ENERGY & THE BUILT ENVIRONMENT

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Final Workbook

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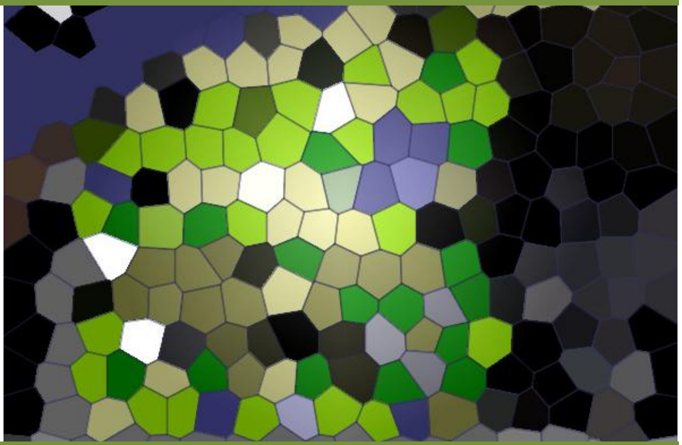

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UNIT A COOPERATE

SITE SELECTION AND SITE DESIGN: URBAN VS. RURAL CONTEXT

The relative sustainability of urban vs. rural development is of less importance than achieving sustainable development strategies within these different settings. Both have significance in the broader context of varying cultural requirements and it is necessary to address sustainable design issues along a spectrum of sites. With this in mind, meeting the objectives of a building program in a rural setting may require very different solutions than in an urban setting. The reason is that while rural and urban sites have common sustainability considerations, they also have distinct issues related to the conditions of location.

Site selection

In the rural context, development can pose a threat to natural landscapes that provide critical ecosystem services. The regulation of climate, maintenance of hydrologic cycles, and balance of ecological systems such as forests are all significant site selection considerations. The introduction of new infrastructures in rural environments can have considerable negative impact on natural systems. Because of this, development in a rural setting should be approached from a perspective of whether new development is needed and if it can be done without disturbing pristine natural environments.[1]

At the same time, site selection in rural areas can provide unique opportunities to achieve a careful balance between the built and natural environments. Selecting sites that allow critical areas of social and environmental significance to be protected can avoid disturbance of wildlife habitat, food production, and water cycles. Additionally, they can also provide unique settings in which to live and work that are conducive to the health and well-being of occupants.[2]

In the urban context, site selection can create opportunities that improve existing relationships between the built and natural environments. Urban settings often offer a wider variety of site conditions including grayfields, urban infill and brownfield. As each of these correlate to previous or existing development on or nearby the site, they can provide opportunity to integrate with existing infrastructures, connect to existing amenities[3] and improve site conditions related to water, climate and green space.

In an urban setting, improving the conditions of a site can take priority over protecting undeveloped land. This is not to say that development of greenfields should be considered, but rather that more opportunities exist to implement effective stormwater strategies, mitigate urban heat islands and create areas for habitat and open space on sites that have been impacted by previous development.

Site design

Many site design principles are shared between rural and urban settings, such as working towards reduced loads, implementing passive strategies and simple systems, using renewable sources and

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[1] *Reexaming priorities in Green Building.* Environmental Building News. November 1 2010. http://www.buildinggreen.com/auth/article.cfm/2010/10/29/Reexamining-Priorities-in-Green-Building/

[2] *Case study. Wind NRG Partners Manufacturing Facility.* Environmental Building News. February 6 2006. http://www.buildinggreen.com/hpb/overview.cfm?projectid=420

[3] *Driving to Green Buildings: The Transportation Energy Intensity of Buildings.* Environmental Building News. September 1 2007. http://www.buildinggreen.com/auth/article.cfm/2007/8/30/Driving-to-Green-Buildings-The-Transportation-Energy-Intensity-of-Buildings/

minimizing waste. However, site design in the rural context can have a more direct and immediate impact on pristine natural environments. The effects of development on habitat, ecosystems and waterways are priority considerations when locating a building (or buildings) on a rural site. Setting aside areas of critical habitat, maintaining pre-development hydrology cycles and protecting pristine ecosystems from damage or pollution during and after construction require priority attention[4].

In the urban context, careful site design can maximize the use of space in dense urban areas and contribute to strategies for increased urban density. Additionally, site design here can reintroduce natural processes through such measures as careful strategies for stormwater management that restore on-site infiltration. In cases of grayfields, site design can bring additional open space and urban wildlife habitats to sites previously composed of impervious, man-made landscapes.[5]

Sustainability along the site spectrum

In both rural and urban settings, the framework for sustainable sites includes common principles such as protecting existing habitat, working with natural hydrologic cycles, optimizing passive strategies for climate control, minimizing waste and prioritizing renewable resources. In practice, the two settings present distinct challenges that require site-appropriate strategies. In rural settings, careful consideration of the direct impact that site selection and design have on the natural environment is a priority. In urban settings, the focus can shift towards regenerative strategies that improve conditions.

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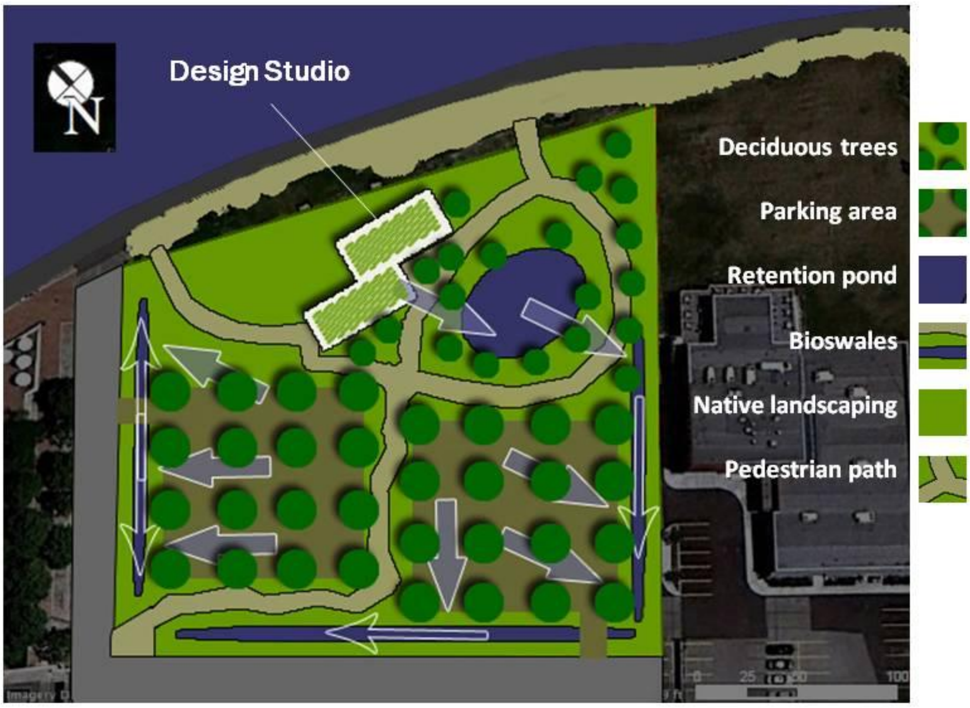
[4] *Dealing with Construction Waste: Innovative Solutions for a Tough Problem.* Environmental Building News. November 11 1992. http://www.buildinggreen.com/auth/article.cfm/1992/11/1/Dealing-with-Construction-Waste-Innovative-Solutions-for-a-Tough-Problem/

[5] *Stormwater Management: Environmentally Sound Approaches.* Environmental Building News. September 1 1994. http://www.buildinggreen.com/auth/article.cfm/1994/9/1/Stormwater-Management-Environmentally-Sound-Approaches/

UNIT A DEMONSTRATE

Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration



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Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

Program:

- Total Site Area 75,000 sf
- Building Footprint 2,100 sf
- Parking 20,000 sf

Other Programmatic Requirements:

- Entrance must face Courthouse Way
- Create pedestrian circulation path to connect South Bay Harbor Trail with the entrance and corner of Liberty Drive and Courthouse Way
- Maximize views of the waterfront

Sustainable Site Goals:

- Orient the building and site elements to maximize passive and active solar design
- Slow down, capture, and treat as much stormwater on site as possible
- Minimize heat island effect
- Maximize habitat for native flora & fauna
- Minimize the energy and water required for maintenance

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Schematic Site Plan
solar orientation, stormwater, heat island effect, and habitat restoration

Sustainable Site Goals:

Orient the building and site elements to maximize passive and active solar design

The design studio holds a footprint of 2,100 sq ft on a staggered east-west axis to maximize passive solar opportunities on the south facade as well as views to the north towards the waterfront and city skyline. The main entrance on the west faces Courthouse Way and is shielded from northern winds by evergreens.

The building design follows New England vernacular in that it creates a sheltered courtyard on the southern facade. This space provides outdoor seating areas with views of gardens and a water feature during temperate months.

Deciduous trees at the courtyard shade the building from summer sun while allowing solar gain in colder months. A light shelf at the south facade brings diffused daylight into interior work spaces. Deciduous trees along the westerly section of the south facade assist in controlling solar gain and glazing along the northern facade contribute natural daylighting with views. The building is sited towards the middle of the Northern site boundary to avoid solar gain disruption from neighboring buildings and allow parking areas to be located in shade of proposed structure at the southern boundary during summer months. The siting reflects the most cost-effective option for parking, i.e. winter maintenance expected to be lower than building a two-story parking structure or underground parking facility.

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Schematic Site Plan
solar orientation, stormwater, heat island effect, and habitat restoration

Sustainable Site Goals:

Slow down, capture, and treat as much stormwater on site as possible

With stormwater outlets located at the south and north corners of the western site boundary, the site is designed to capture rainwater and direct it through biofiltration areas towards stormwater outlets. The retention pond in the northeast corner discharges into the bioswales and water flow is directed clockwise around the site boundary into the stormwater outlets.

The bioswales placed along the west, east and south boundaries capture runoff from both the site parking areas and adjacent streets creating opportunity for biofiltration of pollutants before recharging groundwater or being discharged to the stormwater outlets.

A green roof located across the expanse of the building supports the stormwater strategy. Runoff from the roof is directed to the retention pond. Additionally, pervious materials are used at pedestrian pathways and parking areas.

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Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

Sustainable Site Goals:

Minimize heat island effect

With high requirements for parking area, the site is designed to disperse shade throughout and integrate water features to moderate the microclimate. Deciduous trees are scattered throughout the 20,000 sq ft parking lots to shade surfaces and vehicles.

The parking area is staggered to allow for vegetation between two main areas and to push towards the shade of neighboring buildings towards the southern site boundary.

The vegetation and water features work to cool air that enters the site from the east, west and south creating a moderate micro-climate at parking areas. At the vegetated northern section of the site, where the building sits, cooler air flows in from the waterfront.

Additionally, the green roof serves another function to lower the radiant heat generated from the building surface.

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Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

Sustainable Site Goals:

Maximize habitat for native flora & fauna

The site is designed for maximum vegetation to be dispersed throughout. Native landscaping is used in garden areas and adjacent to pedestrian pathways to provide intermediary habitats, such as low shrubs, grasses and reeds, for songbirds, insects and small mammals.

Deciduous trees throughout the site provide ample habitat for larger birds, such as crows and owls. The bioswales and retention pond create ideal habitat for amphibians and water fowl, such as Canadian Geese and mallards, as well as butterflies like migratory Monarchs.

Native plants to be used could include goldenrod to attract butterflies, native honeysuckle for hummingbirds, and switch grass, dogwood or juniper to provide songbird habitat.

The site could also potentially serve as a nesting site for sea birds found along the Atlantic coasts, such as Wood Storks.

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Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

Sustainable Site Goals:

Minimize the energy and water required for maintenance

The site design employs passive solar strategies to optimize solar control and regulate the micro-climate. Solar orientation of the design studio allows solar gain during colder months to lower energy loads for heating. The orientation also protects the building from solar gain during hotter months to reduce cooling requirements.

Glazing along the southern facade uses external solar protection and light shelf features to bring diffuse natural daylight into work areas. Additional glazing along the northern facade provides daylight as well as views of water and city skyline. Both decrease energy requirements for electric lighting and improve the quality of lighting for work spaces.

In addition to supporting the stormwater strategy and mitigating urban heat island effect, the green roof helps reduce the cooling requirements of the building during hotter months. Native landscaping throughout the site reduces the need for irrigation.

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Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

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UNIT B COOPERATE

MARKET FACTORS AND SUSTAINABLE DESIGN TECHNIQUES

What market factors have prevented the wider use of the sustainable design techniques described in today's lecture and readings?

Energy conserving design strategies can encompass a range of techniques from passive solar to high-tech applications. The relationship of buildings with the local environment and micro-climate can also vary in complexity depending on the building program and size. Passive design strategies are evident in many vernacular buildings worldwide, and when implemented in contemporary structures provide effective measures to respond to climate through design. Still, structures that prioritize sustainable design are in the minority of new development and even feasible strategies for energy conserving design are often not considered.

An indicator of increasing energy demand can be seen in statistics of new residential housing in the United States. In 1973, the ratio of new homes built with air-conditioning to those without was 49:51. In 2010, the ratio is 88:12 showing a significant shift away from passive cooling strategies to mechanical dependent systems.[6] Similar data shows that residential construction is increasing in size. In 1973, the median square feet for a home in the Northeast was 1450 compared to 2336 in 2010.[7]

The figures show that homes are increasing in size and in energy demand despite tremendous developments in technology, policy and knowledge over the past 30+ years. The facts about residential design are alarming in light of statistics that show, for example, in the UK that residential buildings account for 30% of energy consumption nationwide.[8]

Both residential and commercial buildings contribute to energy consumption, and both can increase energy efficiency through implementation of both passive and active energy conserving strategies. However, market factors related to demand and costs play a significant role in determining the strategies engaged in both sectors.

According to a 2011 report from the US Department of Energy, 'the perceived market risks of doing energy efficiency are greater than any potential benefits.'[9] This finding relates to the cost-effectiveness of 'high-performance' buildings which implement technology in the design and construction. In this context, an important outcome of the research was that 'the savings must be *bankable*.' The message is clearly that economics are a motivating factor for the uptake of energy conserving measures.

The same might be held true for residential structures, which are in large part driven by consumer demand. The growing size and energy consumption of single family homes in the US reflects priorities that do not consider energy savings to be a financial consideration, or at least not one that is relevant to their personal investment in a property.

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[6] US Census information from NAHB. Characteristics of New Single-Family Houses Completed. 2010. http://www.census.gov/construction/chars/pdf/aircond.pdf.

[7] US Census information from NAHB. Characteristics of New Single-Family Houses Completed. 2010. http://www.census.gov/construction/chars/pdf/medavgsqft.pdf.

[8] *The Autonomous House: Complexity and Contradictions.* Brenda and Robert Vale, IPENZ Transactions, 1999, Vol 26, #1/GEN.

[9] High-Performance Buildings – Value, Messaging, Financial and Policy Mechanisms. McCabe, MJ. February 2011. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-20176.pdf.

The perception that 'green' design and construction is more costly may correlate to the amount of time that, in the US, an owner expects to hold a property. The "average American" makes 11.7 moves in a lifetime[10] and commercial buildings are often built on speculation to be sold after completion. Within this context, any energy conserving strategy that involves higher up-front costs with a long term payback would not be recouped by the original building owner and are therefore not *bankable*.

This then poses the question as to why energy conserving design strategies don't appeal to the market? In the case of Germany, the rating for energy performance of a building for sale or lease is now required by federal law since 2010[11] as part of the country's ambitious goal to become the world's most energy efficient country.[12] This strategy is also a recommendation, among others, from the finding of the US DOE report 'High-Performance Buildings – Value, Messaging, Financial and Policy Mechanisms':

> *Develop a prototype 'energy usage sticker' to provide a visible indicator of usage, thereby impacting tenant and occupant interest in building performance and demand for high-performance buildings.* [13]

There are a multitude of factors that could contribute to a lag in energy efficient strategies for construction, both in residential and commercial buildings. It seems that a significant factor is if long-term occupancy is not a priority of the developer. In this case, increased demand from the market is needed in order to motivate design and construction towards energy efficiency. This can only be achieved through transparency of (long-term) energy costs, and a competitive 'green' building market through better informed consumers.

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UNIT B DEMONSTRATE

SIZE THE HOT WATER COLLECTOR AREA AND SPACING FOR A FLAT ROOF

1. In Table #1, please select the value for a "good" quality concentrating collector, chosen because of our relatively cold winter climate. Please use the value for Imperial Units, *not* SI units. **= 211**

[10] US Census. http://www.census.gov/population/www/pop-profile/geomob.html. Accessed 28 January 2012.

[11] German Energy Agency website. www.dena.de. Accessed January 28 2012.

[12] *Germany to Become World's Most Energy-Efficient Country.* Deutsche Welle. April 29 2007. http://www.dw-world.de/dw/article/0,,2459564,00.html.

[13] High-Performance Buildings – Value, Messaging, Financial and Policy Mechanisms. McCabe, MJ. February 2011. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-20176.pdf.

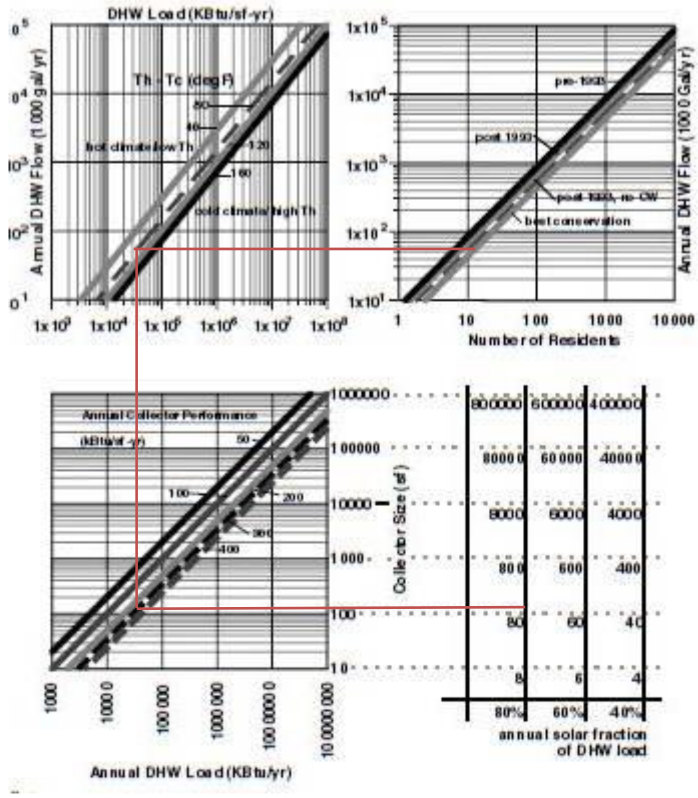
2. Note that the latitude for Boston is **42°**

3. Note that in Figure #2 the groundwater temperature line conveniently falls right on Boston = **52 degrees**

4. In Figure #3, start with the groundwater temperature from Figure #2**,** move upward to the Supply Hot Water temperature of 120°**,** then read horizontally to the left from the intersection to find the amount of the temperature rise. = **68 degrees**

5. Size the collectors for a residential household of **15 people** (since our office is the size of a residence, not a typical office building), using the "Best Conservation" line on the first chart in Figure #5. **= 50**

6. Using the residence chart, size the collectors for an 80% solar fraction, extrapolating between the figures shown on the last chart for Collector Size and Annual Solar Fraction (i.e. subtract the number below from the number above and multiply by the fractional distance between them which can be read from the lines shown on the previous chart, then add this figure to the number below). = **110 sq ft**



7. Use Table #2 to find the spacing between collectors facing due south with a tilt of Latitude + 15°, since we want to have the best water heating during the winter months. For the length of the collector "L", use 6 ft. Extrapolate between the D/L values for 40° and 44° latitude. **= 6 x 2.7 = 16.2**

Answers:

1. Residential collector area @ 80% of load: ≈ **110 sq ft**
2. Spacing between collectors: **16.2 feet**
3. Number of rows of south-facing collectors we can have on our roof: **2**
4. Total possible collector area on the roof: 2 x 60' x 6' = 7**20 sq ft**
5. Is this enough to meet the required collector area for our Office @ 80% of load? **Yes!**

UNIT C COOPERATE

WHAT MAKES FOR A COMFORTABLE THERMAL ENVIRONMENT?

The goal of thermal comfort could be described as meeting subjective requirements through specific measures intended to regulate air temperature, humidity, air flow and velocity and other indoor climate values. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) defines thermal comfort as a 'state of mind in humans.'[14] The fact that organizations such as ASHRAE and the American National Standards Institute (ANSI) use subjective language to define thermal comfort and in standards meant to set measurable indicators and requirements is evidence that it is difficult to define thermal comfort in absolute quantifiable terms. There is in fact a very 'human' element to thermal comfort, meaning that variables are part of the equation, both in efforts to achieve it as well as in measuring success.

While thermal comfort may be difficult to define, ASHRAE sets out a guideline that aims for 80% thermal comfort satisfaction of occupants for offices.[15] Along the spectrum of human responses, reaching this indicator marks a level we, at least most of us, can live with. To meet this goal a number of concrete factors can be applied including measures of air temperature, mean radiant temperature, humidity, and air velocity within the space, along with the personal factors of clothing insulation and activity level.[16] Additionally, factors relating to human variables can be approached through various strategies that respond to findings on the psychology of thermal comfort.

Most of us can point to a difference between our own thermal comfort requirements and that of someone with whom we share indoor space, whether at work or home. For example, my sister-in-law typically feels cold in environments where most others feel comfortable. She could be considered the '20%' acceptable failure rate in ASHRAE's guidelines. However, the reasons behind her individual discomfort convey the subjective aspects of thermal comfort success and are part of a broader discussion on 'adaptive thermal comfort'.

As AHRAE, and designers, sets out to control the measures of tangible factors, such as air velocity, addressing the human element requires a more flexible approach to controlling indoor environments. According to Building Green, adaptive thermal comfort must consider 'the ways that people's perceptions of their environment change based on seasonal expectations of temperature and humidity as well as their capacity to control the conditions in a space.'[17]

Meeting expectations and perceptions is a daunting challenge, particularly in buildings that service occupants with diverse frames of reference. A frequent example of skewed expectations can be seen in conference settings where participants travel from various regions. A foreigner might expect that their participation in meetings in Cameroon, for example, will place them in a hot, humid environment. This is a practical assumption, however the operator of the meeting venue may expect that foreigners will be uncomfortable in such a setting and have established mechanical air conditioning to create a cool environment. Here the expectations and the measures to meet thermal comfort are at opposite ends of the spectrum, and the result can be dissatisfaction in the thermal setting.

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[14] ANSI/ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy. http://www.ashrae.org/.

[15] ANSI/ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy. http://www.ashrae.org/.

[16] *Expanding the Engineers' Comfort Zone: Working with Adaptive Thermal Comfort*, Environmental Building News. 1 July 2004. http://www.buildinggreen.com/auth/article.cfm/2004/7/1/Expanding-the-Engineers-Comfort-Zone-Working-with-Adaptive-Thermal-Comfort/.

[17] *Adaptive Thermal Comfort*, Environmental Building News. 1 May 2009. http://www.buildinggreen.com/auth/article.cfm/2009/4/29/Adaptive-Thermal-Comfort/

The task to align controls with expectations is an attempt at satisfying ASHRAE's '20%'. In highly controlled and regulated larger buildings where climate follows an automated plan for shading, heating, cooling and ventilation, individual adaptability or broader options of adaptability may not be feasible. Where options exist to provide automated or user-controlled climates, or a combination, there may be opportunity to assess occupant requirements through pre-occupancy surveys.

Imagine again the scenario of a meeting of foreigners mentioned above. If thermal comfort could be included as a priority for planning logistics, a venue operator could ask a series of questions to inform their climate control plan. Asking questions of occupants could help better determine their expectations, and even provide a sense of climate control to them to alleviate the perception of being subjected to a thermal comfort zone rather than having chosen one. In this way, where occupants have been given options the results are within their expectations. In a meeting room planned for natural ventilation, based on pre-occupancy survey, participants may experience warmer temperatures but have their desire for fresh air met and feel more comfortable overall.

In addition to setting prescriptive measures to control indoor environments, thermal comfort has to include at least some subjective methodology. Designing buildings that control climate solely for energy efficiency misses the inevitable human element that might intervene and lead to greater energy consumption. As the concept of adaptive thermal comfort gains more research and understanding, new strategies that better incorporate and address the expectations of occupants will emerge.

One example of adopting this idea into large scale strategies was seen in Japan in 2005 where the Prime Minister called on businessman to 'loosen the tie' in order to accommodate lower energy demand for cooling. The initiative focused on human activity to enable thermostats to be set higher (for cooling) as part of a strategy towards Kyoto Protocol commitments.[18] While only one of many potential strategy elements, the example acknowledges the human element in lowering energy consumption.

At current, our understanding of how to achieve thermal comfort is robust in meeting general perceptions for human comfort. It is in meeting the needs of the other '20%' where new opportunities exist, particularly in connecting occupants to outdoors through natural ventilation while maintaining effective energy reduction strategies. As research in adaptive thermal comfort advances, we may find that humans are less conditioned than we might expect and more comfortable in an indoor environment that is less controlled than our current schemes allow.

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[18] *Japan Dresses Down to Save Energy*, Environmental Building News. 1 June 2005. http://www.buildinggreen.com/auth/article.cfm/2005/6/1/Japan-Dresses-Down-to-Save-Energy/

UNIT C DEMONSTRATE EUI

Heating Load Calculation Exercise – Part One

Wall Assembly Values

Insulated part of Wall:

0.17	Outside Air Film
0.813	Wood Siding
1.05	Wood Sheathing
0.060	Vapor Barrier
11.00	3" Batt Insulation
1.13	.5" Air Space
0.32	Gyp Board
0.68	Inside Air Film

R_{WALL} = 15.223 **U_{WALL} = 0.066**

Stud part of Wall:

0.17	Outside Air Film
0.813	Wood Siding
1.05	Wood Sheathing
0.060	Vapor Barrier
0.230	2x4 softwood stud
0.32	Gyp Board
0.68	Inside Air Film

R_{STUD} = 3.323 **U_{STUD} = 0.301**

Roof Assembly Values

Insulated part of Roof:

0.17	Outside Air Film
0.33	Roofing Material
1.25	Wood Decking
22.00	6" Batt Insulation
1.03	3.5" Air Space
0.060	Vapor Barrier
0.32	Gyp Board
0.61	Inside Air Film

R_{ROOF} = 25.770 **U_{ROOF} = 0.039**

Rafter part of Roof:

0.17	Outside Air Film
0.33	Roofing Material
1.25	Wood Decking
0.084	2 X 10 softwood rafter
0.060	Vapor Barrier
0.32	Gyp Board
0.61	Inside Air Film

R_{RAFTER} = 2.824 **U_{RAFTER} = 0.354**

Window Assembly Values

Outside Air Film	R = 0.170
Single Glazing	R = 0.885
Inside Air Film	R = 0.680

R_T = 1.735 **U_{SINGLE} = 0.576**

Outside Air Film	R = 0.170
Double Glazing	R = 1.724
Inside Air Film	R = 0.680

R_T = 2.574 **U_{DOUBLE} = 0.389**

Heating Load Calculation Exercise – Part Two

Provide the following numeric values for an office addition in Boston.

Please show your calculations on this page.

1. Total Slab Edge 36' + 36' + 60' **= 132 ft** (only the edges exposed to the outside)
2. Stud Wall Area (not including glazing) (60' + 36' + 36') x 16 = 2112ft2 x 0.15 = 316.8 ft2 - 24 ft2 **= 292.8 ft2**
3. Insulated Wall Area (60' + 36' + 36') x 16 = 2112ft2 x 0.85 = 1795.2 ft2 – 24 ft2 **= 17712 ft2**
4. Rafter Area (60' x 36') x 0.15 **= 324 ft2**
5. Insulated Roof Area (60' x 36') x 0.85 **= 1836 ft2**
6. Insulated Wall U-value **0.066**
7. Stud Wall U-value **0.031**
8. Insulated Roof U-value **0.039**
9. Rafter U-value **0.354**
10. Total Glass Area 3' x 4' x 2 **= 24 ft2**
11. Room Volume 36' x 60' x 16' = **34560 ft3**
12. Delta T =**75 F**
13. Total Q @ slab edge 55 BTUH x 132 ft **= 7260** BTUH **5.727%**
14. Total Q @ roof (324 ft2 x 0.354 X 75) + (1836 ft2 x 0.039 x 75) = **13972.5** BTUH **11.023%**
15. Total Q @ exterior wall (not including glazing) (292.8 ft2 x 0.031 x 75) + (1771.2 ft2 x 0.066 x 75) = **9448.2** BTUH **7.454%**
16. Total Q @ Single glazing 24 ft2 x 1.13 x 75 = **2034** BTUH **1.605%**
17. Total Q @ infiltration (1.1 x 34560 ft3 x 2 x 75) / 60 = **95040** BTUH **74.978%**
18. Total Q for the office 7260 + 13972.5 + 9448.2 + 1036.8 + 95040 = **126757.5** BTUH **100%**

Total Heat Loss Q after changing the single glazed windows to insulating (double-pane) glass.

19. U Value for Double Glazing = **0.58**
20. Total Q @ Double glazing = 24 ft2 x 0.58 x 75 **= 1044 BTUH**
21. Revised Total Q for room w/ new windows **= 125767.5 BTUH**

UNIT C DEMONSTRATE WATTSTOPPER

LIGHTING CALCULATOR

1. Specify the number of hours open on a weekday = 8, the weeks per year = 52, weekend hours = 0, weekends per year = 0

2. Room type = Office – Open, room area = include both ground floor and mezzanine, # = 1

3. Existing Fixture 1 = T8 Standard Electronic Ballast, Number of Lamps/ Fixture = 2, # = 17
   Proposed Fixture 1 = T8 High Efficiency Ballast, Number of Lamps/ Fixture = 2, # = 17

   Existing Fixture 2 = Standard Incandescent, Number of Lamps/ Fixture = 1, # = 12 Proposed Fixture 2 = LED Lighting, Number of Lamps/ Fixture = 1, # = 12

   Existing Fixture 3 = U-Tube Fluorescent, Number of Lamps/ Fixture = 1, # = 17 Proposed Fixture 3 = LED Lighting, Number of Lamps/ Fixture = 1, # = 17

4. Current Energy Use: **9247.83 kWh/yr**

5. Proposed Lighting System Energy Usage: **6138.11 kWh/yr**

WattStopper Plug Load Calculator

1. Specify the number of hours open on a weekday = 8, the weeks per year = 52, weekend hours = 0, weekends per year = 0

2. Room type = Office – Open, room area = include both ground floor and mezzanine, number of similar rooms = 1

3. Specify "On Day / Off Night" for everything except surge protectors, which are "Always On".

4. Desktop Computers: 12
   LCD Monitors: 12
   Surge Protectors: 12
   Cable Modems: 12
   Multi-Function Laser: 1

5. Total for Office: **Baseline = 8737.51 kWh/yr**

UNIT D COOPERATE

DOES A WHITE ROOF SAVE ENERGY FOR ALL TYPES OF BUILDINGS IN ALL CLIMATES?

While light-colored roof finishes can play a role as an energy saving feature to reduce cooling loads they may not be the best option to meet overall energy savings in all climates. Lighter colored roofs with high-reflectivity coatings can reduce cooling loads[19] but insulation and other features also factor into

[19] *Whiter roofs mean lower cooling bills,* Environmental Building News. 1 September 1993. http://www.buildinggreen.com/auth/article.cfm/1993/9/1/Whiter-Roofs-Mean-Lower-Cooling-Bills/

overall energy savings, particularly in climates that experience severe temperate swings throughout the year.

According to EBN, cool roofing is a good option for hotter climates, particularly zones 1-3, as a cost-effective energy saving feature. However, in different climates the question becomes more complex and the answer less straightforward. [20] The Roof Savings Calculator (RSC) presents an overview on the considerations that need to be evaluated. The online calculator is comprised of more than 20 questions geared to weigh the variables that determine the best option. From building location to HVAC equipment to types of insulation, the scope of survey in the RSC calculator reveal that there's more to cool roofs than meets the eye.[21]

A wide range of options exist for maximizing roofs as part of overall an energy conserving building strategy. Determining which option is best for a climate and building program requires a comprehensive approach. Green roofs provide benefits such as stormwater control and pollutant removal, reduced cooling loads, regulation of urban heat island effect, wildlife habitat, and green space. Using roofs for photovoltaic arrays brings another option that can couple on-site energy generation with shading strategy to cool the building and lower the energy load.

Determining which option best suits a building in a specific climate, also needs to consider the building itself. For example, identifying whether a building's heat generation is envelope dominated or internally dominated is an important factor. The materials used to achieve a lighter roof also require scrutiny against the building requirements related to fire codes or maintenance.

In general, white roofs may work well in warmer climates where external (solar) heat gain charges energy loads for cooling. In colder regions, the summertime energy savings may literally go 'through the roof' in winter if other considerations such as proper insulation aren't in place. Climate is a key determining factor in choosing the right 'green' roof strategy. An innovation from MIT researchers may prove a better solution for cold climates: color-changing roof tiles that adapt to the season. The concept aims to create a climate-reactive surface where tiles are dark in cold seasons and lighter in hotter seasons.[22] Whether the technology is successful or not, it conveys the important lesson that buildings need to be designed to the particular local climate. In colder climates, whiter roofs may not be the energy saving answer.

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[22] *Color-changing roof tiles absorb heat in winter, reflect it in summer,* Physorg, 8 October 2009. http://www.physorg.com/news174209373.html

UNIT D DEMONSTRATE

INDIRECT GAIN & ISOLATED GAIN: THERMAL STORAGE (TROMBE) WALLS & SUNSPACES

Le Corbusier said 'it is the mission of modern architecture to concern itself with the sun'. The insight points towards passive solar strategies as not only a way to maximize natural resources in structures, but to also consider the sun as a source of life that should be incorporated into the built environment. In designing buildings that interact with their environment, this concept can be realized through passive solar strategies that contribute to overall energy conservation.

Indirect gain through Thermal Storage (Trombe) Walls

One passive solar approach is to capture the sun's heat in thermal mass wall systems or Trombe walls. This feature can regulate heat gained to interior spaces in various forms. However its effectiveness depends on how well the chosen system aligns with the energy goals of a building.

Trombe walls work by absorbing solar gain and storing it for release. In this way, they act as passive radiators through a 'lag-time' effect that transfers heat through conduction. With the objective of creating a thermal mass, Trombe walls can be constructed of solid materials such as concrete or stone, but they can also be made of water storing materials and use water to create the thermal mass.

As part of a passive solar heating strategy, Trombe walls can provide not only a source of heat but also act as regulating features that lower overall energy loads. This quality has regained attention in the sustainable design discourse around building resiliency, designing buildings that are independent of external energy input.

The downside of Trombe walls is that they are ideal for situations where daylight is not desired. Given the relevance of daylighting to energy savings and indoor environmental quality, the loss of daylighting may not fit a buildings overall energy goals. Trombe walls are limited in broader integrated design strategies as they can block daylight. Options that integrate Trombe walls with glazing can be designed to allow daylighting and views while capturing solar energy for heat. However, in smaller scale implementations the heat capture may not be significant to warrant the installation. In this sense, Trombe wall installations can be considered as an unacceptable aesthetic element.

The benefit of Trombe walls is that they can provide significant heat to buildings, using renewable energy through a low-tech, low-cost feature. A recent study on the effectiveness of Trombe walls in Turkey revealed that they are an effective measure for heating buildings where other building elements are deficient, such as insulation. In this setting, Trombe walls were identified as a low-cost solution to increasing energy efficiency and lowering CO_2 emissions.[23]

At the Fan Pier site in Boston, strategies for passive solar gain must be coupled with those for daylighting and views. In this building, goals to maximize views of the waterfront and provide optimal daylighting would indicate a design that is not conducive to using a Trombe wall on the southern facade. This feature would compromise daylighting opportunities as well as diminish the benefits of views across landscape features to the southeast.

Isolated Gain through Sunspaces

Where Trombe walls limit daylighting opportunities, sunspaces can prove to be an asset to passive solar heating strategies while providing daylight and views in an adjunct spaces. Sunspaces can be designed as

[23] Türkan Göksal Özbalta1 and Semiha Kartal. *Heat gain through Trombe wall using solar energy in a cold region of Turkey.* Scientific Research and Essays Vol. 5(18), pp. 2768-2778, 18 September, 2010.

attached, semi-enclosed or enclosed areas that heated solely by the sun and allowed to fluxuate in temperature without mechanical system intervention. They use a similar passive solar strategy as Trombe walls, in that they are intended to collect solar heat. Except sunspaces are intended to ventilate heat into interior spaces through convection. They can also store heat in thermal mass of floors and walls, passing the gain to interior spaces via conduction through common structural elements.

The benefits of sunspaces are that they provide thermally comfortable, daylit spaces which can be controlled through natural ventilation. They use the concepts found with Trombe walls and provide regulated heating to interior spaces. However they also integrate qualitative aspects of indoor environmental quality such as views to the outdoors.

A downside to sunspaces is that their use can be limited in extreme temperatures. If poorly designed or managed, they can either overheat or become too cold. Additionally, without proper management to control ventilation into interior spaces, they can reduce energy efficiency by drawing heat out of a building.

At the Fan Pier site in Boston, a well-designed sunspace could improve overall energy efficiency while providing an intermediary space for limited use. If located on the building's southern facade, a sunspace could be used as an entryway or even as a seasonal seating area.

Passive solar considerations

With either feature of a Trombe wall or sunspace, there are several common considerations including building orientation, shading and the heat storing capacity of materials. Where orientation can be optimized towards southern exposures (in the Northern hemisphere), passive solar strategies can be well implemented. The ability to shade from solar gain as needed is also an important consideration to avoid excessive heat during hotter seasons. The heat capacity of materials plays a role as well. In Trombe walls, materials with high conductance contribute to the efficiency. Water holds a high heat capacity, although presents challenges in certain settings due to the potential for structural failure that can lead to issues such as humidity. Solid materials, such as concrete or stone, can provide heat storage while also serving as structural elements.

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UNIT E COOPERATE

HOW MUCH TRANSPARENCY IS TOO MUCH TRANSPARENCY?

In vernacular design, we're less likely to find envelopes that use extensive openings or glazings. More typical is a series of strategically placed and sized openings that provide enough natural daylighting to light interior spaces. Of course, traditional strategies for interior lighting were approached without modern interventions such as energy efficient windows that moderate solar gain or the advent of electric lighting that allowed us to illuminate interiors independent of the sun's trajectory. In today's context, we again recognize that we have much to gain by inviting the abundant energy of the sun to light up our buildings. However we may still be adjusting to how we can best integrate natural daylighting into complex sustainable building programs.

As natural daylighting has again become a priority, it is out of the need to reduce building energy loads and in light of research that finds strong arguments that it supports objectives related to health, productivity and even economic objectives beyond energy savings. Studies on daylighting in learning environments have shown that daylighting can lead to faster learning comprehension. In retail settings studies have shown that daylighting can lead to improved sales.[24] Our growing understanding of these benefits starts to show that we indeed feel better when we are exposed to natural light.

Since our foray into electrically lit interiors during the rise of fluorescent lighting mid-1900s, there have been numerous architectural ventures that experiment with the transparency of our building envelopes and the benefits that variations bring. Phillip Johnson's Glass House challenged our perceptions of structure as a place from which to view the outdoors.[25] The use of extensive glazing provided a built environment that invited the outdoors in. While touted for its inspiring form and still standing as an iconic mid-century modern design, the house poses the question *how much transparency do we really need?*

The energy benefits of daylighting make sense: it provides opportunity for a naturally abundant resource to replace requirements for artificial energy therefore reducing energy load. However, as noted in Environmental Building News, 'while it is generally assumed that daylighting will save energy, this is not necessarily the case.'[26] Making efficient use of daylighting requires a careful strategy that integrates all elements of a building program.

How to do this requires significant research of the individual project, the objectives, the feasibility of passive strategies and the available technologies. These considerations must also be weighed against constraints of budget and time. EBN's Alex Wilson argues that daylighting design 'is neither easy nor inexpensive' and that it requires 'in-depth physical or computer modelling.'[27] In light of the complex relationship between energy and daylighting, this perspective is substantiated. Wilson also notes that special features to enhance daylighting 'almost always cost more.'

The answer to the question of *How much transparency is too much transparency?* depends on myriad factors. The right answer can only be found through more detailed inquiry to identify the building purpose, location, and budget, and to use an integrative design process to find solutions unique to each building program.

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UNIT F COOPERATE

DAYLIGHTING FOR HEALTH AND PRODUCTIVITY

Indoor Environmental Quality is affected by a variety of different factors including thermal comfort, ventilation, air contaminants, materials, daylighting, views and acoustical attributes. Each factor plays a role in overall indoor quality and can be integrated into a strategy for an indoor environment conducive to heath, wellness and productivity. While all factors are significant to alleviating negative health issues, the provision of daylighting can have a positive impact on occupant experience.

The importance of this IEQ issue has been researched in school settings with results showing that 'that daylighting in schools may significantly increase students' test scores and promote better health' (Plympton, et al). These findings indicate that while other IEQ factors such as reducing toxins and contaminants are important to health they may be more of a minimum standard requirement. Daylighting and views on the other hand shift building environments into a positive realm. Instead of solely avoiding negative effects these factors increase health and productivity.

A significance reason behind the benefits of daylighting is that exposure to natural light affects sleep/wake cycles and melatonin production which modifies this cycle. The regulation of these functions relates directly to alertness, focus and even light related illness such as seasonal affective disorder or SAD. In short, sufficient daylighting informs us at a biological level that *it is time to be awake*.

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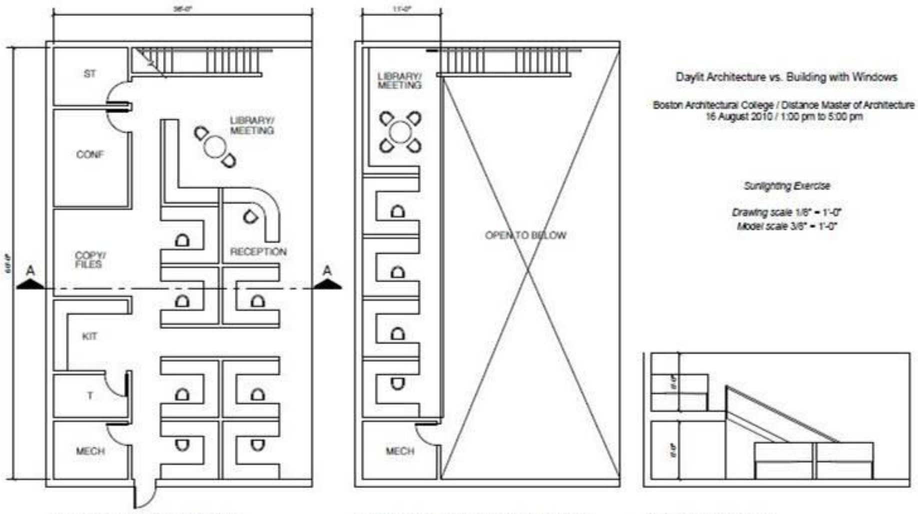
UNIT F DEMONSTRATE

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics

Indoor Environmental Quality is affected by a variety of different factors including thermal comfort, ventilation, air contaminants, materials, daylighting, views and acoustical attributes. Each factor plays a role in overall indoor quality and can be integrated into a strategy for an indoor environment conducive to heath, wellness and productivity.



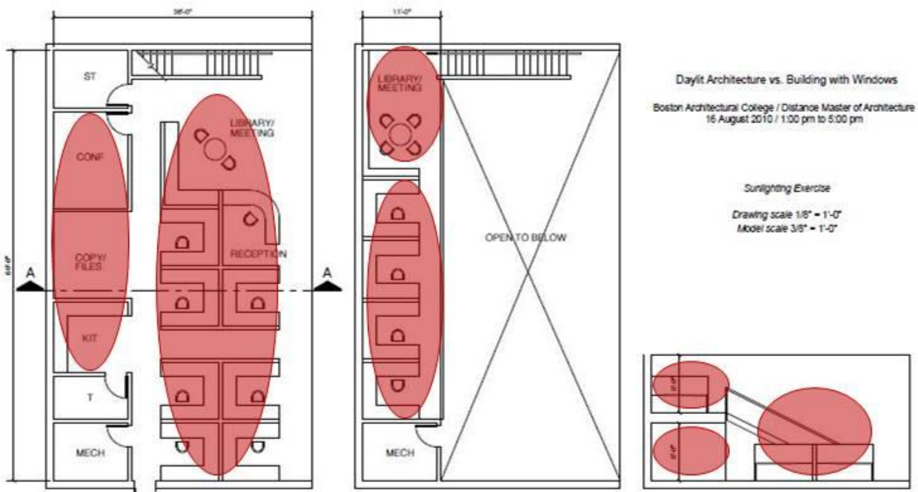
FIRST FLOOR PLAN | MEZZANINE LEVEL PLAN | SECTION A-A

KRISCENSKI | ENERGY AND THE BUILT ENVIRONMENT | SPRING 2012

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics

With an open floor plan that includes a mezzanine level, managing thermal comfort is a task that requires evaluation of varying space requirements. On the ground floor, a large open work space and library may be prone to cooler temperatures than the offices and meeting room above as they exist in different levels of the same thermal environment. Achieving thermal comfort needs to consider individual controls within the larger thermal environment.



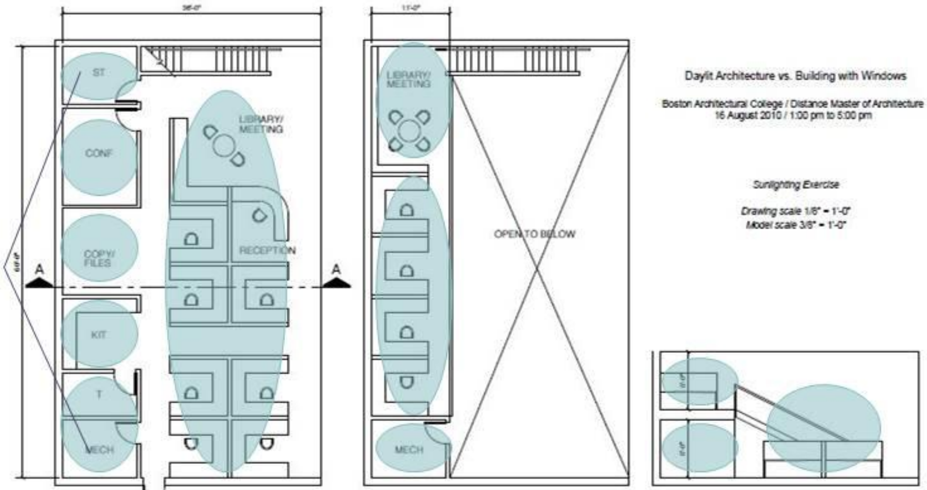
FIRST FLOOR PLAN | MEZZANINE LEVEL PLAN | SECTION A-A

KRISCENSKI | ENERGY AND THE BUILT ENVIRONMENT | SPRING 2012

IEQ Strategy | Fan Pier Design Studio

thermal comfort| **ventilation**| light| views| acoustics

Ventilation in this building needs to be managed according to the space functions. With mechanicals grouped at one end (on both 1st and 2nd floors), the building plan allows a straightforward ventilation program that isolates open spaces and individual rooms with varying functions. Special attention to mechanical spaces, copy center, conference room and kitchen is significant in reducing pollutants such as CO2, chemicals, print particles and odors. Additionally, air at the upper level can be expected to hold more contaminants.



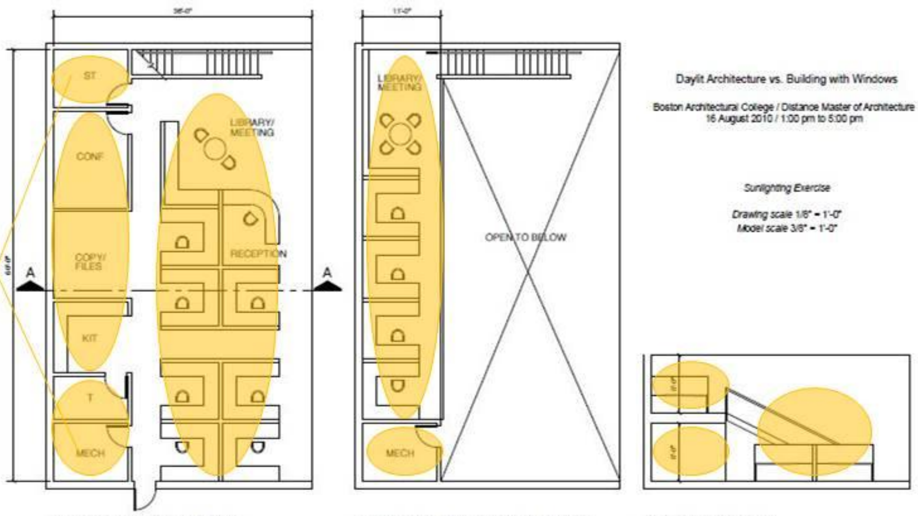
FIRST FLOOR PLAN MEZZANINE LEVEL PLAN SECTION A-A

KRISCENSKI | ENERGY AND THE BUILT ENVIRONMENT | SPRING 2012

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| **light**| views| acoustics

The building plan facilitates ample use of natural daylighting in work and meeting areas, mainly three different zones of the ground floor open office, ground floor covered spaces (kitchen, copy and conference) and the mezzanine office and meeting spaces. In storage and mechanical rooms, daylighting is less relevant although with control can also be used to light these areas.



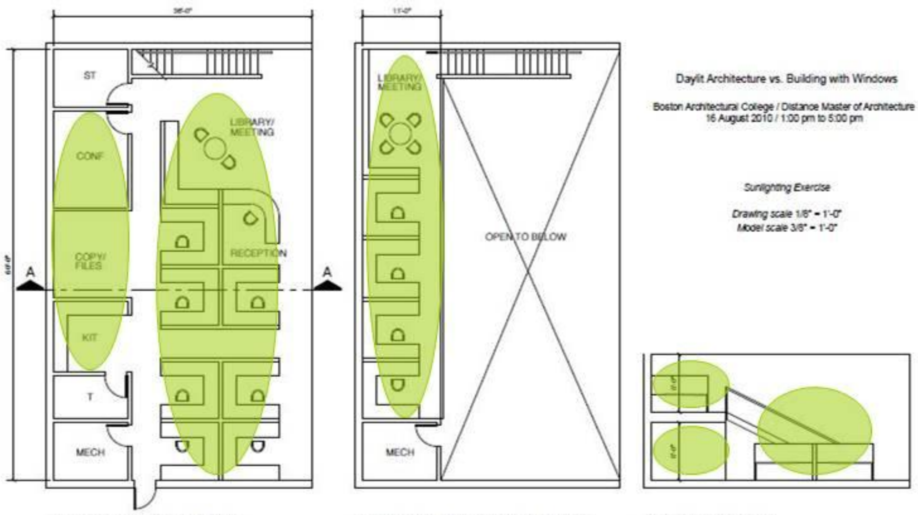
FIRST FLOOR PLAN MEZZANINE LEVEL PLAN SECTION A-A

KRISCENSKI | ENERGY AND THE BUILT ENVIRONMENT | SPRING 2012

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| **views**| acoustics

The integration of views into the work and meeting areas, including the copy center and kitchen, is an opportunity to increase the occupant experience. On the northern facade, views to the Boston Harbor and city skyline can be dramatic and inspiring. In the main work areas of the ground floor, views to the south allow vantage across a park-like landscape.



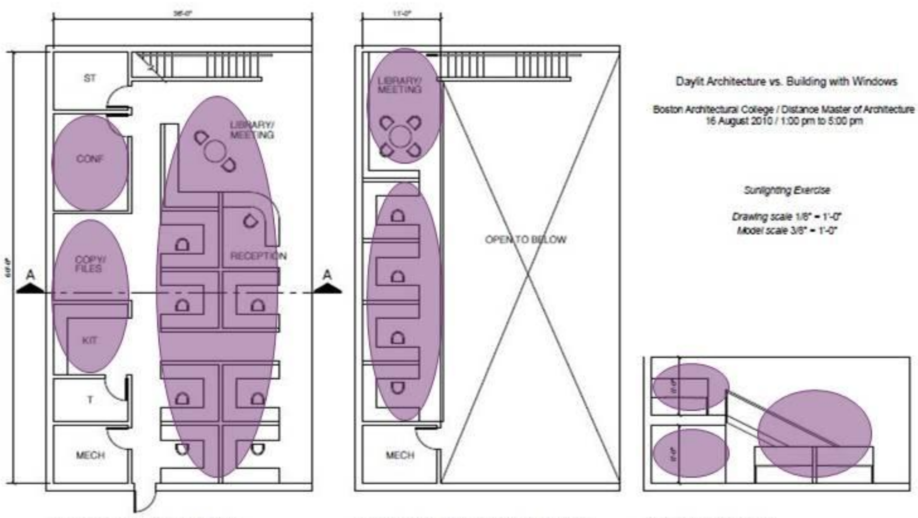
FIRST FLOOR PLAN MEZZANINE LEVEL PLAN SECTION A-A

KRISCENSKI | ENERGY AND THE BUILT ENVIRONMENT | SPRING 2012

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| **acoustics**

As an open plan, one of the biggest challenges in the Fan Pier design studio building is to manage acoustics. Only one meeting space is enclosed and with a range of activities occurring in common spaces, the control of acoustic disturbances needs careful consideration to avoid constant distraction from noise in other areas.



FIRST FLOOR PLAN MEZZANINE LEVEL PLAN SECTION A-A

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics | **strategy**

In order to optimize Indoor Environmental Quality, a first step is to identify zones of similar requirements to each IEQ component and consolidate functions for cost-effectiveness and comfort. Zones can be grouped according to occupant type (single, multiple, etc.) and also to accommodate the function of the areas.

Thermal comfort zoning isolates common areas, work areas and meeting areas. Personal adjustments are considered at private work areas such as at the ground floor where the library and desks share an open floor space, VAV controls are installed at desk areas.

Ventilation zoning considers occupancy rate, pollutants and allows individual control through operable windows in enclosed offices.

Light zoning prioritizes quality daylighting wherever possible to minimize energy load.

Views to the water, city skyline and on-site gardens are prioritized for all high occupancy areas including offices, meeting rooms and common areas such as kitchen.

Acoustics pose a particular IEQ challenge in this open floor plan. Interior glazing and sound absorbing materials support overall IEQ strategy while minimizing noise distraction.

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics | **optimization**

thermal comfort

Optimal conditions: Air temperature, humidity, air flow and velocity are regulated to create thermal comfort for majority of occupants (80%) according to ASHRAE Standard 55-2004) *and* provides measures to accommodate occupants at the extreme ends of the thermal comfort spectrum.

Systems:

- Under floor air distribution system at ground floor with variable air volume controls.
- Operable windows in (glass) enclosed mezzanine offices and in enclosed meeting spaces.
- Heat recovery air exchange system to support humidity control (30 – 40%).
- Individually adjustable task lighting at desks and work stations.

ventilation

Optimal conditions: While small in size, the building benefits from controlled ventilation that integrates fresh air intake and under floor air distribution system, heat recovery, and monitoring. An overall strategy for mechanical ventilation is supplemented by isolated occupant controlled windows for thermal comfort.

Systems:

- Demand controlled ventilation system, to monitor temperature and CO2.
- Operable windows in (glass) enclosed mezzanine offices and in enclosed meeting spaces.
- Heat recovery air exchange system to support humidity control (30 – 40%).
- Direct exhaust from high contaminant areas (copy center, mechanicals, etc.)

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IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics | **optimization**

light

Optimal conditions: Natural daylighting is used in controlled manner to create high quality light conditions in work and meeting areas. Additionally it is used to lower energy demand in enclosed spaces such as storage and mechanicals.

Systems:

- Clerestories at north and south elevations for indirect daylighting
- Interior glazing at mezzanine offices, 1st floor conference and exterior glazing (modeled)
- Open floor plan to allow exterior daylight to penetrate to the interior
- Individually adjustable task lighting at desks and work stations
- Occupant sensor operated lighting in common areas and meeting rooms

views

Optimal conditions: The building design and glazing maximizes views to the Boston Harbor and to on-site landscaping features from all work and meeting areas.

Systems:

- Interior glazing at mezzanine offices, 1st floor conference and exterior glazing (modeled)
- Open floor plan to allow views from all work and meeting spaces

acoustics

Optimal conditions: Work and meeting areas provide an acoustic environment that minimizes distracting noises from other activities.

Systems:

- Interior glazing at mezzanine offices, 1st floor conference
- carpeting and sound absorbing finishes at walls

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics | **bibliography**

KRISCENSKI | ENERGY AND THE BUILT ENVIRONMENT | SPRING 2012

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UNIT G COOPERATE

COMPARING THE PHAROS PROJECT FRAMEWORK AND CRADLE TO CRADLE CERTIFICATION

A major challenge in creating sustainable supply chains is setting credible frameworks that evaluate the environmental and social aspects of products and processes with rigor. The challenge is both in the quality of these frameworks and in determining the robust processes behind various approaches. Two innovations that aim to inform on the 'eco' aspects of products are the Pharos Project and Cradle to Cradle Certification. Both offer useful information and ratings. However, the validity and scope of each system must be considered when making decisions for green building material.

Pharos Project

The Pharos Project is best described as an information tool, rather than a certification scheme. It uses a protocol to rate products in the categories of: Health & Pollution, Environment & Resources, Social & Community. Each category has 5-6 subcategories related to specific attributes or topics.

As a source of product information on a broad scope of sustainability issues, Pharos is an extremely relevant tool in today's sustainability landscape. It fulfils a much needed void to collate cross-issue criteria into a comprehensive overview for decision-making. In effect, it pulls together information that would otherwise be addressed independently by single-issue eco-labels.

As example, Pharos looks at occupational health and safety and consumer health and safety. Often these two issues are addressed separately by respective eco-labels and typically one or the other is not reflected in consumer facing information about the product. In this way, Pharos combines eco-label certification information with aspects of environmental performance and life-cycle analysis. This is good.

The question however is in the methodology behind Pharos, which is not explicitly apparent from the project website. Some category protocols are missing details. Where scoring protocols are listed and prioritized, the criteria for basing ratings on the chosen certification schemes is not evident.

As example, the 'User Toxics' category identifies 4 schemes that score a '9' on the Pharos scale. However, 2 of the 4 standards are set by the certification body which has a direct financial incentive to sell the certification. This poses questions to the aspect of independent assessment of environmental or social attributes.

More information on how the schemes which set the framework for Pharos rating are chosen would provide a clearer idea of how useful the system is overall. The most important answer needed is whether the rating from Pharos relates directly to an environmental or social impact for a particular issue through third party verification. This determination lies in the standards that set the framework.

Cradle to Cradle

As a certification program, Cradle to Cradle sets ambitious goals for products. It looks at multiple product attributes that relate to safety, health, environment and resource management through a product's overall life-cycle. Like Pharos, C2C aims to provide a comprehensive assessment of products that integrates issues otherwise addressed independently.

The categories used by C2C also include five categories including: Material Health, Material Reutilization, Renewable Energy Use, Water Stewardship, and Social Responsibility. It is based on three point principles of equity, ecology and economy or triple bottom line.

As a certification system, C2C is much more robust than Pharos with clear standards for achieving different levels of C2C recognition. However, the system is organized in a way that poses some conflict of interest and doesn't offer a level of transparency that ensures truly 3rd party verification.

Firstly, the assessment is performed by C2C in a consultant type role. This relationship creates an incentive for certification by the standard setter. While this may work as a 'from within' mechanism of change for businesses it doesn't validate the certification as a truly independent evaluation. The other issue of C2C is that it is unclear how the standard is developed and who is involved in the process. If this is done in collaboration with industry partners, then the impact of the products is questionable.

Summary

The challenge for a sustainable economy is to balance between rigorous assessments on the impact of products and to present information in a way that enables businesses and consumers to make the right choices for people and the planet. The task is daunting as considerable criteria, data, research, monitoring and reporting is behind credible eco-labels. Too much, in fact, for businesses and consumers. Both Pharos and C2C offer ways to alleviate the information overload and inform our sustainable minded choices. However, the methods behind each system need to address the above issues in order to be stand alone decision-making tools. Both systems are contributing to our greatest challenge. However, closer alignment to the 'credibility principles' set by ISEAL would make these systems more valuable to those setting specifications for building materials.

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http://www.isealalliance.org/sites/default/files/ISEAL%20Credibility%20Principles%200.1%20May10.pdf

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UNIT G DEMONSTRATE

MATERIAL SELECTION: ACOUSTIC CEILING & WALL PANELS

As a small, busy design studio with an open floor plan the Fan Pier building's IEQ has the potential to be challenged by acoustic disruption between work spaces. In order to address this issue, this proposal presents recommendations for Acoustic Ceiling & Wall Panels that support a sound 'sound' strategy in the library / meeting room area.

Room description / requirements

The library / meeting room is a two-story space at the building entrance. It is adjacent to primary work areas on the ground floor. As a meeting space in an open plan it has the potential to affect the acoustic comfort throughout the building. It also serves as a library, requiring at times for it to be a space for quiet, focused research and study. Addressing acoustic issues within this space will serve the building's overall Indoor Environmental Quality by reducing noise and stress.

Priorities

Avoid carcinogens, VOCs. Seek renewable and responsible sources. Durability. Aesthetics.

Options

EcoGrille wood ceiling tiles	Phonstop ceiling / wall tiles	BIOLINE wood ceiling tiles
 9Wood www.9wood.com	 Pinta Acoustic www.pinta-acoustic.com	 Pinta Acoustic www.pinta-acoustic.com
+ Made from FSC certified wood = responsible sourcing from well-managed forests or plantations (rapidly renewable species used in EcoGrille) + Low-emitting = low VOC material, doesn't contribute to indoor air contamination or pollution, low VOC finishes also available + Biobased + sustainably sourced = made from a natural material, the product avoids much of the negative aspects of manufacturing artificial materials + Improves acoustical performance = absorbs sound and prevents sound transmission	+ Post consumer recycled content (glass bottles) = diverts waste from landfill + Suitable for indoor / outdoor use + Can be used at walls and ceiling + Customizable finish colors + Improves acoustical performance = absorbs sound and prevents sound transmission	+ Post consumer recycled content = 80 percent recycled, post-industrial material (by weight), diverts waste from landfill + Made from FSC certified wood = responsible sourcing from well-managed forests or plantations (core and veneer) + Variety of finishes: three standard wood shades in light, medium, dark or custom shades + No added formaldehyde + UV-cured, waterborne-finish with UV blockers for color stability + Improves acoustical performance = absorbs sound and prevents sound transmission
- Must be cared for in a controlled interior environment, high maintenance	- requires adhesive backing which may impact IEQ / occupant health	- finishes may include VOCs that impact IEQ / occupant health

Recommendation

Of the three material options, the BIOLINE wood ceiling tiles offer the most eco-attributes and design versatility. They use recycled materials as well as natural materials from responsible sources. This combination provides opportunity to divert post-consumer waste from landfill while supporting sustainable forest management.

Unlike the 9wood tiles or the Phonstop tiles, the BIOLINE tiles can meet a variety of aesthetic requirements. In the design studio, this is an attractive quality as the tiles will set a design standard at a highly visible area. Additionally, the BIOLINE can be configured in a suspended (drop) assembly allowing more versatility to isolate the noise issues that may be present in the library.

BIOLINE avoids added urea-formaldehyde in fabrication and uses a finish that protects the product for longer use. While made of low-VOC materials, the standard finish is not specified low-VOC. While it is unclear if the waterborne finish contains VOCs, this specification can be customized and a low or no-VOC finish can be specified.

In summary, the BIOLINE wood ceiling tiles contribute well to the overall IEQ strategy while supporting other objectives such as minimizing waste and using renewable materials. Compared to the other options, this material provides more environmental benefits and will contribute better to the overall IEQ of the building.

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UNIT H COOPERATE

BENEFITS OF WATER CONSERVATION IN A WET CLIMATE

Water is a fundamental element of all life on earth, and it is a basic human right. We are currently living in a UN decade of action to ensure 'Water for Life' (2005 – 2015). The UN General Assembly Resolution 64/292 - 'the human right to water and sanitation' – highlights the urgency of worldwide water issues:

...approximately 884 million people lack access to safe drinking water and that more than 2.6 billion do not have access to basic sanitation, and alarmed that approximately 1.5 million children under 5 years of age die and 443 million school days are lost each year as a result of water- and sanitation-related diseases...[1]

At a global scale, we can easily see that access to safe and clean drinking water is a pressing concern. Still, it can be difficult to understand how local water conservation measures can impact other regions of the world. This is in part because of the physicality of water and the immense infrastructures needed to transport it between locations.

Water is a finite resource. A starting point for understanding the benefits of water conservation, even in places where it is abundant, is to recognize that it is a finite resource. While it may be plentiful at the present, this doesn't mean the conditions won't change or be impacted by human activity. Thinking of natural resources as endless has never proven a successful or sustainable strategy. Following basic economics, we tend to equate scarcity with increased value. While this may be correct, that doesn't mean that a stock of resources is without value and worth protecting.

Protection ensures continued quality. Water conservation measures contribute to keeping fresh water clean and maintaining ecosystems. Water rich regions may not have to consider a foreseeable end to supply. However, when fresh water is diverted for use the output can be (and often is) of lower quality. Even when pollution is not an issue in water discharge, industrial uses can change the properties of water - such as temperature – or divert water from critical habitats. Human interventions to the quality and course of water can greatly affect ecosystems and wildlife.

Pollution can be prevented. Water pollution can be caused by small actions, such as washing a car, and large activities, such as developing a new commercial building. Water conservation measures contribute to lowering the likelihood of pollution by decreasing the amount of water used.

Virtual water trade. While the concept of embodied water is becoming more widely recognized in sustainability accounting, a variation of this idea is also taking root in the 'virtual water' trade. The concept of trading based on the water-intensive quality of products could support water poor regions. Theoretically, by importing water-intensive products, water-poor regions could put less demand on their local resources.[2]

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UNIT H DEMONSTRATE

FAN PIER SITE WATER BUDGET OVERVIEW

The Fan Pier site has the potential to take advantage of water conserving strategies to reduce the water (and overall ecological) footprint of the studio, parking and landscaping. Through a strategy that aims to maximize water conservation by utilizing on-site resources and reducing demand, the Fan Pier site can be specified for components including water harvesting, low demand fixtures and landscaping.

The water budget is calculated for the following values:

- Building occupancy is based on workspace capacity at 18 people.
- Roof Area 2,100 sf
- Parking Area 10,000 sf
- Landscaping Area 52,900 sf

Selection of low-flow fixtures compared with potential on-site harvesting reveals that the site is water rich in theory. At first calculation, a roof runoff coefficient of 0.9 (roof) was used with a pavement runoff coefficient of 0.8. The initial calculations run showed total harvest potential over 500,000 gallons annually compared to demand of around 140,000 gallons. Surplus water is expected throughout the year with peak surplus in November at 1957% and lowest surplus in July at just 107%. The surplus runs on a varying cycle following the seasonal climate of Boston.

Harvesting

Water harvesting is calculated based on conservative coefficients for the roof, parking and landscaping. While the roof area's use is a variable – either solar or green roof – the surplus of water overall indicates that preventing runoff at the roof could be an effective storm water strategy. In this case, a green roof may be the optimal design choice and an off-roof location for the PV array could be found. Compared to a coefficient of 0.9, vegetation at the roof could potentially reduce the runoff coefficient to under 0.5 while the overall surplus would be maintained.

Adjusting the roof runoff rate and specifying the parking area pavement to a material with a lower runoff coefficient of 0.7 led to a reduction in runoff and surplus. A permeable pavement is preferred over other options such as gravel or vegetation due to the extreme climate and maintenance needs, such as snow removal. These two adjustments reduced overall harvest to ~436,000 gallons annually and 312% surplus annually. The reduction indicates a shortage of water availability in July (88%), however the surplus in other months could be stored and used as needed.

Demand

Fixtures: Without shower facilities, water demand from inside the building is mainly from lavatories and the kitchen areas. A low-flow kitchen sink with a flow rate of 1.8 gal/min is specified based on 3, 30 second uses per person per day. To ensure operating efficiency, a knee or foot control could be installed to minimize duration of water use. Additionally, HET dual flush (full-flush) water closets with a flow rate of 1.6 gpf and high efficiency urinals with 0.5 gpf are specified in the lavatories.
Irrigation: While drought tolerant species are ideal in terms of reducing demand, the size of the landscaped area is considerable relative to the built areas of the site. Considering that drought tolerant species may not be suitable throughout the 50,000+ landscaped areas an average species factor for mixed trees, shrubs and ground cover was used (0.5). Irrigation efficiency was calculated at 0.90 with a drip system.

Further Considerations

As a design studio, there may be additional water demand that is not considered in the water budget calculations. For example, modelling or other creative work that might increase water use, or frequent increase in building occupants for meetings or events. More details on the actual building function would be useful to develop a successful water conservation strategy. It would be interesting to explore the opportunities for water reuse at the Boston site, particularly options for storage and potentially under the parking area to reduce construction impact.

UNIT I COOPERATE

<u>WHICH TYPE OF PV CELL WOULD BE BEST SUITED FOR YOUR USE IF YOU WERE TO PURCHASE A SYSTEM FOR YOUR OWN HOME?</u>

I live in a four-unit apartment building. The structure is located in Bonn, Germany, and sited on an east-west axis. It already incorporates some passive solar strategies utilizing solar gain in main living spaces in line with the seasonal requirements. The building could also take advantage of PV solar opportunities to increase energy efficiency. While not renowned for its sunshine, Germany is often an example of prolific residential solar investment.

However, the building is owned by a non-resident landlord, and is an investment where the energy efficiency affects the tenants rather than the owner. In this context, the cost and return on investment for a solar PV system is a considerable factor.

The building orientation and setting are conducive to PV. Shading from neighboring buildings or vegetation is not an issue with a medium pitched roof (~7/12 or 30 degrees). The building is two stories, with unfinished space in the attic which could house the PV controls system.

At latitude 50, it is estimated that potential for solar is about 3 $kWhr/m^2/day$.[1] A panel efficiency of 0.15, and an array of 15 panels (200 sf) a poly-crystalline silicon cell system could generate 2.625 kW for around 20,000 USD. This option would make sense for a homeowner who would recoup expenses through energy savings, however may not be enough incentive for the landlord.

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UNIT I DEMONSTRATE

PHOTOVOLTAICS ASSIGNMENT

1. Select a PV module from the list on http://www.wholesolarpower.com/solar-panels-2/worldwide-pv-panel-efficiency/ . First Solar is the first one on the list, so let's use it. This is a cadmium telluride (CdTe) PV module with a STC rating of 75 DC Watts and a module size of 7.76 SF.

2. The size of a photovoltaic (PV) system is its nameplate DC power rating. This is determined by adding the PV module power listed on the nameplates of the PV modules in watts and then dividing the sum by 1,000 to convert it to kilowatts (kW).
http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/US/change.html

3. The total roof area of our building: **2160 sf**

4. Roof Area divided by Module Area = Number of PV modules that can fit on our roof: **278**

5. Number of Modules times STC rated power divided by 1000 = Total DC Power for the whole system: **20.85 kW**

6. Go to PVWatts calculator, version 1, and select MA and Boston:
http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/

7. For *PV System Specifications* / DC Rating (kW) enter figure from Line 5: **20.85**

8. For *DC to AC Derate Factor*: use the default value
   For *Array Type* use: Fixed Tilt
   For *Array Tilt (degrees):* enter "0" (flat on the roof, no tilt)

For *Array Azimuth (degrees)*: use the default value 180 (due south)
Leave all other values as they are (default settings)
Hit the "Calculate" button

9. On the screen that will then appear look at the bottom of the Results table under the *AC Energy (kWh)* column. The annual energy production for this type of PV system in Boston is: **20911 kWh**

10. Try changing the settings for a **tilted** array:

    Area of panels = 7.76 SF.

    Assuming a panel length "L" of **3'** gives a width "W" of = **2.59**

    Use the Collector Spacing Ratio of **2.7**

    2.7 * L = **8.1** between rows

    With a roof width of 36' we can have how many rows of PV panels? **4**

    Rows are 60' / W = 23 panels long

Number of panels times the STC rating = **6900** W / row.
rows * 6900 W / row = 6900 W
W / 1000 = **6.9 kW** power rating for the system

11. Using PVWatts, input the power rating for the system and an Array Tilt at the default (latitude 42.4)

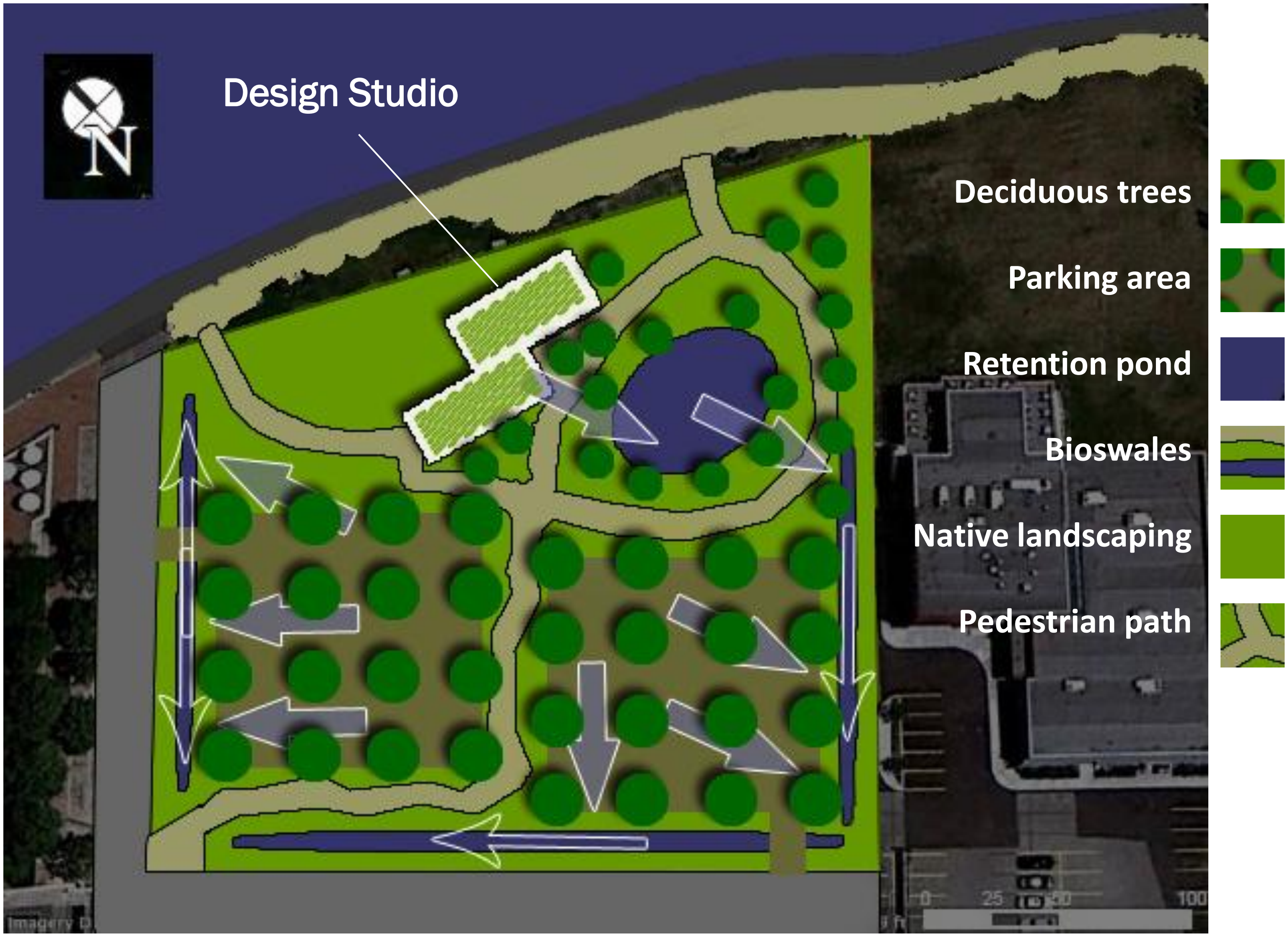
12. Annual energy production for this type of PV system in Boston should be: **8581 kWh / yr**.

13. Is this enough power to offset our lighting and plug loads, even at best efficiency? Show your calculations.
    No – this is about 58% of energy use (based on energy conserving strategies).

Proposed lighting system energy usage:	**6138.11 kWh/yr**
Proposed plug load energy usage:	**8737.51 kWh/yr**
<u>Total:</u>	**<u>14875.62 kWh/yr</u>**
	8581/14875.62 = 58/100 (58%)

Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration



Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

Program:

- Total Site Area 75,000 sf
- Building Footprint 2,100 sf
- Parking 20,000 sf

Other Programmatic Requirements:

- Entrance must face Courthouse Way
- Create pedestrian circulation path to connect South Bay Harbor Trail with the entrance and corner of Liberty Drive and Courthouse Way
- Maximize views of the waterfront

Sustainable Site Goals:

- Orient the building and site elements to maximize passive and active solar design
- Slow down, capture, and treat as much stormwater on site as possible
- Minimize heat island effect
- Maximize habitat for native flora & fauna
- Minimize the energy and water required for maintenance

Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

Sustainable Site Goals:

Orient the building and site elements to maximize passive and active solar design

The design studio holds a footprint of 2,100 sq ft on a staggered east-west axis to maximize passive solar opportunities on the south facade as well as views to the north towards the waterfront and city skyline. The main entrance on the west faces Courthouse Way and is shielded from northern winds by evergreens.

The building design follows New England vernacular in that it creates a sheltered courtyard on the southern facade. This space provides outdoor seating areas with views of gardens and a water feature during temperate months.

Deciduous trees at the courtyard shade the building from summer sun while allowing solar gain in colder months. A light shelf at the south facade brings diffused daylight into interior work spaces. Deciduous trees along the westerly section of the south facade assist in controlling solar gain and glazing along the northern facade contribute natural daylighting with views. The building is sited towards the middle of the Northern site boundary to avoid solar gain disruption from neighboring buildings and allow parking areas to be located in shade of proposed structure at the southern boundary during summer months. The siting reflects the most cost-effective option for parking, i.e. winter maintenance expected to be lower than building a two-story parking structure or underground parking facility.

Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

Sustainable Site Goals:

Slow down, capture, and treat as much stormwater on site as possible

With stormwater outlets located at the south and north corners of the western site boundary, the site is designed to capture rainwater and direct it through biofiltration areas towards stormwater outlets. The retention pond in the northeast corner discharges into the bioswales and water flow is directed clockwise around the site boundary into the stormwater outlets.

The bioswales placed along the west, east and south boundaries capture runoff from both the site parking areas and adjacent streets creating opportunity for biofiltration of pollutants before recharging groundwater or being discharged to the stormwater outlets.

A green roof located across the expanse of the building supports the stormwater strategy. Runoff from the roof is directed to the retention pond. Additionally, pervious materials are used at pedestrian pathways and parking areas.

Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

Sustainable Site Goals:

Minimize heat island effect

With high requirements for parking area, the site is designed to disperse shade throughout and integrate water features to moderate the microclimate. Deciduous trees are scattered throughout the 20,000 sq ft parking lots to shade surfaces and vehicles.

The parking area is staggered to allow for vegetation between two main areas and to push towards the shade of neighboring buildings towards the southern site boundary.

The vegetation and water features work to cool air that enters the site from the east, west and south creating a moderate micro-climate at parking areas. At the vegetated northern section of the site, where the building sits, cooler air flows in from the waterfront.

Additionally, the green roof serves another function to lower the radiant heat generated from the building surface.

Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

Sustainable Site Goals:

Maximize habitat for native flora & fauna

The site is designed for maximum vegetation to be dispersed throughout. Native landscaping is used in garden areas and adjacent to pedestrian pathways to provide intermediary habitats, such as low shrubs, grasses and reeds, for songbirds, insects and small mammals.

Deciduous trees throughout the site provide ample habitat for larger birds, such as crows and owls. The bioswales and retention pond create ideal habitat for amphibians and water fowl, such as Canadian Geese and mallards, as well as butterflies like migratory Monarchs.

Native plants to be used could include goldenrod to attract butterflies, native honeysuckle for hummingbirds, and switch grass, dogwood or juniper to provide songbird habitat.

The site could also potentially serve as a nesting site for sea birds found along the Atlantic coasts, such as Wood Storks.

Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

Sustainable Site Goals:

Minimize the energy and water required for maintenance

The site design employs passive solar strategies to optimize solar control and regulate the micro-climate. Solar orientation of the design studio allows solar gain during colder months to lower energy loads for heating. The orientation also protects the building from solar gain during hotter months to reduce cooling requirements.

Glazing along the southern facade uses external solar protection and light shelf features to bring diffuse natural daylight into work areas. Additional glazing along the northern facade provides daylight as well as views of water and city skyline. Both decrease energy requirements for electric lighting and improve the quality of lighting for work spaces.

In addition to supporting the stormwater strategy and mitigating urban heat island effect, the green roof helps reduce the cooling requirements of the building during hotter months. Native landscaping throughout the site reduces the need for irrigation.

Schematic Site Plan

solar orientation, stormwater, heat island effect, and habitat restoration

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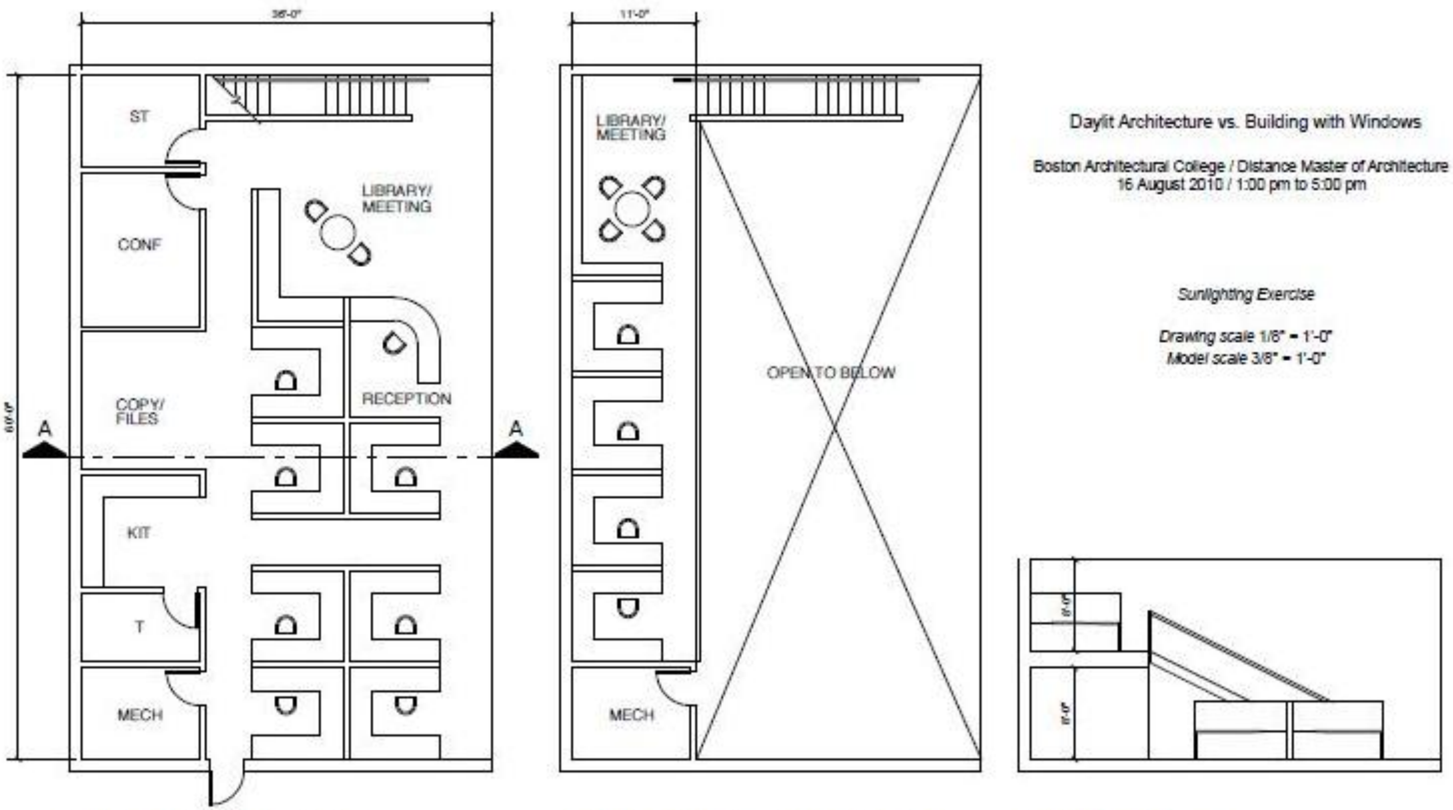
IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics

Indoor Environmental Quality is affected by a variety of different factors including thermal comfort, ventilation, air contaminants, materials, daylighting, views and acoustical attributes. Each factor plays a role in overall indoor quality and can be integrated into a strategy for an indoor environment conducive to heath, wellness and productivity.

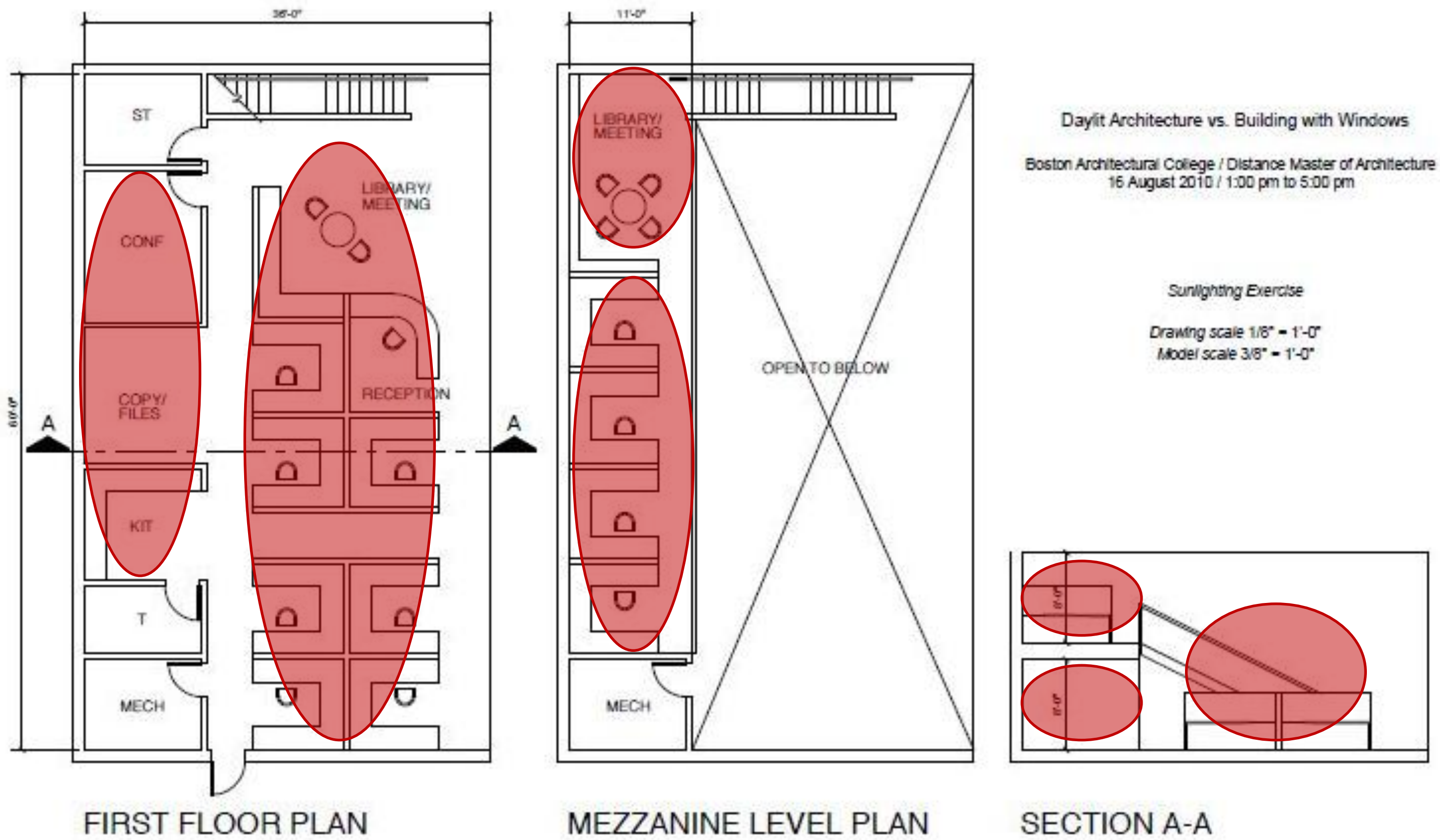


FIRST FLOOR PLAN | MEZZANINE LEVEL PLAN | SECTION A-A

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics

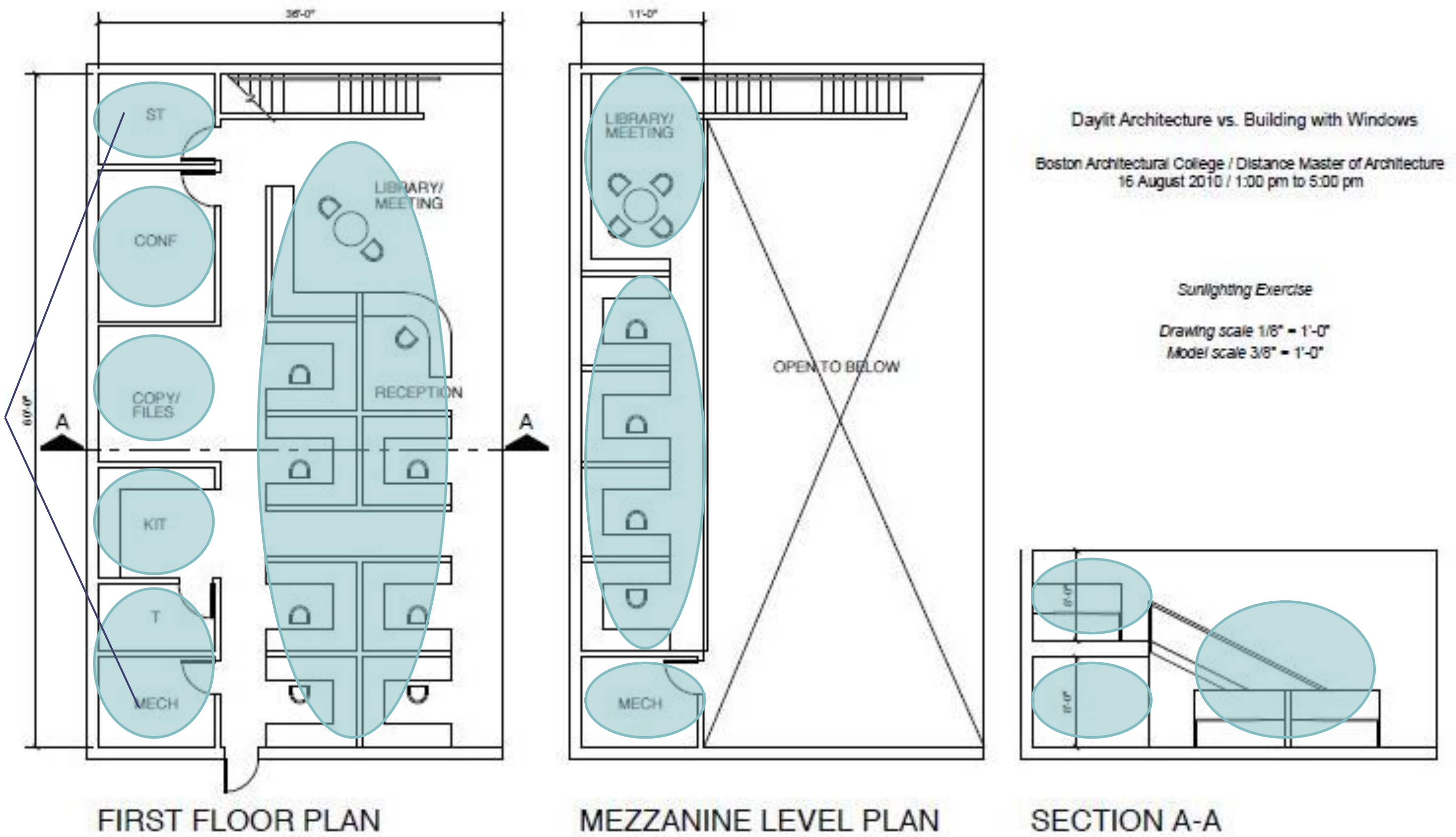
With an open floor plan that includes a mezzanine level, managing thermal comfort is a task that requires evaluation of varying space requirements. On the ground floor, a large open work space and library may be prone to cooler temperatures than the offices and meeting room above as they exist in different levels of the same thermal environment. Achieving thermal comfort needs to consider individual controls within the larger thermal environment.



IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics

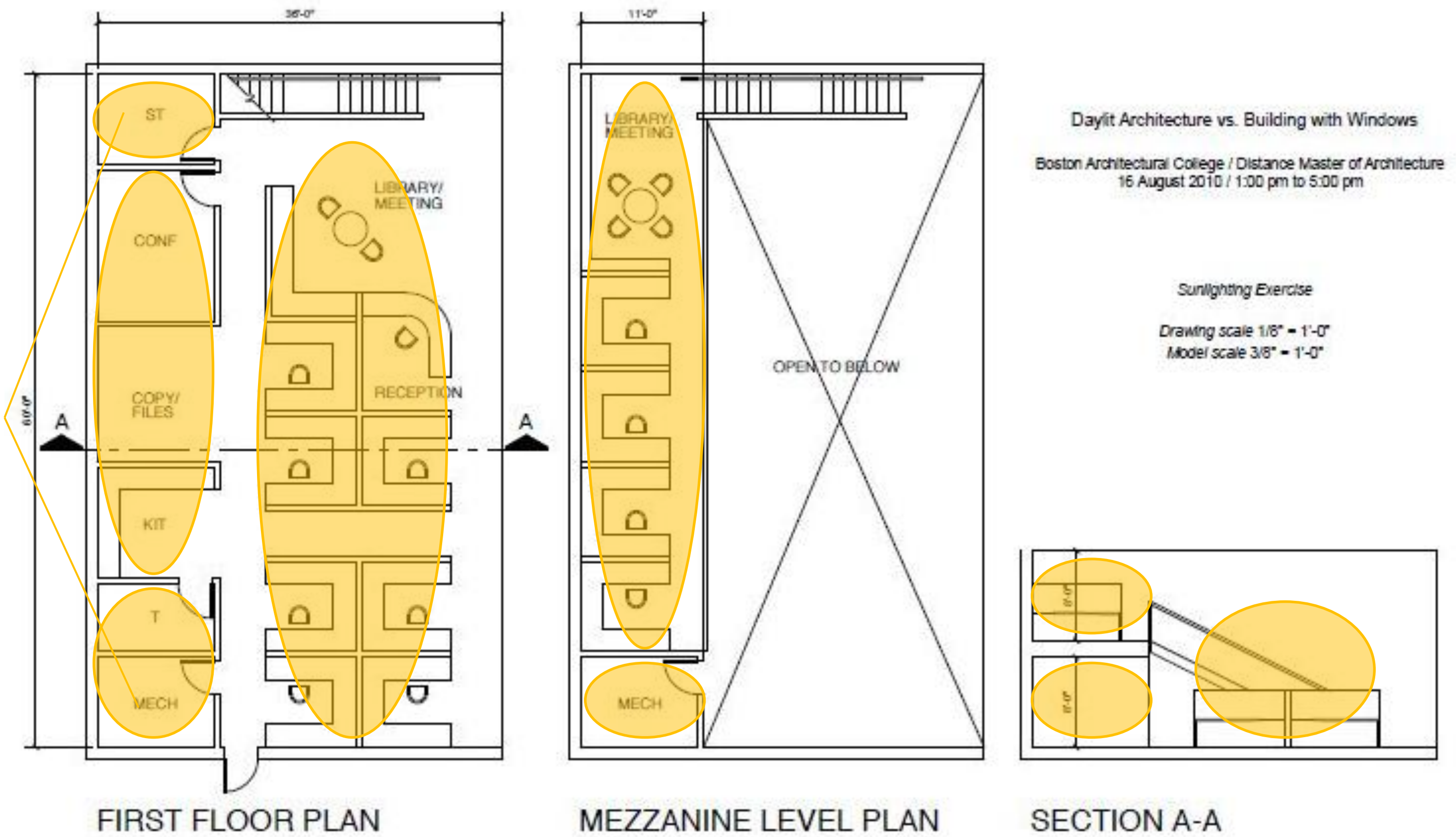
Ventilation in this building needs to be managed according to the space functions. With mechanicals grouped at one end (on both 1st and 2nd floors), the building plan allows a straightforward ventilation program that isolates open spaces and individual rooms with varying functions. Special attention to mechanical spaces, copy center, conference room and kitchen is significant in reducing pollutants such as CO2, chemicals, print particles and odors. Additionally, air at the upper level can be expected to hold more contaminants.



IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics

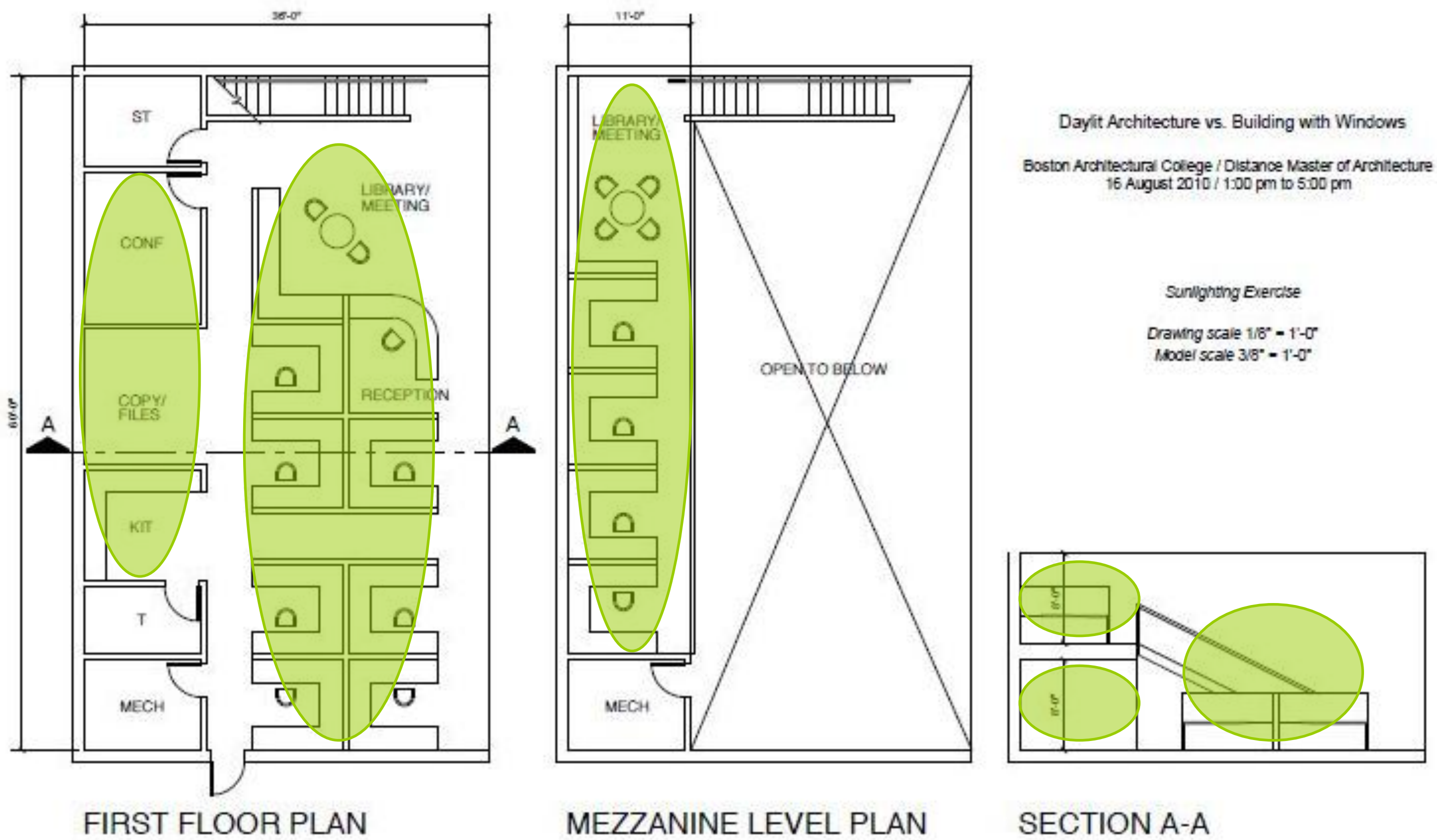
The building plan facilitates ample use of natural daylighting in work and meeting areas, mainly three different zones of the ground floor open office, ground floor covered spaces (kitchen, copy and conference) and the mezzanine office and meeting spaces. In storage and mechanical rooms, daylighting is less relevant although with control can also be used to light these areas.



IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics

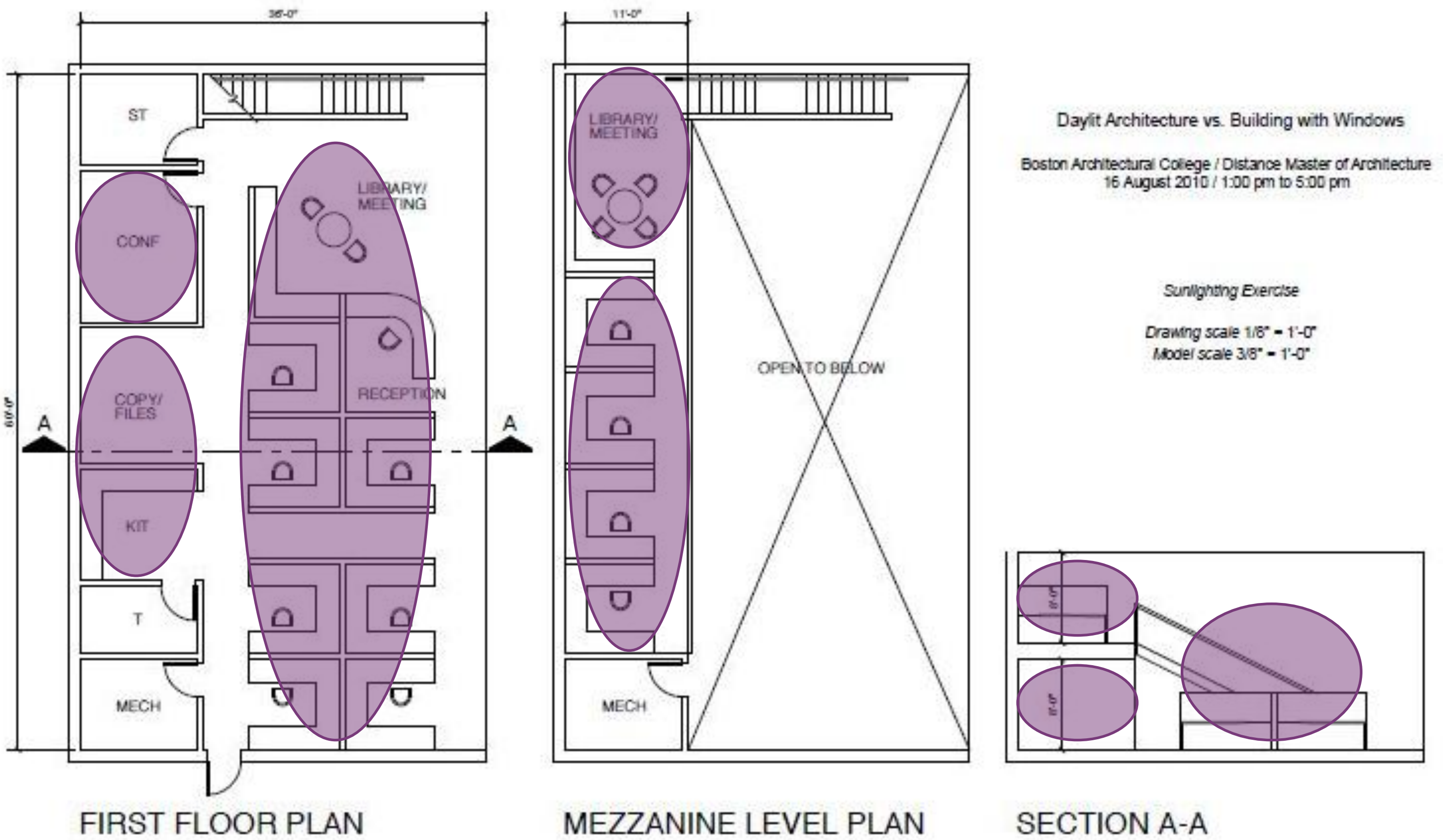
The integration of views into the work and meeting areas, including the copy center and kitchen, is an opportunity to increase the occupant experience. On the northern facade, views to the Boston Harbor and city skyline can be dramatic and inspiring. In the main work areas of the ground floor, views to the south allow vantage across a park-like landscape.



IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics

As an open plan, one of the biggest challenges in the Fan Pier design studio building is to manage acoustics. Only one meeting space is enclosed and with a range of activities occurring in common spaces, the control of acoustic disturbances needs careful consideration to avoid constant distraction from noise in other areas.



IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics | **strategy**

In order to optimize Indoor Environmental Quality, a first step is to identify zones of similar requirements to each IEQ component and consolidate functions for cost-effectiveness and comfort. Zones can be grouped according to occupant type (single, multiple, etc.) and also to accommodate the function of the areas.

T**hermal comfort** zoning isolates common areas, work areas and meeting areas. Personal adjustments are considered at private work areas such as at the ground floor where the library and desks share an open floor space, VAV controls are installed at desk areas.

Ventilation zoning considers occupancy rate, pollutants and allows individual control through operable windows in enclosed offices.

Light zoning prioritizes quality daylighting wherever possible to minimize energy load.

Views to the water, city skyline and on-site gardens are prioritized for all high occupancy areas including offices, meeting rooms and common areas such as kitchen.

Acoustics pose a particular IEQ challenge in this open floor plan. Interior glazing and sound absorbing materials support overall IEQ strategy while minimizing noise distraction.

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics | **optimization**

thermal comfort

Optimal conditions: Air temperature, humidity, air flow and velocity are regulated to create thermal comfort for majority of occupants (80%) according to ASHRAE Standard 55-2004) *and* provides measures to accommodate occupants at the extreme ends of the thermal comfort spectrum.

Systems:

- Under floor air distribution system at ground floor with variable air volume controls.
- Operable windows in (glass) enclosed mezzanine offices and in enclosed meeting spaces.
- Heat recovery air exchange system to support humidity control (30 – 40%).
- Individually adjustable task lighting at desks and work stations.

ventilation

Optimal conditions: While small in size, the building benefits from controlled ventilation that integrates fresh air intake and under floor air distribution system, heat recovery, and monitoring. An overall strategy for mechanical ventilation is supplemented by isolated occupant controlled windows for thermal comfort.

Systems:

- Demand controlled ventilation system, to monitor temperature and CO_2.
- Operable windows in (glass) enclosed mezzanine offices and in enclosed meeting spaces.
- Heat recovery air exchange system to support humidity control (30 – 40%).
- Direct exhaust from high contaminant areas (copy center, mechanicals, etc.)

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics | **optimization**

light

Optimal conditions: Natural daylighting is used in controlled manner to create high quality light conditions in work and meeting areas. Additionally it is used to lower energy demand in enclosed spaces such as storage and mechanicals.

Systems:

- Clerestories at north and south elevations for indirect daylighting
- Interior glazing at mezzanine offices, 1st floor conference and exterior glazing (modeled)
- Open floor plan to allow exterior daylight to penetrate to the interior
- Individually adjustable task lighting at desks and work stations
- Occupant sensor operated lighting in common areas and meeting rooms

views

Optimal conditions: The building design and glazing maximizes views to the Boston Harbor and to on-site landscaping features from all work and meeting areas.

Systems:

- Interior glazing at mezzanine offices, 1st floor conference and exterior glazing (modeled)
- Open floor plan to allow views from all work and meeting spaces

acoustics

Optimal conditions: Work and meeting areas provide an acoustic environment that minimizes distracting noises from other activities.

Systems:

- Interior glazing at mezzanine offices, 1st floor conference
- carpeting and sound absorbing finishes at walls

IEQ Strategy | Fan Pier Design Studio

thermal comfort| ventilation| light| views| acoustics | **bibliography**

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