Gregory D. Thomson

University of Wisconsin-Milwaukee

Solar Decathlon Carbon Neutral House Project

Spring 2008 - mixed UG/G comprehensive design studio (first semester)

The course work shown here is part of the University of Wisconsin-Milwuakee Solar Decathlon Project. The Solar Decathlon is a student design-build-evaluate project, which is interdisciplinary, runs over the course of two academic years, and encompasses several courses outside of the design studio. Students involved in the project have taken either the design studio, one of the subject area lectures or seminars, or more a combination thereof.

While the first studio was broken into several phases, having to do with precedent studies, climate evaluation, and design iterations focused on clarifying the program and formal elements of the design. The studio project, as defined by the Solar Decathlon competition is a real building that is designed, constructed, and tested to be net-zero energy for its operations. The University of Wisconsin-Milwuakee Solar Decathlon Project is documenting construction decisions and materials in an effort to track carbon emissions associated with construction.

PROGRAM STATEMENT

The program for the U.S. Department of Energy Solar Decathlon is for an 800 square foot house. The University of Wisconsin-Milwuakee team has framed the program as a 1-2 person accessory dwelling unit. The Solar Decathlon, as a competition and as a multi-year Federally sponsored program intends to make the argument that renewable energy, specifically photovoltaics, can, and should, have a place in the residential market.

CLIMATE + TYPE PROFILE

The building type is a skin load dominated building.

The project is designed to live in Milwaukee, Wisconsin, which is a cool northern climate (as defined by the AIA Research Corporation). The project is also designed to compete in Washington, D.C., which is described as a Mid-Atlantic Coastal climate.

Special Topics: Energy Simulation

The following software has been utilized in the design of this project:
Microsoft Excel: An excellent tool for simple data evaluation, such as climate data.
Integrated Environmental Solutions - Virtual Environment: This software is not free, but can be acquired for a short period from the people at IES, Ltc. Student versions are inexpensive by software standards. The software has many powerful tools for visualizing daylighting, thermal conditions, and solar access.

PARALLEL COURSES

There have been several courses running in parallel with this course. They have primarily been architectural courses addressing structural design, thermal comfort and illumination, and visualization strategies for explaining technical data and communicating ideas about the architectural and engineering design of the University of Wisconsin-Milwuakee entry into the Solar Decathlon.

The design studio has been team taught between architecture faculty Gregory D. Thomson and Chris T. Cornelius. The design studio was elective, other courses were required, as part of the BSAS and MArch programs, or electives as part of the Concentration in Ecological Design.

Meltwater:
UW-Milwuakee Solar Decathlon Carbon Neutral House Project

Schematic Design Model, on display at the Wisconsin State Fair, as part of the UWM display of sustainability initiatives. Designed by Daniel Schindhelm. Built by Andrew Bayley.

Studio Teaching Topic KEY

Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

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TEACHING TOPICS PROFILED

1. Climate Analysis

Begin with the design of space with an understanding of place. The physical context of the site and the influence this has on climate and microclimate can be understood through analysis of climate with respect to human occupation of space and place.

2. Daylight & Solar Control

Develop a sunshading strategy for controlling solar radiation and daylighting as bioclimatically appropriate. Perform solar control and sunshading device analysis using progressively more complex methods. Begin with manual calculations and design sketches that address conceptual issues. Design development issues should be evaluated with accurate digital tools.

3. Passive Heating & Cooling

Develop strategies for passive heating and cooling. Investigate the relationship between quantitative aspects of the physical contexts and the qualitative design opportunities associated with placemaking. Analyze bioclimatic data for conceptual design appropriateness. Develop schematic design detail for the chosen strategy, using more detailed climatic information, such as monthly and hourly data for more accurate analysis.

4. Fresh Air Ventilation

Develop strategies for natural ventilation. Investigate the relationship between quantitative aspects of the physical contexts and the qualitative design opportunities associated with placemaking. Analyze bioclimatic data for conceptual design appropriateness. Develop schematic design detail for the chosen strategy, using more detailed climatic information, such as monthly and hourly data for more accurate analysis.

5. On-site Energy Production

Create adequate on-site energy to power all of the appliances, heating and cooling, and lighting systems. Use conceptual data for first pass information about energy demand and production capacity. Increase detail in the analysis by using accurate solar radiation data and array size and orientation.

6. Embodied Energy & Carbon Sequestration

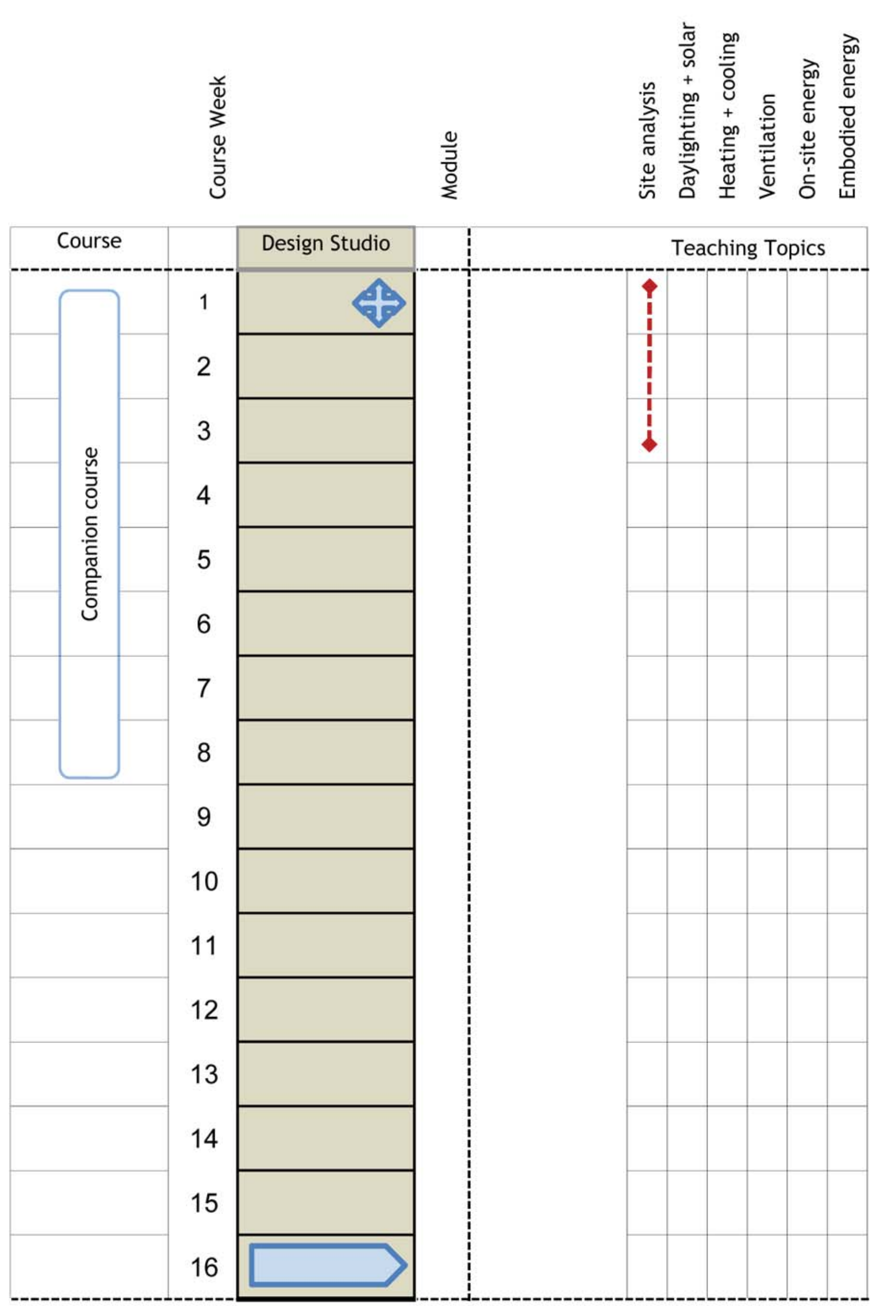
Understand the carbon footprint (both positive and negative) implications of material choices in the design process. Prepare comparative structural and construction systems for evaluation material properties, and carbon sequestration.

7. Energy Modeling in the Design Studio

Create analytical component to the design studio that can evaluate design intentions and criteria. Use parametric energy models and iterative design steps to set the stage to evaluate relative differences between design choices.

8. BIM & CND

Create single model interoperability between architectural documentation tools and energy analysis tools to rapidly evaluate design decisions. Complete several iterations of the design project using BIM techniques. Import designs into energy analysis software for evaluation of the design decisions.



Philosophy of CND Studio Instruction

Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

Spring 2008 UWM Solar Decathlon Carbon Neutral House Project- mixed UG/G comprehensive design studio (first semester)

The design of a carbon neutral building requires that students and faculty be engaged in the series of broad topic areas listed below. These are the same ten topic areas that are critical to my teaching of carbon neutral design, as well as the areas where students make their biggest mistakes in the design process.

[a] Contextually Appropriate
[b] Climatically Appropriate
[c] Culturally Appropriate
[d] Clear Design Intentions
[e] Collaborative Design
[f] Integrated Design
[g] Iterative Design Process
[h] Leading Edge Digital Simulation
[i] Measurement + Verification
[j] Academy-Industry Partnerships

In order to design carbon neutral buildings, students of architecture must be able to understand how to make their buildings Contextually, Climatically, and Culturally appropriate. By setting the stage for the design of buildings that are responsive to place, climatic conditions, and the people that will occupy them, the design student will be in a position to develop a clear set of design intentions and the metrics by which those intentions can be verified.

Clarity of intent should lead to clarity of concept. By having clear intentions and concepts, the collaborative design team can develop a well integrated design that begins with controlling external and internal loads, takes advantage of passive strategies, and uses the iterative design process to test ideas, compare results, and move the design forward to the point where design concept and performance can be tested with leading edge digital simulation. The use of digital simulation is another step in the iterative process and will provide the team with detailed feedback about parametric design ideas and their relative impact on performance, and, as a result, changes in building appearance. This measurement and verification process can only be achieved through the careful establishment of the problem and parameters that are to be evaluated, including what the measures of success are for specific aspects of the project.

In addition to the critical issues, precedent is brought into the studio in a way that includes evaluations of past projects of similar type, and the assignment of selected readings outside of the discipline of architecture. These readings are intended to highlight the key issues of the studio, but with the perspective of other professions addressing issues of outcomes and verification of intended performance. While the two quotes below are examples from within the profession of architecture and design, they are related by approach and thought to those issues of the UWM Carbon Neutral House project.

The first quote is from Victor Papenek, whose book Design for the Real World should be mandatory reading for all students of design (architecture, landscape architecture, industrial design, etc.). He sets the bar for designers by stating, in essence, 'be part of the solution, not part of the problem.' While this seems like a simple premise, it demands that individual ego be removed from the process, and that the end product of the design be something that fits its purpose.

"Ecology and the environmental equilibrium are the basic underpinnings of all human life on earth; there can be neither life nor human culture without it. Design is concerned with the development of products, tools, machines, artifacts, and other devices, and this activity has a profound and direct influence on ecology. The design response must be positive and unifying. Design must be the bridge between human needs, culture, and ecology."

Victor Papanek, The Green Imperative: Natural Design for the Real World, p. 29.

The second quote, from Bob Berkebile (the first AIA-COTE national chair), is an imperative for students and practitioners of architecture.

"You can't change what you don't understand; and you can't understand what you are unwilling to measure."

As quoted by Bob Berkebile, BNIM Architects at the 2006 Northeast Sustainable Energy Association Building Energy Conference, Boston, MA.

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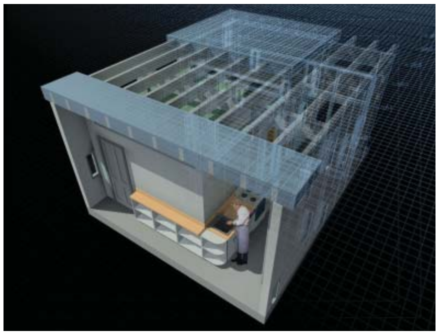
10 Critical Issues / 10 Common Mistakes

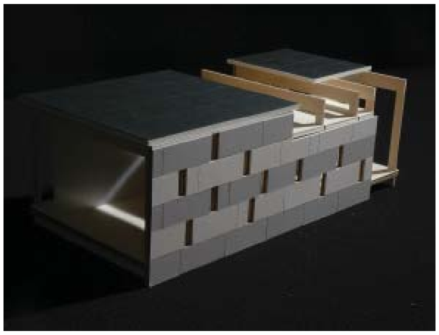
Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

Spring 2008 UWM Solar Decathlon Carbon Neutral House Project- mixed UG/G comprehensive design studio (first semester)



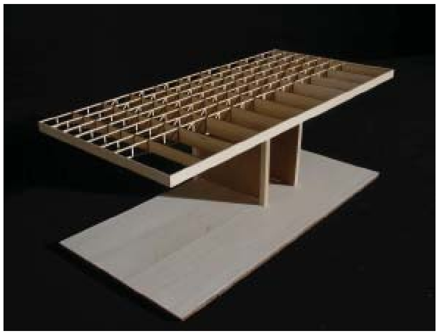
10 critical issues in THE teaching of Carbon Neutral Design

[1] *Contextually Appropriate*
[2] *Climatically Appropriate*
[3] *Culturally Appropriate*
[4] *Clear Design Intentions*
[5] *Collaborative Design*
[6] *Integrated Design*
[7] *Iterative Design Process*
[8] *Leading Edge Digital Simulation*
[9] *Measurement + Verification*
[10] *Academy-Industry Partnerships*



10 student design mistakes that undermine the goal of Carbon Neutral Design

[1] *Contextually Inappropriate*
[2] *Climatically Inappropriate*
[3] *Culturally Inappropriate*
[4] *Lack of Clear Design Intentions*
[5] *Anti-Collaborative Design*
[6] *Non-Integrated Design*
[7] *Lack of Iterative Design Process*
[8] *Lack of Performance Simulation*
[9] *No Measurement + Verification*
[10] *Design Disconnected from Reality*



Supporting Material

Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

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Material Possibilities:

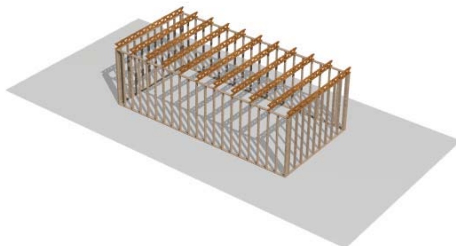
An Analysis of the Ecological Ramifications of

Structural Systems

04.14.08

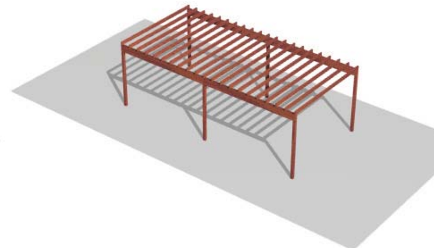
The Material Options Filter

The idea is to keep materials that are harmful to humans and the environment out of the project to begin with. To this end, we design a filter that each option for a particular application in our building must go through. After all the products are analyzed, we make an informed material selection with a graphic justification.



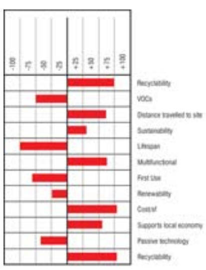
Light Timber Frame

The typical method of residential construction. Built on site by carpenters, the structure is nominal 2x lumber members spaced 16" or 24" on center with a header and sill member. Opening can be thought of as punched through a bearing wall, and therefore are limited in their dimensions. Insulation typically fiberglass bat placed between vertical members, although closed cell foam can be used. The assembly is not complete until sheathing and a finish material is placed on both sides, providing shear resistance and a finished wall. This assembly acts as envelope and structure combined.



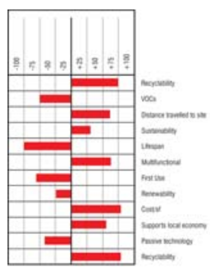
Heavy Timber Frame

A post and lintel system comprised of wood members. By consolidating the mass of wood into large members, the vertical loads flow towards the ground through a small number of points, as opposed to linear bearing walls. This condition frees the envelope from transferring loads to the ground, creating the opportunity for it to become highly expressive and environmentally responsive. For this project, the posts would be 6x6 and spanning members 6x16"s, with 3x8 purlins.h



The Chart of Truth:

Here we explain this diagram. It is intended as a single metric that is to be applicable across different scales of the project. Ideally, we will use it to justify choices from the main structural material all the way down to appliances in the kitchen and the stuffing in the mattress. The result of this system is to be an integer representing the material's (or appliance) effect on physical and ecological footprint of our project.



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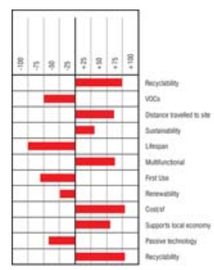


score: +325

Meltwater:
UW-Milwuakee Solar Decathlon
Carbon Neutral House Project
Preliminary materials rating system development for UWM Solar Decathlon Project. Designed by Andrew Bayley.

COURSE MATERIALS

(PDF) Thomson. CND Course Materials Compilation

1. Course Syllabus with clearly articulated learning objectives
2. Module 01: Solar Decathlon Precedents
3. Module 01a: Goals, Objectives, Intentions.
4. Module 01b: Bioclimatic Design Principles, *Context, Culture, Climate.* Collecting, Analyzing, Displaying Data.
5. Module 02: Carbon Neutral Conceptual Design
6. Module 02a: Iteration 01 [40 ideas]
7. Module 02b: Iteration 02 [20 ideas]
8. Module 02c: Iteration 03 [8 ideas]
9. Module 02d: Iteration 04 [4 ideas]
10. Module 03: Carbon Neutral Design/ Performance Integration
11. Module 03a: Iteration 01: Charrette
12. Module 03b: Iteration 02: Charrette
13. Module 03c: Iteration 03: Charrette
14. Module 03d: Iteration 04: Charrette

STUDENT WORK

Bioclimatic design parameters and climate analysis for Milwaukee, Wisconsin and Washington, D.C. Prepared by the UWM Solar Decathlon Team.

Construction Documents for *Meltwater: UWM Solar Decathlon - Carbon Neutral House Project.*

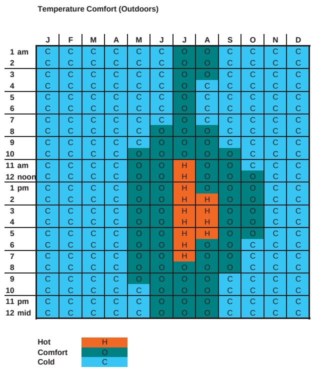
Preliminary Materials Rating System for *Meltwater: UWM Solar Decathlon - Carbon Neutral House Project*

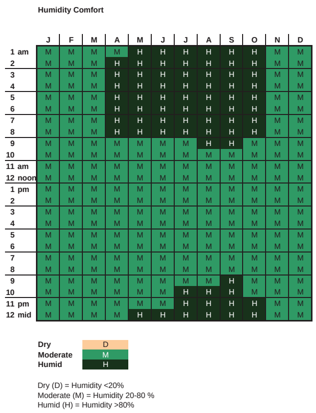
Climate Analysis

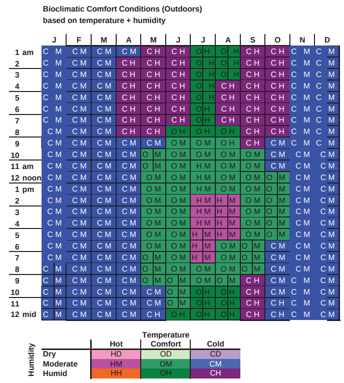
Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

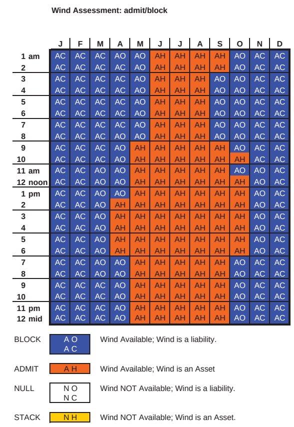
Spring 2008 UWM Solar Decathlon Carbon Neutral House Project- mixed UG/G comprehensive design studio (first semester)

Sterling, VA
39 º 0' 0.27" N Latitude, 77 º 24' 21.16" W Longitude

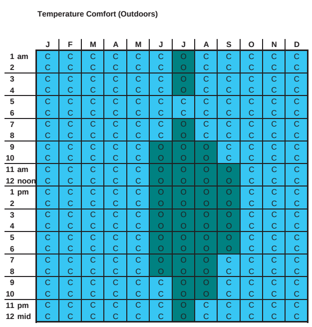


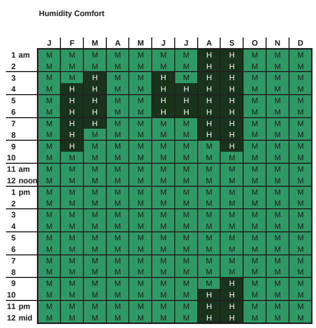


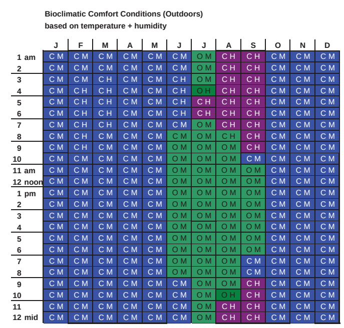


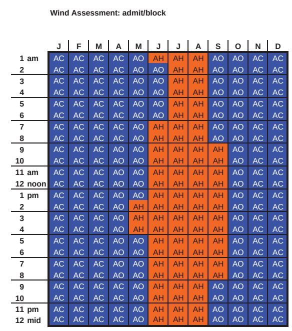


Milwaukee, WI
42 º 57' N Latitude, 87 º 54' W Longitude









Design/Performance Objective

Analyze the bioclimatic design context; prepare a bioclimatic evaluation

Investigative Strategy

Collect climatic data and apply to the psychrometric chart or bioclimatic chart, review different months and seasons.

Evaluation Process

Make comparisons across climates or between different months and discuss the absolute conditions of one and the relative differences between two or more.

A critical first step in the understanding of what the appropriate passive and active strategies are possible.

Any climate analysis begins with the evaluation of the psychrometric chart and the basics of average monthly temperature and relative humidity. This should quickly expand beyond those conditions to a point where the design student can understand the depth of information that is available and necessary to use in the analysis of building designs. The detailed analysis can begin with the creation of heating and cooling season psychrometric charts to look in detail at threshold and boundary conditions for heating and cooling.

I prefer to use the TMY (Typical Meteorological Year) data from the National Renewable Energy Lab (NREL) in the detailed analysis. The methods of analysis that are performed in Sun, Wind & Light are useful, and helpful as a basis for the parsing of this data.

Evaluative Criteria

Climate Analysis
Sally Massman and Keith Stachowiak

Comparative climate analysis of the two climate types in which the UWM Solar Decathlon project will be tested. The technique demonstrated is described in Sun, Wind & Light by G.Z. Brown

Cautions- Possible Confusions

Duration of Exercise

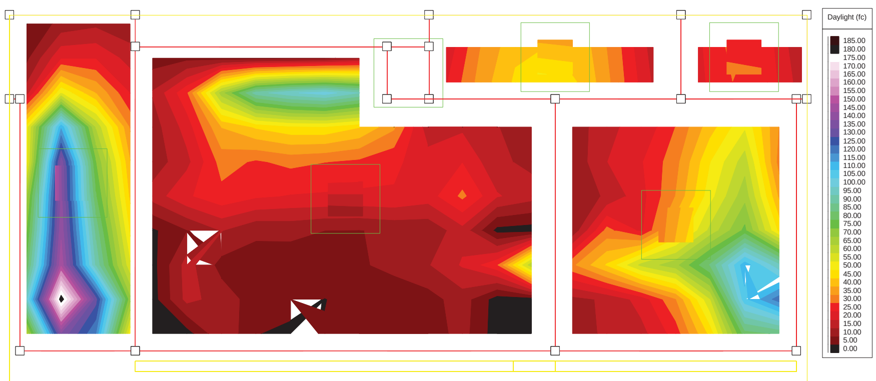
Degree of Difficulty

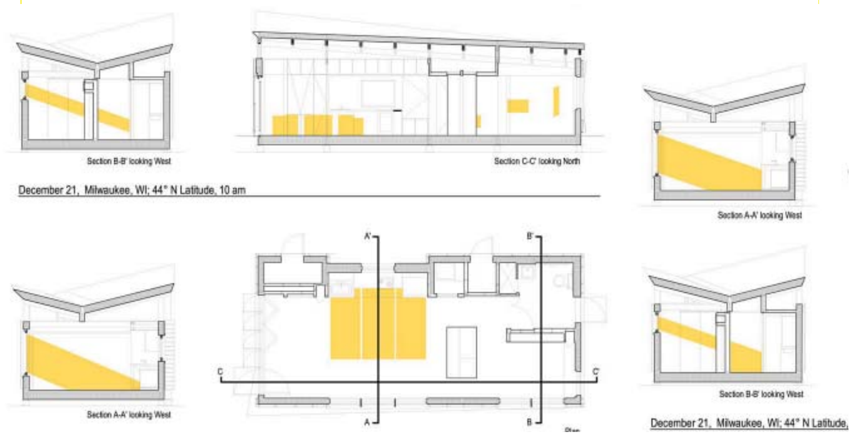
References

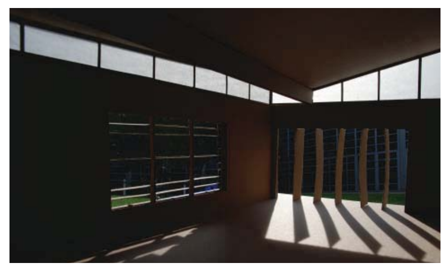
Daylighting & Solar Control

Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

Spring 2008 UWM Solar Decathlon Carbon Neutral House Project- mixed UG/G comprehensive design studio (first semester)







Design/Performance Objective

Develop a sunshading strategy that controls solar radiation and daylighting as bioclimatically appropriate.

Investigative Strategy

Perform solar control and sunshading device analysis using progressively more complex methods. Begin with manual calculations and design sketches that address conceptual issues. Design development issues should be evaluated with accurate digital tools, both visual and numerical.

Evaluation Process

Compare each level of analysis against the previous step. Discuss relative and absolute changes in the patterns and locations of sun penetration. Reference model photographs, digital images, and drawings to one another. Digital model making can be a useful tool in this exercise, but only if student are using it after they know what the expected outcomes are going to be.

Using the Sun Angle Calculator as a means of establishing an hypothesis, can be a good method of checking the locations and patters of the digital model against that of a physical model or a simple plan and section sketch.

In addition, there are only two programs that I know if that allow the user to cut horizontal or vertical sections through the building, without losing the shadow casting of the pieces of the building behind the section cut. EcoTect is the other software with this capacity, and it has a specific sunshading device design module, which removes some of the analytical thought from the process.

Evaluative Criteria

Daylight Analysis

UWM Solar Decathlon Team

The design of daylighting systems in buildings requires that there be seveal steps in the process. They should start with physical models of conceptual and schematic design to see daylight penetration in a space using sun peg charts. These can be prefaced by looking at daylight penetration patterns in design drawings. These should be compared to the physical models and to any digital models to ensure that there are no errors in the model making and analysis process. The work shown above includes course work from an associated lecture course on illumination and thermal comfort.

Cautions- Possible Confusions

Duration of Exercise

Degree of Difficulty

References

Passive Heating & Cooling

Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

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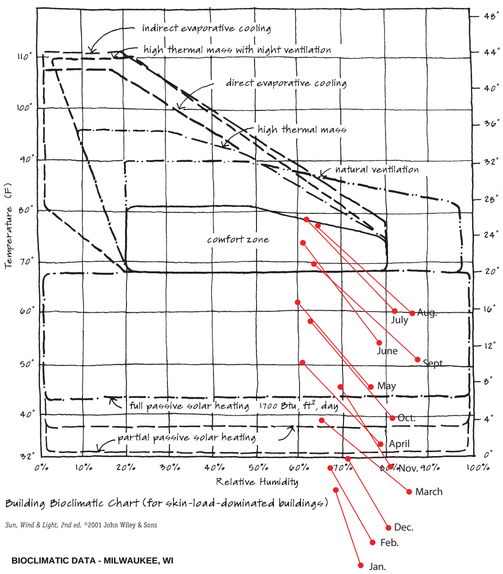


Building Bioclimatic Chart (for skin-load-dominated buildings)

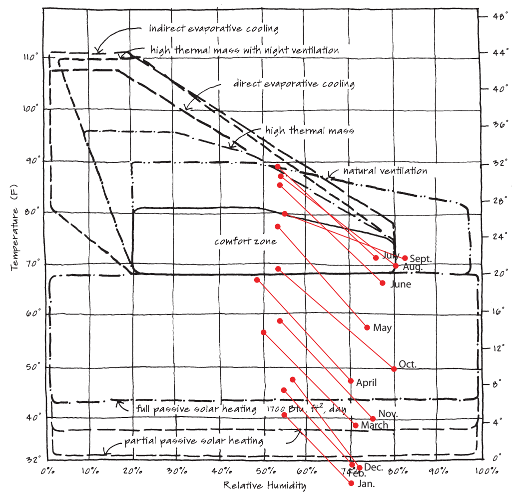
Sun, Wind & Light, 2nd ed. ©2001 John Wiley & Sons

BIOCLIMATIC DATA - MILWAUKEE, WI

	Jan		Feb		Mar		Apr		May		Jun	
TEMPERATURE (DBT) DEG. F [MAX/MIN]	26	12	30	16	40	26	53	36	64	45	75	55
RELATIVE HUMIDITY [MIN/MAX]	69	75	67	77	65	79	62	78	60	77	61	79
	Jul		Aug		Sep		Oct		Nov		Dec	
TEMPERATURE (DBT) DEG. F [MAX/MIN]	80	62	78	61	71	53	59	42	45	31	31	18
RELATIVE HUMIDITY [MIN/MAX]	62	82	64	86	64	86	63	81	68	80	71	79

Source: Comparative Climatic Data for the US, Northeast Regional Climate Center

Balance Point Temperature: 59.5° F
Maximum Heat Loss: 5.0 Btu/DDF sqft
Actual Heat Loss: 17.2 Btu/DDF sqft
Annual Fuel Consumption: 123,499 CF/year (propane)



Building Bioclimatic Chart (for skin-load-dominated buildings)

Sun, Wind & Light, 2nd ed. ©2001 John Wiley & Sons

BIOCLIMATIC DATA - WASHINGTON D.C. (NAT'L AP)

	Jan		Feb		Mar		Apr		May		Jun	
TEMPERATURE (DBT) DEG. F [MAX/MIN]	42	27	46	29	57	38	67	46	76	57	85	67
RELATIVE HUMIDITY [MIN/MAX]	56	70	53	70	50	71	49	70	53	74	53	76
	Jul		Aug		Sep		Oct		Nov		Dec	
TEMPERATURE (DBT) DEG. F [MAX/MIN]	89	71	87	70	80	63	69	51	58	41	47	32
RELATIVE HUMIDITY [MIN/MAX]	53	76	55	80	55	81	53	80	54	75	57	72

Source: Comparative Climatic Data for the US, Northeast Regional Climate Center

Balance Point Temperature: 59.0° F
Maximum Heat Loss: 7.0 Btu/DDF sqft
Actual Heat Loss: 17.2 Btu/DDF sqft
Annual Fuel Consumption: 123,499 CF/year (propane)

Arch 520
Thermal Comfort & Illumination
Instructor. G. Thompson

Group Memebers
Andrew Laufenberg
Tami McCullough
Katie Vondrasek

October 6th 2008

Thermal Analysis

Balance Point Temperature & Annual Fuel Consumption

1.01d

Design/Performance Objective

Develop Strategies for passive heating and cooling.

Investigative Strategy

Analyze bioclimatic data for conceptual design appropriateness. Develop schematic design detail for the chosen strategy, using more detailed climatic information. Progress from annual average conditions to detailed monthly and hourly data for more accurate analysis.

Evaluation Process

Compare the conceptual passive strategies chosen by bioclimatic analysis with the results of more detailed analysis methods. Discuss absolute and relative differences between monthly conditions and climate zones. While these are shown as different categories on the CND project list, I see them as part and parcel of the same design problem. In part this is true because any passive strategies – heating or cooling, require that the strategy be bioclimatically appropriate beyond the conceptual level.

This exercise starts with the re-evaluation of the psychrometric and bioclimatic charts. Climate will dictate what is appropriate and achievable. In the case of the Solar Decathlon project, mass is eliminated as a passive strategy because of the travel component of the competition. It is therefore necessary to look at the passive cooling and heating gas a stepped process that progresses from conceptual conditions of annual and monthly average climatic conditions to a finer grain of detail that is evaluated using monthly and hourly climatic data.

Thermal Analysis

UWM Solar Decathlon Team

The evaluation of bioclimatic conditions in a building should start with conceptual models of analysis. Using the climate data from previous exercises, students can evaluate conceptual and schematic thermal conditions. This process is based on the work of Victor and Aladar Olgyay. The work shown above includes course work from an associated lecture course on illumination and thermal comfort.

Cautions- Possible Confusions

Duration of Exercise

Degree of Difficulty

References

Fresh Air Ventilation

Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

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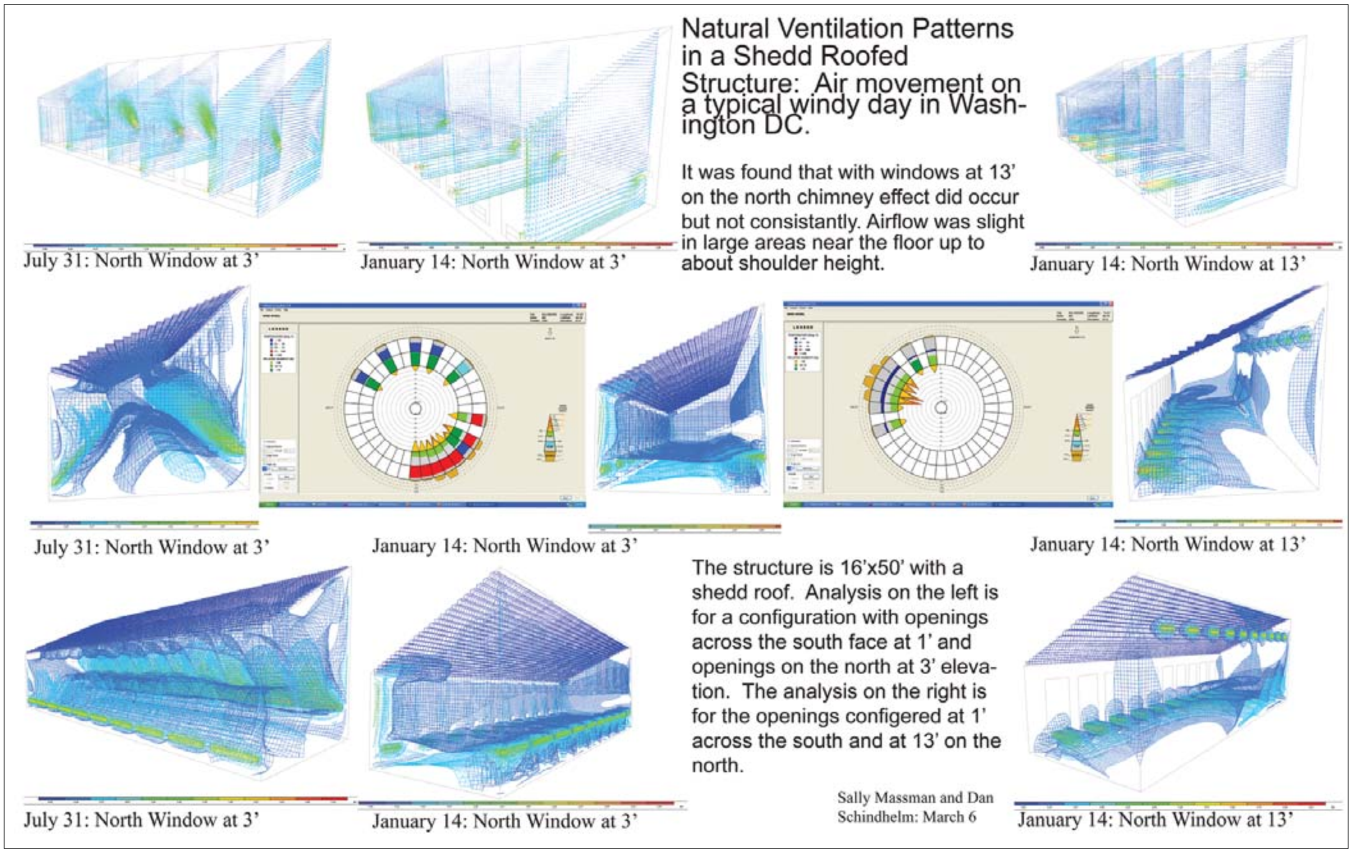


Design/Performance Objective

Develop Strategies for natural ventilation.

Investigative Strategy

Prepare digital simulations of natural ventilation strategies using Computational Fluid Dynamics (CFD).

Evaluation Process

Compare the design intentions to the results of the CFD models, and measure against the verification methods determined during pre-design. The passive cooling through natural ventilation is easy to signal intent with the use of arrows and expected patterns of wind flow.

We have also been using Computational Fluid Dynamics to visualize air-flow patterns in the building. This is something that crosses the line between rule-of-thumb, and detailed cooling analysis, into energy modeling, but is worth mentioning as it is one of the few ways to visualize natural ventilation strategies without doing wind tunnel or full-scale testing.

Evaluative Criteria

Cautions- Possible Confusions

Duration of Exercise

Degree of Difficulty

References

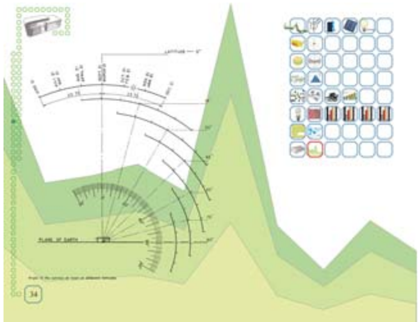
Ventilation Analysis
Student Name

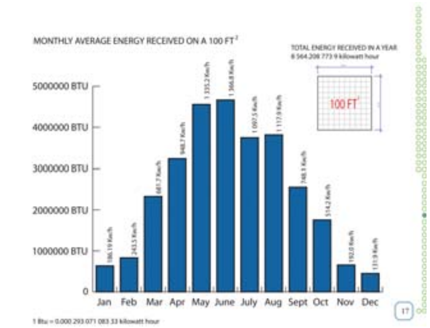
Captions should start with a title and describe in a few sentences what is being illustrated. They might also contain digressions critiquing the work and pointing out what the criteria for judgement of the student work is- what is good and not so good about the work shown in relation to the topic it is illustrating. Finally, credit the student(s) who's work it is.

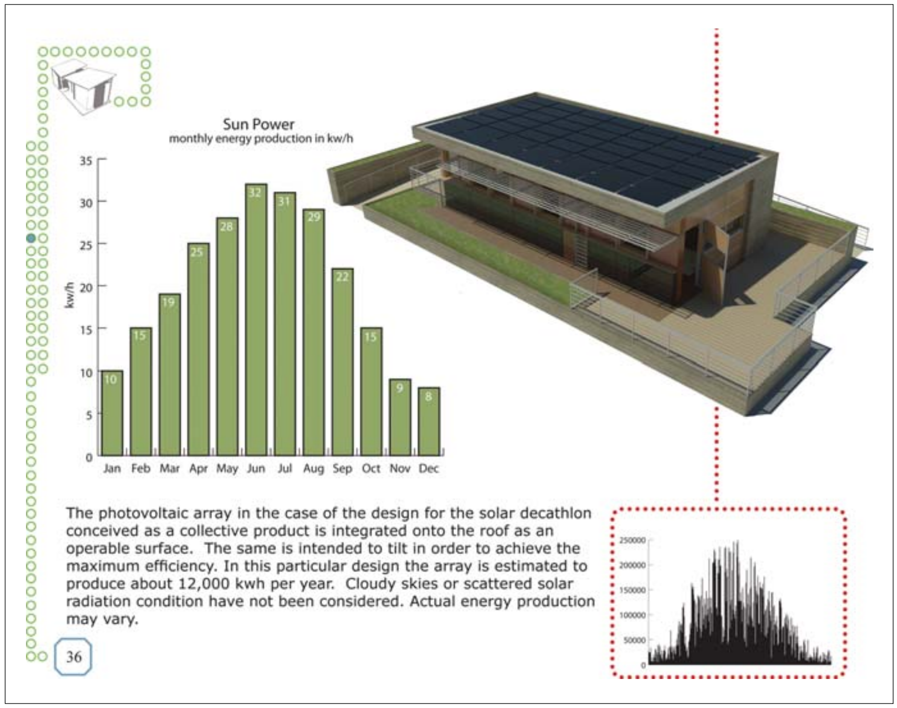
On-Site Energy Production

Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

Spring 2008 UWM Solar Decathlon Carbon Neutral House Project- mixed UG/G comprehensive design studio (first semester)







Design/Performance Objective

Create adequate on-site energy to power all of the appliances, heating and cooling, and lighting systems for the UWM Solar Decathlon Carbon Neutral House Project.

Investigative Strategy

Use conceptual data for first pass information about energy demand and production capacity. Increase detail in the analysis by using accurate solar radiation data and array size and orientation.

Evaluation Process

Use Solar Advisor and other proprietary analysis software to insure greatest accuracy of evaluation of the energy production potential. Compare this to Energy Star data to determine array sizing.

Sun, Wind & Light has a variety of information available to make these predictions, as well as NREL, the Energy Information Administration, and DOE Energy Star.

The big picture calculations were expanded through the use of detailed TMY data analysis, the use of UWM Associate Professor Mike Utzinger's BIPV analysis, and the development of detailed roof model studies in IES-VE.

We have also been using the NREL Solar Advisor tool, which has plug-in capacity with TRNSYS. These studies have used data from Solar PV manufacturers, TMY data, and numerous roof form model analysis.

Evaluative Criteria

Cautions- Possible Confusions

Duration of Exercise

Degree of Difficulty

References

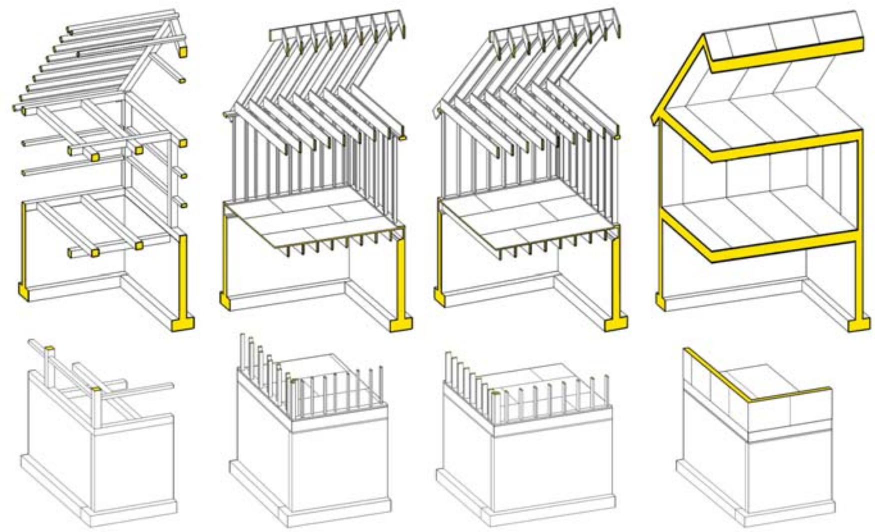
Energy Production Analysis
Student Name

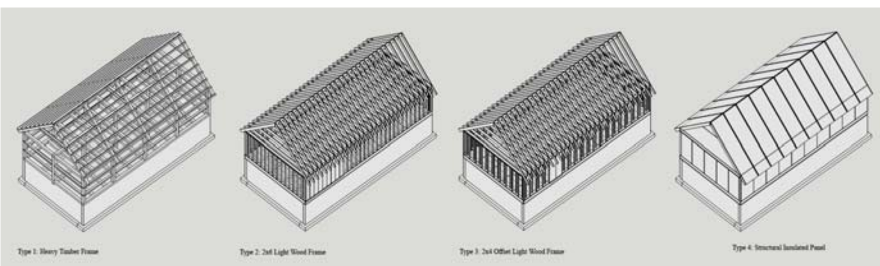
Captions should start with a title and describe in a few sentences what is being illustrated. They might also contain digressions critiquing the work and pointing out what the criteria for judgement of the student work is- what is good and not so good about the work shown in relation to the topic it is illustrating. Finally, credit the student(s) who's work it is.

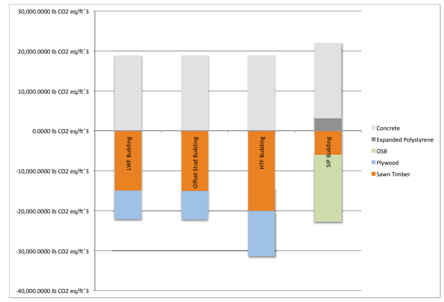
Embodied Energy & Carbon Sequestration

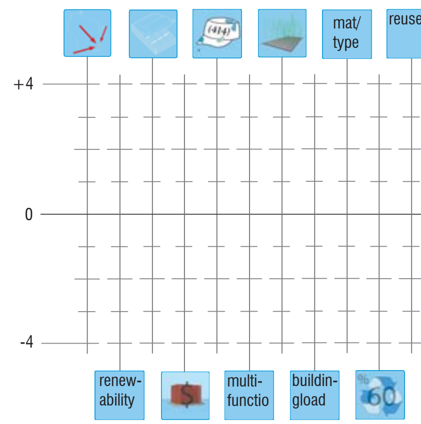
Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

Spring 2008 UWM Solar Decathlon Carbon Neutral House Project- mixed UG/G comprehensive design studio (first semester)









Design/Performance Objective

Understand the carbon footprint (both positive and negative) implications of material choices in the design process.

Investigative Strategy

Prepare comparative structural systems for evaluation of structural properties, material properties, and carbon sequestration.

Evaluation Process

Use embodied energy and carbon emission (CO2-eq) data to make absolute and relative comparisons between systems. Also compare other relevant statistics between systems, such proximity, reuse potential, etc., that may have an impact on the life cycle analysis.

Our embodied energy and carbon sequestration studies have been focused on making material take-offs from the AutoDesk Revit Model and using them to calculate embodied energy by mass and volume of material as well as looking at the carbon balance of the material selections.

The beginning of these calculations have focused on the alternatives for structural framing and envelope conditions, as opposed to interior finishes. Initial studies for the structural frame types concentrated on the big picture differences between load bearing walls, light framing techniques, and heavy framing techniques.

Initial studies have also included the creation of an evaluation methodology that begins to account for the benefits and drawbacks of material selections based on a number of criteria including carbon content, reuse potential, use of recycled materials, impact on building loads, and proximity.

Embodied Energy Analysis
UWM Solar Decathlon Team

Several students have contributed to the development of embodied energy analysis. The images above are from an outgrowth of initial studies analyzing residential construction typologies and their absolute and relative amounts of embodied energy in the form of emissions equalized for Carbon Dioxide.

Evaluative Criteria

Cautions- Possible Confusions

Duration of Exercise

Degree of Difficulty

References

Energy Modeling in the Design Studio

Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

Spring 2008 UWM Solar Decathlon Carbon Neutral House Project- mixed UG/G comprehensive design studio (first semester)

Design/Performance Objective

Create analytical component to the design studio that can evaluate design intentions and criteria.

Investigative Strategy

Use parametric models and iterative design steps to set the stage to evaluate relative differences between design choices.

Evaluation Process

Evaluate the results of the parametric analysis. Discuss the implications of design decisions, and evaluate the pros and cons of the iterative steps. Prepare a second set of iterative models and analyze them in the same manner. The UWM Carbon Neutral House project has attempted to introduce leading edge energy modeling software into the design studio in a way that is intended to aid in the design process. It has been a complicated process and not the smoothest transition between design and evaluation. It has been informative to the design in that it has allowed us to see the implications of design decisions, primarily with respect to the location and number of window openings. This has been true both in the daylighting and heating / cooling realms. The greatest benefit of the use of this software has been the capacity to evaluate design intent with simulated performance. While we don't know how close our predictions are to real conditions at this point, we have been able to perform a nice variety of parametric studies that show us the relative difference between design choices.

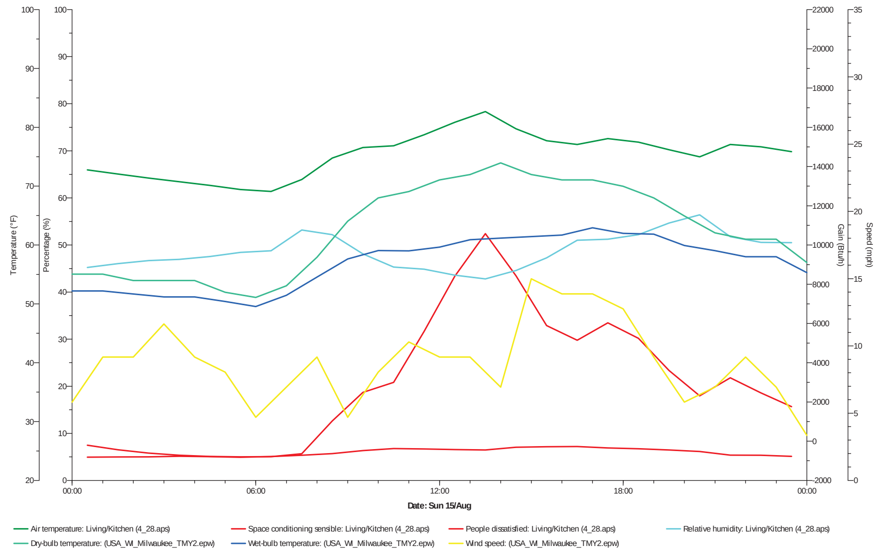
Evaluative Criteria

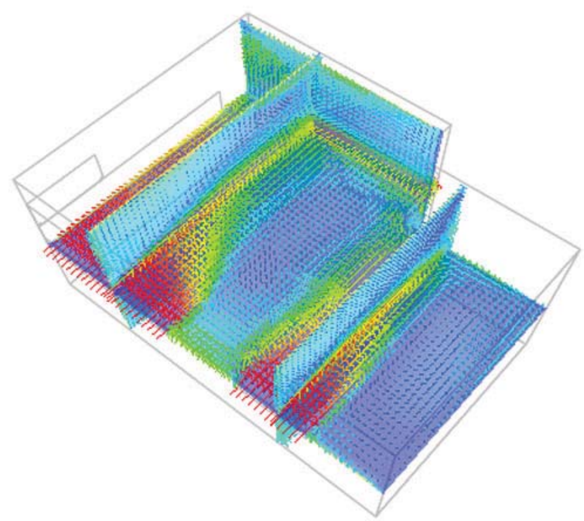
Cautions- Possible Confusions

Duration of Exercise

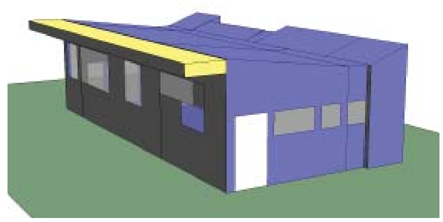
Degree of Difficulty

References





Velocity	0.00	0.28	0.55	0.83	1.10	1.38	1.65	1.93	2.20	2.47	2.75	3.02 ft/s
Temperature	75.23	76.20	77.17	78.13	79.10	80.06	81.03	82.00	82.96	83.93	84.89	85.86 °F



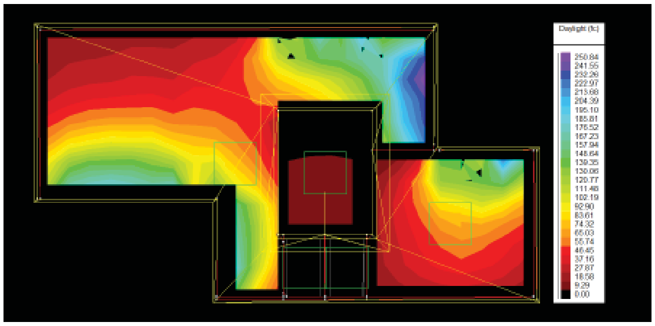
Energy Modeling
Sally Massman

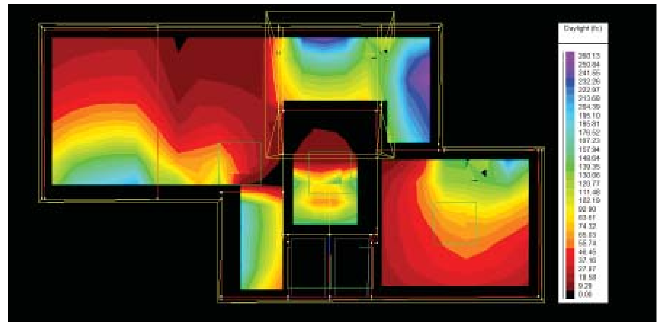
Energy modeling in the design studio took several approaches. Most of the effort in the first semester of the Solar Decathlon was to evaluate passive measures of thermal and solar control. Interior ventilation and comfort were studied using computational fluid dynamics. The primary tool for these analyses was IES - Virtual Environment. In addition, energy incident on the building was studied (and related back to the on-site energy production section of the studio), in order to understand the potentials for producing electricity through solar electric systems.

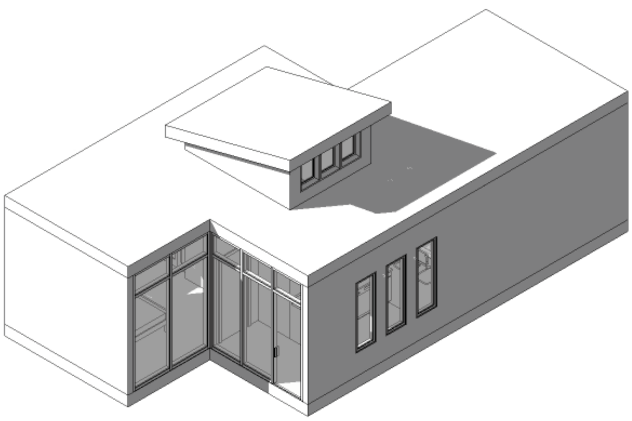
BIM & CND

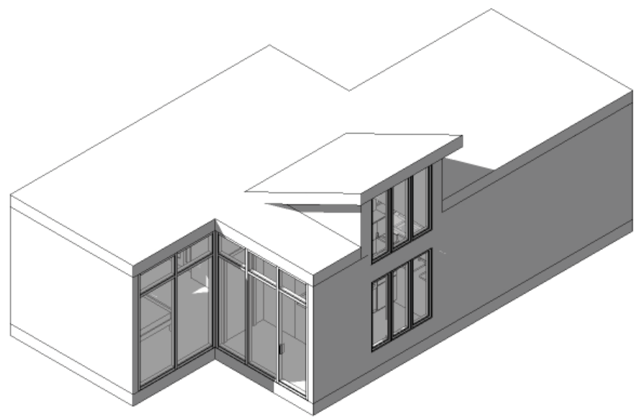
Gregory D. Thomson, Assistant Professor
University of Wisconsin, Milwaukee

Spring 2008 UWM Solar Decathlon Carbon Neutral House Project- mixed UG/G comprehensive design studio (first semester)









Design/Performance Objective

Create single model interoperability between architectural documentation tools and energy analysis tools to rapidly evaluate design decisions.

Investigative Strategy

Complete several iterations of the design project using BIM techniques and export to / import into energy analysis software for evaluation of the design decisions.

Evaluation Process

Discuss the results of the energy model with the design. Evaluate the areas where the design is creating minimal, or positive, impact on performance and where it is causing negative impact. Use the results of the analysis to begin the design-evaluation-redesign feedback loop. Our use of BIM in the CND studio process was bifurcated in its function. One avenue was to produce materials information about the building with regard to volumetric and area accounting. It was also used to generate an interface between the 3D digital model and the energy simulation model. The most positive aspect of this process was exposing students to the complexities of energy simulation models, and the differences between architectural models and energy models. Again, as in the energy simulations, the use of BIM had the greatest impact when used in a parametric and comparative fashion.

Evaluative Criteria

Building Information Modeling

Robert Koehler

One of the objectives with the UWM Solar Decathlon project was to begin closing the loop between digital design software, architectural documentation software, and building performance analysis software. Autodesk Revit and IES Virtual Environment have begun to close that loop by working through the .XML extension. This technique was used in the design studio to analyze different design alternatives with respect to daylighting and thermal comfort.

Cautions- Possible Confusions

Duration of Exercise

Degree of Difficulty

References