ADVANCED ENERGY PERFORMANCE (AEP)

ARCH A4682
SPRING 2013

COURSE DESCRIPTION

Energy is increasingly a driving factor behind architectural design. Sustainable design today is giving way to resilient design, buildings that not only use less energy, but are more robust in the face of challenges from climate change. Our approach to reduction of carbon and driving efficiency in buildings will be critical over the next few decades as design and standards evolve to new regulation, social pressures and changing climate conditions. Design for energy efficiency must start to be integral to design processes, not simply an added element.

But how is energy used efficiently? How can it potentially define form and influence key client decisions? Key projects are increasingly LEED rated, and some profess to be NET ZERO energy. Understanding these trends in technology development is key to an advanced performance approach in architecture today. Even today, energy performance remains a key untapped area in many architectural solutions. Introducing integration across disciplines will be the focus of the course to enable students to better understand the process of driving energy performance in architecture.

Advanced Energy Performance will expand upon previous work in the AT sequence. It will explore the integration of three primary aspects of built form: energy use, envelope design and lighting. An understanding of the integrated nature of these design influences will be the ultimate outcome of the course. Lectures will review advanced concepts in performance modelling. Coursework will include hands on teaching of current computational modelling software with experts across the fields of energy modelling, lighting and envelope design. Lab work will computational modelling that is current state of the art in building design for thermal performance and optimization. Case studies of key current projects will be reviewed. A Class final design project will be developed to further advance students understanding of use of advanced tools in methods in performance design.

The class will use “Introduction to Building Physics”, Hagentoft. as a reference textbook. Additional references for further study are included at the end of the syllabus.

CLASS INSTRUCTORS

Professor	Craig Schwitter	craig.schwitter@burohappold.com
Guest Speakers	Erik Verboon	erik.verboon@burohappold.com
	Michael Marvin	Michael.marvin@burohappold.com
	Gabe Guilliams	gabe.guilliams@burohappold.com
Teaching Assistants:	Andrew Maier	am3709@columbia.edu (Lead TA)

CLASS HOURS

Class time: Wednesday 9 – 11am
Location: 408 Avery

HOMEWORK ASSIGNMENTS

There will be 6 homework assignments in the class that review key concepts and use of introduced software tools during the course. Sample problems will be outlined to HW Assignments will be assigned and distributed after class and be turned in by start of class the following week.

FINAL PROJECT

A final project will be developed as the capstone element of the class. A building will be selected by each student to perform environmental analysis and optimization studies. Buildings will be selected in various climate zones and analysed for base case performance and energy conservation measures (ECM's) to achieve performance targets.

GRADING:

ATTENDANCE	20%
HW (6)	40%
FINAL PROJECT	40%

High Pass	>90%
Pass	60 – 90%
Low Pass	50 – 60%
Fail	<50%

CLASS SCHEDULE AND LECTURE OUTLINE

1/22 LECTURE 1 **Intro to Advanced Energy Performance (AEP)**

Topics: **Intro to class. Review of basics concepts of energy performance in buildings. Introduction to computational systems and simulation software to be used in the class.**
HW: No Assignments

1/29 LECTURE 2 **Boundary Conditions and Heat Transfer**

Topics: Overview of standards on temperature, humidity, ventilation, construction and material use in buildings. Development of understanding of boundary conditions and thermal zones including definition of boundaries for computational modelling purposes. Review of area weighted calculation methods and comparison to computational tools.
Tools: LBNL THERM and WINDOW
HW: HW1

2/5 LECTURE 3 **Site, Solar and Environmental Assessment**

Topics: External environments and environmental variables for use in modelling. Review of sun angle and solar radiation calculations with rule of thumb options for conceptual design and verification of computational methods.
Lab:
Tools: ECOTECT. IES Sofware Introduction.
HW: HW2

2/12 LECTURE 4 **Wind and Natural Ventilation**

Topics: Introduction to wind and air properties and outline strategies for natural ventilation in buildings.
Lab:
Tools: IES software introduction continued. Macroflow simulation.
HW: HW3

2/19	**LECTURE 5**		**Pyschrometrics, Indoor Environment and Thermal Comfort**
		Topics:	Review of use of pyschrometric chart for establishing thermal comfort criteria. Review and analysis of strategies to understand and maximize thermal comfort in buildings. Overview of ASHRAE 55 and comfort assessment tools.
		Tools:	IES and THERM
		HW4:	HW4
2/26	**LECTURE 6**		**Office Visit and Case Study Review (At Buro Happold Offices)**
		Topics:	Office visit to Buro Happold NYC office. Review of sample case study current projects including lighting, energy and other strategies employed in delivering low energy building projects.
		HW:	No Assignment
3/5	**LECTURE 7**		**Active Systems**
		Topics:	Introduction of heating and cooling systems in basic IES models. Review of simulation of typical heating and cooling systems including understanding of modifying HVAC system settings within IES.
		Tools:	IES
		HW:	HW5
3/12	**LECTURE 8**		**Daylighting**
		Topics:	Introduction to daylight design and its benefits. Review of performance parameters (visual comfort, views, thermal comfort, etc.). Development of daylight systems and use in buildings. Introduction to RADIANCE to analyse light levels.
		Tools:	RADIANCE (ECOTECT)
		HW:	HW6
3/19	**NO CLASS – SPRING BREAK**		
4/2	**LECTURE 9**		**Passive Systems and Renewable Strategies**
		Topics:	Incorporation of previous topics into integrated passive strategies for building design including natural ventilation, daylight, and other ECM. Review of specific building examples and applications of IES simulations. Review of results for energy optimization and minimization of energy consumption.
		Tools:	IES
		HW:	No Assignments
3/27	**LECTURE 10**		**Final Project Proposals**
		Lab:	In class presentations for final project. Establish key project elements and set target goals for performance improvements.
		HW:	Development of existing/base case performance metrics
4/2	**LECTURE 11**		**Workshop/Crits on Final Projects**
		Lab:	Desk reviews of model development and results
		HW:	Develop ECM strategy
4/9	**LECTURE 12**		**Workshop/Crits on Final Projects**
		Lab:	Desk reviews of model development and results
		HW:	Review of modelling results
4/16	**LECTURE 13**		**Workshop/Crits on Final Projects**
		Lab:	Desk reviews of model development and results

HW: Review of modelling results/strategies for data presentation

4/23 LECTURE 14 Final Project Review (AT BURO HAPPOLD OFFICES)

Topics: Final project presentation to panel of building physicists at Buro Happold offices. Presentations to include review of project, model creation, modelling strategies and performance metric targets from baseline case to optimized results.

4/30 NO CLASS – FINAL REVIEW WEEK

REFERENCE LIST

Class Text:

“Introduction to Building Physics”, Hagentoft, Studentlitteratur

Supplementary Texts:

“Introduction to Heat Transfer”, 4th edition, Incropera and DeWitt, John Wiley and Sons
“Mechanical Engineering Reference Manual” Lindeburg, Mark, Professional Publications
“Engineering Thermodynamics Work and Heat Transfer” Rogers and Mayhew, Longman Group
“Energy and Climate in the Urban Built Environment”, edited by Santanmouris, M.
“Mechanical and Electrical Equipment for Buildings”, 9th edition, McGuiness, Stein and Reynolds, John Wiley and Sons.
“Natural Ventilation in Buildings”, Design Handbook edited by Francis Allard, James and James
“Integrated Buildings – The Systems Basis of Architecture” Bachman, John Wiley and Sons
“Heating, Cooling, Lighting” Norbert Lechner
“Sun, Wind, & Light” Brown & DeKay
“LEED Reference Guide”,US Green Building Council
“ASHRAE GreenGuidelines”, edited by David L. Grumman
“Advance Building Simulations”, edited by Ali M. Malkawi and Godfried Augenbroe