Zero Energy Housing: Design, Simulation and Feasibility

Spec Topic-Design & Tech - 28619 - COA 8833 - FGT

course time: Wednesday, Friday:
10:30 am – 12 noon
322 Cherry-Emerson Building

instructors: Godfried Augenbroe
Daniel Castro-Lacouture
Michael Gamble
Russell Gentry

Teaching Assistant:
Marcel A. Granier
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COURSE DESCRIPTION + OBJECTIVES

Zero Energy Housing: Design, Simulation and Feasibility will focus on the design, analysis, operation, construction, and cost feasibility of net zero energy buildings. The entire semester will focus on the design of small-scale ecologically-sensitive residential developments. Incorporating high-performance active and passive systems will be the key to the design activity. Students will work in cross-disciplinary teams to develop their proposals, characterizing:

- energy demand,
- energy production,
- building operational strategies,
- mechanical and electrical systems,
- building site and solar suitability,
- construction specifications and building process,
- initial cost estimating and return on investment,
- risks associated with implementing new technologies,
- building simulation, and
- life-cycle assessment.

The mantra for this course is "prove it" – all design decisions and building system selections must be justified through analysis, simulation, and calculations.

COURSE PROCEDURES AND ORGANIZATION

The course will meet twice a week. Typically, Wednesdays will be used for lectures and Fridays for in class working sessions/tutorials. Student teams will also meet weekly in "working session" at a published place and time (determined by the team) so that the instructors and/or teaching assistant can join as necessary. The once-per-week lectures will complement the design + research trajectory. Lectures will focus on building technology, case studies, introduction to simulation tools, construction specifications and cost estimating. We will introduce a spreadsheet-based methodology for tabulating energy demands and production and will lead the tutorials on design, building systems, building simulation, and cost-estimating.

Independent learning, initiative, and project-based work will be critical in this course. The final grade will be assigned wholly on the development of the zero energy housing proposal and the presentations and reports prepared to illustrate the proposal. Class members must be willing to work on the same team for the entire semester, and to contribute constructively to the work product of the team. Individual contributions to the final team product will be assessed by the team members themselves and by the faculty.

The basic trajectory of the semester is outlined in the **Proposed Lecture and Submittal Schedule,** below. It is likely that adjustments will be made during the semester. Though the proposed trajectory appears linear, the process of design is not. The teams must embrace an iterative process where design decision making and subsequent technical analysis work continuously throughout the semester. Those responsible for analysis should craft their analysis methodologies to permit quick changes to working assumptions about building configuration, envelope, systems, energy use, etc. Those responsible for design must be prepared to accept technical feedback and adjust designs accordingly.

FINAL ASSIGNMENT

The final project will be documented in single PDF document, in 11x17 format, that captures all of the components of the research and the proposed building. Appendices, including larger-scale drawings, calculations, spreadsheets, and models can be added based on the teams' individual work. The outline for this document follows the trajectory of the course itself, as follows:

1. Site
2. Architecture
3. Building Construction and Envelope
4. Mechanical Systems
5. Energy Systems
6. Material Take-Off and Cost Estimate
7. Financial Analysis
8. Life Cycle Assessment
9. Risk Analysis

ADDITIONAL GEORGIA TECH REQUIREMENTS

- The Student Bill of Academic Rights - http://www.catalog.gatech.edu/rules/22.php
- Academic Honor Code - http://www.catalog.gatech.edu/rules/18b.php
- Access Disabled Assistance Program for Tech Students - http://www.adapts.gatech.edu/

GRADING

Participation, Leadership and Peer Evaluation	**10%**
Assignments	**60%**
[1] Project Site Selection and Site Analysis	
[2] Building Program and Architectural Design	
[3] Design Development and Initial Building Energy Analysis	
[4] Building Systems Selection and Analysis	
[5] Building Cost Analysis, Feasibility, and Marketing Plan	
[6] Building Energy Analysis 2, Performance Indicators, Risk Analysis	
[7] Life Cycle Assessment	
Final Submission and Presentation	**30%**
Total	**100%**

Proposed Lecture and Submittal Schedule

Week			Lecture / Activity	Submittal
1	1/10	Schematic Design	Introduction + Teaming Site Assignment [MG + RG]	
2	1/17		Site Analysis + Building Form [MG} Passive Solar Design [RG]	Site Selection and Analysis
3	1/24		1st Order Energy Analysis [RG + GA] CEN Iso Method [RG + GA]	Site Plan, Building Program, Form, Massing **[1]**
4	1/31		Performance Benchmarks [GA] Cost Estimating Framework [DC]	
5	2/7		Mechanical Systems/Operations [RG] Architectural Pin-Up [MG]	Building Plans, Wall Sections, Systems **[2]**
6	2/14	Systems, Energy, Design Development	Georgia Power Lecture [Hansen]	Building Monthly Energy Analysis 1 **[3]**
7	2/21		PV Systems Lecture [Begovic]	Loads Analysis and System Sizing Modes of Operation **[4]**
8	2/28		System Specifications and Sizing [GA and RG]	
9	3/7			Mid-Term: Revised Building Design and Analysis. Systems. Monthly Energy Model. Revision of **[1 thru 4]**
10	3/14		Business Plan, Developer Perspective [MG and guest] Energy Modeling [GA and RG]	
	3/21		Spring Break	
11	3/28	Feasibility and Risk Analysis	Energy Modeling	
12	4/4		Risk Analysis	Feasibility, Cost Analysis, Marketing Plan **[5]**
13	4/11			
14	4/18		Life Cycle Assessment	Energy Modeling and Risk Analysis **[6]**
15	4/25		Final Document Production	
16	5/4		Final Presentations (during scheduled exam period) including LCA **[7]**	
Initials in brackets [xx] indicated lecturer. Numbers in brackets **[x]** are tied to list of assignments.				

References, Resources, Tools

ACCA Manual J Spreadsheet for Load Calculations: http://www.acca.org/speedsheet/

ASHRAE Fundamentals: Chapter 17, Residential Cooling and Heating Load Calculations[1]

ASHRAE Fundamentals: Chapter 19, Energy Estimating and Modeling Methods

[1] ASHRAE Fundamentals is available on-line at no cost thru the Georgia Tech Library.

Boyle, Godfrey, *Renewable Energy* (Oxford University Press; The Open University, 2004)

Build America Benchmark (residential building energy loads) http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/44816.pdf.

Dunster, Bill, *From A to ZED, Realising Zero (fossil) Energy Developments* (Bill Dunster architects ZEDfactory Ltd, 2003)

Dunster, Bill; Simmons, Craig; Gilbert, Bobby, *The ZED Book, Solutions for a Shrinking* World (Taylor & Francis; New York, 2008)

Ecotect:Building Site, Solar, and Shading Analysis: *http://usa.autodesk.com/adsk/servlet/pc/index?siteID=123112&id=12602821*

Galloway, Terry, *Solar House, A Guide for the Solar Designer* (Architectural Press- Elsevier; London, 2004)

Hastings, Robert; Wall, Maria, *Sustainable Solar Housing, Strategies and Solutions* (Earthscan; London, 2007)

Hinrichs, Roger A. and Kleinbach, M., *Energy: Its Use and the Environment*, 4th Edition.

Homer: Energy Analysis for Distributed Energy Systems, NREL, https://analysis.nrel.gov/homer/

ISO 13790:2008 "Energy performance of buildings -- Calculation of energy use for space heating and cooling", International Standards Organization.

Keeler, Marian and Burke, Bill, 2009, *Fundamentals of Integrated Design for Sustainable Building*, Wiley.

Kwok + Grondzik, *The Green Studio Handbook – Environmental Strategies for Schematic Design* (Elsevier, Architectural Press; Oxford England, 2007)

Mazria, Edward, *The Passive Solar Energy Book: A Complete Guide to Passive Solar Home, Greenhouse and Building Design*

Mubarak, Saleh, *How to Estimate With Means Data and Costworks* (R.S. Means Company; Kingston, 2002)

Rutkowski, Hank, Manual J: Residential Load Calculation

Retscreen Energy Project Analysis Software, Natural Resources Canada, http://www.retscreen.net/ang/home.php

Solar Dwelling Design Concepts (AIA Research Corporation and US Department of Housing, 2003).

Szokolay, Steven, 2004, *Introduction to Architectural Science: The Basis of Sustainable Design*, Elsevier Architectural Press.

U.S. Air Force, Passive Solar Design Guide, Volume 1, available on line at: http://www.wbdg.org/ccb/AF/AFH/pshbk_v1.pdf

U.S. Air Force, Passive Solar Design Guide, Volume 2, available on line at: http://www.wbdg.org/ccb/AF/AFH/pshbk_v2.pdf

www.toolbase.org (information clearing house of the National Association of Homebuilders)

http://www.natresnet.org/ (Residential Energy Services network – steward of the Household Energy Rating System)

Yannas, Simos, *Solar Energy and Housing Design; Volume 1: Principles, Objectives, Guidelines* (Architectural Association; London, 1994)

Yannas, Simos, *Solar Energy and Housing Design; Volume 2: Examples*

7group and Reed, Bill, 2009, *Integrative Design Guide to Green Building*, Wiley.