SUMAK4119: Empirical Approaches to Building Energy Assessment

Prof. Lynnette Widder

The built environment includes more than the “bricks and mortar” that make up the buildings we inhabit. It also encompasses the environmental forces acting on a building, from gravity and weather to urban stresses, and the way we humans interact in the spaces we make for ourselves. A full understanding of building energy assessment should take all of this into account. This approach includes complexities and challenges that neither digital modeling nor exclusively bricks-and-mortar analyses alone can fully apprehend.

In this course, we will consider modeling and spread sheet-based approaches to energy assessment but will spend most of our time honing the ability to see, hear and sense how thermal and electrical energy interfaces with our social and building practices. We will work with 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. Finally, we will deploy open source software to assist in calculating building envelope transmissivity, alternate models for building energy inputs and other data. Our focus will be local, on Columbia campus, and our work will compliment the more generalized building assessments already completed for many campus buildings.

Work in this course will be project based, comprising a shorter initial project, and a longer analytic and projective study: you will be expected to work with your colleagues to assess, benchmark and propose interventions into a campus building. The group make-up will be elective for the first group project and then reconfigured by the professor for the second group project. 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 energy demands;
- Describe current protocols for energy benchmarking and improvement;
- Use energy tracking equipment to assess specifically the energy flows to which a building is subject;
- Understand methods to assess and impact human interaction with the energy systems of the built environment;
- 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 labs, 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 15% of grade*.

- Class attendance and participation in the question and answer period after each lecture is expected. There will be 3-4 in-class labs. *individual 10% of grade*.

- Several key readings will be assigned; reading guides to frame central questions will be provided. You are asked to post initial written comments on Courseworks at least one day prior to class to prepare the conversation. You will be evaluated on your preparation of the readings and in-class contributions. *individual 10% of grade*

· “Thermal Scavenger Hunt” exercise: You will track a palpable thermal anomaly on Columbia campus. You discover through empirical research the source of this anomaly, describe its effect on people and map its behavior. *individual 15% of grade*

· Thermal Building Analysis: Working in groups of 4-5 students, you will record the thermal behavior of the building we will study using the tools provided. 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. You will present your work to the class as a whole and post your findings and analysis on the class site. *group 25% of grade*

· Building systems design and proposal for Building: Working in groups of 4-5 (you may chose to stay in your original group or reconfigure), you will develop integrated strategies for the improvement of your building’s performance. This will include technical, human and design ideas, conceived to create synergies. Creativity, diagramming, brainstorming and innovation are called for. Workshop time in the second portion of the semester will be used as a lab for consultation with the professor. *group 25% of grade*

Group Work and Individual Grading:

The work this semester is equally divided between individual and group work. Since you are required to work with different people in the two group assignments, your unique input will be evident in the way it influences these different constellations. I will be working intensively with the groups during lab times, and your contribution to those discussions will also evidence your investment. In-class lab assignments will also give you opportunity to demonstrate the quality of your efforts. Finally, the “dossier” submission, which will be submitted at the end of the class, is your opportunity to offer cumulative evidence of your work’s quality and breadth.

The criteria for grading will value deep, open-minded engagement with the course material. I expect active class participation, evidence of solid preparation and willingness to invest your own expertise in group work. You may email me or visit office hours for concerns and clarifications.

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

· research (20% of grade) – offer technological context, describe appropriate case studies

· analysis (20%) – collect data on site, collate, evaluate

· synthesis/mission statement (20%) – based on research and analysis, identify a retrofit strategy

· thoughtful presentation (10%) – verbal and visual presentation including original diagrams

· creativity/integrative thinking (30%) – qualitative evaluation of the framing and resolution of the problems you identify

Evaluations for the projects will include both comments and letter grades so that students can improve their performance over the semester. However, final work may not be redone and resubmitted to a new grade. Requests for extensions will only be granted if made in advance and warranted by 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 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. You will be working in groups for all semester assignments, although you are welcome to switch or reconfigure groups after each benchmark deadline. As masters students from a broad spectrum of disciplines, group work will offer you the chance to leverage your colleagues' expertise in a creative, design-based set of projects. You will be responsible for recording your work for submission to me for grading, so please carefully document both process and product. I recommend a **dedicated course notebook** and/or dossier to facilitate this. You may include your preparation of readings for class discussions, class notes, sketches or research notes, brainstorming sessions, etc in addition to the required final submissions of the group projects.

We will meet once a week for just under two hours. 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 reviewing readings and discussing questions. As needed, we will also dedicate part of the second hour to questions or concerns you may bring that affect and are of interest to the class as a whole.

Guest lectures will discuss new approaches and technologies, as well as case studies drawn from their own practices.

In the latter portion of the semester, we will devote more time to consultation and group discussion about your research on/proposals for the campus building we will study. I will continue to lecture of specific topics for the first part of the class, but the second part of the class will be dedicated to lab time and consultations. The last classes of the semester and two intermediary classes along the way will consist of student group presentations; I will assemble a panel of guests to review and discuss your findings.

All readings will be made available to you. Please be sure that you have a paper or digital copy for reference during class. Reading guides (posted on courseworks) will help to structure our discussions, but you should take initiative to prepare questions and comments independently.

Schedule:

Part I: Tool kit and Techniques for Energy Assessment

Week 1:

Lecture: Defining Energy in the Built Environment – from Thermodynamics to Geopolitics

Week 2:

Lecture: Thermal Comfort

Lab: Temperature and humidity tracking

Reference: *The Green Studio Handbook* Chapters 3 and 4 Heating and Cooling, esp. p. 105, 137 and 152

Assignment: Thermal Scavenger Hunt exercise

Week 3:

Lecture: Solar Energy Interactions: Tempering and Daylighting

Lab: Solar orientation/Light

Reference: *The Green Studio Handbook* Chapters 2 and 3 Lighting and Heating esp. p. 94-98

Due: Statement of purpose, Thermal Scavenger Hunt (upload on Feb. 6)

Assignment: Thermal Scavenger Hunt (ongoing)

Week 4:

Lecture: Legacy and new building systems/occupant interface

Lab: Developing an occupant survey

Reference: *The Green Studio Handbook* Chapter 5 Energy

Assignment: Thermal Scavenger Hunt (ongoing)

Week 5:

Lecture: Building load worksheet

Submission: Thermal Scavenger Hunt

Assignment: Campus Building Energy Assessment (Building tours must be scheduled during business hours outside of class time).

Part II: Energy Assessment and Conceptual Framework

Week 6:

Lecture: Comfort, Culture and Technology

Readings: 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;

Vladimir Jankovic, *Confronting the Climate: British Airs and the Making of Environmental Medicine* (Palgrave Macmillian: New York, 2010) Chapter 2 ‘Cursed by Comfort’

Austin Troy, *The Very Hungry City* (Yale University Press: New Haven and London, 2012), Chapter 6 ‘The Building Energy Diet’

Tutorial: Campus Building Energy Assessment initial findings and postulates

Week 7:

Lecture: Building Envelope: Materials, Layers, Stresses

Readings: Bill Bryson, *At Home* (Random House: New York, 2010) 'The Cellar'

John Straube, 'The Building Enclosure' (Building Science Digest 018, 8/2006)

Andrea Deplazes, *Constructing Architecture Materials Processes Structures: A Handbook* (Birkhäuser: Basel and Boston, 2005) p.295-302

Arthur Rüegg, 'Window/Façade: Gigon Guyer Architects' (a+u)

Tutorial: Campus Building Energy Assessment data mapping and trends

Week 8:

Guest Lecture: Luke Falk, The Related Companies,'Quantifying Building Assessment'

Readings: 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'

(*please note*: this reading will not be discussed during class time but it is a good text to diagnose the building you are studying creatively; please post your comments on Courseworks and we will discuss it that way)

Lab: Campus Building Energy Assessment summarizing and representing data

Week 9:

Presentation: Campus Building Energy Assessment (invited panel)

Assignment: Campus Building Energy Retrofit Proposal

Part III: Energy Retrofit Proposals

Week 10:

Guest Lecture: Floris Keverling Buisman, 475 High Performance Building Supply, 'New Strategies in Building Envelope'

Lab: Campus Building Energy Retrofit initial postulates and research plan

Week 11:

Lecture: Fiona Cousins, Principal, Sustainability Consulting, Arup, ‘New Approaches to Building Systems’

Lab Time: Campus Building Energy Retrofit building systems address

Week 12:

Guest Lecture: Theodore Prudhon, Architectural Integrity and Retrofit

Lab Time: Campus Building Energy Retrofit building envelope and occupancy address

Week 13:

Lab Time: Campus Building Thermal Retrofit consultations

Student Presentations, Campus Building Energy Retrofit Project:

Week 14/15: Final Projects Due, Final Presentations with guest reviewers

Book for Purchase:

Allison Kwok and Walter Grondzik, *The Green Studio Handbook* (Elsevier Press, 2007)

Resources (online):

http://www.nrel.gov/gis/mapsearch/

The NREL (National Renewable Energy Lab) 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.

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 AssessmentToolkit 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)