GREEN BUILDING ENVELOPES 101

Defining the FIRST STEPS to Carbon Neutral Design

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What is a Green Building Envelope?

A new skin on an old building?

A skin that responds to the climate?

A skin on a LEED™ building?

A Skin that addresses Global Warming and Sustainable Design!

- A priority has been placed, above and beyond current trends in Sustainable Design, on the reduction of GHG emissions
- Buildings account for more than 40% of the GHG
- Green, Sustainable and High Performance Buildings are not going far enough, quickly enough in reducing their negative impact on the environment
- Carbon Neutrality focuses on the relationship between all aspects of “building/s” and CO_2 emissions
- Carbon Neutral Design strives to reverse trends in Global Warming

Basic Concept of Sustainable Design:

Sustainable design is a *holistic* way of designing buildings to minimize their environmental impact through:

- **Reduced dependency on non-renewable resources**
- **A more bio-regional response to climate and site**
- **Increased efficiency in the design of the building envelope and energy systems**
- **A environmentally sensitive use of materials**
- **Focus on healthy interior environments**
- **Characterized by buildings that aim to *"live lightly on the earth"* and**
- ***"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."***

United Nations World Commission on Environment and Development

From ZED to Carbon Neutral

A **Near Zero Energy** building produces at least 75% of its required energy through the use of on-site renewable energy. Off-grid buildings that use some non-renewable energy generation for backup are considered near zero energy buildings because they typically cannot export excess renewable generation to account for fossil fuel energy use.

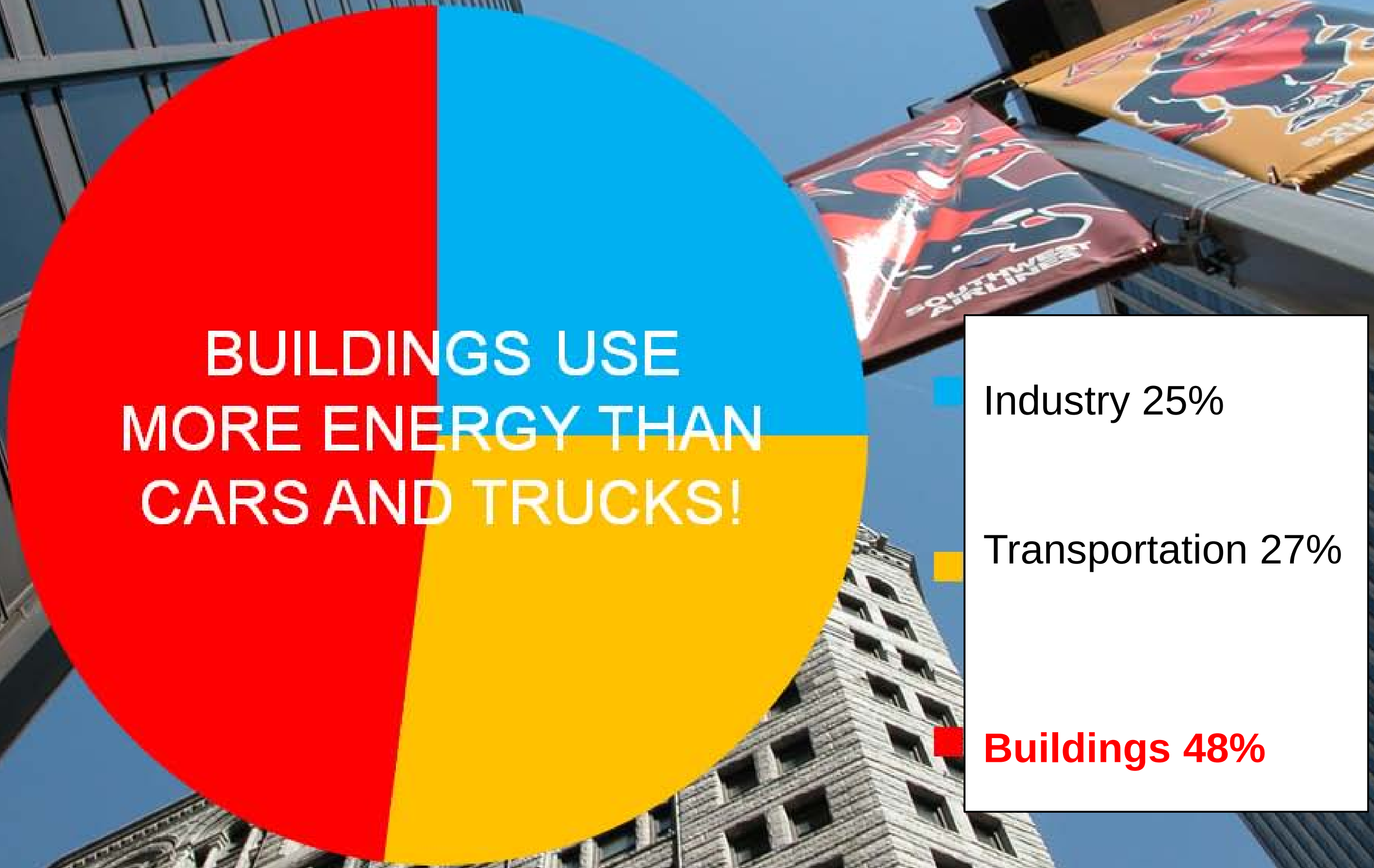
A **Carbon Neutral Building** derives 100% of its energy from non fossil fuel based renewables.

Why Assess Carbon Neutrality?

- Sustainable design does not go far enough
- Assessing carbon is complex, but necessary
- The next important goal to reverse the effects of global warming and reduce CO^2 emissions it to make our buildings **“carbon neutral”**
- **“architecture2030”** is focused on raising the stakes in sustainable design to challenge designers to reduce their carbon emissions
by 50% by the year 2030

www.architecture2030.org

ENERGY CONSUMPTION IN NORTH AMERICA



The Global Warming Pie....

These values look at Secondary **Energy Use** by Sector in Canada (2006)

(*energy used by the final consumer i.e. operating energy*)

The LEAP to Zero Carbon and beyond…

- Energy Efficient (mid 1970s "Oil Crisis" reaction)
  - High Performance (accountable)
  - **Green (environmentally responsive)**
    - Sustainable (holistic and accountable)
    - Carbon Neutral (Zero Fossil Fuel Energy)
    - Restorative
    - Regenerative (Living Buildings)

…a steady increase in the nature and expectations of performance criteria

… a steady increase in the requirements on the building envelope

Fossil Fuel Reduction Standard:

The fossil fuel **reduction standard** for all **new buildings** shall be increased to:

60% in 2010
70% in 2015
80% in 2020
90% in 2025
Carbon-neutral in 2030 (using no fossil fuel GHG emitting energy to **operate**).

Source: www.architecture2030.org

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	✓								

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

2030 Targets – Residential:

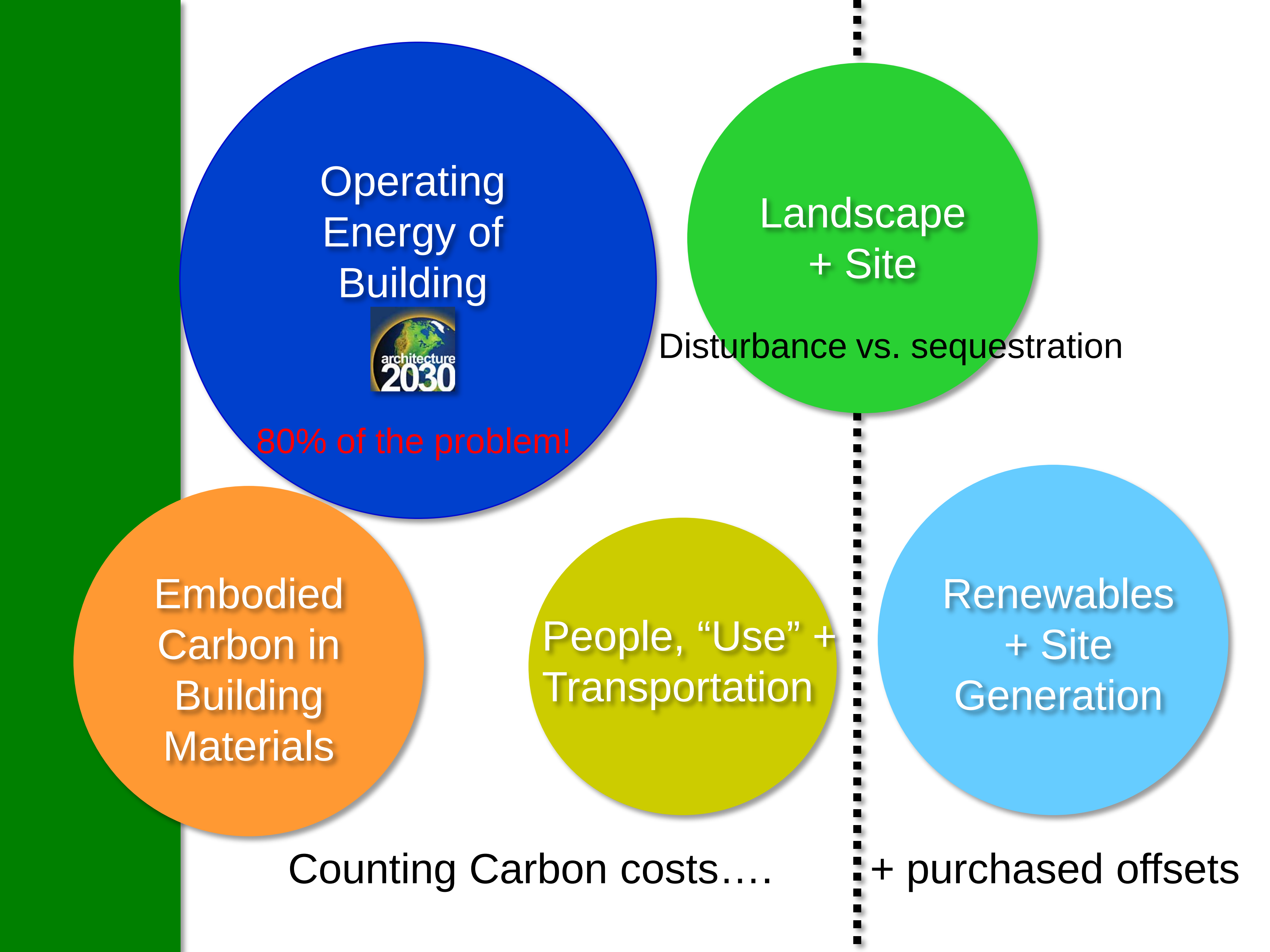
2030 CHALLENGE Targets: Residential Regional Averages

U.S. Regional Averages for Site Energy Use and 2030 Challenge Energy Reduction Targets by Residentail Space/Building Type (RECS 2001)[1]
From the Environmental Protection Agency (EPA): Use this chart to find the site fossil-fuel energy targets.

Residential Space/Building Type[2]	Average Source EUI[3, 4] (kBtu/Sq.Ft./Yr)	Average Site EUI[3, 5] (kBtu/Sq.Ft./Yr)	2030 Challenge Site EUI Targets (kBtu/Sq.Ft./Yr)				
			50% Target	60% Target	70% Target	80% Target	90% Target
Northeast							
Single-Family Detached	67.5	45.7	**22.9**	18.3	13.7	9.1	4.6
Single-Family Attached	68.6	50.3	**25.1**	20.1	15.1	10.1	5.0
Multi-Family, 2 to 4 units	78.8	57.8	**28.9**	23.1	17.3	11.6	5.8
Multi-Family, 5 or more units	98.2	60.7	**30.4**	24.3	18.2	12.1	6.1
Mobile Homes	145.5	89.3	**44.6**	35.7	26.8	17.9	8.9
Midwest							
Single-Family Detached	76.2	49.5	**24.7**	19.8	14.8	9.9	4.9

…etc.

http://www.architecture2030.org/downloads/2030_Challenge_Targets_Res_Regional.pdf


Operating Energy of Building
architecture 2030
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

Operating Energy of Building

architecture 2030

80% of the problem!

Embodied Carbon in Building Materials

Building envelope performance directly impacts operating energy

Building envelope material selection and sourcing directly impacts embodied energy

Counting Carbon costs….

Energy vs Greenhouse Gas Emissions

In BUILDINGS, for the sake of argument

ENERGY CONSUMPTION = GHG EMISSIONS

BUILDING ENERGY IS COMPRISED OF

EMBODIED ENERGY

+

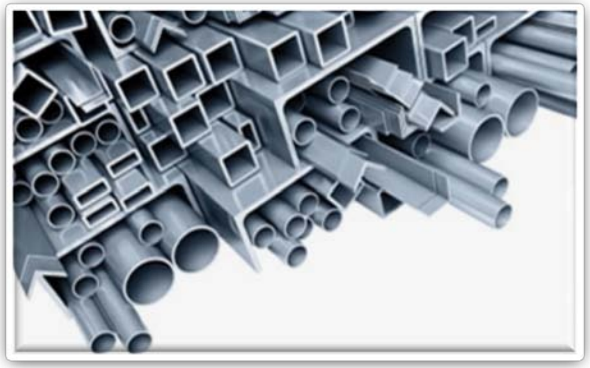
OPERATING ENERGY

Energy Use in Buildings

Embodied Energy

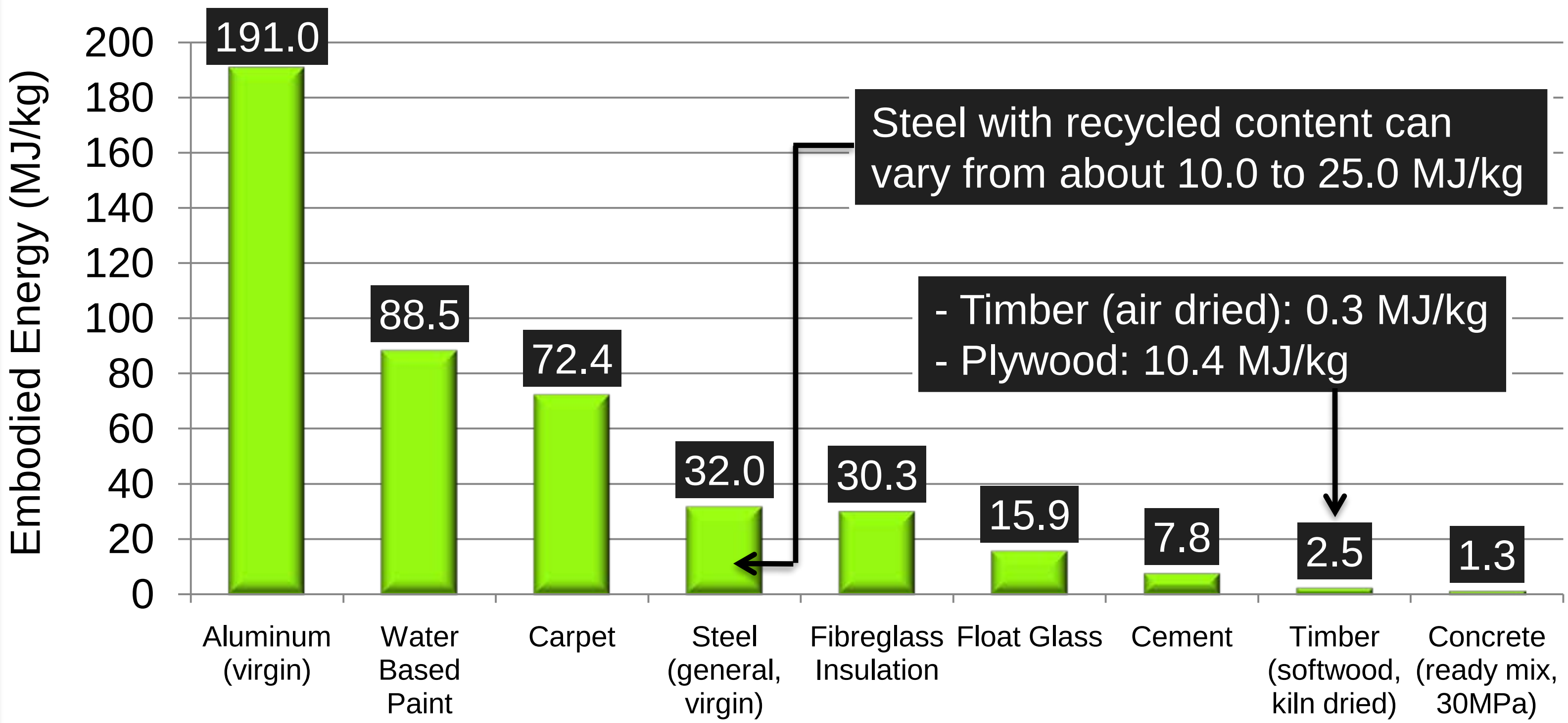
– **<u>Initial Embodied Energy</u>:** Non-renewable energy consumed in the acquisition of raw materials, their processing, manufacturing, transportation to site, and construction

– **<u>Recurring Embodied Energy</u>:** Non-renewable energy consumed to maintain, repair, restore, refurbish or replace materials, components, or systems during life of building



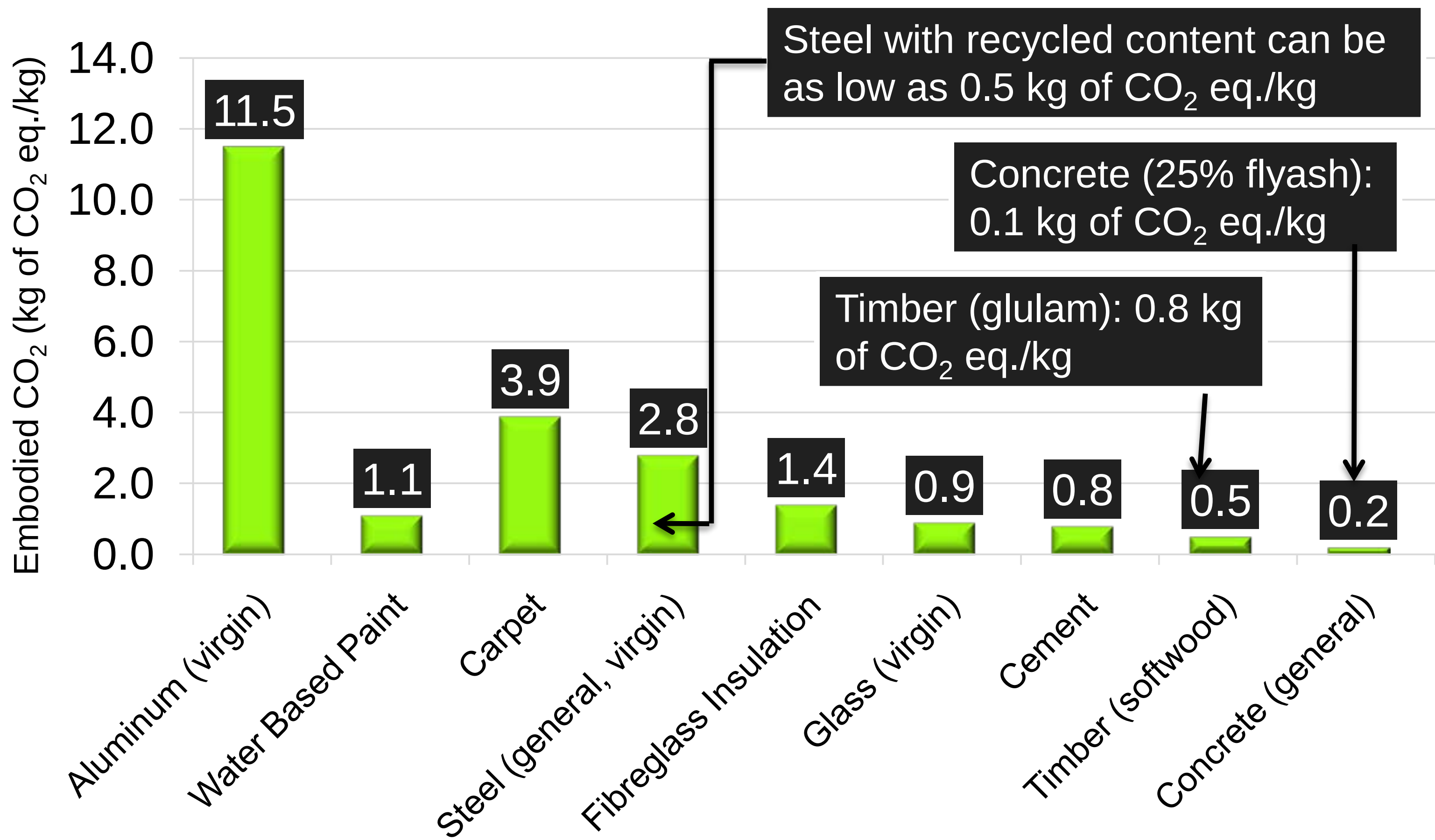
www.cn-sbs.cssbi.ca

Initial Embodied Energy of Building Materials Per Unit Mass



Source: University of Wellington, NZ, Center for Building Performance Research (2004)

Embodied Carbon Dioxide of Building Materials Per Unit Mass



Source: University of Bath, UK, Inventory of Carbon and Energy (2008)

The Life Cycle of a Material

Life-Cycle Assessment (LCA)

– The main goal of a LCA is to quantify energy and material use as well as other environmental parameters at various stages of a product’s life-cycle including: resource extraction, manufacturing, construction, operation, and post-use disposal

Life-Cycle Inventory (LCI) Database

– A database that provides a cradle-to-grave accounting of the energy and material flows into and out of the environment that are associated with producing a material. This database is a critical component of a Life-Cycle Assessment

Life Cycle Assessment Methodology

Embodied Energy

– <u>**ATHENA® Impact Estimator for Buildings**</u>

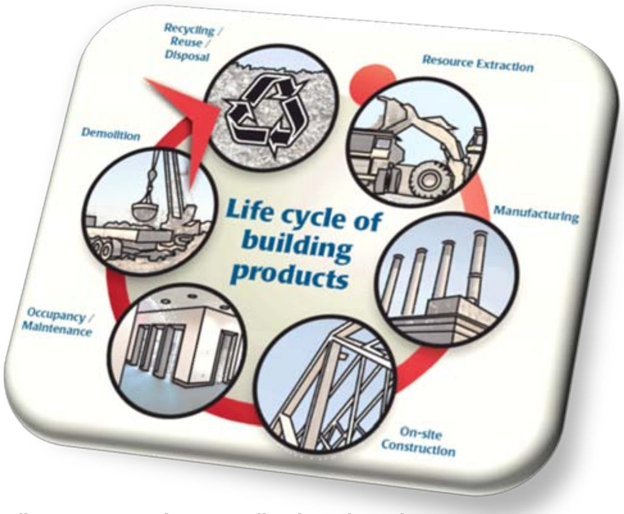
– **The only North American specific software tool that evaluates whole buildings and assemblies based on internationally recognized LCA methodology**

– **Non-profit organization that has been around for more than 10 years**

– **One of the most comprehensive LCI databases in the world with over $2 million spent on database development**

– **Considers the life-cycle impacts of:**

- ✓ Material manufacturing including resource extraction and recycled content
- ✓ Related transportation
- ✓ On-site construction
- ✓ Regional variation in energy use, transportation, and other factors
- ✓ Building type and assumed lifespan
- ✓ Maintenance, repair, and replacement effects
- ✓ Demolition and disposal
- ✓ Operating energy emissions and pre-combustion effects

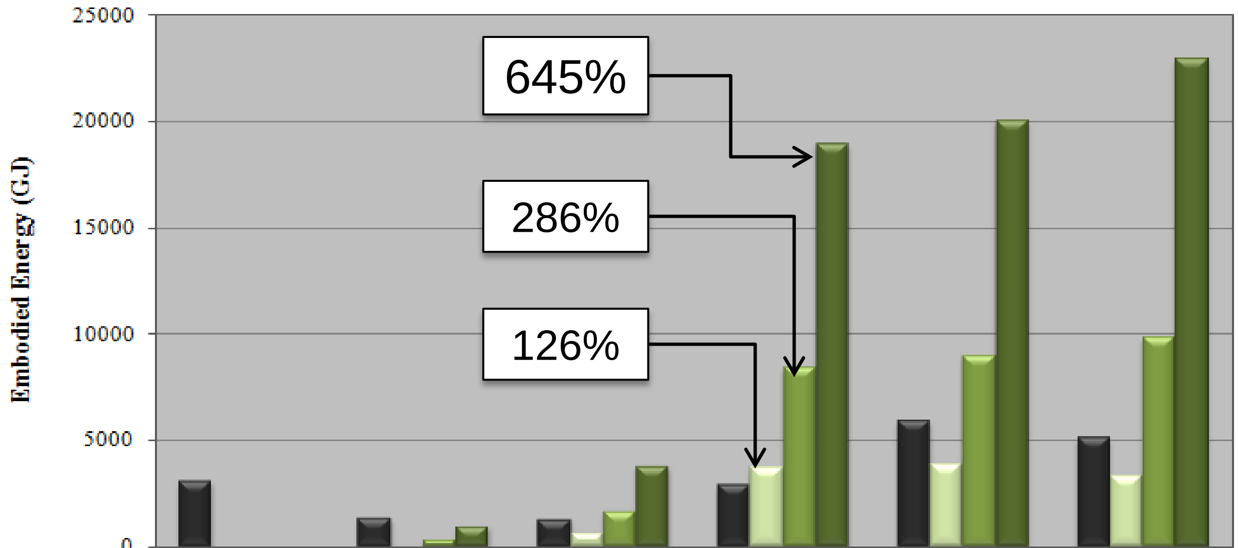


Source: The ATHENA Institute   http://www.athenasmi.org/tools/impactEstimator/index.html

Energy in Common Building Components

Initial Embodied Energy vs. Recurring Embodied Energy of a Typical Canadian Office Building Constructed from Wood

Finishes, Envelope, & Services dominate the embodied energy over the building's lifespan



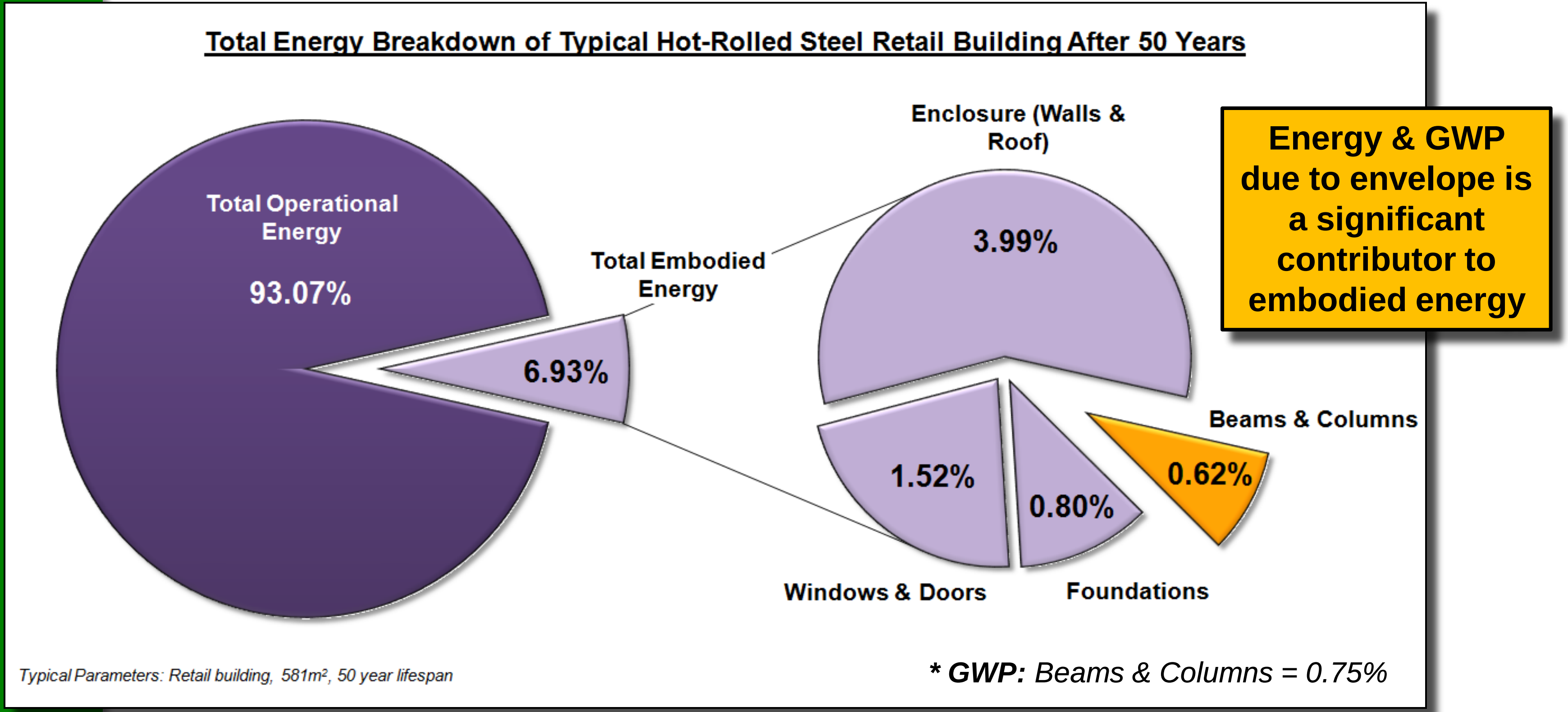
	Structure	Site Work	Construction	Finishes	Envelope	Services
Initial	3088	1344	1289	2935	5935	5110
25 Years	0	65	658	3696	3873	3338
50 Years	0	358	1653	8397	8943	9859
100 Years	0	1001	3777	18936	20060	22955

Source: Cole , R. & Kernan, P. (1996). Life-Cycle Energy Use in Office Buildings. Building and Environment, 31 (4), 307-317

Orders of Environmental Impact

Total Energy Breakdown of Typical Hot-Rolled Steel Retail Building After 50 Years

(other building types are similar)



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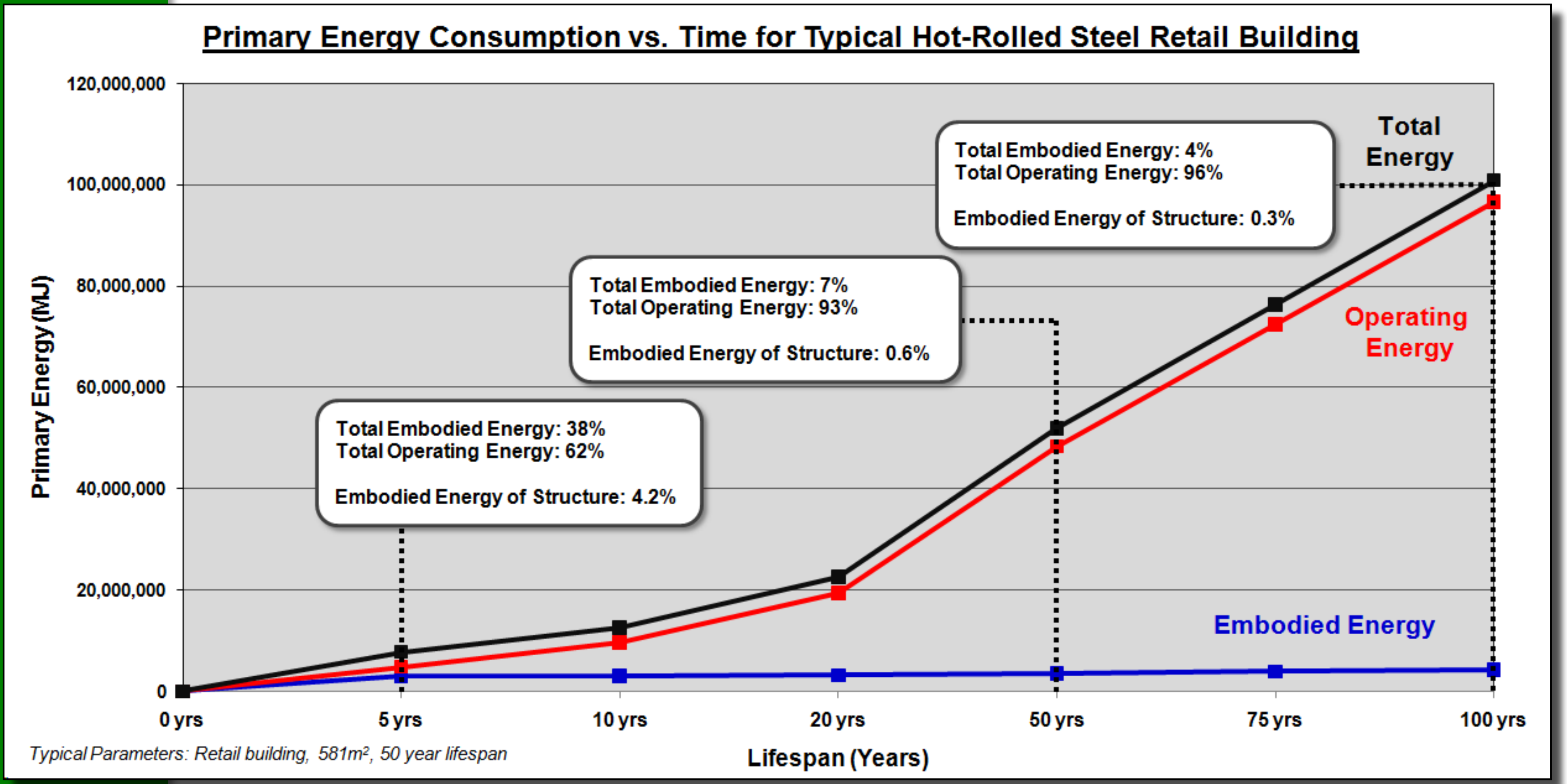
Orders of Environmental Impact

Primary Energy Consumption vs. Time for Hot-Rolled Steel Retail Building (*other building types are similar)*



Source: Kevin Van Ootegham

www.cn-sbs.cssbi.ca

Embodied Energy Findings

In conventional buildings, the building envelope (walls and roof), building services, and building finishes contribute the most towards the total embodied life-cycle energy (and total embodied GWP) when looking at the Embodied Energy of the Entire Building, including Structure.

To lower GHG, choice of materials needs to reflect:

-issues of **DURABILITY**

- ability of material to assist **PASSIVE DESIGN**

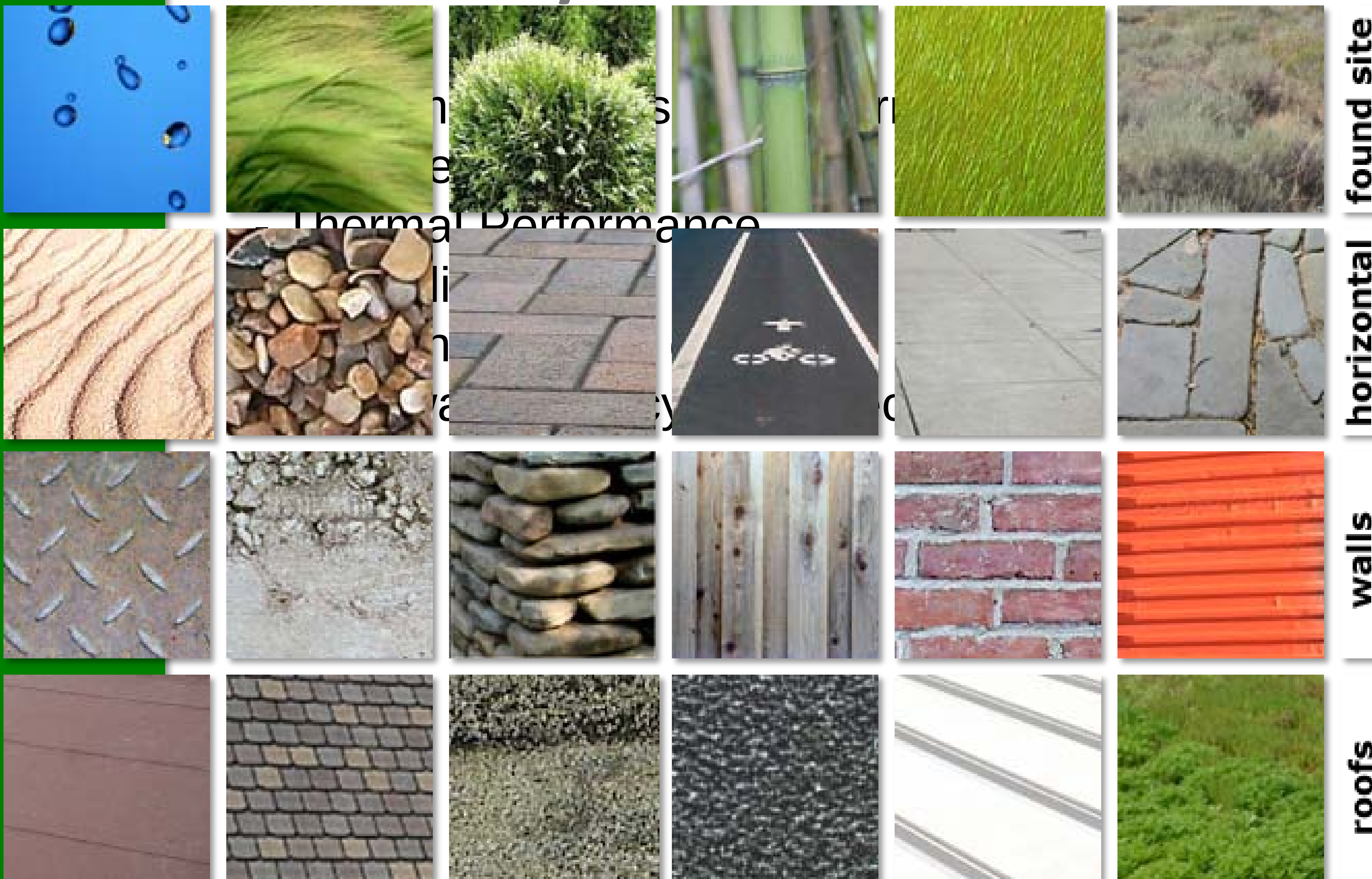
- local sourcing to reduce **TRANSPORTATION**

- **Cradle to Cradle concepts**

- ability of material to be 1st **REUSED** and 2nd RECYCLED

Materiality

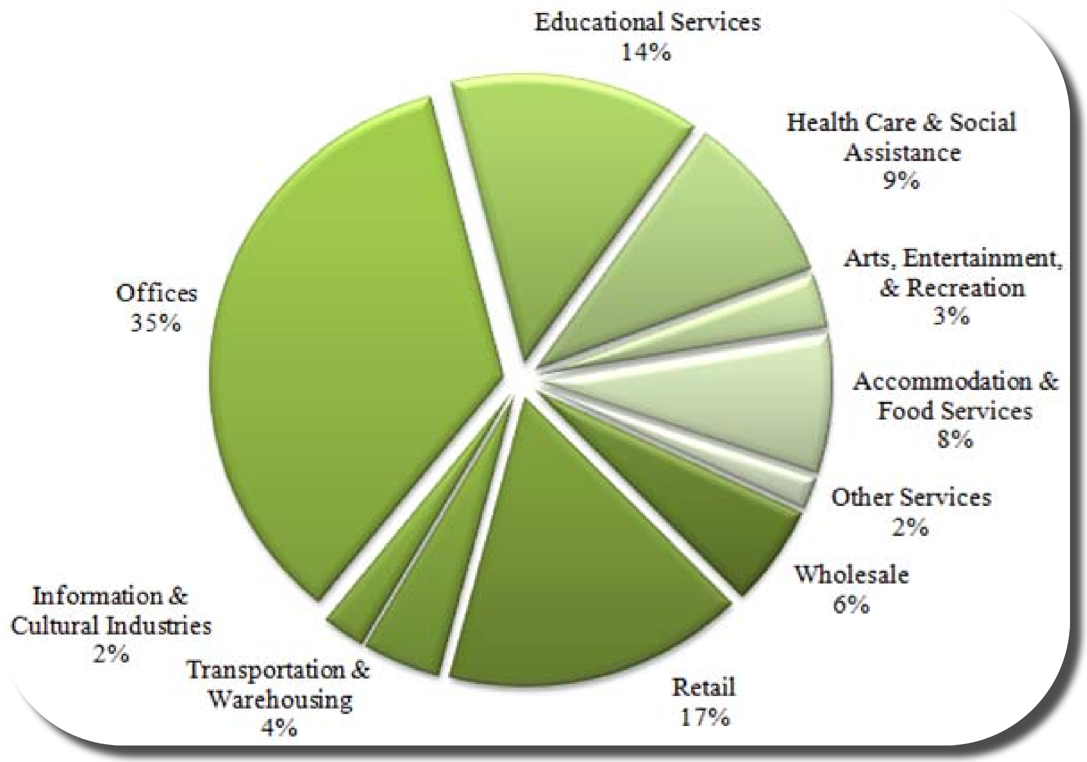
– Thermal Performance



Energy Use in Buildings: Operating Energy

Amount of energy that is consumed by a building to satisfy the demand for heating, cooling, lighting, ventilation, equipment, etc.

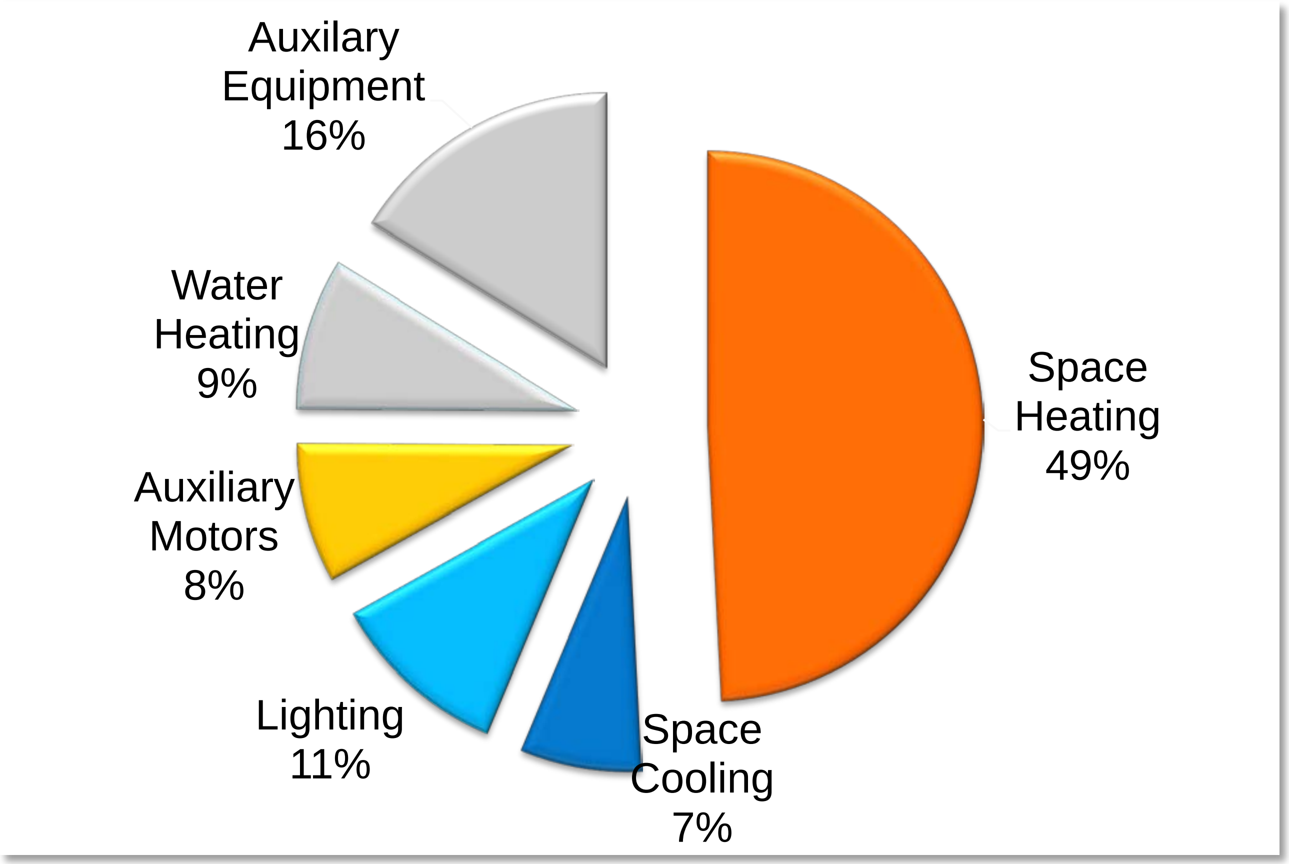
Total Commercial/Institutional Secondary Energy Use by Activity Type in Canada (2006)



Source: Natural Resources Canada, 2006

Energy Use in Buildings: Operating Energy

Total Commercial/Institutional Secondary Energy Use by End Use in Canada (2006)



Source: Natural Resources Canada, 2006

Four Key Steps – IN ORDER:

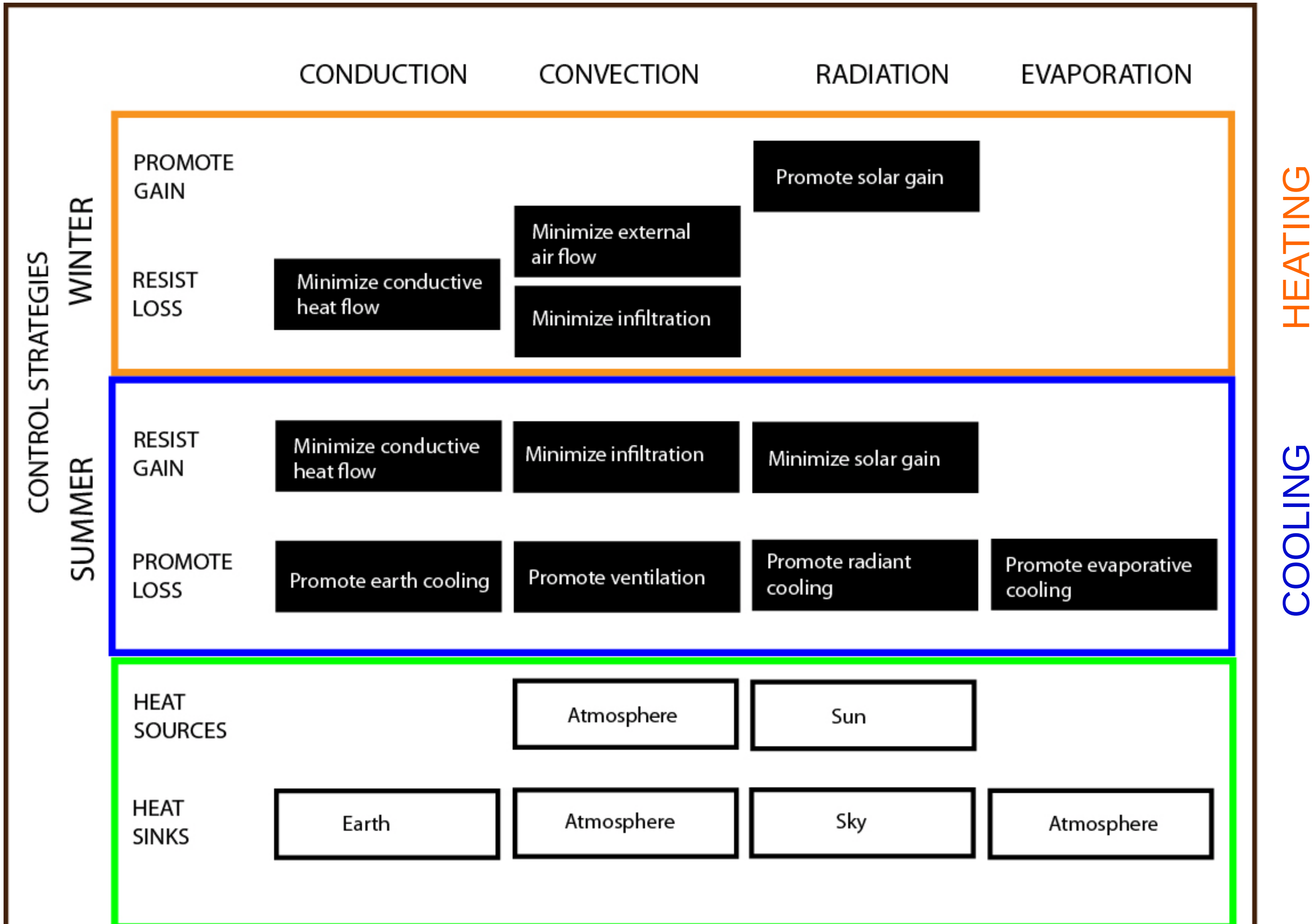
#1 - Reduce loads/demand first (conservation, passive design, daylighting, shading, orientation, etc.)

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

#3 - **Use 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.)

#4 - **Use purchased Offsets** as a *last resort* when all other means have been looked at on site, or where the scope of building exceeds the site available resources.

Begin with Passive Strategies for Climate Control to Reduce Energy Requirements



Strategies of Climate Control

(chart modeled after Watson "Climatic Building Design")

REDUCING OPERATING ENERGY

Carbon Reduction: The Tier Approach

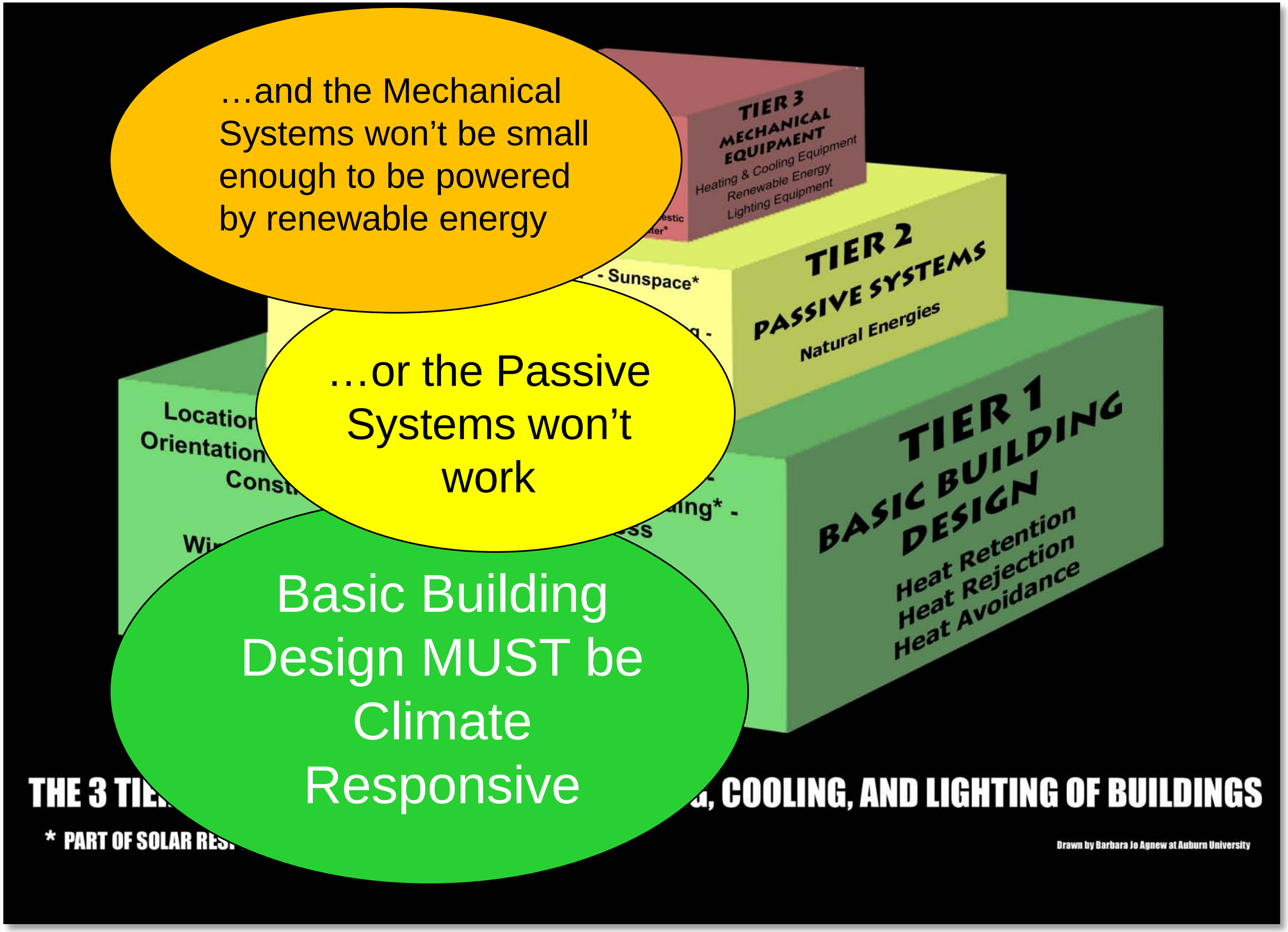
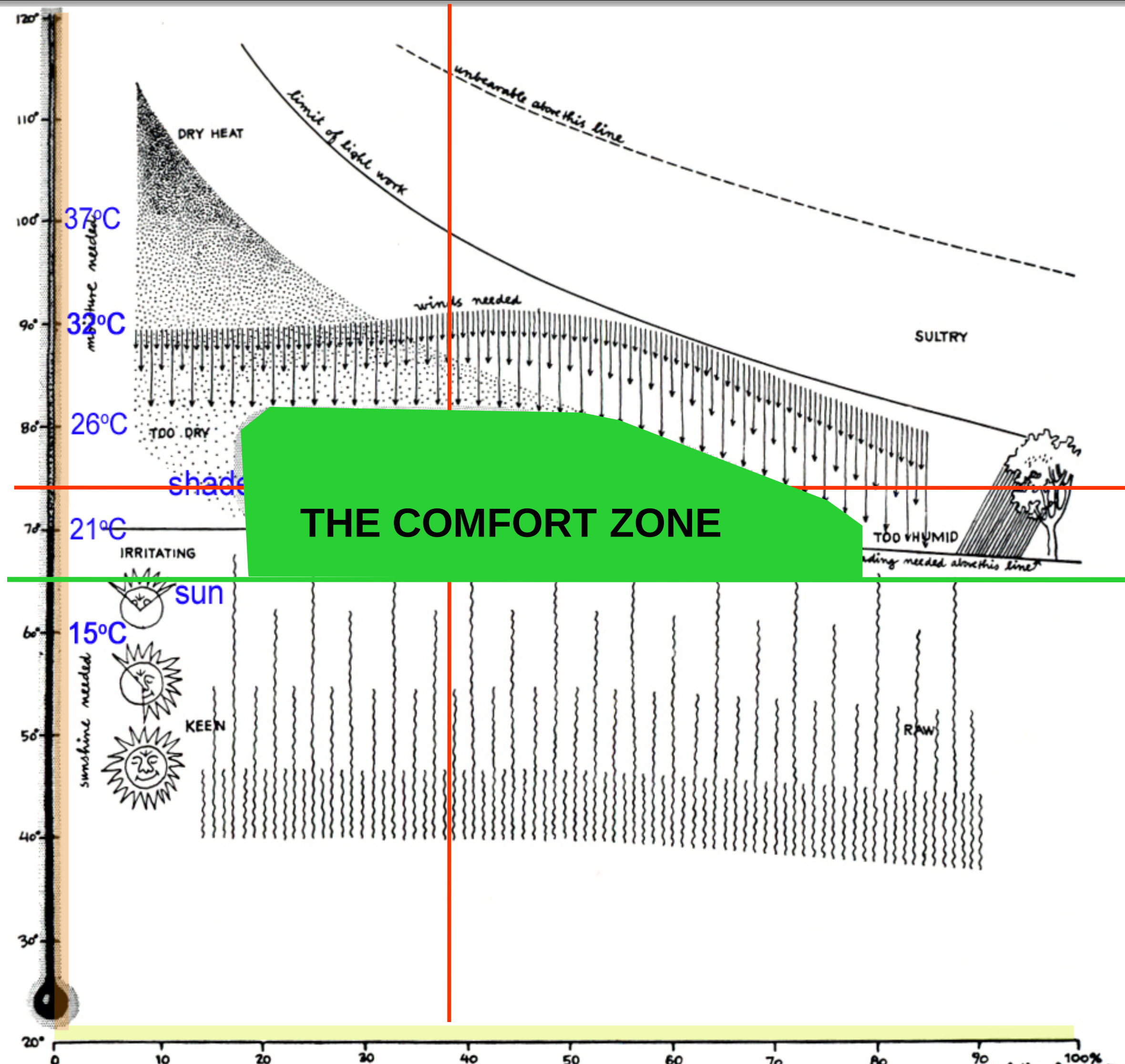


Image: Norbert Lechner, "Heating, Cooling, Lighting"

Designing to the **Comfort Zone** vs. Comfort Point:



46. Schematic bioclimatic index.

This famous illustration is taken from "Design with Climate", by Victor Olgyay, published in 1963.

This is the finite point of expected comfort for 100% mechanical heating and cooling.

To achieve CN, we must work within the broader area AND DECREASE the "line" to 18C – point of calculation of heating degree days.

Passive Bio-climatic Design: COMFORT ZONE

Comfort expectations may have to be reassessed to allow for the wider “zone” that is characteristic of buildings that are not exclusively controlled via mechanical systems.

Creation of new **“buffer spaces”** to make a hierarchy of comfort levels within buildings.

Require **higher occupant involvement** to adjust the building to modify the temperature and air flow.

Climate as the Starting Point for a Climate Responsive Design

North American Bio-climatic Design:

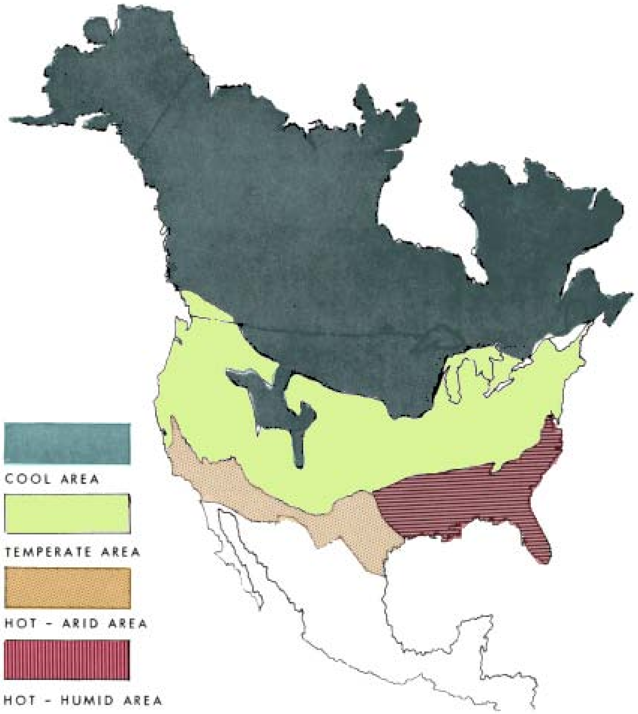
Design must first acknowledge regional, local and microclimate impacts on the building and site.

COLD

TEMPERATE

HOT-ARID

HOT-HUMID

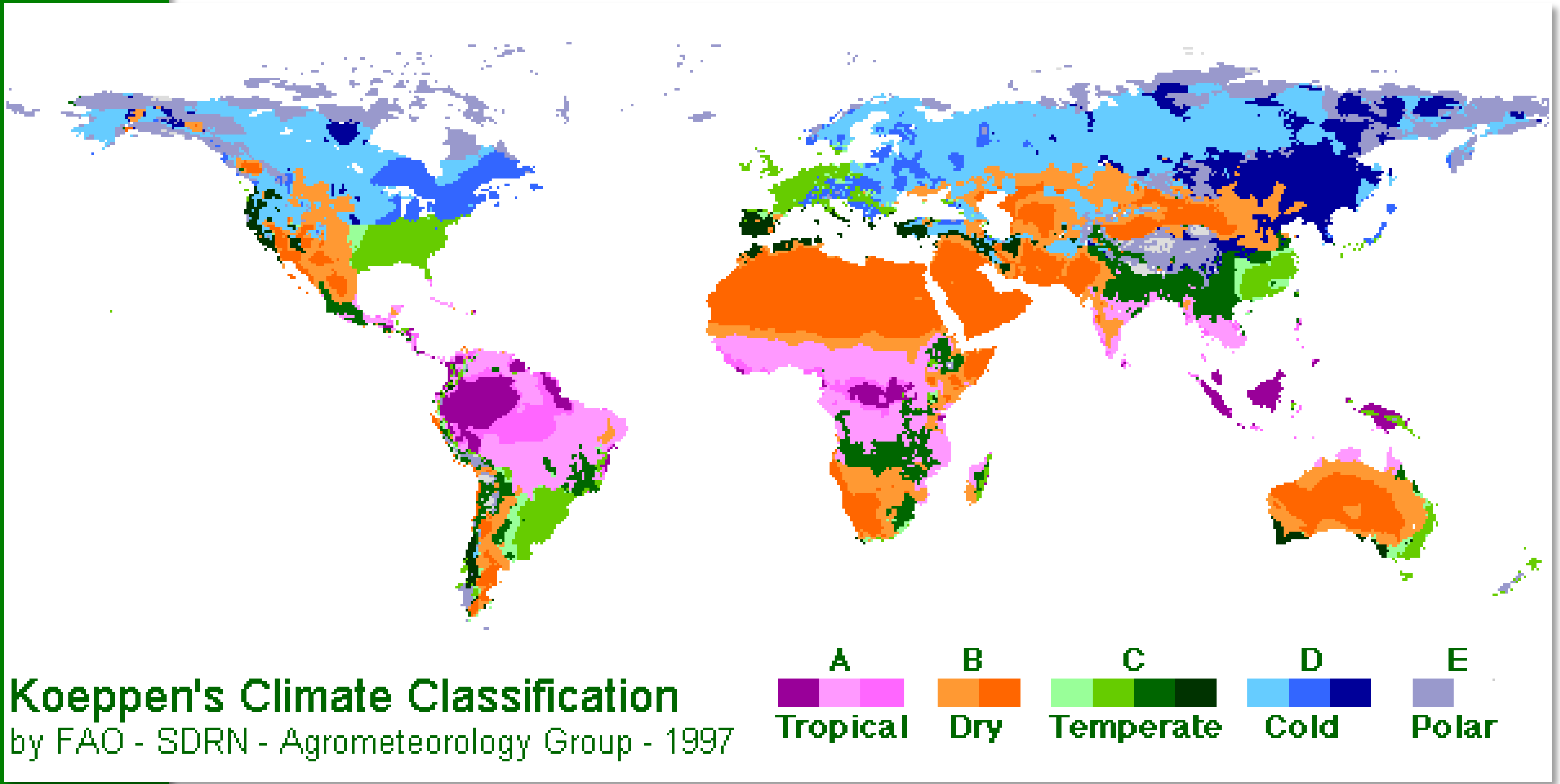


11. Regional climate zones of the North American continent.

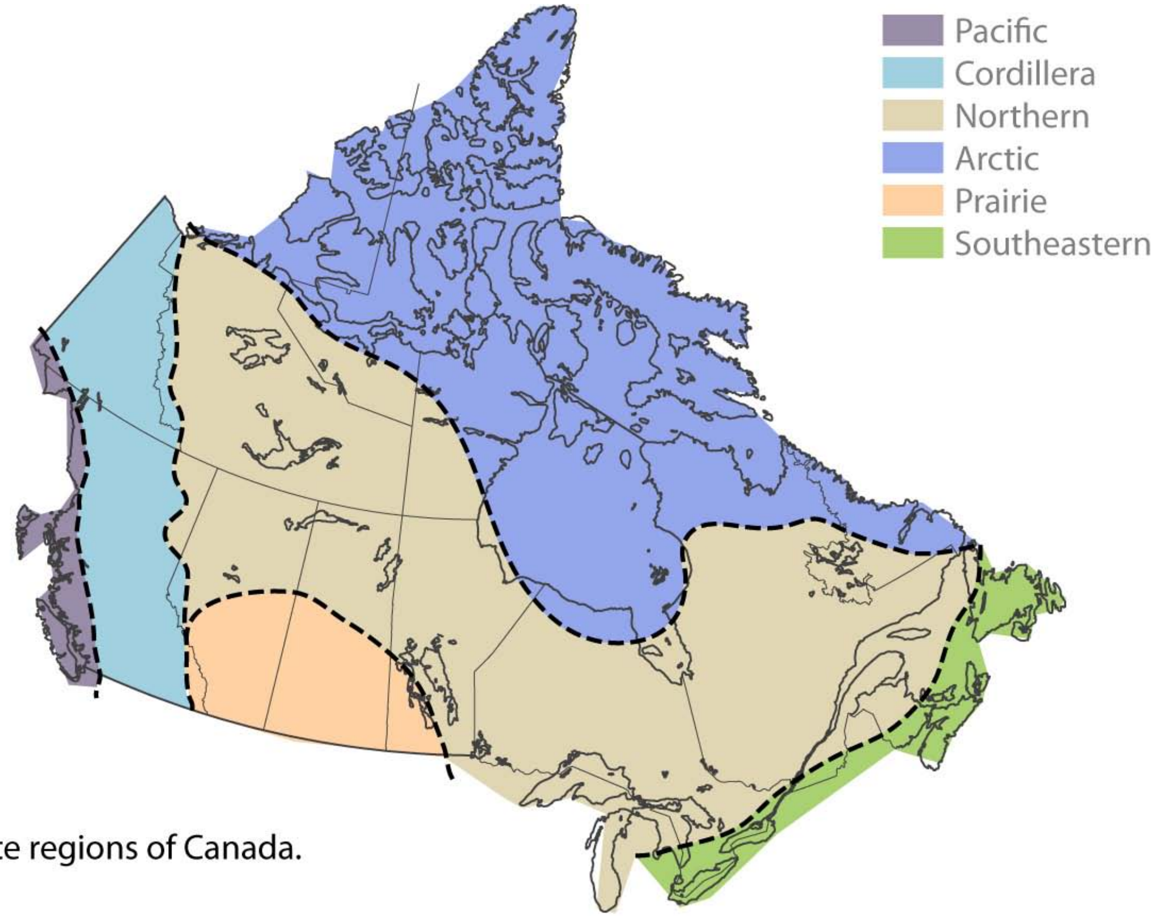
Image: 1963 “Design With Climate”, Victor Olgyay.

Global Bio-climatic Design:

Design must first acknowledge regional, local and microclimate impacts on the building and site.



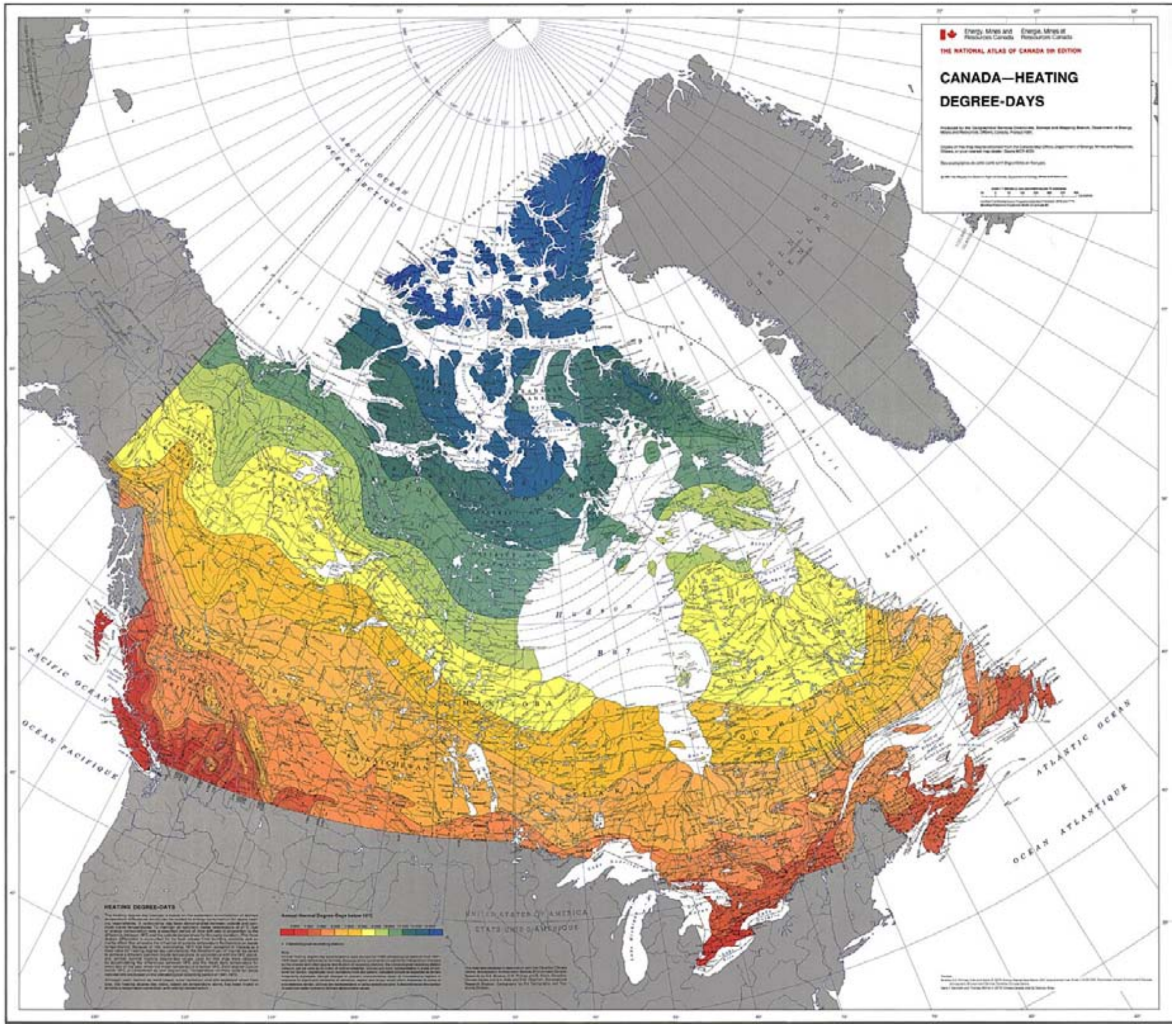
The climate regions of Canada



Climate regions of Canada.

Even within Canada, there exist variations in climate, enough to require very different envelope design practices and regulations. This mostly concerns insulation and water penetration, as well as humidity concerns.

Heating and Cooling Degree Days



This map shows the annual sum of heating degree days (an indicator of building heating needs). Data for period 1941 to 1970. **Determine if the climate is *heating* or *cooling* dominated** …this will set out your primary strategy.

The Goal is Reduction

CLIMATE AS THE STARTING POINT

FOR RETHINKING ARCHITECTURAL DESIGN

Bio-climatic Design: HOT-ARID

Where **very high summer temperatures** with great fluctuation predominate with **dry conditions** throughout the year. **Cooling degrees days greatly exceed heating degree days.**

RULES:

- SOLAR AVOIDANCE: keep DIRECT SOLAR GAIN out of the building
- avoid daytime ventilation
- promote nighttime flushing with cool evening air
- achieve daylighting by reflectance and use of LIGHT non-heat absorbing colours
- create a cooler MICROCLIMATE by using light / lightweight materials
- respect the DIURNAL CYCLE
- use heavy mass for walls and DO NOT INSULATE

Traditional House in Egypt

Bio-climatic Design: HOT-HUMID

Where **warm to hot** stable conditions predominate with **high humidity** throughout the year. **Cooling degrees days greatly exceed heating degree days.**


House in Seaside, Florida

RULES:

- **SOLAR AVOIDANCE** : large roofs with overhangs that shade walls and to allow windows open at all times
- **PROMOTE VENTILATION**
- **USE LIGHTWEIGHT MATERIALS** that do not hold heat and that will not promote condensation and dampness (mold/mildew)
- *eliminate basements and concrete*
- use STACK EFFECT to ventilate through high spaces
- use of COURTYARDS and semi-enclosed outside spaces
- use WATER FEATURES for cooling

Bio-climatic Design: TEMPERATE

The summers are hot and humid, and the winters are cold. In much of the region the topography is generally flat, allowing cold winter winds to come in form the northwest and cool summer breezes to flow in from the southwest. **The four seasons are almost equally long.**

RULES:

- BALANCE strategies between COLD and HOT-HUMID
- maximize flexibility in order to be able to modify the envelope for varying climatic conditions
- understand the natural benefits of SOLAR ANGLES that shade during the warm months and allow for heating during the cool months

IslandWood Residence, Seattle, WA

Bio-climatic Design: COLD

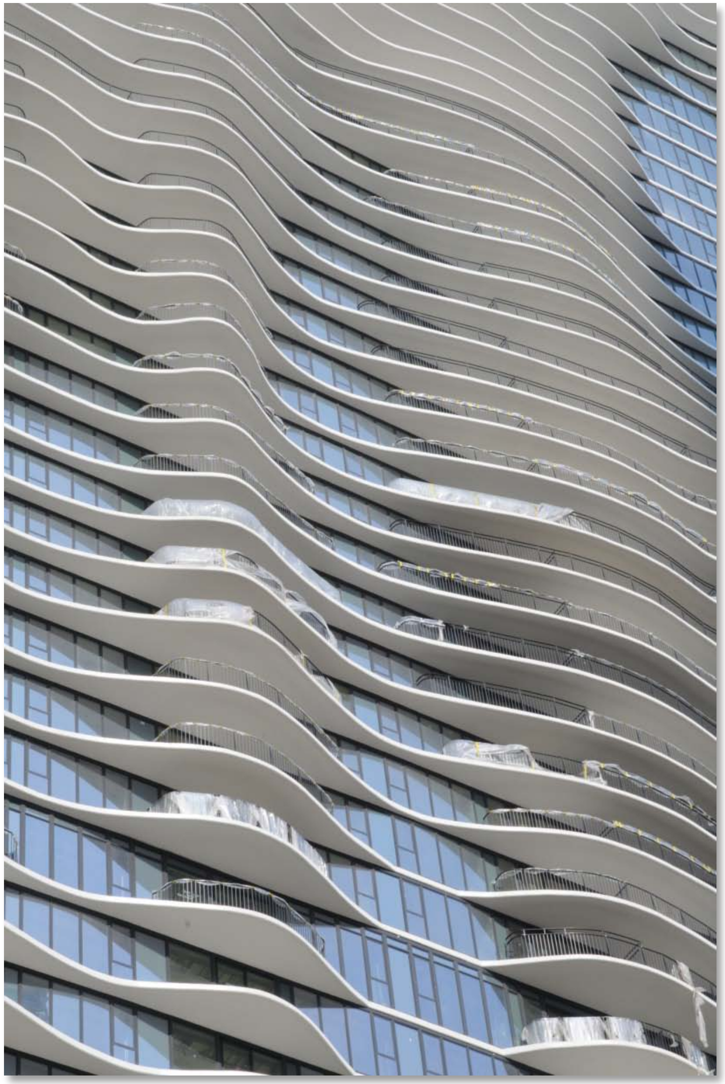
Where **winter** is the dominant season and concerns for conserving heat predominate all other concerns. **Heating degree days greatly exceed cooling degree days**.

RULES:

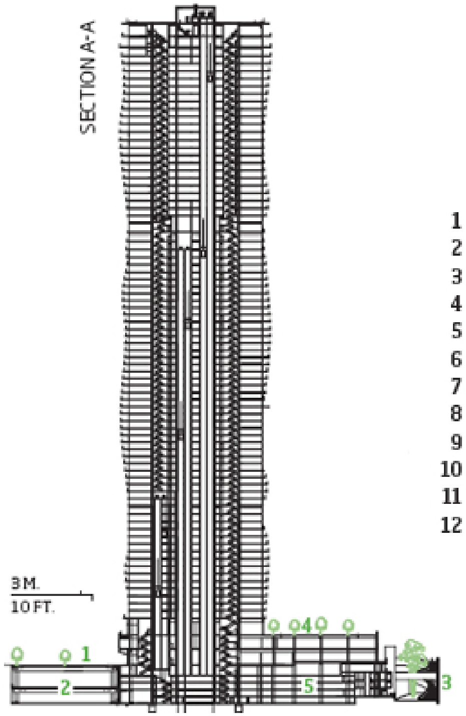
- First **INSULATE**
- *exceed* CODE requirements (DOUBLE??)
- minimize infiltration (build tight to reduce air changes)
- Then **INSOLATE**
- **ORIENT AND SITE THE BUILDING PROPERLY FOR THE SUN**
- maximize south facing windows for easier control
- fenestrate for **DIRECT GAIN**
- apply **THERMAL MASS** inside the building envelope to store the FREE SOLAR HEAT
- create a sheltered MICROCLIMATE to make it LESS cold

YMCA Environmental Learning Centre, Paradise Lake, Ontario

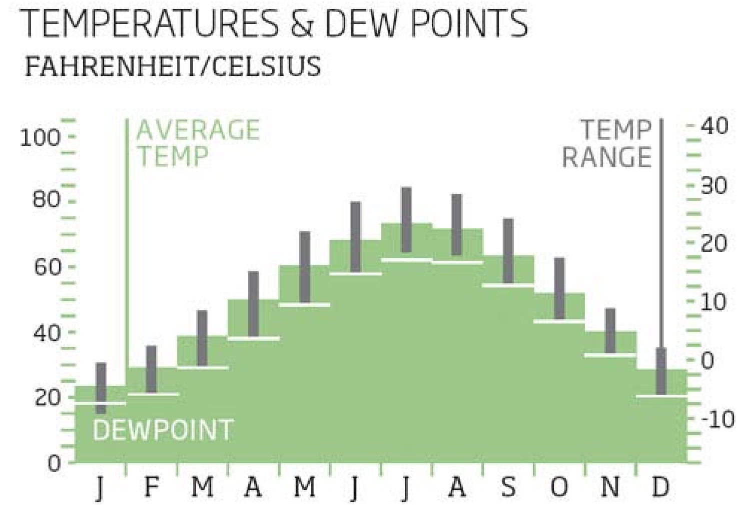
The Controversial "Cover" of Greensource Magazine



A "sustainable" Chicago residential skyscraper – going for LEED



1 Upper Columbus Drive
2 Lower Columbus Drive
3 Stair to Harbor Park
4 Roof garden
5 Parking
6 Living/dining room
7 Den
8 Kitchen
9 Bedroom
10 Master bedroom
11 Great room
12 Dining room



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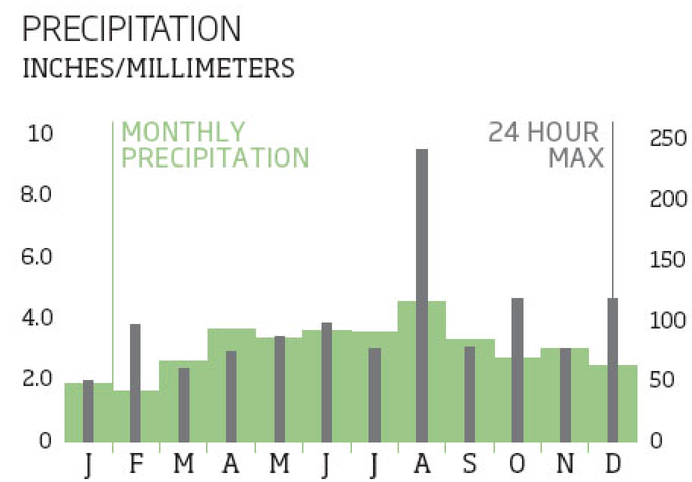
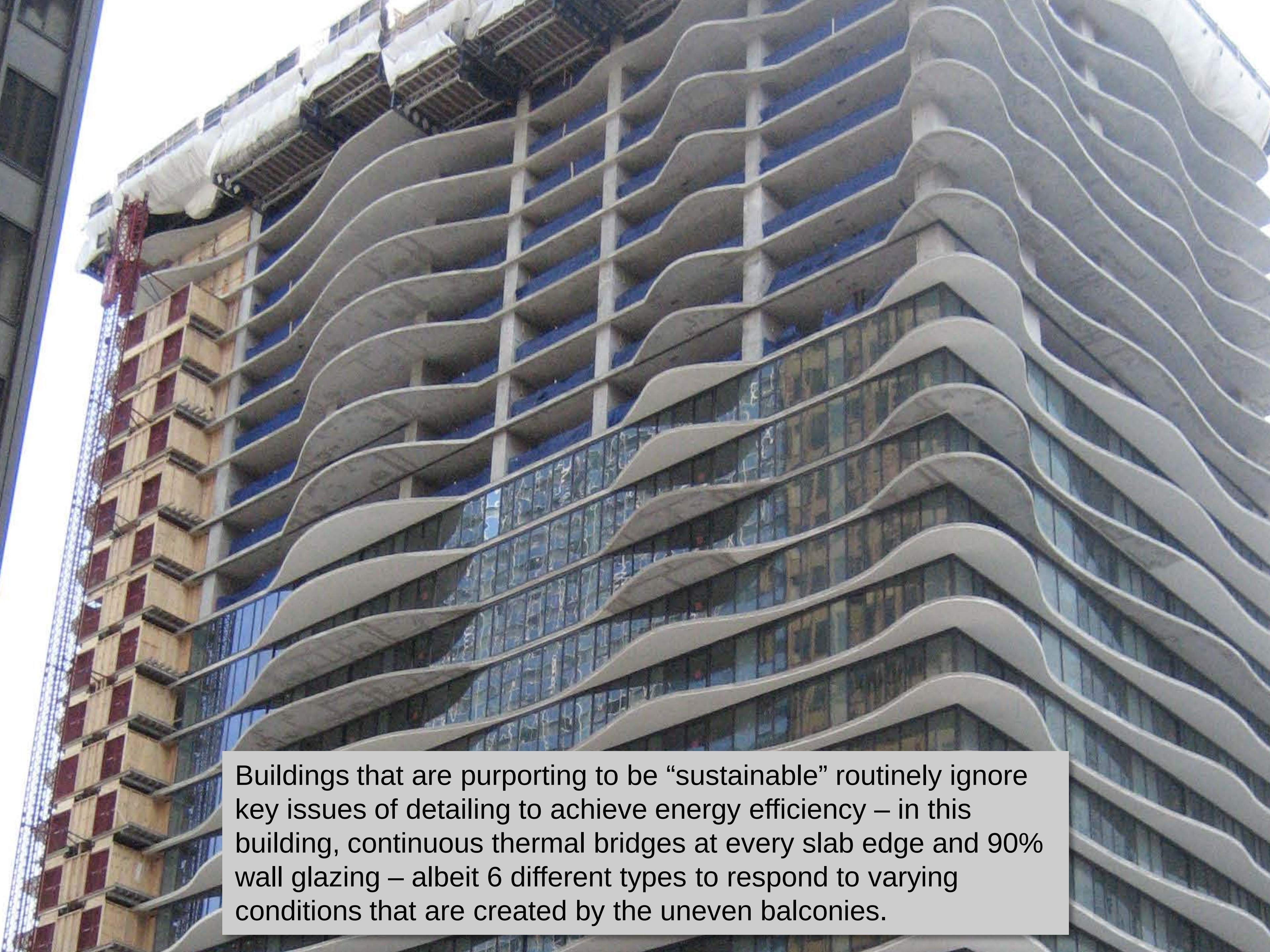


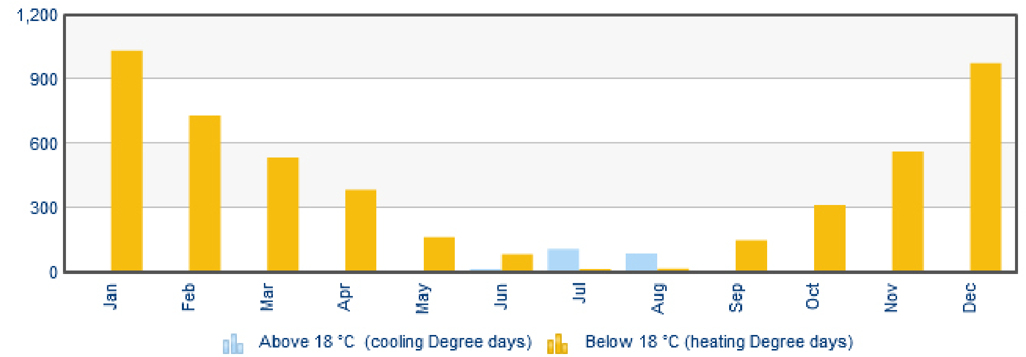
Heating degree days 3,582 ^{o}C

Cooling degree days 417^{o}C



Buildings that are purporting to be "sustainable" routinely ignore key issues of detailing to achieve energy efficiency – in this building, continuous thermal bridges at every slab edge and 90% wall glazing – albeit 6 different types to respond to varying conditions that are created by the uneven balconies.

Degree days



Degree-day

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Above 18 °C (cooling Degree days)	0	0	0	0	1	14	108	88	3	0	0	0
Below 18 °C (heating Degree days)	1033	731	534	385	164	85	16	16	150	315	564	976
Above 24 °C	0	0	0	0	0	0	7	4	0	0	0	0
Above 15 °C	0	0	0	3	13	49	188	168	22	0	0	0
Above 10 °C	0	0	0	30	105	172	341	321	116	19	0	0
Above 5 °C (Growing Degree days)	0	0	23	84	241	320	496	476	244	107	12	0
Above 0 °C	0	22	104	180	395	470	651	631	393	243	60	4
Below 0 °C	475	231	80	25	0	0	0	0	0	0	84	421
Below 5 °C	630	354	154	79	1	0	0	0	1	19	186	573
Below 10 °C	785	499	286	175	20	2	0	0	23	86	324	728
Below 15 °C	940	644	441	298	83	30	3	3	79	222	474	883

http://www.theweathernetwork.com/statistics/degreedays/cl5023262

Winnipeg

Cooling Degree Days
214 ^{o}C

Heating Degree Days
4,969 ^{o}C

Locate Comprehensive Climate Data

http://www.energy-design-tools.aud.ucla.edu/

Climate Consultant 5 is a free tool available from the above address.

You will need to download .epw climate data for your city from this website

http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm

Choose Comfort Model

- Buildings are designed for their use, occupancy or occupants
- Normally it is the people that need to be comfortable in doing their tasks, not the building
- Some uses can accommodate a much higher range of temperatures than others
- Decide if using a fully automated heating AND cooling system
- Can the building **eliminate an A/C system** due to climate?
- Can the building **use passive solar to heat** the building?
- Can the building **use passive ventilation** to cool the building?
- Can the building **take advantage of daylight** to light the building?

Choose Comfort Model

ASHRAE Handbook of Comfort Fundamentals 2005

For people dressed in normal winter clothes,

Effective Temperatures of 68°F (20°C) to 74°F (23.3°C) (measured at 50% relative humidity), which means the temperatures decrease slightly as humidity rises.

The upper humidity limit is 64°F (17.8°C) Wet Bulb and a lower Dew Point of 36F (2.2°C).

If people are dressed in light weight summer clothes then this comfort zone shifts 5°F (2.8°C) warmer.

ASHRAE Standard 55-2004 Using Predicted Mean Vote Model

Thermal comfort is based on dry bulb temperature, clothing level (clo), metabolic activity (met), air velocity, humidity, and mean radiant temperature.

Indoors it is assumed that mean radiant temperature is close to dry bulb temperature.

The zone in which most people are comfortable is calculated using the PMV model.

In **residential settings** people adapt clothing to match the season and feel comfortable in higher air velocities and so have wider comfort range than in buildings with centralized HVAC systems.

Adaptive Comfort Model in ASHRAE Standard 55-2004

In naturally ventilated spaces where occupants can open and close windows, their thermal response will depend in part on the outdoor climate, and may have a wider comfort range than in buildings with centralized HVAC systems.

This model assumes occupants adapt their clothing to thermal conditions, and are sedentary.

There must be no mechanical Cooling System, so this method does not apply if a Mechanical Heating System is in operation.

The ability to completely eliminate a Mechanical Cooling System has great potential for Carbon savings, but comfort must be maintained passively.

Climate Data for Winnipeg

Climate Consultant 5.0 (Build 3, Oct 19, 2010)

File Criteria Charts Help

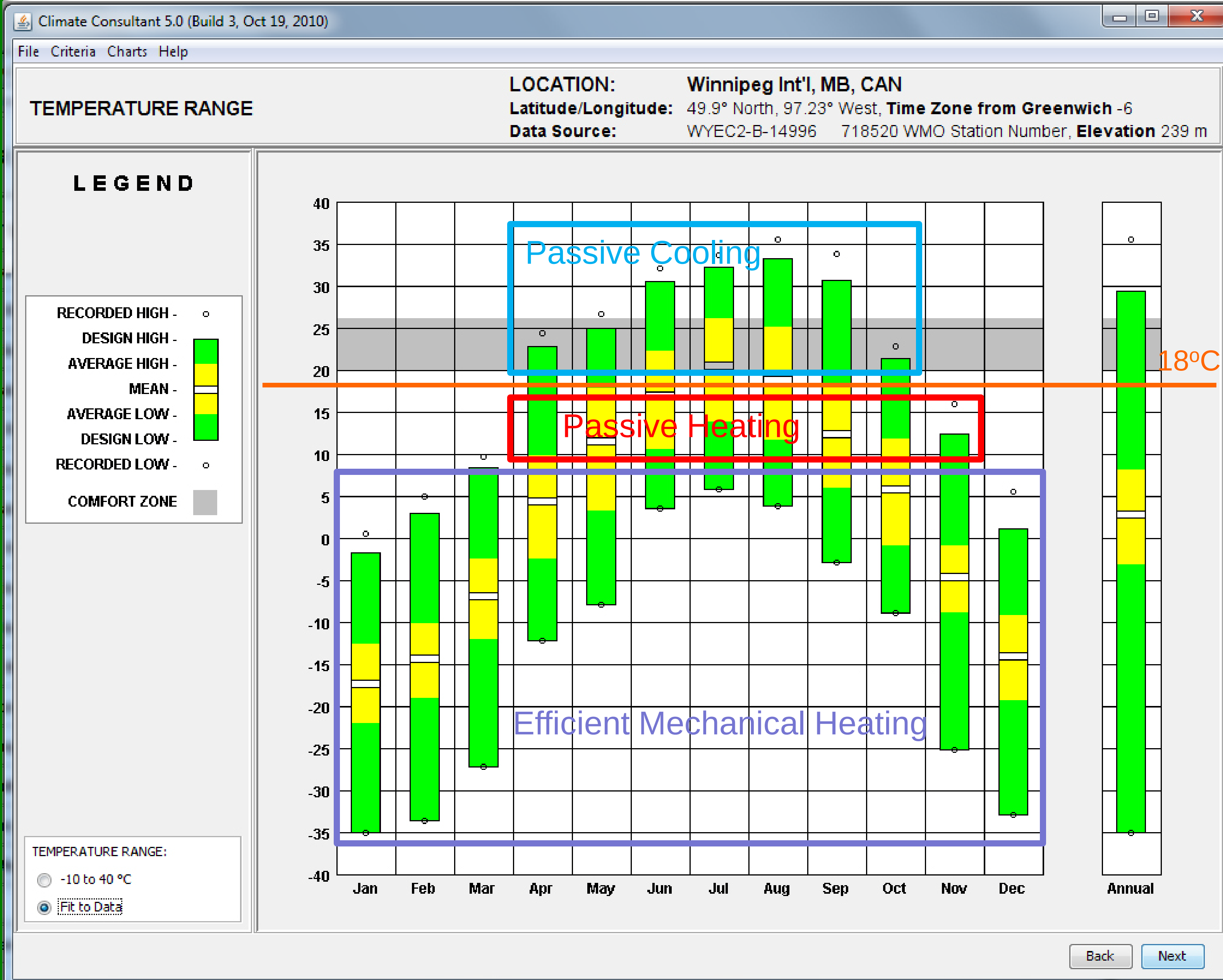
WEATHER DATA SUMMARY

LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, **Time Zone from Greenwich** -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, **Elevation** 239 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	197	290	369	417	461	440	474	430	337	257	176	185	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	389	395	448	458	481	423	477	455	379	358	272	396	Wh/sq.m
Diffuse Radiation (Avg Hourly)	92	148	153	156	163	165	162	157	139	109	93	85	Wh/sq.m
Global Horiz Radiation (Max Hourly)	416	536	736	882	995	959	910	855	764	616	418	341	Wh/sq.m
Direct Normal Radiation (Max Hourly)	868	976	926	1000	1012	989	929	947	907	929	910	901	Wh/sq.m
Diffuse Radiation (Max Hourly)	868	976	926	1000	1012	989	929	947	907	929	910	901	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	1426	2370	3718	4929	6122	6438	6397	5387	3640	2293	1322	1149	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	2796	3507	4701	5549	6574	6260	6689	5820	4345	3421	2212	2511	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	700	1229	1584	1887	2217	2444	2236	2016	1530	1000	707	566	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	21612	32630	41694	46922	51850	49612	53326	48532	38136	28831	19648	20034	lux
Direct Normal Illumination (Avg Hourly)	37327	40526	47384	48765	51353	45049	51190	48618	40274	37367	27029	37425	lux
Dry Bulb Temperature (Avg Monthly)	-17	-14	-6	4	11	17	20	18	12	5	-4	-14	degrees C
Dew Point Temperature (Avg Monthly)	-20	-17	-11	-2	1	9	13	11	6	0	-8	-16	degrees C
Relative Humidity (Avg Monthly)	76	74	69	62	55	63	66	67	68	64	76	81	percent
Wind Direction (Avg Monthly)	181	198	145	145	125	173	190	132	185	200	202	198	degrees
Wind Speed (Avg Monthly)	6	5	4	5	5	4	4	3	5	4	5	4	m/s
Ignore values for snow.													cms
Ground Temperature (Avg Monthly of 3 Depths)	-7	-9	-8	-6	1	7	12	14	13	9	3	-2	degrees C

Back Next

Data taken from Climate Consultant 5


Climate Consultant 5.0 (Build 3, Oct 19, 2010)
File Criteria Charts Help
TEMPERATURE RANGE
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
RECORDED HIGH -
DESIGN HIGH -
AVERAGE HIGH -
MEAN -
AVERAGE LOW -
DESIGN LOW -
RECORDED LOW -
COMFORT ZONE
TEMPERATURE RANGE:
-10 to 40 °C
Fit to Data
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Annual
Passive Cooling
18°C
Passive Heating
Efficient Mechanical Heating
Back
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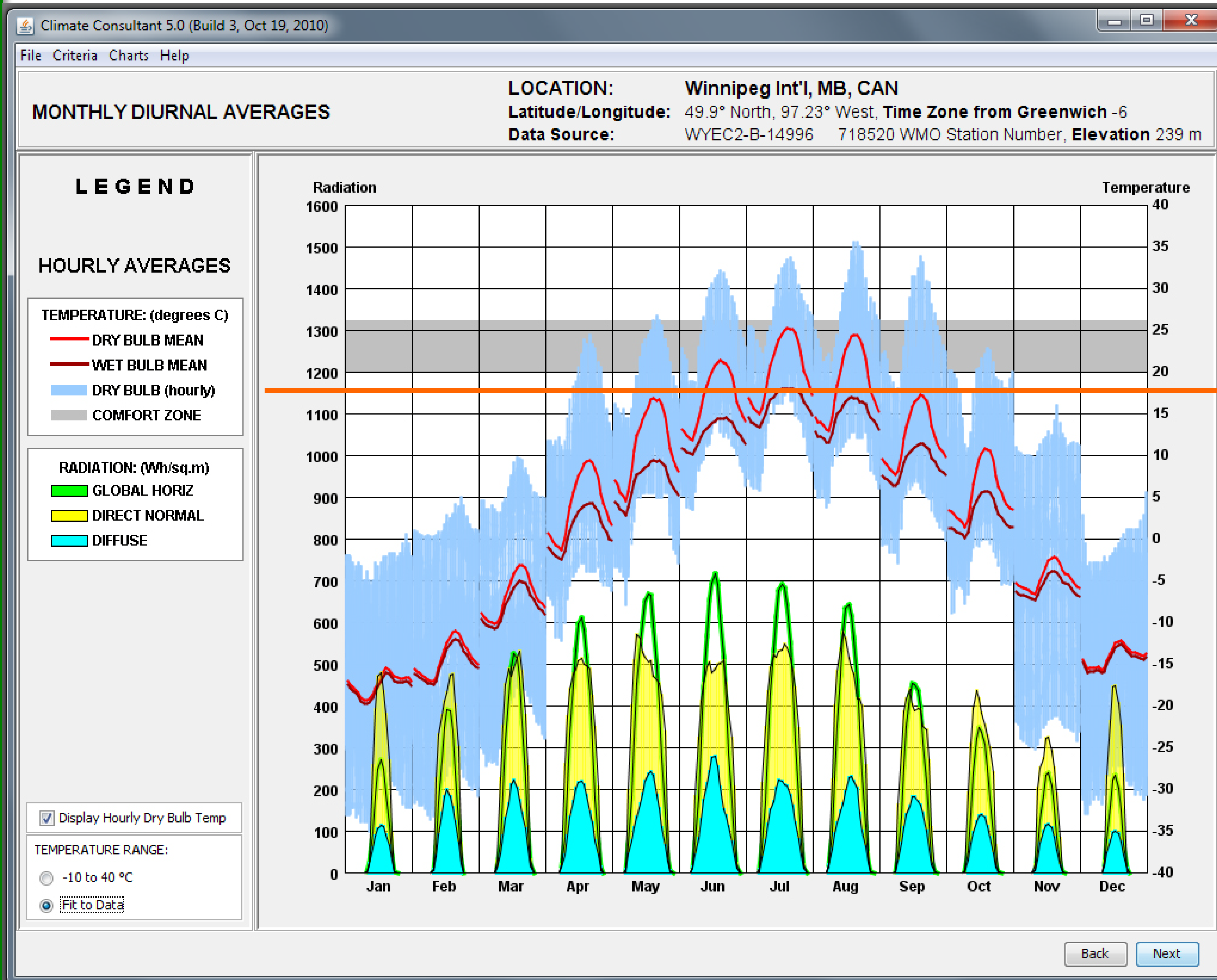
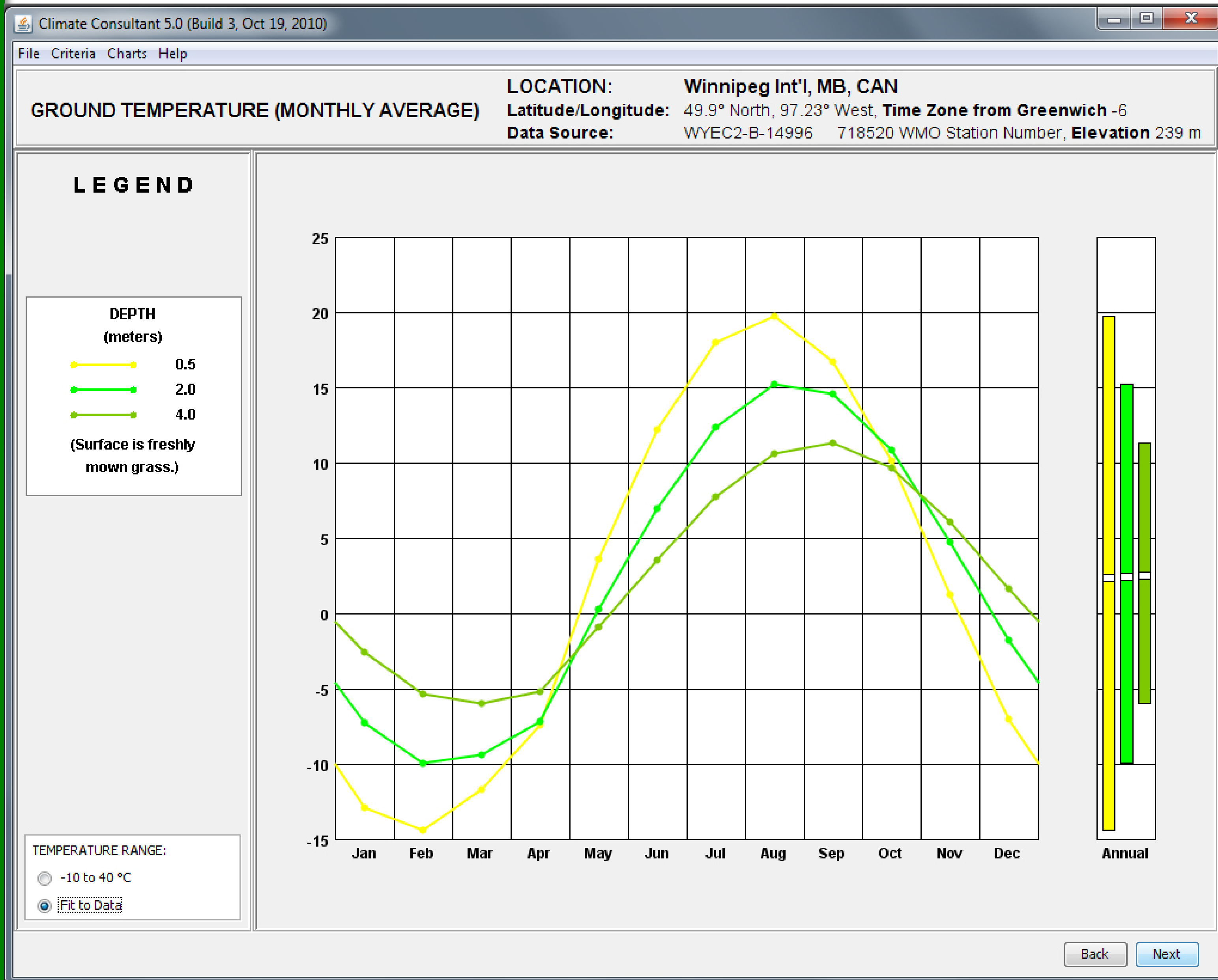
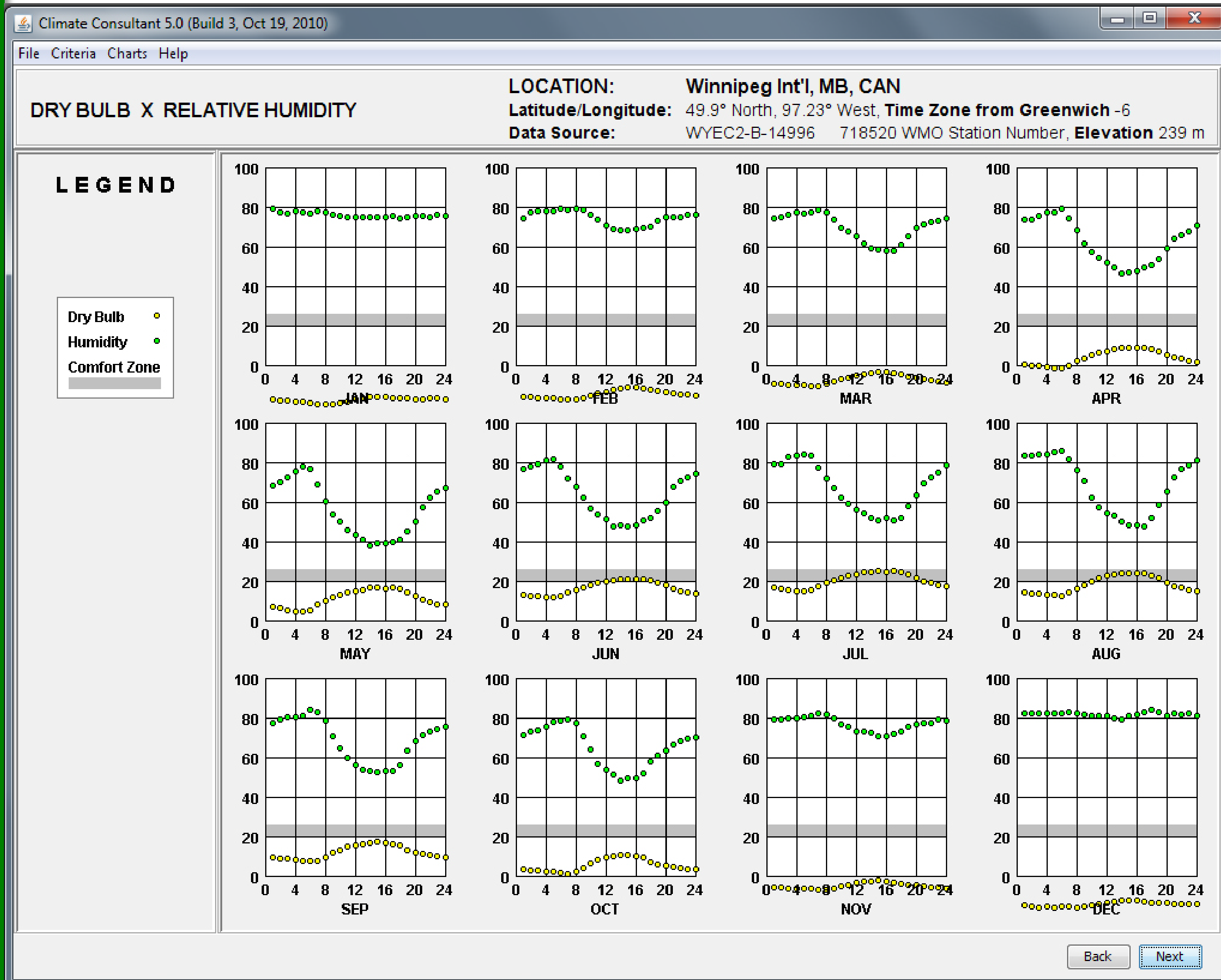

Climate Consultant 5.0 (Build 3, Oct 19, 2010)
File Criteria Charts Help
MONTHLY DIURNAL AVERAGES
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
HOURLY AVERAGES
TEMPERATURE: (degrees C)
DRY BULB MEAN
WET BULB MEAN
DRY BULB (hourly)
COMFORT ZONE
RADIATION: (Wh/sq.m)
GLOBAL HORIZ
DIRECT NORMAL
DIFFUSE
Display Hourly Dry Bulb Temp
TEMPERATURE RANGE:
-10 to 40 °C
Fit to Data
Radiation
Temperature
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Back
Next



Climate Consultant 5.0 (Build 3, Oct 19, 2010)
File Criteria Charts Help
GROUND TEMPERATURE (MONTHLY AVERAGE)
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
DEPTH (meters)
0.5
2.0
4.0
(Surface is freshly mown grass.)
TEMPERATURE RANGE:
-10 to 40 °C
Fit to Data
25
20
15
10
5
0
-5
-10
-15
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Annual
Back
Next



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File Criteria Charts Help
DRY BULB X RELATIVE HUMIDITY
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
Dry Bulb
Humidity
Comfort Zone
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Back
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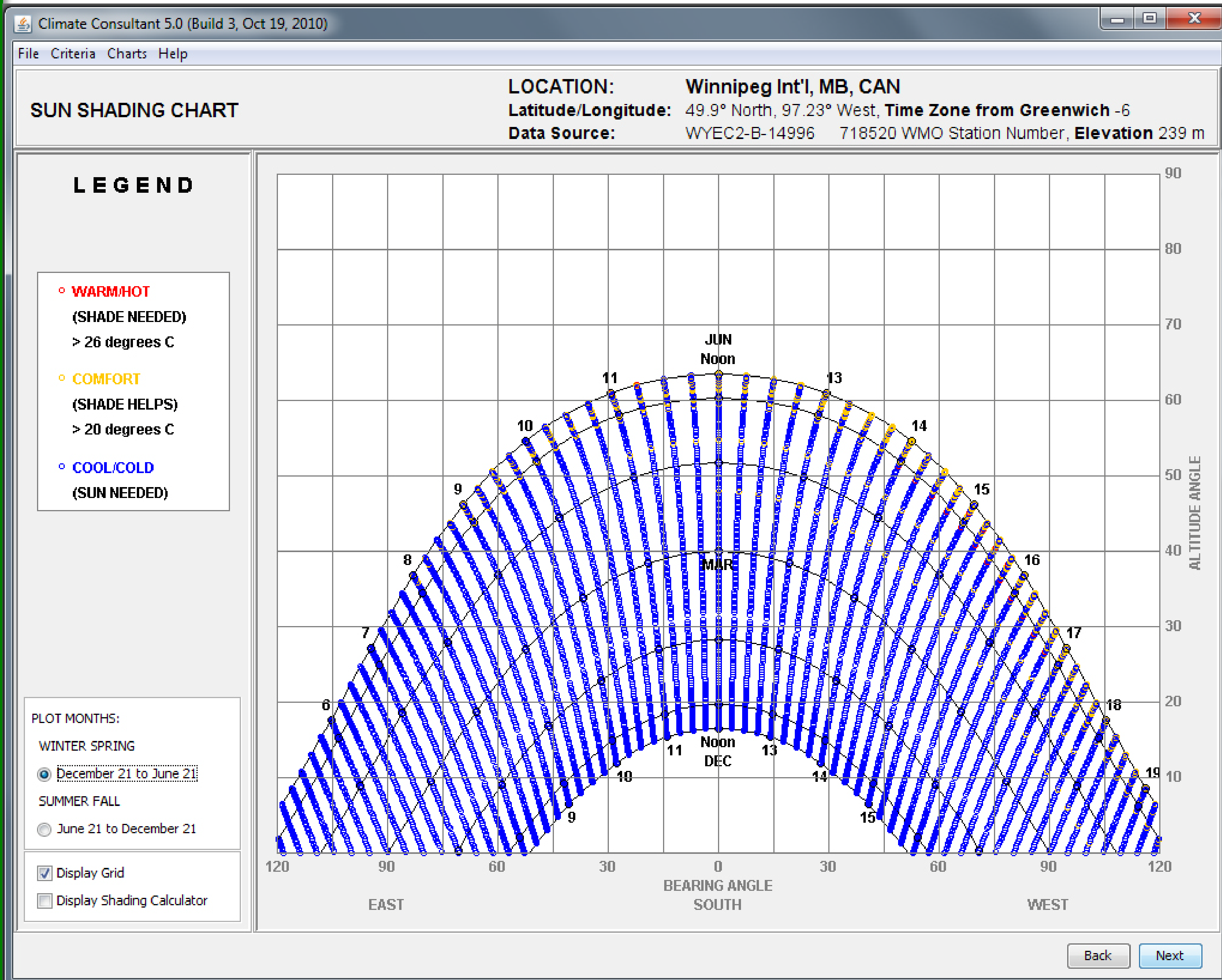
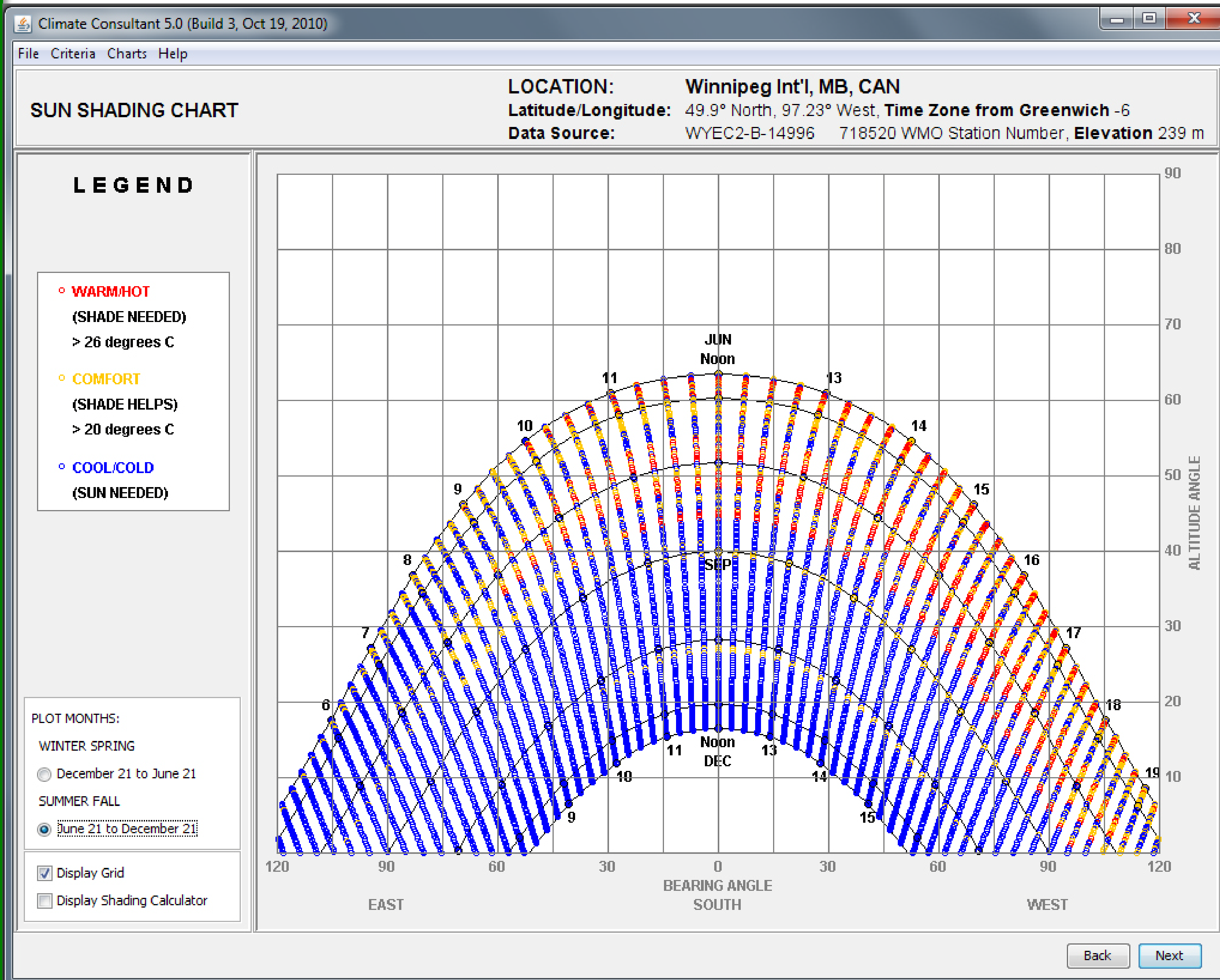
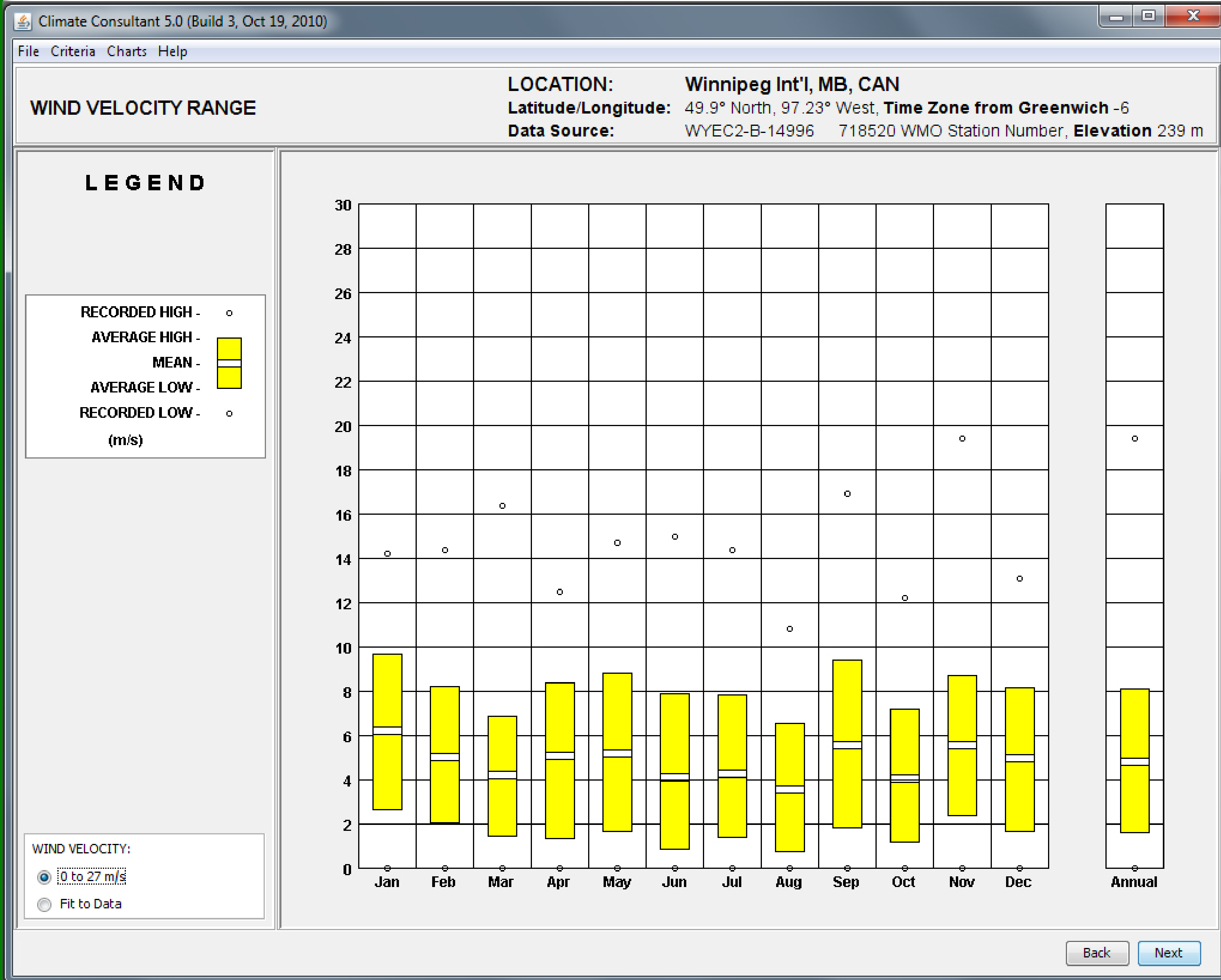


Climate Consultant 5.0 (Build 3, Oct 19, 2010)
File Criteria Charts Help
SUN SHADING CHART
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
WARM/HOT
(SHADE NEEDED)
> 26 degrees C
COMFORT
(SHADE HELPS)
> 20 degrees C
COOL/COLD
(SUN NEEDED)
PLOT MONTHS:
WINTER SPRING
December 21 to June 21
SUMMER FALL
June 21 to December 21
Display Grid
Display Shading Calculator
JUN
Noon
MAR
Noon
DEC
ALTITUDE ANGLE
BEARING ANGLE
SOUTH
EAST
WEST
Back
Next



Climate Consultant 5.0 (Build 3, Oct 19, 2010)
File Criteria Charts Help
SUN SHADING CHART
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
WARM/HOT
(SHADE NEEDED)
> 26 degrees C
COMFORT
(SHADE HELPS)
> 20 degrees C
COOL/COLD
(SUN NEEDED)
PLOT MONTHS:
WINTER SPRING
December 21 to June 21
SUMMER FALL
June 21 to December 21
Display Grid
Display Shading Calculator
JUN
Noon
SEP
Noon
DEC
ALTITUDE ANGLE
BEARING ANGLE
SOUTH
EAST
WEST
Back
Next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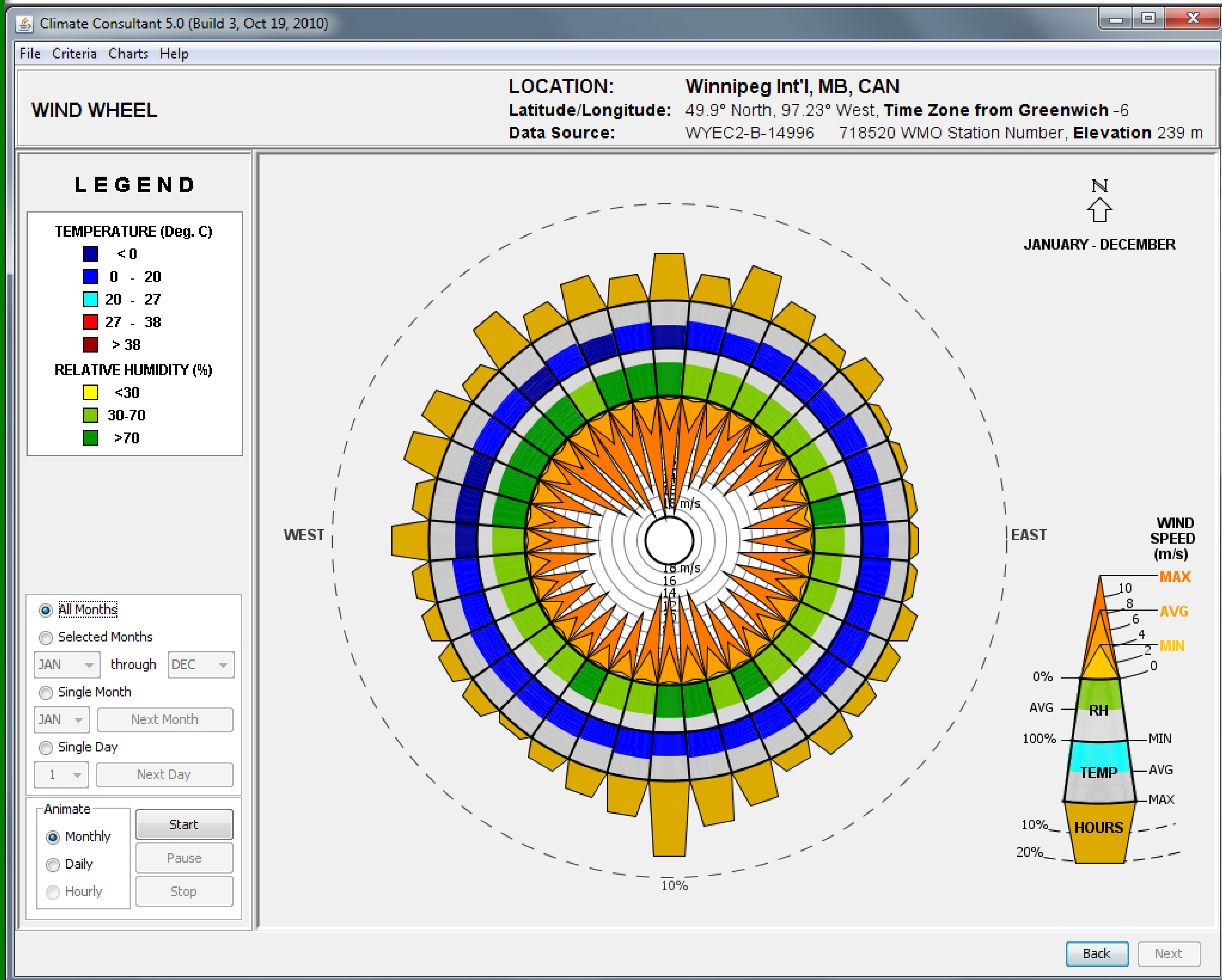
File Criteria Charts Help
WIND VELOCITY RANGE
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
RECORDED HIGH -
AVERAGE HIGH -
MEAN -
AVERAGE LOW -
RECORDED LOW -
(m/s)
WIND VELOCITY:
0 to 27 m/s
Fit to Data
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Annual
Back
Next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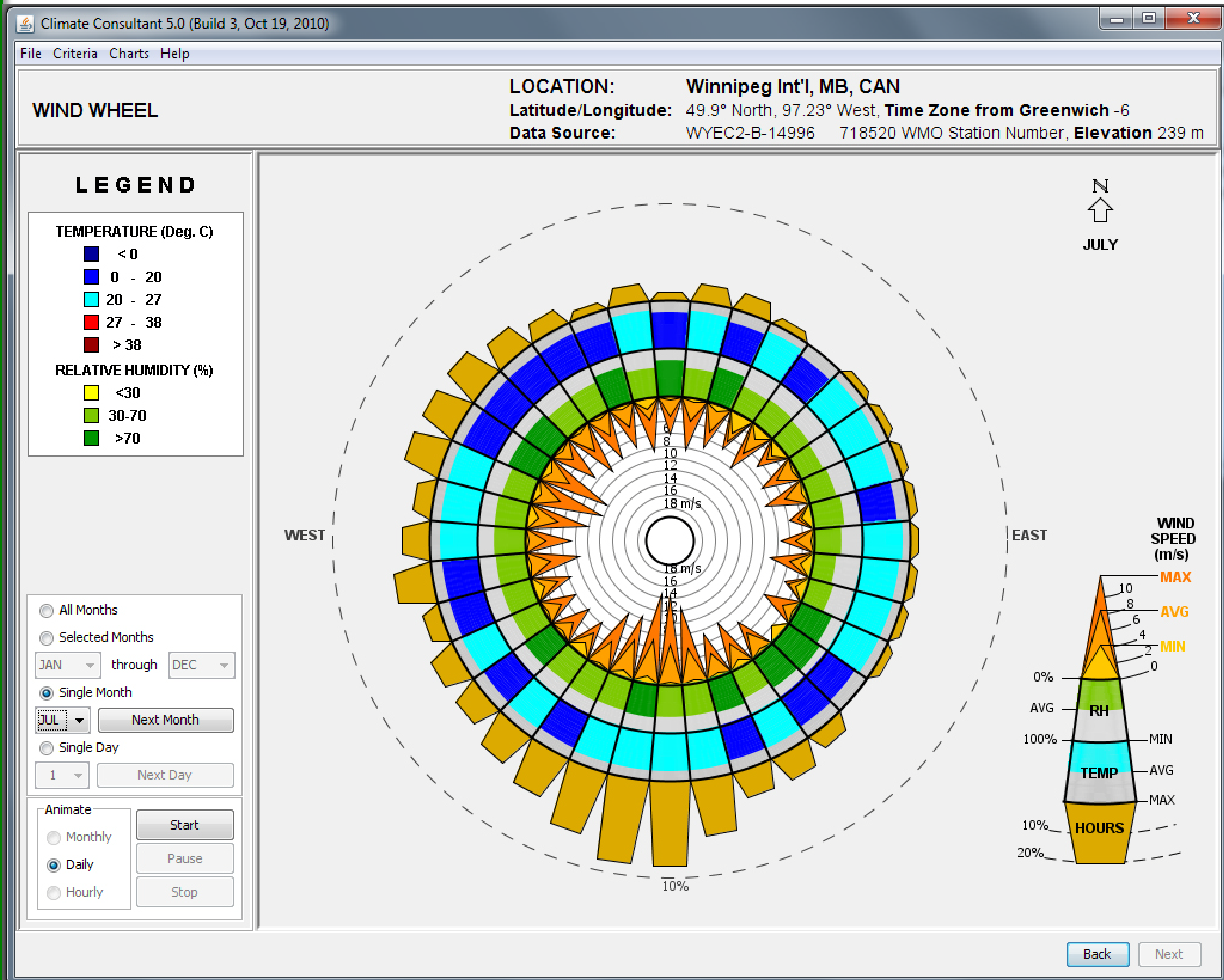
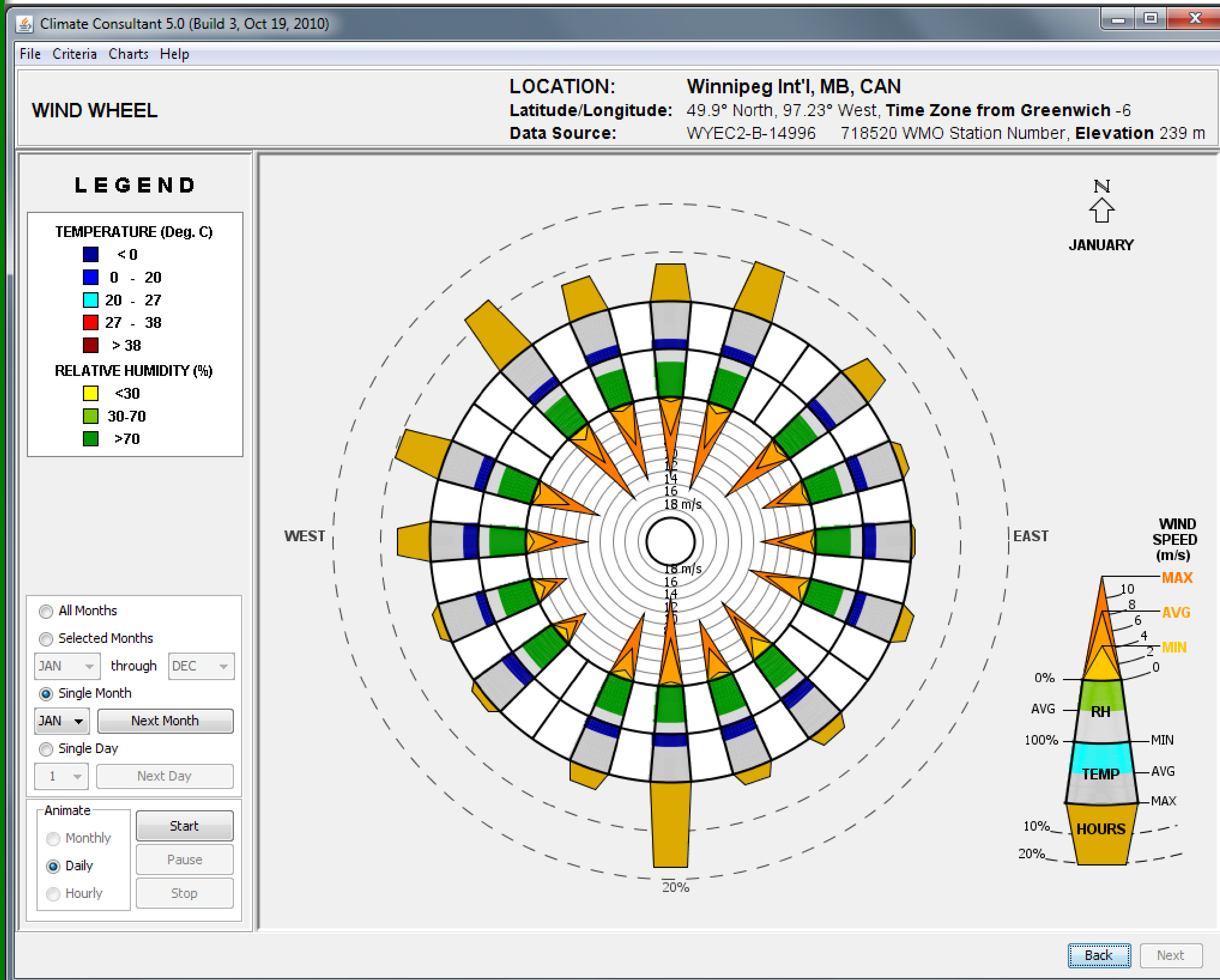
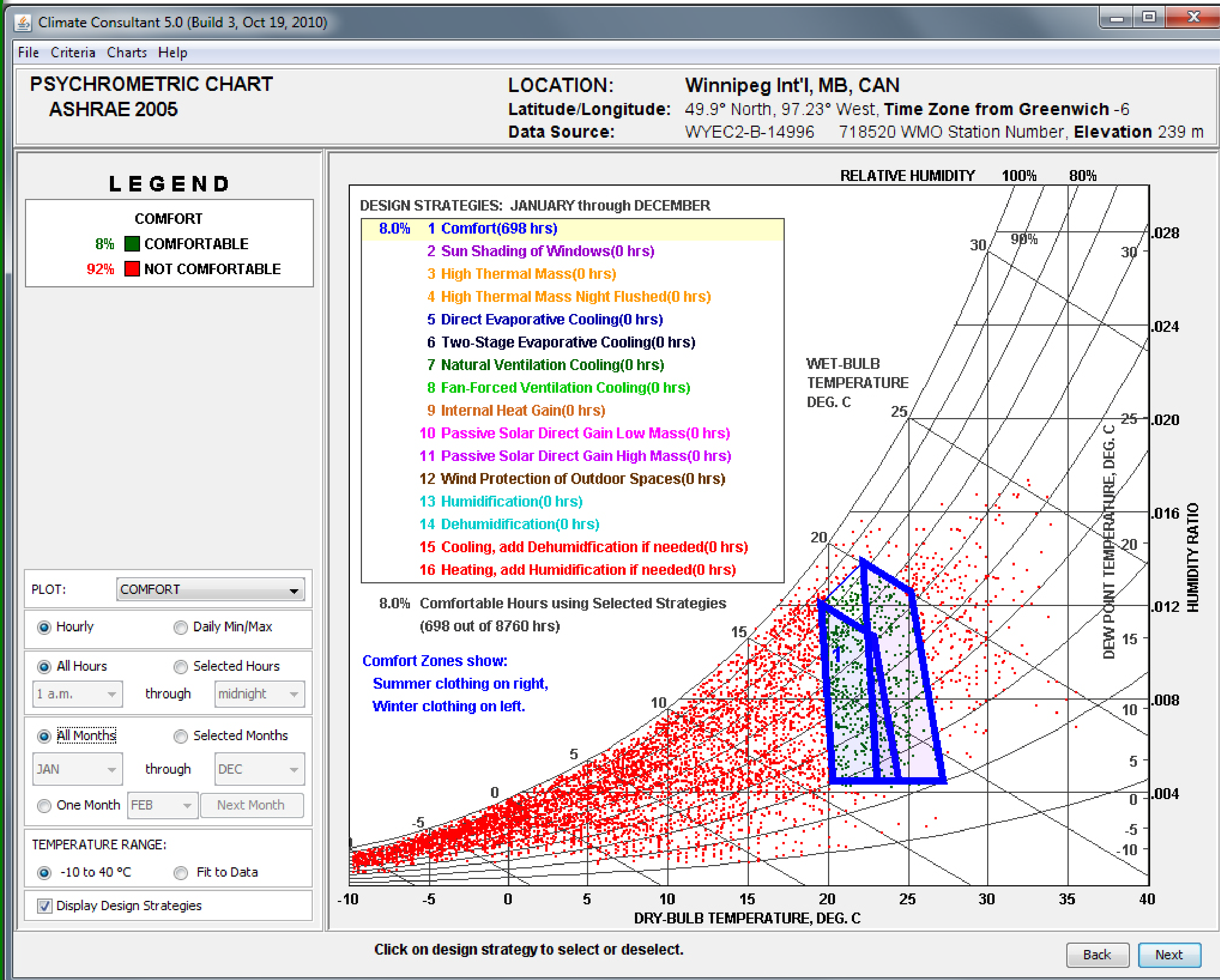
File Criteria Charts Help
WIND WHEEL
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
TEMPERATURE (Deg. C)
< 0
0 - 20
20 - 27
27 - 38
> 38
RELATIVE HUMIDITY (%)
<30
30-70
>70
All Months
Selected Months
JAN through DEC
Single Month
JAN Next Month
Single Day
1 Next Day
Animate
Monthly
Daily
Hourly
Start
Pause
Stop
N
JANUARY - DECEMBER
WEST
EAST
18 m/s
16
14
12
10
10%
WIND SPEED (m/s)
MAX
AVG
MIN
10
8
6
4
2
0
0%
AVG
100%
RH
MIN
AVG
MAX
TEMP
10%
20%
HOURS
Back
Next



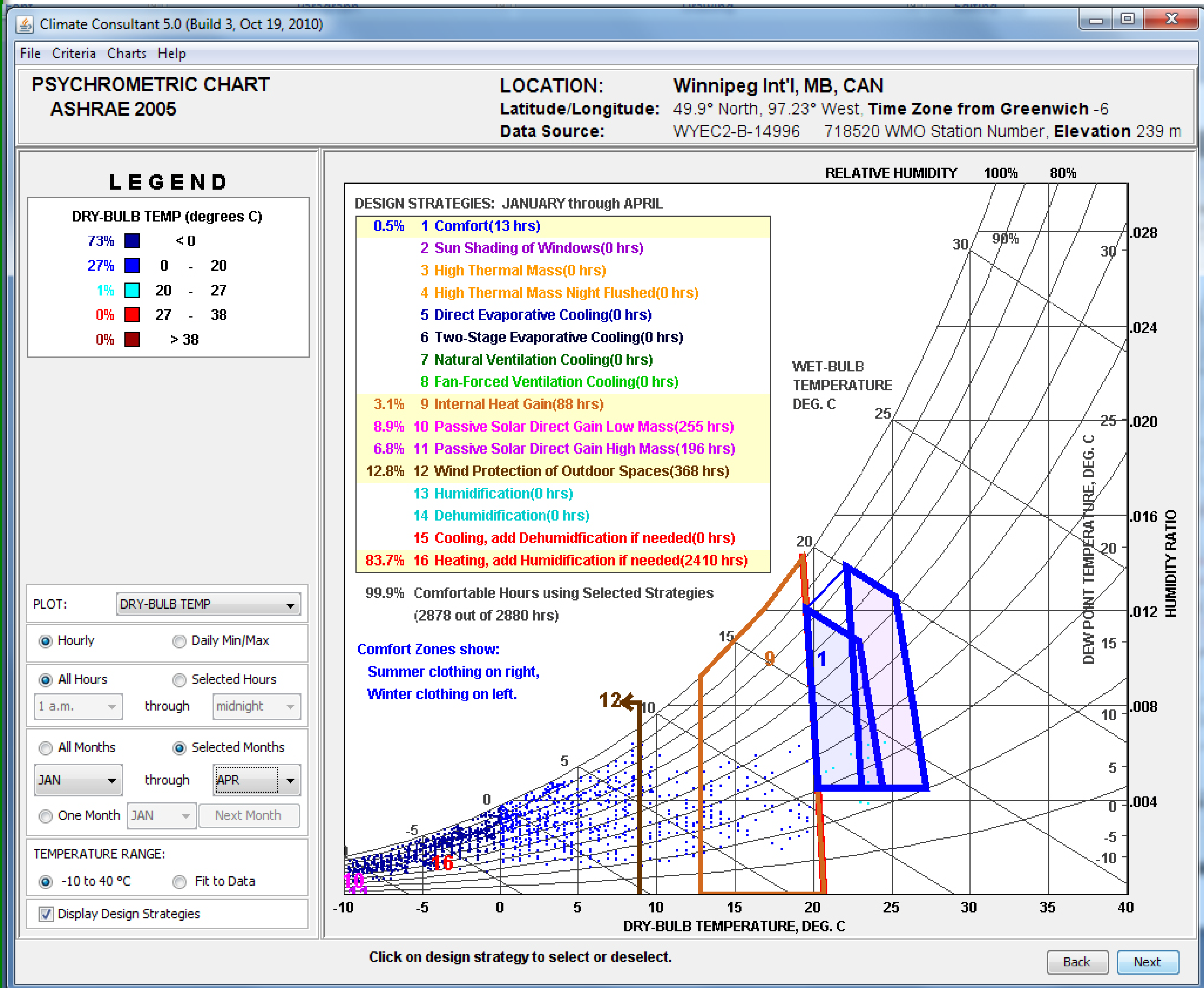
Climate Consultant 5.0 (Build 3, Oct 19, 2010)
File Criteria Charts Help
WIND WHEEL
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
TEMPERATURE (Deg. C)
< 0
0 - 20
20 - 27
27 - 38
> 38
RELATIVE HUMIDITY (%)
<30
30-70
>70
All Months
Selected Months
JAN through DEC
Single Month
JUL
Next Month
Single Day
1
Next Day
Animate
Monthly
Daily
Hourly
Start
Pause
Stop
N
JULY
WEST
EAST
18 m/s
10%
WIND SPEED (m/s)
MAX
AVG
MIN
0%
AVG
RH
100%
MIN
TEMP
AVG
MAX
10%
HOURS
20%
Back
Next



Climate Consultant 5.0 (Build 3, Oct 19, 2010)
File Criteria Charts Help
WIND WHEEL
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
TEMPERATURE (Deg. C)
< 0
0 - 20
20 - 27
27 - 38
> 38
RELATIVE HUMIDITY (%)
<30
30-70
>70
All Months
Selected Months
JAN through DEC
Single Month
JAN Next Month
Single Day
1 Next Day
Animate
Monthly
Daily
Hourly
Start
Pause
Stop
N
JANUARY
WEST
EAST
18 m/s
16
14
12
10
20%
WIND SPEED (m/s)
MAX
AVG
MIN
10
8
6
4
2
0
0%
AVG
RH
100%
MIN
TEMP
AVG
MAX
10%
HOURS
20%
Back
Next



Climate Consultant 5.0 (Build 3, Oct 19, 2010)
File Criteria Charts Help
PSYCHROMETRIC CHART
ASHRAE 2005
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
COMFORT
8% COMFORTABLE
92% NOT COMFORTABLE
PLOT: COMFORT
Hourly
Daily Min/Max
All Hours
Selected Hours
1 a.m. through midnight
All Months
Selected Months
JAN through DEC
One Month FEB Next Month
TEMPERATURE RANGE:
-10 to 40 °C
Fit to Data
Display Design Strategies
RELATIVE HUMIDITY 100% 80%
DESIGN STRATEGIES: JANUARY through DECEMBER
8.0% 1 Comfort(698 hrs)
2 Sun Shading of Windows(0 hrs)
3 High Thermal Mass(0 hrs)
4 High Thermal Mass Night Flushed(0 hrs)
5 Direct Evaporative Cooling(0 hrs)
6 Two-Stage Evaporative Cooling(0 hrs)
7 Natural Ventilation Cooling(0 hrs)
8 Fan-Forced Ventilation Cooling(0 hrs)
9 Internal Heat Gain(0 hrs)
10 Passive Solar Direct Gain Low Mass(0 hrs)
11 Passive Solar Direct Gain High Mass(0 hrs)
12 Wind Protection of Outdoor Spaces(0 hrs)
13 Humidification(0 hrs)
14 Dehumidification(0 hrs)
15 Cooling, add Dehumidification if needed(0 hrs)
16 Heating, add Humidification if needed(0 hrs)
8.0% Comfortable Hours using Selected Strategies
(698 out of 8760 hrs)
Comfort Zones show:
Summer clothing on right,
Winter clothing on left.
WET-BULB TEMPERATURE DEG. C
DEW POINT TEMPERATURE, DEG. C
HUMIDITY RATIO
.028
.024
.020
.016
.012
.008
.004
-10 -5 0 5 10 15 20 25 30 35 40
DRY-BULB TEMPERATURE, DEG. C
Click on design strategy to select or deselect.
Back
Next


Climate Consultant 5.0 (Build 3, Oct 19, 2010)
File Criteria Charts Help
PSYCHROMETRIC CHART
ASHRAE 2005
LOCATION: Winnipeg Int'l, MB, CAN
Latitude/Longitude: 49.9° North, 97.23° West, Time Zone from Greenwich -6
Data Source: WYEC2-B-14996 718520 WMO Station Number, Elevation 239 m
LEGEND
DRY-BULB TEMP (degrees C)
73% < 0
27% 0 - 20
1% 20 - 27
0% 27 - 38
0% > 38
PLOT: DRY-BULB TEMP
Hourly
Daily Min/Max
All Hours
Selected Hours
1 a.m. through midnight
All Months
Selected Months
JAN through APR
One Month JAN Next Month
TEMPERATURE RANGE:
-10 to 40 °C
Fit to Data
Display Design Strategies
RELATIVE HUMIDITY 100% 80%
DESIGN STRATEGIES: JANUARY through APRIL
0.5% 1 Comfort(13 hrs)
2 Sun Shading of Windows(0 hrs)
3 High Thermal Mass(0 hrs)
4 High Thermal Mass Night Flushed(0 hrs)
5 Direct Evaporative Cooling(0 hrs)
6 Two-Stage Evaporative Cooling(0 hrs)
7 Natural Ventilation Cooling(0 hrs)
8 Fan-Forced Ventilation Cooling(0 hrs)
3.1% 9 Internal Heat Gain(88 hrs)
8.9% 10 Passive Solar Direct Gain Low Mass(255 hrs)
6.8% 11 Passive Solar Direct Gain High Mass(196 hrs)
12.8% 12 Wind Protection of Outdoor Spaces(368 hrs)
13 Humidification(0 hrs)
14 Dehumidification(0 hrs)
15 Cooling, add Dehumidfication if needed(0 hrs)
83.7% 16 Heating, add Humidification if needed(2410 hrs)
99.9% Comfortable Hours using Selected Strategies
(2878 out of 2880 hrs)
Comfort Zones show:
Summer clothing on right,
Winter clothing on left.
WET-BULB TEMPERATURE DEG. C
DEW POINT TEMPERATURE, DEG. C
HUMIDITY RATIO
DRY-BULB TEMPERATURE, DEG. C
Click on design strategy to select or deselect.
Back
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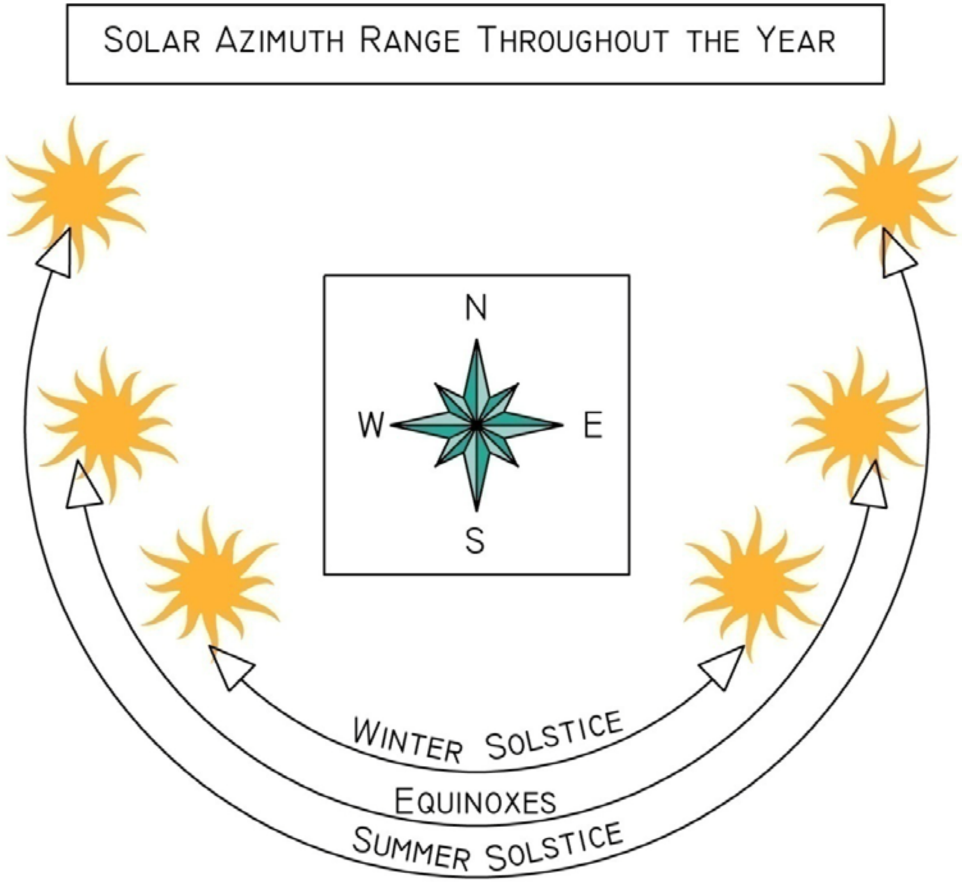
Climate as the Starting Point
for a
Climate Responsive Design

PASSIVE STRATEGIES

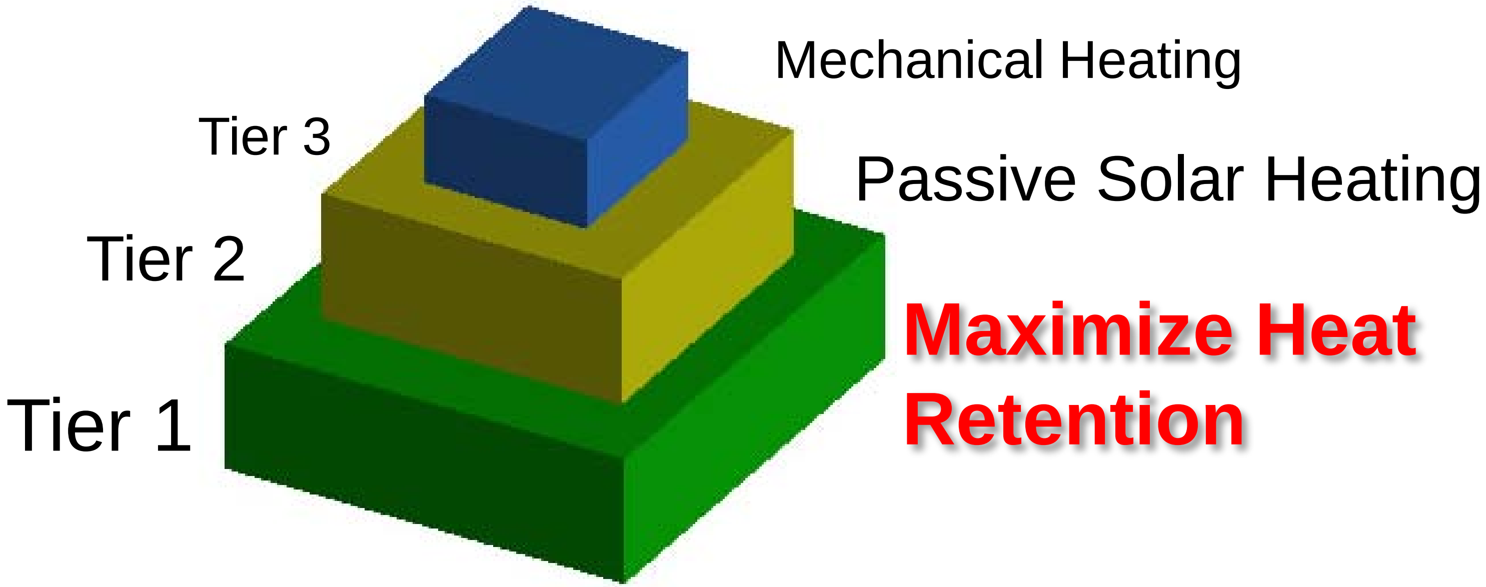
#1 Architectural Starting Point – Locate the SUN



… and work with it! For FREE HEAT
and FREE LIGHT

Reduce loads: Passive Strategies

The tiered approach to reducing carbon for **HEATING**:



First reduce the overall energy required, then maximize the amount of energy required for mechanical heating that comes from renewable sources.

Source: Lechner. Heating, Cooling, Lighting.

Passive Heating Strategies:
Maximize Heat Retention

1. Super insulated envelope (*as high as double current standards*)
2. Tight envelope / controlled air changes
3. Provide thermal mass **inside** of thermal insulation to store heat
4. Top quality windows with high R-values – up to triple glazed with argon fill and low-e coatings on two surfaces

Premise – what you don't "lose" you don't have to create or power…. So make sure that you keep it! *(…NEGAwatts)*

Passive Heating Strategies:
Maximize Solar Gain

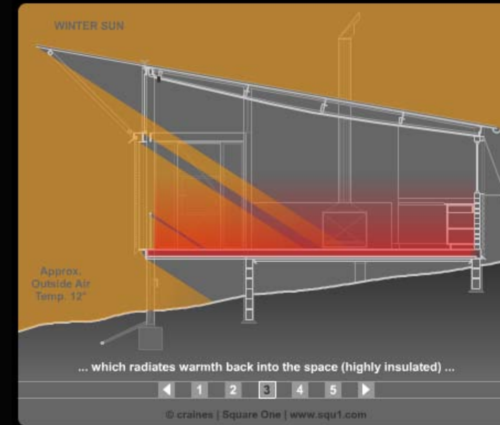
1. primarily south facing windows
2. proportion windows to suit thermal mass and size of room(s)

3 MAIN STRATEGIES:

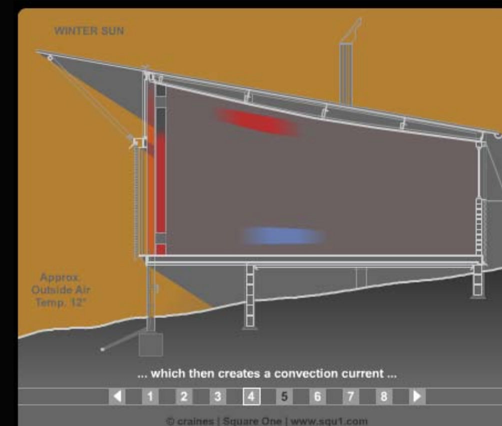
Direct Gain

Thermal Storage Wall

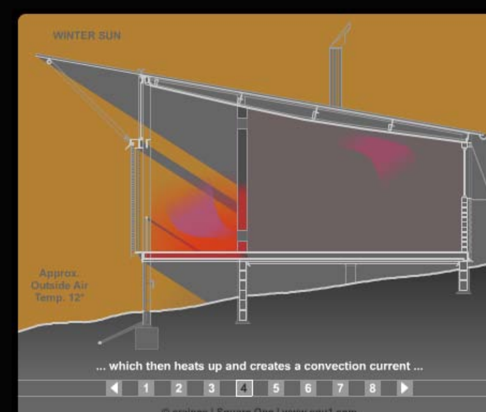
Sunspace



Direct Gain



Trombe Wall



Sun Space

Source: Square One Archives (http://squ1.com/archive/)

Passive Solar Opaque Envelope Requirements

- Very tight construction
- Thermal mass on the INSIDE
  - **Gypsum board is not of sufficient thickness**
  - **Thickness of 50 to 100mm preferred**
- Increased insulation levels
  - **Choose insulation that is more “sustainable”**
  - **Insulation with low embodied energy**
  - **Insulation from renewable sources**

Question: What does a building envelope with 2X insulation look like?

Sustainable Insulation

Alternates are in... – including, recycled paper, recycled denim, soya based,hemp, icynene...

Fibreglass is out!

Super-Insulation

Subsection 12.3.2 - Thermal Insulation

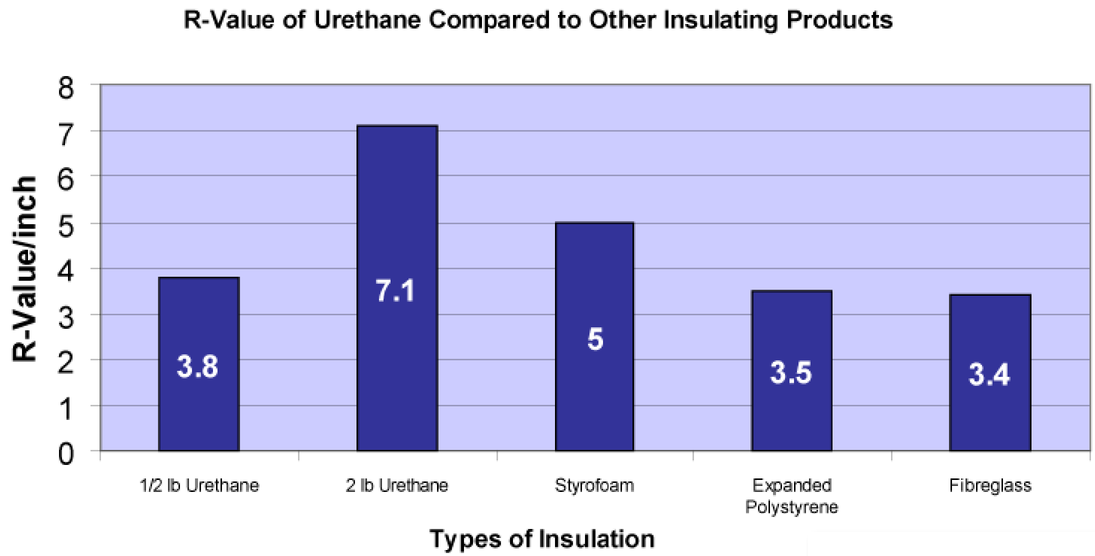
Mininum thermal insulation requirements:

2006-2011 only	Ontario South – In force		Ontario North – in force	
	Gas/Oil	Electrical	Gas/Oil	Electrical
Wall	R19	R29	R24	R29
Ceiling	R40	R50	R40	R50
Basement	R12	R19	R12	R19

And when relying on renewable energy to supplement, often electricity based, the requirements are even higher.

- Cold climates in particular are looking at double code insulation levels to reduce heat loss
- This implies choosing either more effective insulation or
- Accommodating thicker insulation in the wall, or a combination of the two strategies

Different R-values require differentiated approach to accommodating higher insulation values in walls.



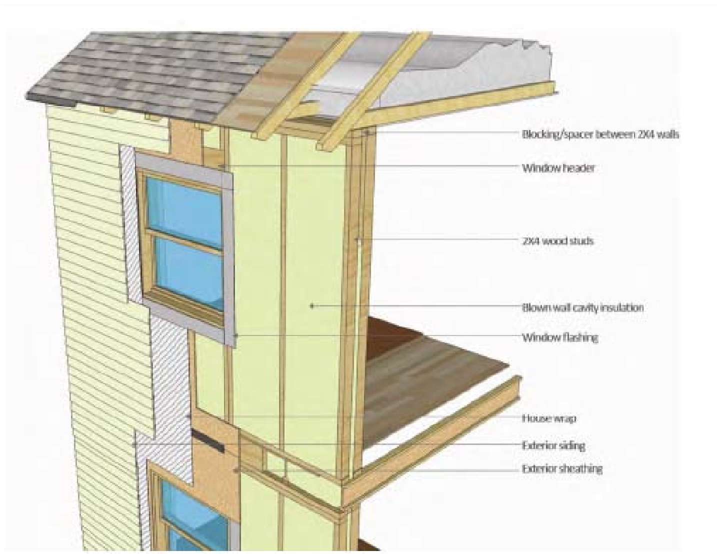


Figure 0.3: A common design of double stud wall. The thermal bridging at the floor and top plate can be seen in this Building America prototype design (Aldrich et al, 2010).

Double stud, increases insulation, high cost, thermal bridges.

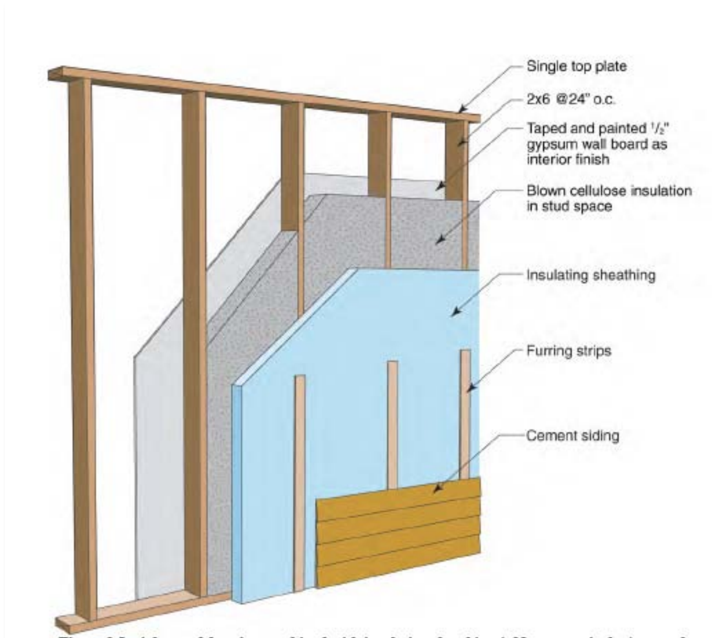


Figure 0.5 : Advanced framing combined with insulating sheathing (of 1 to many inches) controls thermal bridging, reduces the risk of condensation, and improves the R-value

Layered approach, increases insulation, lower cost, eliminates thermal bridges.

Building America Special Research Project: High R-Value Enclosures for High Performance Residential Buildings in All Climate Zones

Research Report - 1005

Draft: 29 October 2010

Final: 1 February 2011

Author: John Straube

Contributors: Joseph Lstiburek, Betsy Pettit, Armin Rudd, Christopher Schumacher, Peter Baker, Kohta Ueno, Alex Lukachko, Jonathan Smegal, Aaron Grin, Ken Neuhauser, Cathy Gates

For more information!
http://www.buildingscience.com/documents/reports/rr-1005-building-america-high-r-value-high-performance-residential-buildings-all-climate-zones

Thermal Mass is Critical!

To ensure comfort to the occupants….

People are 80% water so if they are the only thermal sink in the room, they will be the target.

And to store the FREE energy for slow release distribution….

Aldo Leopold Legacy Center: Concrete floors complement the insulative wood walls

Thermal mass is the “container” for free heat…

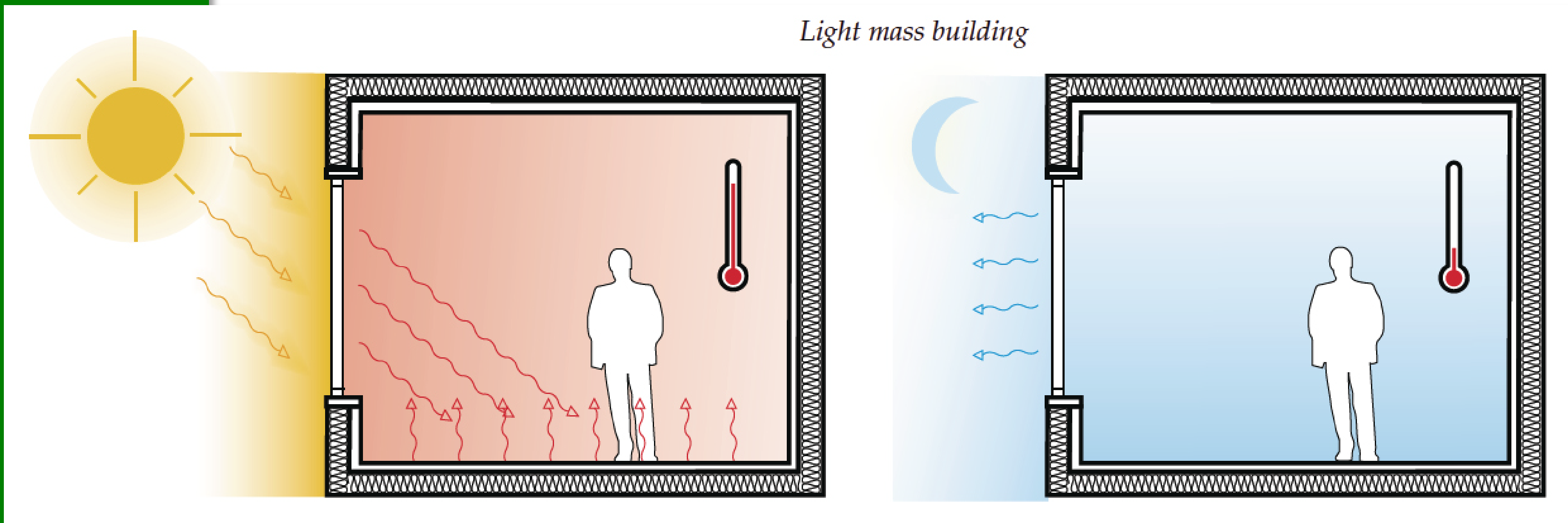
If you “pour” the sun on wood, it is like having no container at all.

Just like water, free solar energy needs to be stored somewhere to be useful!

Thermal mass runs counter to the standard method of residential construction in Canada.

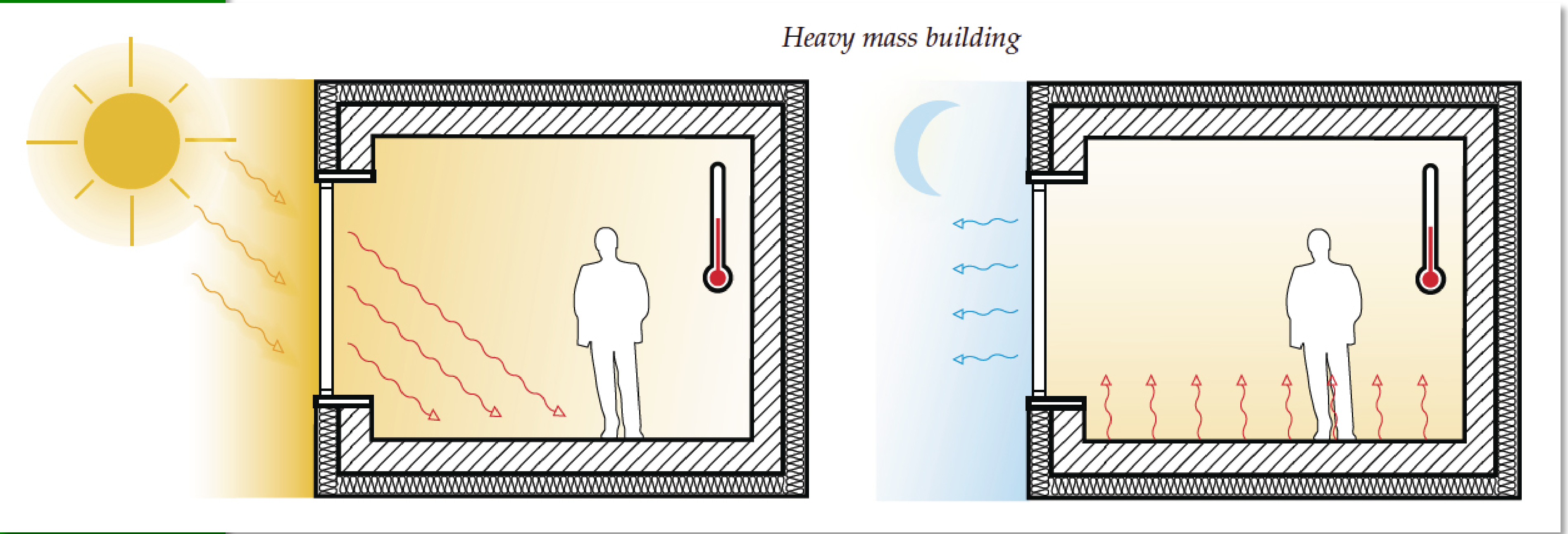
Thermal mass is needed on the INSIDE of the envelope – as floor and/or walls.

Light Mass Building



- Wide swings of temperature from day to night
- Excess heat absorbed by human occupants
- Uncomfortably cold at night

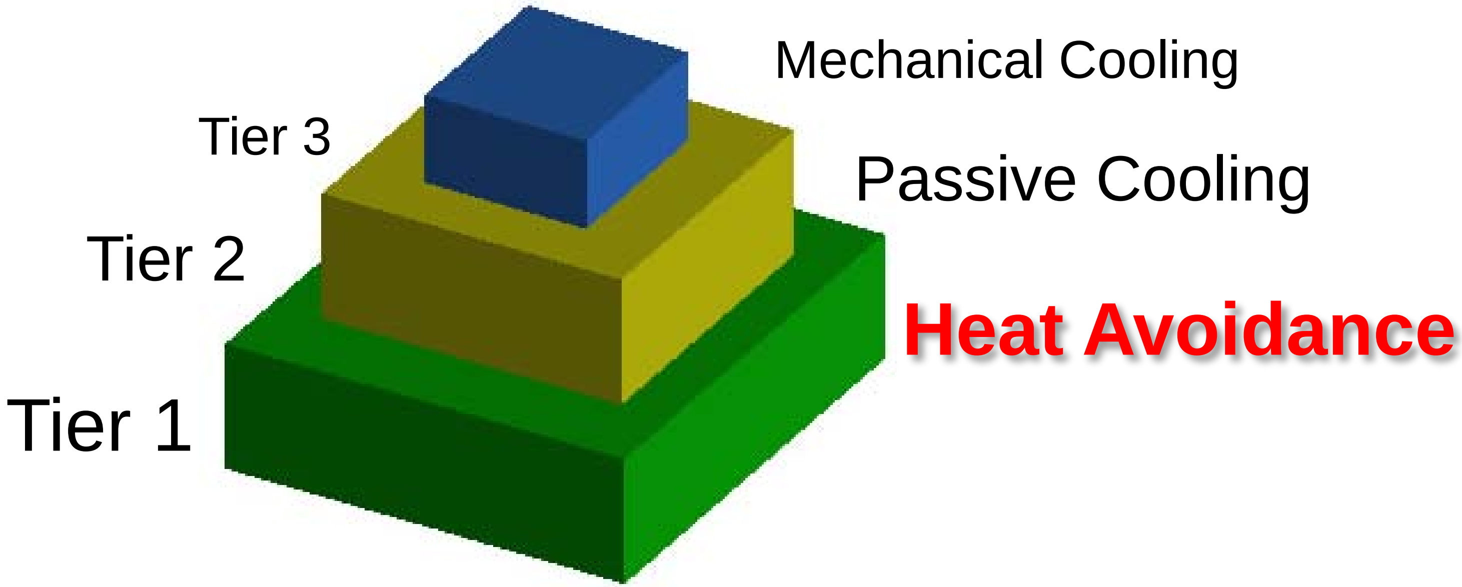
Heavy Mass Building



- Glass needs to permit entry of solar radiation
- Also need insulating blinds to prevent heat loss at night.

Reduce loads: Passive Strategies

The tiered approach to reducing carbon for COOLING:



Maximize the amount of energy required for mechanical cooling that comes from renewable sources.

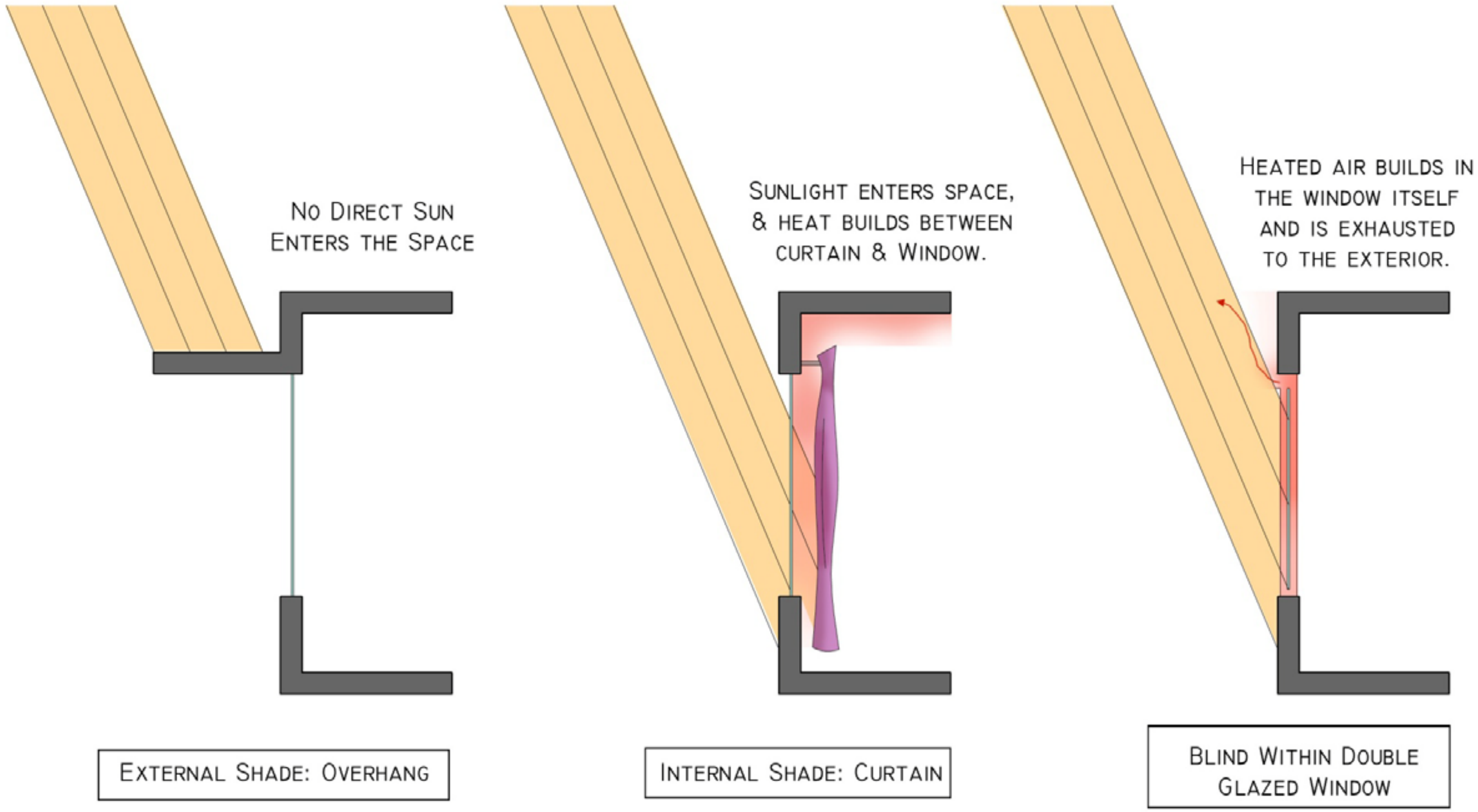
Source: Lechner. Heating, Cooling, Lighting.

Passive Cooling Strategies:
Heat Avoidance

1. shade windows from the sun during hot months
2. design materials and plantings to cool the local microclimate
3. locate trees and trellis' to shade east and west façades during morning and afternoon low sun

If you don't invite the heat in, you don't have to get rid of it…..

Interior vs Exterior Shades



Once the heat is IN, it is IN!

Internal blinds are good for glare, but not preventing solar gain.

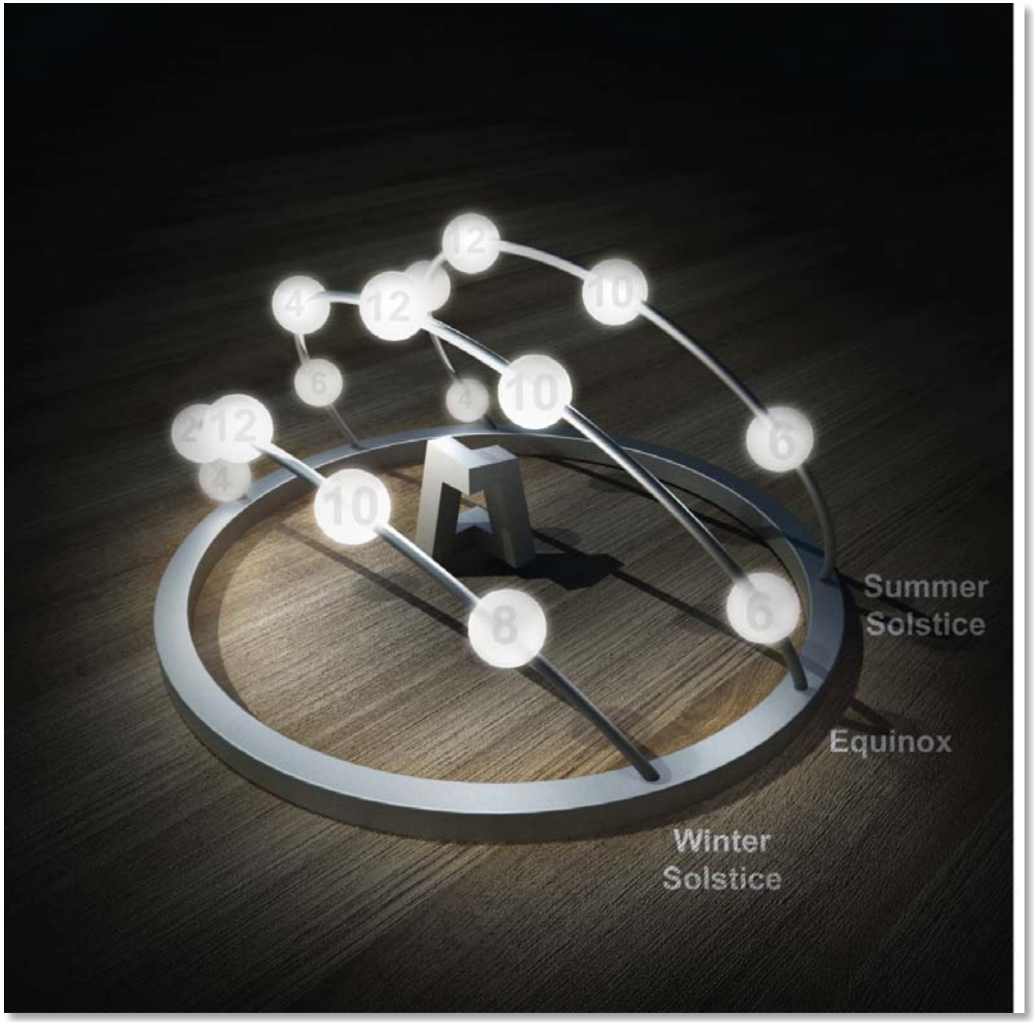
Solar Geometry

The local solar path affects:

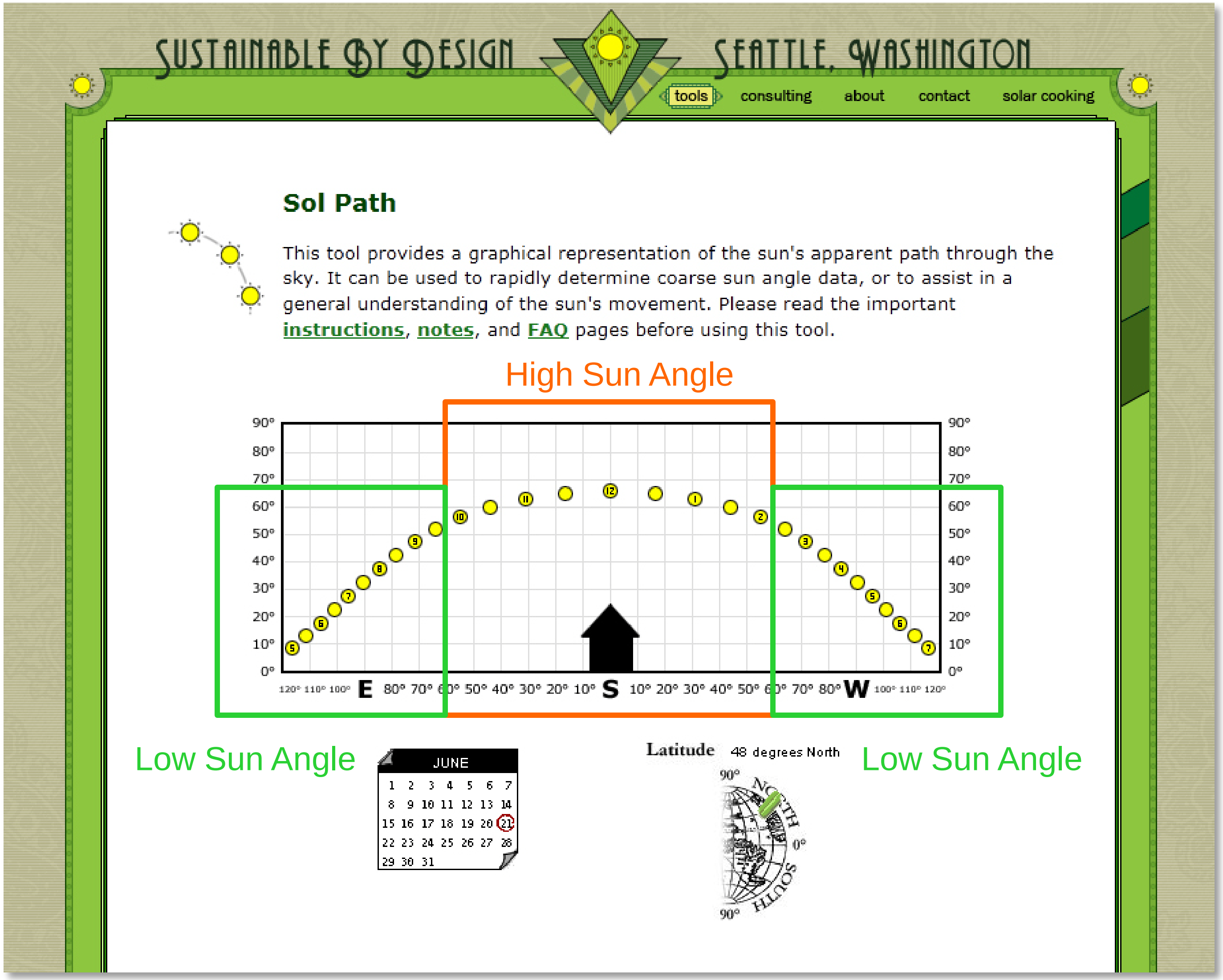
➢ Location of openings for passive solar heating

➢ Design of shading devices for cooling

➢ Means differentiated façade design



Differentiated Shading Strategies



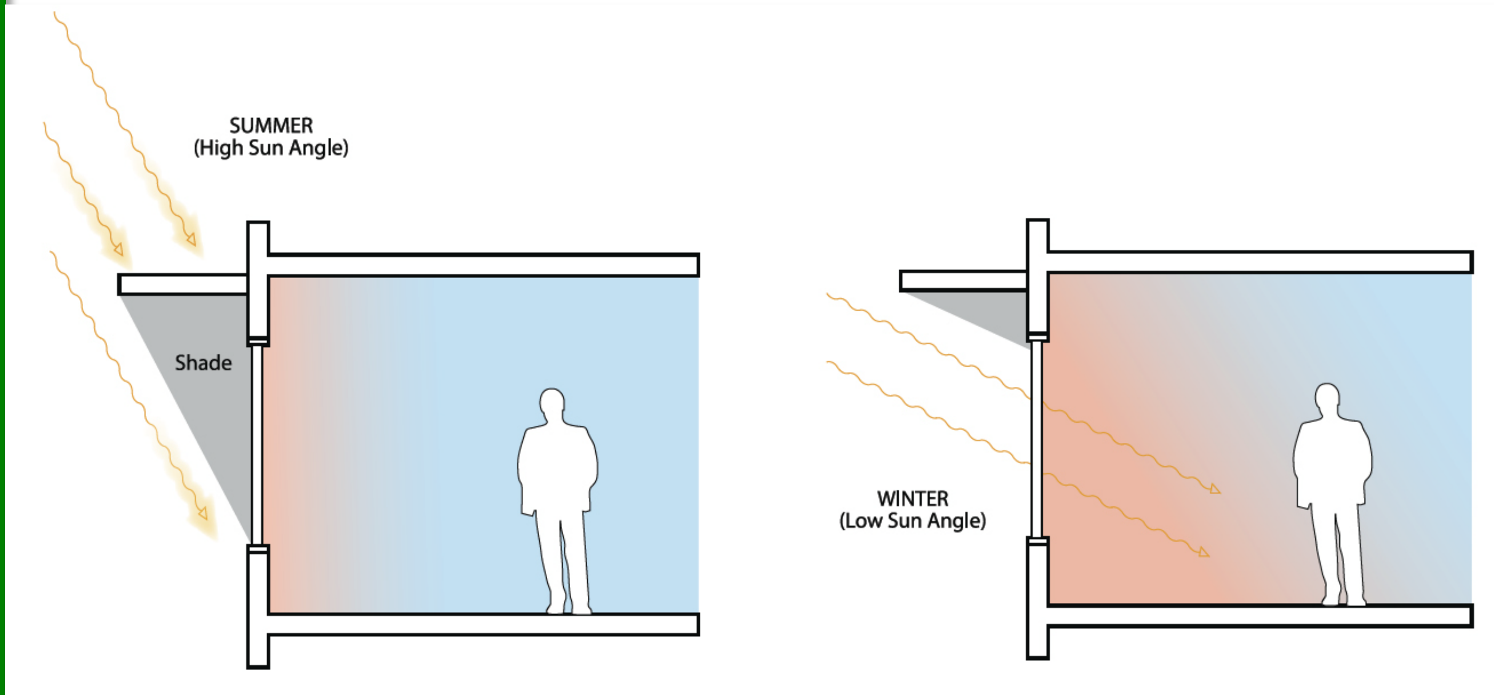
http://susdesign.com/tools.php

Differentiated façade treatment

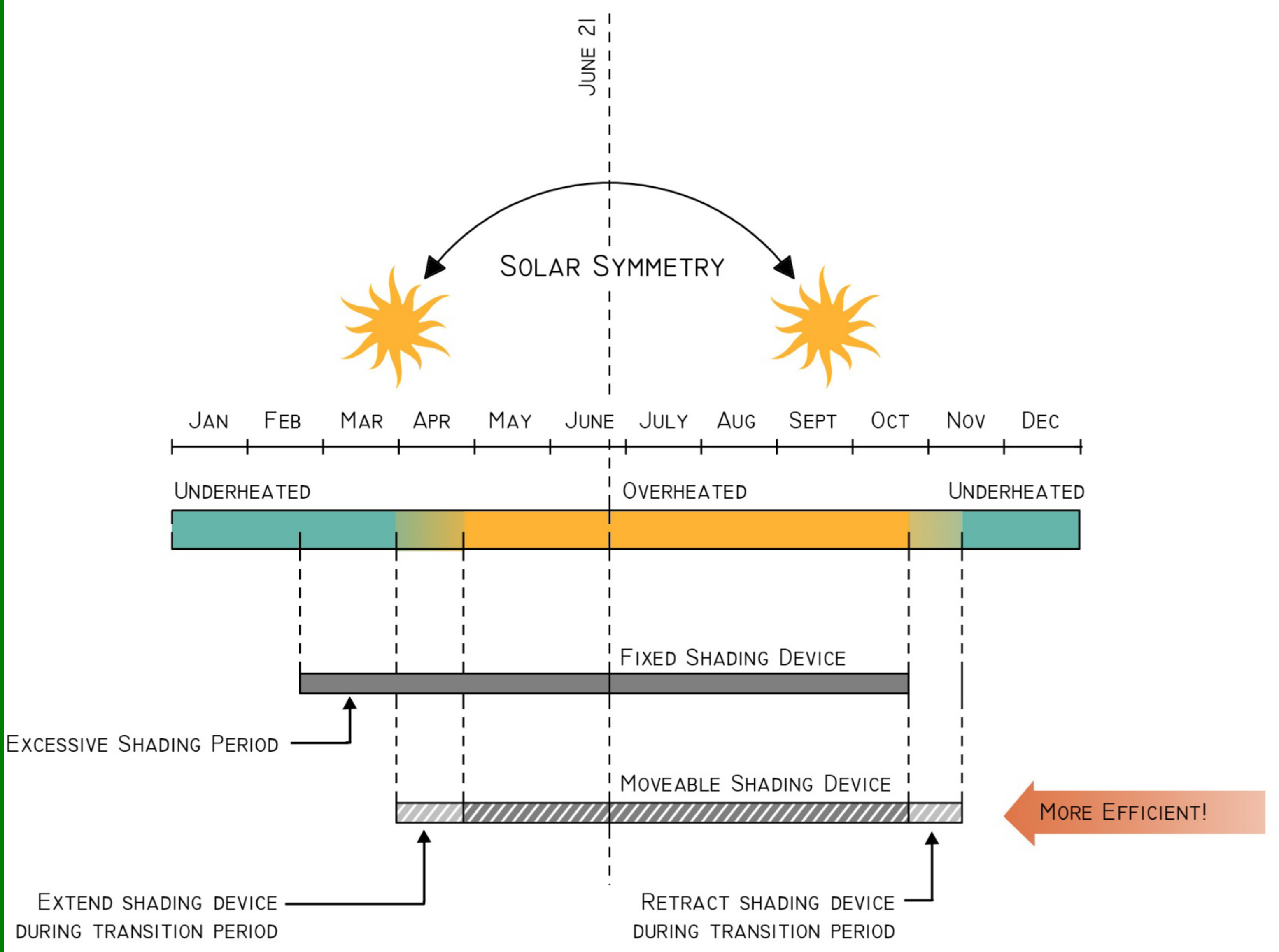
Different envelope construction on north, east/west and south

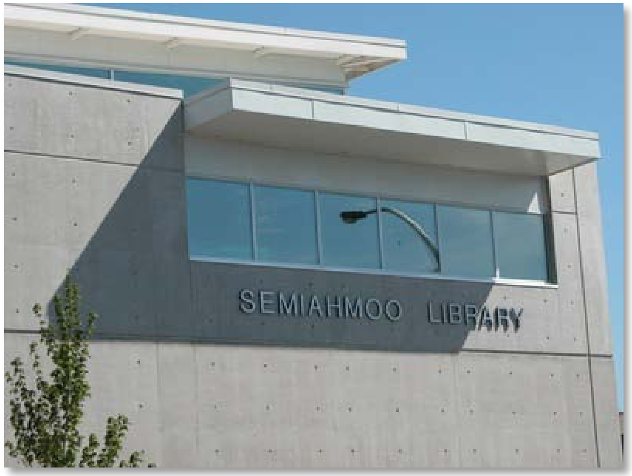
Terasan Gas, Surrey, BC

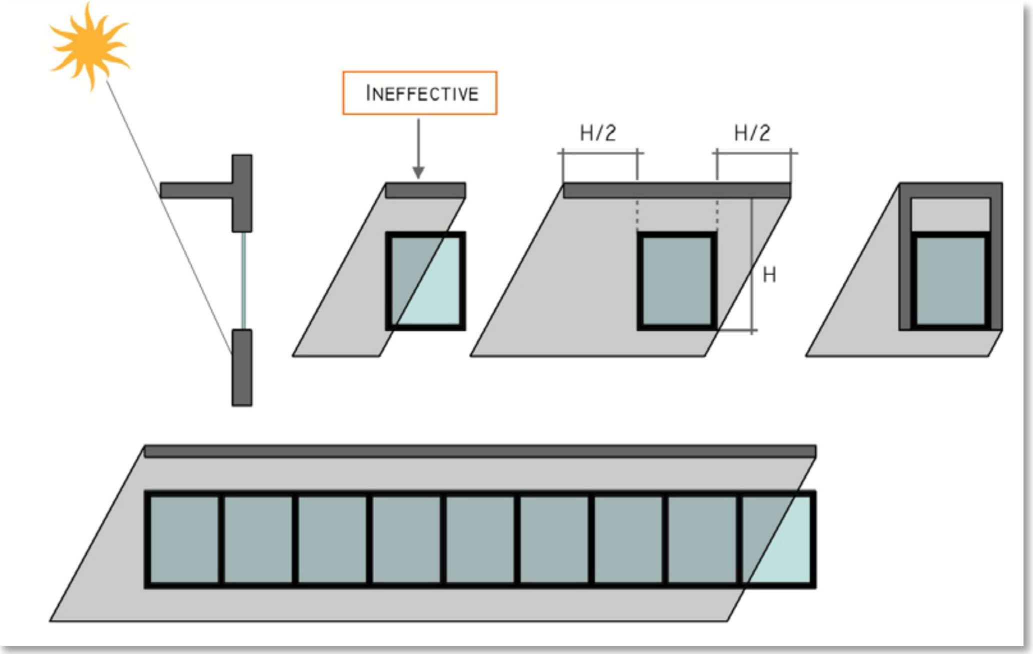
South Façade Strategies



- South façade is the easiest to manage as simple overhangs can provide shade in the summer and permit entry in the winter.
- Need to design for August condition as June to August is normally a warm period.

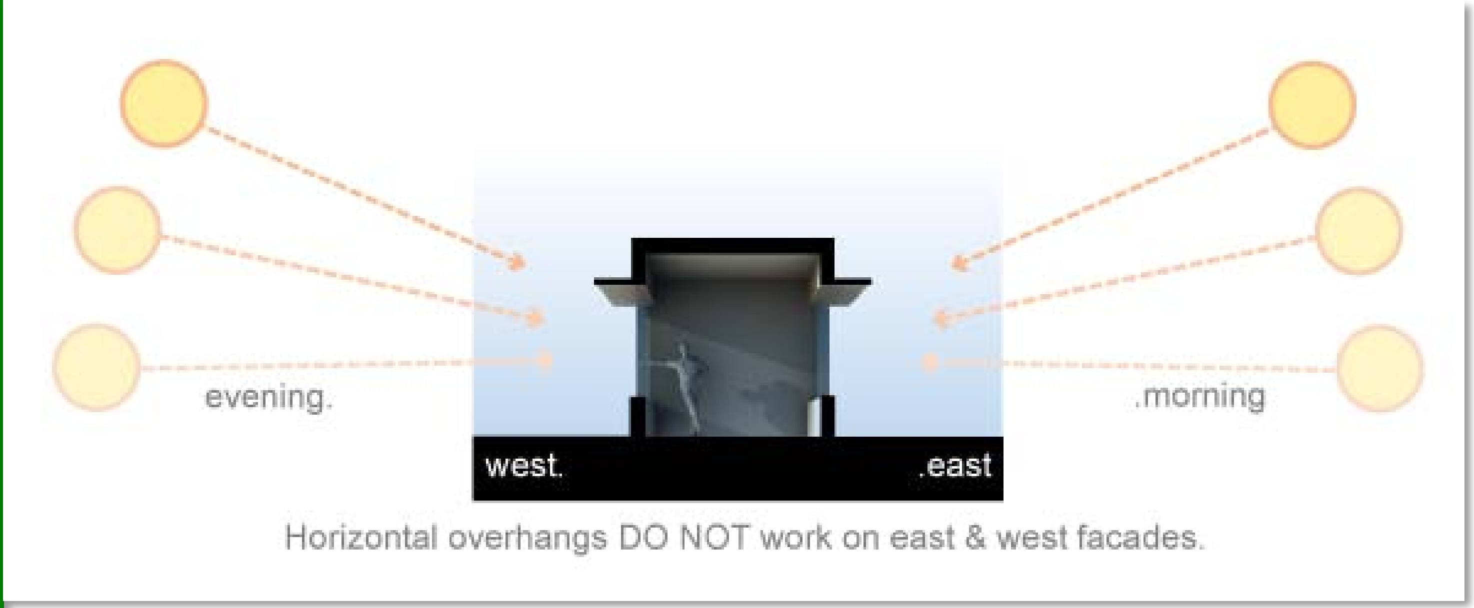

June 21
Solar Symmetry
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec
Underheated
Overheated
Underheated
Fixed Shading Device
Excessive Shading Period
Moveable Shading Device
More Efficient!
Extend shading device during transition period
Retract shading device during transition period





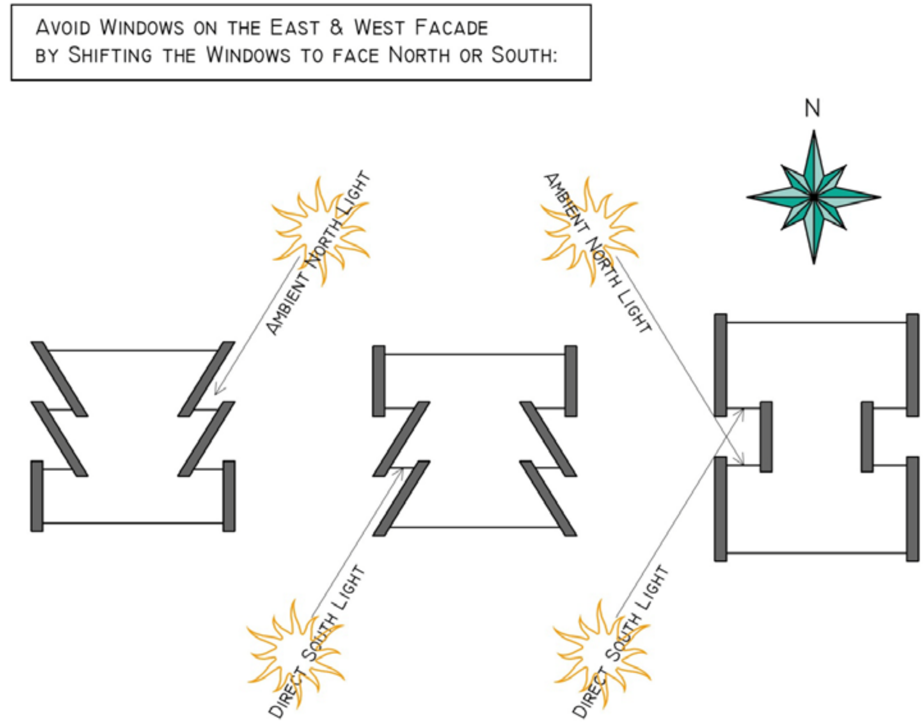
…extend device for full shading

East and West Façade Strategies



East and west façade are both difficult to shade as the sun angles are low and horizontal shades do not work.

1. The best solution by far is to limit using east and especially west windows (as much as possible in hot climates)

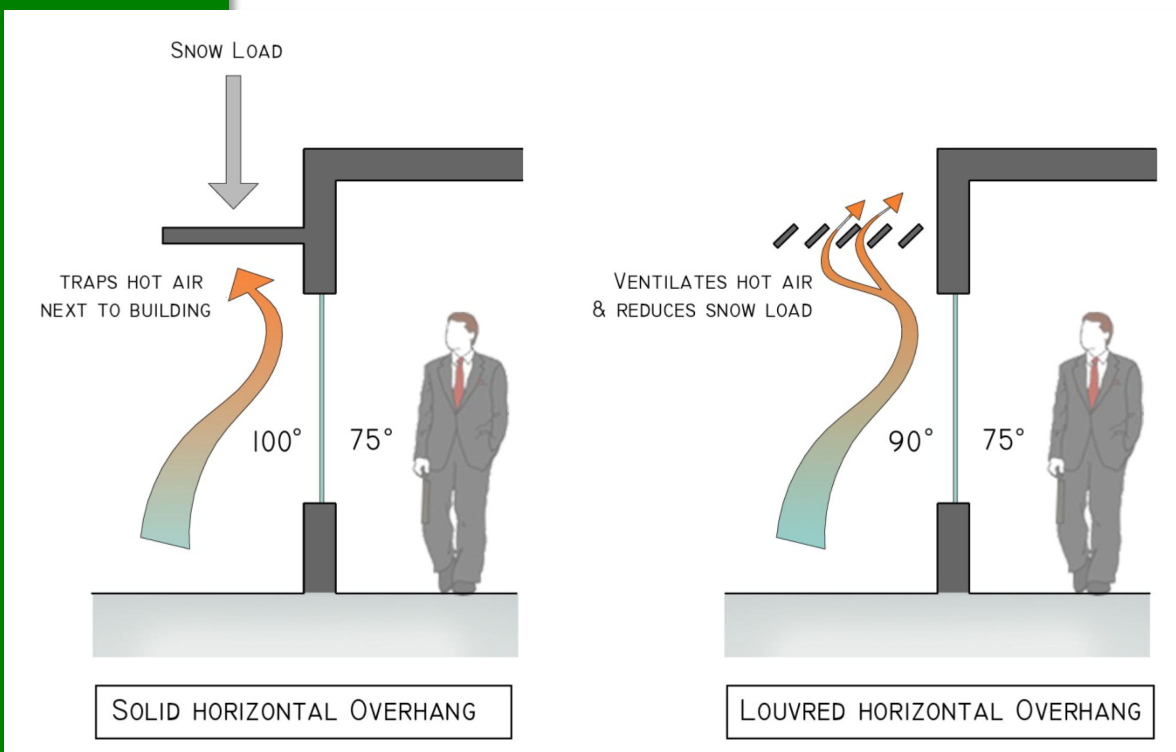


2. Next best solution is to have windows on the east and west façades face north or south

Shading Devices and the Envelope

- Can be an extension of the roof
- On multi storey buildings normally attached to the envelope
- Can be incorporated into the curtain wall
- Must contend with snow loading
- Must be durable and low maintenance

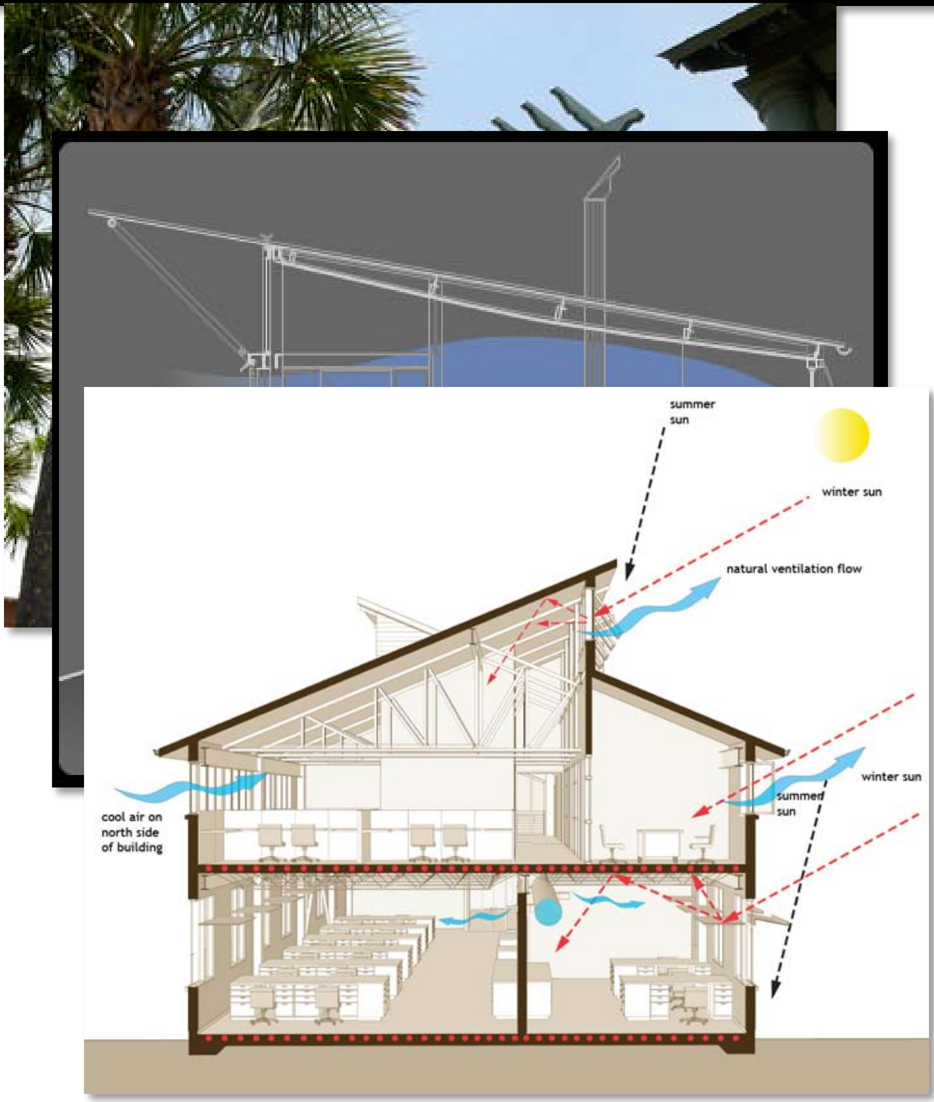
This one uses ceramic fritted glass that is sloped, to allow some light but shed rain and wet snow.



The above two use louvres or grates that will let snow, rain and wind through.

Passive Cooling Strategies - Ventilation:

1. design for maximum ventilation
2. keep plans as open as possible for unrestricted air flow
3. **use easily operable windows** at low levels with high level clerestory windows to induce stack effect cooling



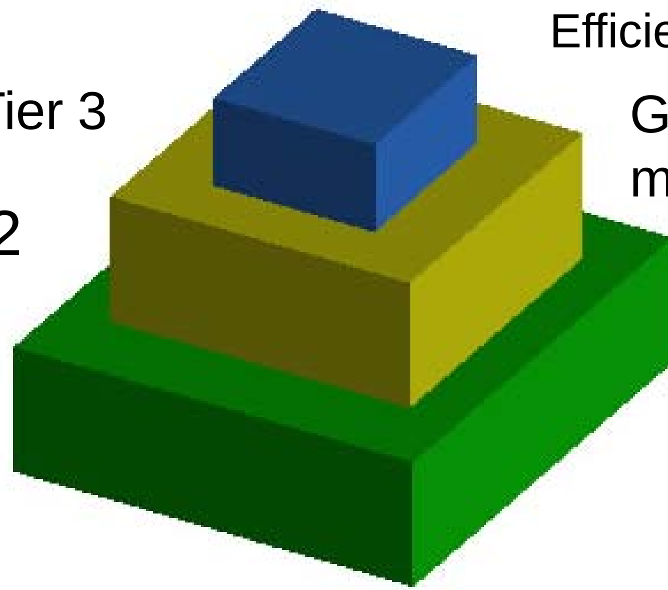
Reduce loads: Daylighting

The tiered approach to reducing carbon with **DAYLIGHTING**:

Tier 3 — Efficient artificial Lighting w/ sensors

Tier 2 — Glare, color, reflectivity and material concerns

Tier 1 — Orientation and planning of building to allow light to reach maximum no. of spaces



Use energy efficient fixtures!

Maximize the amount of energy/electricity required for artificial lighting that comes from renewable sources.

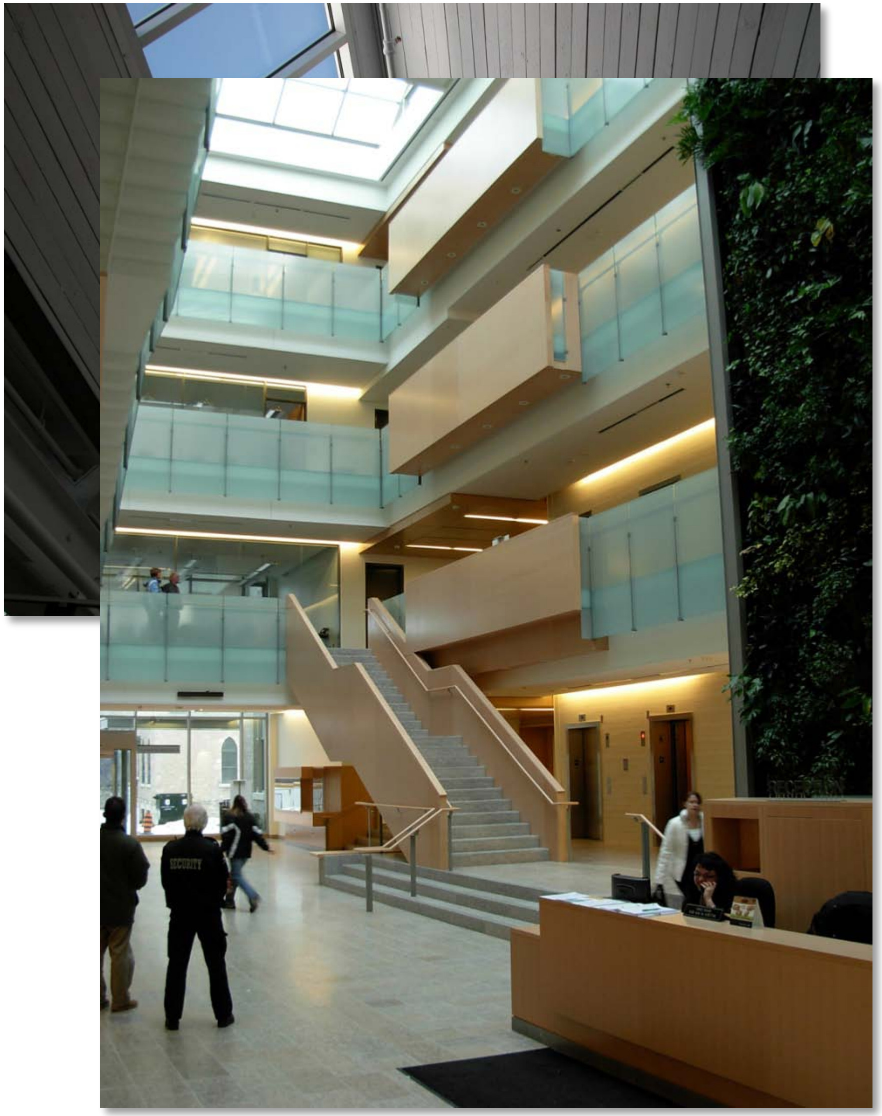
Source: Lechner. Heating, Cooling, Lighting.

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

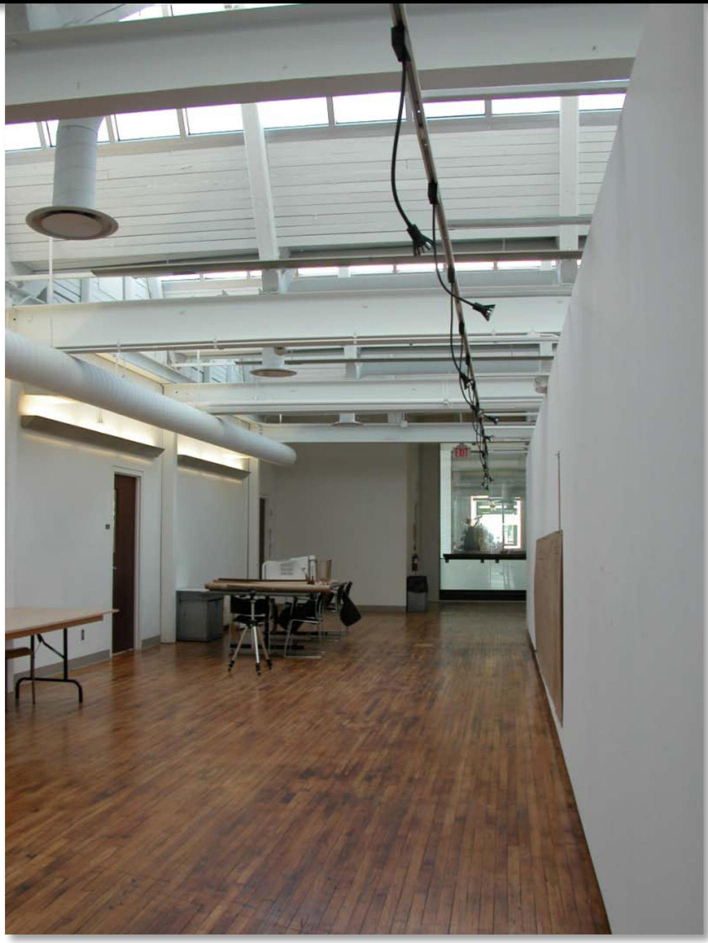
Passive Lighting Strategies:
Glare, color, reflectivity and materials

- 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



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!

Reduce, Renew, Offset

And, a *paradigm shift* from the recycling 3Rs…

Reduce - build less, protect natural ecosystems, build smarter, build efficiently

Renew - use renewable energy, restore native ecosystems, replenish natural building materials, use recycled and recyclable materials

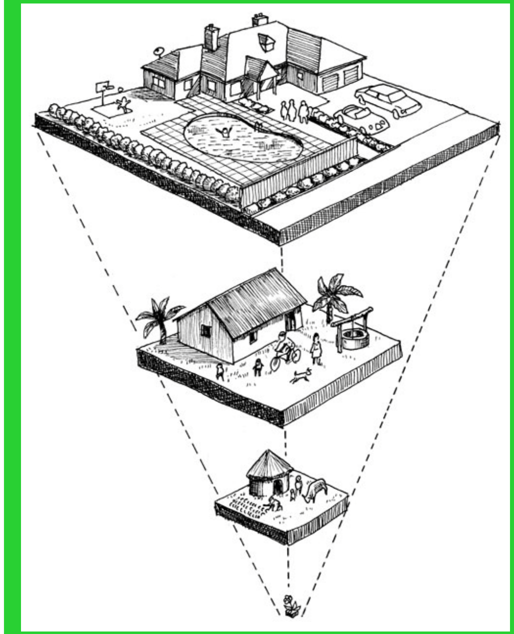
Offset - compensate for the carbon you can't eliminate, focus on local offset projects

Net impact reduction of the project!

source: www.buildcarbonneutral.org

Smaller is better.

- ***Simple!***…**less** building results in **less** embodied carbon; i.e. **less** carbon from materials used in the project, **less** requirements for heating, cooling and electricity….
- Re-examine the building program to see what is *really* required
- How is the space to be used?
- Can the program benefit from more inventive double uses of spaces?
- Can you take advantage of outdoor or more seasonally used spaces?
- **How much building do you *really* need?**
- **Inference of LIFESTYLE changes**



Calculating your “ecological footprint”

… can naturally extend to an understanding of your “carbon footprint”

Source: http://www.cycleoflife.ca/kids/education.htm

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.

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.

Sustainable Design has gone mainstream

as a result of LEED™

The question remains,

"How effective are current sustainable design practices and rating systems at achieving Greenhouse Gas Reduction?"

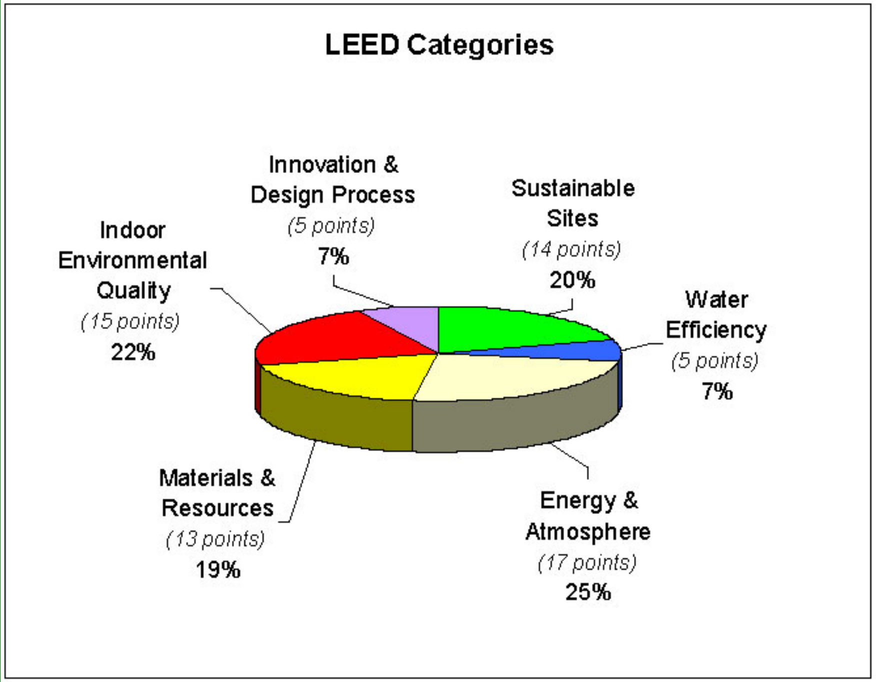
And the answer is:

"Really, NOT very…

Most LEED™ Gold and Platinum buildings earn less than 5/17 of the Energy and Atmosphere credits.

Sadly, there is NO Magic Bullet….

Even current high standards of “Green and High Performance Building” are not targeting significant reduction of Energy and GHG emissions.



Buildings are accredited by the number of points gained:

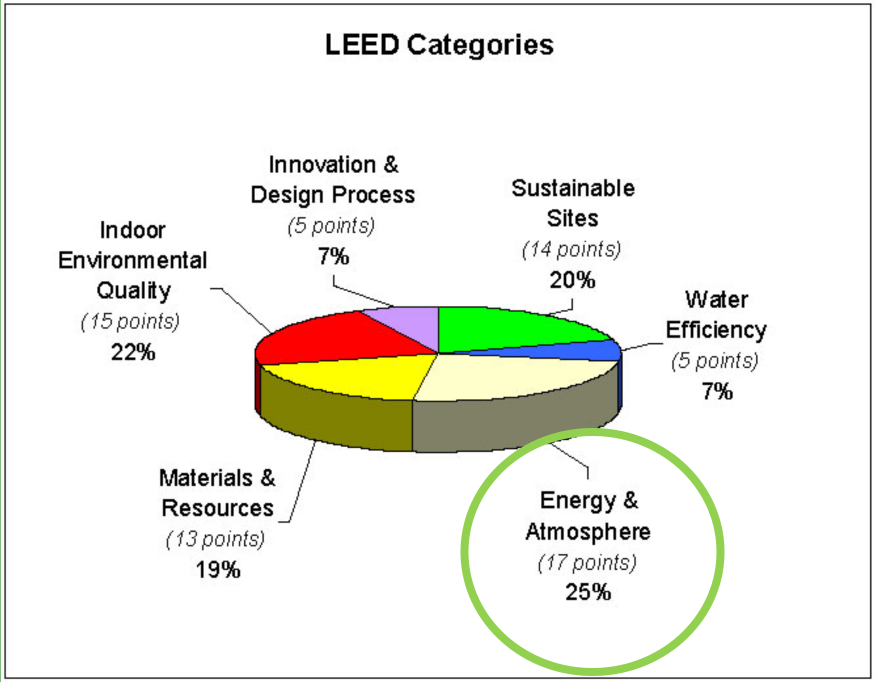
26 to 32 point is LEED certified;

33 to 38 points is LEED Silver;

39 to 51 is LEED Gold, and;

LEED Platinum is awarded to projects with 52 or more points.

Note: information based on LEED NC (not 2009)

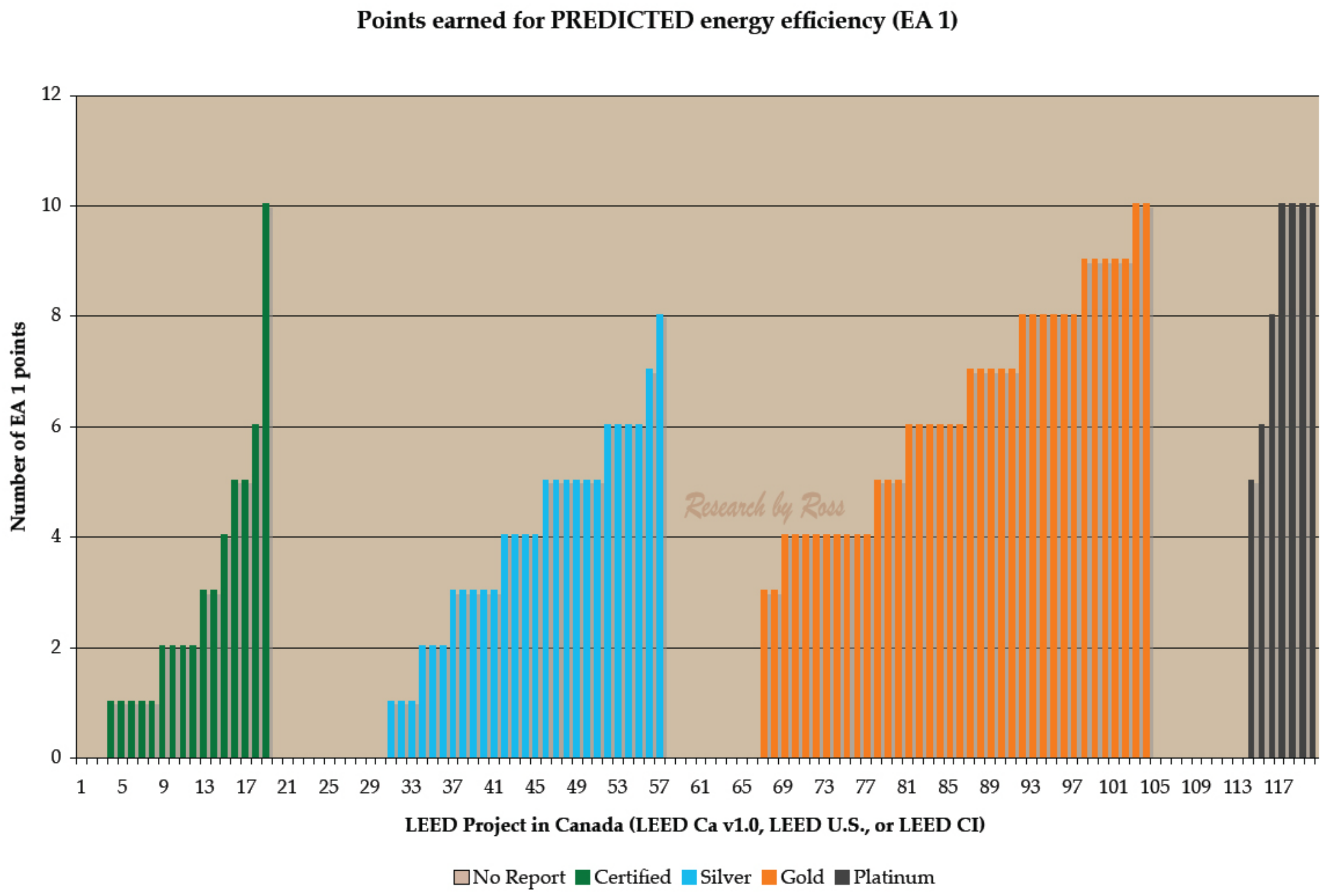


- Only 25% of the LEED credits are devoted to energy.
- Of those, 10/70 are for optimization.
- Maximum reduction is 60%.

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

It would seem that LEED is perhaps not RADICAL enough to be the only means to tackle the Carbon Problem….

LEED and Predicted Energy Credits



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

Mining LEED^{TM} for Carbon:

Energy Effective Design and LEED^{TM} Credits

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

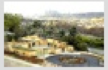
Comparing Carbon Neutral to LEED™

- 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!***

Existing Carbon Neutral/Zero Energy Buildings

	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
☐		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

8 project(s)

Remove selected project(s) | Add/Remove column(s) | Download | Help

The list on http://zeb.buildinggreen.com/ has not grown in 2 years.

Aldo Leopold Legacy Center

Baraboo, Wisconsin

The Kubala Washatko Architects
LEED^{TM} Platinum 2007

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

Aldo Leopold Center LEED^{TM} 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

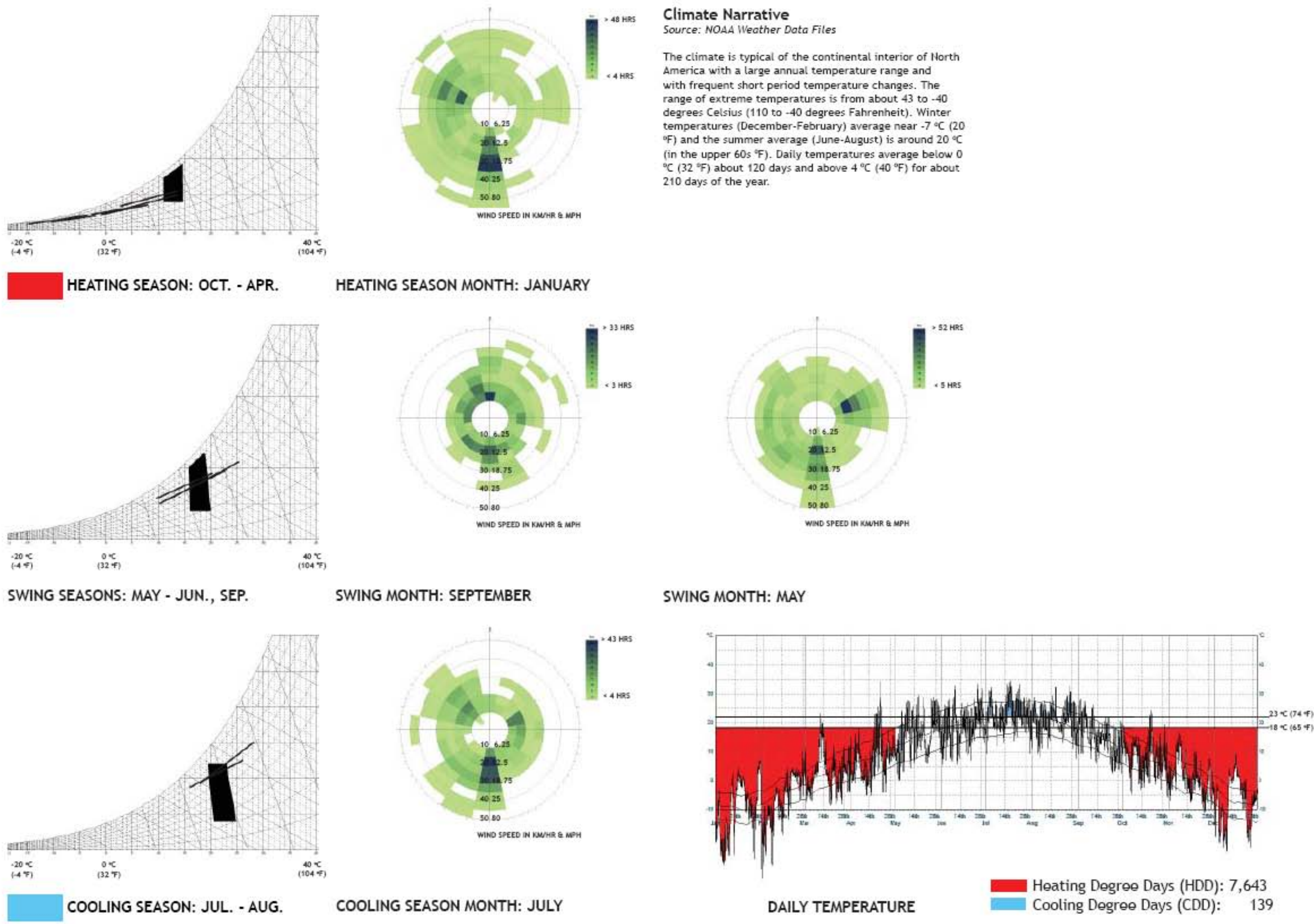
and

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

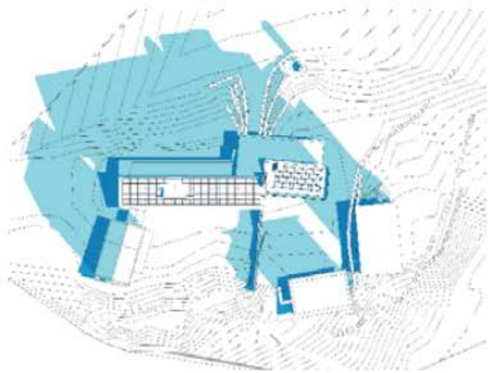
Leopold Approach to Carbon Neutral Design

- **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)**

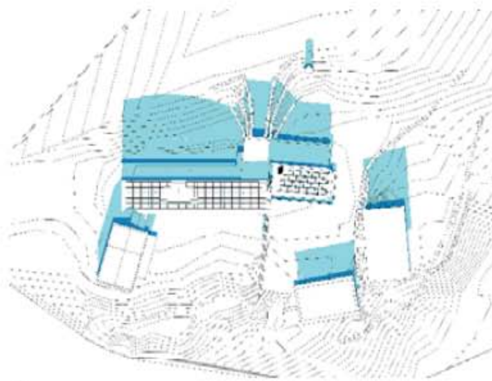
Climate Analysis as the Starting Point



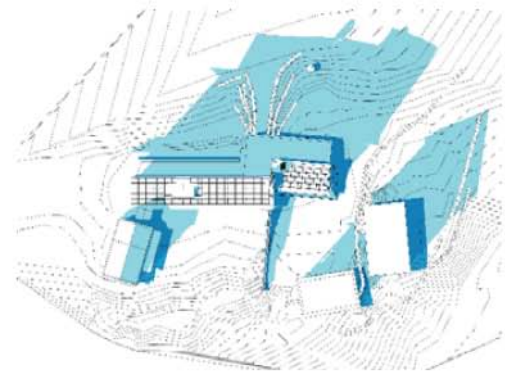
Site Analysis to Determine Solar Potential



9:00 am



Noon

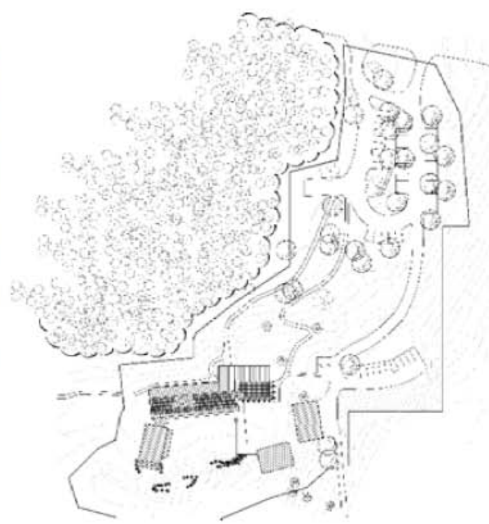


3:00 pm

Site Shading Study

June 21
December 21

Ariel Image from South
Source: ____________



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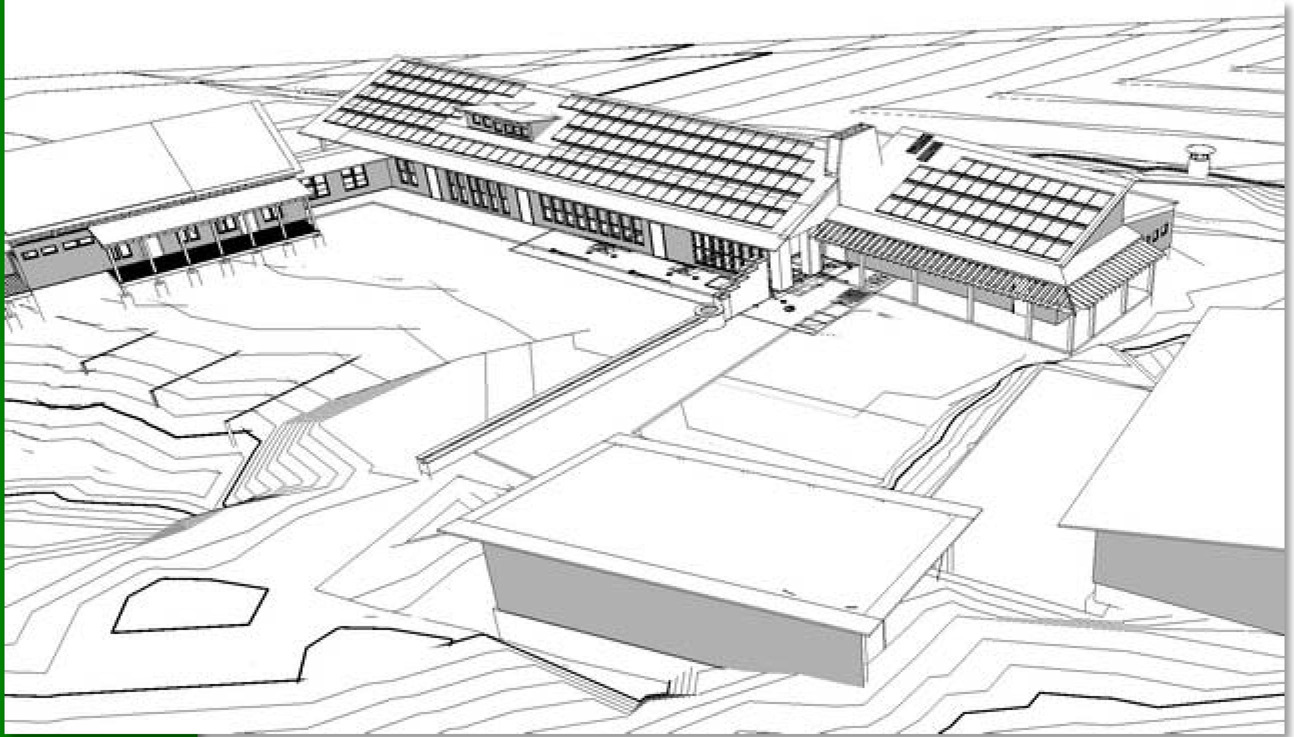
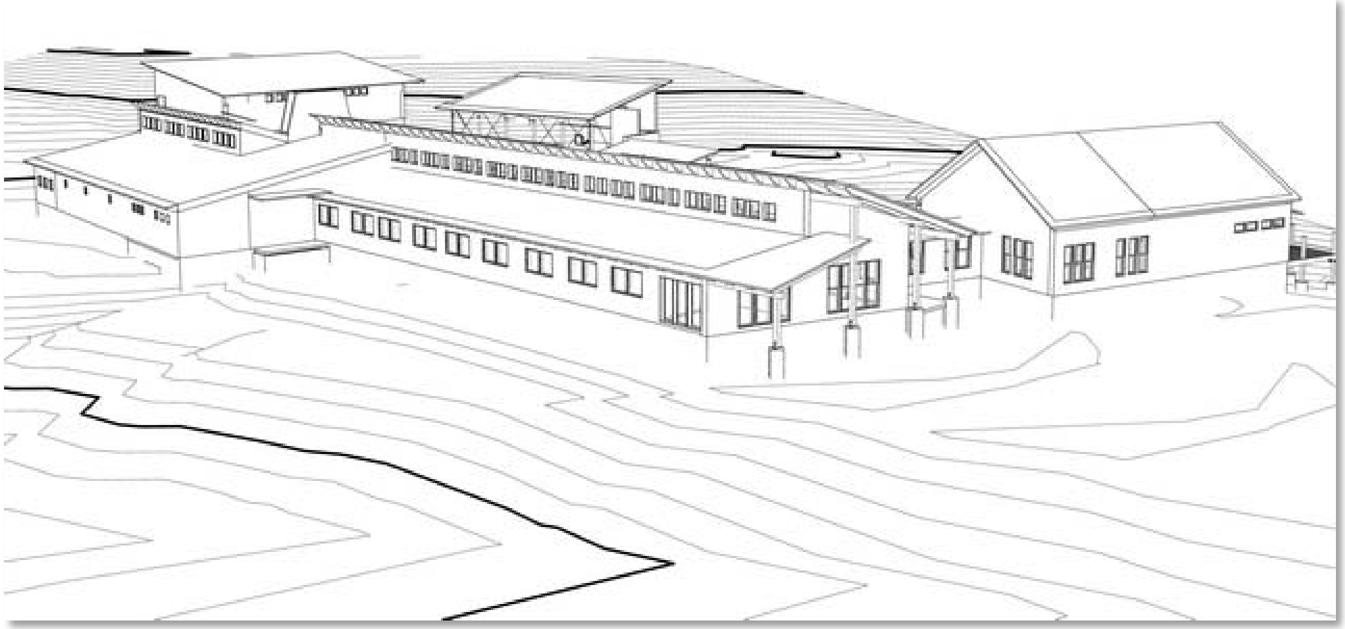


The South elevation is designed to capture energy.

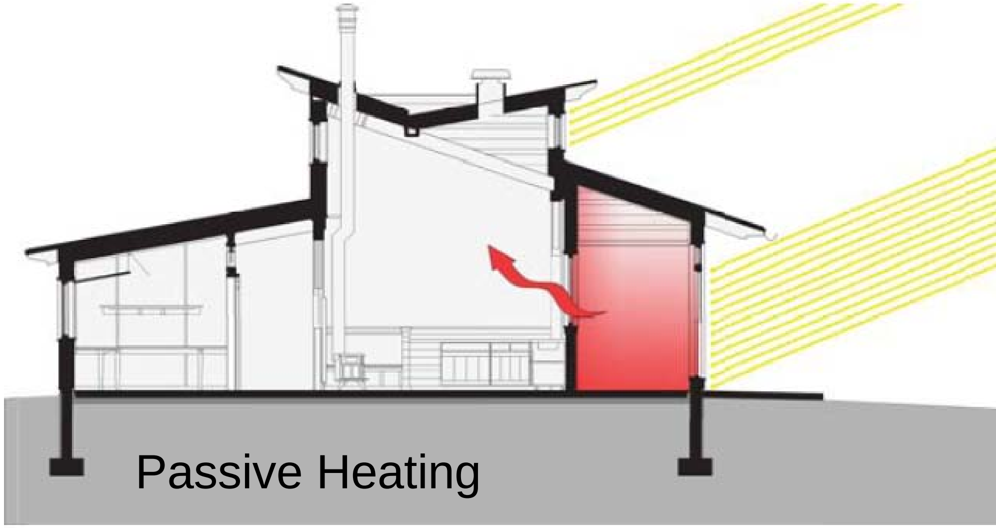


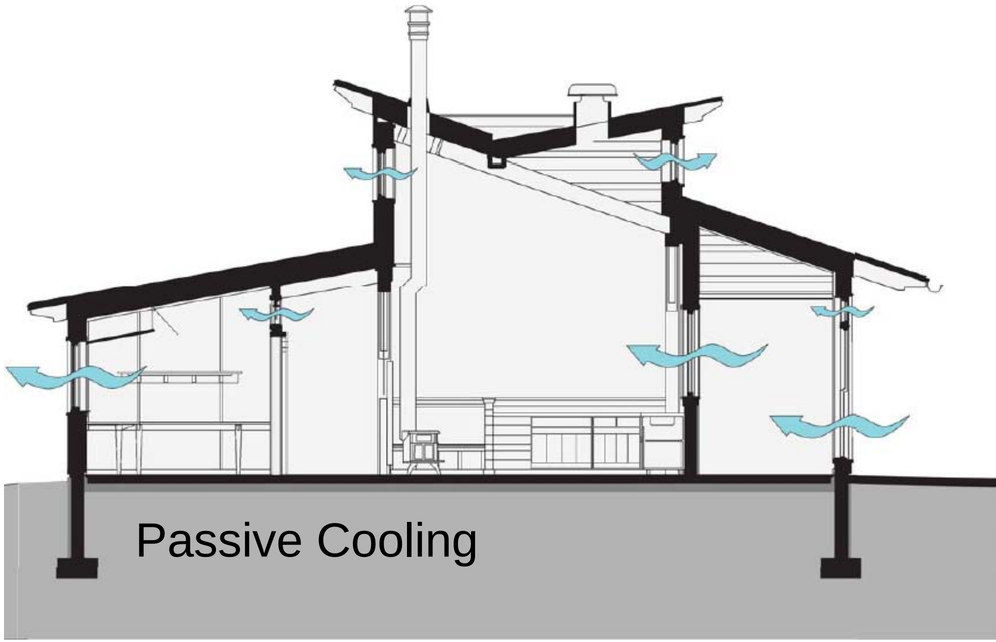
The North elevation is designed for thermal resistance, daylighting and ventilation.

The buildings were arranged in a U shape around a solar meadow that ensured access to sun for passive solar heating and energy collection.

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

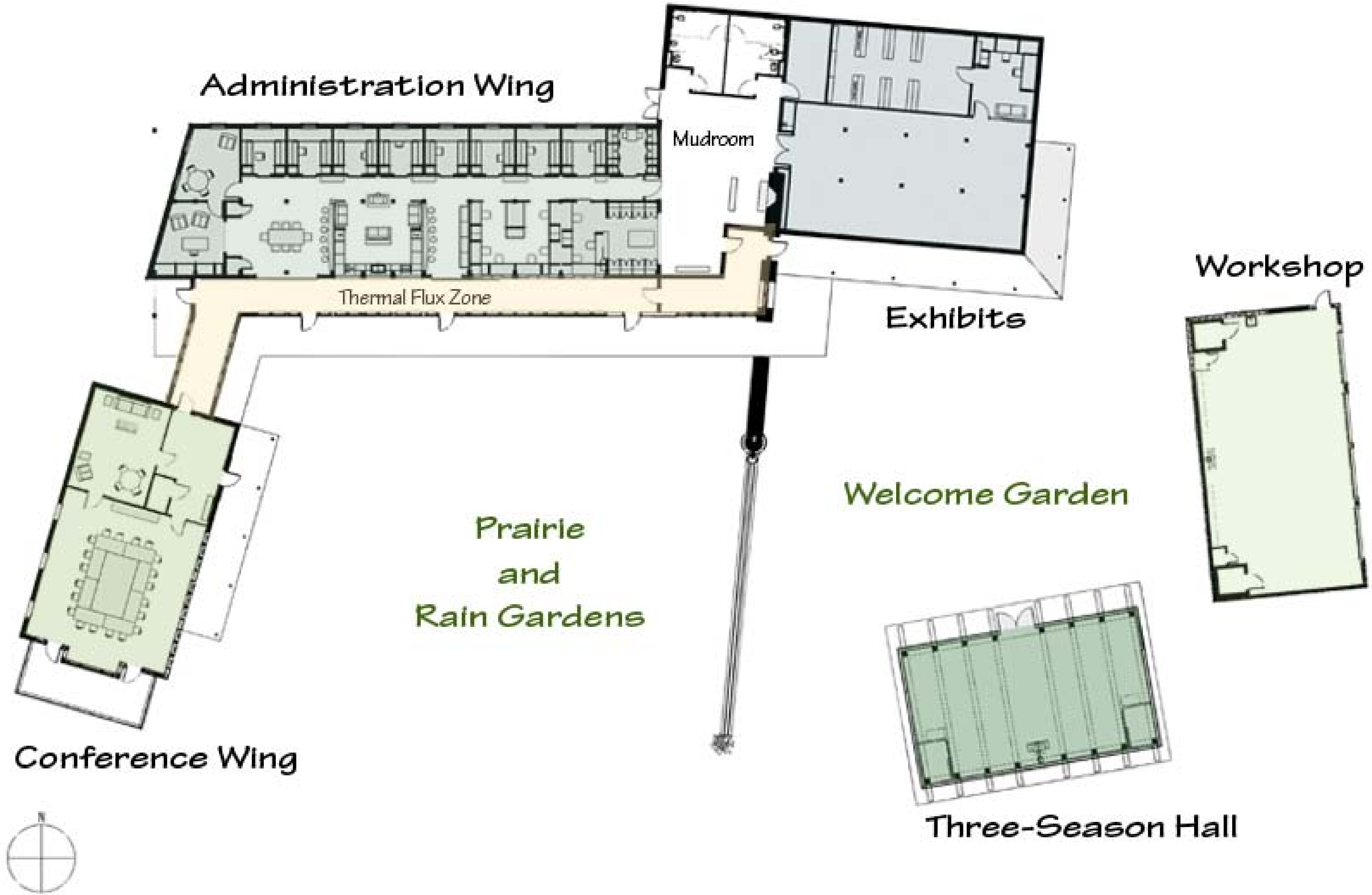
EA Credit 4, Ozone Depletion

EA Credit 5, Measurement and Verification

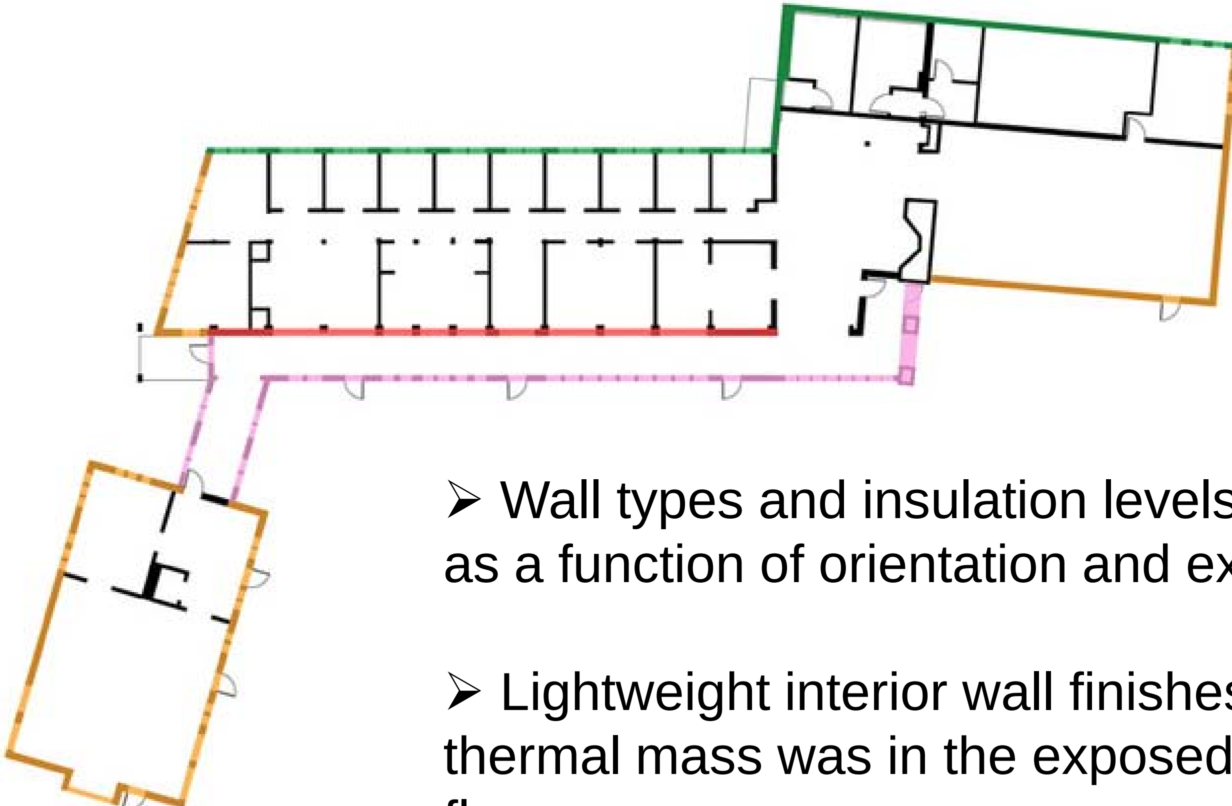
EA Credit 6, Green Power

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

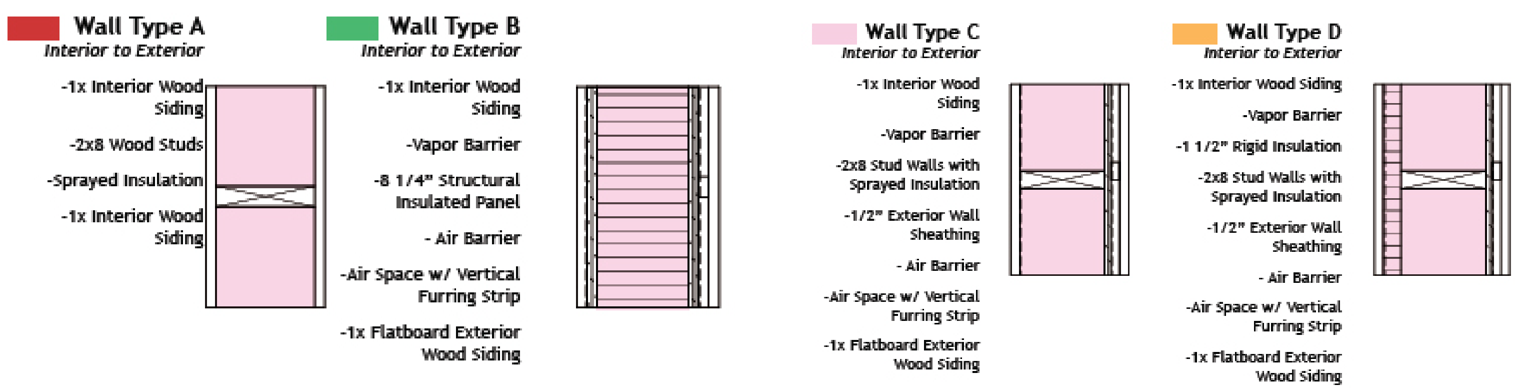
Thermal Zones ~ Perimeter Zones

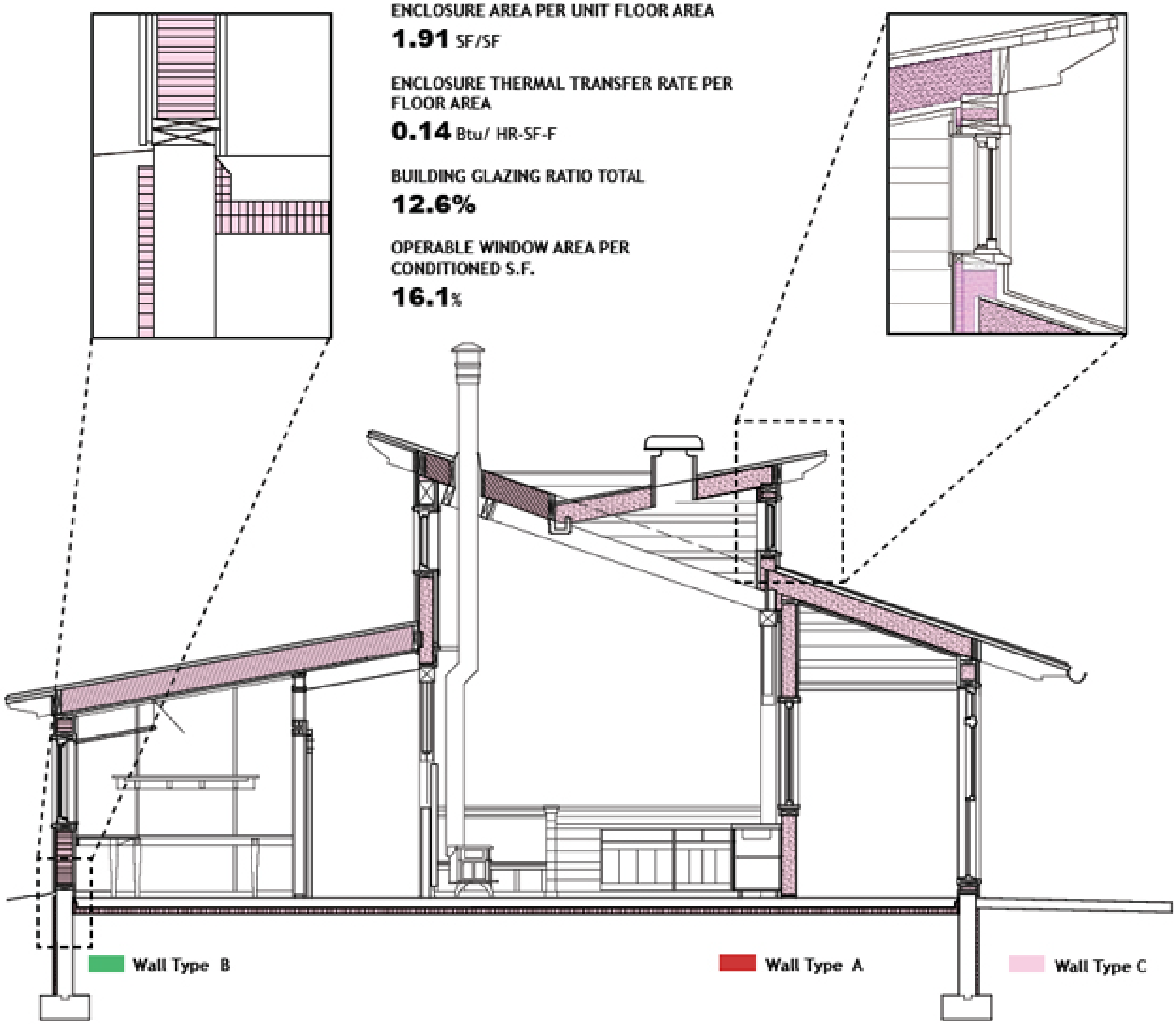


Keep the buildings thin to allow for maximum daylight and use of solar for passive heating with operable windows to make natural ventilation work.

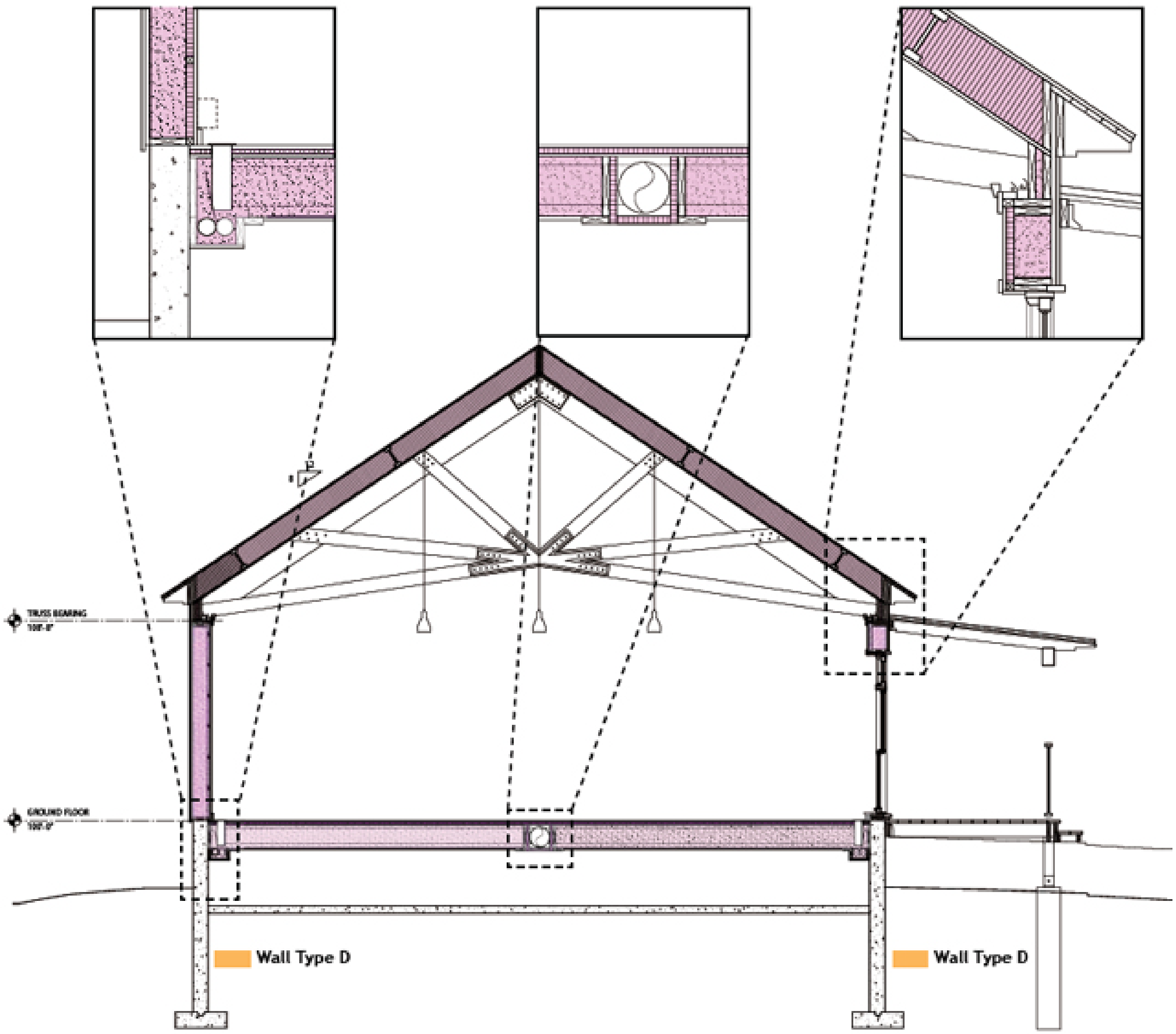


- Wall types and insulation levels are varied as a function of orientation and exposure
- Lightweight interior wall finishes meant thermal mass was in the exposed concrete floor.





Wall, roof types and insulation levels varied as a function of exposure.

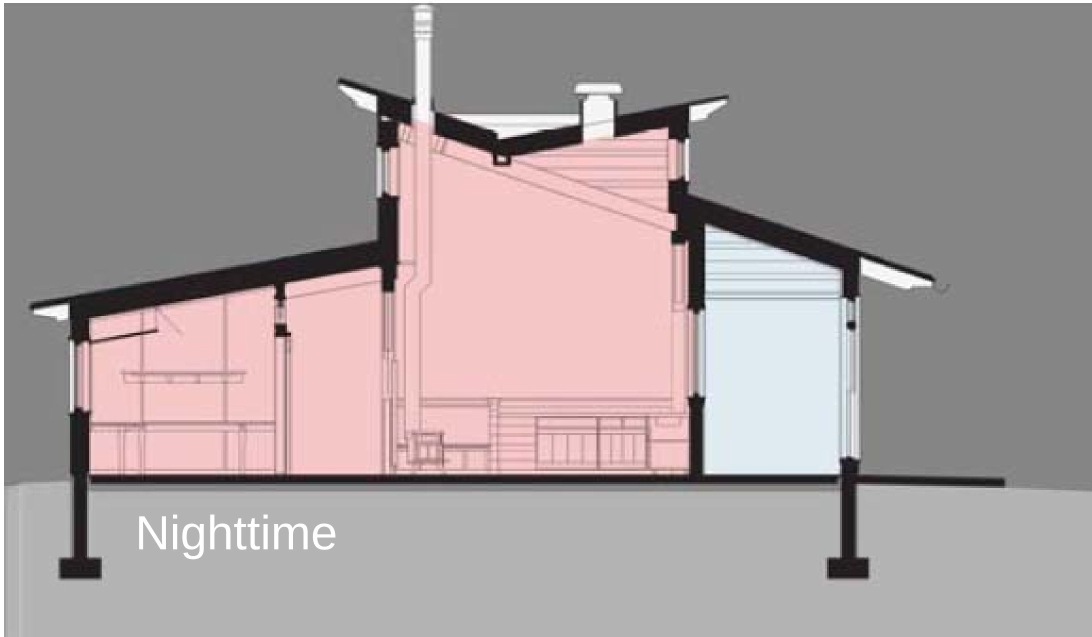


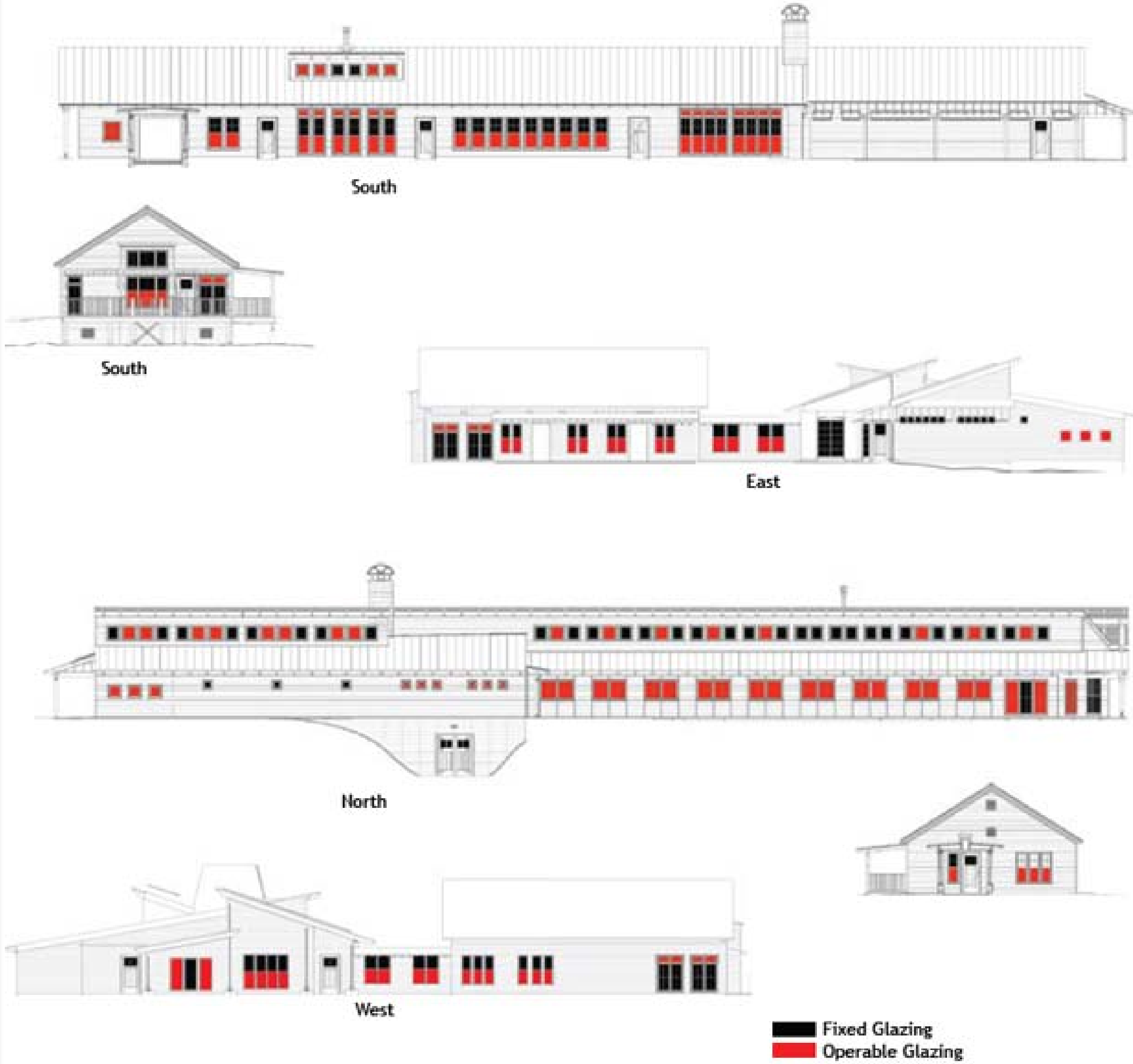
TRUSS BEARING
GROUND FLOOR
Wall Type D
Wall Type D

Passive Solar Heating

- Passive heating is used to minimize the energy needed for radiant floor 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

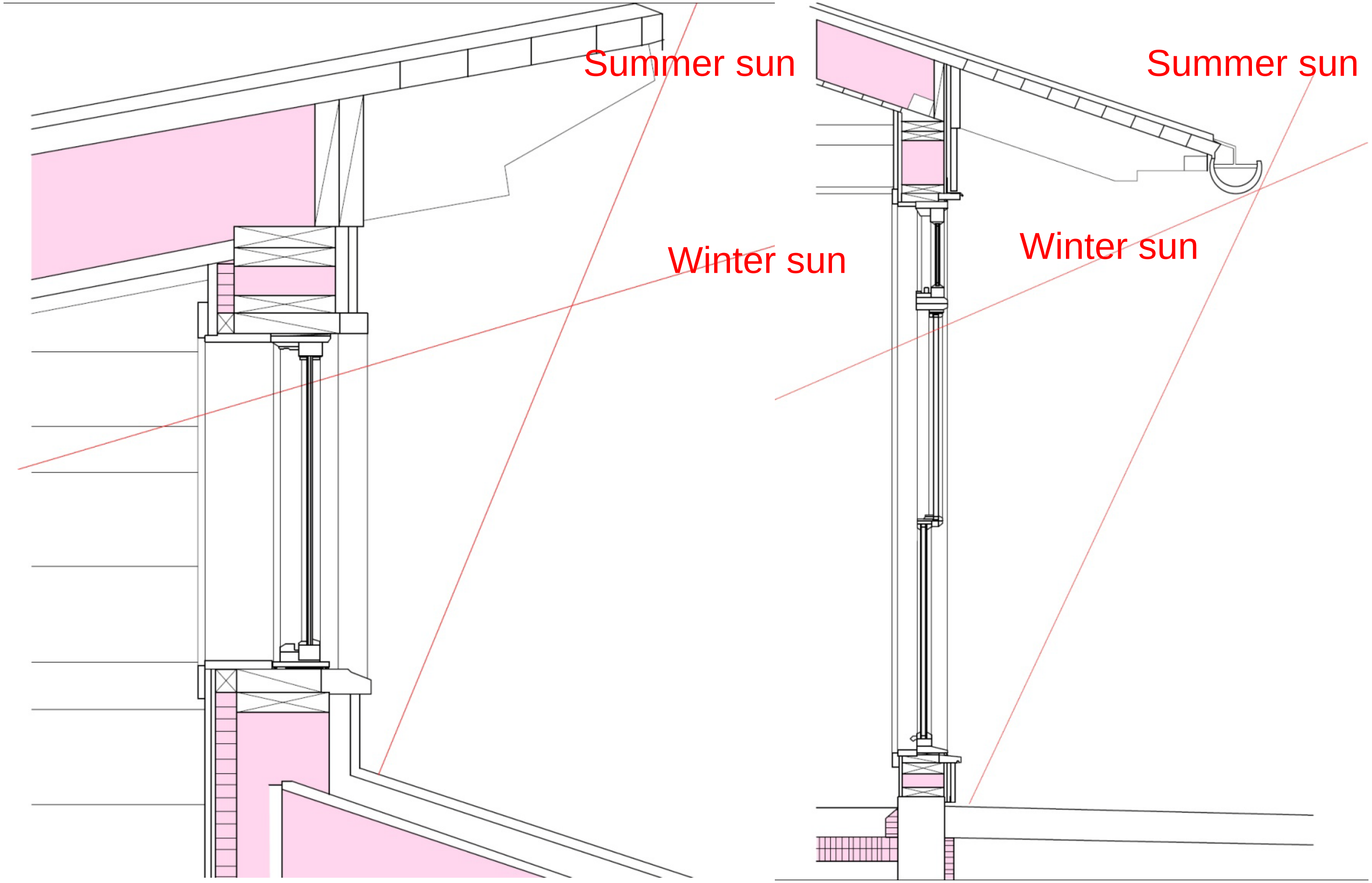
Daytime



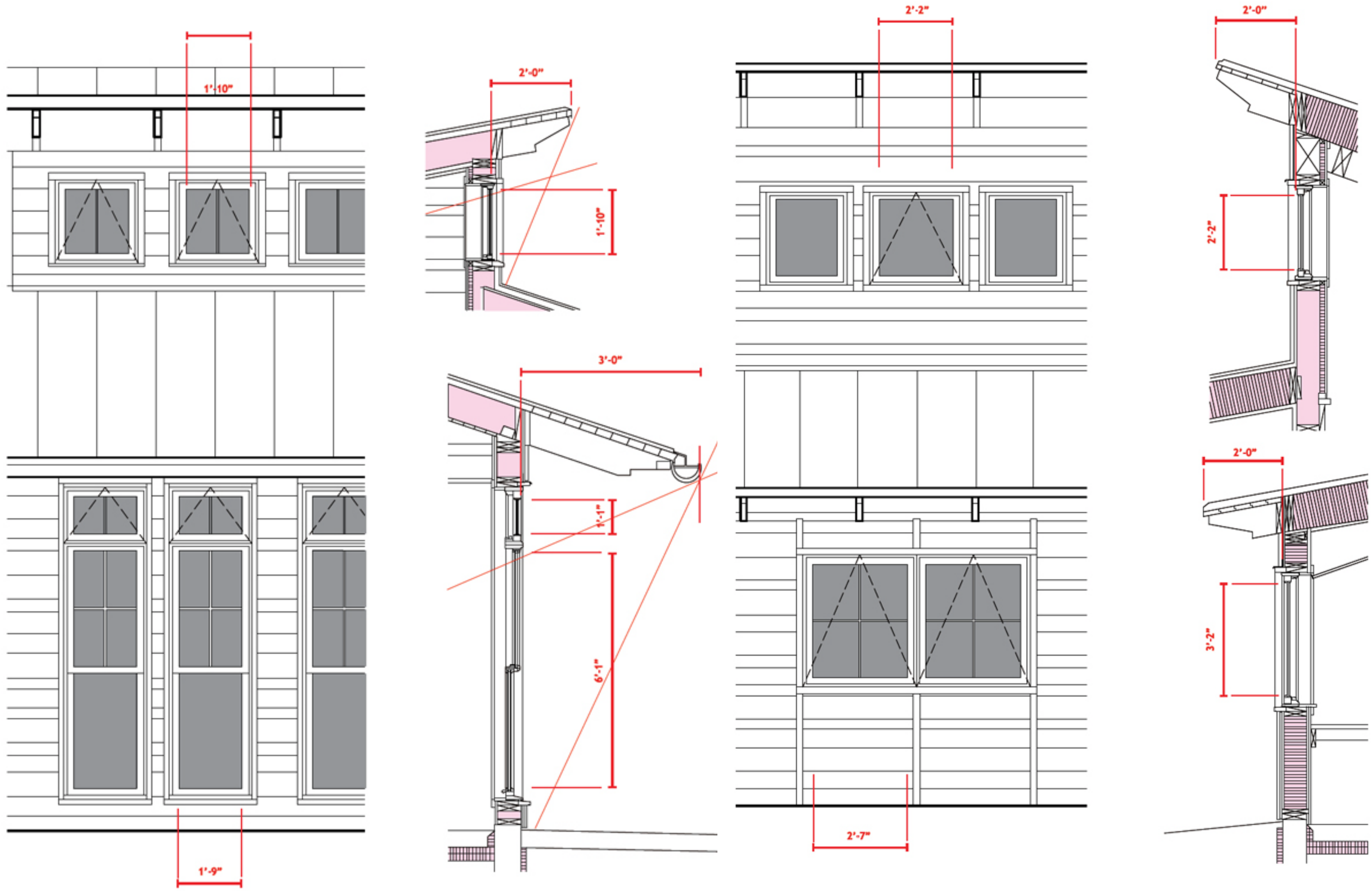


Glazing study for fixed vs operable and orientation.
Higher than usual amount of operable panels in envelope to facilitate natural ventilation. Infers $$$.

Passive Cooling:
Shade Windows During Summer



Basic first tier principle of HEAT AVOIDANCE.



façades 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

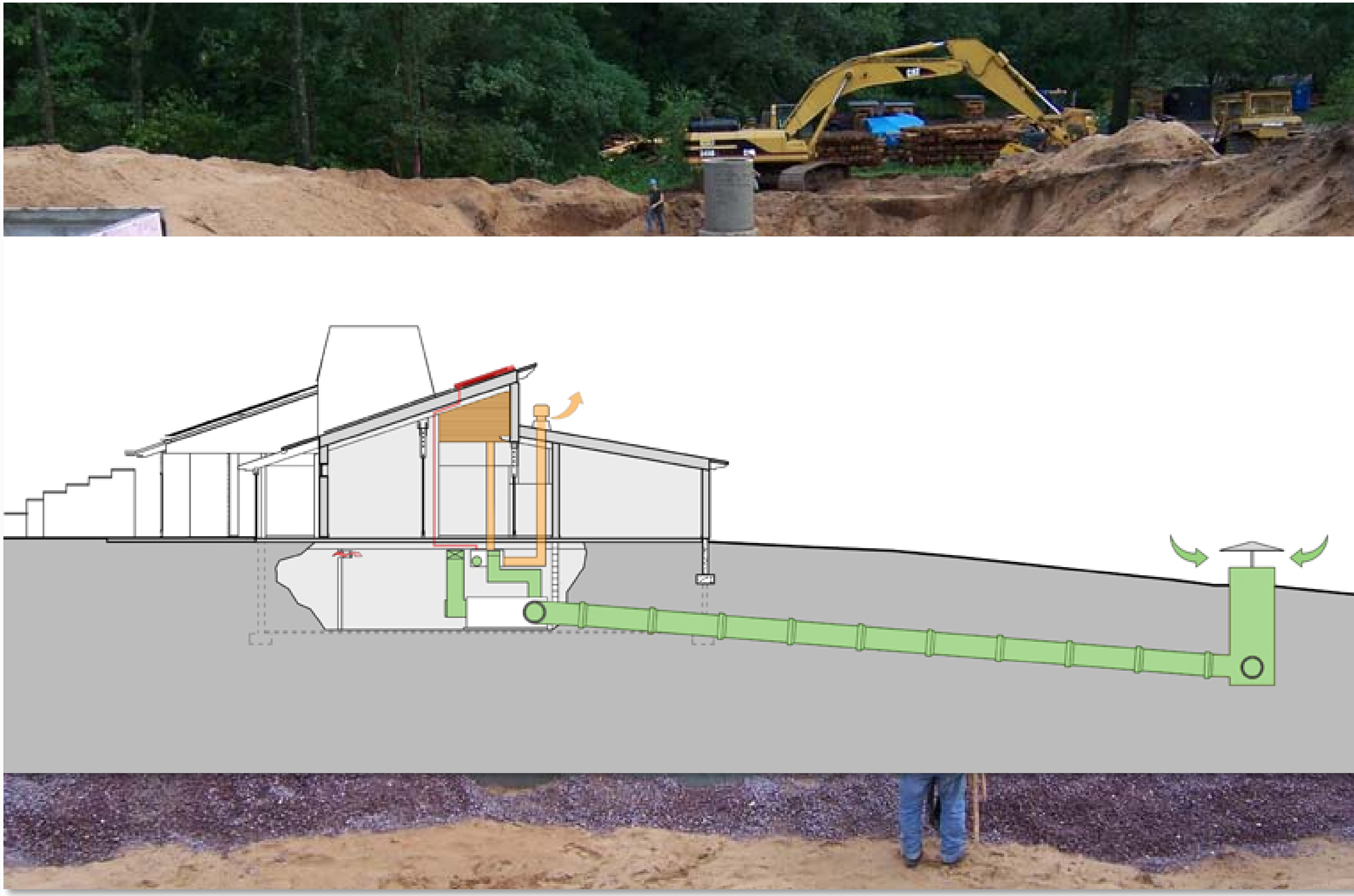
- Operable windows

- Flow through strategy

- Insect screens to keep out pests

- Chilled slabs in summer associated with geothermal system

Earth Duct for Air Pretreatment



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

Radiant Heating and Cooling

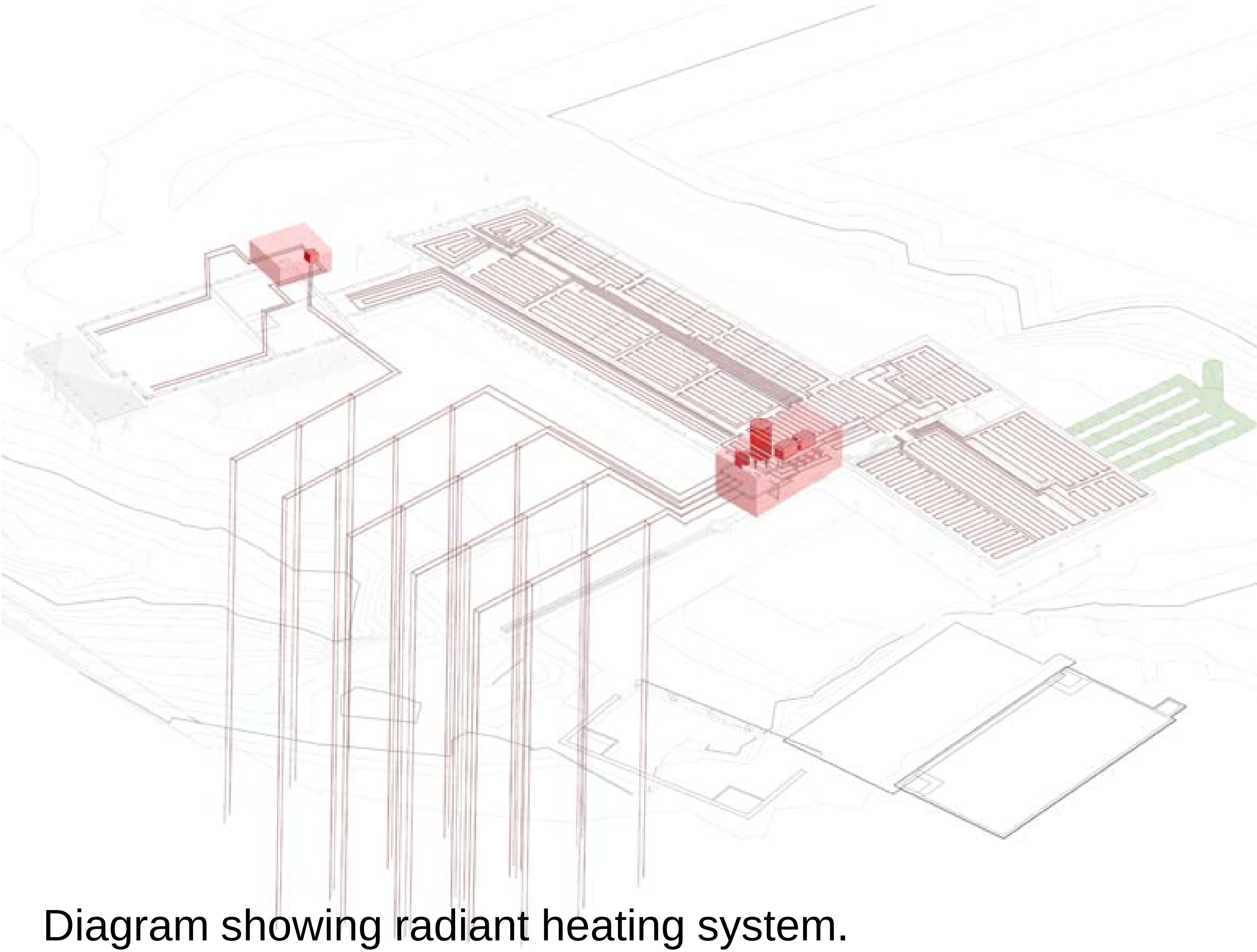


Diagram showing radiant heating system.

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. Cuts down on energy requirements overall.

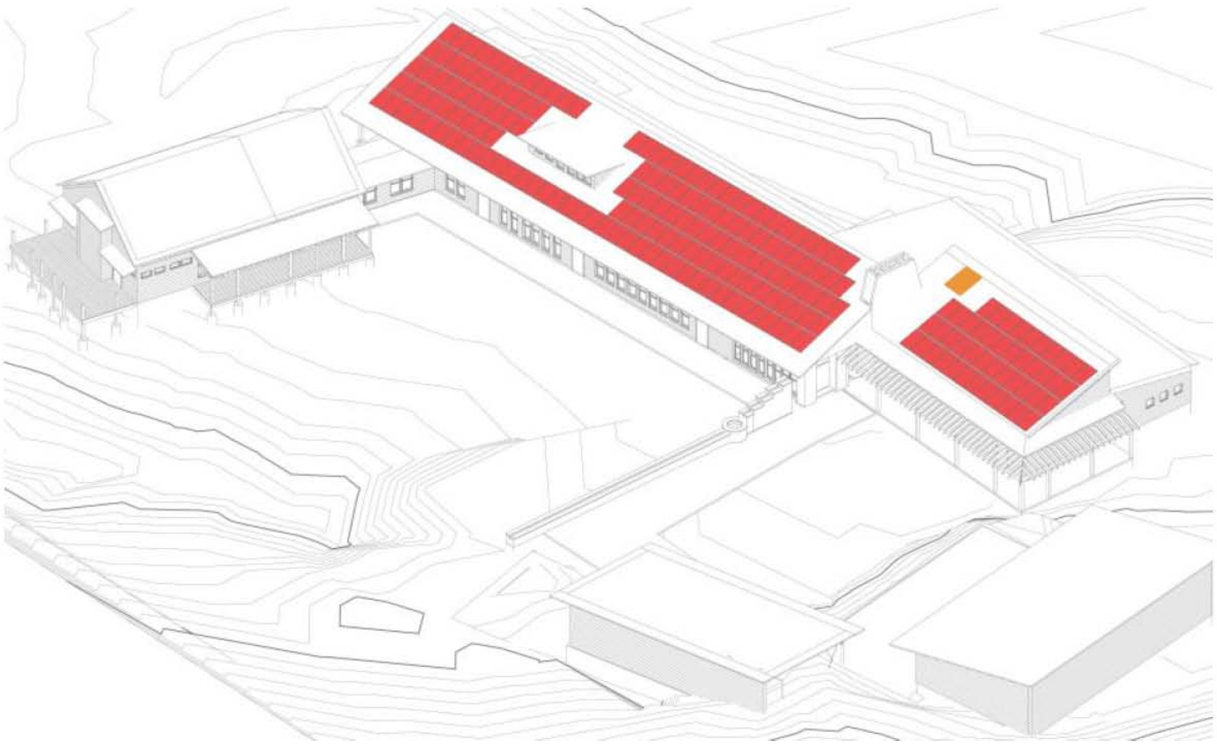
Energy and Atmosphere, 17 of 17 possible points: EA Credit 2 and Credit 6

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.

Infers modification of roofing selection and design to accommodate attachment of solar systems.

Ground Source Heat Pumps

Super insulate hot water runs to minimize heat losses.

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

Landscape + Site

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

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

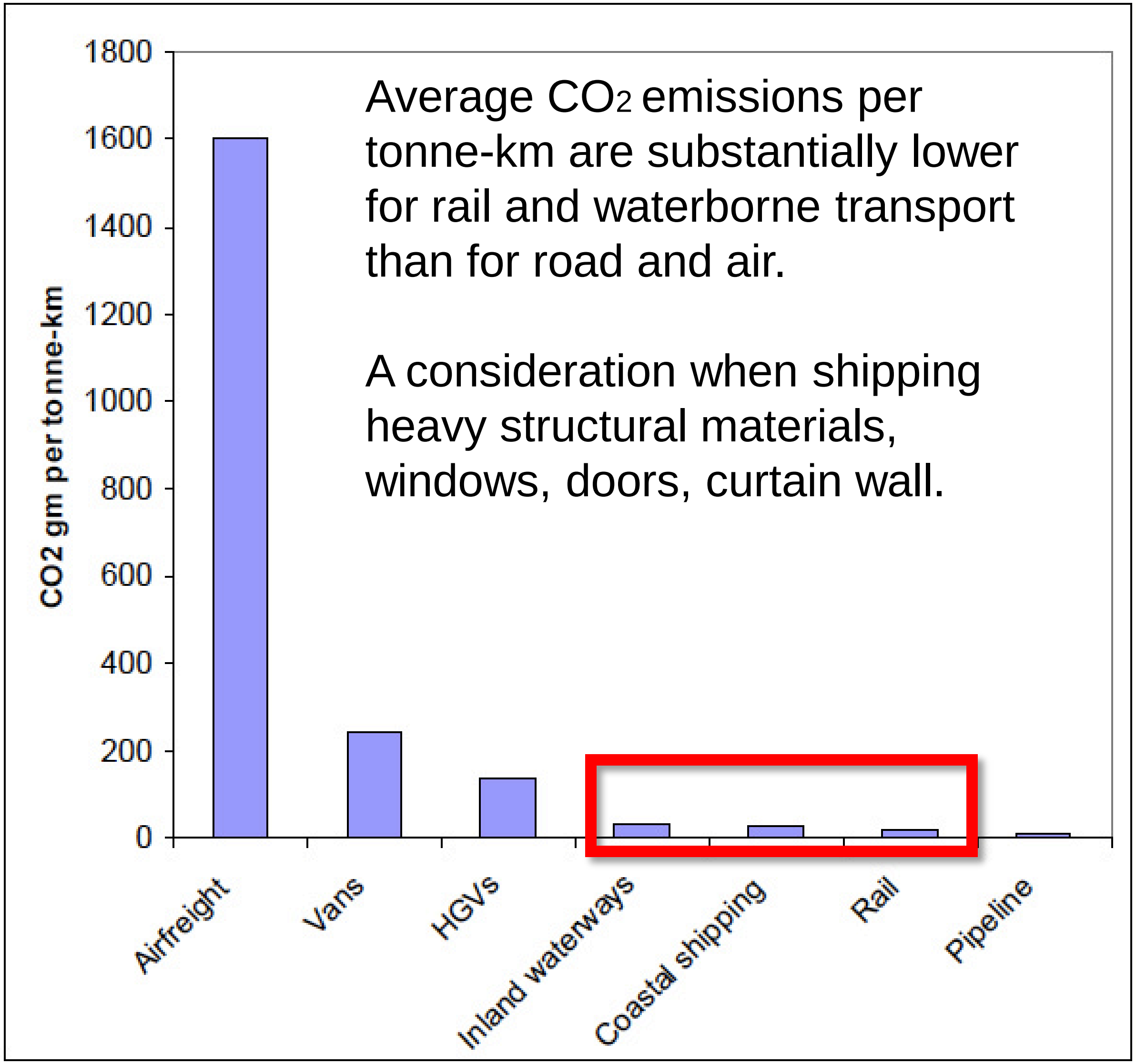
SS Credit 8, Light Pollution Reduction

Landscape + Site

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.

Operating energy

Transportation choice matters.



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.

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)
- **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

People, "Use" + Transportation

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%

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

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.

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

COMMON SENSE

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

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 (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

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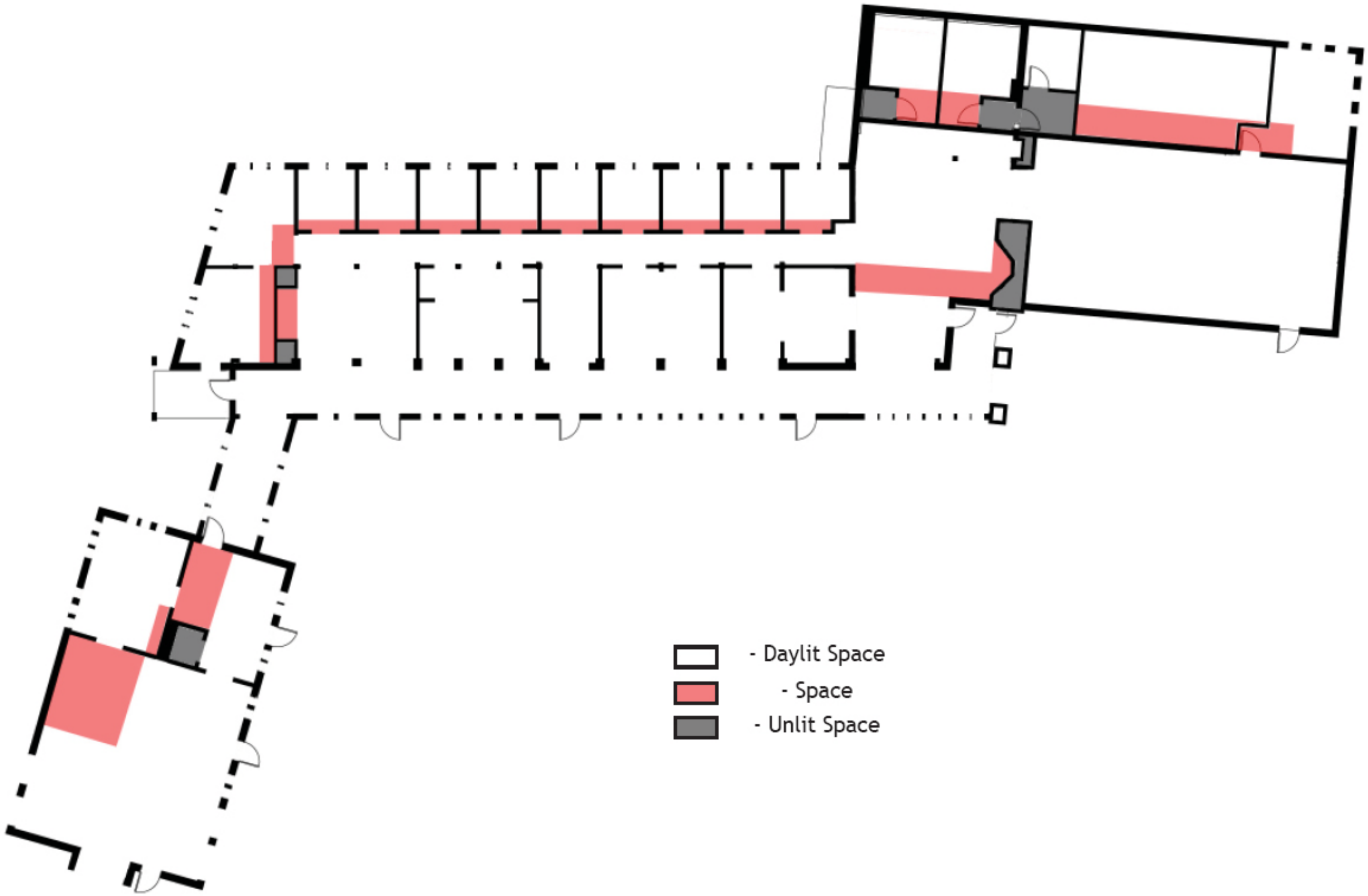
EQ Credit 8.1, Daylight & Views, Daylight 75% of Spaces

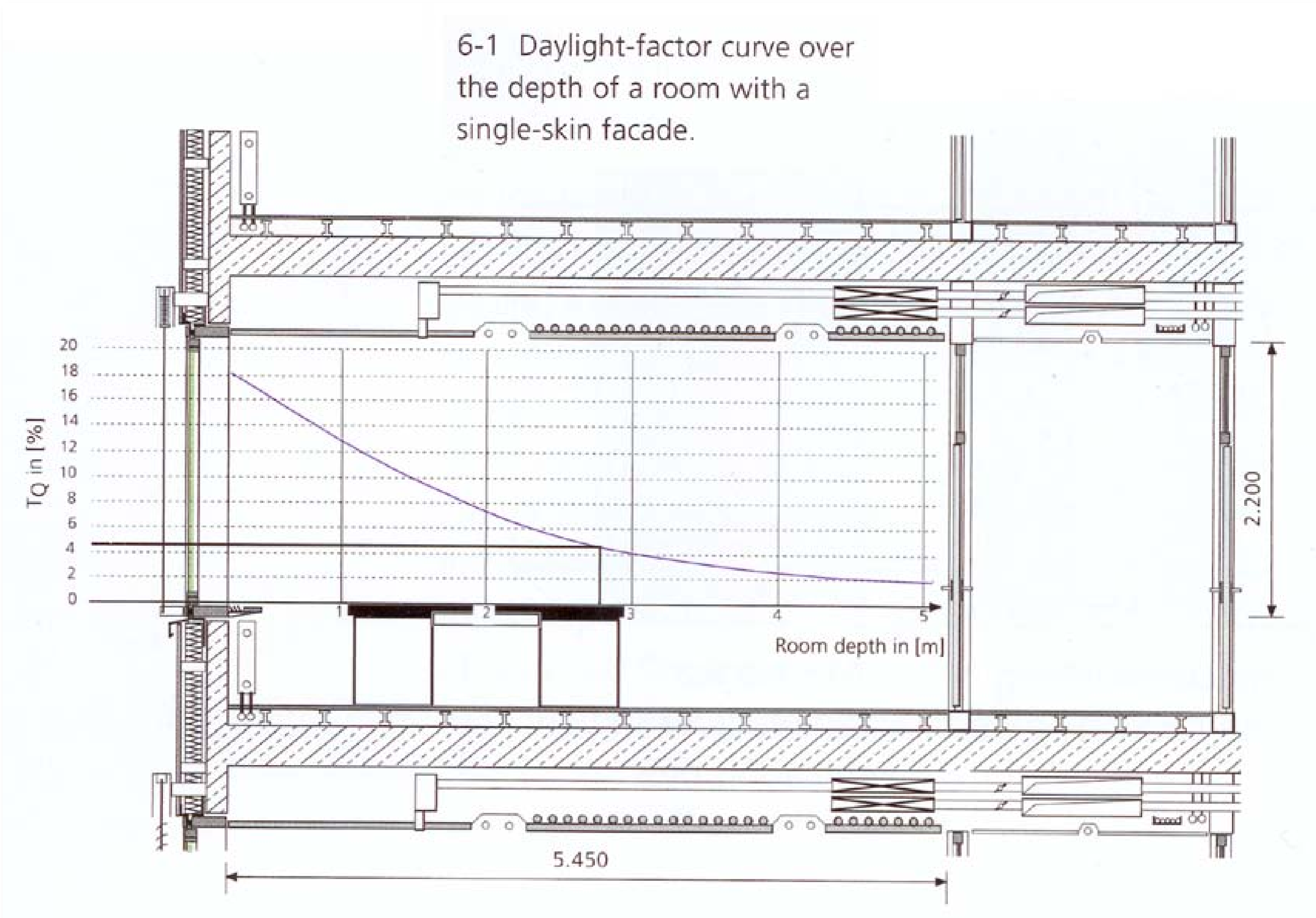
EQ Credit 8.2, Daylight & Views, Views for 90% of Spaces

Operating energy

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.

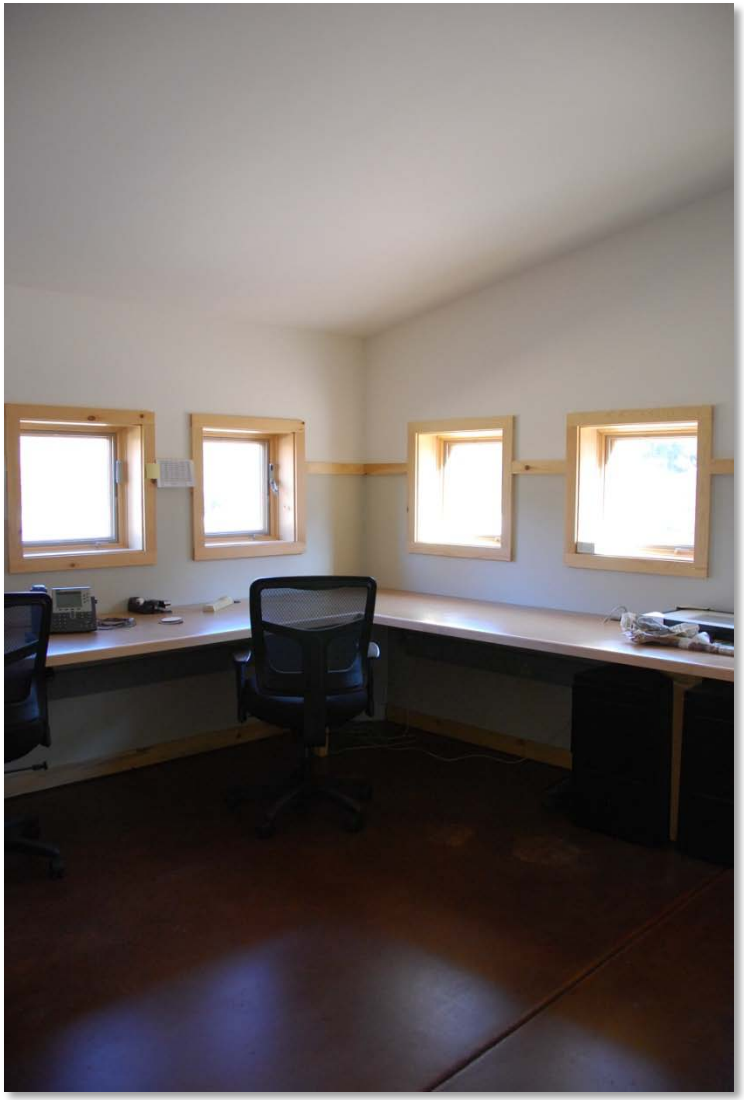


6-1 Daylight-factor curve over the depth of a room with a single-skin facade.

• 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%

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



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.

Solar Decathlon 2009

Focus on net positive energy production pushed the decathlon entries largely into the Carbon Neutral Operating energy arena.

North House – Ontario/BC

Very high efficiency quadruple glazed system allowed for the modern glass box to be efficient to the point of net positive energy.

Exterior shading system highly criticized by jury however did provide excellent solar control against unwanted gain.

Germany

Winning entry. The building envelope is completely covered with PV shingles. Very different detailing issues.

High expense involved with incorporating solar collection throughout the entire envelope. Detailing issues for attachment.

Cornell University

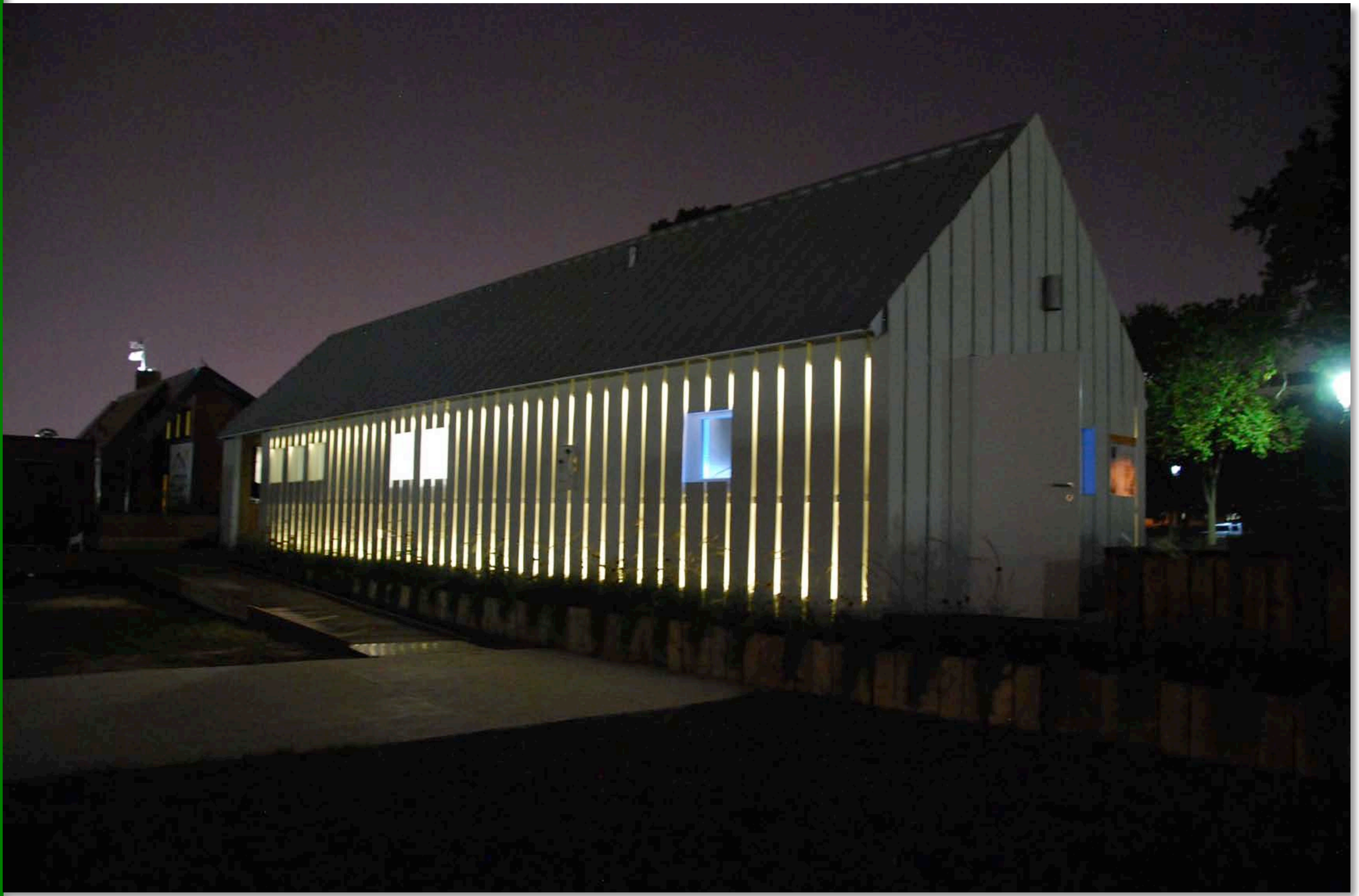
Weathering steel type exterior presents detailing issues associated with mix of other materials.

University of Illinois at Champlain Urbana

Second place. PV over entire south face of roof. Some very difficult to maintain details at roof edges.

Highly differentiated amount of glazing on façades.

LED lighting behind façade pushes this rain screen to the point of being very difficult to maintain.



Louisiana State University

Also designed to be hurricane resistant. Designed for high humidity climate.

Highly differentiated amount of glazing on façades. Definite acknowledgment of solar orientation in the design.

University of Wisconsin-Milwaukee

The only decathlon entry that included carbon neutral embodied energy in its design.

Experimental cladding presents challenges for detailing the building envelope.

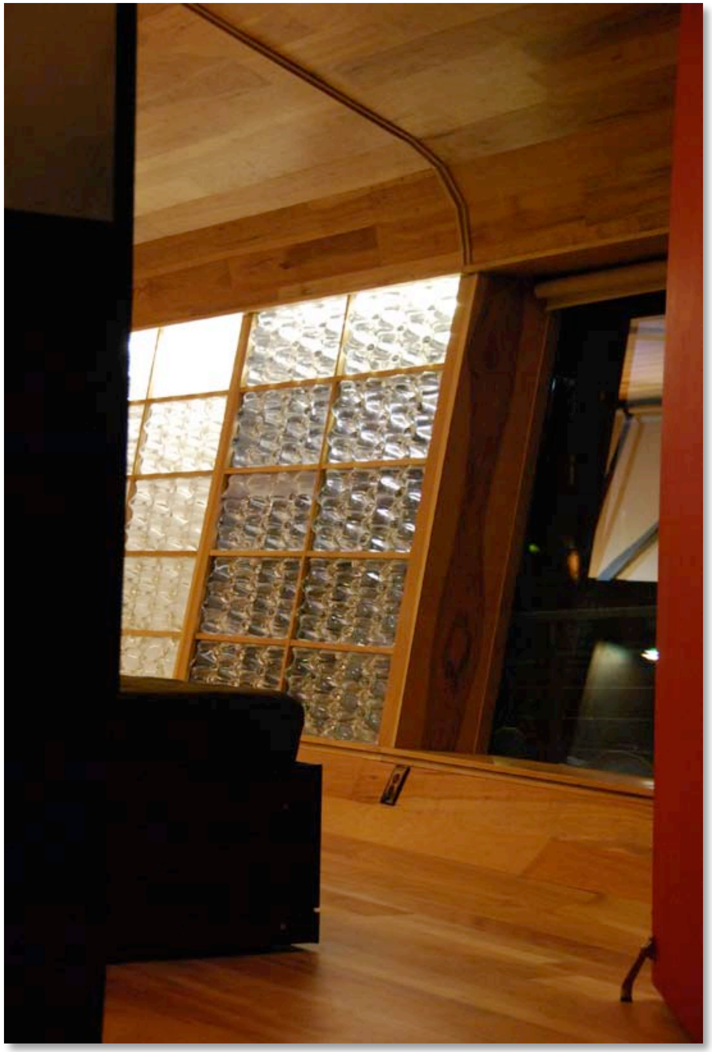
Different materials on the interior with an increased emphasis on wood. Clerestory windows at upper level for light and ventilation.

Butterfly roof for water collection presents challenges for detailing the building envelope.

Roof mounted solar collection also presents detailing issues and potential roof failures.

Arizona State University

Big passive push on this project. Back wall is trombe wall with water storage.



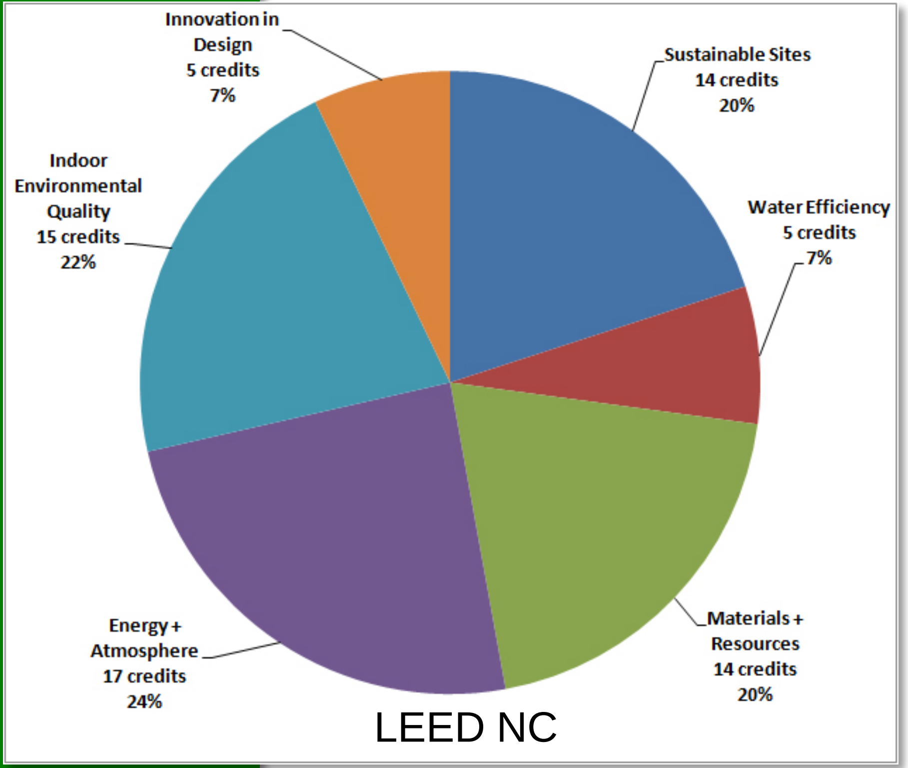
What is new in LEED 2009?

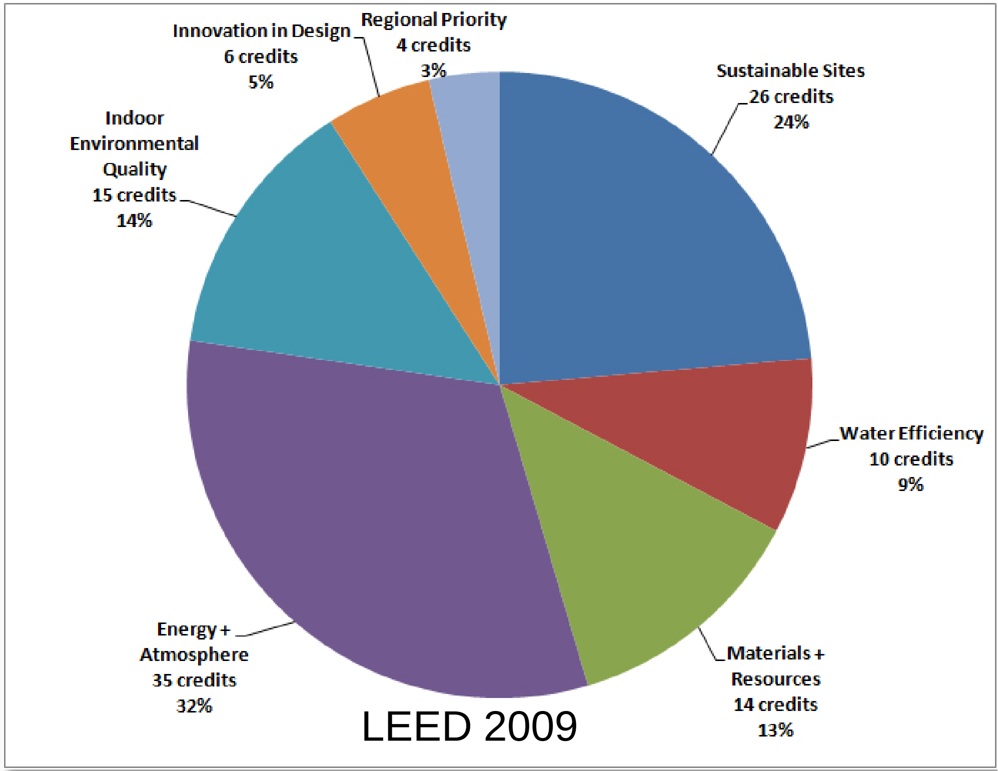
LEED 2009 and Carbon

General Changes:

- Total point score out of 110 rather than 70
- Credit weightings have changed, increasing some, lowering others
- Merger of two-part credits when only difference was threshold (e.g., MR Credit 4.1 and 4.2 are now MR Credit 4 with two different threshold levels)

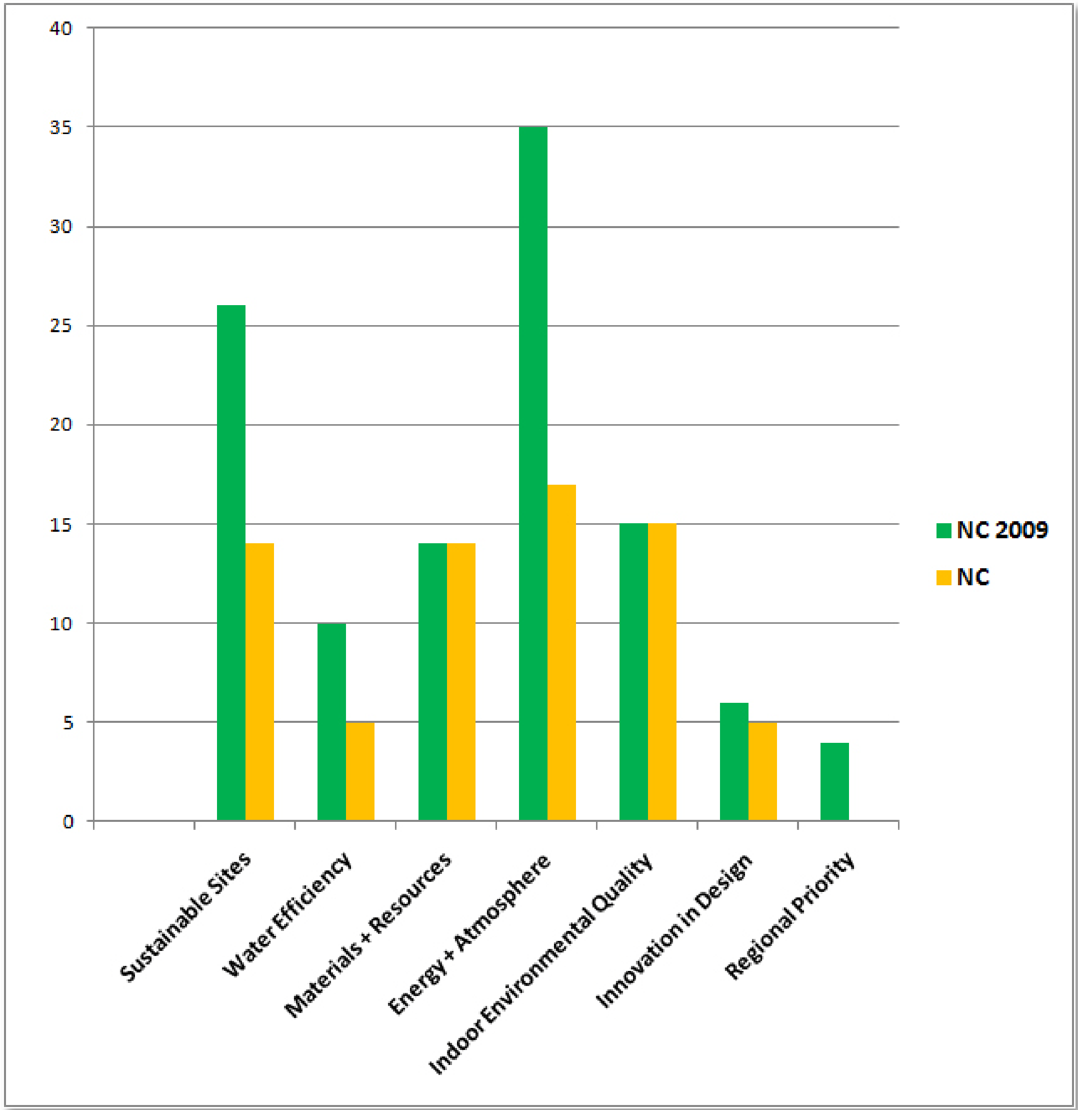
LEED 2009 Credit Comparison





The most obvious change in the system is the increase in percentage of points for Energy & Atmosphere and Sustainable Sites.

LEED 2009 vs LEED Credit Distribution



LEED 2009 Awards

LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009
100 base points; 6 possible Innovation in Design and 4 Regional Priority points

Certified	40–49 points
Silver	50–59 points
Gold	60–79 points
Platinum	80 points and above

Note that projects must meet all prerequisites and achieve 40 points from other credits before they may earn any points from Regional Priority credits.

Sustainable Sites

SUSTAINABLE SITES		26 POSSIBLE POINTS
❐ Prereq 1	Construction Activity Pollution Prevention	Required
❐ Credit 1	Site Selection	1
❐ Credit 2	Development Density and Community Connectivity	3, 5
❐ Credit 3	Brownfield Redevelopment	1
❐ Credit 4.1	Alternative Transportation: Public Transportation Access	3, 6
❐ Credit 4.2	Alternative Transportation: Bicycle Storage and Changing Rooms	1
❐ Credit 4.3	Alternative Transportation: Low-Emitting and Fuel-Efficient Vehicles	3
❐ Credit 4.4	Alternative Transportation: Parking Capacity	2
❐ Credit 5.1	Site Development: Protect and Restore Habitat	1
❐ Credit 5.2	Site Development: Maximize Open Space	1
❐ Credit 6.1	Stormwater Design: Quantity Control	1
❐ Credit 6.2	Stormwater Design: Quality Control	1
❐ Credit 7.1	Heat Island Effect: Non-Roof	1
❐ Credit 7.2	Heat Island Effect: Roof	1
❐ Credit 8	Light Pollution Reduction	1

Sustainable Sites

Credit		Major Changes
Sustainable Sites		
Prereq 1	**Construction Activity Pollution Prevention**	• *2003 U.S. EPA Construction General Permit* replaces the *1992 U.S. EPA Storm Water Management for Construction Activities, Chapter 3*
Credit 1	**Site Selection**	• Additional requirement to not development on land that is previously undeveloped or graded land within 15.2 metres of a water body which supports or could supports fish, recreation or industrial use • Correction to definition of farmland as many provinces and territories do not have an agricultural land reserve as referenced previously – new definition better aligns with USGBC's LEED NC 2009
Credit 2	**Development Density and Community Connectivity**	• Update to list of services for community connectivity • Additional option to achieve community connectivity without the site density requirement for subset of points
Credit 3	**Brownfield Redevelopment**	-

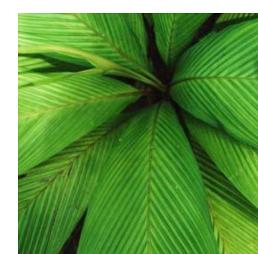
Landscape + Site

Sustainable Sites

Credit		Major Changes
Sustainable Sites		
Credit 4.1	**Alternative Transportation: Public Transportation Access**	• Distance must be measured from main building entrance • An alternate compliance path for a Transportation Demand Management plan has been added
Credit 4.2	**Alternative Transportation: Bicycle Storage & Changing Rooms**	• Bicycle storage must be covered for FTE occupants • Calculations are based on peak transient use
Credit 4.3	**Alternative Transportation: Low-Emitting & Fuel-Efficient Vehicles**	• Fuel efficient vehicle definition has changed
Credit 4.4	**Alternative Transportation: Parking Capacity**	• Projects are restricted to a parking capacity upper limit of 3.5 spaces per 93 m^2 (1000 ft^2) • Carpool requirement is based on total parking spaces (including visitor spaces)
Credit 5.1	**Site Development: Protect and Restore Habitat**	• Slightly increased requirements for greenfield sites
Credit 5.2	**Site Development: Maximize Open Space**	• Provided new pathway for sites with local zoning but no open space requirements

People, "Use" + Transportation

Landscape + Site



Sustainable Sites

Credit		Major Changes
Sustainable Sites		
Credit 6.1	**Stormwater Design: Quantity Control**	• For sites with existing imperviousness 50% or less, a new option has been provided to implement a stormwater management plan that protects receiving waterways from excessive erosion by implementing velocity and quantity control strategies
Credit 6.2	**Stormwater Design: Quality Control**	• Requirement for a stormwater quality management plan has been added • Total phosphorous requirement has been removed from calculations and replaced w management plan to minimize pollution and eutrophication of waterways (with no levels)
Credit 7.1	**Heat Island Effect: Non-Roof**	• Clarification of options and expanded to include, for example, shading from solar panels
Credit 7.2	**Heat Island Effect: Roof**	-
Credit 8	**Light Pollution Reduction**	• Modified requirements for interior and exterior light pollution • Language added to clarify IESNA RP-33 zones • Added public rights-of-way boundary exception for zones LZ2, LZ3 & LZ4 • Clarified site boundary for luminaires in intersections • Updated referenced standard to ASHRAE/IESNA Standard 90.1-2007
Credit 9	**Tenant Design and Construction Guidelines**	• New Core & Shell credit

Landscape + Site

Operating energy

Operating energy

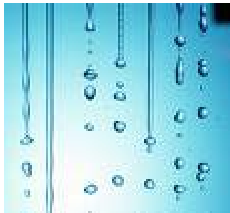
Potential here to assist occupants in maintaining low operating energy

Heat island roof impacts envelope and selection of roofing systems.

Water Efficiency

WATER EFFICIENCY		10 POSSIBLE POINTS
❒ Prereq 1	Water Use Reduction	Required
❒ Credit 1	Water Efficient Landscaping	2, 4
❒ Credit 2	Innovative Wastewater Technologies	2
❒ Credit 3	Water Use Reduction	2-4

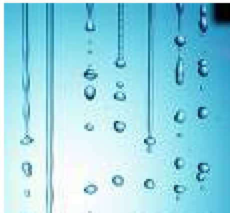
Direct impact of water credits on carbon not very clear.



Water Efficiency

Credit		Major Changes
Water Efficiency		
Prereq 1	**Water Use Reduction, 20% Reduction**	• New to LEED 2009, based on previous WE Credit 3.1 with the addition of a building/property water meter • Updated baselines for flow rates, based on the U.S. Energy Policy Act of 1992 and subsequent rulings by the U.S. Department of Energy, requirements of the Energy Policy Act of 2005, and the plumbing code requirements as stated in the 2006 editions of the Uniform Plumbing Code or International Plumbing Code
Credit 1	**Water Efficiency Landscaping**	• Merger of WE Credit 1.1 and WE Credit 1.2 • Minimum area clarified (5% of total project site area (including building)) • Added factors for calculating mid-summer baseline case • Addressed groundwater seepage for use in irrigation • Temporary irrigation systems limited to 1 year but no restrictions on type
Credit 2	**Innovative Wastewater Technologies**	• Reduction of on-site treatment threshold to 50%
Credit 3	**Water Use Reduction**	• See WE Prerequisite 1 changes for flow rate updates • Point thresholds have been increased with 3 levels available (30%, 35% and 40%)

Direct impact of water credits on carbon not very clear. Landscape aspects might assist in lowering heat island as this pertains to the selection of indigenous species and site disturbance.



Energy and Atmosphere

ENERGY AND ATMOSPHERE			35 POSSIBLE POINTS
❒	Prereq 1	Fundamental Commissioning of Building Energy Systems	Required
❒	Prereq 2	Minimum Energy Performance	Required
❒	Prereq 3	Fundamental Refrigerant Management	Required
❒	Credit 1	Optimize Energy Performance	1-19
❒	Credit 2	On-Site Renewable Energy	1-7
❒	Credit 3	Enhanced Commissioning	2
❒	Credit 4	Enhanced Refrigerant Management	2
❒	Credit 5	Measurement and Verification	3
❒	Credit 6	Green Power	2

Direct impact of the increase in points devoted to both energy efficiency and energy sources is very important for carbon. Also increased incentive for Green Power as well as Measurement and Verification.

Energy and Atmosphere

	Credit	Major Changes
Energy & Atmosphere		
Prereq 1	**Fundamental Commissioning of Building Energy Systems**	• Clarified Commissioning Authority (CxA) experience
Prereq 2	**Minimum Energy Performance**	• Updated referenced standard to ASHRAE/IESNA Standard 90.1-2007 • Performance Compliance Paths (comparison to MNECB and ASHRAE) are demonstrated through total building energy cost improvements including process loads • Prescriptive Compliance Paths are available
Prereq 3	**Fundamental Refrigerant Management**	• Requirement for zero use of halons in fire suppression equipment has been incorporated into EA Credit 4 • Added alternative compliance path for campus projects using existing district chilled water plants only
Credit 1	**Optimize Energy Performance**	• As per EA Prerequisite 2 • Point thresholds have changed • Different thresholds for Core & Shell projects
Credit 2	**On-Site Renewable Energy**	• Point thresholds have been reduced but now based on total building energy cost (not only regulated loads) • Different thresholds for Core & Shell projects

Operating energy

Energy optimization directly impacts insulation and air tightness of envelope.

Energy and Atmosphere

Credit		Major Changes
Energy & Atmosphere		
Credit 3	**Enhanced Commissioning**	• Clarified Commissioning Authority (CxA) experience and independency requirements • The same CxA overseeing the enhanced commissioning tasks (EA Credit 3) must also oversee the fundamental commissioning tasks (EA Prerequisite 1) • Clarifications were made to standardize LEED Commissioning Scope of Work
Credit 4	**Enhanced Refrigerant Management**	• Fire suppression systems must be free of ozone-depleting substances • Refrigerants must comply with a maximum threshold for the combined contributions to ozone depletion and global warming potential • Added option for not using refrigerants
Credit 5	**Measurement and Verification**	• Requirement added to provide process for corrective action if M&V plan shows energy savings are not being achieved • Removed requirement for a water M&V program • Separation of tenant submetering from base building creating two credits (EA Credit 5.1 and 5.2) for Core & Shell projects
Credit 6	**Green Power**	• Point threshold has been reduced to 35%, but now includes all building electricity (not only regulated loads) • Clarified that all purchases of green power are based on the quantity of energy consumed, not cost

Operating energy

Materials and Resources

MATERIALS AND RESOURCES		14 POSSIBLE POINTS
❒ Prereq 1	Storage and Collection of Recyclables	Required
❒ Credit 1.1	Building Reuse: Maintain Existing Walls, Floors, and Roof	1-3
❒ Credit 1.2	Building Reuse: Maintain Interior Non-Structural Elements	1
❒ Credit 2	Construction Waste Management	1-2
❒ Credit 3	Materials Reuse	1-2
❒ Credit 4	Recycled Content	1-2
❒ Credit 5	Regional Materials	1-2
❒ Credit 6	Rapidly Renewable Materials	1
❒ Credit 7	Certified Wood	1

Not much has changed in this section that will impact carbon.

Materials and Resources

Credit		Major Changes
Materials & Resources		
Prereq 1	**Storage and Collection of Recyclables**	• Area for the collection of organic waste must be provided in municipalities that support such collection
Credit 1.1	**Building Reuse: Maintain Existing Walls, Floors, and Roof**	• Combined with previous MR Credit 1.2 • Point added for new lower threshold (55%)
Credit 1.2	**Building Reuse: Maintain Interior Non-structural Elements**	• Credit no longer available to Core & Shell projects
Credit 2	**Construction Waste Management**	-
Credit 3	**Materials Reuse**	• Only lower threshold available to Core & Shell projects (5%)
Credit 4	**Recycled Content**	• Point thresholds have been increased (10% and 20%)
Credit 5	**Regional Materials**	• Point thresholds have been increased (20% and 30%) • Products must be extracted and processed within 800 km of the manufacturer rather than site • Allowance for fractions of products to be used to achieve credit
Credit 6	**Rapidly Renewable Materials**	• Point threshold has been reduced (2.5%) • Credit no longer available to Core & Shell projects
Credit 6/7	**Certified Wood**	• Credit 6 for Core & Shell projects • No exemption from Chain-of-Custody requirements for last vendor

Embodied Carbon in Building Materials

Materials selection of envelope feeds directly into these credits.

Envelope reuse can present issues with increased insulation/air tightness requirements.

Indoor Environmental Quality

INDOOR ENVIRONMENTAL QUALITY		15 POSSIBLE POINTS
❒ Prereq 1	Minimum Indoor Air Quality Performance	Required
❒ Prereq 2	Environmental Tobacco Smoke (ETS) Control	Required
❒ Credit 1	Outdoor Air Delivery Monitoring	1
❒ Credit 2	Increased Ventilation	1
❒ Credit 3.1	Construction Indoor Air Quality Management Plan: During Construction	1
❒ Credit 3.2	Construction Indoor Air Quality Management Plan: Before Occupancy	1
❒ Credit 4.1	Low-Emitting Materials: Adhesives and Sealants	1
❒ Credit 4.2	Low-Emitting Materials: Paints and Coatings	1
❒ Credit 4.3	Low-Emitting Materials: Flooring Systems	1
❒ Credit 4.4	Low-Emitting Materials: Composite Wood and Agrifibre Products	1
❒ Credit 5	Indoor Chemical and Pollutant Source Control	1
❒ Credit 6.1	Controllability of System: Lighting	1
❒ Credit 6.2	Controllability of System: Thermal Comfort	1
❒ Credit 7.1	Thermal Comfort: Design	1
❒ Credit 7.2	Thermal Comfort: Verification	1
❒ Credit 8.1	Daylight and Views: Daylight	1
❒ Credit 8.2	Daylight and Views: Views	1

Indoor Environmental Quality

Credit		Major Changes
Indoor Environmental Quality		
Prereq 1	**Minimum Indoor Air Quality Performance**	• Updated referenced standard to ASHRAE Standard 90.1-2007
Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	• Residential (Case 2) clarified to include hotels, motels, and dormitories • Added language addressing signage in Option 1 and Option 2 • Added requirement to weatherstrip exterior doors and windows in residential projects • Added requirement to weatherstrip all residential unit doors leading to common hallways – however, if the common hallways are pressurized with respect to the residential units, an allowance is provided to follow Option 2 (considering the residential unit as the smoking room) • Updated referenced standard for demonstrating acceptable sealing of residential units to Chapter 4 (Compliance Through Quality Construction) of the Residential Manual for Compliance with California's 2001 Energy Efficiency Standards
Credit 1	**Outdoor Air Delivery Monitoring**	• Updated referenced standard to ASHRAE Standard 62.1-2007 • Clarified requirement to monitor CO_2 concentrations in all densely occupied areas (Case 1 - Mechanically Ventilated Spaces) • Added requirement for outdoor airflow measurement (Case 1 - Mechanically Ventilated Spaces) • Added specific requirements for naturally ventilated spaces (Case 2 - Naturally Ventilated Spaces)
Credit 2	**Increased Ventilation**	• Credit has been changed from ventilation effectiveness to requiring outdoor air ventilation rates 30% above minimum rates required by ASHRAE Standard 62.1-2007 • Naturally ventilated spaces may alternatively meet the recommendations of the CIBSE Applications Manual • Specific compliance path (Case 3) for residential projects requiring outdoor air ducted directly to the suite with air distributed to all regularly occupied areas

Ventilation can help to avert use of Air Conditioning for cooling. Natural ventilation impacts the design of the envelope and selection of window systems.

Indoor Environmental Quality

Credit		Major Changes
Indoor Environmental Quality		
Credit 3.1	**Construction Indoor Air Quality Management Plan During Construction**	• Updated referenced standard to the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines For Occupied Buildings Under Construction, 2nd Edition 2007, ANSI/SMACNA 008-2008 (Chapter 3) • Clarified that filtration media must be replaced immediately prior to occupancy • Removed requirement to make provisions for inspections of building HVAC systems
Credit 3.2	**Construction Indoor Air Quality Management Plan Before Occupancy**	• Clarified the IAQ Management Plan implementation timeline requirements • Clarified that all finishes must be installed prior to flush-out • Flush-out during occupancy ventilation rate has been increased from 0.76 to 1.54 $L/s/m^2$ • Threshold for formaldehyde level was revised from 50 to 27 parts per billion in Option 2, Air Testing
Credit 4.1	**Low-Emitting Materials: Adhesives and Sealants**	• Clarification on use of VOC budget • Clarification on interior of the building • VOC thresholds no longer updated to match date of building permit but set as per rating system requirements
Credit 4.2	**Low-Emitting Materials: Paints and Coatings**	• As per IEQ Credit 4.1 • Moved primers from Green Seal requirements to SCAQMD requirements
Credit 4.3	**Low-Emitting Materials: Flooring Systems**	• Requirements now reflect all low-emitting flooring materials and finishes • All flooring must comply with a minor exemption of up to 5% for speciality areas
Credit 4.4	**Low-Emitting Materials: Composite Wood and Agrifibre Products**	-

Interior finish selection associated with the envelope impacts air quality.

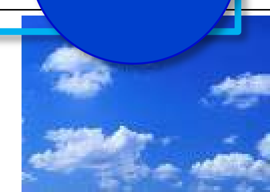
Indoor Environmental Quality

Credit		Major Changes
Indoor Environmental Quality		
Credit 5	**Indoor Chemical and Pollutant Source Control**	• Required entryway system travel distance length increased and systems are required at regular entry points • Combinations of permanently installed systems along with walk-off mats with provisions for maintenance are allowed • Added exemption for new air filtration media for air handling equipment with a maximum flow rate of 283 L/s (600 cfm) or less provided they are equipped with the highest supply air filtration level commercially available for the specific equipment • For residential projects, carbon monoxide alarms are required in areas adjacent to combustion equipment
Credit 6.1	**Controllability of System: Lighting**	• Re-structured credit from perimeter spaces to lighting control • Credit not available to Core & Shell projects
Credit 6.2	**Controllability of System: Thermal Comfort**	• Re-structured credit from non-perimeter spaces to thermal comfort control • Clarification of requirements for use of operable windows • Thermal comfort controls as described by ASHRAE Standard 55-2004 • Clarification on scope for Core & Shell projects
Credit 7.1	**Thermal Comfort: Design**	• Increased demonstration of compliance with ASHRAE 55-2004 -now required.
Credit 7.2	**Thermal Comfort: Verification**	• An occupant thermal comfort survey is required • An alternative compliance path was added for residential buildings • Credit no longer available to Core & Shell projects
Credit 8.1	**Daylight and Views: Daylight**	• Multiple options now available – simulation, prescriptive, measurement or combin
Credit 8.2	**Daylight and Views: Views**	-

Pro Passive Design

Operating energy

Increased amount of daylight modifies envelope design.



Innovation in Design + Regional Priority

INNOVATION IN DESIGN		6 POSSIBLE POINTS
❒ Credit 1	Innovation in Design	1-5
❒ Credit 2	LEED® Accredited Professional	1

REGIONAL PRIORITY		4 POSSIBLE POINTS
❒ Credit 1	Durable Building	1
❒ Credit 2	Regional Priority Credit	1-3

Innovation in Design

Credit		Major Changes
Innovation in Design		
Credit 1	**Innovation in Design**	• Expanded innovation strategies allowed from 4 to 5 • Added stipulation that no more than 3 exemplary performance points can be awarded
Credit 2	**LEED® Accredited Professional**	-

Focusing on carbon can earn you quite a few of these credits.

Regional Priority

Credit		Major Changes
Regional Priority		
Credit 1	**Durable Building**	• Formerly MR Credit 8 in LEED Canada NC v1.0
Credit 2	**Regional Priority Credit**	• New to LEED 2009

Embodied Carbon in Building Materials

Not sure yet what the Regional Credit might do for carbon.

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A pdf of this presentation will be found at:

www.architecture.uwaterloo.ca/faculty_projects/terri/