Building Simulation in Design Practice
ARCH 4240 / ARCH 6241

Schedule: Wed, Friday 10:35-11:55; Location Clough 323
Instructor: Godfried Augenbroe, and PhD students

SYNOPSIS

Be able to use mainstream building simulation packages to support building design and retrofit studies, at a mid level. Type of simulation domains: Energy, airflow, lighting, ventilation, thermal comfort
Software packages to be considered (determination will be made each year depending on availability): **Ecotect, eQuest, EPC calculator, EnergyPlus, CONTAM, ANSYS-Fluent, Radiance, IES-VE** and one or more modeling front ends such as **Simergy, Open Studio, Design Builder, Green Building Studio.**

Scope:

- Mid to late design studies (no early conceptual design), e.g. for rating methods such as LEED, or ASHRAE 90.1 energy code conformance (and to some extent the LEED use of ASHRAE 90.1 (i.e. annex G)
- We will focus on the correct use of simulation software in practitioners' context, i.e. to recommend design options, make retrofit report, financial and other post-analysis
- Understand ongoing discussions about energy modeling, and underlying building energy performance issues

Energy emphasis (first part):

- Urban site climate analysis: Ecotect
- Simplified (reduced order) modeling and ranking: EPC calculator
- Advanced Energy modeling and simulation, energy demand studies, verification of saving potential: eQuest, EnergyPlus (3 iterations: plain, with ventilation studies (using CONTAM), with control study (using embedded EMS)
- Each a special purpose tool will be selected and added to the palette of tools.

Specialization: auditing and calibration of EnergyPlus model with monitored consumption data.

The overarching theme for this course is HANDS-ON use of the tools of the trade; understand the modeling principles, avoid mistakes, check and interpret results.

Individual specialization for students in undergraduate section:

(A) Lighting study with Rhino and Grasshopper plug in: DIVA
This study can be done as an application in the campus building or in the form of a parameter study on chosen building prototypes

(B) Urban energy study with EPC applied at the campus or city scale

(C) Test of existing platform for retrofits or building assessments, such as EnergyIQ (LBL), Building Performance Analysis (Autodesk), Commercial Building Energy saver (LBL), UMI (MIT), etc.

Individual Specialization for students in graduate section:

(A) Advanced auditing and calibration; multi scale modeling (façade vs. whole building; this could be aligned with the parallel Façade Engineering course)

Your building model will not produce accurate results for the chosen building unless you perform an audit of the building, identifying operational schedules, peculiarities, etc. If necessary this can be followed up by a calibration to bring the model in line with the measurement data that is collected. The auditing and calibration will be conducted with the EnergyPlus model.

(B) Uncertainty Analysis: subjecting your EnergyPlus model to an uncertainty analysis with the Georgia Tech Uncertainty and Risk Analysis Workbench (GURA-W)

Other possible specializations (To be selected by student and affirmed by Instructor)

- lighting: Radiance
- CFD: ANSYS-Fluent
- Other energy simulation: IES-VE, TRNSYS

A chosen tool specialization must have a clearly specified target that aligns with the services that energy modeling firms offer in the market, e.g. deep retrofit recommendation, audit report, investment risk, thermal and visual comfort studies, zero energy target feasibility, control system design, HVAC sizing, etc.

COURSE PROCEDURES AND ORGANIZATION

The course will meet twice a week. Wednesdays will be used for lectures and Fridays for in team working sessions and tutorials. Working sessions will be co-instructed by PhD students that have experience in the tool that we are dealing with.

Attendance

After two absences it will be necessary to speak with the instructor 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.
ARCH 4226/ARCH 6226 (Green Construction) is a prerequisite for this course. If you have not taken this course you need to talk to the instructor to determine whether there is a way that you can catch up on the prerequisite material outside of class (in the first two weeks).

Assignments:

Pre-condition: each team selects building from list (avoid duplicates; focus on buildings that have monitoring data). List will be provided. Each team will choose a Ga Tech building on campus and all team assignments will relate to that building. Students will become an expert in that building and at the end of the course each team will produce a report that is a full energy analysis of the building, with additional (non energy) aspects added as appropriate. The individual studies (Assignment 8) will be added to the final report as two additional chapters.

First part (teams of 2):

Assignment 1: Energy STAR benchmark, Ecotect site analysis, EPC calculator
Assignment 2: eQuest, IES-VE
Comparative analysis EPC, eQuest, IES-VE (demand, delivery, primary)
+ ASHRAE 90.1 calculation with IES-VE or eQuest
Assignment 3: (a) EnergyPlus with DB; (b) EnergyPlus with other front end
Assignment 4: (b) Energyplus with CONTAM (ventilation)
Assignment 5: (c) EnergyPlus with EMS (control)
Assignment 6: Comparative analysis of results 1-5
Assignment 7: Auditing/Calibration of EnergyPlus model

Second part (individual; selection is different for students in graduate and undergraduate section).

Assignment 8: Special assignment based on chosen specialization, i.e. any of the topics listed above as individual specialization. Other topics are possible but need to be agreed by Instructor. In rare cases Assignment 8 can be done by a team, but this needs prior approval by the instructor.

Student teams can meet weekly outside of class in "working session" with PhD students in HPB lab (HINMAN).

The Wednesday lectures will introduce the bigger picture and raise issues like;

- When to use this tool
- What modeling know-how is required
- What are the crucial modeling decisions
- How to get familiar with the tool through self study (tutorials)

The Friday sessions are to learn from each other, raise questions, get help when students get stuck.

Independent learning, initiative, and self guided energy assessment work are critical in this course. The final grade is assigned wholly on the final energy assessment report of the assigned building. Individual contributions

to the final team product will be assessed based on the hand in final report and the presentations in class.

Students spend many hours on tutorials, trying out different model concepts, testing outcomes and refining model inputs. It is checked bi-weekly that students do not fall behind or lift along with their partners!

FINAL REPORT (FR)
The total building assessment must documented in single PDF document at the end of the class.

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	**Undergrad**	**Grad**
Participation, Activity	10%	10%
Assignments 1-7	50 %	40%
Assignment 8	30%	40%
Final Report + Presentation	10%	10%
Total	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.

Proposed Schedule (2014 PhD lab assistants)

Week	**(due) dates)**	**Lecture / Activity**	**Comments**
1		W/F: INTRO; F Lecture Modeling issues. W: Recap of Ecotect, EPC, IES-VE	Form teams, choose building Data collection Support EPC: Jeannie
2	**A1**	Issues in Ecotect, EPC, IES-VE F: Start eQuest (Yuna), IES Q&A (Jeannie)	Half students have worked with IES-VE; they train the other half IES support: Jeannie
3		W: Modeling issues ASHRAE 90.1 (Jeannie) F: Q&A eQuest (Yuna)	Perform ASHRAE 90.1 check with eQuest (if possible) and IES-VE
4	**A2**	WED: Modeling issues FRI: Modeling lab	Other students get extra training in IES-VE and eQuest as needed (Jeannie/Yuna)

5	**A2+**	W: Start EnergyPlus (Qi/Yuna)) F: EnergyPlus modeling, DB, OS (Qi, Yuna)	
6	**A3**	W: Modeling issue, gbXML, front ends F: Q&A Sketchup, DB, OS (Qi, Yuna)	
7		W: HVAC systems (Qi, Qinpeng) F: Q&A OS/DB+EnergyPlus (Qi/Qinpeng)	
8	**A4**	W: Ventilation, Cp, nodal vs. CFD F: Intro CONTAM (Qinpeng, Yiyuan)	
9		W: Control; EMS approach (Qinpeng, Yiyuan F: Q&A EnergyPlus+EMS (Qinpeng, Yiyuan)	
10	**A5**	W: Review of models and outcomes F: Audit/calibration intro (Qi/Qinpeng)	Model adaptation: calibration Q&A: Qi
SPING BREAK **START INDIVIDUAL SPECIALIZATION**			
11	**A6**	Applications: Auditing; retrofit; F: Comparative analysis roundtable	Auditing procedures Support: Qinpeng/Qi
12	**A7**	W: Other simulation tools; TRNSYS or TBD (Yiyuan)	TRNSYS 3 day course (Yiyuan)
13		W: Other simulation tools; UA F: lab day with GURA-W (Qi/Qinpeng)	Use of UA workbench (uncertainties) (optional): Qinpeng
14		W: Lecture: other simulation tools DIVA (daylighting), other, TBD	Guest lectures DIVA and others (Sandeep/Patrick)
15	**A8**	W: Lecture: The future of BSim F: Cancelled	Final presentation date TBD
16	**Final Report**	**05/01: Final presentations** **05/02: Final report (pdf) due**	

REFERENCES: Tool tutorials, manuals and modeling guides. Other: TBD