano, *Teaching the Convergence of Matter + Energy In the Design of Building Envelopes*, pg. 1-8 (8 pages) Franca Trubiano, *Design and Construction of High-Performance Homes*, (Routledge, 2012), p. 3-21, 31-71 (52 pages)
Ongoing:	Campus Building Assessment – Integrate data across working groups, outline presentation
Week 12	April 11
Field Report:	Erik Olsen, Transsolar Climate Engineering Transsolar project case studies
Readings:	Podcast and Transsolar Newsletter
Ongoing:	Campus Building Assessment – See Professor and TA to review presentation
Week 13	April 18
Lecture:	Feedback for Sustainable Buildings – emerging technologies in materials and systems
Workshop:	Campus Building Assessment – in-class review of diagrams and visualization strategies

Student Presentations, Campus Building Energy Assessment Project:

Week 14 April 25
Workshop: Campus Building Energy Assessment – in class lab time and consultations

Due May 2 Final individual research paper; final slide deck and presentation of Campus Building Assessment group project

Resources (online):

http://www.nrel.gov/gis/mapsearch/
The NREL (National Renewable Energy Workshop) is an amazing resource for data. The link above will take you to state-wide, regional and national analyses of wind, biomass and insolation annual averages overlaid on geographical maps.

http://aom.giss.nasa.gov/solar4x3.html
Solar insolation information by month, year and latitude/longitude.

http://www.cbe.berkeley.edu/research/survey.htm
Occupant survey models and recommendations

http://www.energy-design-tools.aud.ucla.edu

On deep energy retrofits:
1. www.urbangreencouncil.org (this is a NYCHA campaign in which 50 – 60% total energy reduction is targeted)
2. www.castledeepenergy.com (this is a study from Boston area, with an average total cost of retrofit at $42,500/retrofit)
3. http://eetd.lbl.gov/publications/deep-energy-retrofits-eleven-california-case-studies (this is from Lawrence Berkley National Workshops, with many good references)

Reference Works:

James Marston Fitch with William Bobenhausen, *American Building The Environmental Forces that Shape It* (Oxford University Press: New York, 1999)

Reyner Banham, *The Architecture of the Well-tempered Environment* (The Architectural Press/The University of Chicago Press: London, Chicago, 1969)

Walter Grondizk, Alison G. Kwok, Benjamin Stein, John S. Reynolds, *Mechanical and Electrical Equipment for Buildings* 11th Edition (John Wiley and Sons: Hoboken, NJ, 2010)

Mary Guzowski, *Towards Zero Energy Architecture* (Lawrence King: London, 2010)

'Energy Efficiency in North American Existing Building Stock' IEA Information Paper, 2009
http://www.iea.org/publications/freepublications/publication/NAM_Building_Stock.pdf

Alexander Zhivov, 'Holistic Assessment Toolkit on Energy Efficient Retrofit Measures' IEA ECBCS Annex 46, 2010 http://www.annex46.de/tool_e.html

Nigel Jollands, Stephen Kenihan, Wayne Wescott, 'Promoting Energy Efficiency Best Practice in Cities' IEA Information Paper, 2008

Mike Davis, *Dead Cities* (The New Press: New York, 2002)

Theo Prudhon, *Preservation of Modern Architecture* (John Wiley and Sons: Hoboken, NJ, 2008)

Victor and Aladar Olgyay, *Design with climate: bioclimatic approach to architectural regionalism.* (Princeton University Press: Princeton, N.J., 1963)