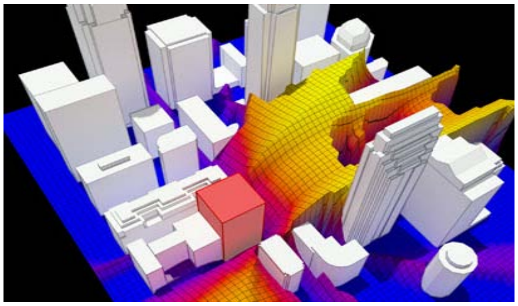
ARCH 5550 • Zero+DESIGN

Envisioning the Sustainable Campus

Integrating carbon, energy, and water management strategies toward zero- and net-positive design



"Every eight months, nearly 11 million gallons of oil run off our streets and driveways into our waters—the equivalent of the Exxon Valdez oil spill."

— "America's Living Oceans"

Americans use 520 megawatt-hours, or 13 percent of U.S. electricity consumption, on water.

_ River Network, in a 2009 Report on Energy and Water

Exercise 4: Assessing Urban Heat Island Impacts and Evaluating Water Waste and Energy Performance

Due Dates

Step A-E: Due Fri. April 22, 1:30 PM, informal presentation; Room 71

Exercise 4.0 Grade weighting: 20% total grade (200 points); team grade

OBJECTIVES

- To gain an understanding of the Urban Heat Island (UHI) impacts of various aspects of building and site design and how to measure and mitigate them.
- To learn to evaluate the energy use associated with potable water use and wastewater treatment.
- To learn to measure the impact of energy use on Water.
- To gain an understanding of the cooling effects of evaporation and transpiration on buildings and to how to evaluate their potential in reducing cooling loads.
- To learn to recapture resources and materials in the solid waste stream and to calculate the potential energy and other benefits.
- To continue to develop your project design towards net-zero and zero+ performance goals.

STEP A: URBAN HEAT ISLAND IMPACT ANALYSIS

Continue analyzing the performance your project and developing strategies to mitigate impacts (less bad) and optimize benefits (more good). As a team, investigate the UHI contributors of your project and how they impact the local and regional urban heat island effect. Consider the following:

1. Context: How will the surfaces and materials of the site and building of your design contribute to urban heat island?
   • *Note: You may want to consider analyzing the incident solar radiation on your building exterior surfaces using Ecotect in order to measure the potential for UHI mitigation for any particular material and surface area.*

2. Make a list of strategies your project could employ to mitigate UHI effects. What would be the expected benefits of these strategies and how could you model them?

   • Present: graphic analysis of the building and site. Show the design interventions and surface areas where you are proposing to mitigate UHI impacts. Summarize the benefits.

STEP B: SOLID WASTE ANALYSIS

Continue analyzing the solid waste characteristics of your project and developing strategies to mitigate impacts (less bad) and optimize benefits (more good). As a team, evaluate the waste and recycling data of your project type (see moodle site) and how they can be improved. Consider the following:

1. As a team, establish a measurable goal for reducing or mitigating Solid Waste from your project. Include goals for construction and for operation.
2. Determine the baseline: What is the likely amount of non-reclaimed solid waste for your project for a typical year?
   • Note: You may want to consider analyzing the incident solar radiation on your building exterior surfaces using Ecotect in order to measure the potential for UHI mitigation for any particular material and surface area.
3. What is the likely amount of reclaimed solid waste that would be collected – provide a breakdown of the typical recycled materials based on waste and recycling data for your project type provided?
   • Note: You may want to consider analyzing the "recyclemania" data for other but similar building types as well, e.g. Dining Hall data could be used to predict waste and recycling for the dining portion of your project.
4. Make a list of strategies your project could employ to reduce the non-reclaimed solid waste volumes you calculated in Step B1. What would be the expected results of implementing these strategies and what are the potential pitfalls and benefits to both your project and the campus or community as a whole? Remember the 3R's and include strategies that address all of them.
   • Present: tabular and/or graphic analysis of the project if current university performance levels were maintained. Include quantities by tonnage and cost implications if known. Show the proposed solid waste mitigation strategies. Summarize the benefits and potential problems.
5. What is your mitigation strategy regarding Construction Demolition Waste reclamation/disposal from the site.
   • Present: analysis of the likely construction debris that will result from clearing of the site and demolition of any existing structures. What would be the likely materials and how do you propose to reclaim or mitigate the costs and impacts of their disposal. Include quantities by tonnage if known.
6. *Optional:* In your analysis for no. 3 include estimated Embodied energy (energy needed to make the material) and possible reclaimed energy values (e.g., if waste is diverted to the HERC plant for incineration or alternatively to some other on-site or off-site digester.)

STEP C: POTABLE WATER USAGE AND WATER BALANCE ANALYSIS

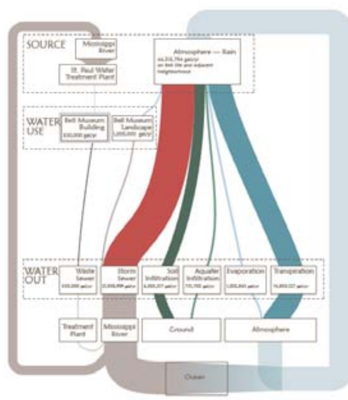
Continue analyzing the water usage characteristics of your project and developing strategies to mitigate impacts (less bad) and optimize benefits (more good). As a team, evaluate the water demand calculated for your project in Exercise 3 Step A. How can this usage be reduced or how can it be satisfied from sources other than the normal city potable water utility? Consider the following:

1. As a team, establish a measurable goal for reducing or mitigating Water Use for your project. Include goals for landscape irrigation and for building operation.

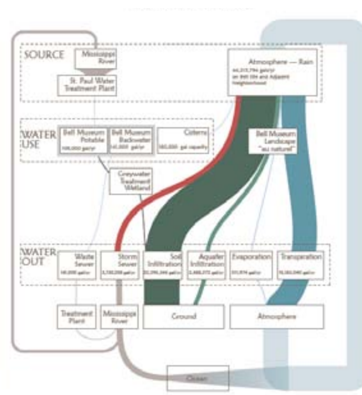
2. Determine the baseline: What is the likely potable water demand for your project for a typical year?
   • Note: You should have completed this calculation in Exercise 3 Step A. Update that value based on

any newly obtained data on your project type. (E.g., lab water use research, dining facility water use data.)

3. What is the likely amount of precipitation from your site or surrounding areas that can be reclaimed and how much could be used to meet some of your water demand and how much should be infiltrated?
   • Note: You should have completed this calculation in Exercise 3 Step A. Recalculate that value based on average annual precipitation of 29" for Minneapolis.
4. Make a list of water reclamation (e.g., grey water treatment and reuse, black-water treatment and reuse, etc.) and efficiency strategies (such as dual flush toilets and automatic controls) your project could employ to reduce the potable water consumption. What would be the expected results of implementing these strategies and how much reduction in potable water use can be achieved through the implementation of your strategies?
   • Present: tabular and/or graphic analysis of the project if current university performance levels regarding potable water consumption were maintained. Estimate the reduction in gallons per year for your proposed water reclamation and efficiency strategies. Summarize the benefits and potential problems.
5. Create a *graphic Water Balance (Supply and demand) analysis of your proposed design including all the reclamation, efficiency and storm water infiltration strategies you are proposing for the building and site. This is your new Design Case water balance analysis to be compare to the updated Baseline Analysis from Exercise 3, Step A.*
   • Present: Water balance model: Proposed Design vs. Baseline. Include any other graphic diagrams, section drawings or charts that help to illustrate your overall sustainable approach to water use and reuse and onsite storm water infiltration.



Baseline Water Balance Diagram



Proposed Design Water Balance Diagram

STEP D: INITIAL ENERGY SHOEBOX ANALYSIS

As a team, establish a measurable goal for reducing or mitigating Energy Use for your project. Include goals for both conservation and for renewable energy sources.

1. Calculate your baseline energy use: Using Excel or a calculator, calculate the probable energy use for your project. Use the typical energy use intensity (EUI) data provided on page 6 and in the "Energy-Use-Examples.xlsx" file on the course Moodle site: https://moodle.umn.edu/mod/resource/view.php?id=1024111
2. Create a Shoebox Energy Model: If you haven't already done so, construct a shoebox energy model of your building. Remember to simplify your model as much as possible. The baseline model should be a simple rectangle in plan and the proposed number of floors with little if any detail. Windows should be repetitive and identical. Rotate the building relative to solar orientation if necessary before running your simulations.) If you run into simulation errors, be persistent or request help from the instructor. Here are the steps:

   a. Develop a simple rectangular floor plan with a suitable number of identical windows and "extrude" or copy the plan up the required number of stories making each floor a complete thermal zone.

b. Set appropriate values for thermal envelope insulation values and glazing types or other object materials, HVAC system type (Full Air Conditioning), occupancy load and schedules, internal loads for lighting and equipment and establish the Set appropriate.

c. After you get your initial results, compare the resulting energy performance to the Baseline Energy Use you calculated in Step D1 above and calibrate the energy performance results of your shoebox model to be similar. To do this, adjust the base model description and run iterative simulations until the results are similar - within a few thousand KBtu. This may take several tries. Again, get help from someone if you need it.

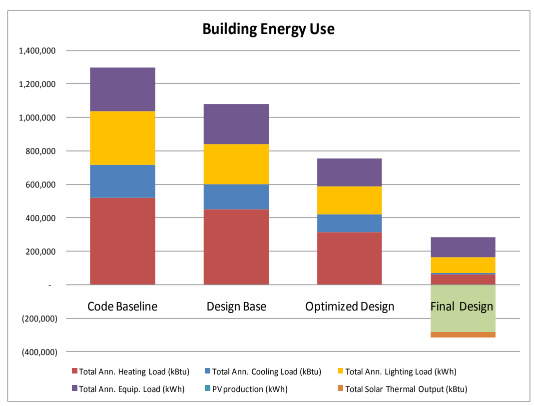
3. **<u>"Shoebox" Analysis of proposed design and to establish building energy perfromance Targets</u>**

As a team, you will investigate the potential for improved energy performance for your project and use the results as your expected Design *Case* for comparison to the Baseline. This will direct you as you proceed to improve your design and work toward achieving a Net-zero energy, carbon neutral *Final Design Case*. Use your Energy Design Tool of choice to accomplish one of the following:

a. Heating and Cooling Loads Studies: Calculate the average monthly heating and cooling loads for your baseline case and create a table 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.

b. If you use Energy 10: Apply the High Performance Energy Strategies you would like to explore in your final design and calculate the resulting improvement in performance. Provide a comparison of your estimated Design Case compared to Baseline for energy use, utility cost and any other metrics you wish to use to communicate the effectiveness of your approach to building energy performance.

c. If you use Ecotect: Add as many as possible of the High Performance Energy Strategies you would like to explore in your final design to your Baseline model, e.g., wall and roof insulation values, green roofs, modified window glazing, size and orientation and building form to add passive gains, reduced air infiltration rates, etc., and calculate the resulting improvement in performance. Using the Zero+ spreadsheet calculator provided (See Tools directory on the course Moodle site) input your resulting heating and cooling loads for both Baseline and Proposed Design Case and calculate your comparative energy use breakdown. Provide a comparison of your estimated Design Case compared to Baseline for energy use and any other metrics you wish to use to communicate the effectiveness of your approach to building energy performance.



d. If you are using some other energy analysis tool or method, see Instructor to develop criteria specific to your proposed methods.

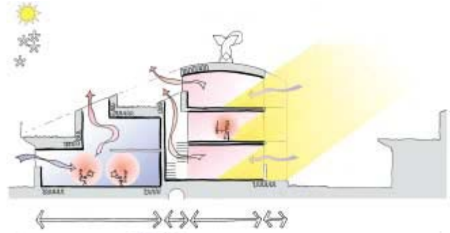
• Present: tabular and/or graphic analysis of the comparative energy performance of your Baseline and Proposed Design Case. Estimate the reduction in EUI (KBtu/SF) total energy use and utility cost (if known) per year for your proposed energy efficiency and source strategies. Summarize the benefits and potential problems.

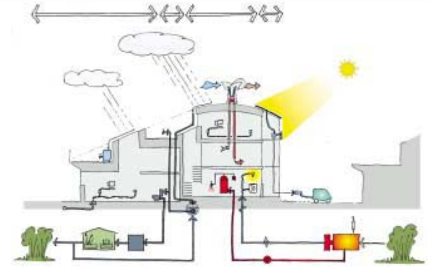
STEP E: CONCEPTUAL DESIGN DRAWINGS: 1/16" Plan, Section and Exterior Elevation Drawings

Due: Friday, April 22, 1:30 p.m. Rapson Room 71; Informal Review

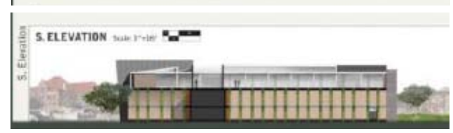
Continue to develop your conceptual design proposal exploring the building programmatic spatial layout, vertical floor –to-floor relationships, and exterior finish and appearance. Keep in mind that these are conceptual drawings which are intended to convey your initial design ideas and approach.

For your informal review on *Friday, April 22* please include the following:





1. Site/Building Plan: Develop annotated floor plans for your first floor and a typical upper level floor plate at 1"=16' scale to illustrate your site layout and ground floor design concept. Identify the key water, energy and waste aspects of your site.
2. Section Drawings: Develop annotated section drawing(s) for your proposed design at 1"=16' scale to illustrate your key energy, water and waste strategies as well as the vertical arrangement of your proposed design concept. Identify any passive integration strategies such as daylighting and natural ventilation, as well as key energy and water systems, such as rainwater harvesting, green roofs, renewable energy systems, etc.
3. Building Elevations: Develop at least two annotated exterior elevation drawings (one should be of the south exposure) for your proposed design at 1"=16' scale to illustrate your exterior cladding and fenestration layout and strategies as well as the aesthetic appearance of your proposed design concept. Identify any passive integration strategies such as shading systems, high performance glazing and wall integrated renewable energy systems, etc.



GRADING CRITERIA - Exercise Two: *20% total of ARCH 5550 grade (200 pts)*

- Clarity, completeness and accuracy of quantitative analysis tables, charts, graphs and diagrams
- Craft and quality of annotated conceptual design drawings
- Clarity and accuracy of written summaries and conclusions drawn

Typical Energy Use Data

Residence Hall Examples			Energy Use Intensity					Energy Use			
Building	Name	GSF	Tot EUI KBtu/sf	Heating KBtu/sf	Cooling KBtu/sf	Elect KWh/sf	Gas/DHW KBtu/sf	Total Heating KBtu	Total Cooling Tons	Total Electric KWh	Total Energy KBTU
028	Sanford Hall	156,993	117	77	3	9	5	12,136,217	39	1,457,491	18,318,570
052	Pioneer Hall	177,550	114	84	2	8	1	14,888,291	24	1,440,544	20,293,110
063	Comstock Hall	174,367	118	72	3	12	4	12,504,889	43	2,018,768	20,524,215
068	Centennial Hall	233,233	109	60	7	11	4	13,901,985	134	2,642,416	25,380,172
	Averages	185,536	114	73	4	10	3	13,357,846	60	1,889,805	21,129,017

Lab Building Examples			Energy Use Intensity					Energy Use			
Building	Name	GSF	Tot EUI KBtu/sf	Heating KBtu/sf	Cooling KBtu/sf	Elect KWh/sf	Gas/DHW KBtu/sf	Total Heating KBtu	Total Cooling Tons	Total Electric KWh	Total Energy KBTU
143	Dwan VCCRC	183,977	435	258	60	34	0.24	47,532,213	919	6,271,137	80,003,284
186	MCB	259,757	413	209	58	43	0.03	54,316,977	1266	11,057,211	107,255,397
197	WMBB	118,858	208	144	13	15	0.05	17,145,675	130	1,748,732	24,681,073
	Averages	187,531	352	204	44	30	0.11	39,664,955	772	6,359,027	70,646,584
Additional Lab not used in average calculations:											
174	Lions / MTRF	152,309	288	103	19	18	106	15,673,122	239	2,696,338	43,849,003