KEELAN KAISER

The School of the Art Institute of Chicago/Judson University

Carbon Neutral Studio

Fall 2007 Arch. 451: Architecture Design V (UG)

This course is located at the fourth year in a six-year degree program. The course is typically structured as a five-week sustainable neighborhood design problem followed by a ten-week building design problem.

I take a rules of thumb approach to "teaching" CND principles in the studio. We need as much land as the footprint of the building for on-site water management, we need to provide roughly the same square feet of PV as gross square feet of facility (in Chicago, IL) in order to approach zero net energy, and so on. Studio pedagogy is as diverse a subject as one could imagine in academia, so my interest is not so much synthesizing a universal approach to CND as it is to hone in on the handful of "first principles" and ensure that students have grasped their importance before beginning future studios...

PROGRAM STATEMENT

A 30,000 g.s.f. Magnet High School with an emphasis in Ecology, this program follows an earlier city plan to locate a new school in this area. The neighborhood site is within city and infrastructure, but vacant. The sites sit along the Fox River and include riparian connections.

The neighborhood and building were chosen because of the perceived need to have the students think beyond the perimeter of the building shell when considering the macro scale issues with CND. Since the building would need to be 2-3 stories, PV would not solve the energy needs entirely.

We also looked at health and welfare issues in conjunction with energy issues (e.g. natural ventilation for improved IAQ, passive solar and daylighting, on-site food production, integrated vegetation, etc. (i.e. Kellert: Building for Life).

An ulterior motive was to use the products of the class to educate the local community in sustainable architecture, envisioning this neighborhood being a low-impact alternative to suburban Greenfield development.

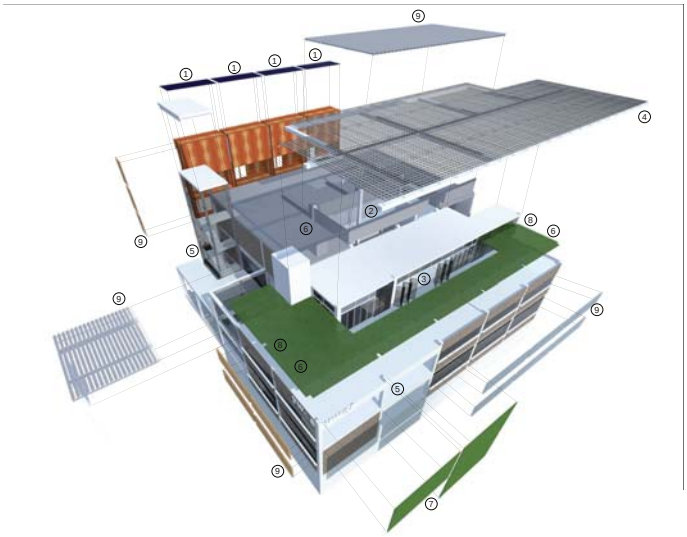
The hope was that this would stimulate discussion among the city council and development community to consider the opportunities to develop mixed-use density within the existing city core. Some progress resulted, and the city has a Sustainable City Masterplan RFP out. I would like to think that some of this work has played a small role in encouraging this thinking in city leadership.

CLIMATE TYPE PROFILE

X-Large – residential and mixed use neighborhood land planning/urban design

Large – School building type

_____- Elgin, Illinois



Sustainable Strategies

1. Solar Evacuated Tube Collectors
2. Natural Daylight
3. Operable Windows
4. Intergrated Photovoltaic Solar Panels
5. Radiant Heat Floor Slabs
6. Rain Water Harvesting
7. Green Wall
8. Green Roof / Urban Garden
9. Sun shading Devices

Studio TEACHING TOPIC Key

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TEACHING TOPICS PROFILED

1. Building Massing/Site Design

This topic is a critical first step. The building massing must address passive solar as a foundational site opportunity.

2.Fresh Air/ Indoor Air Quality

The objective then, for the design studio, is for the students to demonstrate that 1) air can move through the environments they have created without relying on fans, and 2) they understand some of the barriers to designing for fresh air.

3. Daylighting, Passive Solar and Solar Control

This topic combines two primary exercises. The first objective is to provide for passive solar gain in during a 5-6 month period of the year to lessen heating demand. The second objective is to integrate effective daylighting in conjunction with the passive solar strategy.

4. Building Integrated Photovoltaics

Combine photovoltaics as an on-site renewable energy strategy with the built form of the studio project.

5. Adaptive Reuse (Alternative Approach 1)

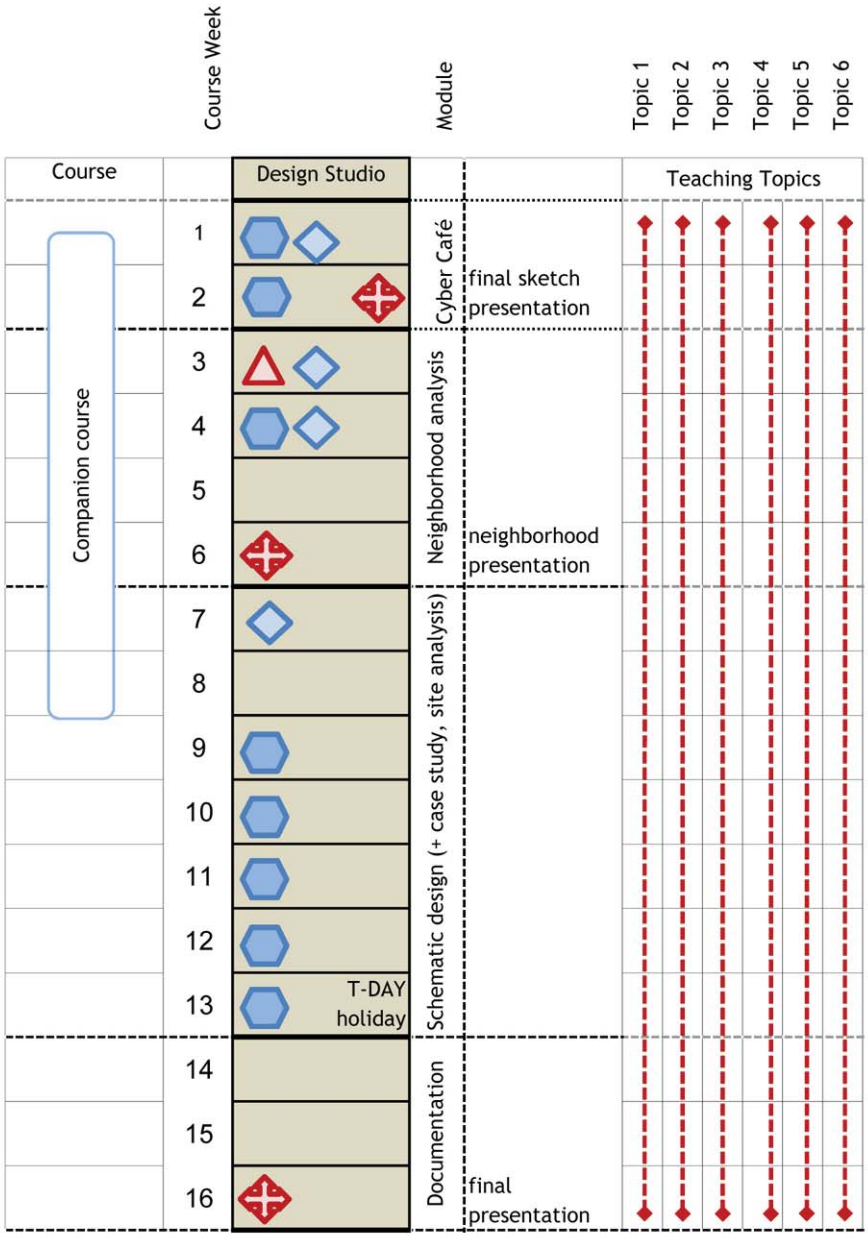
Using existing building stock, transform a building from its original use to a new use as a means of limiting new construction to demolition redesign of existing infrastructure and finishes as needed.

6. Neighborhood Design (Alternative Approach 2)

Design a green community development plan on an existing municipal site.

THE TEACHING TOPICS IN THE CONTEXT OF THE COURSE

Since it is a studio it is hard to partition the decision making flow from one topic to another. They are all introduced and investigated simultaneously. Granted this is senior level and graduate work, so the mature student is able to manage these issues simultaneously better than a beginning or intermediate level student. The neighborhood design actually comes first in the sequence to set the stage for a larger view of sustainable design, then the building project follows with the four topics covered here.



Philosophy of CND Studio Instruction

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Carbon Neutrality in the built environment includes two main considerations: now-conventional views of low energy and high performance buildings and site/building oriented regeneration strategies. The former has gained traction in both academia and practice, while the latter continues to be a vision of only a few, since addressed formally by Lyle in the 70's, revisited by Orr in the 90's.

One means by which I am communicating with my students is by addressing health and welfare issues inherent in the building enterprise. This touches on values, as I have observed them, held by the majority students. I have found Building for Life and Biophilic Design, both authored by Steven Kellert, to be particularly useful in communicating the value of healthy buildings and our interrelation to nature and natural systems. I also like these titles because they fit nicely with my own value of life and position architecture and the built environment to affect positively human experience and quality of life. The works are not limited to science but introduce a faith and spiritual perspective that I find refreshingly human and beyond the mechanical.

I take a rules of thumb approach to "teaching" CND principles in the studio. We need as much land as the footprint of the building for on-site water management, we need to provide roughly the same square feet of PV as gross square feet of facility (in my location) in order to approach zero net energy, and so on.

Studio pedagogy is as diverse a subject as one could imagine in academia, so my interest is not so much synthesizing a universal approach to CND as it is to hone in on the handful of "first principles" and ensure that students have grasped their importance before beginning future studios. Like principles of building safety, accessibility, and energy, CND can parallel these first principle values. Of course, the key is to communicate value to the student, or in practice to the client.

I have used a two-part exercise in teaching low energy and high performance building concepts in studio. On the one hand, I have my students research a particular building and conduct a case study of that work, focusing on a building envelope strategy. This usually takes an architectural expression direction. But there is value in this, because it stimulates curiosity in the relationship between built form and building performance.

On the other hand, the students build a digital section model of a key zone of the building they have studied. I find this to be superior to a section drawing, since the student builds all of the components present in a section drawing and elevation. The model is usually extruded approximately 12'-20' to accommodate elevation considerations as well. The student can then visualize the principle (section diagram perhaps) as well as the execution (the built assembly) of the assembly system at work. Of course, this can be visualized from multiple views; solar geometry and daylighting can be assessed against the model, etc.

An important part of the CND equation for my teaching is the inclusion of regeneration concepts. Regeneration involves generating, in addition to necessarily depleting, renewable energy and resource production on-site. On-site water and waste treatment and management, power generation, food production, habitat and biodiversity, are but a few items that I discuss and value during studio.

It is not without difficulty. It is entirely another scale of commitment to design for regeneration; and it tends to be land intensive, natural resource intensive, solar access intensive, to name a few of the critical site needs. It is also clear that there are limits to regenerative design, and it might be that regeneration can only truly happen at a larger scale, say that of a neighborhood or larger. But the future of the built environment must include regeneration to reach a truly sustainable world with self-supporting built environments.

Neighborhood Plan
Austin Fredrickson
Tyler Hughes

Case study of Bayer by MurphyJahn
Stewart

Building Massing/Site Design
Thomas Sharp

10 Critical Issues / 10 Common Mistakes

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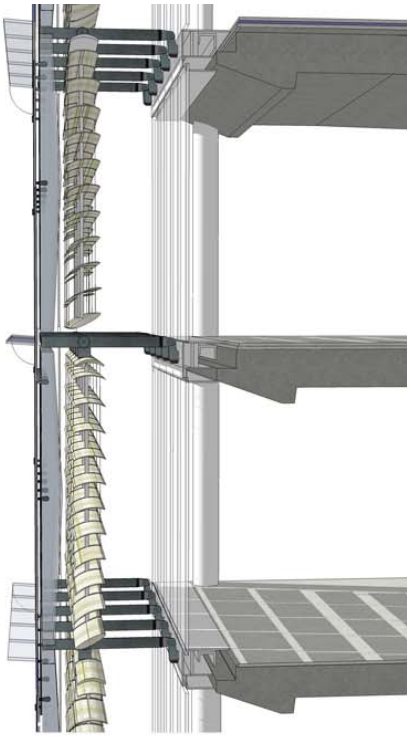
10 Critical Issues in the Teaching of Carbon Neutral Design

1. *Thick, but not fat, east-west orientation, , with parallel considerations of daylighting, natural ventilation, construction efficiency, and access to natural environments.*
2. *PV, Green roof/wall, Rainscreen: all Integrated, not applied*
3. *Thermal mass exposed to interior to lower indoor temperature swings during natural ventilation modes*
4. *Integration of passive solar as a given requirement for any CND project to harness solar radiation energy*
5. *Appropriate solar shading on E, S, W, each one customized to orientation, to minimize cooling load*
6. *Cross ventilation: mitigate cooling, IAQ, increase user control*
7. *Stack ventilation: mitigate cooling, IAQ, night flushing*
8. *Include users/civic leaders in programming, process, and review*
9. *Include all considerations for how the building and site can harness and harvest natural and renewable resources*
10. *Privileged building performances issues as a parallel consideration to all other design priorities including client needs, aesthetic approach, and cost evaluation; i.e. parallel considerations, not in series.*



10 Student Design Mistakes that Undermine the Goal of Carbon Neutral Design

1. *Inadequate response to solar geometry*
2. *Building performance considerations after preliminary design*
3. *Tack-on applications rather than integrative thinking*
4. *Building massing/decisions related to harnessing and harvesting*
5. *"The mechanical engineer can make my design work"*
6. *A priori building performance thinking will constrain innovation*
7. *Solar shading can be treated the same on all elevations*
8. *Conventional thinking about MEP*
9. *Thinking CND is about calculations/proofs alone*
10. *Thinking CND can be achieved without calculations/proofs*

Case Study of Bayer by MurphyJahn
Stewart

Supporting Material

Keelan P. Kaiser
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COURSE MATERIALS

Kaiser ARC 451 Syllabus and Schedule 2007. PDF

PAPERS

Kaiser, K. *A green studio pedagogy: using scale changes to influence architectural design for sustainability.* 2007 Architectural Research Centers Consortium (ARCC) conference.

BIBLIOGRAPHY:

Building for Life, Stephen Kellert, Island Press, 2005, ISBN 1-55963-721-8
Sustainable Architecture and Urbanism, GauzinMuller, Birkhauser, 2002, ISBN 3-7643-6659-1
Green Studio Handbook, Alison Kwok and Walter Grondzik, Elsevier, 2007, ISBN 0-7506-8022-9
Community by Design, Hall and Porterfield, McGraw Hill Publishing, ISBN 0-07-134523-X
Design Thinking, Peter Rowe, MIT Press, ISBN 0-262-68067-0
Site Planning, Kevin Lynch and Gary Hack, MIT Press, ISBN 0-262-12106-9
The Nature of Design: Ecology, Culture, and Human Intention, David Orr, Oxford University Press, 2002, ISBN 0-19-514855-X

ON THE WEB:

Green Globes:www.greenglobes.com
Ecocalculator:www.athenasmi.ca/tools/ecoCalculator/downloadEcoCalculator.html
US Green Building Council: www.usgbc.org
LEED for Neighborhood Dev.: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=148
LEED for New Construction: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220

Final Site
Thomas Sharp

Building Massing/Site Design

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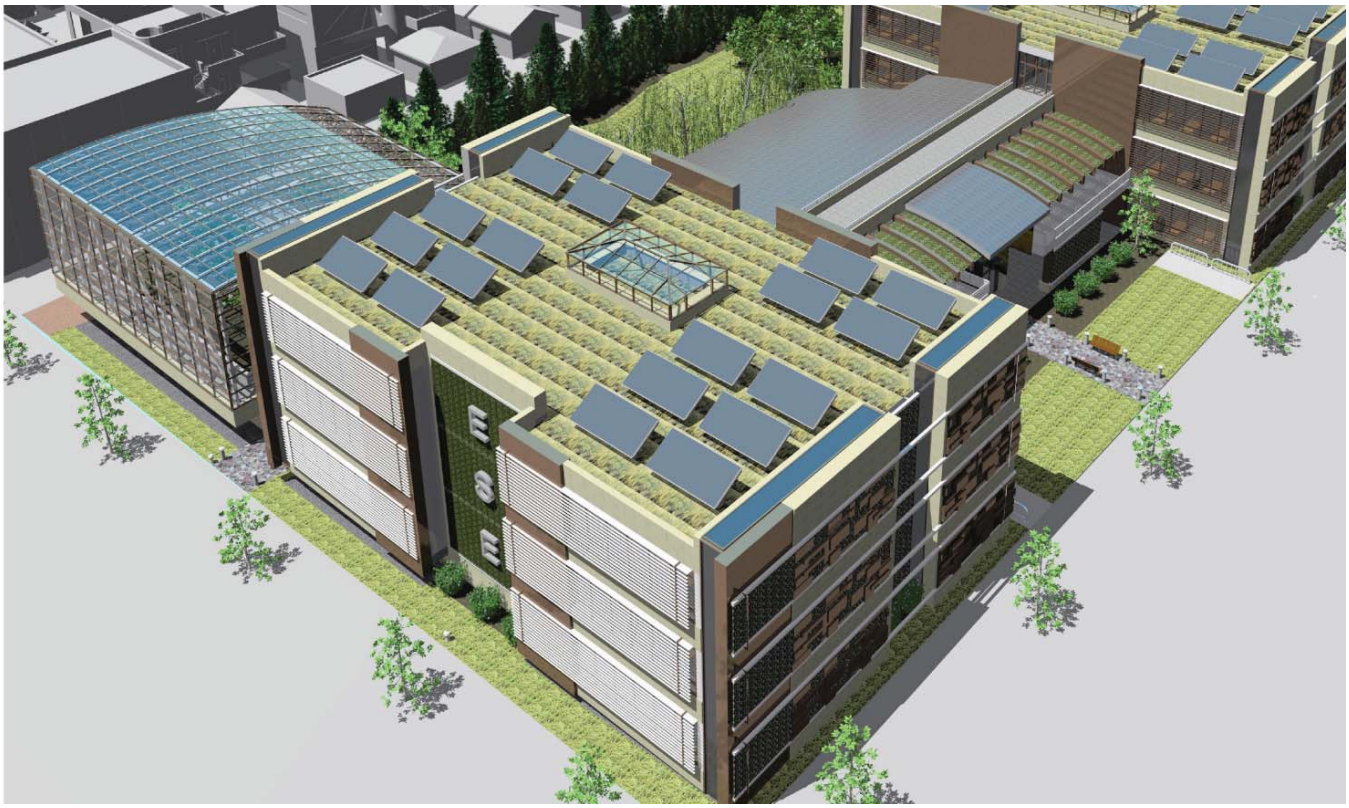

Building Massing/Site Design
Tyler Hughes

A southeast view of the building massing reveals the strategy of working on a primarily north-south oriented site. The student subdivided the program requirements for this school into two main classroom blocks, both maximizing an east-west orientation to maximise southern exposure. South facade and east facade are treated differently according to their orientation.

Design/Performance Objective

This topic is a critical first step. The building massing must address passive solar as a foundational site opportunity.

If we consider thermal mass storage of passively gained solar radiation a given for CND, then, the south façade of all buildings must include a passive strategy. Of course this introduces a host of compromises to daylighting, glare, energy modeling, etc. all of which make the design studio experience richer.

Investigative Strategy

Students investigate site plan adaptations to a square site with a building program that requires a single story over the entire site, or a vertical solution. The students measured the relationships of surface area on the south and north elevations against the surface areas of the east and west elevations and strove to accomplish a 2:1 ratio. Not that this is a magic ratio, but it pushes the design solution into the right arena of a building mass that is east-west in its orientation, and sets the stage for more detailed work to follow.

Evaluation Process/ Criteria

The student must find a way to mass the built environment in such a way as to maximize wanted solar gain potential, and avoid unwanted solar gain. Of all of the topics, this one is the most straightforward. Yet it is also the one that is the most challenging from a “concept” perspective, because students (and practitioners) often toss out gesture designs that by their very nature are not going to perform well without significant technology. Therefore the assessment for this topic is based upon the very low-tech or pre-tech approach to design at the very beginning stages of the design process. It is pre-tech because it does not yet consider technological solutions. Rather, it sets the stage for low-tech middle ground solutions followed by high-tech end-game solutions.

Building Massing/Site Design (cont.)

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Cautions- Possible Confusions

So simple anyone can do it. The main things to avoid are north-south oriented plans and squarish plans.

Duration of Exercise

Very Brief, one or two 4 hour studios. One might consider this a kind of sustainability charrette.

Degree of Difficulty

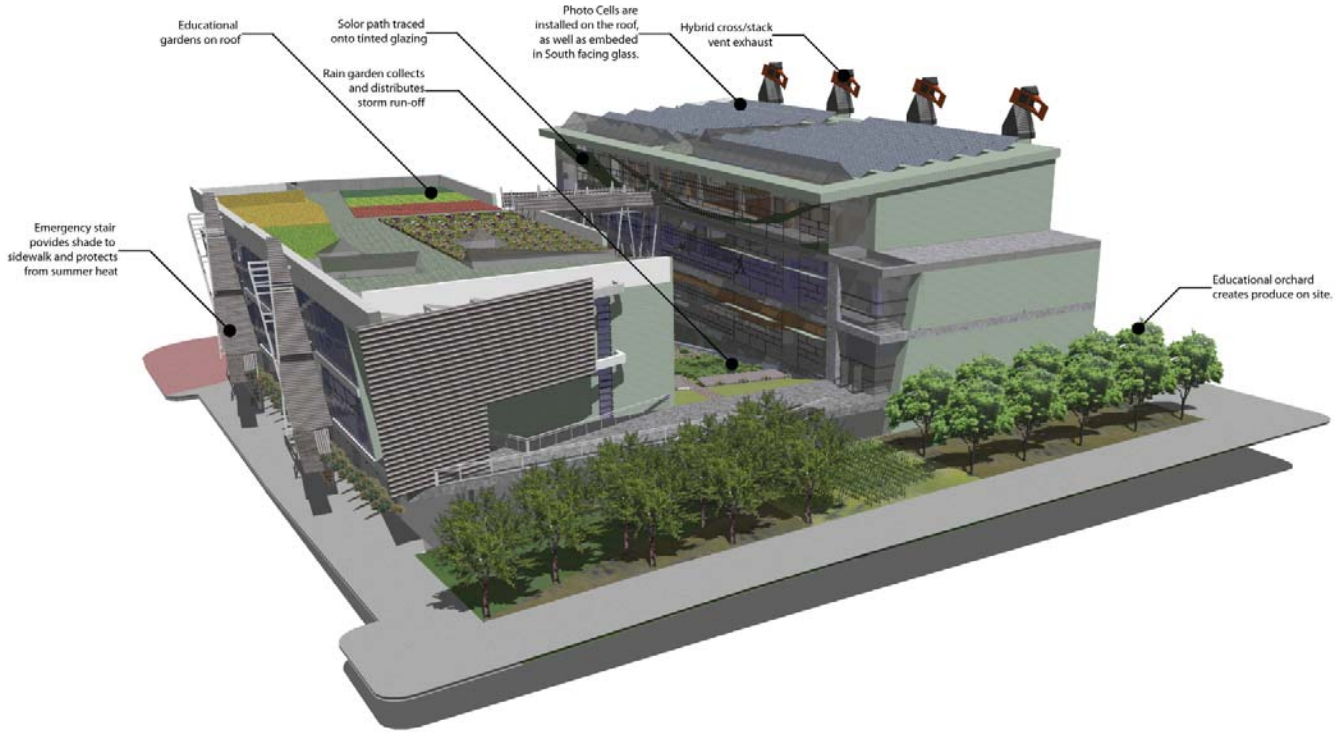
Easy enough for a freshman, but meaningful enough for graduate students.

References

Regenerative Design for Sustainable Development, John Tillman Lyle, Wiley, ISBN 978-0471178439, Building for Life, Stephen

Building Massing/Site Design
Thomas Sharp

A southeast view of another solution to the same site. The student plans a garden level first floor on the southern mass and creates an open courtyard between masses connected by enclosed walkways. The student was careful to ensure that the southern mass did not create unwanted winter shadows on the northern mass. This site included significant regeneration concepts as well afforded by a tight building footprint that allowed for on-site produce and landscape architecture.



Fresh Air/ Indoor Air Quality

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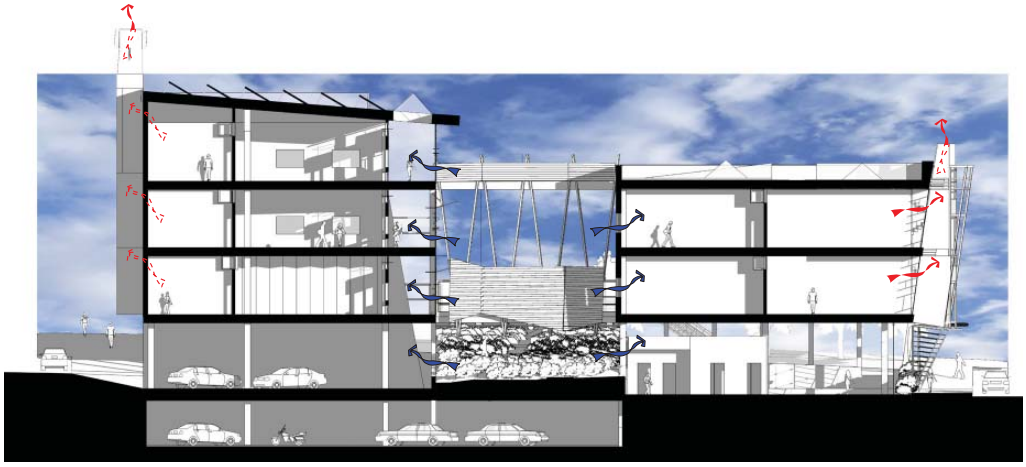

Natural Ventilation Diagram
Thomas Sharp

Students create drawings and diagrams which convey their understanding of the routes of air through spaces in their designs. This particular example includes a vegetated core between buildings that generates an edge in-edge out ventilation strategy. Stack effect cross ventilation is employed at a conceptual level demonstrating the basic principle of air buoyancy.

Design/Performance Objective

This topic is complex because it is not directly related to carbon neutrality, but if design is taught well, it is a happy by-product of the process. Students must be exposed to the importance of fresh air and high levels of indoor air quality as it relates to the health and welfare of users. The mechanisms for achieving this have to do with ventilation strategies including cross and stack ventilation, as well as the design of mechanical systems with adequate air changes. The former can be discussed and resolved in the studio, the later is more of a professional practice and consultant relationships issue. The objective then, for the design studio, is for the students to demonstrate that 1) air can move through the environments they have created without relying on fans, and 2) they understand some of the barriers to designing for fresh air.

Investigative Strategy

The strategy for achieving success in this topic is by creating section drawings with air flow assumptions. In advanced courses, students might use software to confirm assumptions and make adjustments. Again, this is a rules of thumb approach, especially for studios without robust resources for "measuring" airflow. It is enough to demonstrate an understanding of air flow through convection and conduction.

Evaluation Process/ Criteria

The basic evaluation criteria is confirming supply and exhaust apertures of sizes that are appropriate to the scale of the space, providing routes for air to move through adjoining spaces, avoiding polluted airs from moving through adjoining spaces, and demonstrating all of these with section drawings (or three-dimensional representations).

Fresh Air/ Indoor Air Quality (cont.)

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Cautions- Possible Confusions

Cautions-Possible Confusions "One doesn't achieve natural ventilation by simply sticking stacks on the tops of their buildings" one colleague commented recently. Students must understand that air flows like fluid flowing through a conduit. If students can imagine and design flow-conduits that move through their designs, they can demonstrate some understanding of fresh air movement, and thereby create opportunities for increased IAQ."

Duration of Exercise

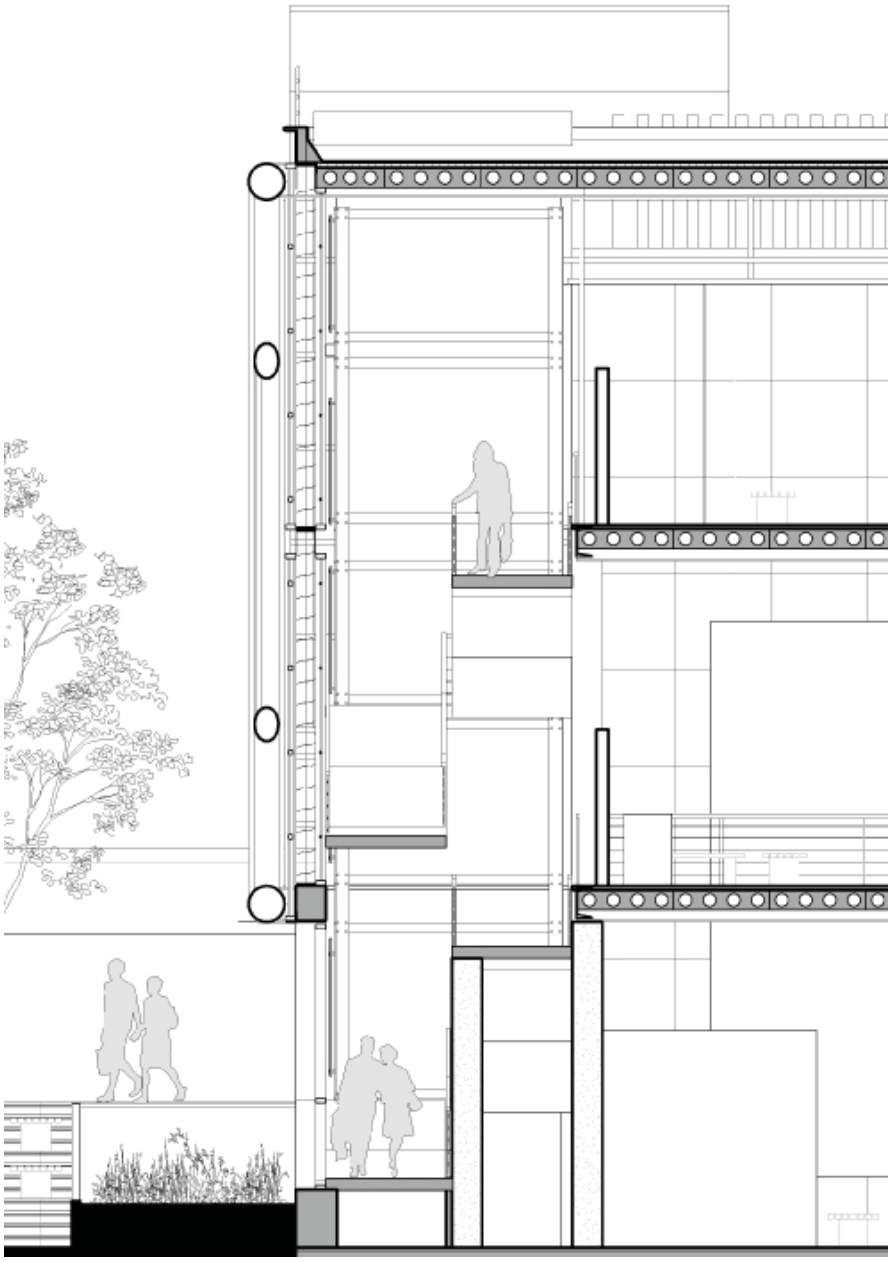
Part of a semester long design studio. I only teach semester long design studios (or two semester long projects). I never teach short "sketch" projects, because they reinforce the idea that you can just breeze in and out of design without any long term responsibility. If a project is a "sketch" problem, it is always tied to a larger relevance in a future project.

Degree of Difficulty

Remarkably easy and remarkably hard. To do abstractly a freshman can do this. Freshmen can abstractly model conduits of form, why not air/fluid flows? Advanced work in ventilation requires a solid foundation of physics. To do accurately a deep knowledge of physics is required. In American schools, this appears to be a severe limitation.

References

Building for Life, Stephen Kellert, Island Press, 2005, ISBN 1-55963-721-8, Lomas, K. 2007. Architectural design of an advanced naturally ventilated building form. Publisher: Energy and Buildings. Lomas, K., Cook, M., Fiala, D., 2007. Low energy architecture for a severe US climate: Design and evaluation of a hybrid ventilation strategy. Publisher: Energy and Buildings. Short, C.A., Lomas, K. 2007. Exploiting a hybrid environmental design strategy in a US continental climate. Publisher: Building Research & Information.



South louvered/ventilating façade detail developed in Revit.
Little

Daylighting, Passive Solar & Solar Control

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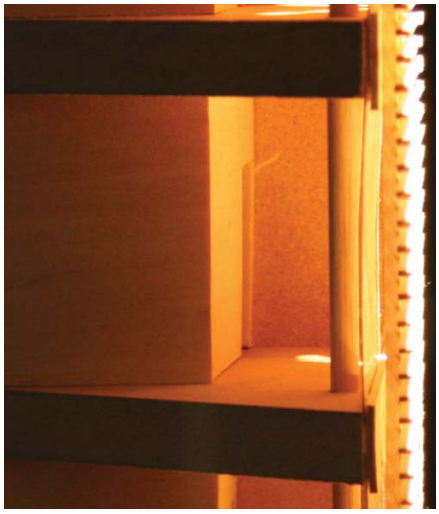

Daylighting/Solar Control (Heliodon Solar Geometry Testing)
Austin Fredrickson

South facade solar control at noon in summer.

Daylighting/Solar Control (Heliodon Solar Geometry Testing)
Austin Fredrickson

South facade solar control at noon in spring/fall.

Daylighting/Solar Control (Heliodon Solar Geometry Testing)
Austin Fredrickson

South facade solar control at noon in winter.

Design/Performance Objective

This topic combines two primary exercises. The first objective is to provide for passive solar gain in during a 5-6 month period of the year to lessen heating demand. The second objective is to integrate effective daylighting in conjunction with the passive solar strategy.

Investigative Strategy

The strategy for investigating this topic is definitely a cyclical one that is borne out primarily in section and plan, culminating with either a physical model or digital model that tests assumptions. Drawings can document concepts but models are really required to provide some testing an proofs. Then, once the models prove or disprove an assumption, legitimate drawings can be developed.

Evaluation Process/ Criteria

It is enough for students to understand that different solar orientations create different situations for gains and losses, as well as different situations for daylighting. If the student can visually and spatially understand this difference, demonstrating control of the variables of solar gain, thermal mass, redundant light and heat filtering systems, then they have achieve a fair amount of understanding and ability. In this example, I was pretty satisfied with the students approach to distinguishing between east and south elevations in terms of opacity and permeability, while maintaining a design sensibility and continuity in the exterior skin. To me this is a critical issue. The student has incorporated an aesthetic approach with a passive solar approach as two parallel issues. The result is an integrated solution.

Daylighting, Passive Solar & Solar Control (cont.)

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Cautions- Possible Confusions

Even in this example, issues of glare and internal shading devices as part of a holistic approach are not considered. Modulation in daylighting, especially in the case of curtain wall systems require acknowledgement that complex relationships generate multiple variables. I choose not to get bogged down in all the variables, but rather allow students to experiment with a couple issues, while also helping them to see the complexity of issues.

Duration of Exercise

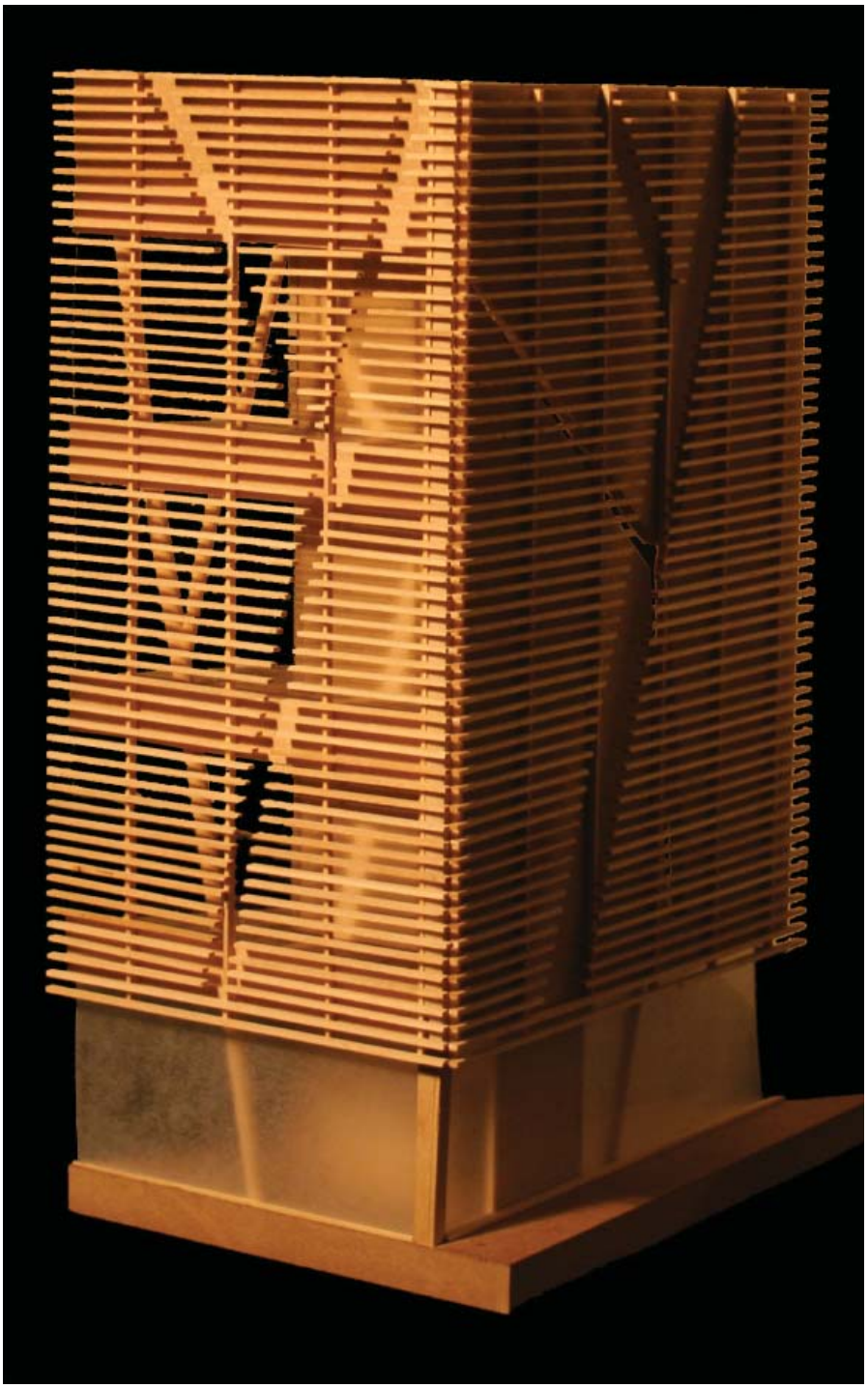
Part of a semester long design studio. I only teach semester long design studios (or two semester long projects). I never teach short "sketch" projects, because they reinforce the idea that you can just breeze in and out of design without any long term responsibility. If a project is a "sketch" problem, it is always tied to a larger relevance in a future project.

Degree of Difficulty

Like other topics, this is as simple or complex as the instructor chooses. A simple study of exterior louvers over a curtain wall can be achieved by very inexperienced students. Fine tuning and elaborating upon the aesthetic quality, function, cost implications, and holistic integration of these systems are possible with upper level students.

References

Regenerative Design for Sustainable Development, John Tillman Lyle, Wiley, ISBN 978-0471178439



Daylighting/Solar Control (Heliodon Solar Geometry Testing)
Austin Fredrickson

Partial south facade (in sun), partial east facade (in shade). Sensible solar considerations of mostly opaque east facade (screen is aesthetically necessary but functionally redundant), and mostly transparent south facade with screening for seasonal solar control. Daylighting is filtered with screen device, with interior space planning considerations.

Building Integrated Photovoltaics

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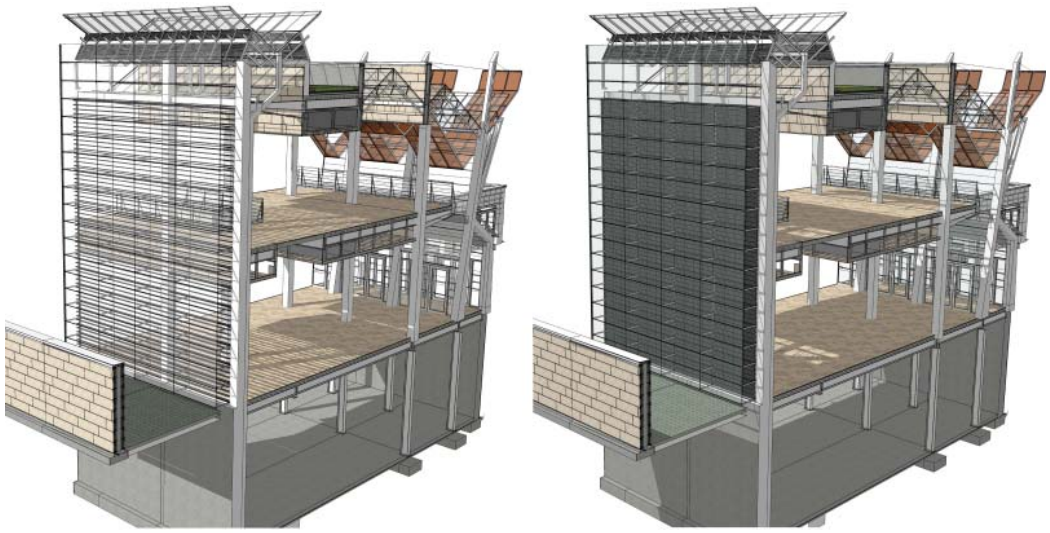

Building Integrated Photovoltaics
Joshua McGarvey

In this student design of a ventilating south facade, the BIPV is installed on the between the two layers of glazing, within the ventilation cavity. Because this wall is not used for fresh air ventilation to the interior, the PV artificially warms the air in the cavity, aiding in its evacuation. The PV is installed on an operable louver, with open and closed positions to allow for solar gain when the louvers are in the horizontal orientation, or to block solar gain when the louvers are in the vertical orientation. The system would have to be carefully managed to maximize the efficiency of this system, but it is an aggressive approach to BIPV.

Design/Performance Objective

Combine photovoltaics as an on-site renewable energy strategy with the built form of the studio project.

Investigative Strategy

BIPV is one strategy that marries the energy production potential with the building envelope. Students estimate an approximate energy load, and compare those estimates with predicted supply from renewable sources including BIPV. In the Chicago climate, the rule of thumb is 10 square feet of roof mounted PV generates approximately 1kW of electricity during peak production hours. Because this translates into 1 square foot PV supplies energy for 1 square foot of the gross building footprint, BIPV and building massing are an important relationship to manage at the conceptual level.

Evaluation Process

To the degree that one can account for the supply and demand of energy on a given studio project, the BIPV should become part of the on-site renewable supply. Assessment of BIPV might consist of the scope of research and investigation undertaken by the student, or it might be related to the accuracy of measuring the output potential, orientation decision-making, and/or building material relationships and joinery. Another accounting method may be for the student to do an annual accounting for electricity generated versus energy consumed. Depending upon hours of daytime and night time operation and other variables, zero net energy may become a possible option.

Evaluative Criteria

An important criteria is the seamless integration of the output technology with the building envelope as 1) a system, and 2) its aesthetic approach/value. Since students are really working at the conceptual level, a degree of speculation is acceptable. But the success of BIPV has to do with the system accomplishing multiple aims beyond simply producing energy.

Cautions- Possible Confusions

If net metering is not available, PV is less valuable as an approach. Daytime and nighttime usage is very important in overall energy accounting, and cannot be overlooked when planning for BIPV.

Duration of Exercise

Part of a semester long design studio. I only teach semester long design studios (or two semester long projects). I never teach short "sketch" projects, because they reinforce the idea that you can just breeze in and out of design without any long term responsibility. If a project is a "sketch" problem, it is always tied to a larger relevance in a future project.

Degree of Difficulty

While this could be offered in a lower level studio (imagine BIPV as a "system" only, a "transparent/translucent co-planar system" that happens to be PV instead of glazing or kalwall), it is most likely an upper level assignment.

References

Adaptive Re-Use (Alternative Approach 1)

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Adaptive Re-use
Matt Kidd, Heidi Hurst, Ben King

The deep plan configuration of the existing building was surgically opened up and adapted for daylight, vegetation and fresh air

Adaptive Re-use
Matt Kidd, Heidi Hurst, Ben King

Adaptive Re-use of existing YWCA facility in Elgin, IL included user group inputs through student interviews. Student team constructed an outline of sustainable features, integrating systems to reduce energy use, maximize solar harvesting, improve daylighting and vegetation, and manage rainwater on-site.

These images document such an approach within the context of a very short period of time in a summer session graduate course. The students in this case were as enthusiastic about redeeming this urban eyesore building and converting it into a highly functional, low-impact facility as a model for future development in a rebounding downtown full of high-impact renovations and new construction.

Design/Performance Objective

Using existing building stock, transform a building from its original use to a new use as a means of limiting new construction to demolition redesign of existing infrastructure and finishes as needed.

Investigative Strategy

If 50% of the existing building stock in the US will be renovated in the next 25 years (2030 Challenge statistics), there is a remarkable opportunity to affect the energy performance of this existing building stock adaptively. Using any existing structure, document it, and reconsider it against a program statement for another use with keen attention to reducing the load required, improving the building envelop performance, improving the experiential quality of space, and providing for renewable energy options.

Evaluation Process

The creation of an energy portfolio that compares predicted loads and predicted gains can be easily generated in a spreadsheet using generalized amounts for building type. Predicted gains can be drawn from generalized amounts, and compared against consumption estimates.

Evaluative Criteria

Here, I am mainly looking for innovative design strategies. Can the students get excited about reusing an existing building and make something happen with it that is exciting and creates value for a real client, demonstrating the potential of an existing building to breathe new life?

Cautions- Possible Confusions

Students in general (and some faculty) don't think that adaptively reusing existing building stock is "architecture." It really is though; it can touch urban design, interior architecture and interior design. All four disciplines touch on sustainability issues, from demolition and waste issues to life cycle considerations and recycling.

Duration of Exercise

Three-student team project in an intensive summer session of 6 weeks.

Degree of Difficulty

References

Neighborhood Design (Alternative Approach 2)

Keelan P. Kaiser
The School of the Art Institute of Chicago/Judson University

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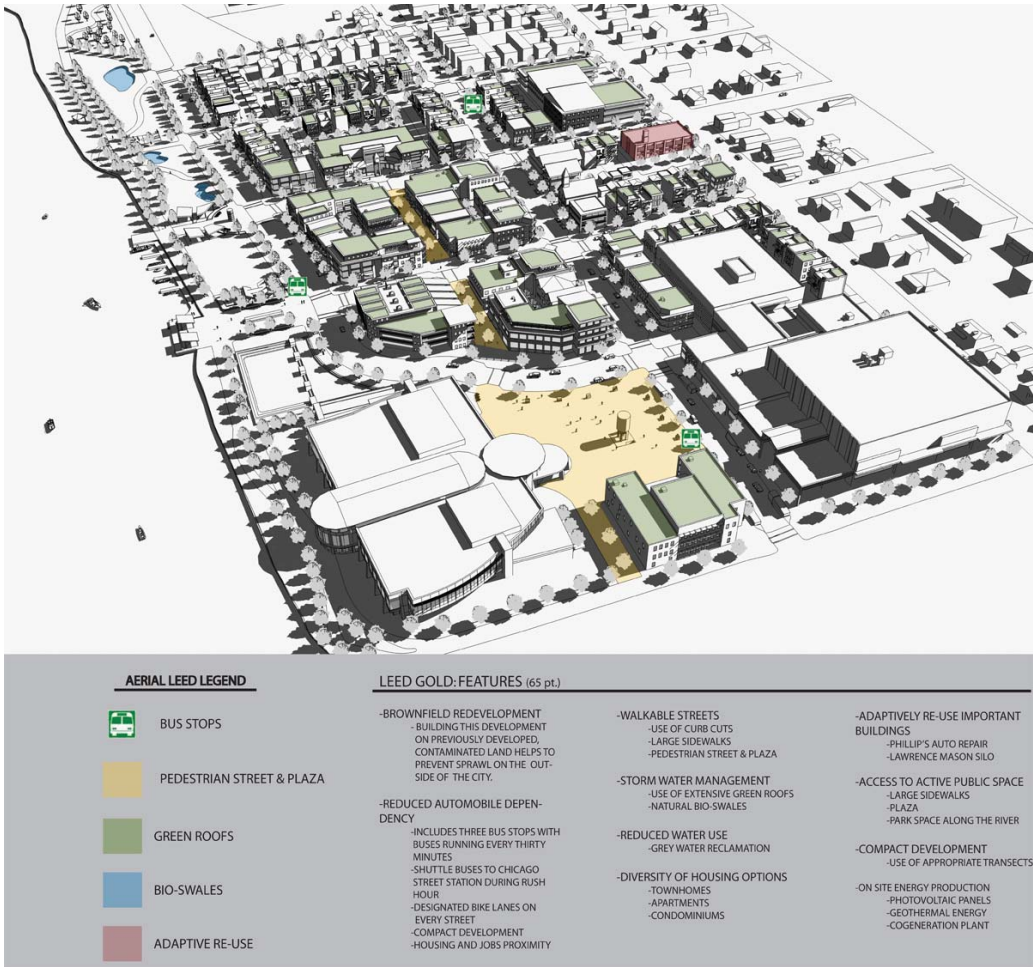
Neighborhood Plan
Austin Fredrickson
Tyler Hughes



Design/Performance Objective

Design a green community development plan on an existing municipal site.

Investigative Strategy

This topic addresses building design and sustainability at the urban neighborhood scale. Using an existing site (preferably not a green field site) that is connected to existing fabric, develop a plan that includes diverse programmatic components appropriate to the site and region. Using LEED-Neighborhood Development and other case studies, develop the site to meet as many of the performance mandates specified for sustainable sites as possible.

Evaluation Process/ Criteria

Refer to precedents in neighborhood development, document their relevance to the project at hand, and adequately account for LEED certification levels.

Cautions- Possible Confusions

Depending upon the level of education of the student, and whether or not Community Planning and/or Civil Engineering exists at the school, some of the allied professional content might be difficult to achieve. Consultants and experts in the profession might be an alternative solution in this case.

Duration of Exercise

Five-student team project in the beginning five weeks of a typical semester studio.

Degree of Difficulty

This project is an upper level studio assignment. It presupposes some background in urban planning and design. Could be a planning precursor to a multifamily housing assignment or, as in this case, an institutional building that is supported by the newly formed fabric.

References

Resources: Community by Design, Hall and Porterfield, McGraw Hill Publishing, ISBN 0-07-134523-X. Site Planning, Kevin Lynch and Gary Hack, MIT Press. ISBN 0-262-12106-9