AE – Capstone Fall 2023 - Spring 2024

Integrated Design: Architectural Composition, Building Science and Net Zero Energy

Professor Anton Harfmann

Course Syllabus

Introduction

This capstone studio provides a complete experience of integrated, net-zero energy design of a building and its systems. The first semester focuses on schematic design and design development, situating the importance of collaboration between varying engineering expertise (structural, mechanical, electrical, construction) throughout an architectural design endeavor. Consequently, the studio begins with wide-ranging questions of the relationships between the disciplines, satisfying the architectural program and responding to the site, then explores major design options and systems integration in response to these. Engineering and construction aspects are imbedded throughout the process from overall site and building design to the ultimate selection of beams, ducts and designing connections and scheduling construction. Additionally, the capstone will weave ethical and professional issues into the overall studio experience to better prepare students for entry into the practice environment.

Content

Students will work together on teams of approximately eight, distributed in a balanced arrangement based on expertise. Four projects will be the focus of the capstone and teams will be assigned to the task of designing one of the four buildings. All four projects will use the rules of the Solar Decathlon Design Challenge to design a Net-Zero Energy building. One team will be designing a STEM high school, one team will be designing an office building, one team will be designing a commercial/multi-family building and one team will be designing an attached housing complex. The sites for all four buildings are in Amersfoort, Netherlands. To gain insights about the climate, social reality and culture, arrangements have been made for teams to consult with Dutch citizens during the design process. By the end of the Fall semester, designs should be 90% complete through the stage of Design Development with a solid strategy established for the integration of site systems, structural systems, mechanical systems, alternative energy systems, energy calculations, and construction logistics. The following Spring semester will focus on detailed design and integration of the systems into a cohesive whole and preparing the final documents and report or submission to the Solar Decathlon national design challenge competition.

The studio will begin with an analysis of the site and program in parallel with initial site and building design ideation. Formal methods that we will use to move through the process of design include morphological analysis, diagramming, and top down/bottom-up strategies for the generation of alternatives—weighted subjective and quantifiable objective criteria analysis for the evaluation of alternatives—and developing design drivers for parametric modeling. We will incorporate 3-D parametric modeling strategies to keep the question of design open for as long as possible. Revit will serve as the primary tool throughout the design process and for extracting information needed for analysis of overall energy, economic and structural performance.

Projects will be substantially completed during the first half of the Spring 2024 semester to meet the deadlines of the Solar Decathlon Design Challenge. Additional details and deadlines will be issued with the Spring semester syllabus and schedule.

Background Narrative and Sites

To exercise your architectural and engineering skills acquired over the past 4 plus years, the sites for design will not be local. As mentioned previously, the sites for the Solar Decathlon will be in Amersfoort, Netherlands. The city of Amersfoort is an historic, small city in the central region of the Netherlands and is a popular stop for tourists. Most European tourists enjoy short stays often driving their RVs and include Amersfoort on of their multi-city tour stops. Like the rest of the Netherlands, Amersfoort is a very progressive city with an extremely sophisticated network of bicycle lanes and paths, easy access to public transportation, pedestrian friendly streets, and of course, a network of canals still in use today. In response to climate change and the growing interest in sustainable lifestyles, the city of Amersfoort wants to capitalize on its central location and invest in a series of different net-zero energy buildings to boost the city's image as a progressive leader in the pursuit of net-zero energy lifestyles. To realize this goal, the city would like to build four dissimilar buildings that together, showcase the integration of energy saving, energy producing and energy storage solutions across a variety of building types. By incorporating these energy strategies into different building types, the city hopes to stimulate the rest of Amersfoort's inhabitants to join the net-zero movement and make the city a destination for its innovative solutions for net-zero living.

Google map and aerial view of Amersfoort and location of the Net Zero sites.

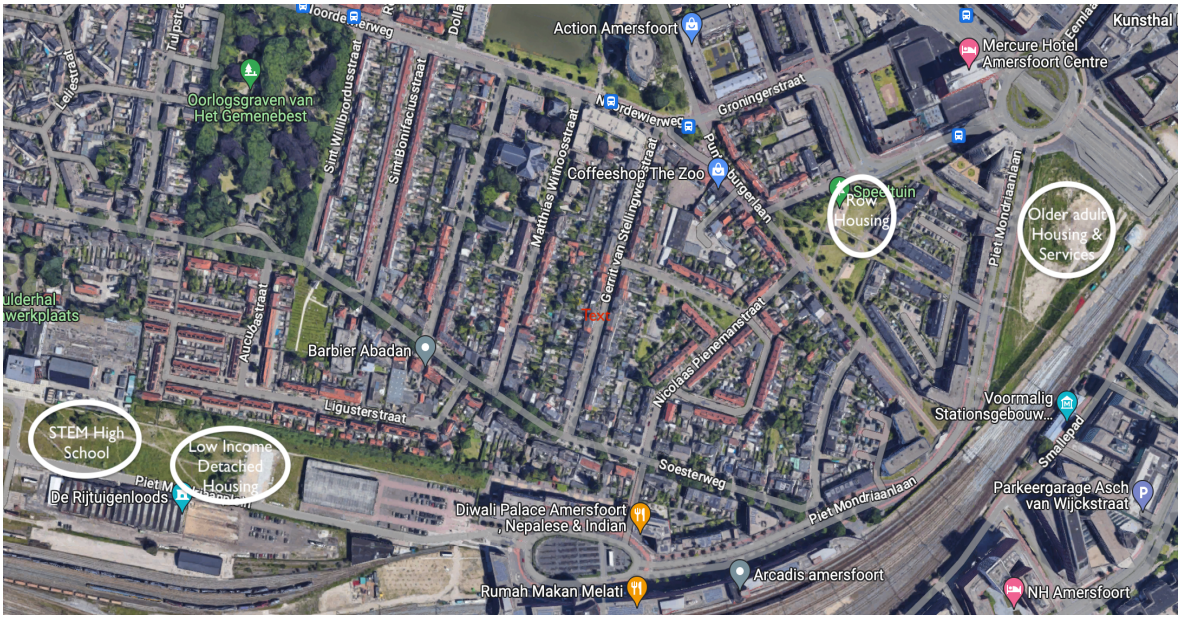
The climate in Amersfoort is more temperate than Cincinnati but is still dominated by heating degree days. However, the northern latitude poses an interesting design challenge when it comes to daylight and access to solar energy. The sun at winter solstice rises at about 8:45am and sets at about 4:30pm limiting access to the sun's energy to only about 6 or 7 hours a day in the winter months. Conversely, at summer solstice, the sun rises at about 5:15am and sets at about 10pm. This uneven access to solar energy forces each team out of their comfort zone - expanding their ability to use their design and engineering backgrounds to design net-zero buildings.

The sites for all four net zero energy buildings are all within walking distance from the main train station in Amersfoort making it easy for net zero energy tourists to find them. The four buildings are programmatically linked through the goal of showcasing net zero design and technologies. The first net-zero showcase complex will be a small, sub-division of detached, single-family houses. For low-income families. The location near the train station provides easy access to public transportation and net zero utility bills will be helpful for families with limited means. The city would like to consider at least three different design concepts (1-BR, 2,BR and 3BR) as well as a sub-division plan that includes at least 12 houses to create a neighborhood for the families living in these houses.

Since the Netherlands is also very well known for how they care for older adults, the second "showcase" building will accommodate housing for older adults as well as services for older adults. The net-zero energy solution will be highly desirable for those on a fixed retirement income and the complex should include parking and EV charge stations to promote the net zero lifestyle.

Attached housing is perhaps the most common housing type in the Netherlands. Consequently, the third building will be an attached housing complex of 6 to 8 units of 2 and 3 bedrooms on a tight site in a residential neighborhood. These units are intended for small families with more modest incomes who would benefit greatly from zero monthly energy bills.

Finally, the fourth building will focus on educating the youth as well as community members through the construction of a public high school that specializes in STEM (Science, Technology, Engineering and Math) education with a directed course of study in alternative energy solutions. The school's main auditorium lecture space and a DYI lab for alternative energy will be open in the evenings for community use and for continuing education classes on sustainable lifestyle, and alternative energy design and integration. The four sites in Amersfoort are shown below.



Detail view of net zero sites for each building.

Course Objectives and Competencies

- Students will demonstrate their ***technical knowledge and information literacy*** through the analysis of site, program, and precedent then ***apply*** this information to affect design decisions.
- Students will demonstrate their ***critical thinking*** abilities by solving complex design problems and integrating net zero strategies in design and construction.
- Students will demonstrate their understanding of how environmental, social, technical and economic issues ***influence*** the design of a building and site.
- Students will demonstrate their ability to ***integrate knowledge*** through synthesizing the design od complex systems within a building including structural, circulation/egress, mechanical and plumbing systems.
- Students will demonstrate their ability to ***collaborate*** with different disciplines through the use of a shared, parametric Building Information Model.
- Students will demonstrate their ability to ***effectively communicate*** verbally, graphically and in written form.
- Students will ***engage*** in a problem-solving exercise responding to various representatives of disciplinary and topical stakeholders.

Activities

Lectures – A series of prepared presentations will be offered during the term to lay the foundation for some of the concepts that may represent new territory. Examples include, basic concepts of parametric modeling, exploring design alternatives using formal design methods, economic analysis and sustainability will be presented as prepared topics with a direct relationship to the studio efforts and progress.

Collaboration – Students will be organized into design teams based on expertise and educational focus and will work on the design and detailing of their building design during the Fall term. Design, topical or systems related group meetings that cut across the focus areas in each team (such as structural system design or photovoltaic array design) will be held throughout the term as well.

Research – Research efforts to illuminate issues that will directly affect the design and detailing of the building project will be assigned to each team. Research topics include codes, options for structural systems, options for mechanical systems, collecting environmental/climate data, cost data, performance data precedent research etc. Teams will incorporate the research into their team projects and reports.

Analysis– Analysis of various aspects of the emerging design will occur throughout the entire design process all year long and will include, energy analysis, structural analysis, cost analysis, code compliance analysis to name a few. Teams will integrate their responses to analyses into their designs and final report documentation.

Design – Instead of a "free-for-all" design process with each student producing ideas "out of the blue," the early stages of the design process will proceed in a highly organized and systematic manner. Individual creative efforts will be dissected and analyzed then added to the overall emerging set of alternatives under consideration. This in turn will stimulate many more alternatives for systematic exploration.

Studio structure

A combination of individual work, small teamwork and large team efforts will be deployed throughout the semester. Overall, students will be divided into 4 teams. Each team will create an identity as an AEC full-service firm and will be asked to propose and develop an approach for completing the entire Design-Engineering-Construction process. All expertise within the student population will need to be evenly distributed across the four teams to ensure a rich and fruitful exchange during the design process with one or two individual group members taking responsibility for the major roles in the design of the building (Structural, Architectural, Mechanical, Electrical, Lighting, Alternative Energy, Construction, Building Information Modeling, etc.) Individual work within each group will be assigned based on disciplinary focus. Meetings will oscillate between team consultations, systems group meetings and disciplinary specific meetings.

Teams

Shown below is the team structure for the three buildings with the self-identified areas of strengths and interests.

Low income-detached housing complex

				Expertise					
				Arch	Struc	HVAC	Light/Elec	Const	Revit
Burger	Zoey Venay	M13282502	burgerzv@mail.uc.edu	1	4	3	5	2	6
O'Neal	Sheridan-Lex	M13353382	onealsx@mail.uc.edu	1	4	5	2	3	5
Graessle	Quinn Parker	M13309285	graessqp@mail.uc.edu	1	3	4	5	2	3
Erhold	Zachary	M13403765	erholdzd@mail.uc.edu	3	2	1	4	5	3
Davis	Abigale	M12853529	davis6a7@mail.uc.edu	5	2	1	3	4	6
Obermeyer Jr.	Jeffrey David	M13353534	obermejd@mail.uc.edu	4	3	1	2	5	4
Spinosi	Nicholas R	M13378731	spinosnr@mail.uc.edu	5	4	2	1	3	3
Gavlak	Alexander	M12797651	gavlakaj@mail.uc.edu	3	4	2	5	1	5
Miller	Jacob Alan	M12804743	mille9ji@mail.uc.edu	5	5	5	5	1	5

Attached Housing

Gast	Abigail	M13306148	gastar@mail.uc.edu	1	4	3	5	2	5
Wickstrom	Ike A	M11213650	wickstia@mail.uc.edu	1	2	5	5	3	6
Polacek	Ryan J	M13244530	polacerj@mail.uc.edu	3	2	1	5	4	4
Hans	Abby	M13312767	hansay@mail.uc.edu	3	5	1	3	4	6
Frank	Aaron Michael	M13453527	frankaa@mail.uc.edu	2	5	3	1	4	5
Kolb	Curtis Scott	M13329964	kolbcs@mail.uc.edu	3	4	2	5	1	5
Biehle	Elizabeth Anne	M13276452	biehleea@mail.uc.edu	3	5	2	5	1	5.5
Beck	Alexander L	M13274086	beck2al@mail.uc.edu	2	3	4	5	1	5

STEM High School and DIY Center

Sharpe	Trevor Donovan	M13373818	sharpetd@mail.uc.edu	1	3	5	4	2	3
Courtney	Elizabeth Ann	M13290326	courtneh@mail.uc.edu	1	3	2	4	5	5
Whittemore	Dylan Kirk	M12477287	whittedk@mail.uc.edu	5	1	2	3	4	7
DeWald	Lucas Gerard	M13403570	dewaldlg@mail.uc.edu	3	5	1	4	2	5
Albrecht	Thomas	M13267708	albrects@mail.uc.edu	5	5	1	4	5	3
Padovani	Samuel Anthony	M13354959	padovasa@mail.uc.edu	5	3	4	1	2	5
Holden	Myia Rae	M12474668	holdenmr@mail.uc.edu	3	5	2	4	1	7
Swisher	Lydia Marie	M13382538	swishela@mail.uc.edu	2	4	5	4	1	5.5

Older adult housing and services

Wirth	Tyler Angland	M13395427	wirthta@mail.uc.edu	1	3	4	5	2	4
Pack	Weston Garrett	M13354895	packwg@mail.uc.edu	1	5	3	4	2	4
Gibbs	Julia Marie	M12990742	gibbsjm@mail.uc.edu	1	5	3	5	3	6
Cramer	Emily	M12794602	cramerej@mail.uc.edu	2	1	5	4	3	4
Burke	Jessica	M13395005	burke3jl@mail.uc.edu	3	5	1	4	2	6
Deardorff	Sophia Rose	M12847866	deardosr@mail.uc.edu	4	5	1	3	2	4
Luebbering III	Robert Charles	M13000501	luebberc@mail.uc.edu	5	4	3	1	2	3
Metzger	Luke William	M13344806	metzgelw@mail.uc.edu	2	5	3	4	1	4

Schedule

A draft schedule for the progress over the two semesters follows. The processes of design and development will, for the most part, be parallel across the teams for the first semester with minor differences that relate to specifics for each building. By the end of the semester a good first draft of the presentation and report required by the Solar Decathlon. The Spring semester entails the completion of the design and analysis process and the finalization of the report to the Solar Decathlon. In addition, students will produce a poster summarizing their design and analysis of their net zero building for both the CEAS exhibition of capstone work and possibly for presentation at other conferences.

Fall 2023 semester

Week 1	Introductions, group assignments
Week 2	Site and program analysis and initial site planning ideation
Week 3	Presentation of analyses and initial building ideation
Week 4	Group work
Week 5	Initial Schematic Design reviews
Week 6	Initial Energy calculations for buildings due
Week 7	Group work
Week 8	Group
Week 9	Mid-term reviews by building type
Week 10	Group
Week 11	Group - begin Design Development
Week 12	First draft of report and presentation
Week 13	Group
Week 14	Group
Week 15	Final Presentations and draft 1 of Final Report

Spring 2024 semester

Week 1	Continue design development– begin detailed energy analysis
Week 2	Group work
Week 3	Presentation of design development and energy analysis
Week 4	Draft 2 of final report due
Week 5	Group work
Week 6	Finalize calculations – Draft 3 of report & draft poster due
Week 7	Semi Final presentation, SD submission due
Week 8	Group work
Week 9	Group work
Week 10	Finalize design
Week 11	Final calculations due
Week 12	Final Report due and submission to Solar Decathlon
Week 13	Supplemental capstone work
Week 14	Solar Decathlon Competition in Denver
Week 15	Poster due and CEAS Expo

Expectations and Products

Students are expected to actively participate in a semester-long effort of research, discourse, design, and evaluation. Individual and group efforts will all contribute to the overall success of the competition. Consequently, individual and group grades will be recorded, and each student will receive evaluations for their work individually and for their efforts as part of a group. Likewise, you will be asked to evaluate your peers and those scores will factor into each student's final grade for the studio.

There are two final products of the studio that range from analysis work accomplished by large groups to individual contributions. Attention must be paid to each of the specific requirements of each of the four competitions. The general descriptions of the final requirements of this semester's studio effort follow:

1. A comprehensive set of documents, and diagrams that describe the qualifications of the team and their approach to providing the full design to construction service. The comprehensive set of documents should also include drawings and diagrams describing and analyzing the site, the program and relevant codes that influence design. The documents shall be presented in a consistent format with each group agreeing to a graphic standard and should also meet all the submission requirements of the Solar Decathlon. Individual efforts within the group effort will be noted on each section of the final report so that we may assess individual contributions. Examples of a format and presentation style will be shown in class, and it is expected that each group will design their own graphic and presentation standards.
2. A comprehensive presentation of the final site and building design that should include traditional 2-D and 3-D information such as floor plans, elevations, sections, axonometric and perspectival views as well as analytical information such as energy consumption, approximate cost, EUI structural analysis, etc. The presentation should also include diagrams of circulation, structure, mechanical and programmatic integration. The final presentation will be delivered through PowerPoint and key features of the design and performance summarized on large color PDFs that can be plotted for a display for the CEAS capstone expo. Details and examples for the presentation will be issued with the problem statements later in the semester.
3. You will be expected to interact and be responsive to external critics and the interests of representative stakeholders.

Assessment

Grades will be determined by your level of understanding and demonstrated ability in five different categories across the various efforts in the studio and design exercise as follows:

- Analytic understanding of content – the ability to understand basic principles developed in lectures, readings, and research with the ability to explain and apply the principles verbally, graphically and in written form in the analysis of existing buildings, the analysis of site, the analysis of program and in the analysis of your team's and your own project work.
- Interpretation of content – the ability to identify the influence of historical, cultural, social, and artistic forces in works of design. The ability to clearly describe the impact these forces have through words and diagrams and the ability to manipulate design in response to these forces.
- Synthetic integration of content – the ability to deal with several elements, ideas, images and goals in a manner that gathers increased meaning and utility from the integration of a large number of often conflicting demands.

- Group work skills – the ability to work in a healthy, productive manner with your peers. The ability to offer appropriate leadership, mentoring and support. The ability to give and receive constructive criticism. The ability to encourage, develop and accept the best effort from all team members.
- Graphic, written, and oral skills – The ability to use appropriate media to express your ideas. The ability to create rich, meaningful, beautiful, and succinct presentations appropriate to the level of investigation.

A significant portion (60%) of each individual grade for the group projects will be determined by peer-to-peer evaluations within each team. Consequently, individual contributions to a group project must be clearly indicated and recorded.

Grades are recorded in the university using letter grades. The various letter grades should be understood to have the following meanings;

A An outstanding, distinguished performance. Evidence of extraordinary accomplishment relative to the objectives and expectations of the course. Work that is exemplary in its clarity, coherence, completeness and inventiveness.

B A good, effective performance. Demonstration of an interest in and general proficiency in meeting the course objectives and expectations. Work that is consistently competent and complete.

C A fair and sufficient but unexceptional performance. Demonstration of basic competency and accomplishment relative to the course objectives and expectations. Work that shows acceptable levels of design performance and reasonable efforts

D A poor, barely acceptable performance. Evidence of a lack of interest and accomplishment relative to course objectives and expectations. Work that is incomplete, minimally competent, disorganized and/or poorly developed.

F An unacceptable performance and work.

Note: Grades for the first semester reflect the current progress of the two-semester project. These grades may be changed based on the final overall performance across both semesters.

Exceptions

The grade "I" (incomplete) can be assigned only to a student who has a legitimate medical emergency or other incapacitating event. Students wishing to withdraw from the course after the fifth week of studio must show evidence of passing work to receive a "W" (withdraw passing).