GREEN CONSTRUCTION
ARCH 4226 / ARCH 6226
Wednesday – Friday, 11:00 to 12:30
Skiles 169

Godfried Augenbroe, fried.augenbroe@coa.gatech.edu
Rm. 228 Hinman,
Office Hours: By appointment

Russell Gentry, russell.gentry@coa.gatech.edu
Rm. 202 Hinman
Office Hours: Monday 3.30 p.m. to 4.30 p.m. or by appointment

Synopsis

This course focuses on means, methods, strategies, and technologies to assess and improve the energy efficiency and performance of buildings. The course focuses on building design, materials selection, construction processes, building operations, and assessment. The first half of the course focus on the "big picture" of energy and the sustainability movement in the building industry and will be led primarily by Prof. Gentry. Prof. Augenbroe will lead the second half of the course which will focus on energy efficiency, impacts and regulations along with a primer in energy modeling.

The class is aimed at students with adequate background in computational approaches to building ecology and building physics through analysis, spreadsheeting, supported by a grasp of the fundamentals of heat transfer in buildings.

Learning Outcomes

Students will gain familiarity with the methods and technologies to improve the energy performance of buildings. They will understand the implications of material selection, construction processes, building operations, and translate them into the benchmarking of energy performance and application of sustainability ratings like LEED and HERS. Students will also learn how to use cost databases for the preliminary cost estimation of energy saving measures. Students will acquire the hands-on skills to work with energy calculation and simulation tools, and be able to use them for first order estimates of energy performance and making cost effective suggestions for retrofits.

Attendance

This course meets twice weekly. After two absences it will be necessary to speak with the instructors and to explain the reasons for any subsequent absences. More than two absences will result in a reduction of the participation component of the final grade.

Students with needs that are administered by the ADAPTS office are asked to meet with Professor Augenbroe or Gentry at the start of the term.

Course Assignments and Grading
The course will be graded based on written assignments and projects completed outside of class. There will be one in-class exam but no final exam. Assignments will consist of:

Assignments

Students will work individually on the assignments in the first half of the course, and work in teams of 2 on the project assignment in the second half of the course. Students enrolled in the graduate section will work on an extension of the project assignment dealing with retrofit auditing and financing.

Projects

Students will work in teams of 2 on the projects in the second half of the course. Each project will deal with incremental assessments of a building on campus.

Students enrolled in the graduate section of the course are expected to read additional material on retrofit/auditing and calibration and do an individual assignment related to an upgrade policy of the selected building on campus.. As precursor to this exercise, the graduate students should complete a set of readings, to include:

- Rocky Mountains Institute: Deep retrofits (2012)
- ASHRAE reports on retrofit auditing and financing (2006)

Assignments and Grading:

	UGrad	Grad
Individual weekly assignments: readings, web research, short “position” papers, calculations, take-offs, cost estimates, drawings, or sketches as required by the assignment. Weekly assignments will be assigned less frequently during the later part of the term when students are working on other longer-term assignments. Due at the start of the next class or as assigned.	40%	30%
Mid-term exam covering the first half of the course material.	30%	20%
Final assignment consisting of written group report with incremental building assessments	25%	25%
Final assignment consisting or written individual report of auditing assessment		20%
Participation	5%	5%
	100%	100%

Course readings and other materials will be distributed through T-square. All communication will be sent via T-square, so be certain that you check the email address that T-Square uses.

Homework assignments must be submitted on time. We expect homework submissions to be well organized. Written assignments must be typed. Homework assignments requiring calculations should be easy to follow and well-documented. All homework assignments that rely on outside sources should cite those sources. Homework assignments will be uploaded to t- square.

Homework assignments will be reviewed for completeness, correctness, and for evidence that students are engaged in the subject. Homework assignment will require outside readings, research, and will have no “closed form” exact solution. Top marks on homework assignments will only be given to those assignments that are technically complete, well-researched and easy to follow.

Honor Policy and Academic Conduct
It is expected that all individual assignments will be completed solely by the student. Students are expected to abide by the Georgia Tech Academic Honor Code. For research and writing assignments, it is critical that all references, including web sites, be identified in footnotes or a bibliography. Note that it is improper to cut and paste text from web documents and represent it as your own work.

Research Assignment and Topics
For the final project a building on the GT campus will be assessed by students as individuals or in small teams. The building will be assessed on three levels: (1) based on consumption data (Energy-STAR, BuildingEQ, other accepted benchmarks), (2) using a normative model (EPC), (3) using a simulation approach (IES-VE, with LEED scoring module). This is followed by a design/retrofit measure analysis. Based on the class size and makeup the class will have both a group component and individual components (a design retrofit analysis).

Reading material
The following textbook will be used, primarily in the second half of the class:
(1) Kjell Anderson: <u>Design Energy Simulation for Architects: Guide to 3D Graphics</u> [Paperback]
For the first part of the class you are also asked to purchase a copy of
(2) <u>Forest Sustainability</u>, by Donald Floyd.
Other reading will be distributed during the course, through t-square.

Proposed Lecture Schedule
The proposed lecture sequence and assignments will undoubtedly change based on our progress through the material. Additional readings and reference materials will be assigned. We will keep an updated version of the syllabus on the course folder for your reference. Guest lectures and field trips may need to be re-scheduled based on the availability of our invited guests.

Week		Lecture		Readings	Assignments
1		Augenbroe	Introduction	Forest Sustainability McDonough: Hannover … Bruntland Report (scan) Campbell: Green Cities … Economist: Changing Science… “Beware of LEED” Forest Sustainability AJC Article: Solar on the Rise	No. 1: Personal Footprintiing www.myfootprint.org
2		Gentry	Sustainability Movement		
3		Gentry	In Class Discussion Global Energy		No. 2: Personal Energy Analysis
4		Gentry	Building Systems – Passive and Active A Brief Review		No. 3. Building System Assessment
5		Gentry	LCA 1: Time Value of Money Return on Investment Life Cycle Costing	Payback Period Spreadsheet Engineering Economics Readings	No. 4: Payoff Period Calculation
6		Gentry	LCA 2: Life Cycle Analysis	Royal Chemical Society LCA of Brick LCAs and EPDs	No. 5: LCA on a given material or system
7		Gentry	LEED NC Rating System	LEED V4	No. 6: Analyze One LEED Point

Week		Lecture		Readings	Assignments
8		Gentry	Rating Systems 2 LEED EB, NAHB, ASHRAE 189, Earthcraft, Living Building Challenge		
9		Gentry	**Mid-Term Exam**		
10		Augenbroe	Benchmarking: EnergyStar, CBECS Building usage related energy consumption	Textbook 1: chapters 1-4 Start EcoTect	EnergyStar rating of campus building; Perform site climate analysis with Ecotect Read: DOE report (Quadr Review)
11		Augenbroe	Urban climate analysis	Textbook 1: Ch 5-7 SW/LW radiation! Data sources, reference models, Usage scenarios: IEA Annex 66	SW/LW radiation: Study references Finish Site Climate analysis Determine Usage profiles (schedules)
12		Augenbroe	Energy Modeling Primer 1: EPC	Textbook 1: Ch 8-10 EPC tutorial	Model campus building in EPC
13		Augenbroe	High performance building aspects First pass: retrofit analysis	Textbook 1: Chapters 10-12 Retrofit studies (reports)	Report (pdf): hand-in: WED Performance study of building: Initial Retrofit report
14		Augenbroe	Energy Modeling Primer 2: IES-VE	IEA-VE tutorials ASHRAE 90.1 Module	IES-VE model of campus building ASHRAE 90.1 score

Week		Lecture		Readings	Assignments
15		Augenbro e	Retrofit analysis-2 Auditing and calibration: the current methods	Investment grade audit book (replace by NPD, EE, CO2 targets) RMI "deep retrofits" report; ASHRAE reports: X% Textbook 1: Ch 10-12	Intervention study with IES Proposed interventions to obtain 50% energy saving Compare EPC to IES - Comparative - Absolute
16		Augenbroe	Energy (retrofit) Financing aspects (costs)	Example study: apartment retrofit Noesis webinar and report DOE-ESPC report	Final Building assessment report (All) Investment report; ESPC (graduate section) Targets: Max NPV Max E-saving, Min CO2
17		Both	Final Presentations		