Mining LEED™ for Carbon:

Energy Effective Design and LEED™ Credits

We will dissect this Platinum + Carbon Neutral Building
To see how LEED™ credits can be used as a
spring point to elevate to Carbon Neutral

Towards Zero Energy \ Zero Carbon:

LEED™ Gold

IslandWood

Early ZED

BEDZed

case studies

Jubilee Wharf

ZED

Aldo Leopold Legacy Center

Carbon Neutral

The ZEDfactory Philosophy…

Key to the necessary paradigm shift required to go ZED, is a re-visioning of priorities for design.

"Architects and engineers say that reaching a zero-energy goal necessarily requires a much more integrated design process than is typical for a conventional building."

Current, unsustainable UK consumption

Image credit: ZEDfactory

BedZED:
Beddington Zero Energy Development

BedZED, Hackbridge, England, was created as a partnership with the BioRegional Development Group, the Peabody Trust, Bill Dunster Architects, Arup, and Gardiner and Theobald. The 82 houses, 17 apartments, and 1,405 m² of workspace were built between 2000-02. An example of early ZED design.

Climate: temperate, inland

BedZED:
Beddington Zero Energy Development

*Starts with **basic** sustainable principles of design:*

- ORIENTATION
- very high environmental standards
- high thermal insulation levels
- triple glazed windows
- sunlight / daylighting
- solar energy (direct gain + PV)
- reduction of energy consumption
- natural ventilation
- waste water recycling
- strong emphasis on roof gardens
- built from natural, recycled, or reclaimed materials
- reduction in parking – pedestrian oriented
- re-allocation of site/use distribution for community's best interests

BedZED: Then goes for Zero Energy….

Density and General Site Strategies

#1.

The development uses a higher density than typical.

#2.

This separates parking from housing.

#3.

And consolidates significant green space.

BedZED:
Alternative Parking/Car Strategies

#1.

Designed to encourage alternatives to car use.

#2.

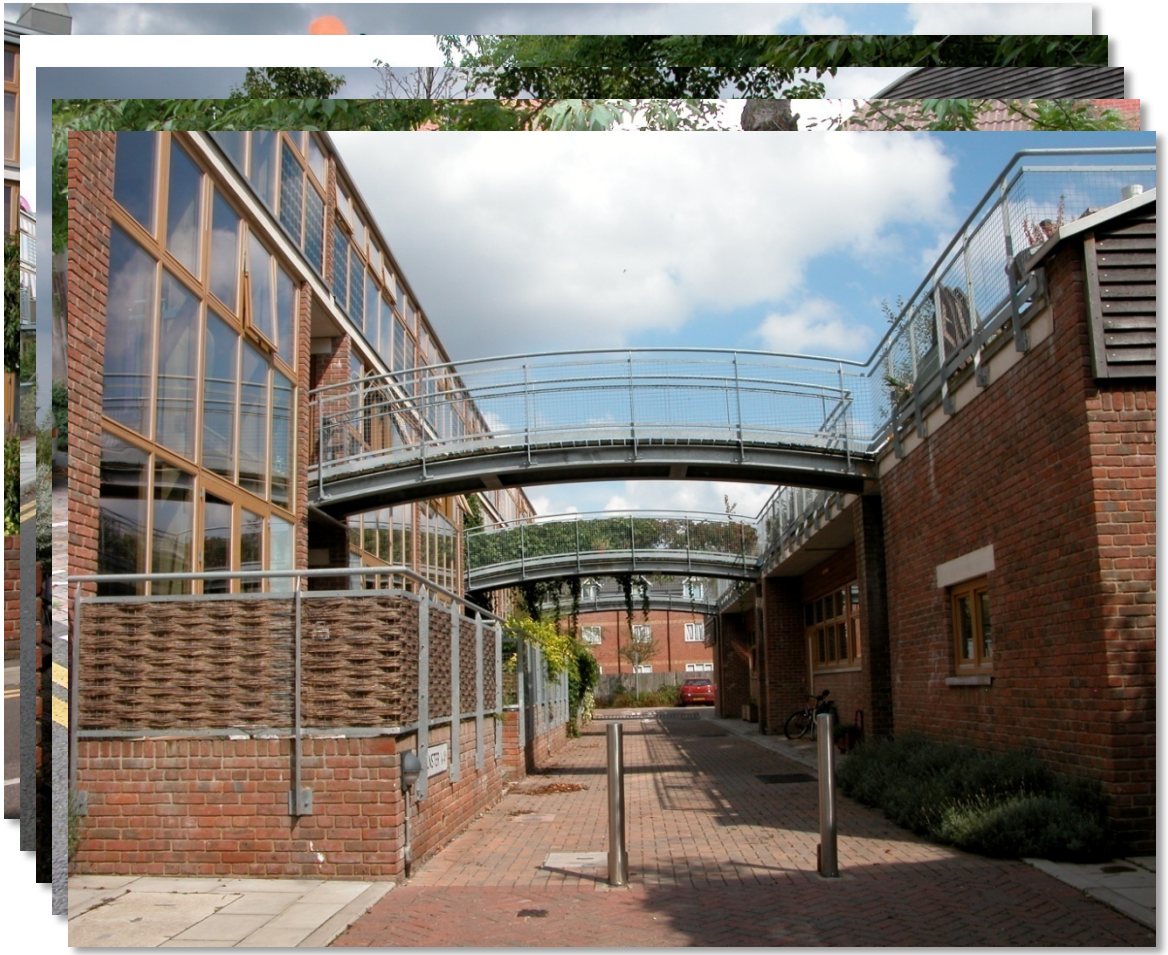
A green transport plan promotes walking, cycling, and use of public transport.

#3.

A car pool for residents has been established. BedZED's target is a 50% reduction in fossil-fuel consumption by private car use over the next 10 years compared with a conventional development.

#4.

A "pedestrian first" policy with good lighting, drop curbs for prams (strollers) and wheelchairs, and a road layout that keeps vehicles to walking speed.



BedZED:
Landscape and Vegetation

#1.

Green space divided into large communal spaces + personal gardens/terraces.

#2.

Green space at grade assists in lowering overall overheating in summer.

#3.

Green space at the roof level is private, and also incorporates seedum roofs.

#4.

Vegetable and edible crops are encouraged.

BedZED:
Passive Solar Strategies

#1.

Uses passive solar techniques to maximize heat gain for cool months

#2.

Houses are arranged in south facing terraces to maximize direct solar gain

#3.

Glass is maximized on south face (minimized on north side to prevent losses).

BedZED:
Passive Cooling Strategies

#1.

Each terrace is backed by north facing offices, which reduces the tendency to overheat and the need for air conditioning.

#2.

Large quantities of operable windows encourage natural ventilation.

#3.

PV is used to shade windows.

#4.

Wind cowls direct ventilation flow.

No A/C is provided.

BedZED:

Non-fossil fuel heating for space and water

Once needs have been reduced passively…

#1.

A centralized heat and power plant (CHP) provides hot water, which is distributed around the site via a district heating system of super-insulated pipes.

#2.

The CHP plant at BedZED is powered by off-cuts from tree surgery waste that would otherwise go to landfill.

The target was for zero fossil fuel use.

BedZED:
Material choices

#1.

Embodied energy (a measure of the energy required to manufacture a product) was key in choosing materials.

#2.

They were sourced within a 35-mile radius of the site when possible, reducing transportation energy.

#3.

Recycled materials and high recycled content were key.

75 year minimum target design life.

BedZED:

Generation of on Site Electricity

#1.

It was felt to be more efficient to generate electricity with the CHP facility.

#2.

PV panels were targeted at fueling electric vehicles.

#3.

PV was installed over 777m2 and was also used for shading.

Excess electricity is sold back to the grid.

BedZED:
Water Systems

Water use is carefully planned…

#1.

Rainwater is collected and used for irrigation and toilet flushing.

#2.

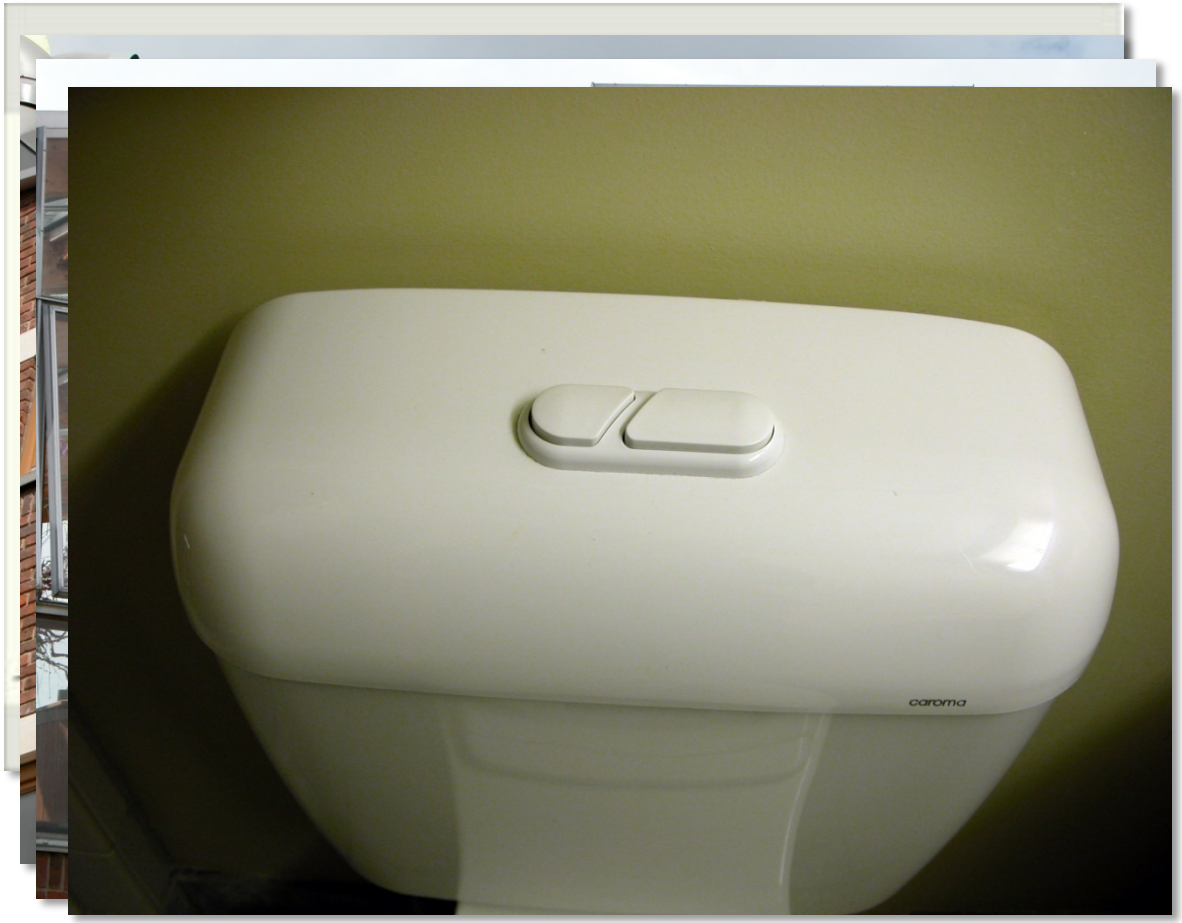
Black water is treated on site and cycled into the irrigation system.

#3.

Dual flush toilets reduce water consumption.

#4.

Shaped bathtubs reduce water requirement.



The target was to cut normal household use by 33%.

BedZED:
Waste Recycling

#1.

Waste recycling collection depots are located throughout the community.

#2.

Kitchens are outfitted with built in recycling storage.

#3.

On site composting.

The target was to reduce landfill waste by 66%.

BedZED:
Integrated Design Process

KEY WORKING CONCEPT:

Such a complex design with delicately inter-layered, synergistic systemic requirements mandates use of the ***Integrated Design Process*** from the early concept stages of development.

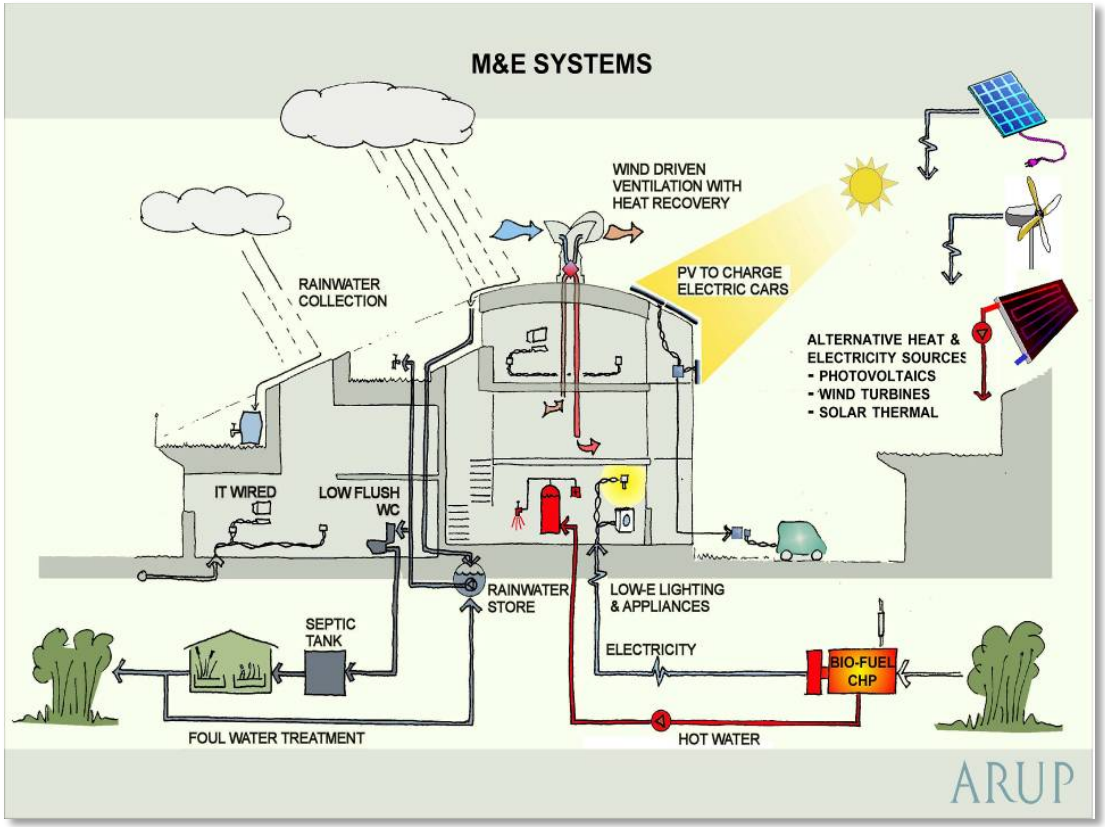


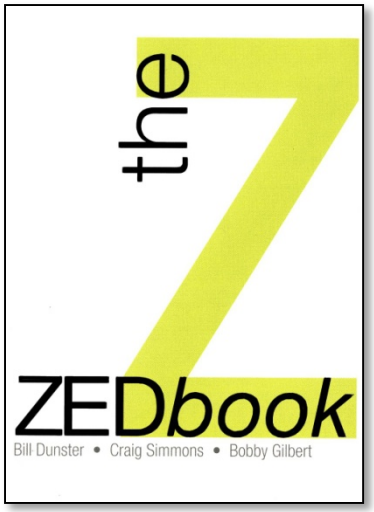
Image credit: ARUP and Dunster

Zero emission design requires strict adherence to a philosophy of conservation and cooperation.

The ZEDfactory Philosophy…

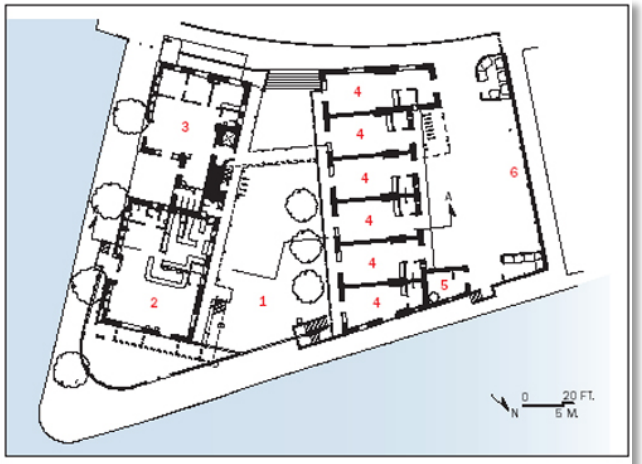
Post BEDZed, ZEDfactory has set a list of priorities that are now incorporated into most designs:

- ✓ First consider the site, climate, solar angles
- ✓ Use brownfields
- ✓ Maximize density, while keeping green amenity space
- ✓ Keep a loose fit to allow for change, adaptation over time
- ✓ Design out the need to travel
- ✓ Minimize thermal and electrical requirements as it is easier to save electricity than to generate it
- ✓ Make an energy efficient envelope
- ✓ Use efficient appliances
- ✓ Use passive solar energy for heat and sun for daylighting
- ✓ Use natural ventilation
- ✓ Use wind cowls to assist natural ventilation
- ✓ Generate maximum renewable energy *from within the site boundaries*
- ✓ Incorporate wind turbines and PV
- ✓ Allow for upgrade paths if not all systems can be installed
- ✓ Use reclaimed or local materials



Jubilee Wharf: ZEDfactory

Architect: ZEDfactory
Location: Jubliee Wharf, Penryn, Cornwall
Client: Robotmother Ltd
Description: Mixed use with residential, workshops and nursery
Start / Completion: October 2004 - September 2006
Climate: temperate, coastal



GROUND FLOOR PLAN

1 Courtyard
2 Cafe
3 Community hall
4 Workshop
5 Boiler room
6 Parking

Jubilee Wharf:
Integrated Design Process

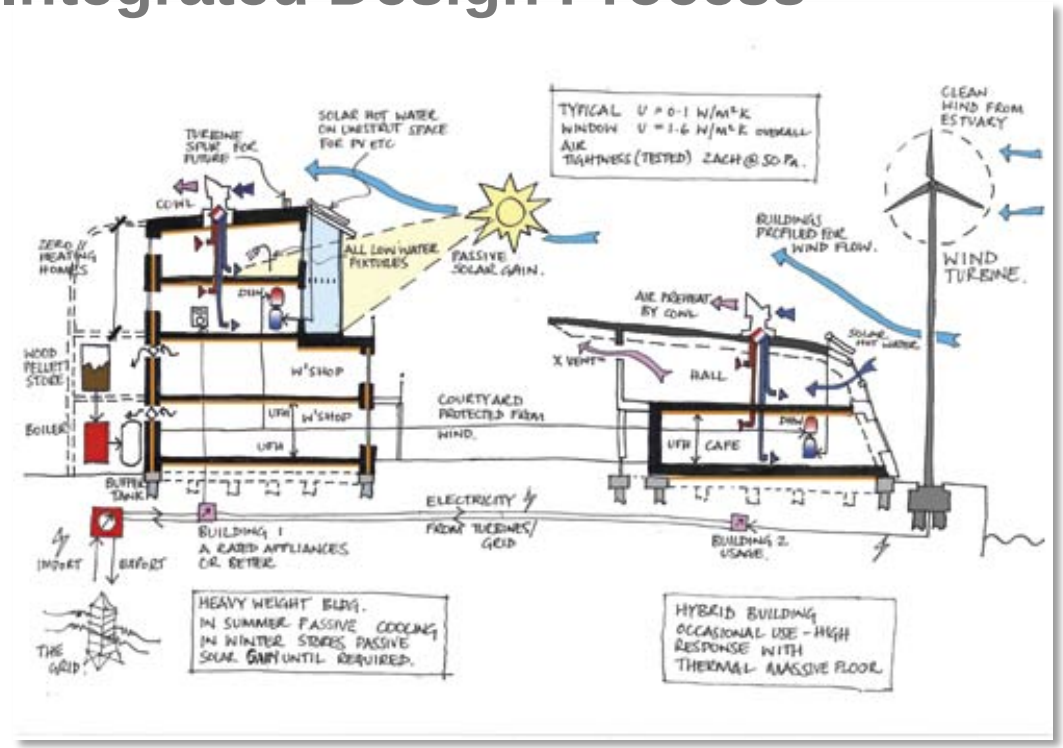


Image credit: ZEDfactory

The project begins with an integrated design approach that takes all of the key ZED concepts into account – from the beginning, starting with the sun, wind and climate.

The IDP diagram provides the basis for decisions throughout the project. It reveals how the building has been zoned by use – intensive residential use on the left, and occasional use on the right. This makes better use of the systems and site.

Jubilee Wharf:
Key Strategies List | Site and Community

Brownfield Site –
The site was previously occupied by a coalyard.

Community creation & revitalization - a hub for craft makers, quality childcare onsite, health & fitness classes, café for socializing.

Pedestrian and public transit oriented - good public transport links, located in central Penryn for easy pedestrian access.

Jubilee Wharf:
Key Strategies List | Envelope

Super Insulation –

300mm insulation reduces energy consumption to less than half a conventional building. This level of efficiency is necessary to reduce consumption and make fossil fuel avoidance possible.

Thermal Mass –

The interior surfaces are made from concrete block, concrete and plaster so that heat is stored efficiently.

Air Tightness –

The interior surfaces are parged with plaster, making sure to seal all cracks between joining materials.

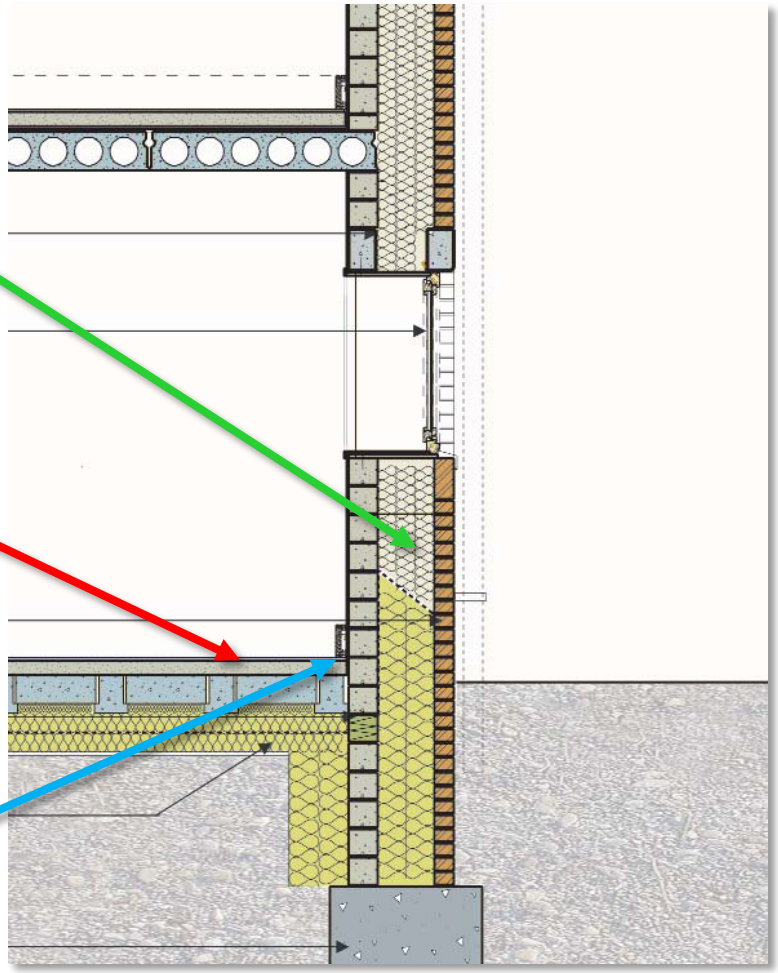


Image credit: ZEDfactory

Jubilee Wharf:
Key Strategies List | Reclaimed Materials

Using local & reclaimed materials - old floorboards, granite, Cornish cedar cladding and larch soffits, and some unused windows from BedZed

For example:
The ceiling of the Yoga space is made of reclaimed floorboards from a Victorian house. The boards have not been changed but simply treated and cut to length.

Image credit: ZEDfactory

Jubilee Wharf:
Key Strategies List | Healthy Materials

Healthy materials - low VOC paints, low formaldehyde floor coverings, natural fibers & surfaces, PVC only where unavoidable – with emphasis on creating a healthy environment.

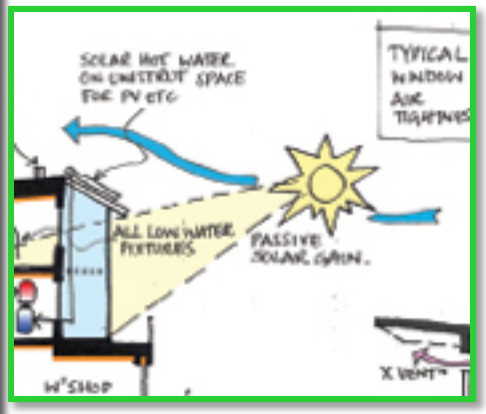
Jubilee Wharf:
Key Strategies List | Energy and Systems

Passive solar heating –

The sun space faces south and is used as a buffer space. In cold months the thermal mass heats up. In hot months the space can be closed off to keep the interior cool. It also shades the interior space.

Daylighting –

Window placement makes use of natural light.



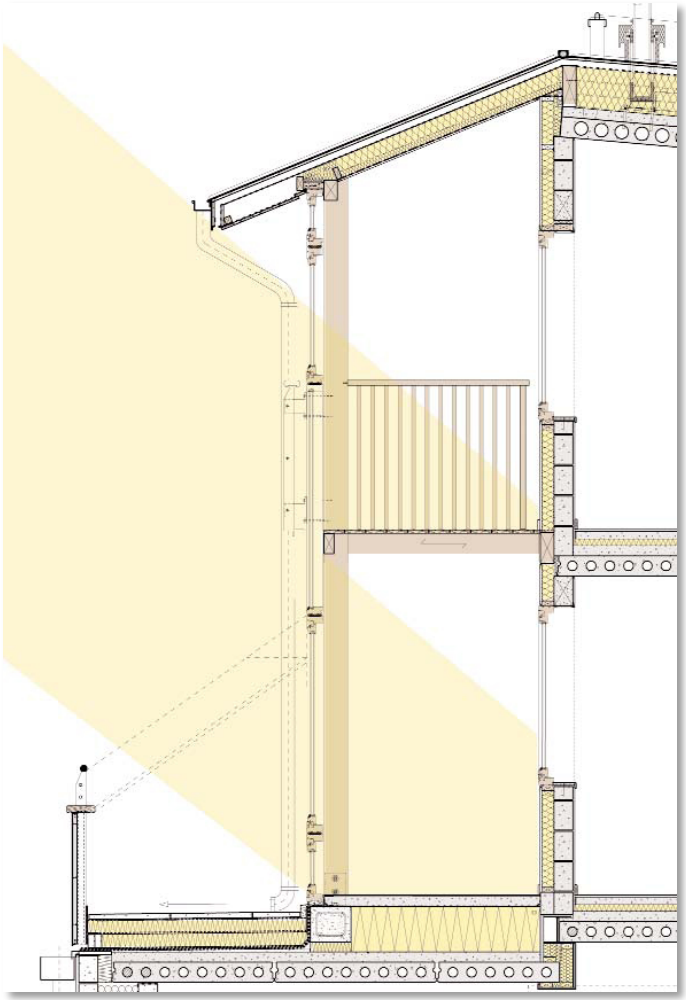


Image credits: ZEDfactory

Jubilee Wharf:
Key Strategies List | Energy and Systems

Natural ventilation –
Wind cowls ventilate without the need for electric fans.

Being passive it uses no electricity.

This displacement ventilation provides fresh air at low level and extracts air at the high level when the temperature of the air in the room has risen.

The cowl turns to face the wind drawing fresh air in via a heat exchanger which warms the incoming air with the outgoing air.

The heat exchanger is 70 - 80% efficient and minimizes heat loss from the building while providing a constant supply of fresh air.

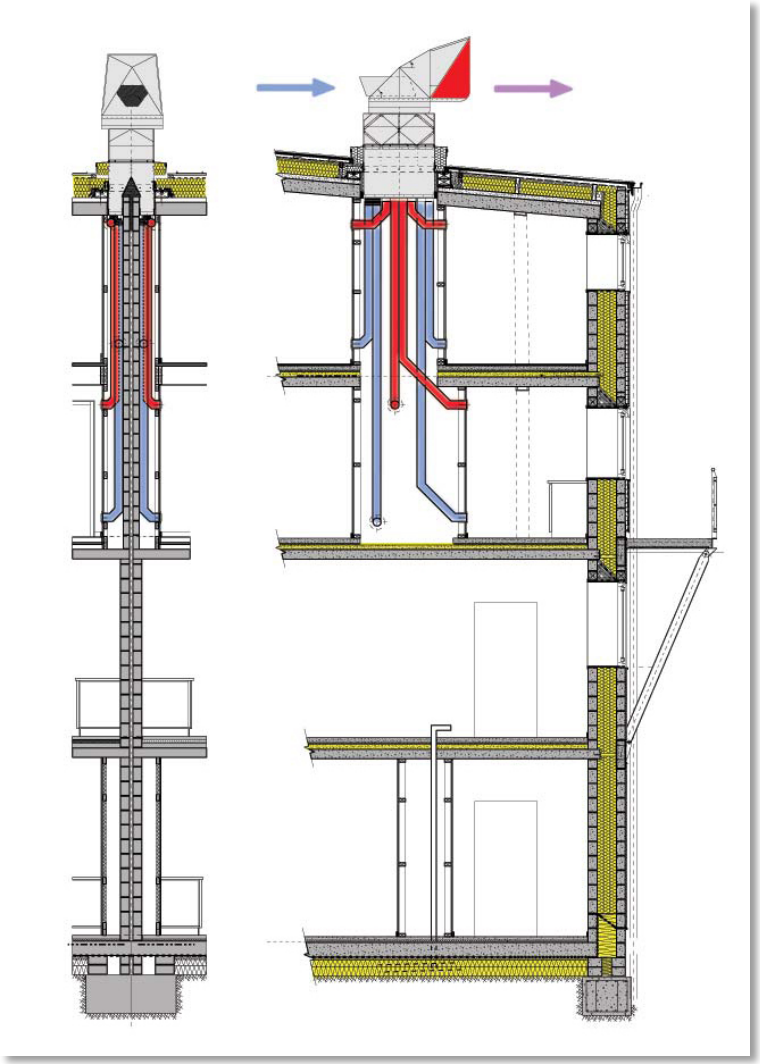


Image credit: ZEDfactory

Jubilee Wharf:
Key Strategies List | Energy and Systems

Solar panels –
The project uses evacuated tubes for water heating – one panel per residence.

Photovoltaics –

Photovoltaic cells were not included in the original budget but provisions have been made for them to be fitted later.

Reduced water consumption –
Low flush toilets, aerated taps, grade “A” consumption appliances.

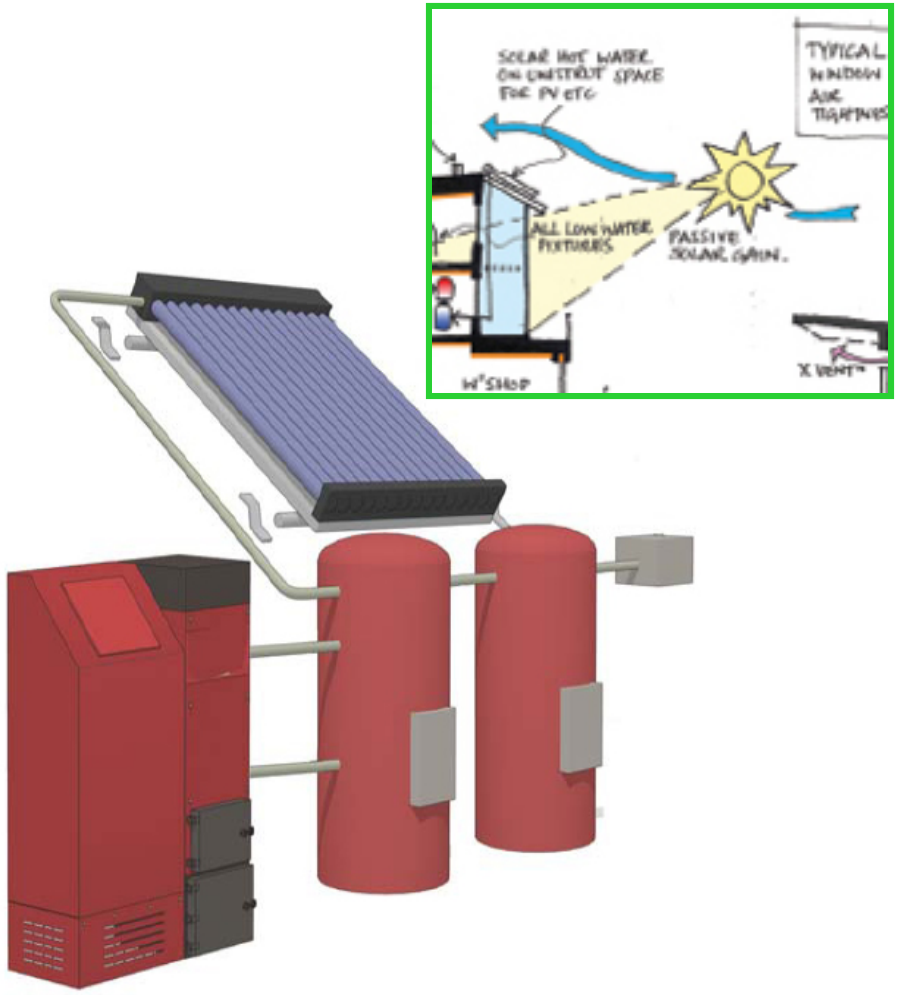


Image credits: ZEDfactory

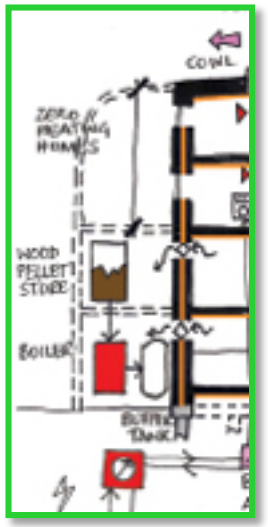
Jubilee Wharf:
Key Strategies List | Energy and Systems

Biomass heating –

Under floor heating and hot water from a 75kW wood pellet boiler.

Onsite micro generation –

4 x 6kW Proven wind turbines provide most of the electricity – giving back to the grid or drawing from as required.



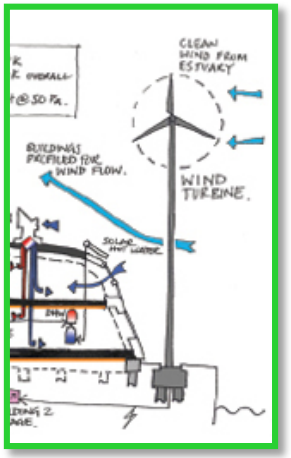


Image credits: ZEDfactory

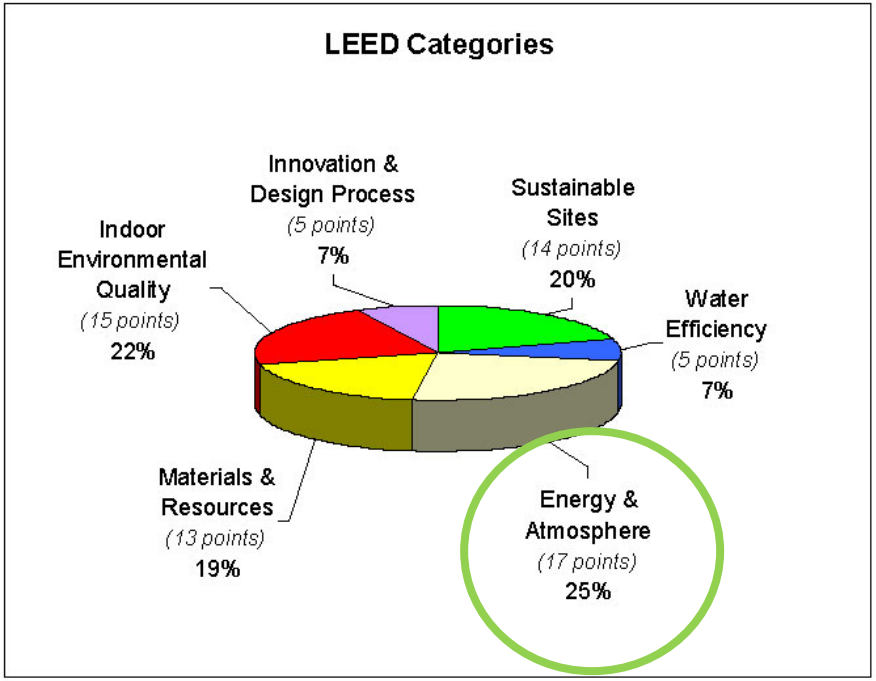
Carbon Neutral – Operating Energy

Comparing Carbon Neutral to LEED™

- LEED™ is a *holistic assessment tool* that looks at the overall sustainable nature of buildings within a prescribed rating system *to provide a basis for comparison* – with the hopes of changing the market

- Projects are ranked from Certified to Platinum on the basis of credits achieved in the areas of Sustainable Sites, Energy Efficiency, Materials and Resources, Water Efficiency, Indoor Environmental Quality and Innovation in Design Process

- LEED™ *does not assess the Carbon value of a building, its materials, use of energy or operation*
- ***Most LEED Gold and Platinum buildings earn a maximum of 5/17 of the Energy and Atmosphere Credits!***



- Only 25% of the LEED credits are devoted to energy.
- Of those, 10/70 are for optimization.
- Maximum reduction is 60%.

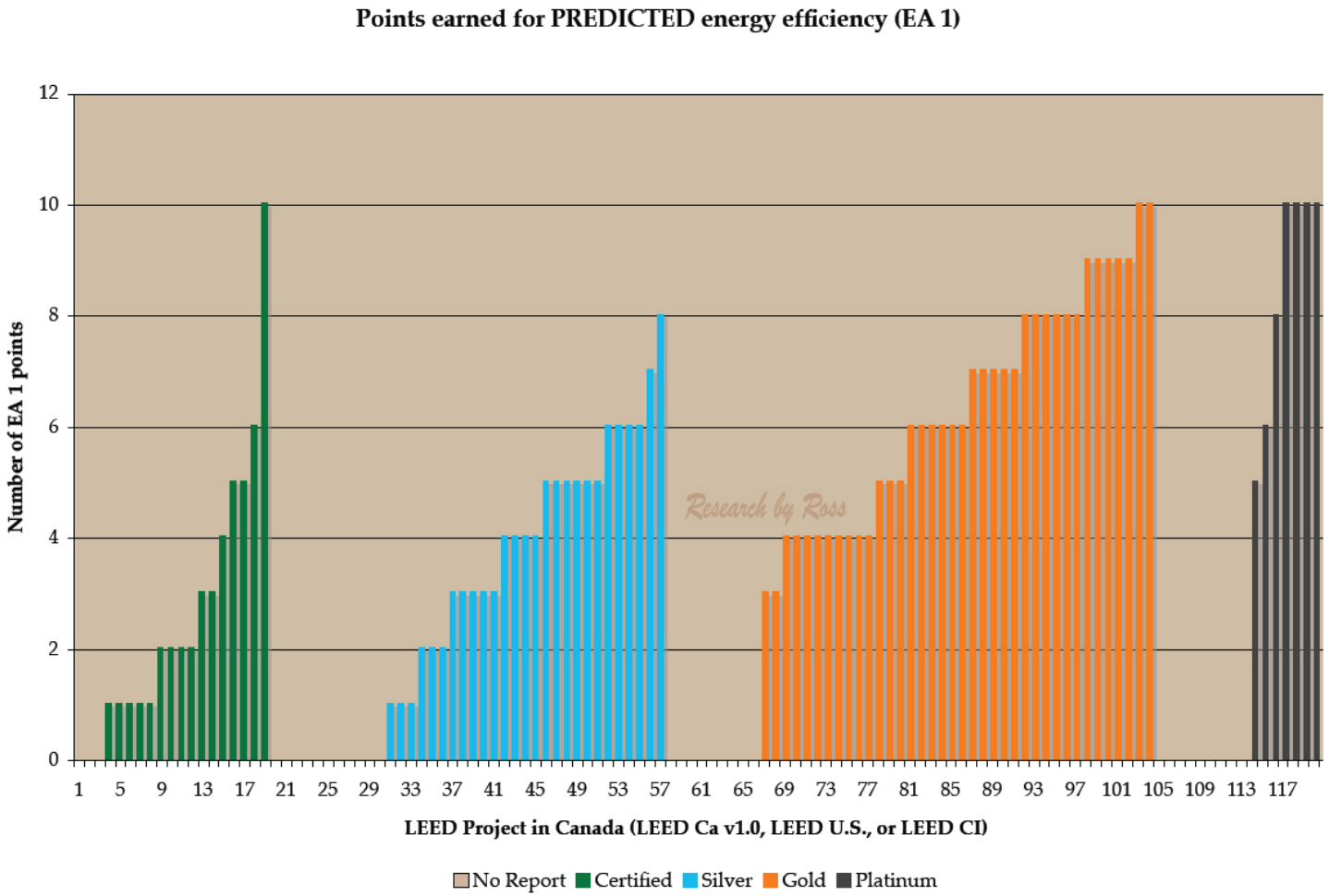
- Most LEED buildings earn less than 5 of these credits…..

And the first aim of Carbon Neutral Design is to achieve 100% reduction…

10	Energy & Atmosphere		Possible Points: 17
Y	Prereq 1	**Fundamental Building Systems Commissioning**	
Y	Prereq 2	**Minimum Energy Performance**	
Y	Prereq 3	**CFC Reduction in HVAC & R Equipment**	
2	Credit 1.1	**Optimize Energy Performance**, 20% New / 10% Existing	
2	Credit 1.2	**Optimize Energy Performance**, 30% New / 20% Existing	
2	Credit 1.3	**Optimize Energy Performance**, 40% New / 30% Existing	
2	Credit 1.4	**Optimize Energy Performance**, 50% New / 40% Existing	
1	Credit 1.5	**Optimize Energy Performance**, 60% New / 50% Existing	
	Credit 2.1	**Renewable Energy**, 5% Contribution	
	Credit 2.2	**Renewable Energy**, 10% Contribution	
	Credit 2.3	**Renewable Energy**, 20% Contribution	
1	Credit 3	**Additional Commissioning**	
	Credit 4	**Elimination of HCFCs and Halons**	
	Credit 5	**Measurement & Verification**	
	Credit 6	**Green Power**	

Scorecard for National Works Yard in Vancouver, LEED™ Gold

LEED and Predicted Energy Credits



Research conducted by Barbara Ross for her M.Arch. Thesis (2009)

2030 Targets - Commercial

2030 CHALLENGE Targets: National Averages

U.S. Average Site Energy Use and 2030 Challenge Energy Reduction Targets by Space/Building Type (CBECS 2003)[1]

From the Environmental Protection Agency (EPA): Use this chart to find the site fossil-fuel energy targets.

Primary Space/Building Type [2]	Available in Target Finder [3]	Average Source EUI [4] (kBtu/Sq.Ft./Yr)	Average Percent Electric	Average Site EUI [4] (kBtu/Sq.Ft./Yr)	2030 Challenge Site EUI Targets (kBtu/Sq.Ft./Yr)				
					50% Target	60% Target	70% Target	80% Target	90% Target
Administrative/Professional & Government Office	✓								
Bank	✓								
Clinic/other outpatient health		219	76%	84.2	**42.1**	33.7	25.3	16.8	8.4
College/university (campus-level)		280	63%	120	**60**	48	36	24	12
Convenience store (with or without gas station)		753	90%	241.4	**120.7**	96.6	72.4	48.3	24.1
Distribution/shipping center		90	61%	44.2	**22.1**	17.7	13.3	8.8	4.4
Fast food		1306	64%	534.3	**267.2**	213.7	160.3	106.9	53.4
Fire station/police station		157	56%	77.9	**39.0**	31.2	23.4	15.6	7.8
Hospital/inpatient health	✓								
Hotel, Motel or inn	✓								
K-12 School	✓								
Medical Office	✓								

Reduction over MNECB kBtu/sf/yr	
123	5%
109	10%
96	15%
82	20%
68	25%
61	30%
54	35%
48	40%
41	45%
34	**50%**

Target Finder is an online tool:
http://www.energystar.gov/index.cfm?c=new_bldg_design.bus_target_finder

LEED™ 2009 and Operating Energy

OPTIMIZE ENERGY PERFORMANCE

	NC	CS
Credit	EA Credit 1	EA Credit 1
Points	1-19 points	3-21 points

EA	
NC	Credit 1
CS	Credit 1

INTENT

To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.

REQUIREMENTS: NC & CS

Select 1 of the 3 compliance path options described below. Project teams documenting achievement using any of the 3 options are assumed to be in compliance with EA Prerequisite 2: Minimum Energy Performance

OPTION 1. WHOLE BUILDING ENERGY SIMULATION (1-19 points for NC, 3-21 points for CS)

EITHER

PATH 1. Model National Energy Code For Buildings (MNECB)

Demonstrate a percentage cost improvement in the proposed building performance rating compared with the reference building performance rating. Calculate the reference building performance according to the Model National Energy Code for Buildings 1997 (MNECB) using a computer simulation model for the whole building project. The minimum energy cost savings percentage for each point threshold is as follows:

LEED™ 2009 and Operating Energy: Path 1 Model National Energy Code for Buildings

NEW BUILDINGS	EXISTING BUILDING RENOVATIONS	POINTS FOR NC	POINTS FOR CS
25%	21%	1	3
27%	23%	2	4
28%	25%	3	5
30%	27%	4	6
32%	28%	5	7
33%	30%	6	8
35%	32%	7	9
37%	33%	8	10
39%	35%	9	11
40%	37%	10	12
42%	39%	11	13
44%	40%	12	14
45%	42%	13	15
47%	44%	14	16
49%	45%	15	17
50%	47%	16	18
52%	49%	17	19
54%	50%	18	20
56%	52%	19	21

The energy analysis done for the building performance rating method must include all the energy costs associated with the building project. To achieve points under this credit, the proposed design must meet the following criteria:

- Compliance with the mandatory provisions of the MNECB 1997.
- Inclusion of all the energy costs within and associated with the building project.
- Comparison against a baseline building that complies with the reference building requirements as defined in the MNECB 1997.

Reduction over MNECB kBtu/sf/yr	
123	5%
109	10%
96	15%
82	20%
68	25%
61	30%
54	35%
48	40%
41	45%
34	**50%**

LEED™ 2009 and Operating Energy: ASHRAE 90.1 - 2007

OR

PATH 2. ASHRAE 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings

Demonstrate a percentage cost improvement in the proposed building performance rating compared with the baseline building performance rating. Calculate the baseline building performance according to Appendix G of ANSI/ASHRAE/IESNA Standard 90.1-2007 (with errata but without addenda[a]) using a computer simulation model for the whole building project. The minimum energy cost savings percentage for each point threshold is as follows:

LEED™ 2009 and Operating Energy: ASHRAE 90.1 - 2007

NEW BUILDINGS	EXISTING BUILDING RENOVATIONS	POINTS FOR NC	POINTS FOR CS
12%	8%	1	3
14%	10%	2	4
16%	12%	3	5
18%	14%	4	6
20%	16%	5	7
22%	18%	6	8
24%	20%	7	9
26%	22%	8	10
28%	24%	9	11
30%	26%	10	12
32%	28%	11	13
34%	30%	12	14
36%	32%	13	15
38%	34%	14	16
40%	36%	15	17
42%	38%	16	18
44%	40%	17	19
46%	42%	18	20
48%	44%	19	21

LEED™ 2009 and Renewable Energy

NEW CONSTRUCTION:

PERCENTAGE RENEWABLE ENERGY	POINTS
1%	1
3%	2
5%	3
7%	4
9%	5
11%	6
13%	7

CORE AND SHELL:

PERCENTAGE RENEWABLE ENERGY	POINTS
0.5%	2
1%	4

A carbon neutral building should be able to supply 100% of operating energy with renewables avoiding the use of fossil fuels.

Towards Zero Energy \ Zero Carbon:

LEED™ Gold

IslandWood

Early ZED

BEDZed

case studies

Jubilee Wharf

ZED

Aldo Leopold Legacy Center

Carbon Neutral

IslandWood – Mithun Architects and Planners

IslandWood is an education center, on Bainbridge Island near Seattle, Washington. It was awarded LEED™ Gold Certification in 2002.

Team members (too numerous to fully list):

Mithun Architects

KEEN Engineering (Stantec)

Berger Partnership Landscape

Western Sun

2020 Engineering

Browne Engineering

IslandWood – Using the LEED™ System

A high LEED™ rating can be used as the basis for considering *extending performance to Zero Carbon.*

Need also to go "back to the basics" of:

- ✓Orientation
- ✓Climate
- ✓Passive solar design
- ✓Passive cooling
- ✓Daylighting
- ✓Low impact materials: low embodied energy, reclaimed, recycled
- ✓Minimization of site impact
- ✓Maximizing energy efficiency of envelope and building
- ✓Reduction of electricity usage
- ✓Minimizing need for additional fuel – maximizing on site renewables

IslandWood – Sustainable Sites
(9/14 possible points)

SS Prerequisite 1, Erosion & Sedimentation Control

SS Credit 1, Site Selection

SS Credit 4.1, Alternative Transportation, Public Transportation Access

SS Credit 4.2, Alternative Transportation, Bicycle Storage & Changing Rooms

SS Credit 4.4, Alternative Transportation, Parking Capacity

SS Credit 5.1, Reduced Site Disturbance, Protect or Restore Open Space

SS Credit 5.2, Reduced Site Disturbance, Development Footprint

SS Credit 6.2, Stormwater Management, Treatment

SS Credit 7.1, Landscape & Exterior Design to Reduce Heat Islands, Non-Roof

SS Credit 8, Light Pollution Reduction

Inference of reduced carbon emissions from personal transportation

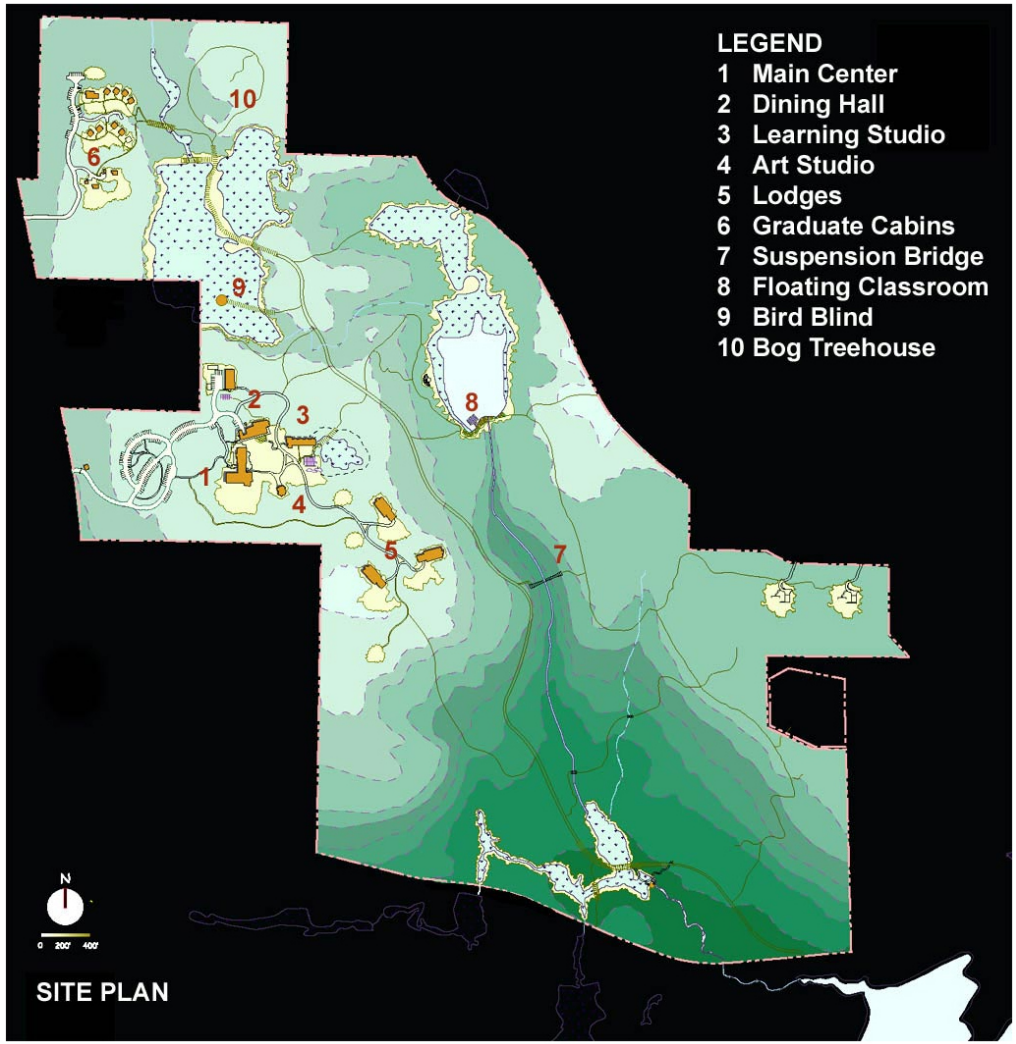
People, "Use" + Transportation

Inference of reduced carbon emissions from site disturbance and possible sequestration potential from restoration of green elements

Landscape + Site

IslandWood – Sustainable Sites
(9/14 possible points)

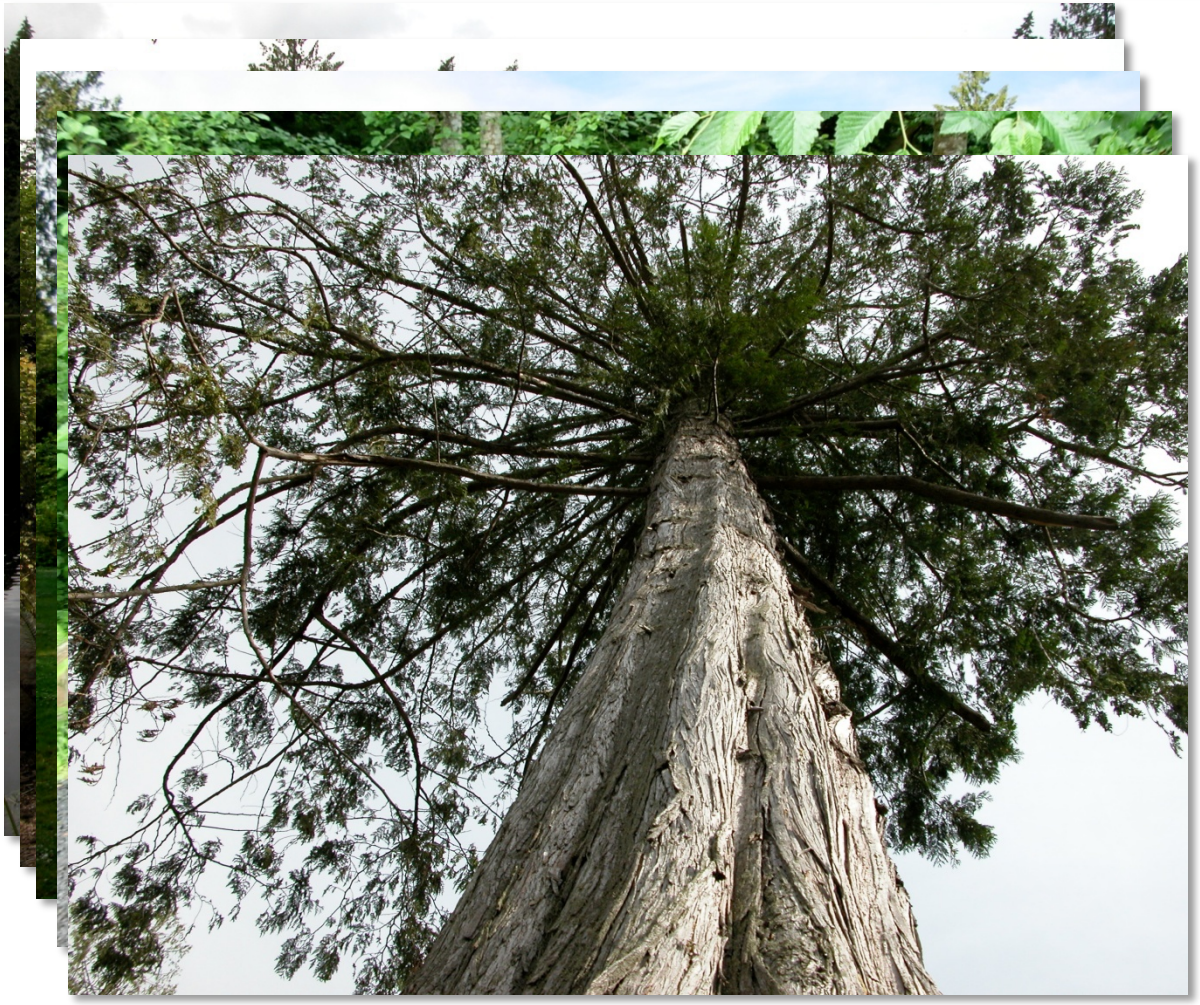
Overview map of the development showing topography and building clustering to ensure the minimum disruption and impact on the land.



http://www.designshare.com/index.php/projects/islandwood/images

IslandWood – Sustainable Sites
(9/14 possible points)

- Wetland was protected
- Building done on most degraded part of site
- Buildings were clustered to 3% of the site
- Parking was limited
- Pathways mostly pervious
- Landscape was considered to promote indigenous species



IslandWood – Energy and Atmosphere
(4/17 possible points)

EA Prerequisite 1, Fundamental Building Systems Commissioning

EA Prerequisite 2, Minimum Energy Performance

EA Prerequisite 3, CFC Reduction in HVAC&R Equipment

EA Credit 1.1a, Optimize Energy Performance, 15% New 5% Existing

EA Credit 1.1b, Optimize Energy Performance, 20% New 10% Existing

EA Credit 1.2a, Optimize Energy Performance, **25% New** 15% Existing

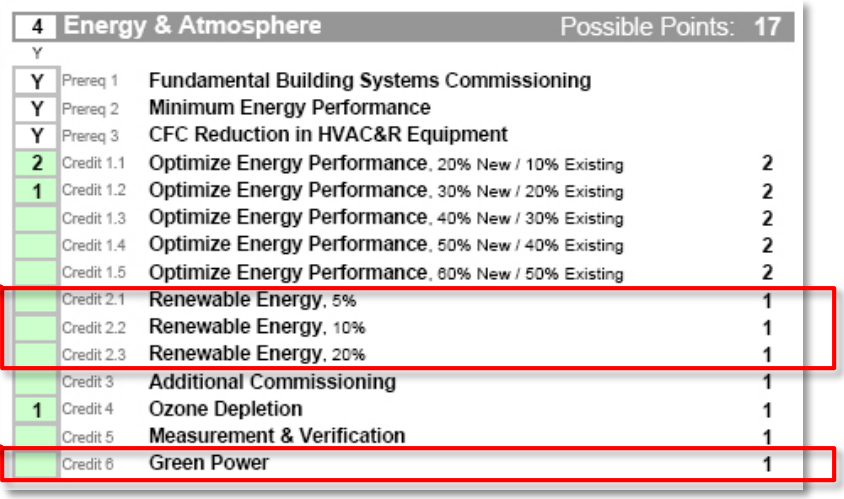
EA Credit 4, Ozone Depletion

Operating energy

Although there is PV on the building, it is not enough to earn any of these credits, so obviously not enough to satisfy a carbon neutral state

Renewables + Site Generation

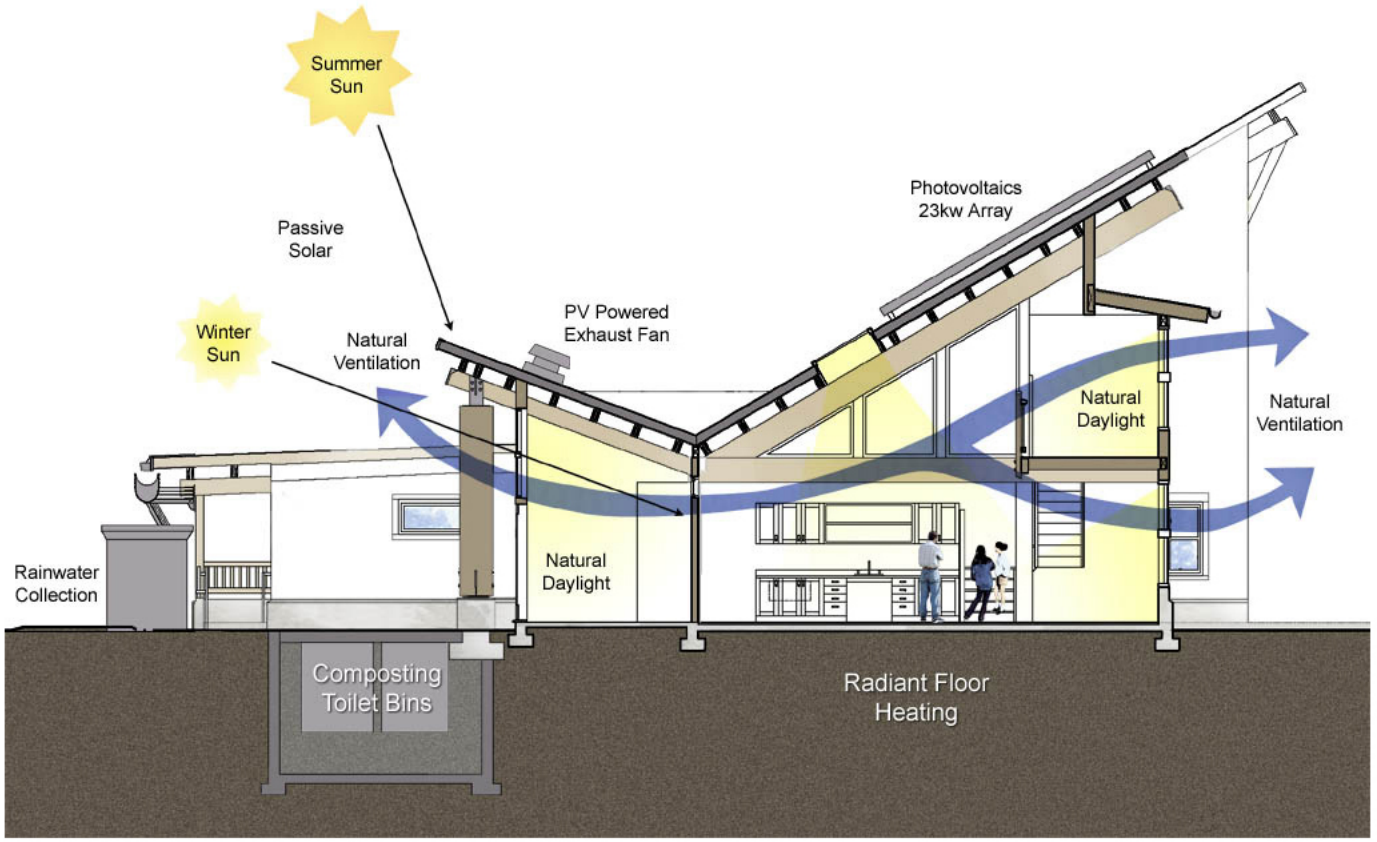
Not using Green Power indicates that electricity purchased *may* be from coal based sources



		Energy & Atmosphere	Possible Points: 17
Y			
Y	Prereq 1	Fundamental Building Systems Commissioning	
Y	Prereq 2	Minimum Energy Performance	
Y	Prereq 3	CFC Reduction in HVAC&R Equipment	
2	Credit 1.1	Optimize Energy Performance, 20% New / 10% Existing	2
1	Credit 1.2	Optimize Energy Performance, 30% New / 20% Existing	2
	Credit 1.3	Optimize Energy Performance, 40% New / 30% Existing	2
	Credit 1.4	Optimize Energy Performance, 50% New / 40% Existing	2
	Credit 1.5	Optimize Energy Performance, 60% New / 50% Existing	2
	Credit 2.1	Renewable Energy, 5%	1
	Credit 2.2	Renewable Energy, 10%	1
	Credit 2.3	Renewable Energy, 20%	1
	Credit 3	Additional Commissioning	1
1	Credit 4	Ozone Depletion	1
	Credit 5	Measurement & Verification	1
	Credit 6	Green Power	1

The building was designed to work with the Bioclimatic condition of Bainbridge Island. ***West Coast*** *(coastal)****Temperate.***

IslandWood –
Passive Design Strategies: Heating and Cooling



http://www.designshare.com/index.php/projects/islandwood/images

IslandWood – Energy and Atmosphere
(4/17 possible points)

- Exploration of passive heating systems
- Solar orientation, creation of “solar meadow” to ensure solar gain
- Large overhangs to prevent overheating
- Natural ventilation
- Solar hot water heating
- Photovoltaic panels

Although the appearance of the buildings gives the impression that its energy use might be as low as a Carbon Neutral Building, the numbers do not bear the same conclusion. ZERO Carbon is a number…

IslandWood – Water Efficiency
(5/5 possible points)

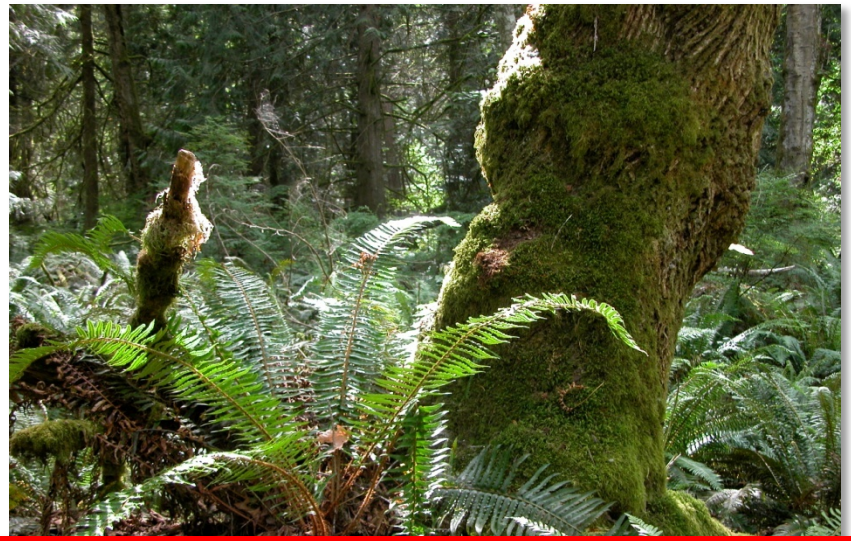
WE Credit 1.1, Water Efficient Landscaping, Reduce by 50%

WE Credit 1.2, Water Efficient Landscaping, No Potable Water Use or No Irrigation

WE Credit 2, Innovative Wastewater Technologies

WE Credit 3.1, Water Use Reduction, 20% Reduction

WE Credit 3.2, Water Use Reduction, 30% Reduction



There is a soft connection between Water Efficiency and Carbon Neutrality if you think of an associated reduction in the energy requirement to run systems (i.e. electricity for pumps)

IslandWood – Water Efficiency
(5/5 possible points)

- Rainwater collection from all roofs – use water for irrigation
- Composting toilets
- Waterless urinals and low flush toilets
- Living Machine to treat blackwater to tertiary level of purification

Statistics show that Water Efficiency credits have the highest percentage of buy in on LEED™ projects.

IslandWood – Materials and Resources
(7/13 possible points)

MR Prerequisite 1, Storage & Collection of Recyclables

MR Credit 2.1, Construction Waste Management, Divert 50%

MR Credit 2.2, Construction Waste Management, Divert 75%

MR Credit 3.1, Resource Reuse, Specify 5%

MR Credit 4.1, Recycled Content: 5% (post-consumer + 1/2 post-industrial)

MR Credit 5.1, Local/Regional Materials, 20% Manufactured Locally

MR Credit 5.2, Local/Regional Materials, of 20% Above, 50% Harvested Locally

MR Credit 7, Certified Wood

These credits address the embodied energy of materials which responds to future Carbon Neutral considerations when we go beyond Operating Energy

Embodied Carbon in Building Materials

IslandWood – Materials and Resources
(7/13 possible points)

- All timber cleared on site was milled into siding and furniture
- Buildings designed with exposed structural systems, including roof trusses, wood shear walls, and concrete slabs, eliminating need for interior finish materials
- Concrete with 50% flyash
- strawbale used for studio
- innovative recycled content “everywhere”

IslandWood – Indoor Environmental Quality
(12/15 possible points)

EQ Prerequisite 1, Minimum IAQ Performance

EQ Prerequisite 2, Environmental Tobacco Smoke (ETS) Control

EQ Credit 1, Carbon Dioxide (CO2) Monitoring

EQ Credit 2, Increase Ventilation Effectiveness

EQ Credit 3.1, Construction IAQ Management Plan, During Construction

EQ Credit 3.2, Construction IAQ Management Plan, Before Occupancy

EQ Credit 4.1, Low-Emitting Materials, Adhesives & Sealants

EQ Credit 4.2, Low-Emitting Materials, Paints

EQ Credit 4.3, Low-Emitting Materials, Carpet

EQ Credit 4.4, Low-Emitting Materials, Composite Wood

EQ Credit 5, Indoor Chemical & Pollutant Source Control

EQ Credit 6.1, Controllability of Systems, Perimeter

EQ Credit 7.1, Thermal Comfort, Comply with ASHRAE 55-1992

EQ Credit 8.2, Daylight & Views, Views for 90% of Spaces

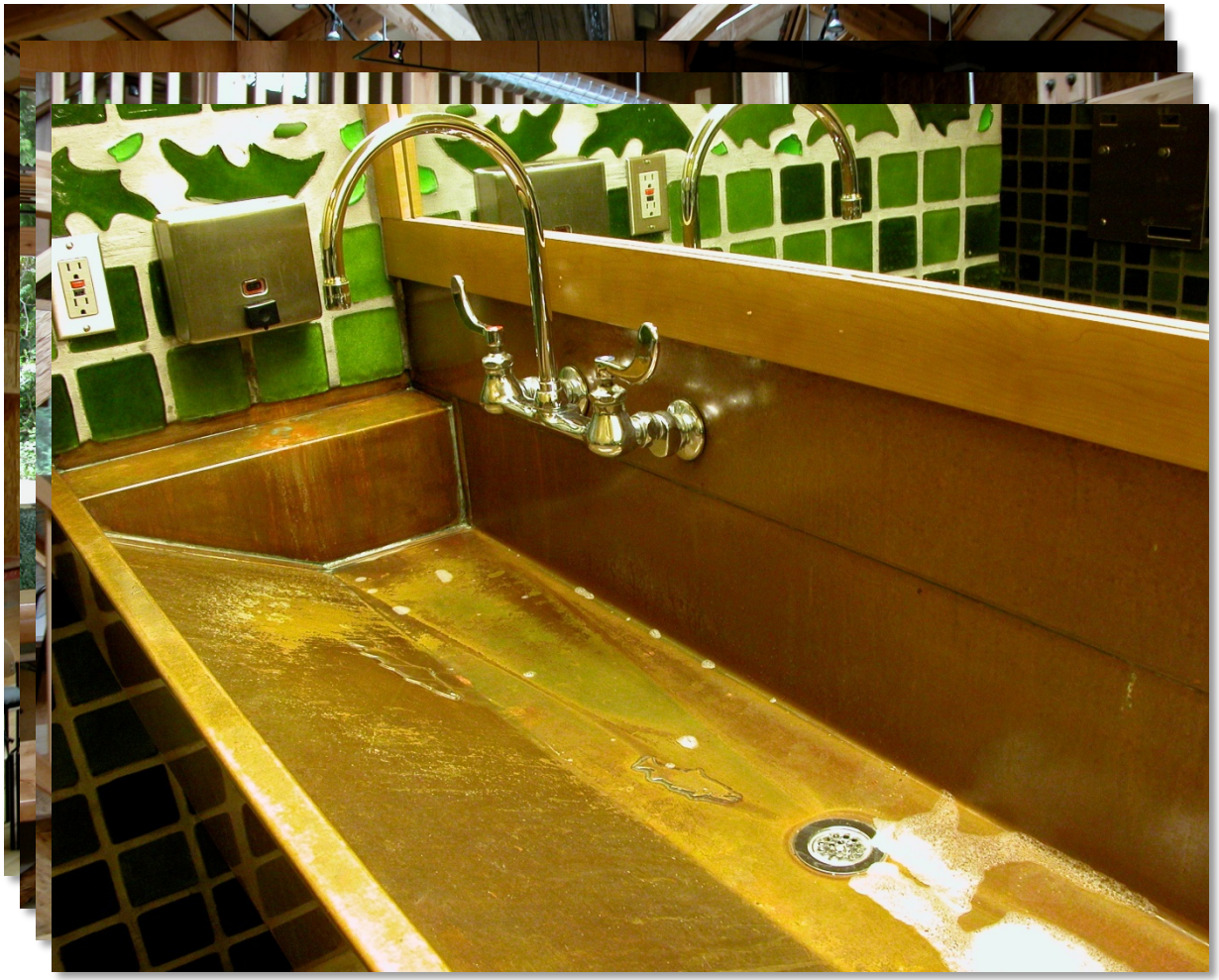
Operating energy

Daylighting has the potential to reduce the requirement for electricity IF used in conjunction with control systems

Daylit spaces at Islandwood

IslandWood – Indoor Environmental Quality
(12/15 possible points)

- All buildings are extensively daylit
- windows are operable
- extensive incorporation of low emitting materials



IslandWood – Innovation in Design Process
(3/5 possible points)

ID Credit 1.1, Innovation in Design "Environmental Education"

ID Credit 1.2, Innovation in Design "High Volume Fly Ash"

ID Credit 2, LEED® Accredited Professional

Carbon Neutrality could be used to gain an Innovation Credit or Multiple Innovation Credits if you exceed the maximum expectations in a number of credit areas.

Existing Carbon Neutral/Zero Energy Buildings

Zero Energy Buildings

Using the Database

Search by Project Name

Search by Owner

Search by Location

Search by Energy Data

Search by Building Type & Size

List All Projects

Detailed Search

The Zero Energy Buildings Database features profiles of commercial buildings that produce as much energy as they use over the course of a year. Learn more about the types of zero energy buildings. This database highlights projects from across the country and provides ideas that can be applied to any new building.

The Zero Energy Buildings Database is part of the High Performance Buildings Database which lists many additional projects. Visit the High Performance Buildings Database to discover more energy efficient building techniques.

To find out more about the zero energy buildings listed below, simply click the name of a project to view in-depth information about the design and construction process, financing, energy use, materials, indoor environment, and more.

Displaying 10 project(s) in the table below. (click here for help).

	Picture	Name	Owner	Location	Building Type	Floor Area (ft²)	Annual Purchased Energy (kBtu/ft²)
☐		Aldo Leopold Legacy Center	The Aldo Leopold Foundation, Inc.	Baraboo, WI	Commercial office; Interpretive Center	11,900	-2.02
☐		Audubon Center at Debs Park	The National Audubon Society	Los Angeles, CA	Recreation; Interpretive Center; Park	5,020	
☐		Challengers Tennis Club	Whittier Foundation	Los Angeles, CA	Recreation	3,500	-0.0955
☐		Environmental Tech. Center, Sonoma State	Sonoma State University	Rohnert Park, CA	Higher education; Laboratory	2,200	-1.47
☐		Hawaii Gateway Energy Center	Natural Energy Laboratory of Hawaii Authority (NELHA)	Kailua-Kona, HI	Commercial office; Interpretive Center; Assembly; Other	3,600	-3.46
☐		IDeAs Z2 Design Facility	David and Stephania Kaneda	San Jose, CA	Commercial office	6,560	-0.00052
☐		Net zero house— Charlotte,VT	David Pill	Charlotte, VT	Single-family residential	2,970	
☐		Oberlin College Lewis Center	Oberlin College	Oberlin, OH	Higher education; Library; Assembly; Campus	13,600	-4.23
☐		Science House	Science Museum of Minnesota	St. Paul, MN	Interpretive Center	1,530	0
☐		TD Bank - Cypress Creek Store	TD Bank, N.A.	Ft Lauderdale, FL	Retail	3,970	

10 project(s)

The list on http://zeb.buildinggreen.com/ sits at 10 projects.

Aldo Leopold Legacy Center

Baraboo, Wisconsin

The Kubala Washatko Architects
LEED™ Platinum 2007

Technical information from Prof. Michael Utzinger, University of Wisconsin-Milwaukee

Aldo Leopold Center LEED™ Analysis

12/14 Sustainable Sites

5/5 Water Efficiency

17/17 Energy and Atmosphere

7/13 Materials and Resources

15/15 Indoor Environmental Quality

5/5 Innovation and Design Process

61/69 Total

For more detailed info on the Leopold Center, visit

http://www.aldoleopold.org/legacycenter/carbonneutral.html

and

http://leedcasestudies.usgbc.org/overview.cfm?ProjectID=946

Operating Energy of Building

80% of the problem!

Landscape + Site

Disturbance vs. sequestration

Embodied Carbon in Building Materials

People, “Use” + Transportation

Renewables + Site Generation

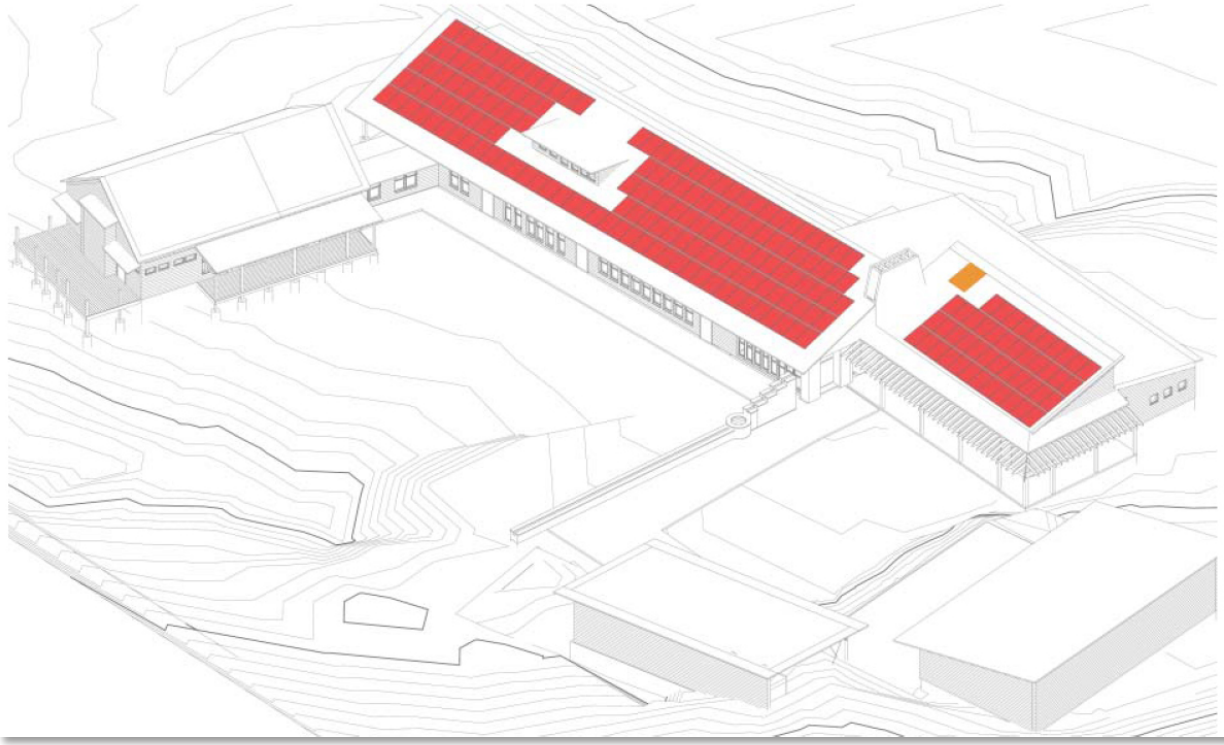
Counting Carbon costs….

+ purchased offsets

Leopold Approach to Carbon Neutral Design

- **Design a Net Zero (Operating Energy) Building**
- **Apply Carbon Balance to Building Operation (Ignore Carbon Emissions due to Construction)**
- **Include Carbon Sequestration in Forests Managed by Aldo Leopold Foundation**
- **Design to LEED™ Platinum (as well)**
- **with 2 unique starting points…**

#1 - Net Zero Energy Design



SOLAR PV DENSITY
(conditioned s.f.)
4.66 Watt / SF

SOLAR THERMAL DENSITY
(conditioned s.f.)
.012 SF / SF

Renewables + Site Generation

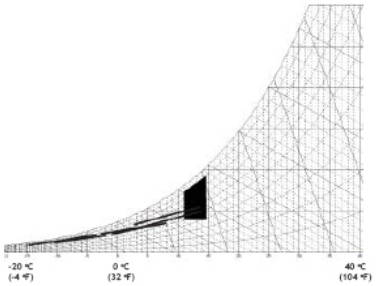
A $US250,000 PV array was included at the outset of the project budget and the building was designed to operate within the amount of electricity that this would generate.

#2 - Site Harvested Lumber:

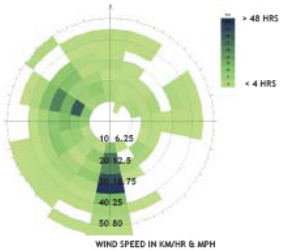
Embodied Carbon in Building Materials

The building was designed around the size and quantity of lumber that could be sustainably harvested from the Leopold Forest.

Climate Analysis



HEATING SEASON: OCT. - APR.

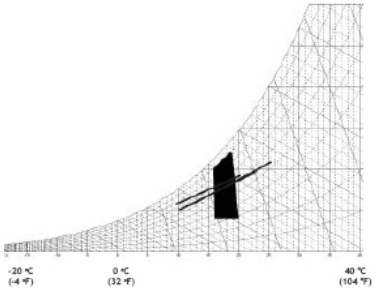


HEATING SEASON MONTH: JANUARY

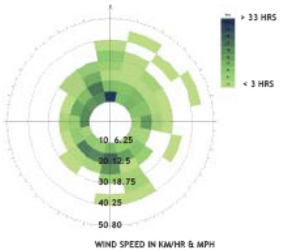
Climate Narrative

Source: NOAA Weather Data Files

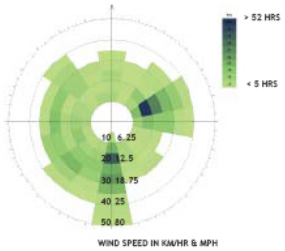
The climate is typical of the continental interior of North America with a large annual temperature range and with frequent short period temperature changes. The range of extreme temperatures is from about 43 to -40 degrees Celsius (110 to -40 degrees Fahrenheit). Winter temperatures (December-February) average near -7 °C (20 °F) and the summer average (June-August) is around 20 °C (in the upper 60s °F). Daily temperatures average below 0 °C (32 °F) about 120 days and above 4 °C (40 °F) for about 210 days of the year.



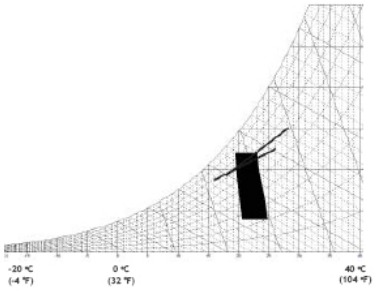
SWING SEASONS: MAY - JUN., SEP.



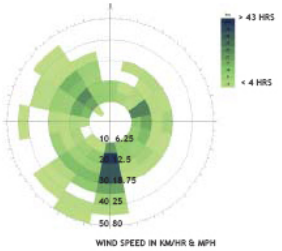
SWING MONTH: SEPTEMBER



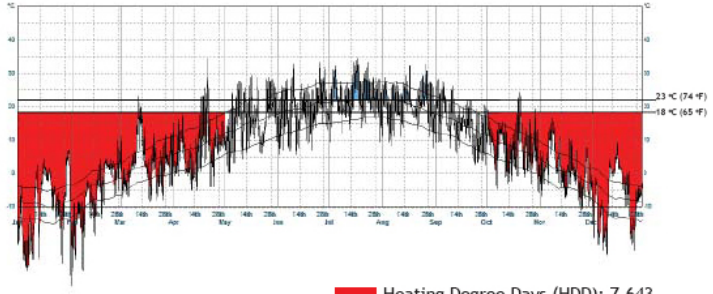
SWING MONTH: MAY



COOLING SEASON: JUL. - AUG.



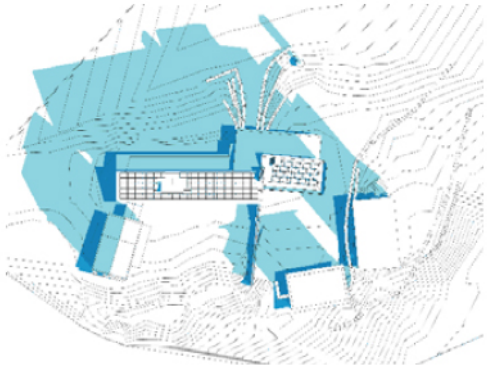
COOLING SEASON MONTH: JULY



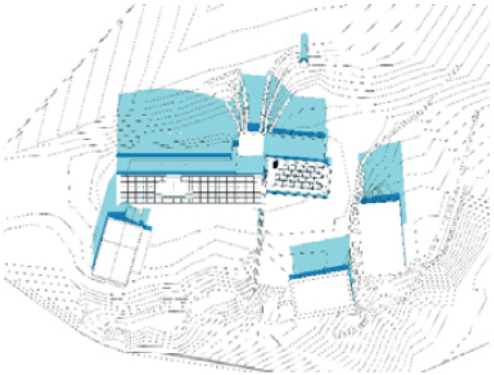
DAILY TEMPERATURE

Heating Degree Days (HDD): 7,643
Cooling Degree Days (CDD): 139

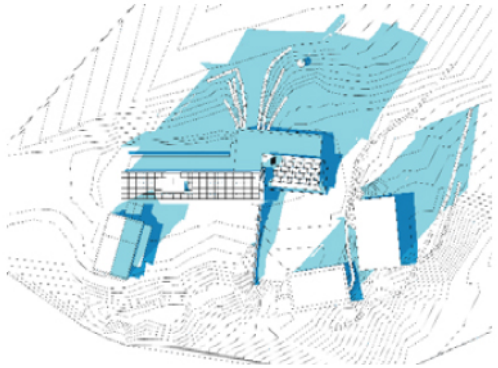
Site Analysis



9:00 am



Noon

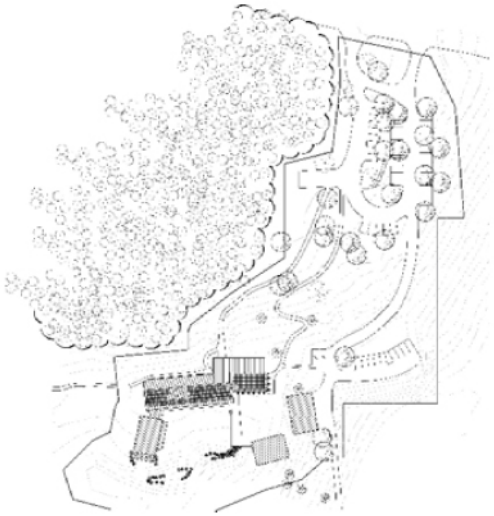


3:00 pm

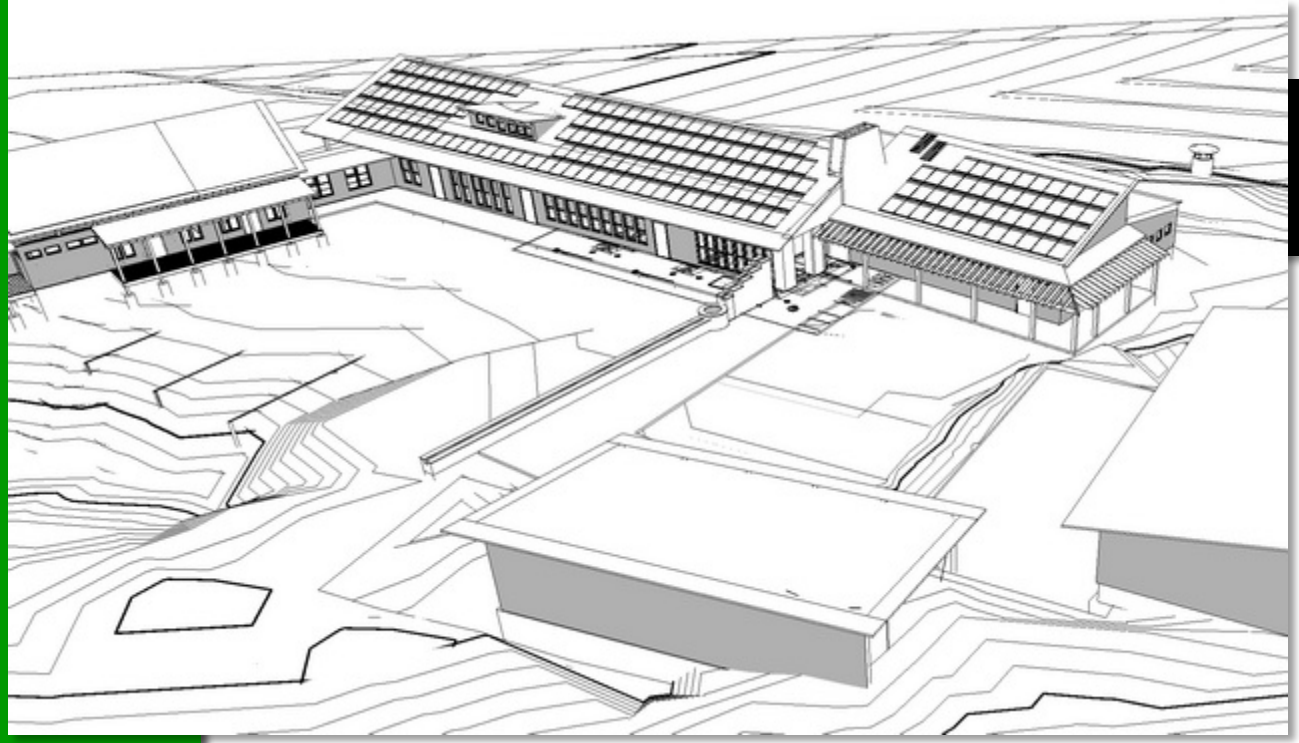
Site Shading Study

June 21
December 21

Ariel Image from South
Source: _____



N



The South elevation is designed to capture energy.

The North elevation is designed for thermal resistance, daylighting and ventilation.

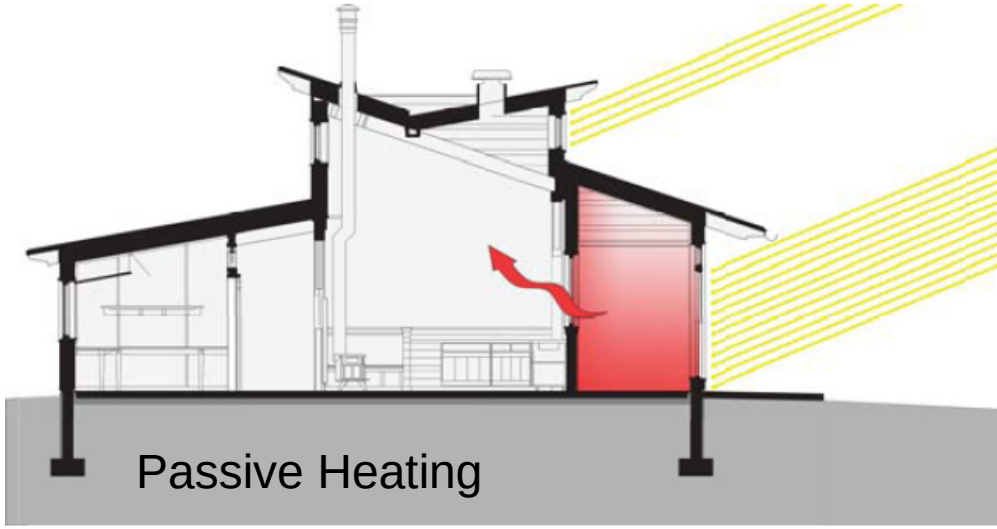
The buildings were arranged in a U shape around a solar meadow that ensured access

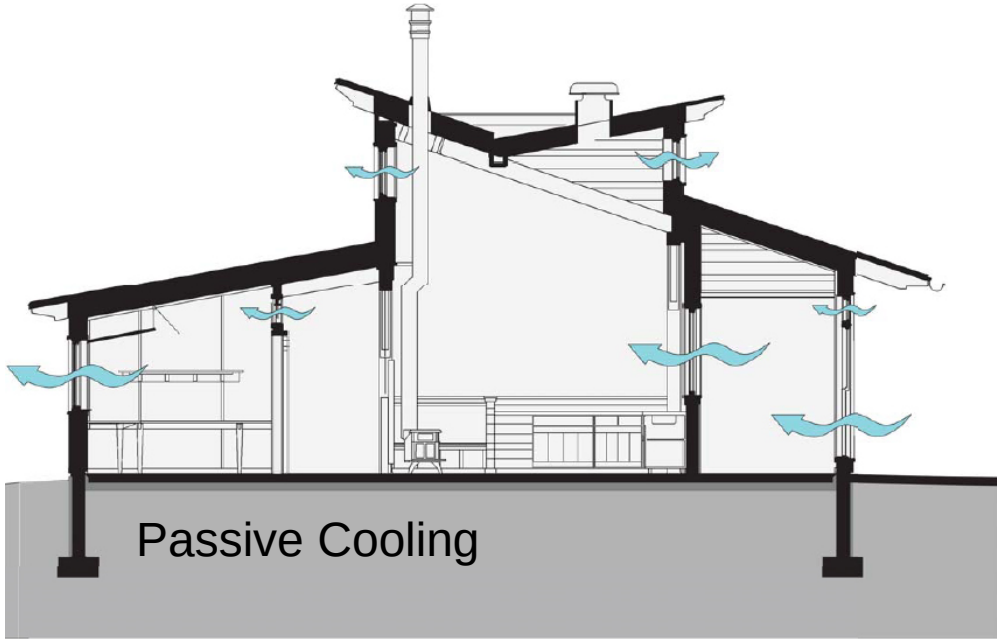
Three Season Hall

A large room designed NOT to be used in the winter when the weather is too severe to allow heating by a combination of passive + fireplace

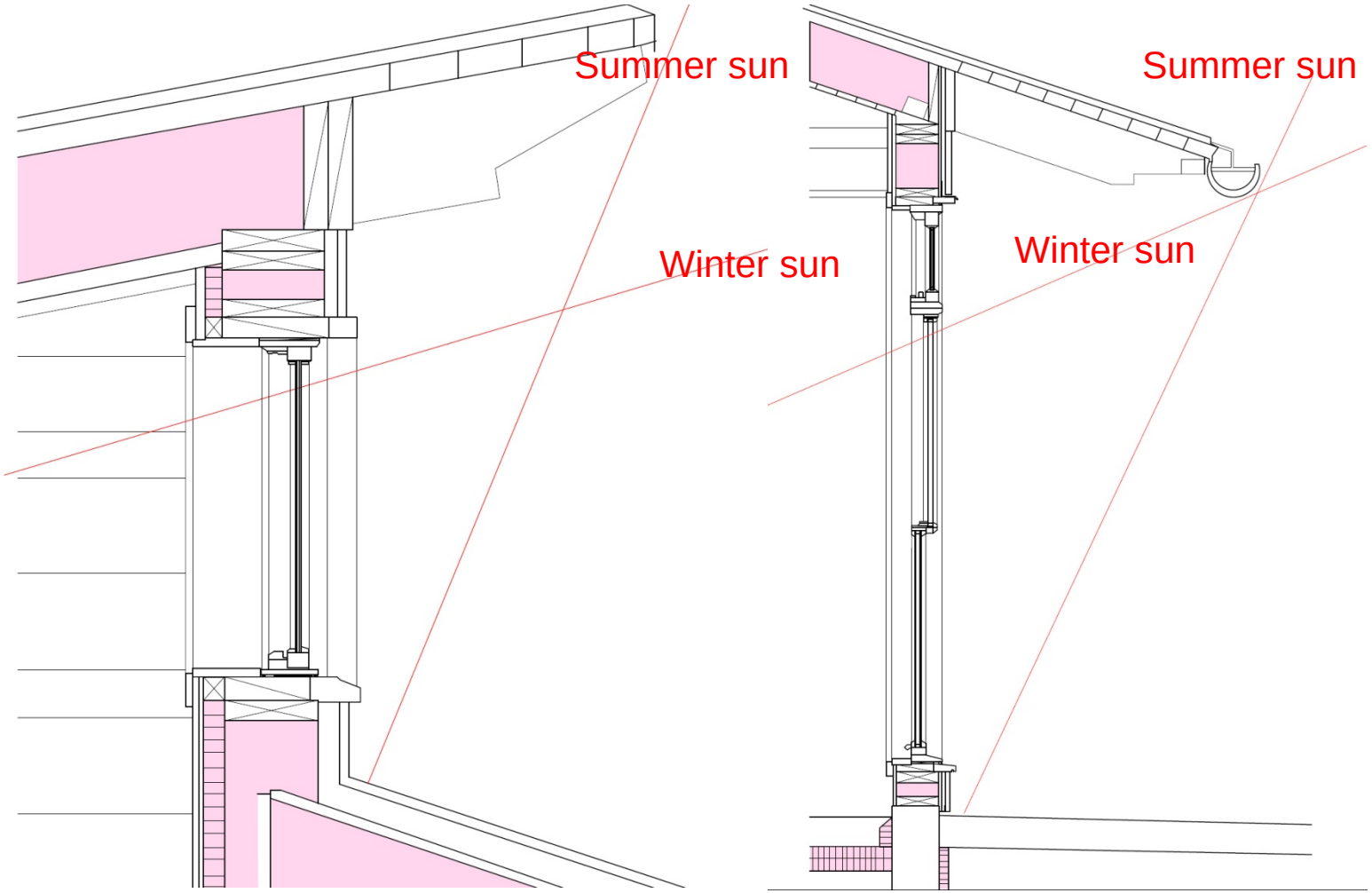
Architectural Design Strategies

- Start with bioclimatic design
- Program Thermal Zones
- All perimeter zones (no interior zones – skin load dominated building)
- Daylight all occupied zones
- Natural ventilation in all occupied zones
- Double code insulation levels
- Passive solar heating
- Shade windows during summer





Passive Cooling:
Shade Windows During Summer



Basic first tier principle of HEAT AVOIDANCE.

Radiant Heating and Cooling

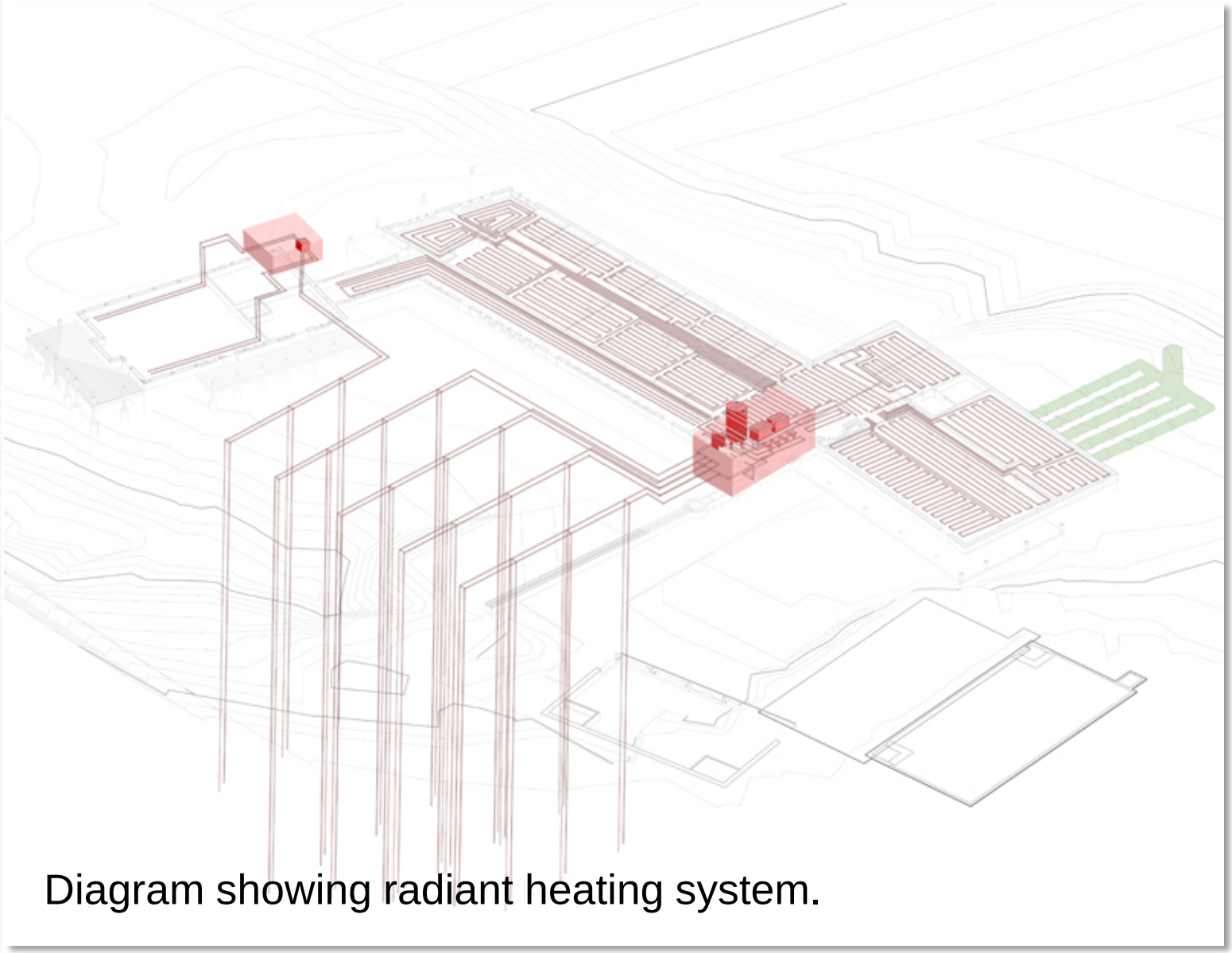


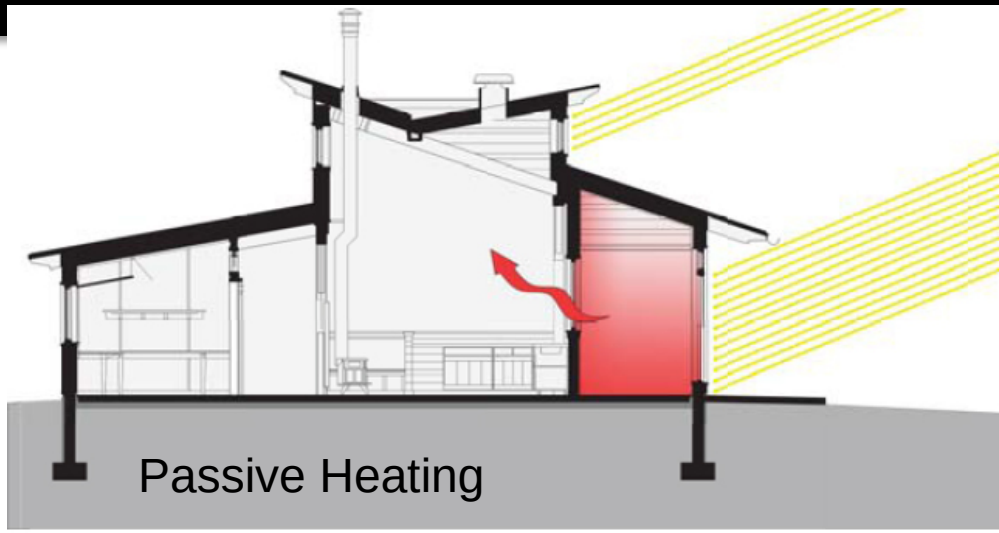
Diagram showing radiant heating system.

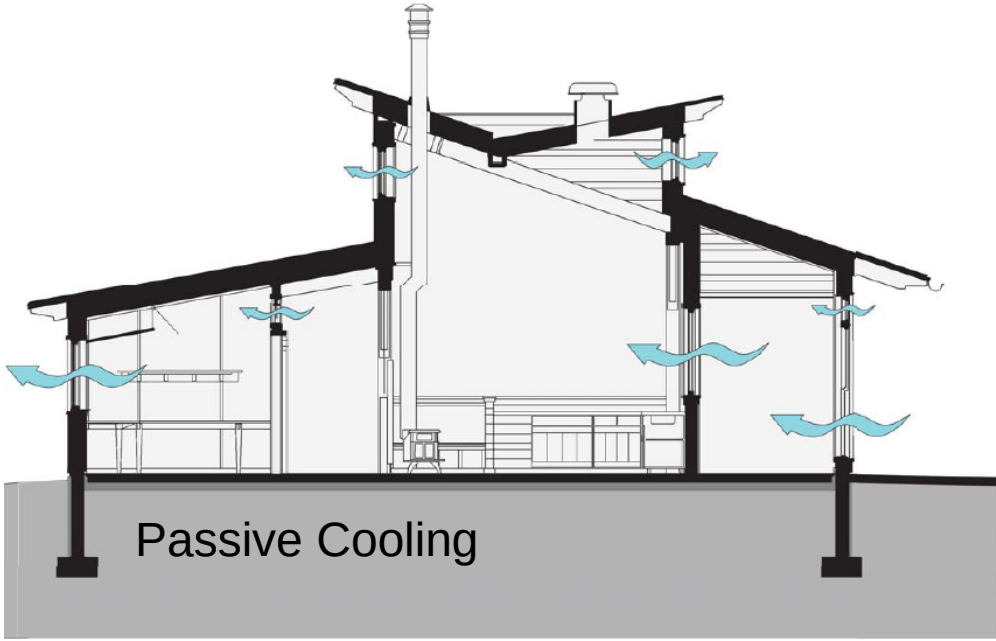
Ground Source Heat Pumps

Super insulate hot water runs to minimize heat losses.

Architectural Design Strategies

- Start with bioclimatic design
- Program Thermal Zones
- All perimeter zones (no interior zones – skin load dominated building)
- Daylight all occupied zones
- Natural ventilation in all occupied zones
- Double code insulation levels
- Passive solar heating
- Shade windows during summer





Energy and Atmosphere, 17 of 17 possible points:
EA Credit 1

EA Prerequisite 1, Fundamental Building Systems Commissioning

EA Prerequisite 2, Minimum Energy Performance

EA Prerequisite 3, CFC Reduction in HVAC&R Equipment

EA Credit 1.1a, Optimize Energy Performance, 15% New 5% Existing

EA Credit 1.1b, Optimize Energy Performance, 20% New 10% Existing

EA Credit 1.2a, Optimize Energy Performance, 25% New 15% Existing

EA Credit 1.2b, Optimize Energy Performance, 30% New 20% Existing

EA Credit 1.3a, Optimize Energy Performance, 35% New 25% Existing

EA Credit 1.3b, Optimize Energy Performance, 40% New 30% Existing

EA Credit 1.4a, Optimize Energy Performance, 45% New 35% Existing

EA Credit 1.4b, Optimize Energy Performance, 50% New 40% Existing

EA Credit 1.5a, Optimize Energy Performance, 55% New 45% Existing

EA Credit 1.5b, Optimize Energy Performance, 60% New 50% Existing

Operating energy

EA Credit 2.1, Renewable Energy, 5%

EA Credit 2.2, Renewable Energy, 10%

EA Credit 2.3, Renewable Energy, 20%

EA Credit 3, Additional Commissioning

EA Credit 4, Ozone Depletion

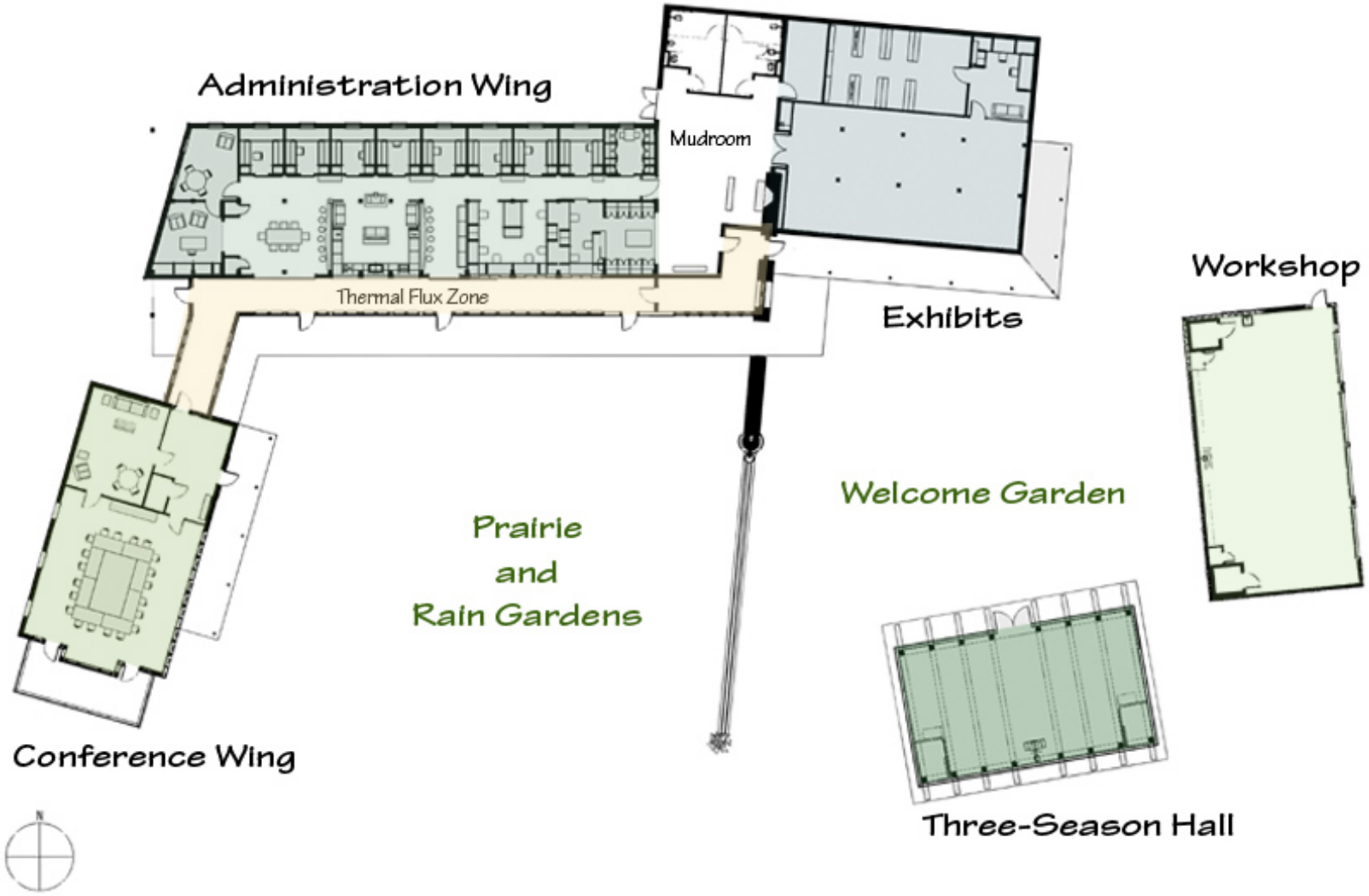
EA Credit 5, Measurement and Verification

EA Credit 6, Green Power

OPTIMIZE = REDUCTION

This needs to be the main area of focus for low Carbon design.

Thermal Zones ~ Perimeter Zones

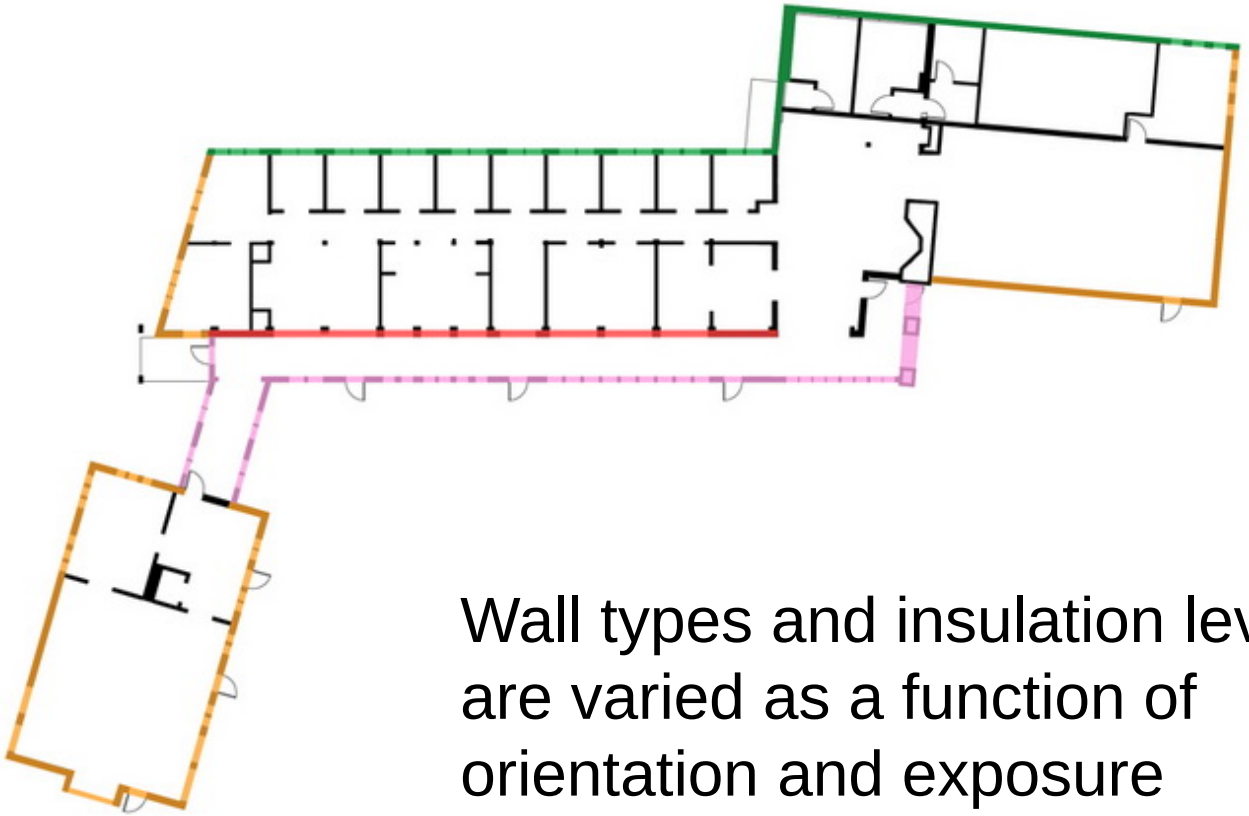


Keep the buildings thin to allow for maximum daylight and use of solar for passive heating with operable windows to make natural ventilation work.

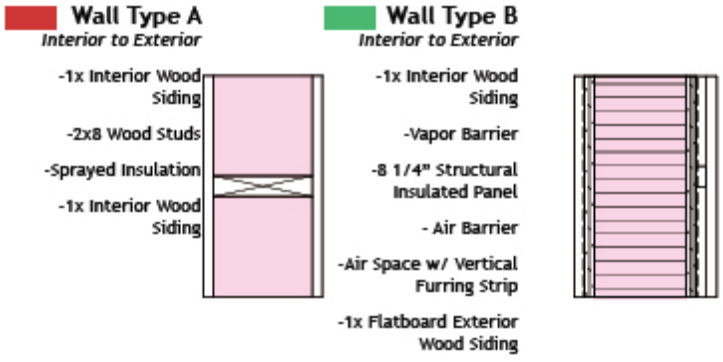
Passive Solar Heating

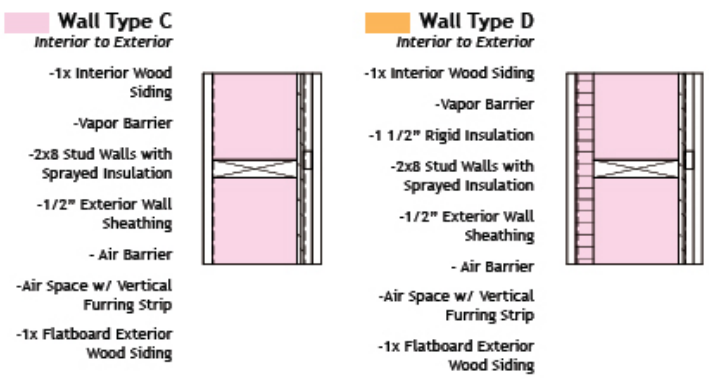
- The concrete floor in the hall is used with direct gain to store heat
- Large doors are opened to allow transfer to occupied spaces

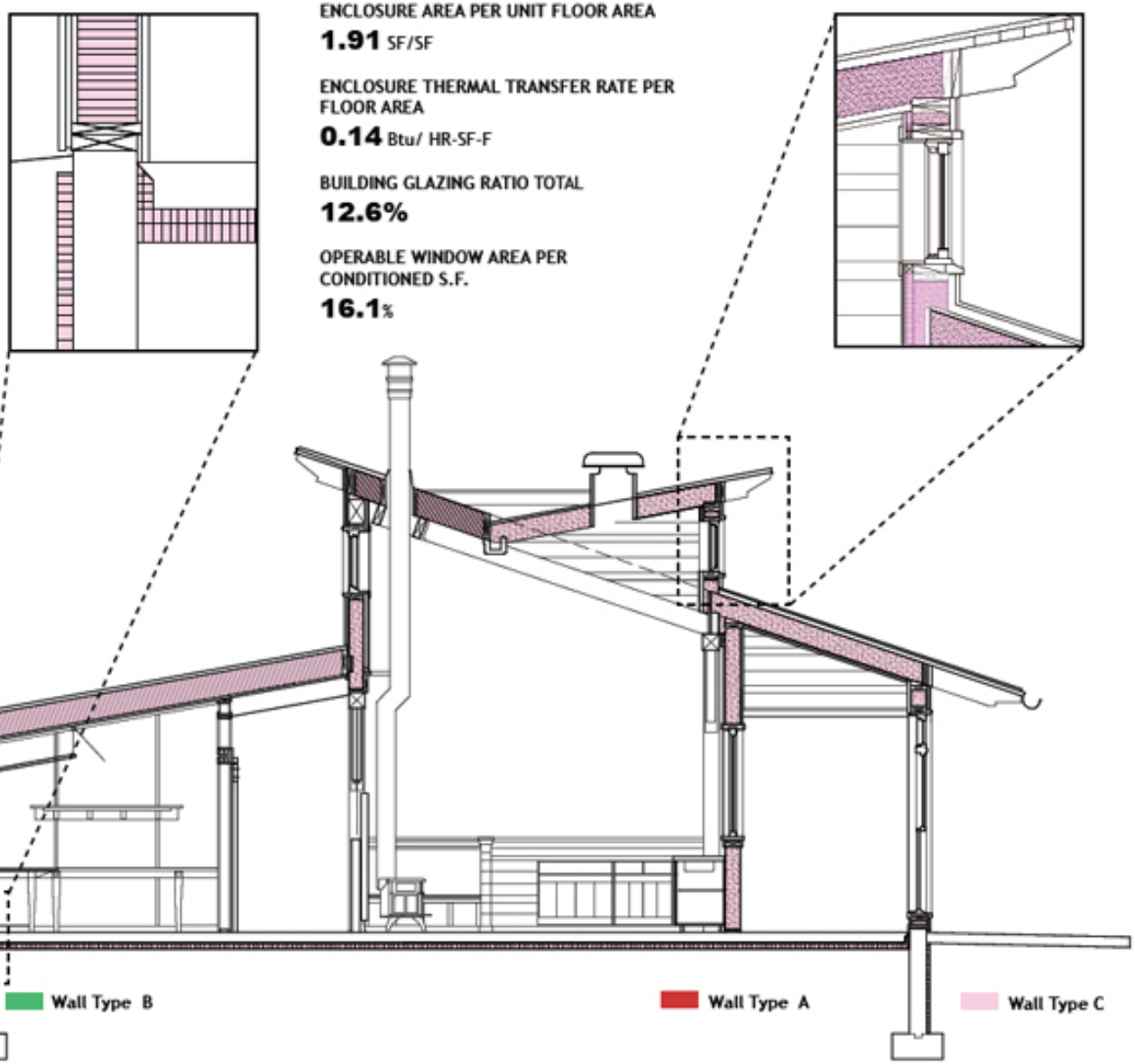
Daytime

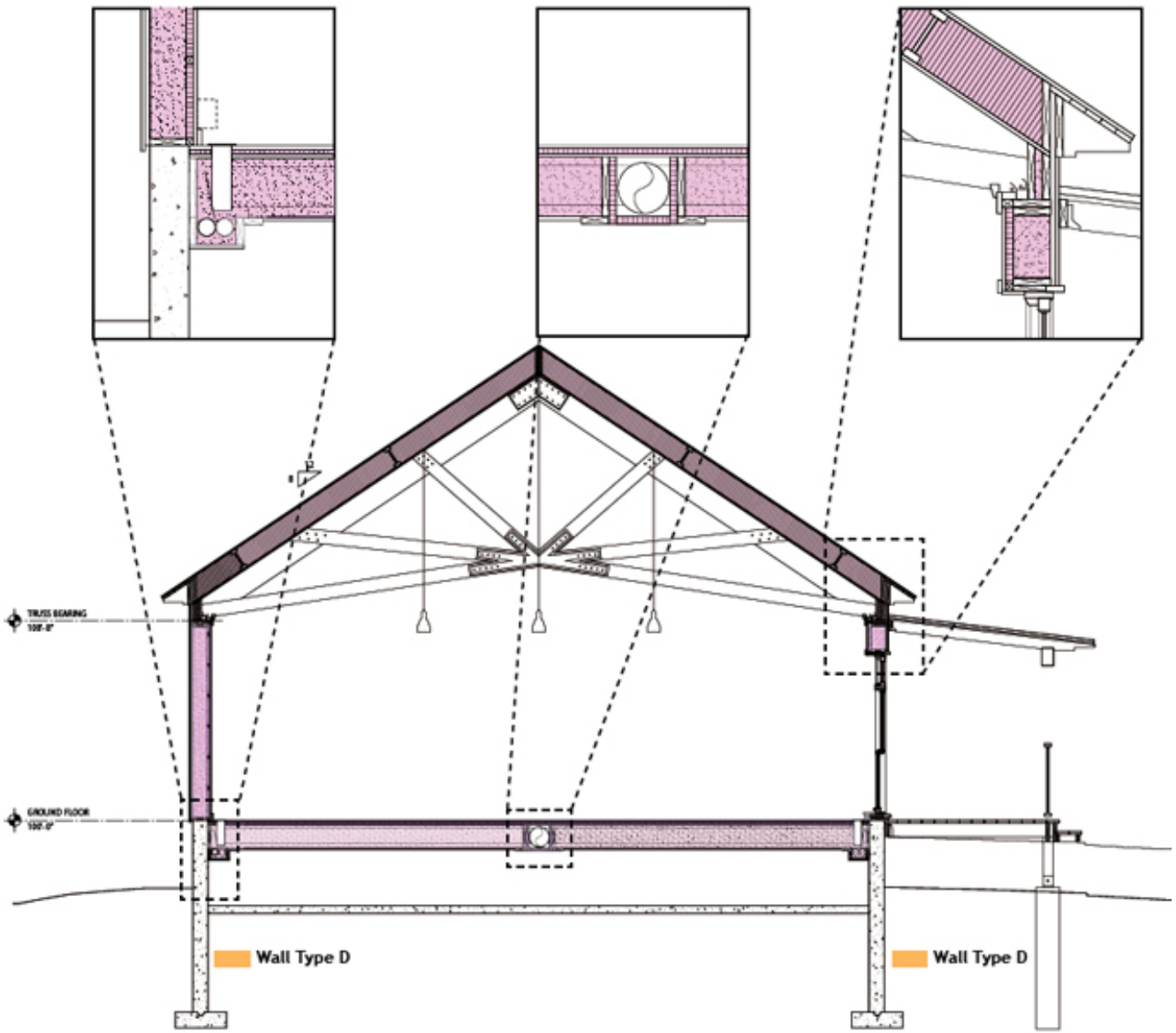


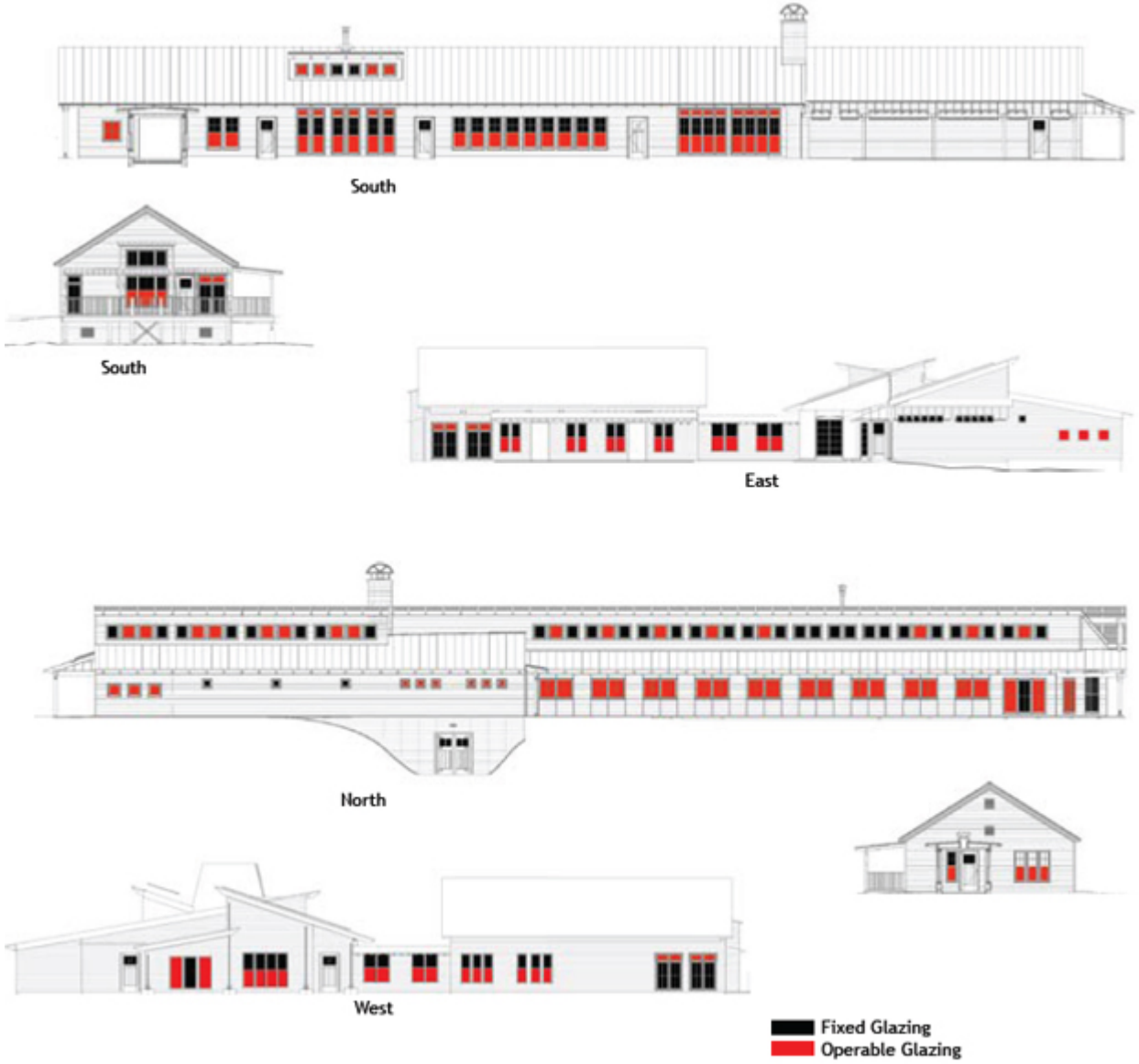
Wall types and insulation levels are varied as a function of orientation and exposure





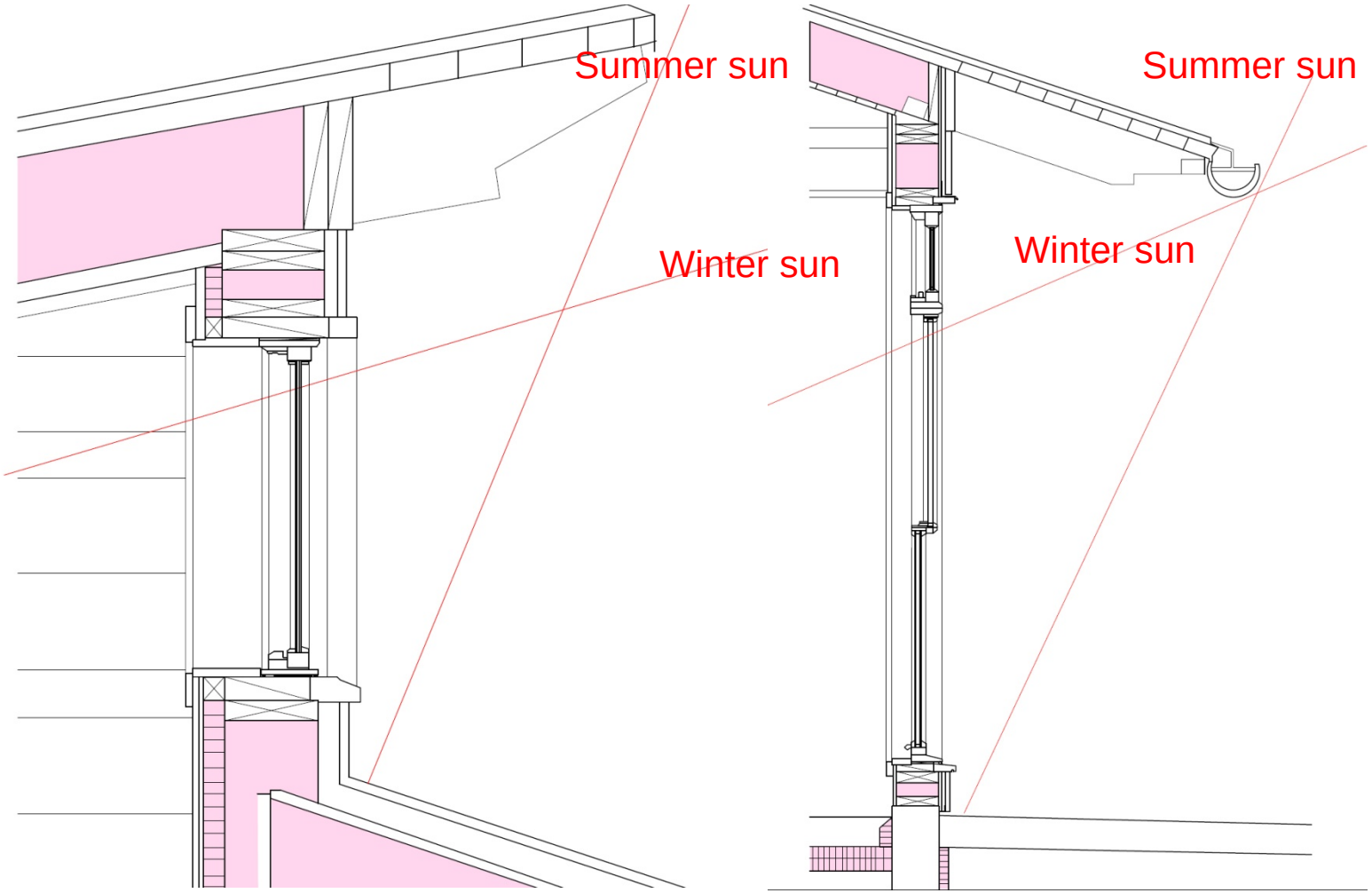

ENCLOSURE AREA PER UNIT FLOOR AREA
1.91 SF/SF
ENCLOSURE THERMAL TRANSFER RATE PER FLOOR AREA
0.14 Btu/ HR-SF-F
BUILDING GLAZING RATIO TOTAL
12.6%
OPERABLE WINDOW AREA PER CONDITIONED S.F.
16.1%
Wall Type B
Wall Type A
Wall Type C


TRUSS BEARING
GROUND FLOOR
Wall Type D
Wall Type D

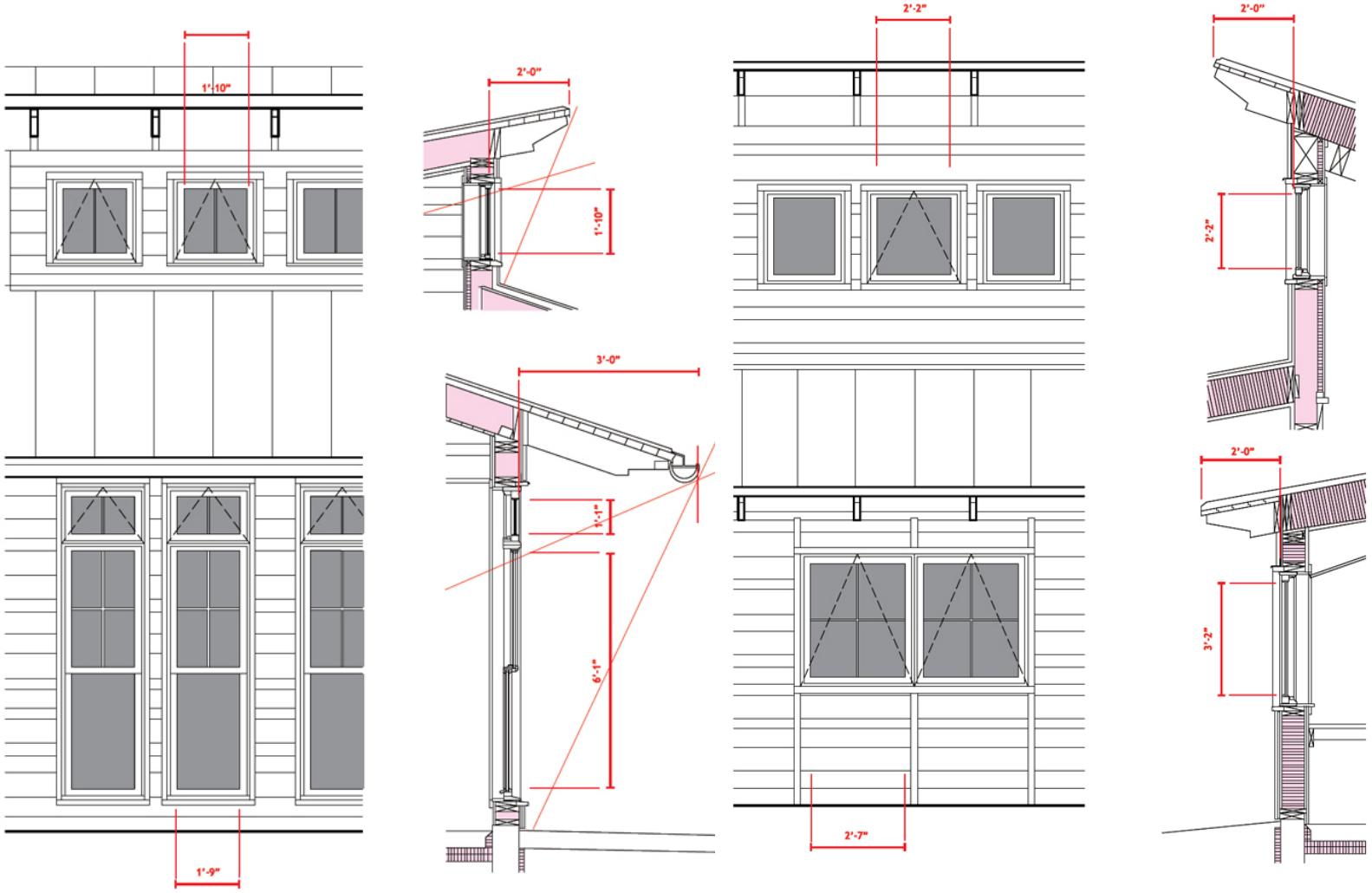


Glazing study for fixed vs operable and orientation

Passive Cooling: Shade Windows During Summer



Basic first tier principle of HEAT AVOIDANCE.



Facades are fine tuned for orientation – overhang length and window size varies

Natural Ventilation

- Natural ventilation strategy based on NO A/C provision for the building
- Operable windows
- Flow through strategy
- Insect screens to keep out pests

Energy and Atmosphere, 17 of 17 possible points:
EA Credit 2 and Credit 6

EA Prerequisite 1, Fundamental Building Systems Commissioning

EA Prerequisite 2, Minimum Energy Performance

EA Prerequisite 3, CFC Reduction in HVAC&R Equipment

EA Credit 1.1a, Optimize Energy Performance, 15% New 5% Existing

EA Credit 1.1b, Optimize Energy Performance, 20% New 10% Existing

EA Credit 1.2a, Optimize Energy Performance, 25% New 15% Existing

EA Credit 1.2b, Optimize Energy Performance, 30% New 20% Existing

EA Credit 1.3a, Optimize Energy Performance, 35% New 25% Existing

EA Credit 1.3b, Optimize Energy Performance, 40% New 30% Existing

EA Credit 1.4a, Optimize Energy Performance, 45% New 35% Existing

EA Credit 1.4b, Optimize Energy Performance, 50% New 40% Existing

EA Credit 1.5a, Optimize Energy Performance, 55% New 45% Existing

EA Credit 1.5b, Optimize Energy Performance, 60% New 50% Existing

EA Credit 2.1, Renewable Energy, 5%

EA Credit 2.2, Renewable Energy, 10%

EA Credit 2.3, Renewable Energy, 20%

EA Credit 3, Additional Commissioning

EA Credit 4, Ozone Depletion

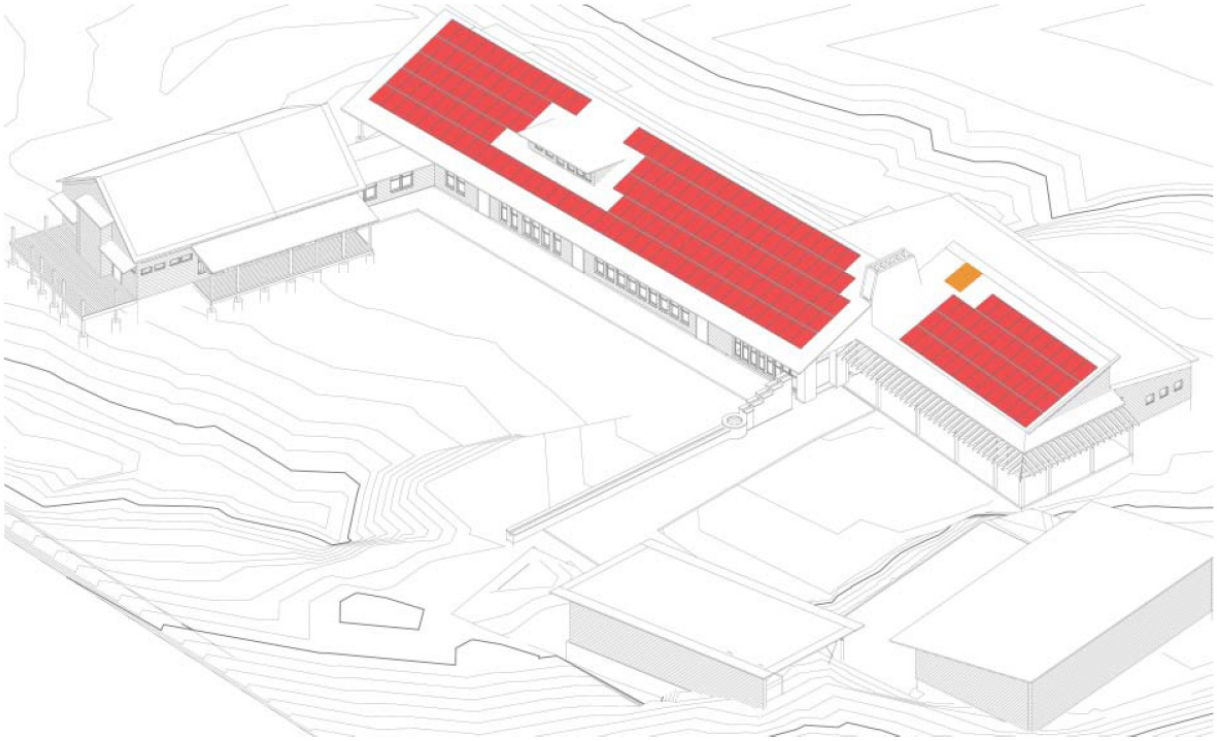
EA Credit 5, Measurement and Verification

EA Credit 6, Green Power

Renewables + Site Generation

If Optimization has not been exhausted, it is very unlikely that Renewable Energy will be adequate to power the mechanical systems.

#1 - Net Zero Energy Design



SOLAR PV DENSITY
(conditioned s.f.)
4.66 Watt / SF

SOLAR THERMAL DENSITY
(conditioned s.f.)
.012 SF / SF

Renewables + Site Generation

A $US250,000 PV array was included at the outset of the project budget and the building was designed to operate within the amount of electricity that this would generate.

Almost every square inch of roof was used for PV and solar hot water array mounting.

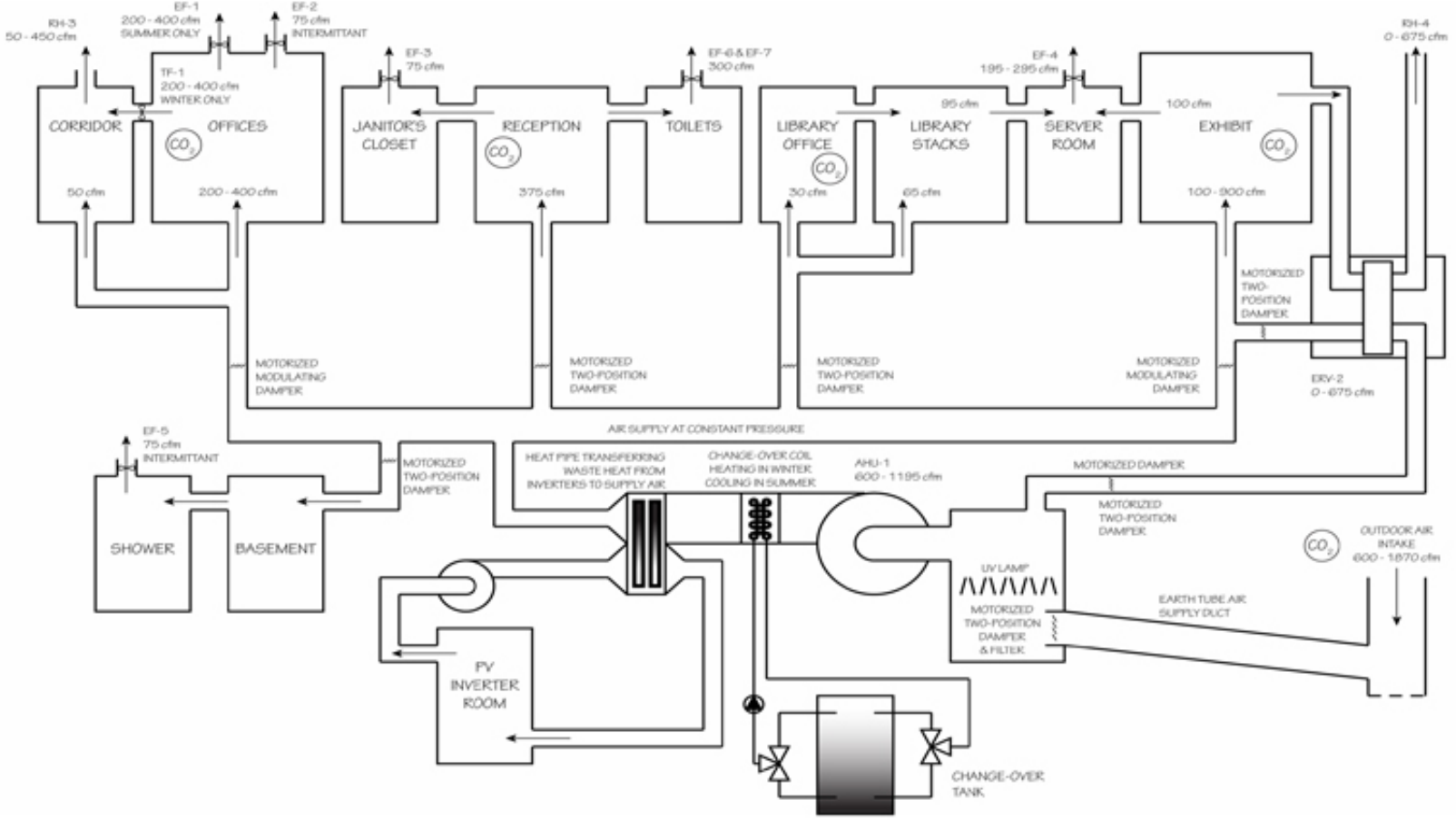
Ground Source Heat Pumps

Super insulate hot water runs to minimize heat losses.

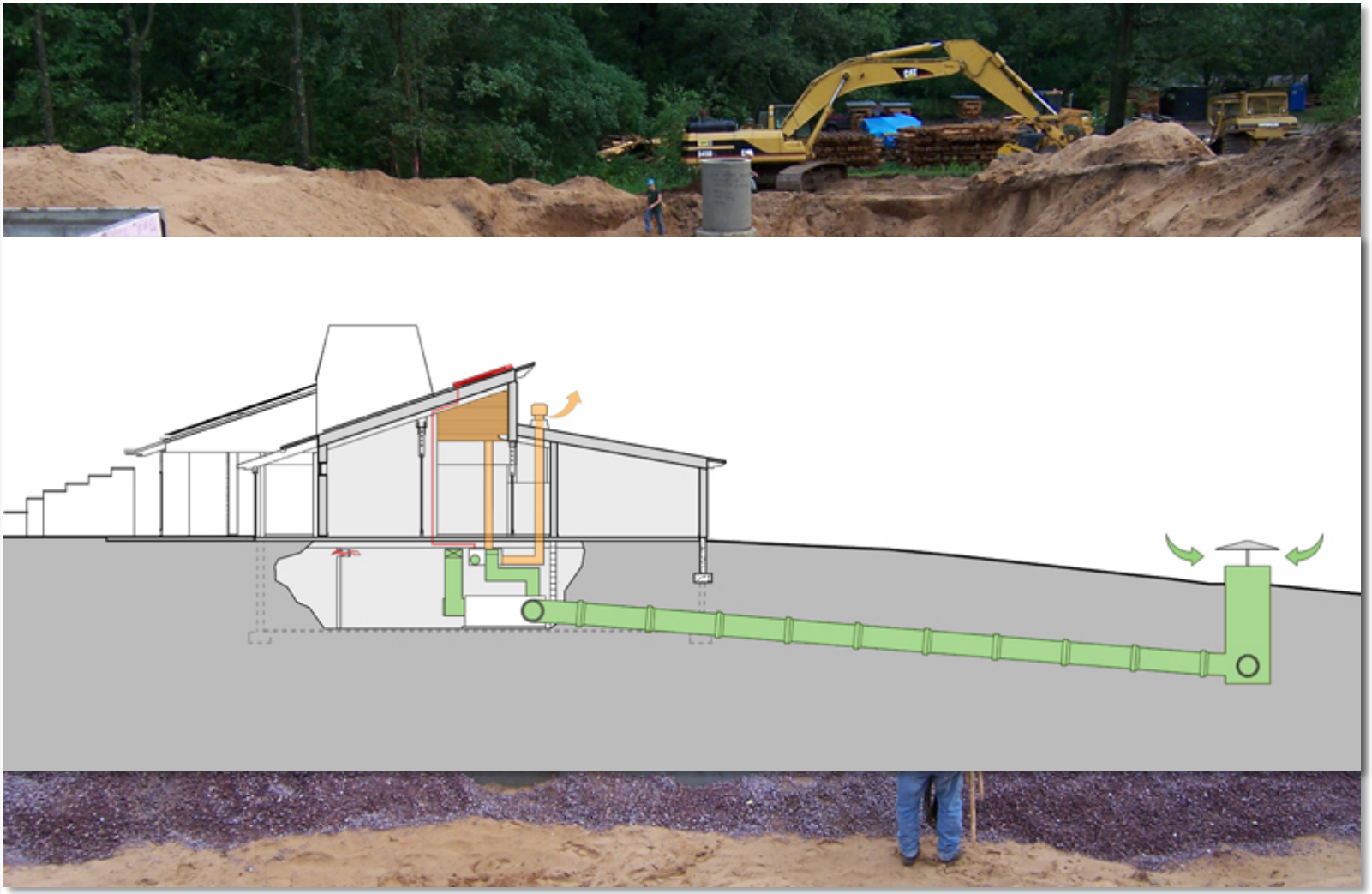
HVAC Strategies

- Ventilate only to Occupant outdoor air requirements (2/3 ACH)
- 100% Outdoor air (no recirculation)
- Earth tube air pretreatment
- Demand Control Ventilation (600 to 2,500 cfm)
- Separate ventilation from heating and cooling
- Radiant floor slabs for heating and cooling
- Use ground as heat source & sink (ground source heat pumps)
- Storage tank as thermal capacitor between heat pumps & load
- Seasonal change-over system
- Solar heated service hot water

Ventilation System



Earth Duct for Air Pretreatment



Installation of large earth ducts to preheat and precool the air.

Sustainable Sites, 12 of 14 possible points:
SS Credit 3

Landscape + Site

SS Prerequisite 1, Erosion & Sedimentation Control

SS Credit 1, Site Selection

SS Credit 3, Brownfield Redevelopment

SS Credit 4.2, Alternative Transportation, Bicycle Storage & Changing Rooms

SS Credit 4.3, Alternative Transportation, Alternative Fuel Refueling Stations

SS Credit 4.4, Alternative Transportation, Parking Capacity

SS Credit 5.1, Reduced Site Disturbance, Protect or Restore Open Space

SS Credit 5.2, Reduced Site Disturbance, Development Footprint

SS Credit 6.1, Stormwater Management, Rate and Quantity

SS Credit 6.2, Stormwater Management, Treatment

SS Credit 7.1, Landscape & Exterior Design to Reduce Heat Islands, Non-Roof

SS Credit 7.2, Landscape & Exterior Design to Reduce Heat Islands, Roof

SS Credit 8, Light Pollution Reduction

Greening an existing brownfield can add plant materials to a site that are capable of sequestering carbon.

Sustainable Sites, 12 of 14 possible points:
SS Credit 4

People, "Use" + Transportation

SS Prerequisite 1, Erosion & Sedimentation Control

SS Credit 1, Site Selection

SS Credit 3, Brownfield Redevelopment

SS Credit 4.2, Alternative Transportation, Bicycle Storage & Changing Rooms

SS Credit 4.3, Alternative Transportation, Alternative Fuel Refueling Stations

SS Credit 4.4, Alternative Transportation, Parking Capacity

SS Credit 5.1, Reduced Site Disturbance, Protect or Restore Open Space

SS Credit 5.2, Reduced Site Disturbance, Development Footprint

SS Credit 6.1, Stormwater Management, Rate and Quantity

SS Credit 6.2, Stormwater Management, Treatment

SS Credit 7.1, Landscape & Exterior Design to Reduce Heat Islands, Non-Roof

SS Credit 7.2, Landscape & Exterior Design to Reduce Heat Islands, Roof

SS Credit 8, Light Pollution Reduction

Alternative transportation reduces the GHG associated with travel to and from the building.

Sustainable Sites, 12 of 14 possible points:
SS Credit 5

SS Prerequisite 1, Erosion & Sedimentation Control

SS Credit 1, Site Selection

SS Credit 3, Brownfield Redevelopment

SS Credit 4.2, Alternative Transportation, Bicycle Storage & Changing Rooms

SS Credit 4.3, Alternative Transportation, Alternative Fuel Refueling Stations

SS Credit 4.4, Alternative Transportation, Parking Capacity

SS Credit 5.1, Reduced Site Disturbance, Protect or Restore Open Space

SS Credit 5.2, Reduced Site Disturbance, Development Footprint

SS Credit 6.1, Stormwater Management, Rate and Quantity

SS Credit 6.2, Stormwater Management, Treatment

SS Credit 7.1, Landscape & Exterior Design to Reduce Heat Islands, Non-Roof

SS Credit 7.2, Landscape & Exterior Design to Reduce Heat Islands, Roof

SS Credit 8, Light Pollution Reduction

Landscape + Site

These credits can add plant materials to a site that are capable of sequestering carbon or repair existing natural landscape. Disturbance of the soil releases carbon into the atmosphere.

Sustainable Sites, 12 of 14 possible points:
SS Credit 7

SS Prerequisite 1, Erosion & Sedimentation Control

SS Credit 1, Site Selection

SS Credit 3, Brownfield Redevelopment

SS Credit 4.2, Alternative Transportation, Bicycle Storage & Changing Rooms

SS Credit 4.3, Alternative Transportation, Alternative Fuel Refueling Stations

SS Credit 4.4, Alternative Transportation, Parking Capacity

SS Credit 5.1, Reduced Site Disturbance, Protect or Restore Open Space

SS Credit 5.2, Reduced Site Disturbance, Development Footprint

SS Credit 6.1, Stormwater Management, Rate and Quantity

SS Credit 6.2, Stormwater Management, Treatment

SS Credit 7.1, Landscape & Exterior Design to Reduce Heat Islands, Non-Roof

SS Credit 7.2, Landscape & Exterior Design to Reduce Heat Islands, Roof

SS Credit 8, Light Pollution Reduction

Heat island reduction lowers summer temperatures and reduces cooling load. *(Impossible to quantify…)* If plantings are used to do this, they can sequester carbon as well.

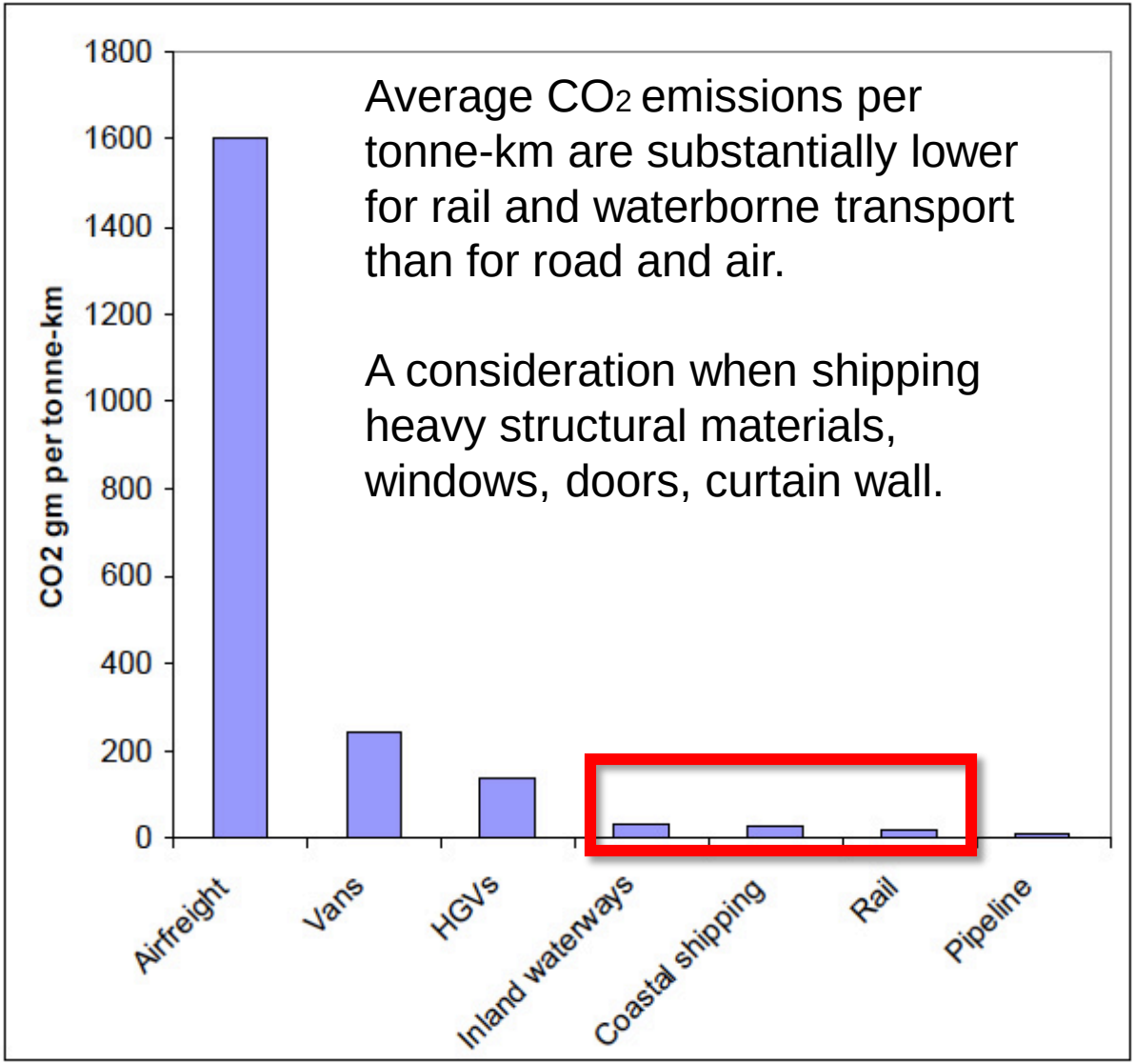
Material choice matters.

- **Material choice can reduce your building's *embodied* carbon footprint.**
- Where did the material come from?
- Is it local?
- Did it require a lot of energy to extract it or to get it to your building?
- Can it be replaced at the source?
- Was it recycled or have significant post consumer recycled content?
- Can it be recycled or reused *easily;* i.e. with minimal additional energy?
- Is the material durable or will it need to be replaced *(lifecycle analysis)?*
- **Select the right material for the right end use**

Foster's GLA – may claim to be high performance, but it uses many high energy materials.

Green on the Grand, Canada's first C-2000 building chose to import special windows from a distance rather than employ shading devices to control solar gain and glare.

Transportation choice matters.



Average CO_2 emissions per tonne-km are substantially lower for rail and waterborne transport than for road and air.

A consideration when shipping heavy structural materials, windows, doors, curtain wall.

Materials and Resources, 7 of 13 possible points:
MR Credit 4

Embodied Carbon in Building Materials

MR Prerequisite 1, Storage & Collection of Recyclables

MR Credit 2.1, Construction Waste Management, Divert 50%

MR Credit 2.2, Construction Waste Management, Divert 75%

MR Credit 4.1, Recycled Content: 5% (post-consumer + 1/2 post-industrial)

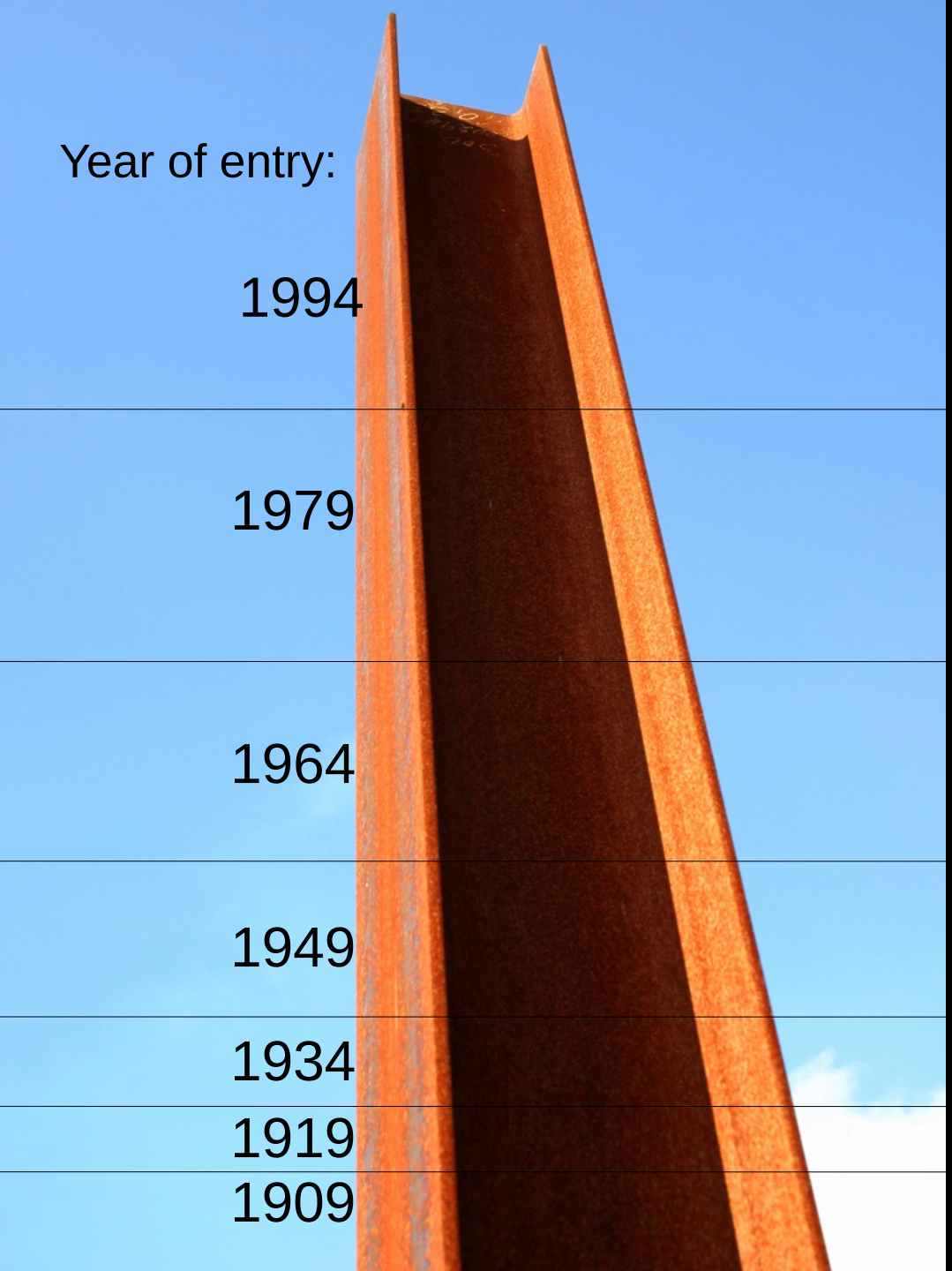
MR Credit 4.2, Recycled Content: 10% (post-consumer + 1/2 post-industrial)

MR Credit 5.1, Local/Regional Materials, 20% Manufactured Locally

MR Credit 5.2, Local/Regional Materials, of 20% Above, 50% Harvested Locally

MR Credit 7, Certified Wood

Many of the MR credits will impact embodied carbon but it is not currently part of the calculation.



The Life of Steel:

Year of entry:		1st life as:
1994	1	Cars
1979	2	Appliances
1964	3	Cans
1949	4	Chairs
1934	5	Building
1919	6	Tanks
1909	7	Bridge

Credit: Sylvie Boulanger CISC

Materials and Resources, 7 of 13 possible points:
MR Credit 5

Embodied Carbon in Building Materials

MR Prerequisite 1, Storage & Collection of Recyclables

MR Credit 2.1, Construction Waste Management, Divert 50%

MR Credit 2.2, Construction Waste Management, Divert 75%

MR Credit 4.1, Recycled Content: 5% (post-consumer + 1/2 post-industrial)

MR Credit 4.2, Recycled Content: 10% (post-consumer + 1/2 post-industrial)

People, "Use" + Transportation

MR Credit 5.1, Local/Regional Materials, 20% Manufactured Locally

MR Credit 5.2, Local/Regional Materials, of 20% Above, 50% Harvested Locally

MR Credit 7, Certified Wood

The Leopold Foundation had a most unusual circumstance, owning their own Forest. However it is not that difficult to source materials locally.

Materials and Resources, 7 of 13 possible points:
MR Credit 7

Embodied Carbon in Building Materials

MR Prerequisite 1, Storage & Collection of Recyclables

MR Credit 2.1, Construction Waste Management, Divert 50%

MR Credit 2.2, Construction Waste Management, Divert 75%

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MR Credit 5.1, Local/Regional Materials, 20% Manufactured Locally

MR Credit 5.2, Local/Regional Materials, of 20% Above, 50% Harvested Locally

MR Credit 7, Certified Wood

Simply using wood is thought to be helpful in GHG as wood sequesters carbon. But this only makes sense if wood is the best or most local choice. Other materials may work better for different building types, uses, Fire code restrictions, etc.

#2 - Site Harvested Lumber:

Embodied Carbon in Building Materials

The building was designed around the size and quantity of lumber that could be sustainably harvested from the Leopold Forest.

Reuse to reduce impact

- Reuse of a building, part of a building or elements reduces the carbon impact by avoidance of using new materials.

- Make the changes necessary to improve the operational carbon footprint of an old building, before building new.

- Is there an existing building or Brownfield site that suits your needs?

- Can you adapt a building or site with minimal change?

- Design for disassembly (Dfd) and eventual reuse to offset future carbon use

The School of Architecture at Waterloo is a reused factory on a remediated Brownfield site.

All of the wood cladding at the YMCA Environmental Learning Center, Paradise Lake, Ontario was salvaged from the demolition of an existing building.

Materials and Resources, other opportunities
MR Credit 1

People, "Use" + Transportation

MR 1.1 **Building Reuse:** Maintain 75% of Existing Walls, Floors, and Roof
MR1.2 **Building Reuse:** Maintain 95% of Existing Walls, Floors, and Roof
MR1.3 **Building Reuse:** Maintain 50% of Interior Non-Structural Elements

Embodied Carbon in Building Materials

- Reuse SIGNIFICANT building elements in order to reduce the need for extraction and processing of new materials
- This saves a significant amount of embodied carbon
- This also saves associated transportation energy as all of this material does not need to be transported to the building site (again)

Materials and Resources, other opportunities
MR Credit 3

MR Credit 3.1 Resource Reuse 5%

MR Credit 3.2 Resource Reuse 10%

Embodied Carbon in Building Materials

- Reuse materials in order to reduce the need for extraction and processing of new materials
- This is very helpful in the reuse of demolished structures
- Structural steel can be easily reused
- Wood can be reused for flooring

Indoor Environmental Quality, 15 of 15 possible points:
EQ Prerequisite 2

EQ Prerequisite 1, Minimum IAQ Performance

EQ Prerequisite 2, Environmental Tobacco Smoke (ETS) Control

EQ Credit 1, Carbon Dioxide (CO_2) Monitoring

EQ Credit 2, Increase Ventilation Effectiveness

EQ Credit 3.1, Construction IAQ Management Plan, During Construction

EQ Credit 3.2, Construction IAQ Management Plan, Before Occupancy

EQ Credit 4.1, Low-Emitting Materials, Adhesives & Sealants

EQ Credit 4.2, Low-Emitting Materials, Paints

EQ Credit 4.3, Low-Emitting Materials, Carpet

EQ Credit 4.4, Low-Emitting Materials, Composite Wood

EQ Credit 5, Indoor Chemical & Pollutant Source Control

EQ Credit 6.1, Controllability of Systems, Perimeter

EQ Credit 6.2, Controllability of Systems, Non-Perimeter

EQ Credit 7.1, Thermal Comfort, Comply with ASHRAE 55-1992

EQ Credit 7.2, Thermal Comfort, Permanent Monitoring System

EQ Credit 8.1, Daylight & Views, Daylight 75% of Spaces

EQ Credit 8.2, Daylight & Views, Views for 90% of Spaces

COMMON SENSE

This requirement presents a huge impediment in Foreign countries.

Indoor Environmental Quality, 15 of 15 possible points:
EQ Credit 8

EQ Prerequisite 1, Minimum IAQ Performance

EQ Prerequisite 2, Environmental Tobacco Smoke (ETS) Control

EQ Credit 1, Carbon Dioxide (CO2) Monitoring

EQ Credit 2, Increase Ventilation Effectiveness

EQ Credit 3.1, Construction IAQ Management Plan, During Construction

EQ Credit 3.2, Construction IAQ Management Plan, Before Occupancy

EQ Credit 4.1, Low-Emitting Materials, Adhesives & Sealants

EQ Credit 4.2, Low-Emitting Materials, Paints

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Passive Lighting Strategies:

- use energy efficient light fixtures (and effectively!)
- use occupant sensors *combined with light level sensors*
- aim to only have lights switch on only when daylight is insufficient
- provide electricity via renewable means: wind, PV, CHP

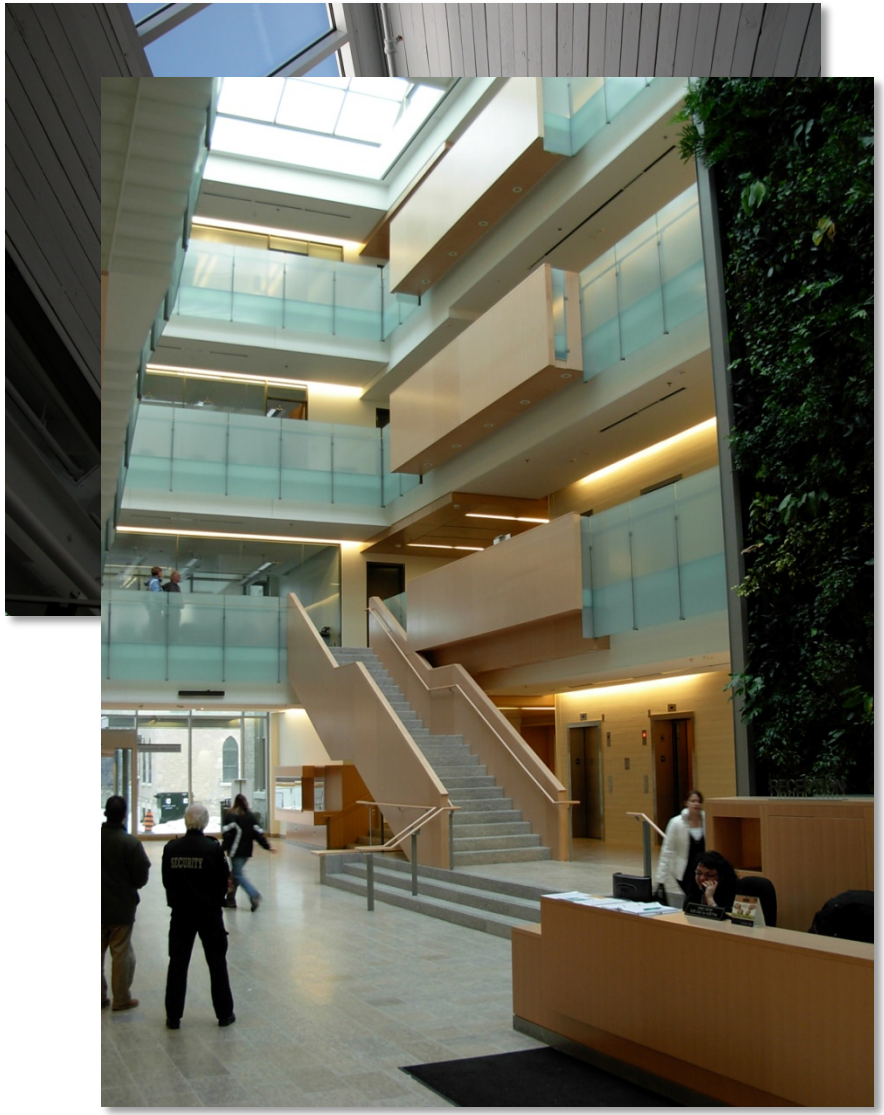
Lights on due to occupant sensors when there is adequate daylight – WASTES ENERGY!

Passive Lighting Strategies:
Orientation and building planning

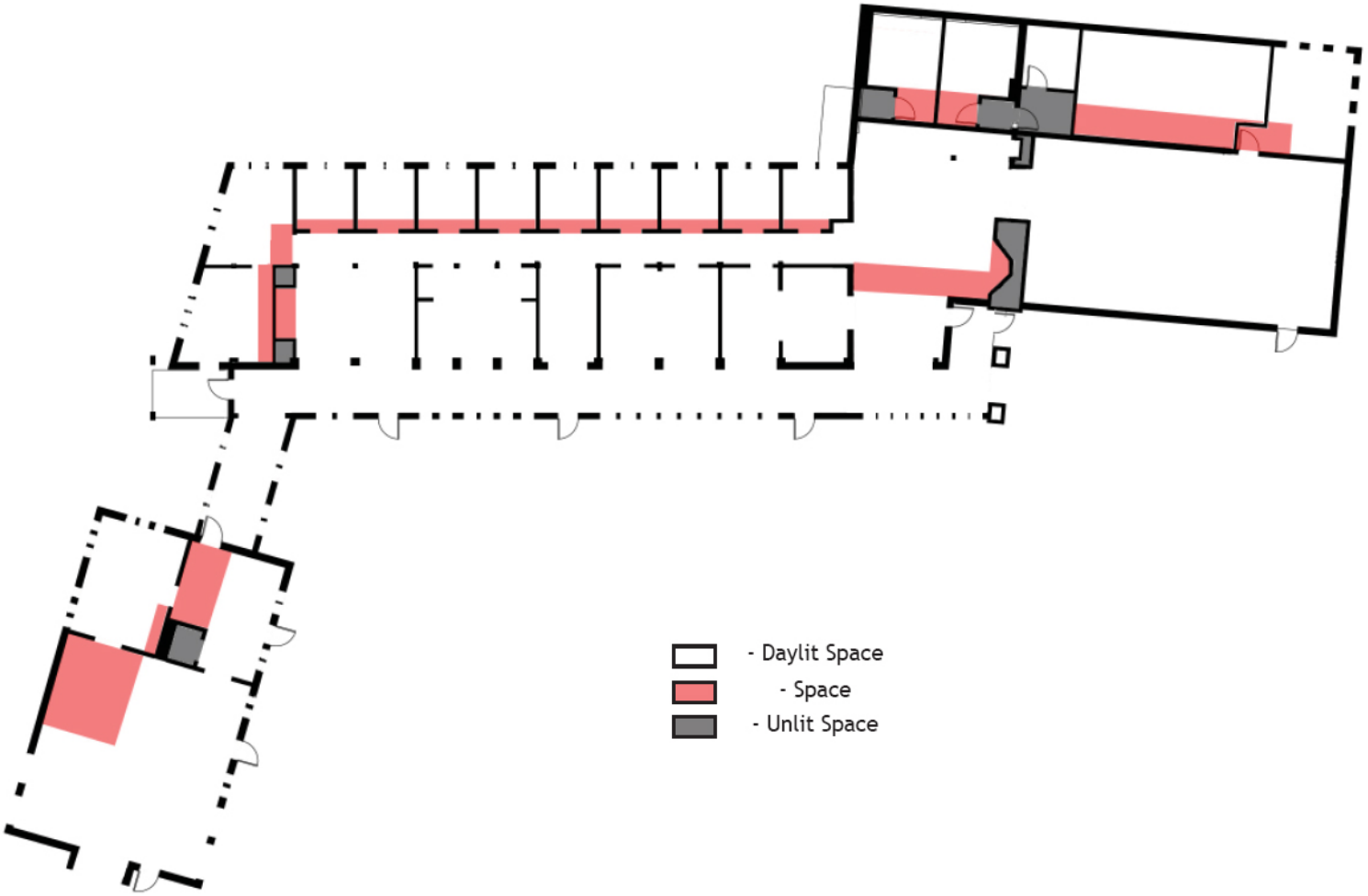
- start with solar geometry
- understand context, sky dome, adjacent buildings and potential overshadowing
- be able to differentiate between sunlight (heat) and daylight (seeing)
- understand occupancy/use requirements
- maximize areas served by daylight
- explore different glazing strategies: side, clerestory, top
- consider light shelves and reflected light

Passive Lighting Strategies:
Glare, color, reflectivity and materials

- incorporate light dynamics
- avoid glare
- understand the function of material selection; ie. reflectivity and surface qualities
- balance color and reflectivity with amount of daylight provided

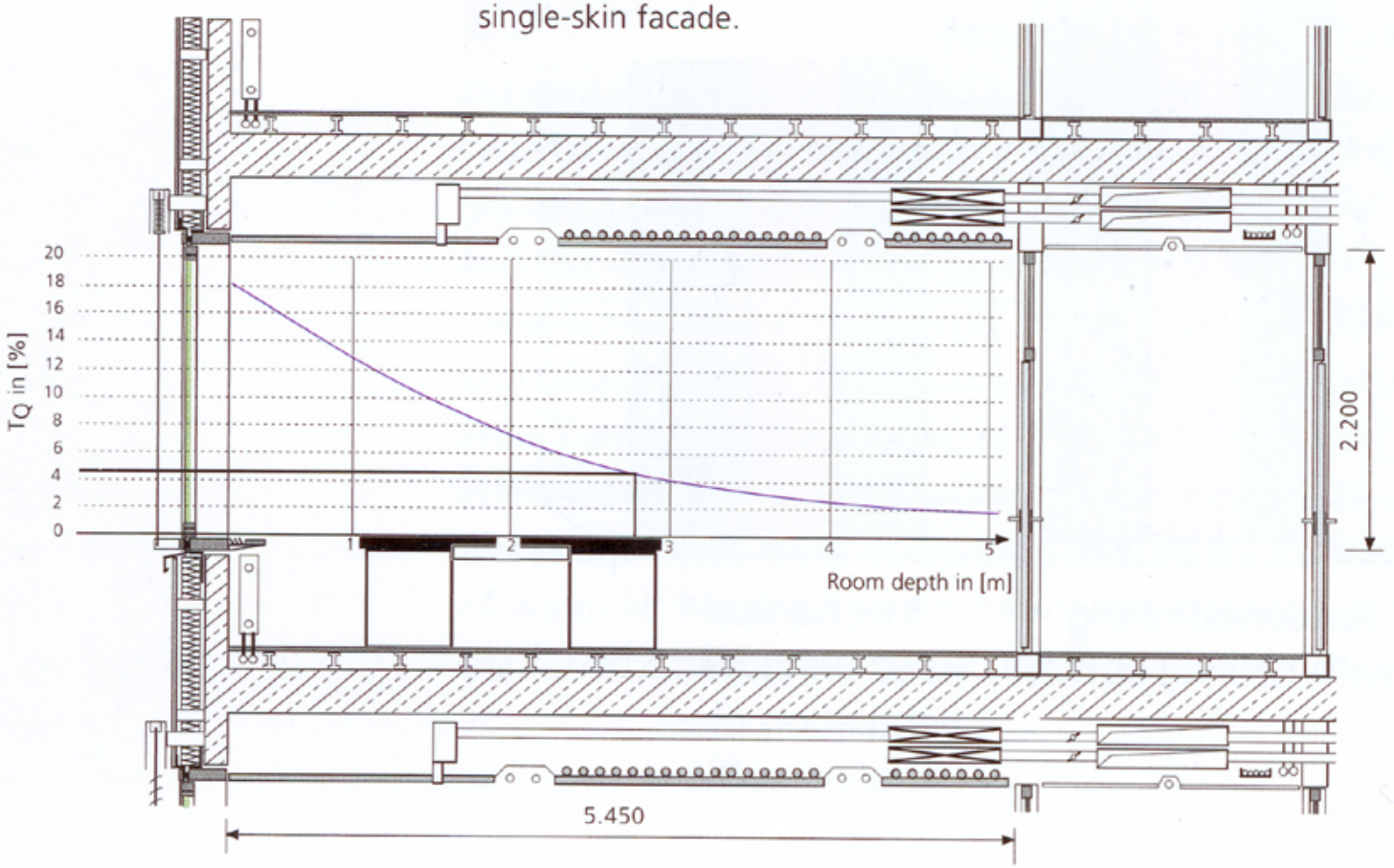


Daylight All Occupied Zones



Electric lights are only ON when there is insufficient daylight. You need a THIN plan to make this work. Depth from window cannot exceed 5 m.

6-1 Daylight-factor curve over the depth of a room with a single-skin facade.



"Double-Skin Façades: Integrated Planning." Oesterle, Lieb, Lutz, Heusler. Prestel, 2001. p.80

- Amount of light determined by height of room, window design, head height, sill height + colour of surfaces and presence of furniture
- LEED daylight credit requires a minimum Daylight Factor of 2%

Watch out for finish colours. The natural colour of the wood made the left hand space more difficult to light naturally.

Innovation and Design Process, 5 of 5 possible points

ID Credit 1.1, Innovation in Design "Exemplary Performance, EAc6"

ID Credit 1.2, Innovation in Design "Exemplary Performance, EAc2"

ID Credit 1.3, Innovation in Design "Carbon Neutral Building Operation"

ID Credit 1.4, Innovation in Design "Exemplary Performance, MRc5.1"

ID Credit 2, LEED® Accredited Professional

Achieving carbon neutrality will pretty well guarantee ID credits for excesses in other categories.

Carbon Balance Analysis

Use the Greenhouse Gas Protocol
of the World Resources Institute
http://www.ghgprotocol.org/

Organizational Boundary:
Aldo Leopold Foundation

Project Boundary:
Aldo Leopold Legacy Center and woodlots certified for sustainable harvest

Carbon Emissions Accounting

- Scope 1: Direct Emissions
  - **Stationary Combustion (boilers, wood stoves)**
  - **Organizational Vehicles**
- Scope 2: Indirect Emissions (electricity generation)
- Scope 3: Indirect Emissions (organizational activities)
  - **Commuting to Work**
  - **Business Travel**

Scope 1:
Direct Greenhouse Gas Emissions

	Fuel	Amount	CO_2 Emissions (metric tons)
Direct combustion	Wood	2 cords	6.7
Vehicles	Gas	1,490 gallons	13.2
Total emissions			**19.9**

Scope 2: Indirect Greenhouse Gas Emissions (Electricity)

Electricity Source	Amount (kWh/year)	CO_2 Emissions (metric tons)
Green power contract	33,400	10.6 (offset)
Site solar generation	32,300	10.2 (offset)
Net carbon offset		**20.8 (offset)**

Scope 2: Indirect Greenhouse Gas Emissions (Organizational Activities)

Activity	Amount	CO_2 Emissions (metric tons)
Employee commuting	1,800 gallons of gas	16.0
Business travel	36,000 air miles	6.0
Solid waste removal	5,200 pounds	3.4
Total emissions		**25.4**

Forest Management & Sustainable Harvest

Before Harvest

After Harvest

Site Harvested Lumber:

The building was designed around the size and quantity of lumber that could be sustainably harvested from the Leopold Forest.

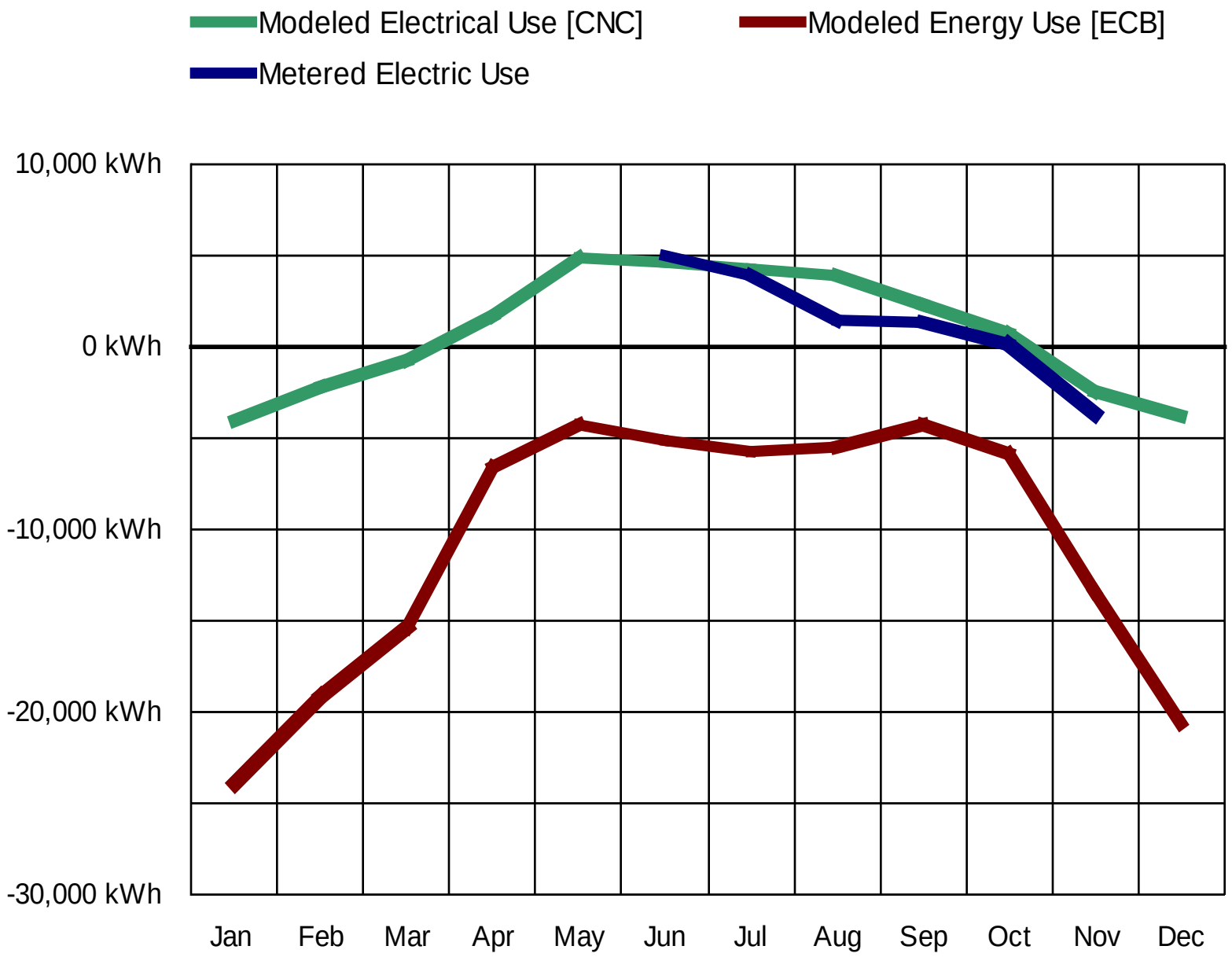
Carbon Sequestration
Carbon Absorbed by Managed Forest

Managed Forest Area	Carbon Sequestration Rate	CO_2 Emissions
35 acres	0.25 IP tons of carbon per acre	29.1 metric tons (offset)

Carbon Balance Summary

	Source	CO_2 Emissions (metric tons)
Scope 1	Direct emissions	19.9
Scope 2	Indirect emissions: electricity	20.8 (offset)
Scope 3	Indirect emissions: organizational activities	25.4
Carbon sequestered	Managed forest	29.1 (offset)
Net carbon offset		**4.6 (offset)**

Aldo Leopold Legacy Center
Net Electricity Sold to Utility



We end, I think, at what might be called the standard paradox of the 20th century: our tools are better than we are, and grow better faster than we do. They suffice to crack the atom, to command the tides. But they do not suffice for the oldest task in human history: to live on a piece of land without spoiling it.

Aldo Leopold, 1938

The Carbon Neutral Design Project Web Site

The Carbon Neutral Design Project

- Curriculum materials project
- Society of Building Science Educators
  www.sbse.org
- Funded by the American Institute of Architects
- Web site dedicated to
  - explaining carbon neutral design
  - examination of building case studies
  - exploration of carbon calculation tools/software
  - exposition of teaching materials at the University level

THE AMERICAN INSTITUTE OF ARCHITECTS

CND Project - BETA SITE - under development

AIA Home > SBSE Home > Teaching Resources > Carbon Neutral Design

- Project Introduction
- What is Carbon Neutral Design?
- Carbon Neutral Design Process
- Carbon Neutral Design Strategies
- Carbon Calculation Protocols
- Carbon Calculation Tools
- Carbon Neutral Case Studies
- Carbon Neutral Teaching
- Resources
- Links

The Carbon Neutral Design Project:

The Aldo Leopold Legacy Center, Baribou, Wisconsin:
the first Carbon Neutral Building in the United States, in addition to being awarded LEED® Platinum
Members of the CND Project enjoy a site tour in November 2008

The Carbon Neutral Curriculum Materials Project is a joint research effort between members of the Society of Building Science Educators (**www.sbse.org**), the American Institute of Architects (**www.aia.org**), and a private donor, the purpose of which is to provide practitioners, faculty and students with the means to meet the 2030 Challenge (**www.architecture2030.org**)- that is, to be able to design and construct buildings to a state of carbon neutrality by the year 2030.

Please use the links at the left to find out more about designing buildings to a state of carbon neutrality.

IMPORTANT: THIS SITE IS A WORK IN PROGRESS - COMPLETION SCHEDULED FOR APRIL 2009

this page last updated Friday, 13-Mar-2009 8:46 AM

http://www.tboake.com/carbon-aia/index.html

The Carbon Neutral Design Project:

Carbon Calculation Tools:

Survey of Available Tools

Note #1: Where professors associated with the Carbon Neutral Design Project have used the software in their coursework, their comments will be located below the software description and a link to their assignment hot linked to their name in the right hand column.

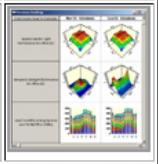
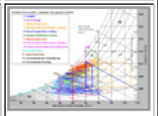
Note #2: It will be noted if the product is available as a FREE DOWNLOAD, ONLINE TOOL or purchased product. For pricing for products for purchase please visit the associated website.

Note #3: The required OS will be noted. Most of the Energy Programs are PC based only. For Mac users, it is recommended to run the programs using a PC simulator such as Bootcamp, Parallels or Virtual PC.

Note #4: Where possible, screenshots will be provided so that you can get an idea of the nature of the interface. These will be located in the right hand column. Click on the thumbnail for a larger version of the image.

Energy Modeling Software

Click on the Image for a Screenshot!

Software Name	Description / URL / Comments	Professors / Projects
A Course in Climate Responsive Building Design	http://www.aud.ucla.edu/energy-design-tools/ FREE DOWNLOAD *(software mostly PC)* The software and problems sets have been provided by Professor Emeritus Murray Milne to assist designers in understanding Climate Responsive Building Design. Scroll towards the bottom of the above linked page for more information, and to access the course materials.	
Building Design Advisor	http://gaia.lbl.gov/BDA/ *(PC only)* A powerful buildings design tool that will unify various specialized tools previously developed at LBNL makes it easy to compare design alternatives and includes multimedia resources such as a case-study library.	
Climate Consultant 4	http://www.aud.ucla.edu/energy-design-tools/ FREE DOWNLOAD *(PC only)* This program graphically displays climate data in either metric or imperial units in dozens of ways useful to architects including monthly bar charts, timetable charts, and psychrometric charts, sun shading charts, and sun dial charts. 3-D plots show temperatures, humidity, radiation, and sky cover. The "Wind Wheel" graphics shows velocity	

CaGBC Zero Carbon Building

The Zero Carbon Buildings Framework is the first stage of a broader CaGBC Zero Carbon Buildings Initiative to champion the move to lower-carbon commercial, institutional and high-rise residential buildings in support of Canada's efforts to reduce GHG emissions by 30 per cent by 2030.

The next phases of the Zero Carbon Initiative include the identification of specific pathways to zero carbon, a zero carbon building pilot program, and the development of a verification program to be completed and launched by CaGBC by the end of the second quarter of 2017

Five Key Components of

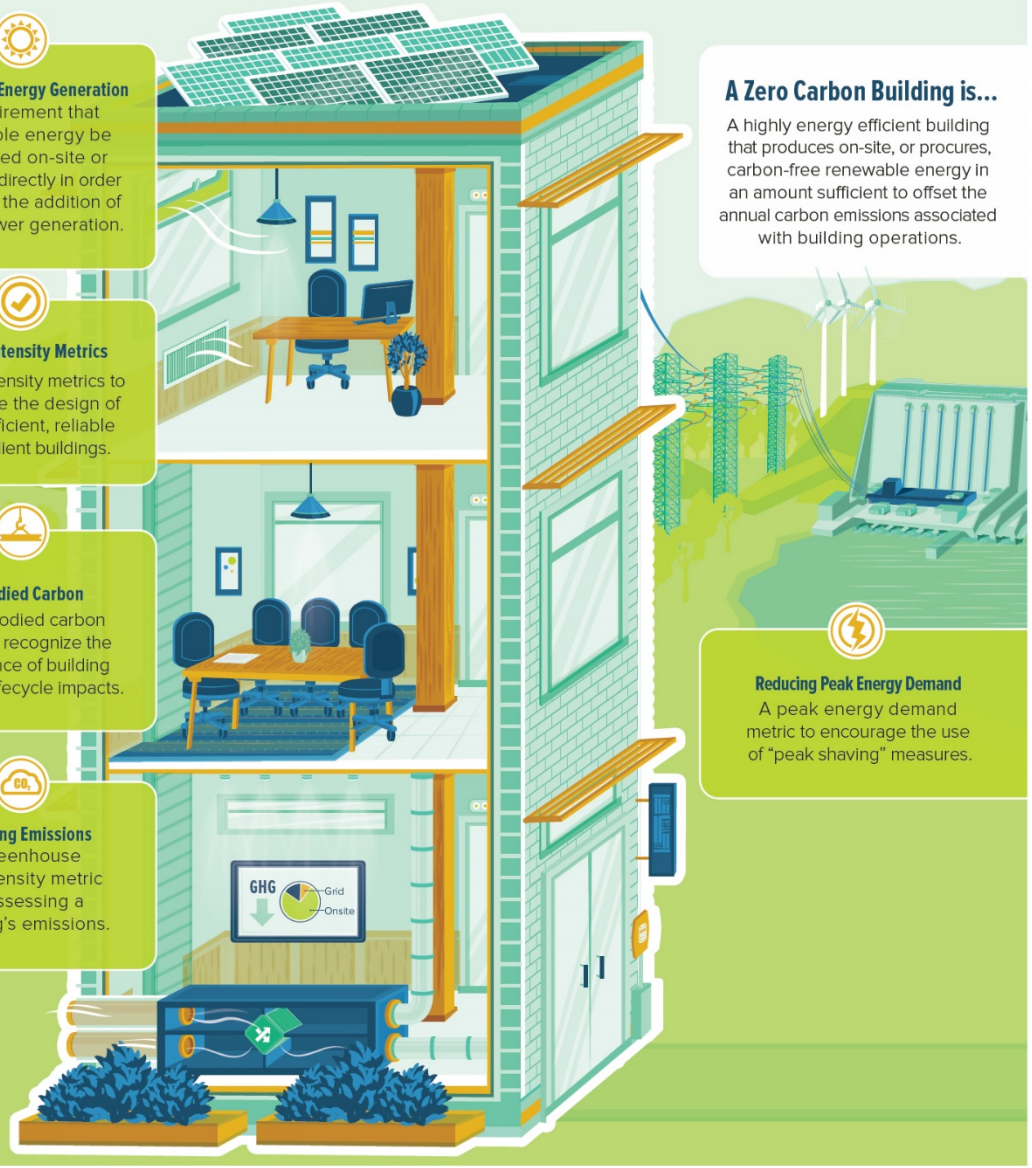
Zero Carbon Buildings

Renewable Energy Generation
A requirement that renewable energy be generated on-site or procured directly in order to ensure the addition of clean power generation.

Energy Intensity Metrics
Energy intensity metrics to incentivize the design of highly efficient, reliable and resilient buildings.

Embodied Carbon
An embodied carbon metric to recognize the importance of building material lifecycle impacts.

Lowering Emissions
A greenhouse gas intensity metric for assessing a building's emissions.



A Zero Carbon Building is...

A highly energy efficient building that produces on-site, or procures, carbon-free renewable energy in an amount sufficient to offset the annual carbon emissions associated with building operations.

Reducing Peak Energy Demand
A peak energy demand metric to encourage the use of "peak shaving" measures.

Remaining “Wicked Problems”

#1 – Building Size and Shape

- Most carbon neutral or ZED buildings to date are small
- No ZED buildings at a large scale to examine or emulate
- Buildings must be designed with a thin plan to allow for daylighting
- Tall buildings will have limited roof area for the installation of PV arrays
- Solar potential of wall areas needs to be studied

#2 - Location

- Most current ZED buildings have been constructed in rural areas
- Rural areas have a higher potential for solar harvesting, wind harvesting, installation of renewables, fresh air, carbon sequestration through use of the property/green space
- Urban areas will have severe issues with overshadowing and other limits on the installation of renewables
- Urban areas have limited site area

#3 – Natural Ventilation

- A key way to reduce the energy required to power a building is via the elimination of A/C
- Not all buildings can tolerate the resulting humidity or fluctuations in interior environment that can result from no A/C
- Urban environments can be too “dirty” for natural ventilation
- Urban environments can be too noisy for natural ventilation

#4 – Severe climates

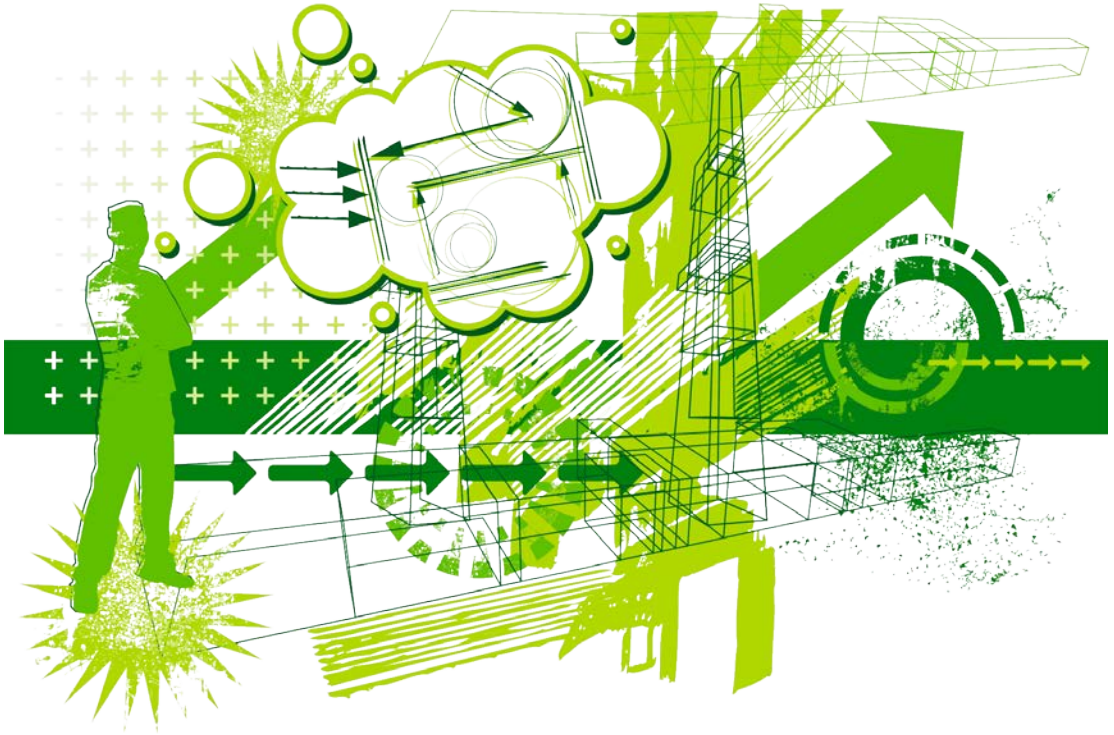
- Severe climates will require more energy to heat and cool buildings
- Northern climates have limited solar potential for both daylighting and passive heating
- Hot-humid climates may require additional energy to bring interior environments to a state of reasonable comfort

#5 – Fee structures

- The bottom line in reduction is to consider building less
- Fees are normally based as a percentage of construction cost
- Disincentive to reduce scope of building as it reduces income
- Need to find a way to link fees to energy savings
- Need to have additional fees to properly engineer the synchronized systems of carbon neutral buildings

#6 – Integrated Design

Carbon Neutral cannot be done without the highest level of early and continued cooperation amongst the client, architect and engineers



http://www.greenhome.org/policy/makers/how_p.html

Summary:

What IS the **difference** between a Sustainable Building (LEED) and a Carbon Neutral Building?

- Sustainable building (LEED) does not equal Carbon Neutral Building
- Sustainable building prefers renewable materials
- Carbon Neutral Building looks for Carbon emission impacts in materials use
- Sustainable building seeks to reduce energy consumption for its heating and cooling systems
- Carbon Neutral building looks for Zero Net Energy in its heating and cooling systems

Summary:

What ARE the KEY STRATEGIES needed to design to a state of CARBON NEUTRALITY?

#1 - Reduce loads/demand first (passive design, daylighting, shading, orientation, etc.)

#2 - Meet loads efficiently and effectively (energy efficient lighting, high-efficiency MEP equipment, controls, etc.)

#3 - Use on-site generation/renewables to meet energy needs (doing the above steps *before* will result in the need for much smaller renewable energy systems, making carbon neutrality achievable.)

Summary:

What are the ARCHITECTURAL IMPLICATIONS of designing to Zero Carbon?

- increased impact of plan and section design in achieving reduced energy requirements

- increased importance of building orientation, siting and treatment of site both during and after construction

- greater need for integrated design process and coordination with consultants from outset of project

- narrower scope of “acceptable” materials

- more energy efficient “systems”

- more highly glazed (daylighting) and insulated buildings

Summary:

What is the POTENTIAL of designing a building to a state of Carbon Neutrality?

- Ability to effect a reduction in CO_2 emissions
- Ability to increase the likelihood of creating a regenerative or restorative building
- Ability to exceed LEED™ design levels
- Ability to create a building that is superior in its durability
- Ability to deliver a building that is extremely low in its energy related operating costs and life cycle costs
- Ability to create a “conscience free” building