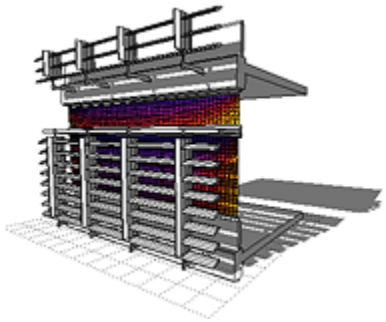
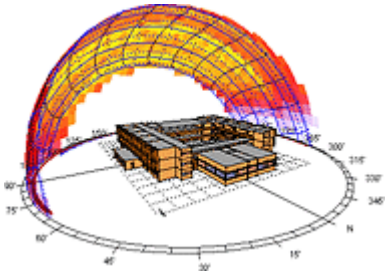
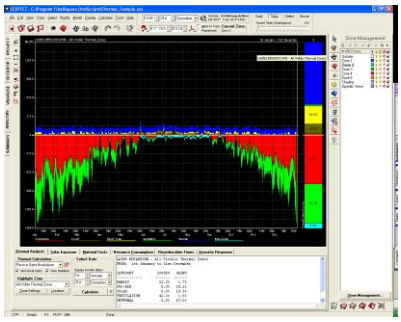




"Thermal analysis basically means using a manual calculation or computer program to mathematically model the interplay of thermal processes within a building. There are a wide range of mathematical models used for this purpose, all of which vary significantly in both in ease of implementation and comprehensive. _Source: Ecotect website

The useful practice of the 'ancients' should be employed on the site so that loggias should be filled with winter sun, but shaded in the summer. -Leone Battista Alberti, De Re Aedificatoria, 1452

PROJECT THREE: Phase 1:

ASSESSING THERMAL PERFORMANCE: Temperature, Loads and Comfort

Overview of Project Schedule

Phase 1: Precedent Study and Passive Solar + Loads Analysis	Due 9:45 AM Wed Feb. 13
Phase 2: Final Thermal Design Whole Building Thermal Analysis	Due 9:00 AM Monday Feb. 18

Phase 1.0: Passive Design and Ecotect analysis of thermal performance

Suggested time limit: 4 days; minimum 16 hours; Phase 1.0 Grading: 20%; 200 points total
Phase 1.0 Due on Wednesday, February 13; 9:45 a.m.: All teams please pin-up by 9:45 on mezzanine (class critiques from 10:00-11:30)

Objectives

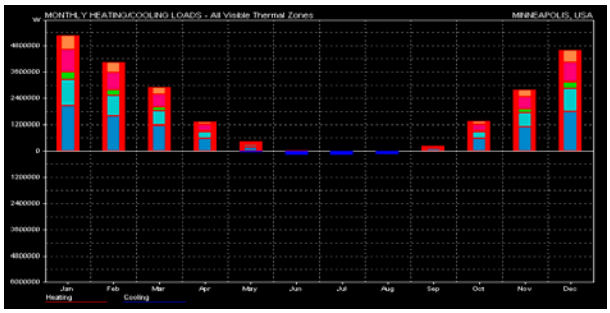
- To study the relationships between solar exposure, envelope design and thermal loads.
- To develop the knowledge and skills needed to conduct thermal design assessments in architectural design.
- To better understand heat flow in buildings, human thermal comfort & thermo-regulation, and the effects of thermal mass.
- To be able to calculate passive gains, temperatures & heating and cooling loads and to interpret results.

Buildings are complex in that they respond to both internal and external fluctuations in heat gains and losses. In the recent past buildings have tended to ignore solar radiation both when desirable and sometimes when undesirable. Architectural form dictates to a large extent a building's ability to benefit from solar flux. Proper orientation of glazed openings, adequate thermal mass and summer shading are the primary factors determining the efficacy of a "passive" building design, however, placement of operating windows and wind shaping through intelligent roof and building form also play a significant role. In Project Two you will explore critical questions concerning thermal comfort and building loads in your designs for a mnZED Lab addition to Rapson Hall. Please consider the following process:

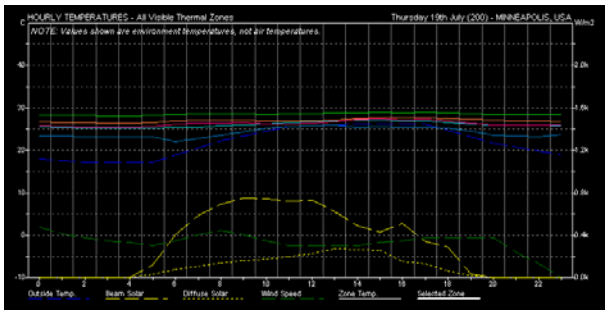
1. **<u>Define the design intent with respect to energy and thermal design goals</u>:** As a team, take time to discuss the results of Project One and how well it responds to the regional and micro-climatic context of your project. Review your energy and thermal design goals. Consider how you can improve the use of passive design strategies to capture and store thermal energy in winter and to reject unwanted thermal gains in the summer. You might consider:
   - *Climate data (changing temperature, wind, sun, and humidity)*
   - *Massing and orientation strategies*
   - *Building program and relative need for thermal comfort*
   - *Surrounding buildings that block sun and wind*
   - *Building envelope materials and resistance to thermal conductivity*
   - *Daylighting and thermal design integration*
   - *Existing building systems integration*
   - *Circulation vs. continually occupied spaces*
   - *Strengths and weaknesses …*

2. **<u>Thermal Strategies Precedent study</u> :** Assign at least 1 precedent research task to each individual in your team pertaining to the various strategies included in your Project One/Two design proposal and as modified by Step 1 (above.) The research assignments should include all critical strategies which will impact the thermal performance of your building. You might consider:
   - *Solar control strategies active and passive*
   - *Glazing materials, technologies and systems*
   - *Thermal envelope materials and insulating methods*
   - *Living Walls, arbors and trellises*
   - *Intelligent Skin concepts*
   - *Phase change thermal storage systems*
   - *Superinsulated Envelope*
   - *Thermal mass materials and configuration*
   - *Natural ventilation strategy*
   - *Cool roof and Green roof strategies*
   - *Passive solar heating strategy*
   - *Passive and Active Solar integration*
   - *Double Envelope Concepts*
   - *Other innovative Thermal Approach*

3. **<u>Thermal Computer Model Preparation</u>**
   Construct a thermal model of your proposed design using ECOTECT. You should be able to use the model constructed for your daylighting studies for Project One. This model will be used to study the various performance aspects of your thermal design. At this stage it is advisable to simplify the model in order to get quicker results. Follow the *Thermal Analysis* tutorials provided (see Course Website: Ecotect) to ensure that you have constructed the model correctly in order to do the prescribed thermal analysis.



Average Monthly heating and cooling loads



Hourly Temperature Distribution by zone

4. **ECOTECT Thermal Analysis:** As a group, you will investigate the climate responsiveness and overall thermal performance for your building. ECOTECT will calculate internal temperatures, spatial comfort and heating and cooling loads for models with any number of zones or type of geometry. You will need to assign material choices to all objects. You will also need to assign HVAC mode and operational schedules for occupancy.
   a. Temperature Profile Study: Calculate the hourly temperatures for all your zones for the hottest and coldest days of the year. Check the Average Hottest and Coldest Days Are they the same? How about the windiest and sunniest days? When do they occur?
   b. Heating and Cooling Loads Studies: Calculate the average monthly heating and cooling loads for your project and create a graph showing the monthly heating and cooling loads for your building for a typical year. Export (or copy) the data table showing the monthly heating and cooling loads values and the peak loads conditions to a table in Word or Excel or another suitable application. Create a diagram showing the passive gains breakdown of your design using the Thermal Analysis Wizard.

c. Optional Passive Solar Study: Vary the size or shading of some south facing window(s) of your model or the overhang depth and evaluate the impact on thermal loads and on daylight contours (you should have produced these graphs for your Project One.) Report your findings.

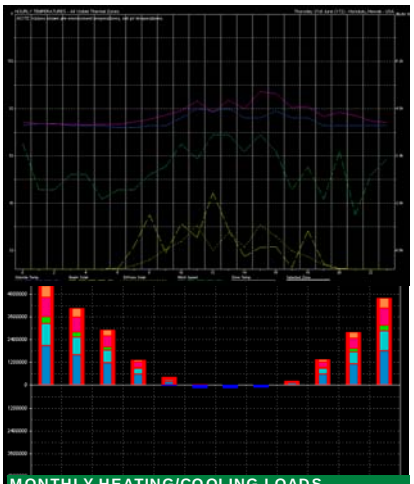
d. Optional Thermal Mass Study: Vary the thermal mass of some element(s) of your model and evaluate the impact on your calculated building loads. Report your findings.

5. Graphical Study of Passive Solar Integration:

Develop an annotated building wall section at an appropriate scale (e.g. ¼" – ½"=1'0") and at least one other detailed diagrammatic study explaining the passive solar heating and cooling strategies integrated into your thermal design.

PRESENTATION CHECKLIST: PROJECT THREE
Phase 1.0 Submission: PINUP FRIDAY, FEBRUARY 8

Work as a team to create an informal presentation.
Suggested format: informal collage in an area no more than 72" W x 36" H. *Label all charts, tables, graphs, sections and other diagrams. Include graphical scale where appropriate.*

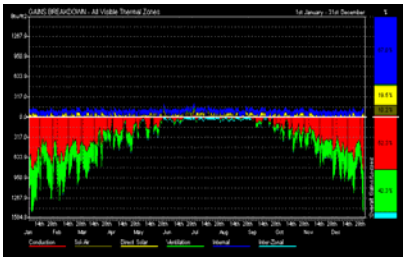


MONTHLY HEATING/COOLING LOADS

All Visible Thermal Zones
Comfort: Zonal Bands

Max Heating: 39224.4 Btu/hr at 05:00 on 31st December
Max Cooling: 10706.2 Btu/hr at 14:00 on 28th May

MONTH	HEATING (Btu)	COOLING (Btu)	TOTAL (Btu)
Jan	17911208	0	17911208
Feb	13847516	0	13847516
Mar	9948593	0	9948593
Apr	4544896	0	4544896
May	1370772	236687	1607459
Jun	74218	612719	686937
Jul	0	663750	663750
Aug	0	474338	474338
Sep	702927	1628	704554
Oct	4613660	0	4613660
Nov	9527052	0	9527052
Dec	15650158	0	15650158
TOTAL	78191000	1989122	80180120
PER M²	1404797	35737	1440534
Floor Area:	599.12 ft2		



1. ***Results of precedent Study - minimum 3 strategies or concepts***
2. ***ECOTECT Thermal Analysis:***
   - ***a. Temperature Profile Study:***
     - Temperature Profile Chart from Ecotect for Hottest Day
     - Temperature Profile Chart from Ecotect for Coldest Day
   - ***b. Heating and Cooling Loads Studies:***
     - Average Monthly Heating and Cooling Loads Chart from Ecotect
     - Monthly Heating and Cooling Loads Data Table showing Peak Heating and Cooling Loads and days - Exported from Ecotect in spreadsheet format
     - Passive Gains Breakdown Chart from Ecotect
   - *c.* ***Optional Passive (South Window) Study:***
     - Recalculate and plot the Average Monthly Heating and Cooling Loads
     - Recalculate and plot the Passive Gains Breakdown Chart from Ecotect
     - Any other Charts that show the before and after condition.
     - Please include other diagrams clarifying your design variation (e.g. increased south window area, increased or decreased overhang depth, etc.)
     - Brief Written Critique:
       - Did it change the results – in what way?
       - Include a brief written summary of your "quantitative analysis"
       - Design Conclusions: Does the strategy help or hurt the design?
   - *d.* ***Optional Thermal Mass Study:***
     - Recalculate and plot the Average Monthly Heating and Cooling Loads
     - Recalculate and plot the Passive Gains Breakdown Chart from Ecotect
     - Recalculate and plot the Daylight Illuminance studies from Project One for the affected area.
     - Please include other diagrams clarifying your design variation (e.g. added CMU walls, Thermal storage objects, etc.)
     - Brief Written Critique:
       - Did it change the results – in what way?
       - Include a brief written summary of your "quantitative analysis"
       - Design Conclusions: Does the strategy help or hurt the design?

3. ***Graphical studies and a brief written narrative highlighting the key concepts and describing the thermal design intent and Passive Solar Integration:***
    - Annotated building wall sections at an appropriate scale (e.g. ¼" – ½"=1'0") explaining your passive design integration strategies.
    - Or include other diagrams to explain your passive integration, e.g., exploded view diagrams, cutaway perspective or axonometric studies. Include sufficient annotation to convey design intentions clearly.
    - Written narrative – 2-4 paragraphs

GRADING CRITERIA Project Three: *25% total Phases 1 and 2 combined*

1. **Phase 1.0: Exploratory Studies:**
    - Overall clarity, accuracy and execution of thermal analysis methods
    - Demonstrated understanding of findings and results

2. **Phase 2.0: TBA**