The Leap to Zero Carbon: The 2030 Challenge

Defining the STEPS to Carbon Neutral Design

ARCH 126: ENVIRONMENTAL BUILDING DESIGN

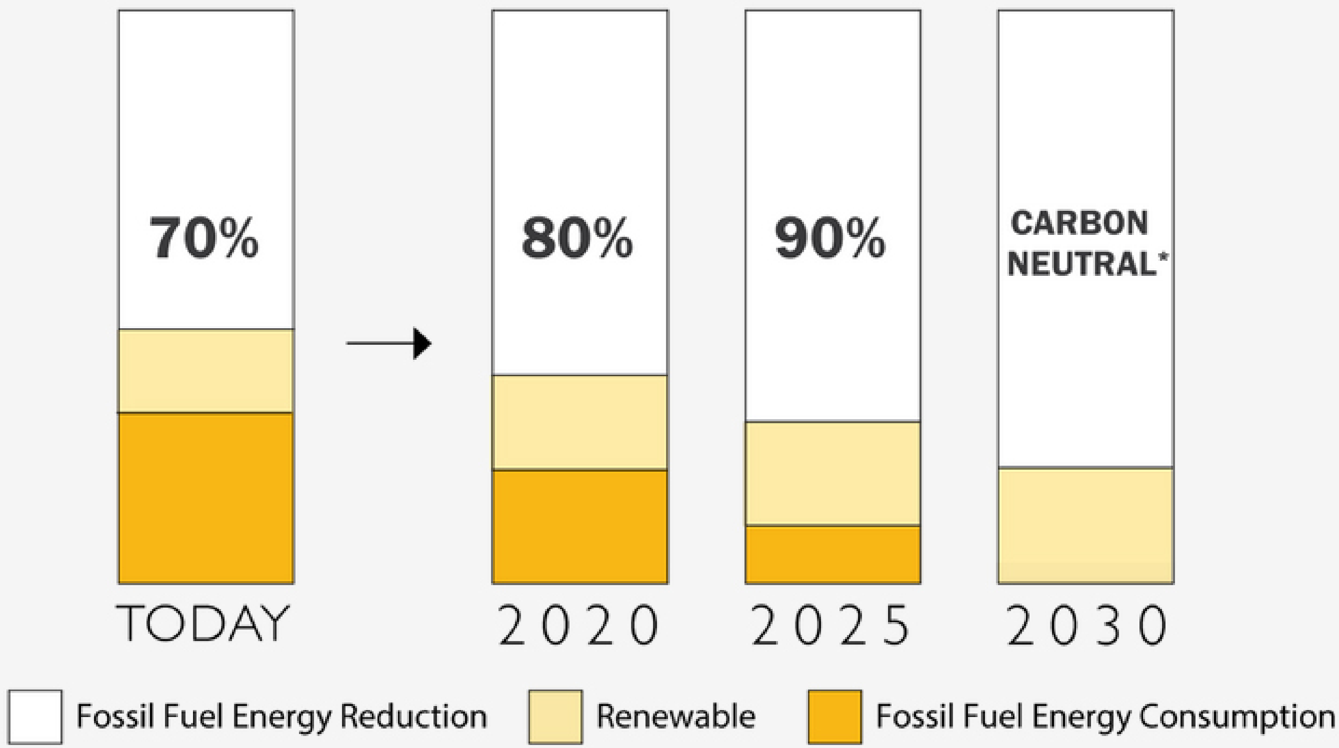
Why Assess Carbon Neutrality?

- 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 radically reduce their carbon emissions by the year 2030

www.architecture2030.org

THE 2030 CHALLENGE

All new buildings, developments, and major renovations shall be carbon-neutral by 2030



The 2030 Challenge

Using no fossil fuel GHG-emitting energy to operate.

DESIGN STRATEGIES

The largest energy reductions can be achieved through design.

TECHNOLOGIES AND SYSTEMS

Including on-site renewable energy systems.

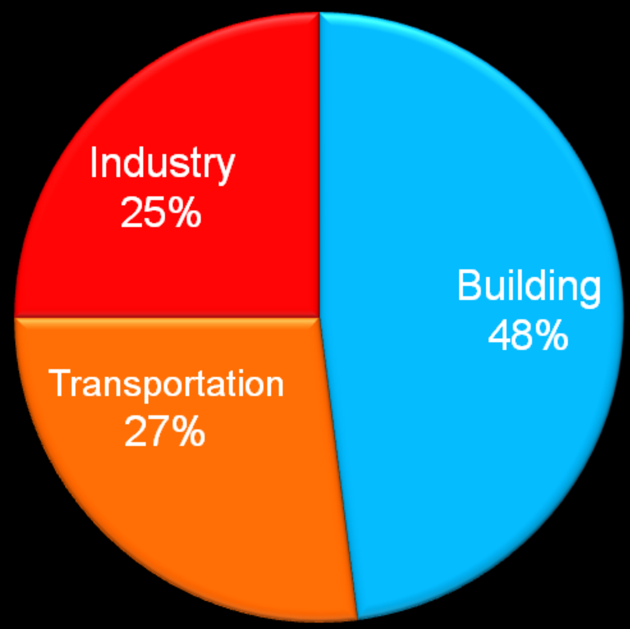
OFF-SITE RENEWABLE ENERGY

20% maximum.

Meeting the 2030 Challenge

Source:

Energy Use by Developed Countries



The Global Warming Pie....

These values look at <u>Secondary **Energy Use** by Sector in Canada (2006)</u>
(*energy used by the final consumer i.e. operating energy*)

The LEAP to Zero Carbon and beyond…

- Energy Efficient (mid 1970s “Oil Crisis” reaction) – add insulation
- High Performance (accountable) – C2000, Hot2000
- **Green (environmentally responsive) –** Kyoto Protocol
- Sustainable (holistic and accountable) – LEED ™
- Carbon Neutral (Zero Fossil Fuel Energy) – Architecture2030
- Restorative
- Regenerative – Living Building Challenge

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

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]

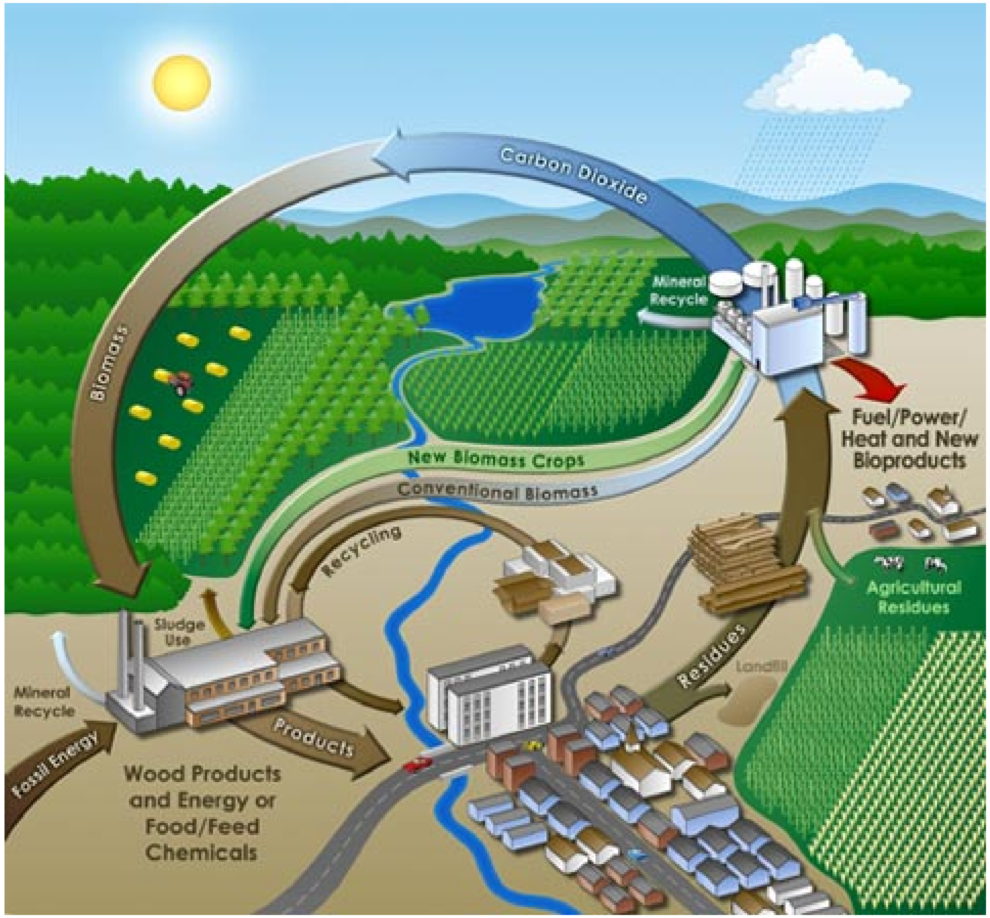
From the Environmental Protection Agency (EPA): Use this chart to find the site fossil-fuel energy targets.

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.

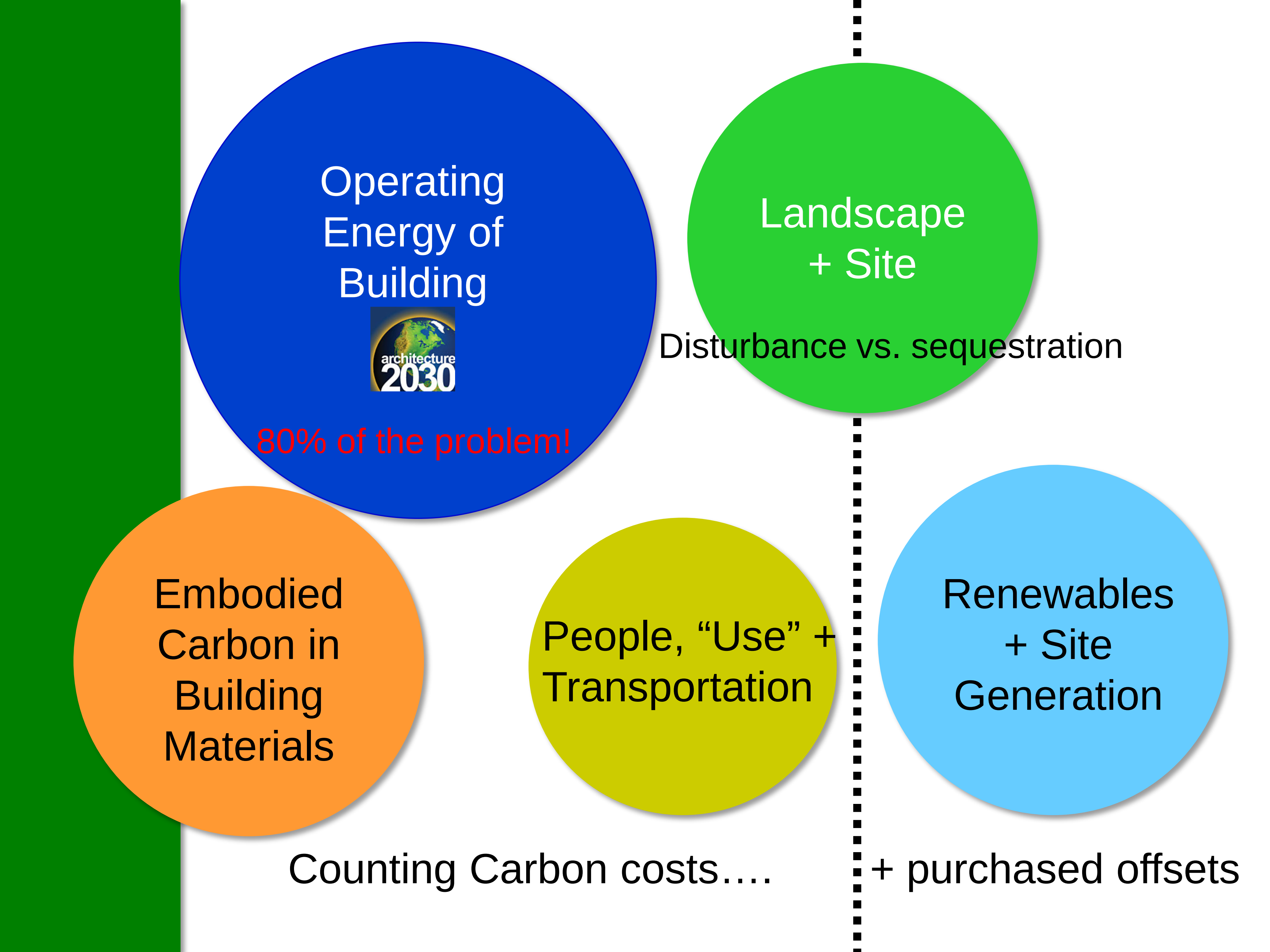
http://www.architecture2030.org/downloads/2030_Challenge_Targets_Res_Regional.pdf

Buildings / Processes and the Carbon Cycle:



http://www.repp.org/bioenergy/bioenergy-cycle-med2.jpg

As the way that buildings interact with carbon is highly complex, the first aim is to reduce operating energy as it is the most significant and easiest to control.


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

Energy vs Greenhouse Gas Emissions

In BUILDINGS, for the sake of argument

ENERGY CONSUMPTION = GHG EMISSIONS

BUILDING ENERGY IS COMPRISED OF

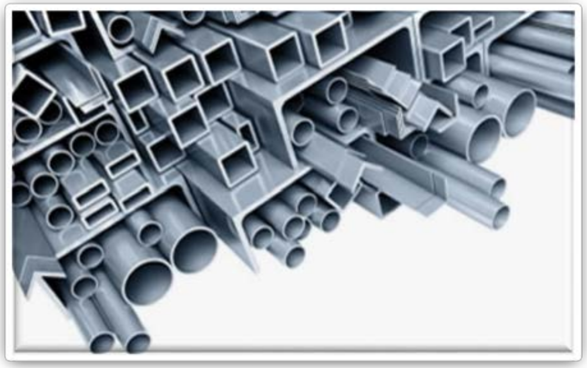
EMBODIED ENERGY
+
OPERATING ENERGY

Energy Use in Buildings

Embodied Energy

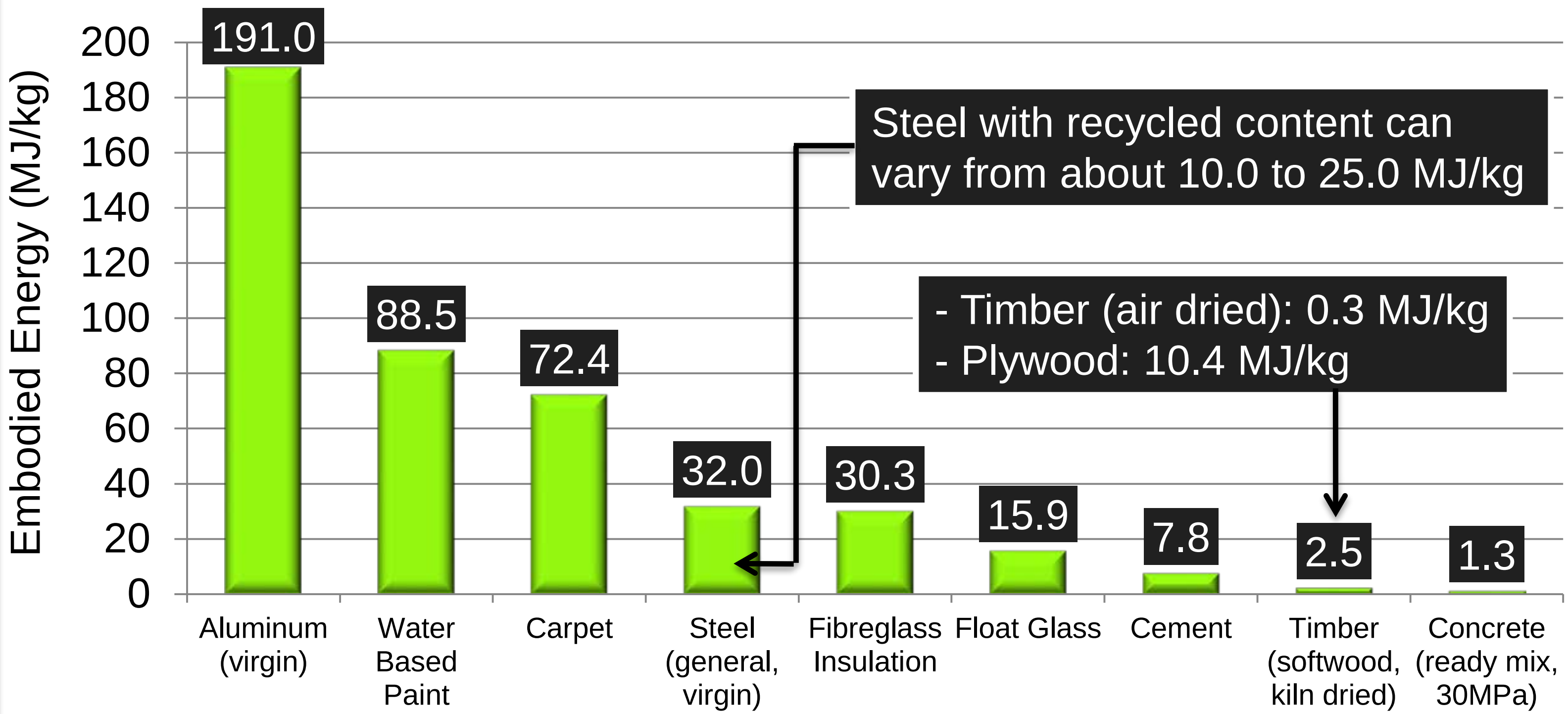
– **Initial Embodied Energy:** Non-renewable energy consumed in the acquisition of raw materials, their processing, manufacturing, transportation to site, and construction

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



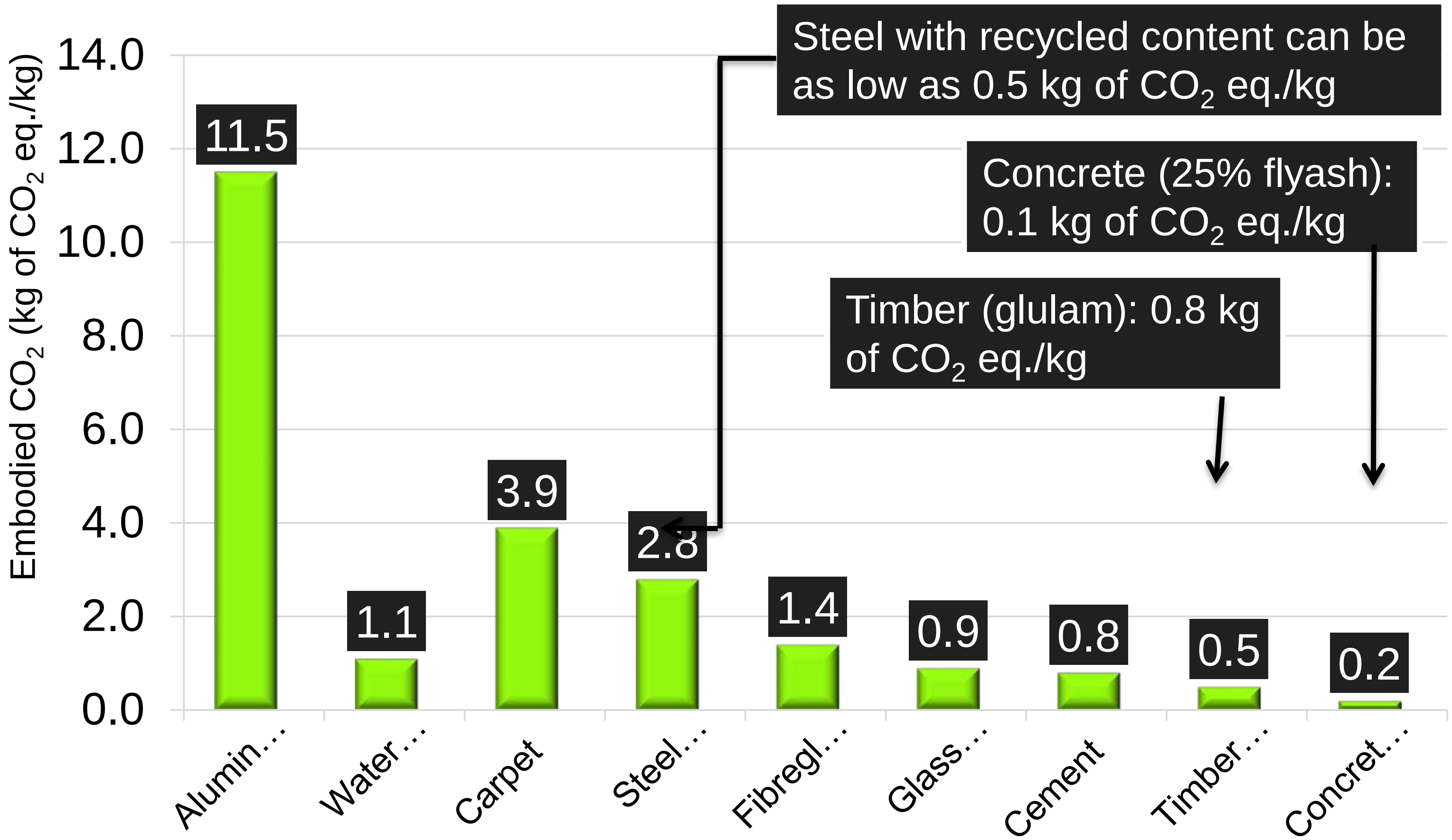
www.cn-sbs.cssbi.ca

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>**

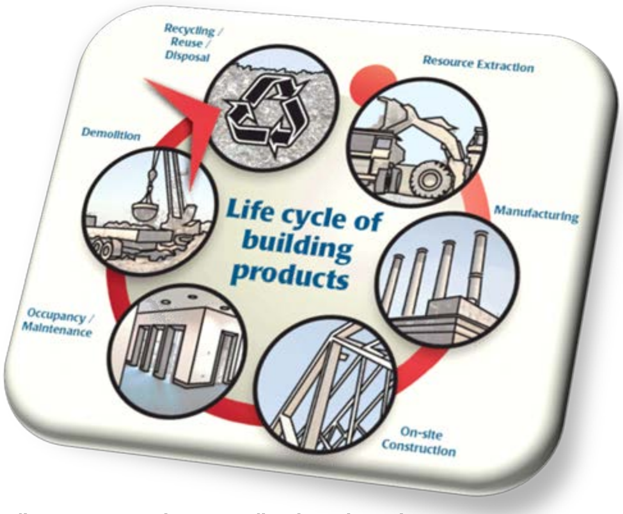
– **The only North American specific software tool that evaluates whole buildings and assemblies based on internationally recognized LCA methodology**

– **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

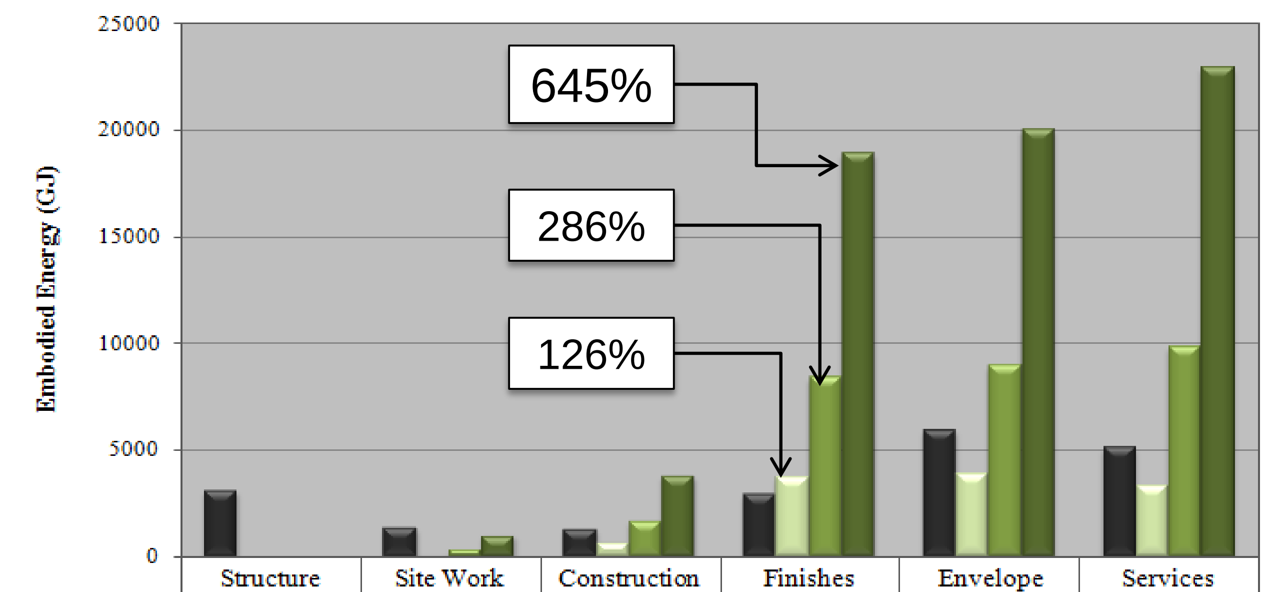


Source: The ATHENA Institute *http://www.athenasmi.org/tools/impactEstimator/index.html*

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

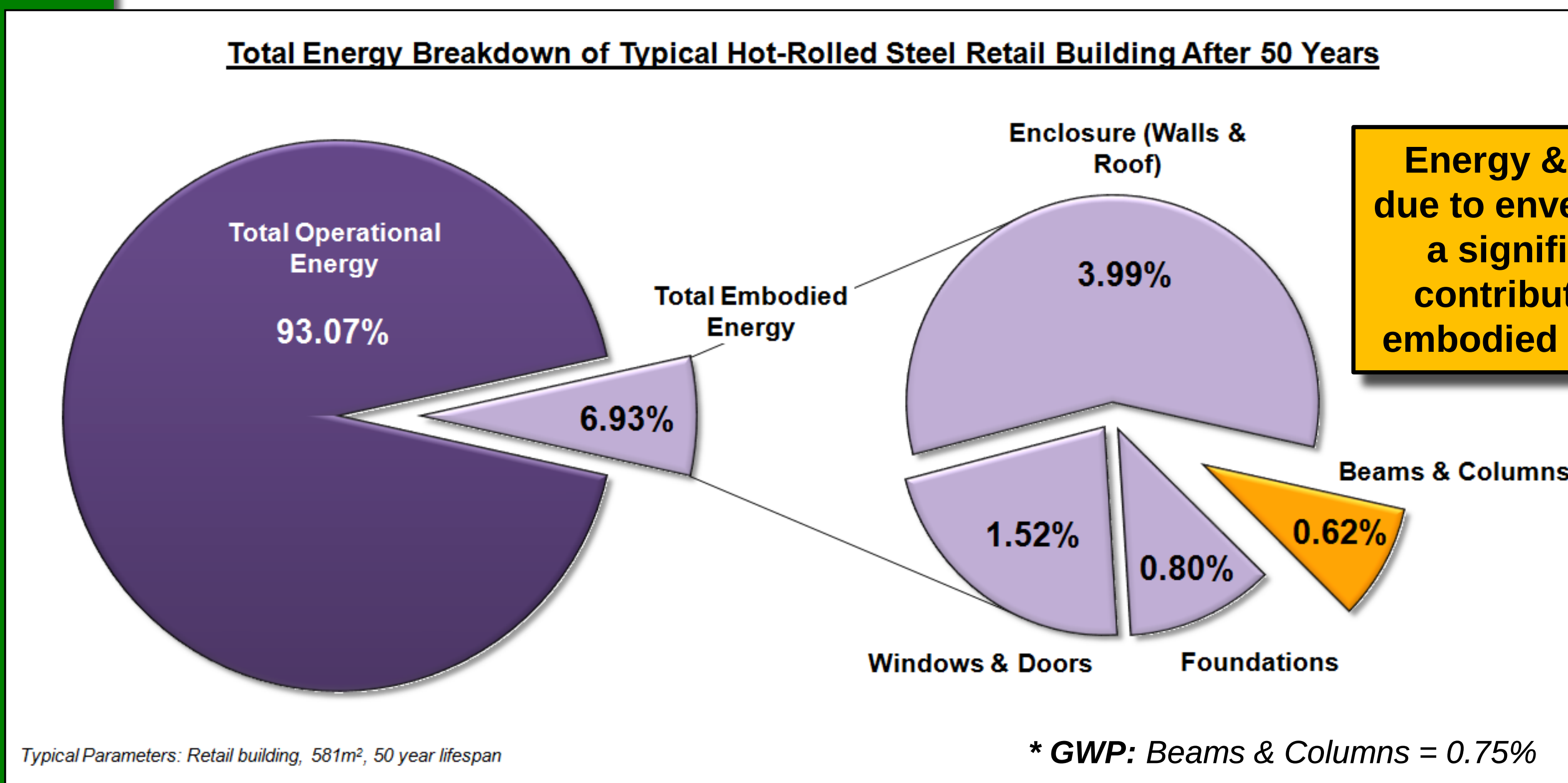


	Structure	Site Work	Construction	Finishes	Envelope	Services
Initial	3088	1344	1289	2935	5935	5110
25 Years	0	65	658	3696	3873	3338
50 Years	0	358	1653	8397	8943	9859
100 Years	0	1001	3777	18936	20060	22955

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)

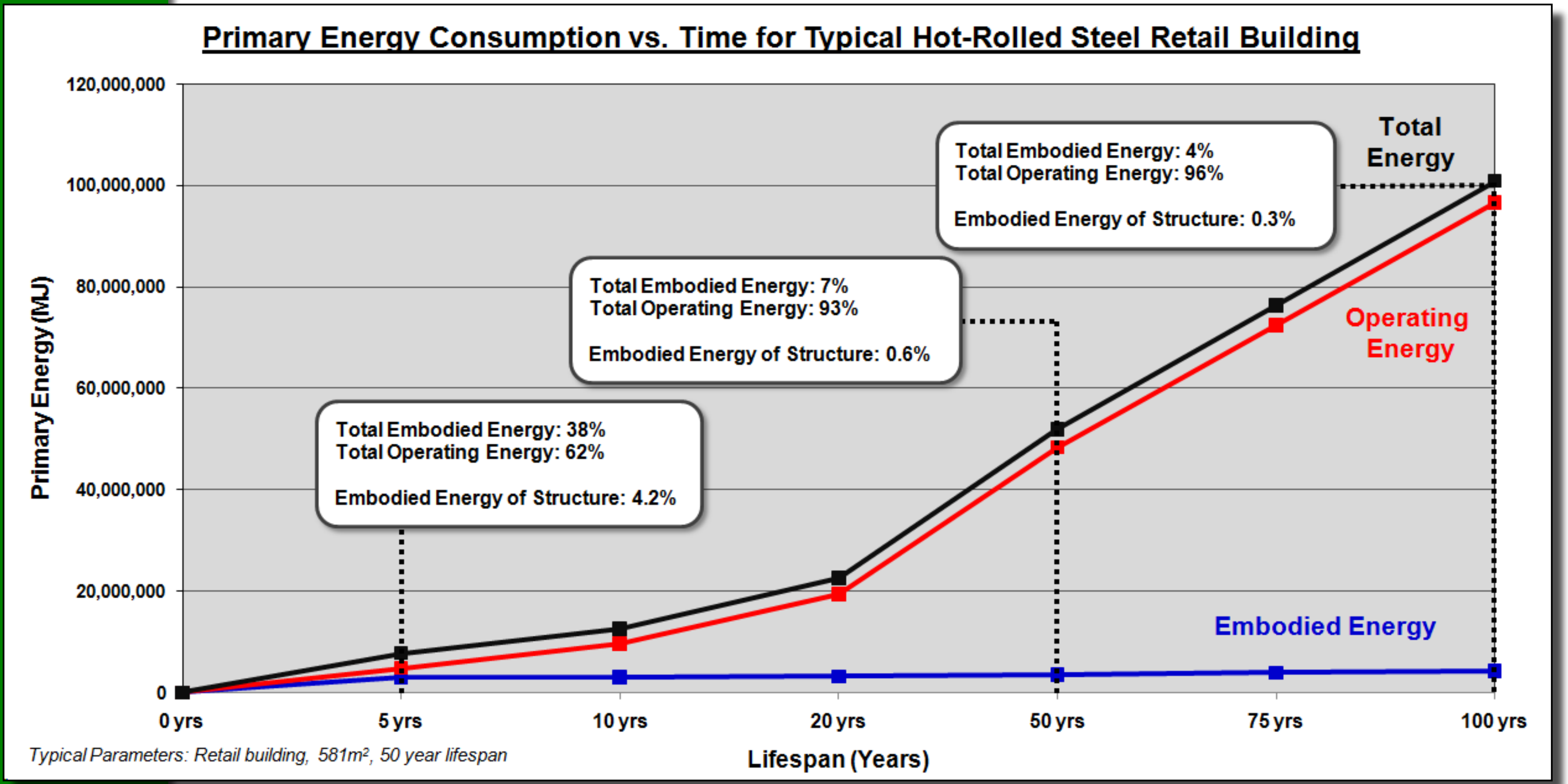


Energy & GWP due to envelope is a significant contributor to embodied energy

www.cn-sbs.cssbi.ca

Orders of Environmental Impact

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



Source: Kevin Van Ooteghem

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**

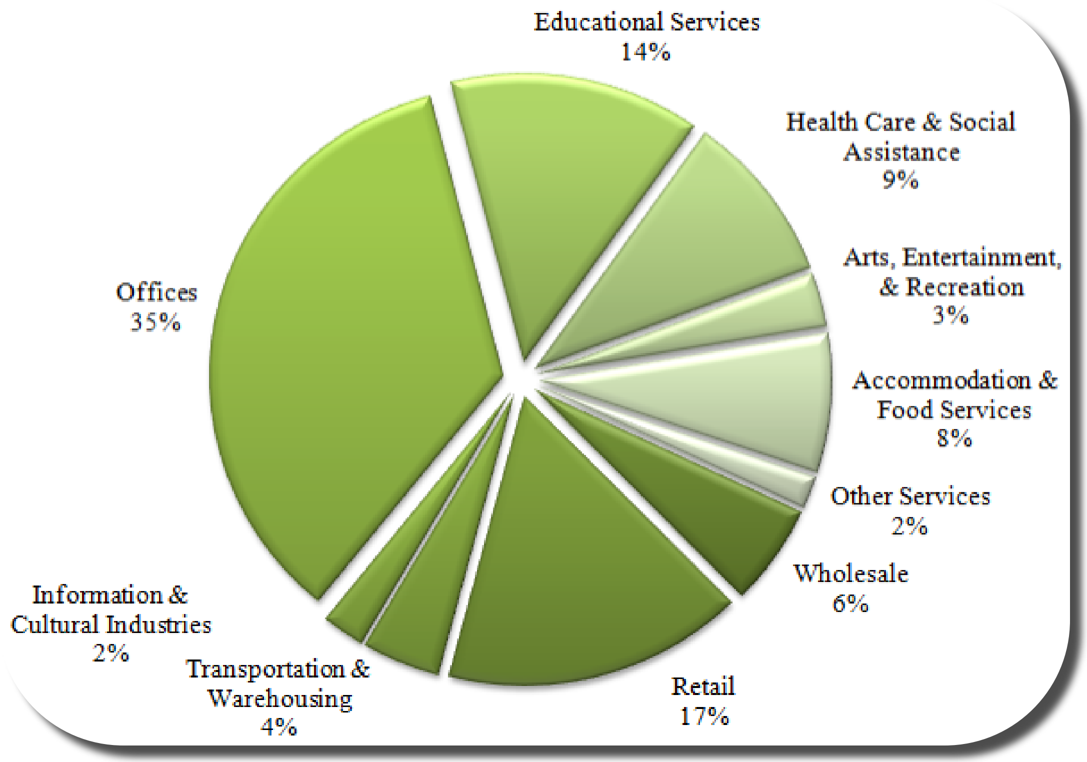
- **Cradle to Cradle concepts**

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

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.

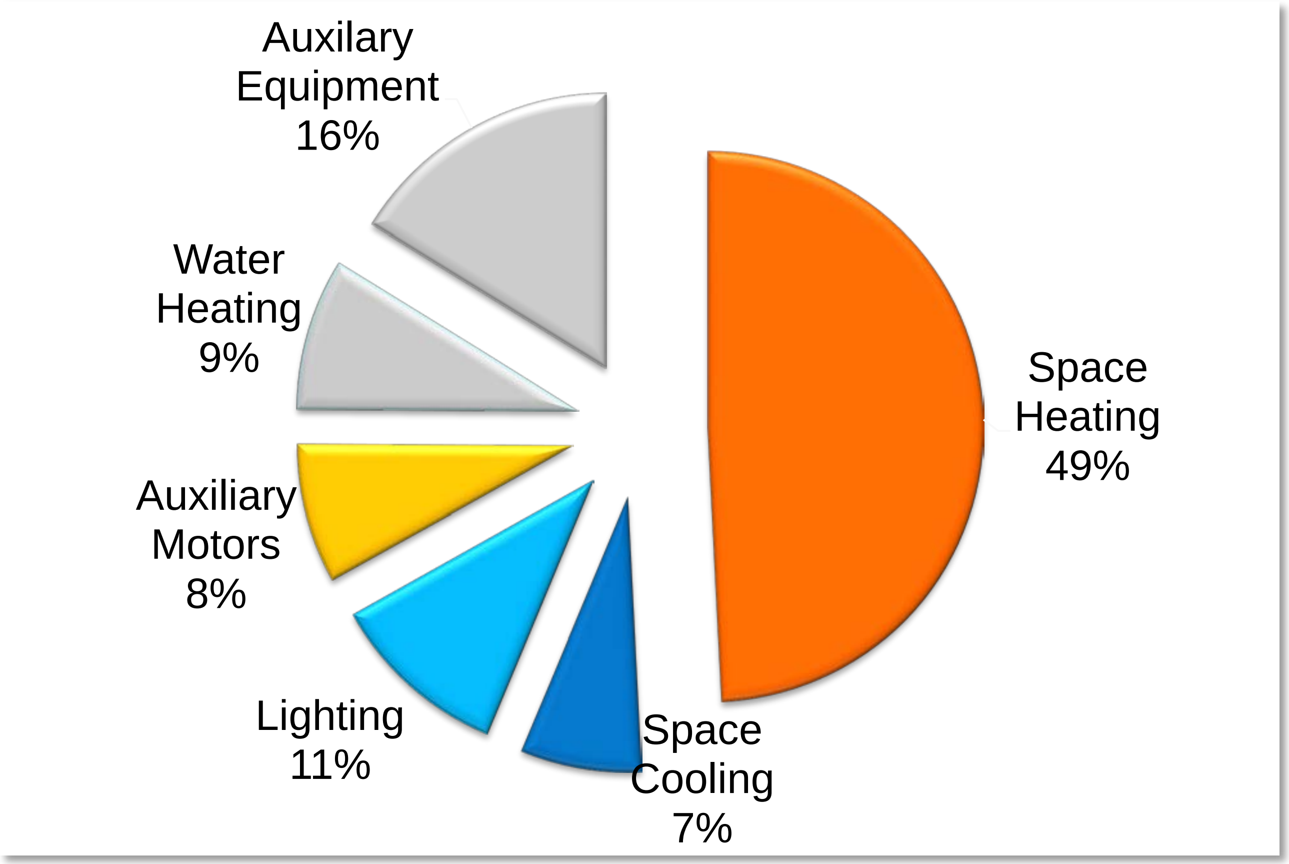
Total Commercial/Institutional Secondary Energy Use by Activity Type in Canada (2006)



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

REDUCING OPERATING ENERGY

Three 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 Mechanical Electrical and Plumbing 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.)

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

CONTROL STRATEGIES		CONDUCTION	CONVECTION	RADIATION	EVAPORATION	
WINTER	PROMOTE GAIN			Promote solar gain		HEATING
WINTER	RESIST LOSS	Minimize conductive heat flow	Minimize external air flow Minimize infiltration			HEATING
SUMMER	RESIST GAIN	Minimize conductive heat flow	Minimize infiltration	Minimize solar gain		COOLING
SUMMER	PROMOTE LOSS	Promote earth cooling	Promote ventilation	Promote radiant cooling	Promote evaporative cooling	COOLING
	HEAT SOURCES		Atmosphere	Sun		
	HEAT SINKS	Earth	Atmosphere	Sky	Atmosphere	

Strategies of Climate Control

(chart modeled after Watson "Climatic Building Design")

Carbon Reduction: The Tier Approach

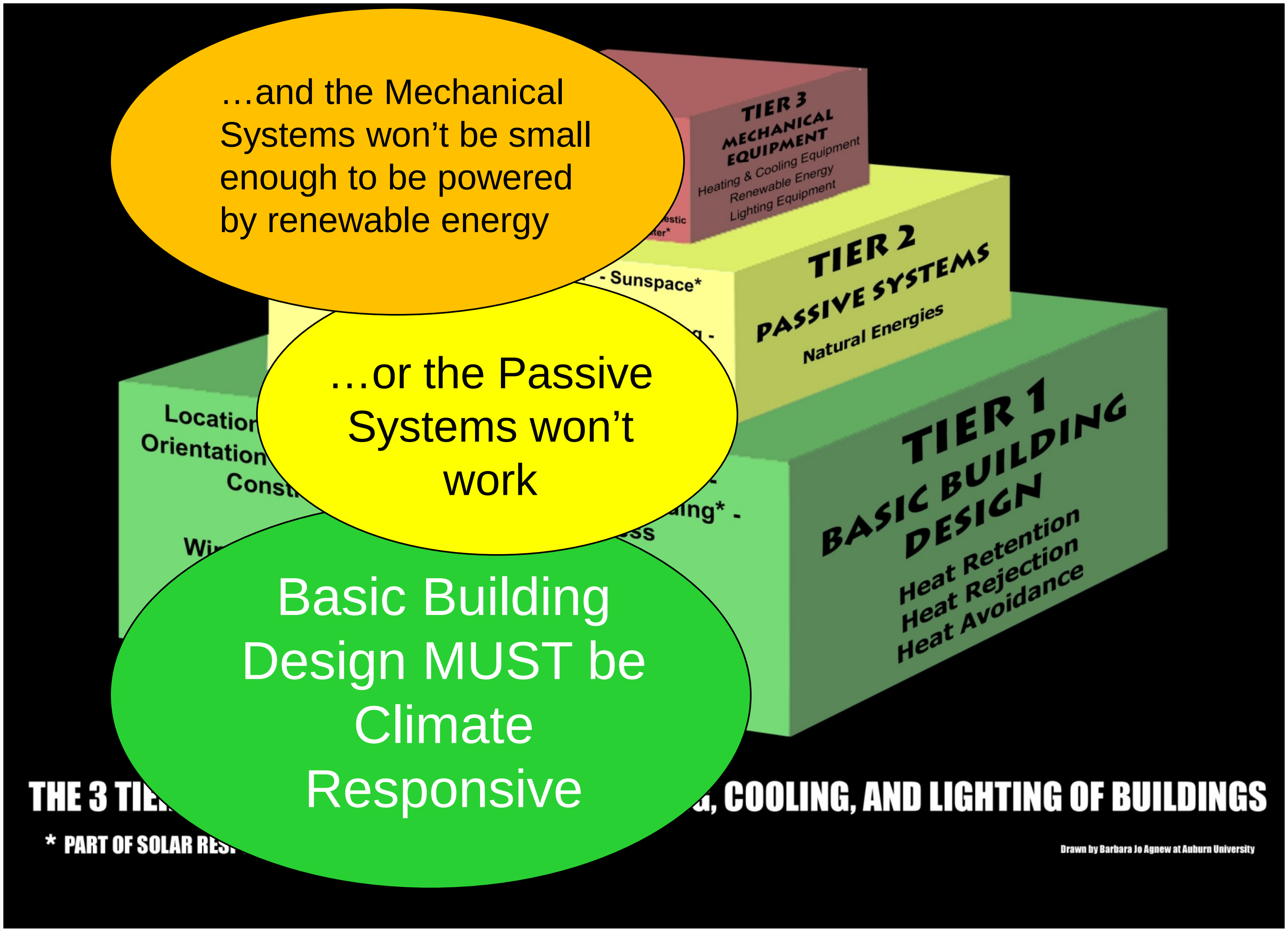
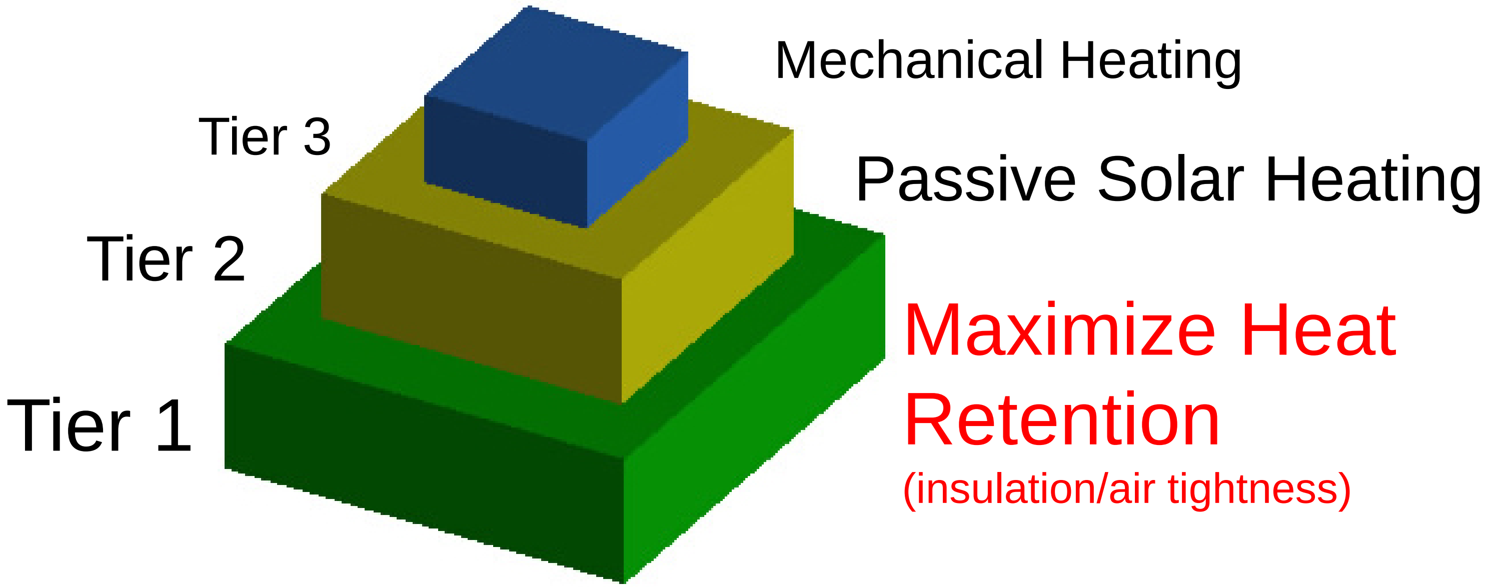


Image: Norbert Lechner, "Heating, Cooling, Lighting"

Reduce loads: Passive Strategies

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

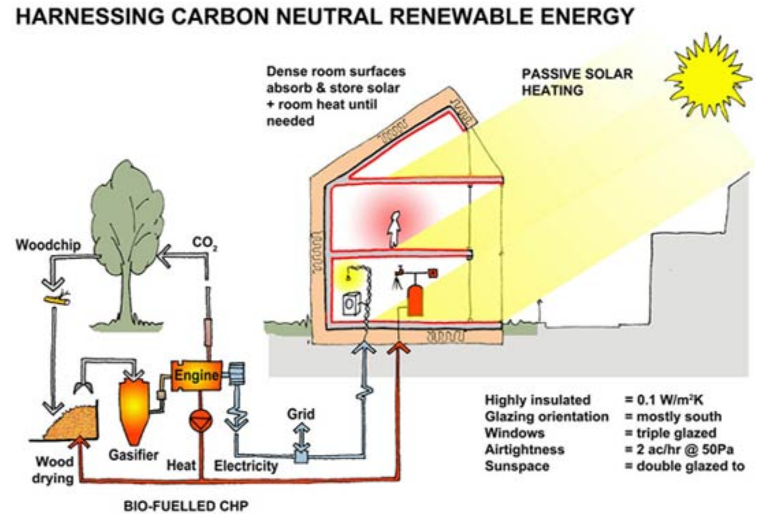


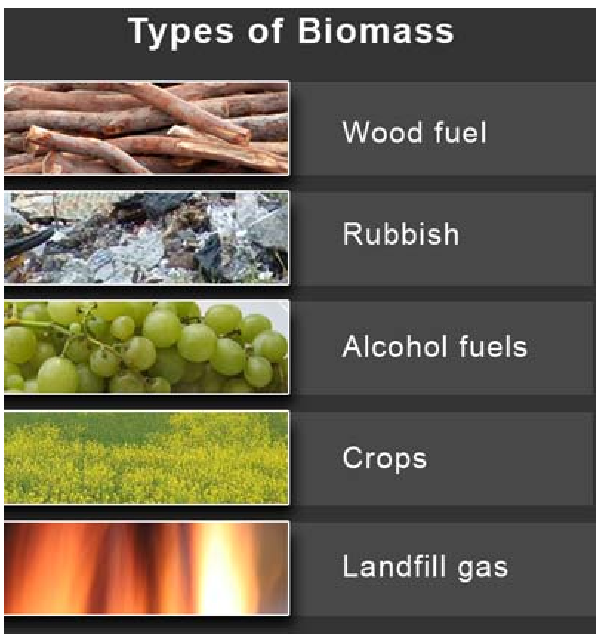
First reduce the overall energy required, then maximize the amount of energy required for mechanical heating that comes from renewable sources.

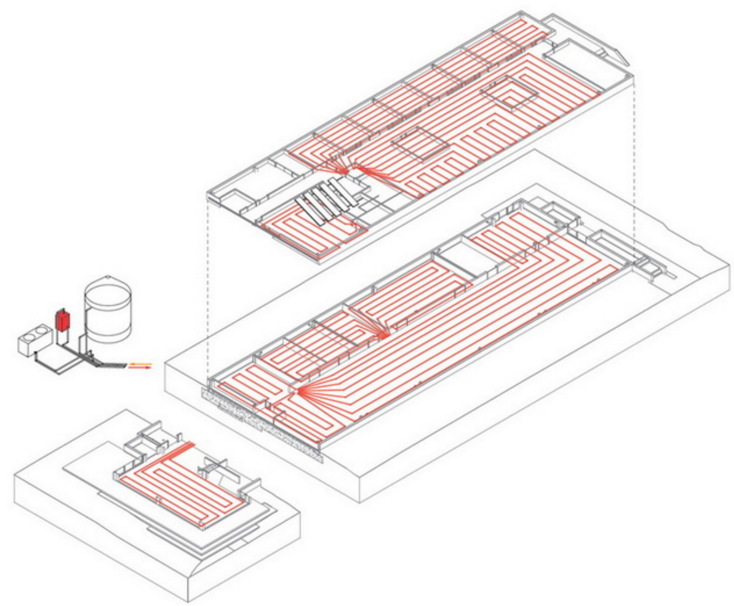
Source: Lechner. Heating, Cooling, Lighting.

Passive Heating Strategies:
Use Renewables for Additional Heating

- Combined heat and power
- Biomass
- Geo exchange systems
- Radiant heating systems
- Verify carbon status of source

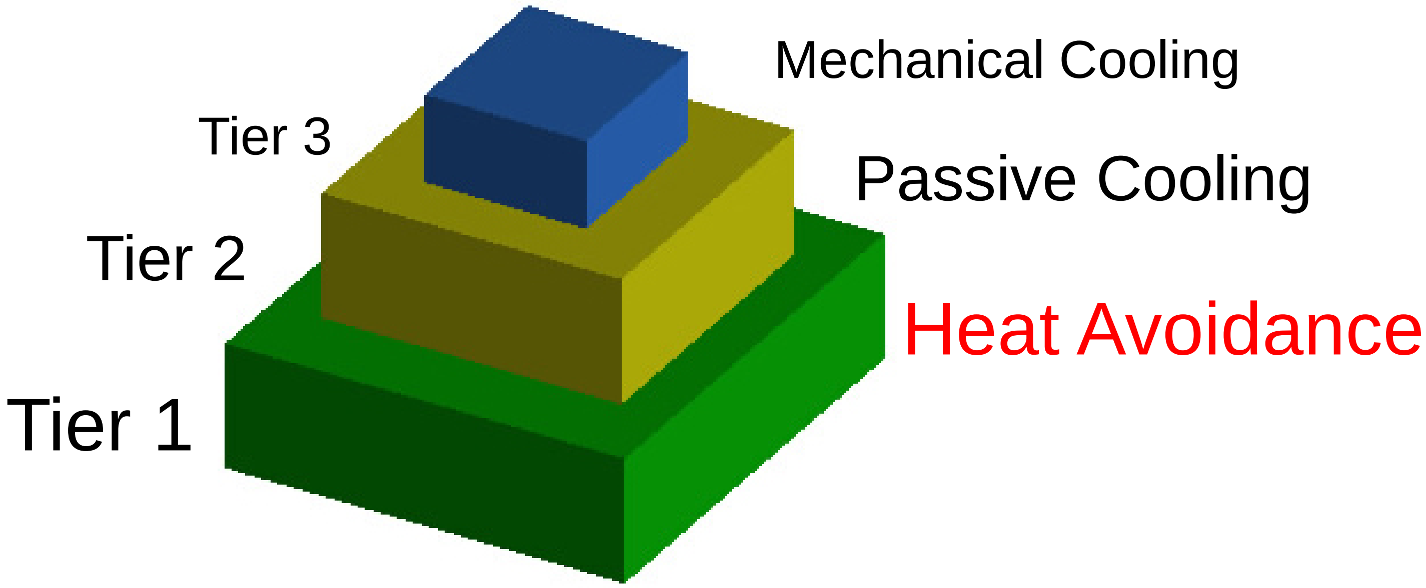






Reduce loads: Passive Strategies

The tiered approach to reducing carbon for COOLING:

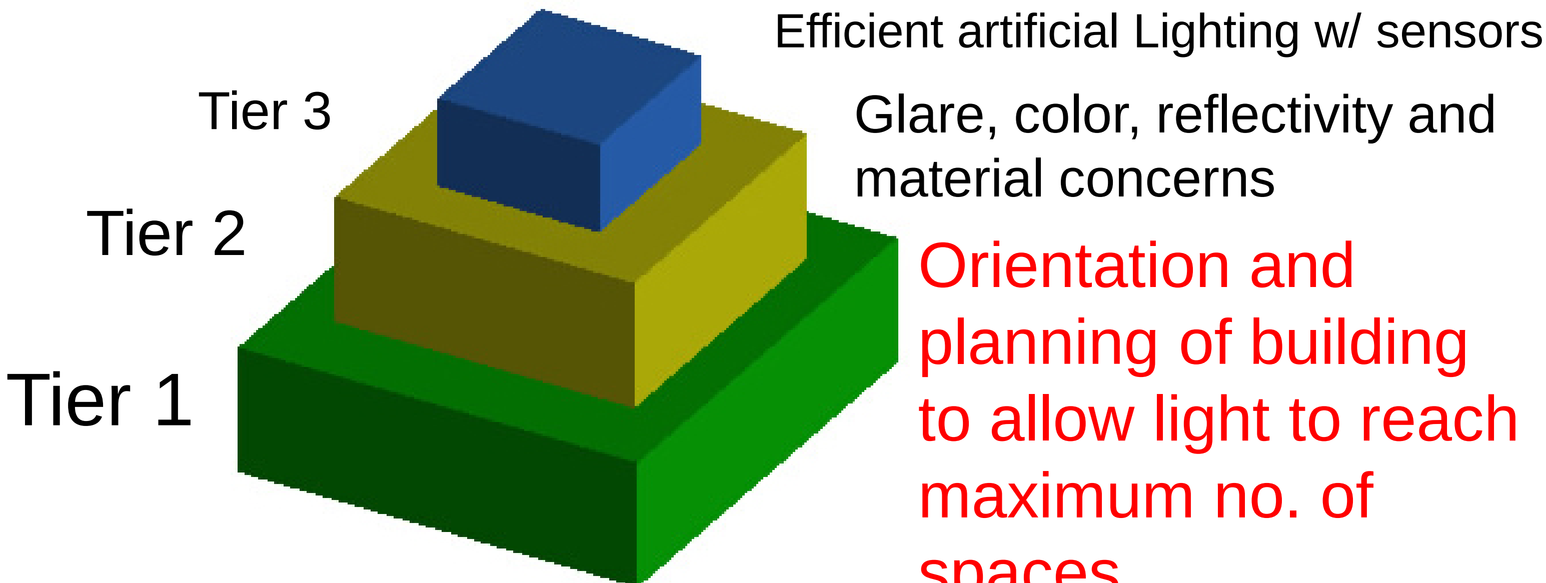


Maximize the amount of energy required for mechanical cooling that comes from renewable sources.

Source: Lechner. Heating, Cooling, Lighting.

Reduce loads: Daylighting

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

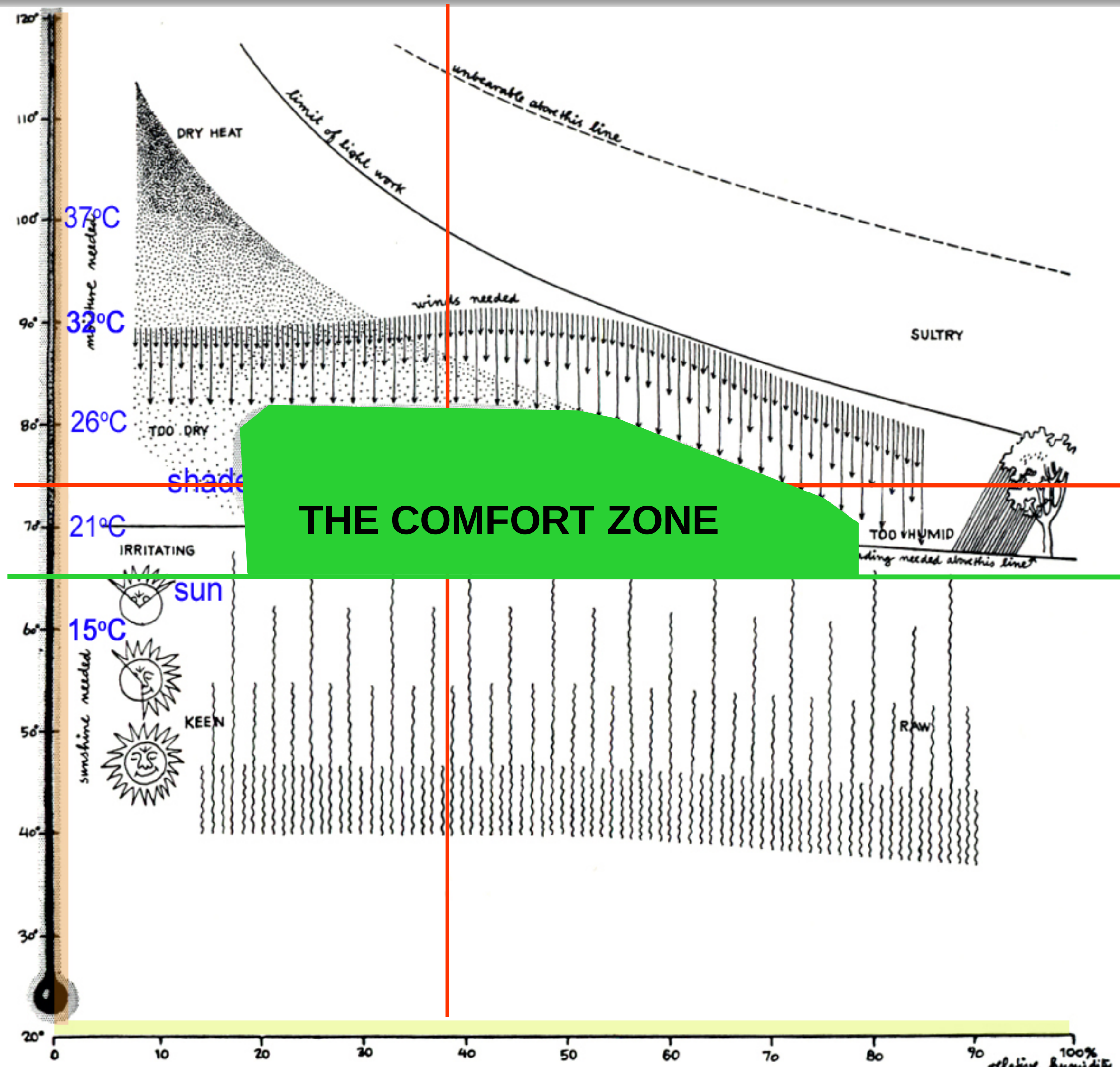


Use energy efficient fixtures!

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

Source: 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:

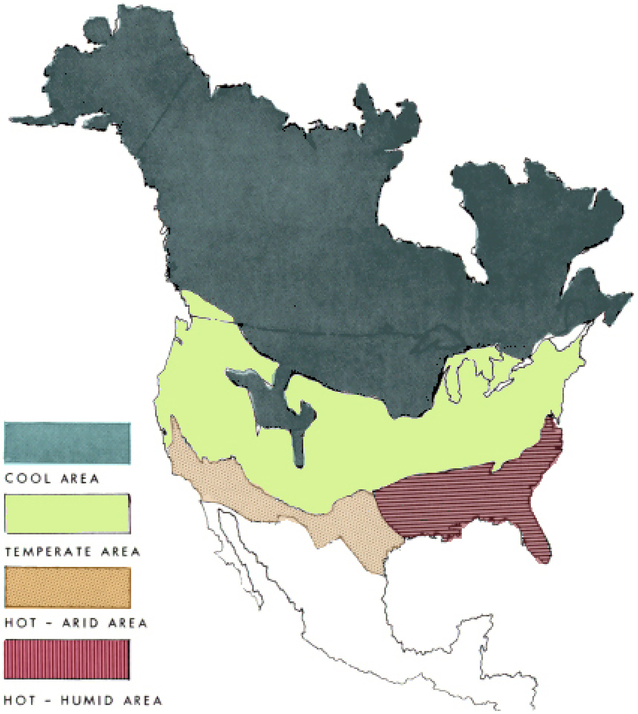
Design must first acknowledge regional, local and microclimate impacts on the building and site.

COLD

TEMPERATE

HOT-ARID

HOT-HUMID

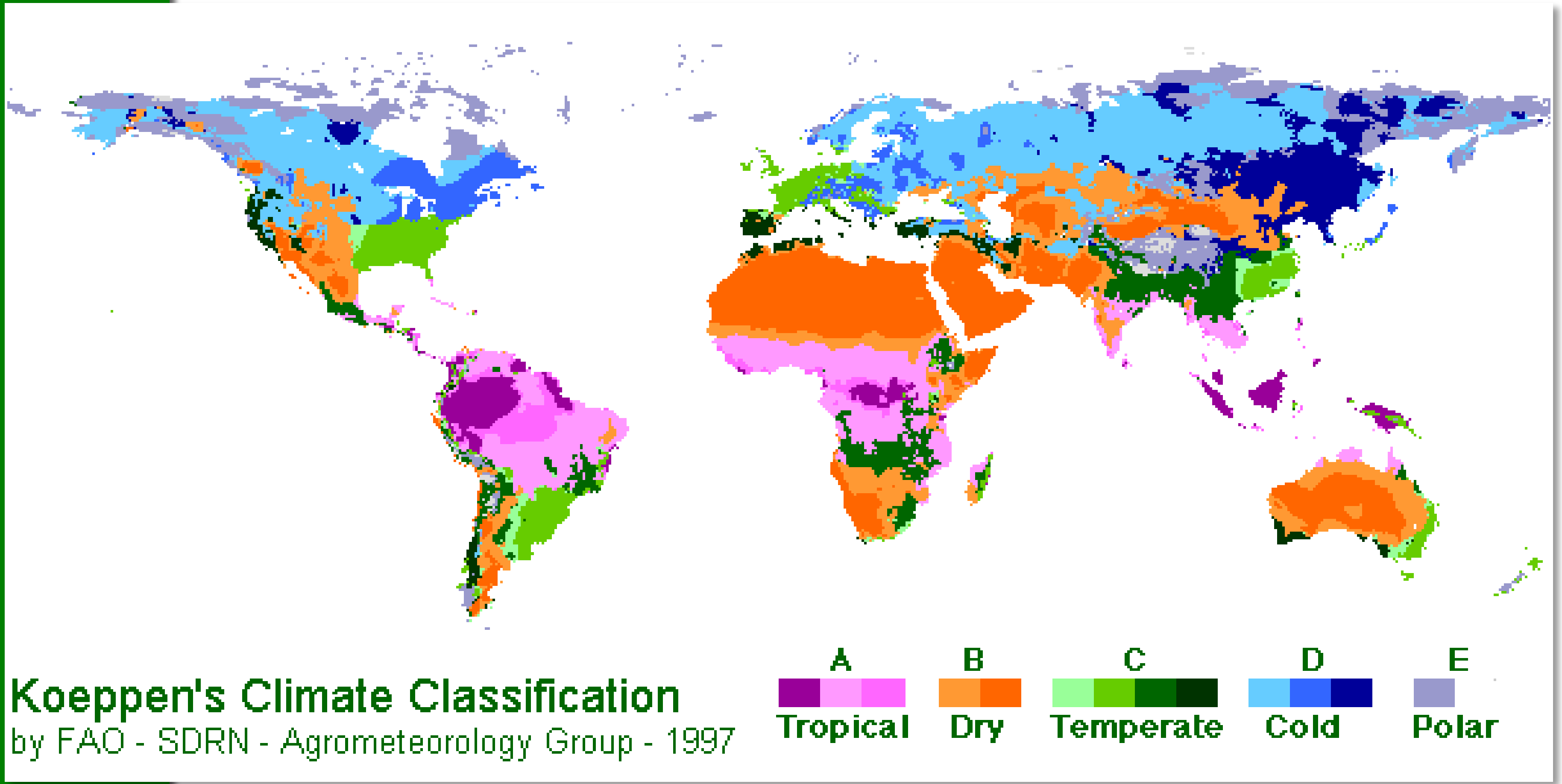


11. Regional climate zones of the North American continent.

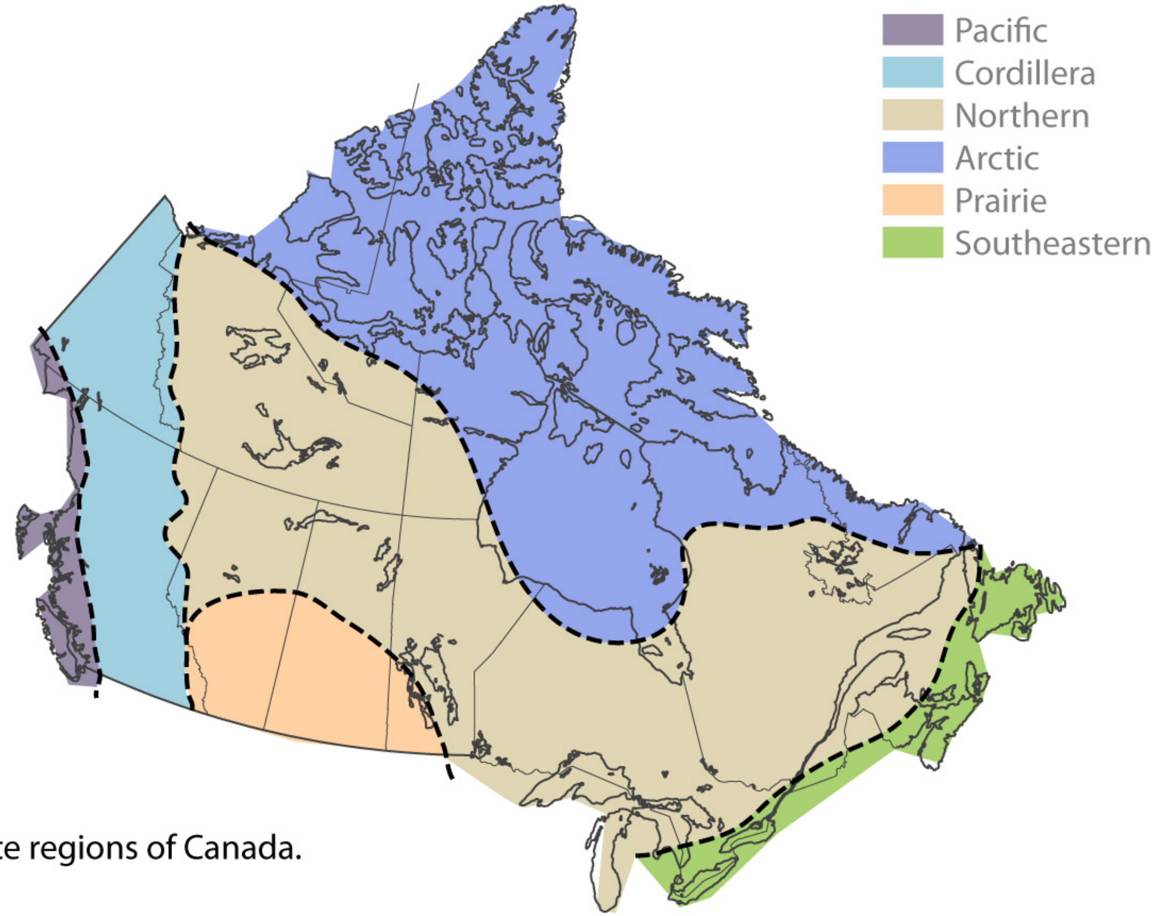
Image: 1963 “Design With Climate”, Victor Olgyay.

Global Bio-climatic Design:

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



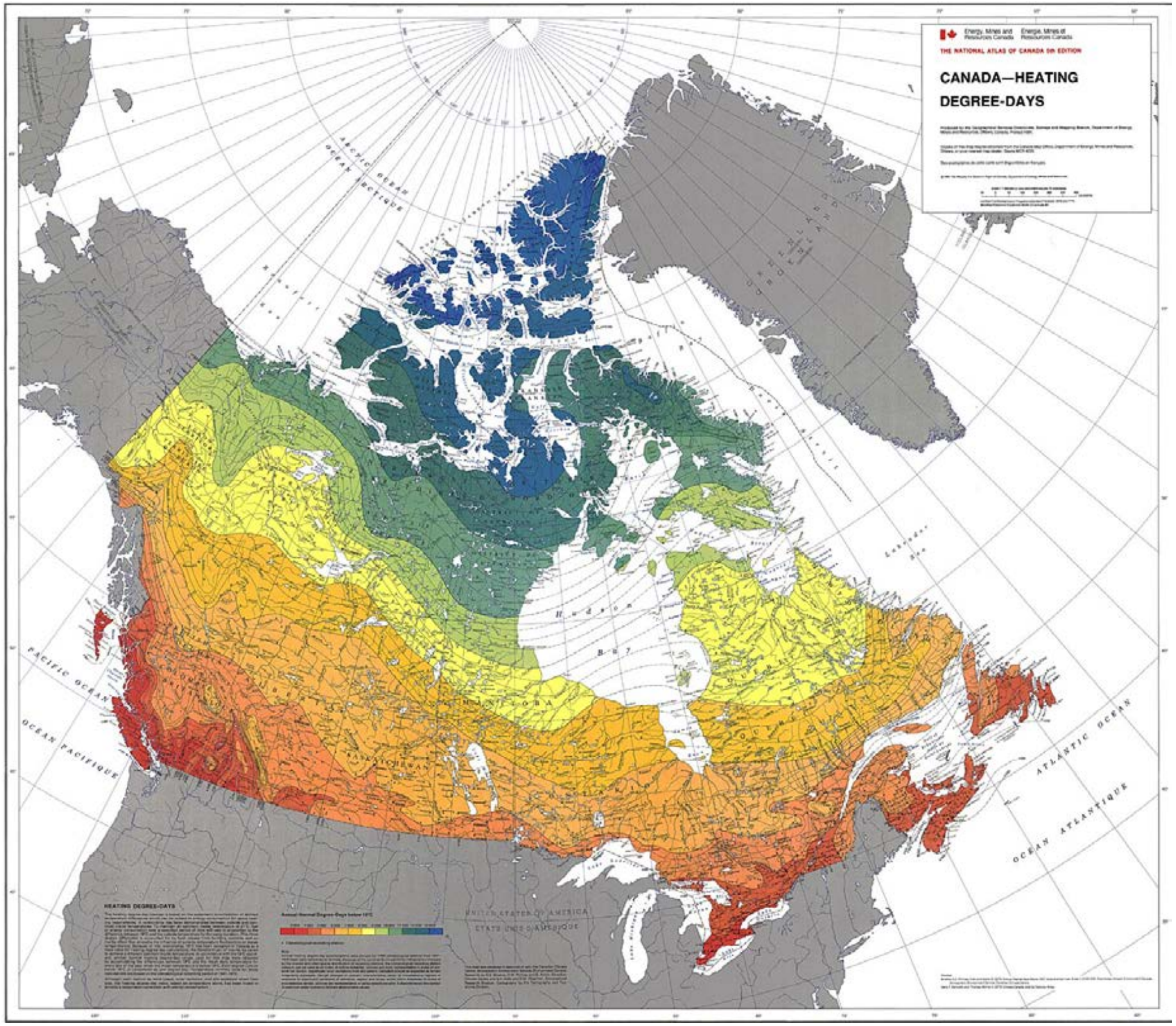
The climate regions of Canada



Climate regions of Canada.

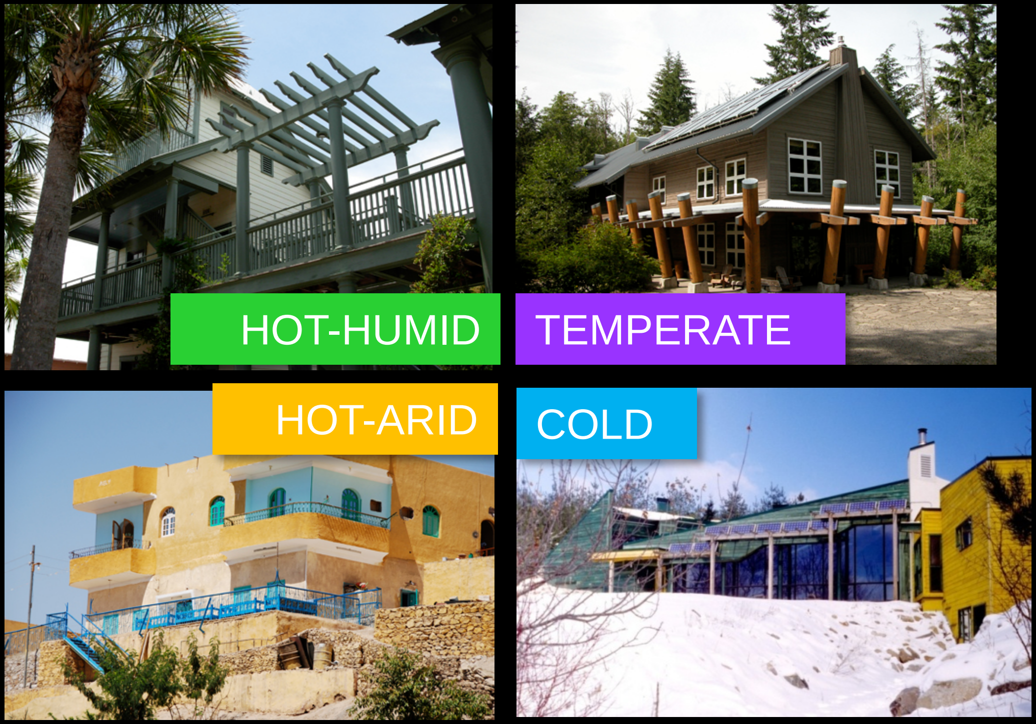
Even within Canada, there exist variations in climate, enough to require very different envelope design practices and regulations. This mostly concerns insulation and water penetration, as well as humidity concerns.

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.**

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

House in Seaside, Florida

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.**

IslandWood Residence, Seattle, WA

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

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

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 reasonably eliminate, focus on local offset projects

Net impact reduction of the project!

source: www.buildcarbonneutral.org

The Importance of Impact Reduction:

If the **impact** of the building is NOT reduced, it may be *impossible* to reduce the CO_2 to zero. Because:

Site and location matter.

- **Design for bio-regional site and climate**
- **Orientation for passive heating, cooling and daylighting**
- Brownfield or conserved ecosystem?
- Urban, suburban or rural?
- Ability to restore or regenerate ecosystems
- All determine *potential* for carbon sequestration on site

7 Impacts source: www.buildcarbonneutral.org

The buildings at IslandWood are located with a “solar meadow” to their south to take advantage of solar heating and daylighting.

Disturbance is impact.

- Protect existing soil and vegetation
- Design foundations to minimize impact
- Minimize moving of soil
- Disturbance changes existing ecosystems, natural habitats and changes water flow and absorption
- Disturbed soil releases carbon
- Disturbance can kill trees, lowering site potential for carbon reduction
- Look at the potential for reusing materials on site

Difficult foundations for a treed, sloped site for the Grand House Student Cooperative in Cambridge, Ontario, Canada

Natural ecosystems sequester carbon.

- Carbon is naturally stored below ground and is released when soil is disturbed

- Proper treatment of the landscape can keep this carbon in place *(sequestration)*

- Proper treatment of the landscape can be designed to store/accumulate/sequester more carbon over time

- Verify landscape design type with your *eco-region* – use of indigenous plant material requires less maintenance/water – healthy plants absorb more CO_2

- Possible to use the natural ecosystems on your site to assist in lowering the carbon footprint of your project

The natural site is preserved at IslandWood, Bainbridge Island.

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

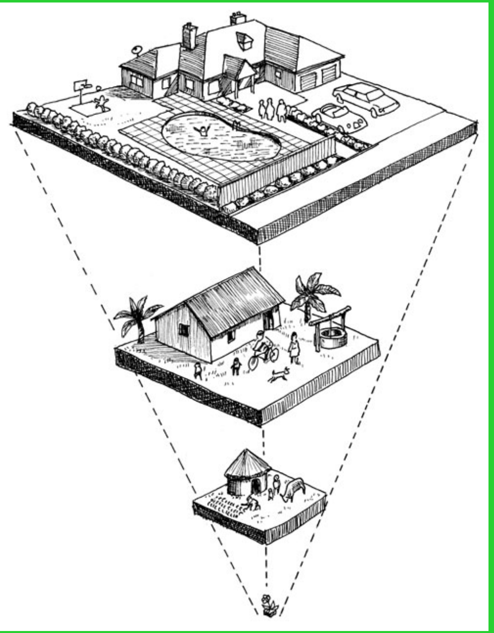
- How is the space to be used?

- 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

Buildings can help to sequester carbon.

- The materials that you choose can help to reduce your carbon footprint.

- Wood from certified renewable sources, wood harvested from your property, or wood salvaged from demolition and saved from the landfill can often be considered net carbon sinks.

- Planting new trees can help to compensate for the carbon released during essential material transport

- Incorporating *green roofs* and *living walls* can assist in carbon sequestration

Green roof at White Rock Operations Center, White Rock, B.C.

Green roof at Vancouver Public Library

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)?*

Note: many of these concerns are similar to what you might already be looking at in LEED™

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.

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

Towards Zero Energy \ Zero Carbon:

LEED^{TM} Gold

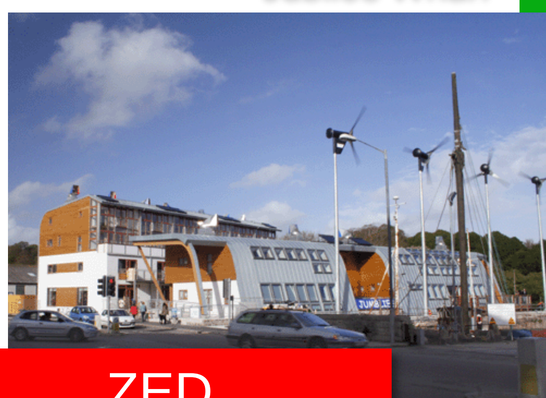
IslandWood

Early ZED

BEDZed

case studies

Jubilee Wharf



ZED

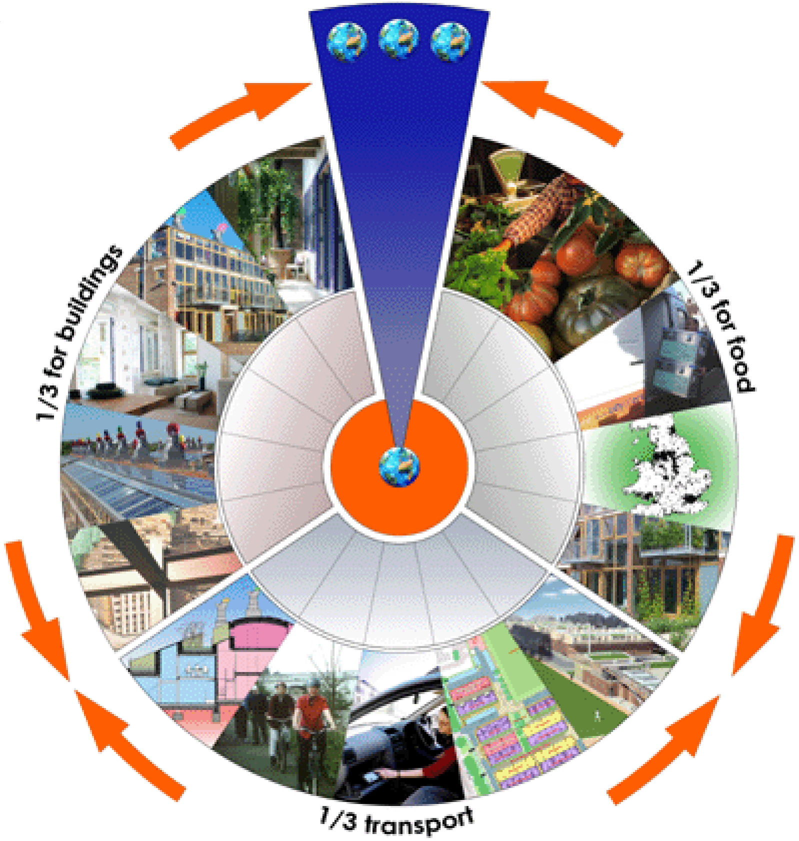
Aldo Leopold Legacy Center

Carbon Neutral

The ZEDfactory Philosophy…

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

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



Current, unsustainable UK consumption

Image credit: ZEDfactory

BedZED:
Beddington Zero Energy Development

BedZED, Hackbridge, England, was created as a partnership with the BioRegional Development Group, the Peabody Trust, Bill Dunster Architects, Arup, and Gardiner and Theobald. The 82 houses, 17 apartments, and 1,405 m^2 of workspace were built between 2000-02. An example of early ZED design.

Climate: temperate, inland

BedZED:
Beddington Zero Energy Development

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

• ORIENTATION

• very high environmental standards

• high thermal insulation levels

• triple glazed windows

• sunlight / daylighting

• solar energy (direct gain + PV)

• reduction of energy consumption

• natural ventilation

• waste water recycling

• strong emphasis on roof gardens

• built from natural, recycled, or reclaimed materials

• reduction in parking – pedestrian oriented

• re-allocation of site/use distribution for community's best interests

BedZED: Then goes for Zero Energy….
Density and General Site Strategies

#1.

The development uses a higher density than typical.

#2.

This separates parking from housing.

#3.

And consolidates significant green space.

BedZED:
Alternative Parking/Car Strategies

#1.

Designed to encourage alternatives to car use.

#2.

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

#3.

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

#4.

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

BedZED:
Landscape and Vegetation

#1.

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

#2.

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

#3.

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

#4.

Vegetable and edible crops are encouraged.

BedZED:
Passive Solar Strategies

#1.

Uses passive solar techniques to maximize heat gain for cool months

#2.

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

#3.

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

BedZED:
Passive Cooling Strategies

#1.

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

#2.

Large quantities of operable windows encourage natural ventilation.

#3.

PV is used to shade windows.

#4.

Wind cowls direct ventilation flow.

No A/C is provided.

BedZED:
Non-fossil fuel heating for space and water

Once needs have been reduced passively…

#1.

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

#2.

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

The target was for zero fossil fuel use.

BedZED:
Material choices

#1.

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

#2.

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

#3.

Recycled materials and high recycled content were key.

75 year minimum target design life.

BedZED:
Generation of on Site Electricity

#1.

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

#2.

PV panels were targeted at fueling electric vehicles.

#3.

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

Excess electricity is sold back to the grid.

BedZED:
Water Systems

Water use is carefully planned…

#1.

Rainwater is collected and used for irrigation and toilet flushing.

#2.

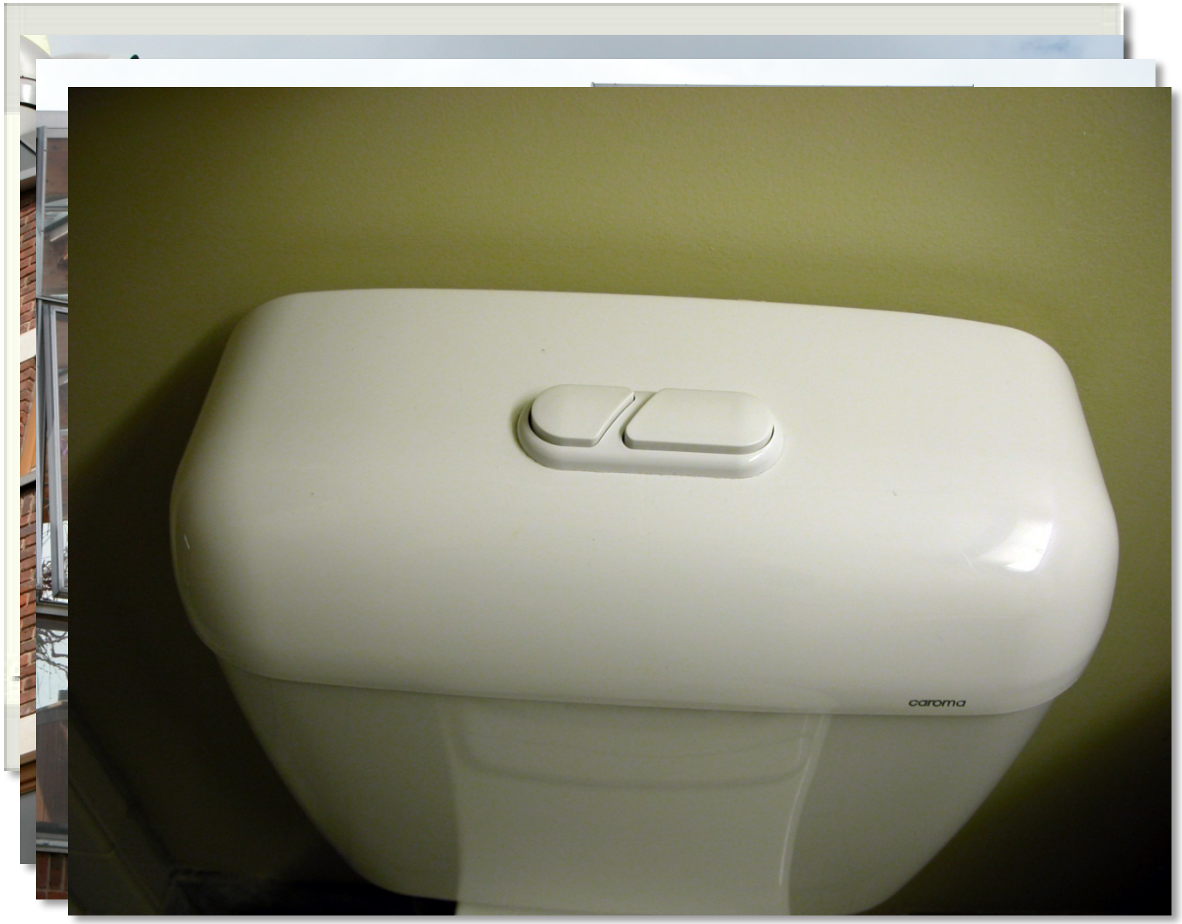
Black water is treated on site and cycled into the irrigation system.

#3.

Dual flush toilets reduce water consumption.

#4.

Shaped bathtubs reduce water requirement.



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

BedZED:
Waste Recycling

#1.

Waste recycling collection depots are located throughout the community.

#2.

Kitchens are outfitted with built in recycling storage.

#3.

On site composting.

The target was to reduce landfill waste by 66%.

BedZED:
Integrated Design Process

KEY WORKING CONCEPT:

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

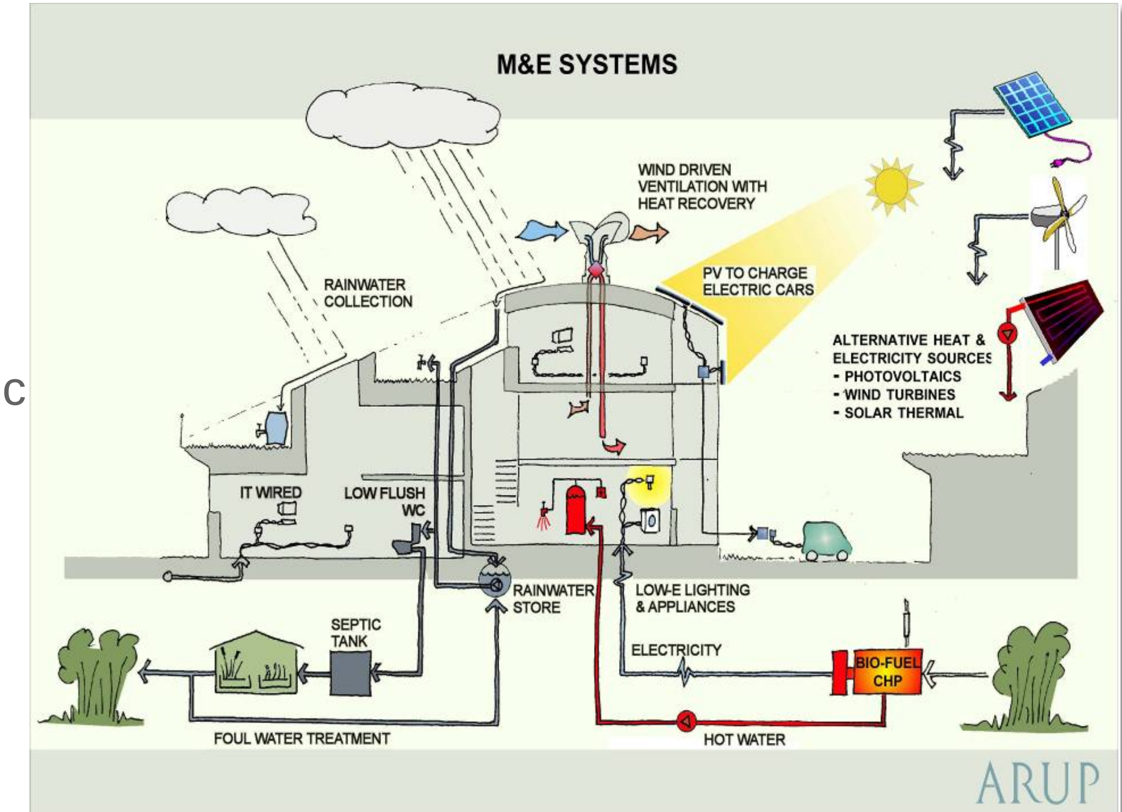


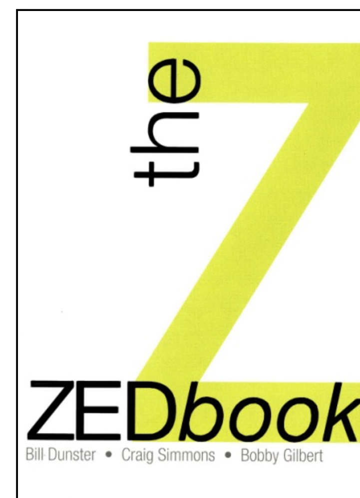
Image credit: ARUP and Dunster

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

The ZEDfactory Philosophy…

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

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



Jubilee Wharf: ZEDfactory

GROUND FLOOR PLAN

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

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

Jubilee Wharf:
Integrated Design Process

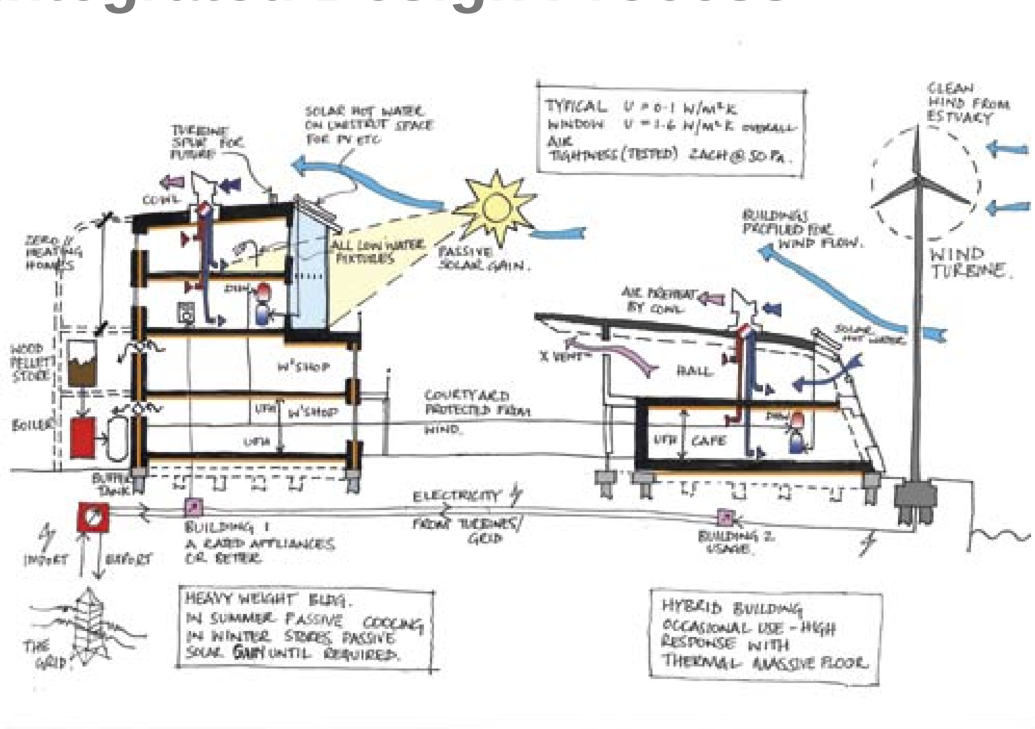


Image credit: ZEDfactory

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

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

Jubilee Wharf:

Key Strategies List | Site and Community

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

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

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

Jubilee Wharf:
Key Strategies List | Envelope

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

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

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

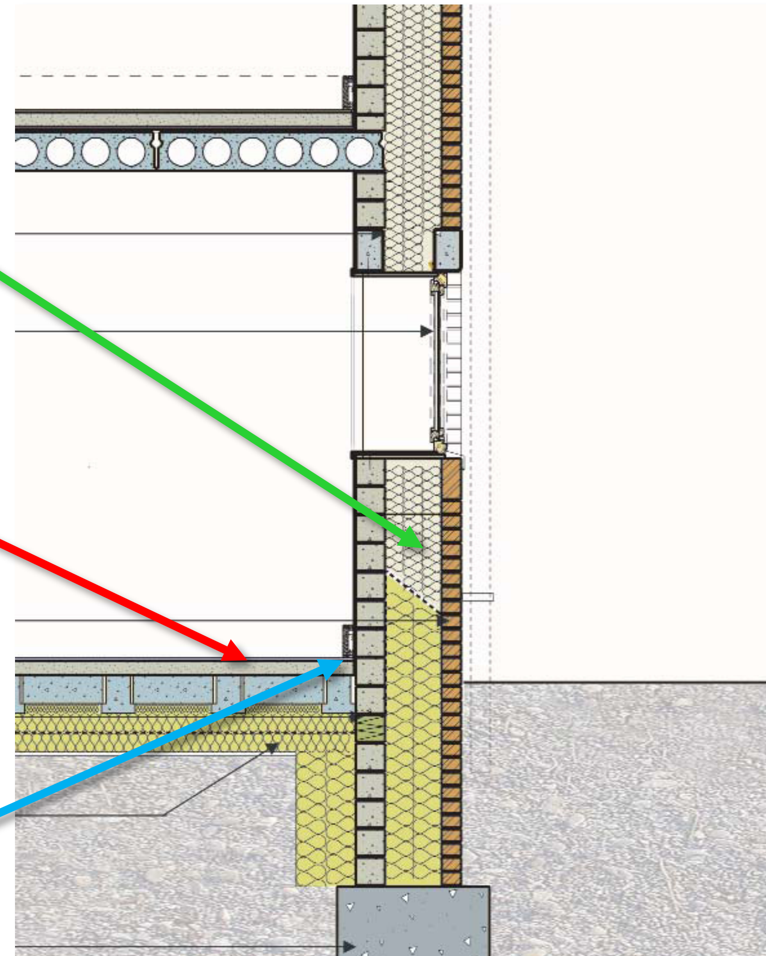


Image credit: ZEDfactory

Jubilee Wharf:

Key Strategies List | Reclaimed Materials

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

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

Image credit: ZEDfactory

Jubilee Wharf:
Key Strategies List | Healthy Materials

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

Jubilee Wharf:

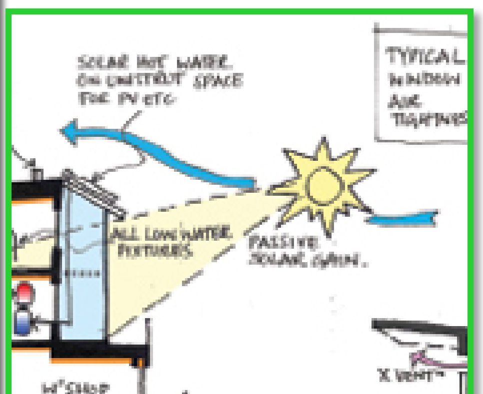
Key Strategies List | Energy and Systems

Passive solar heating –

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

Daylighting –

Window placement makes use of natural light.



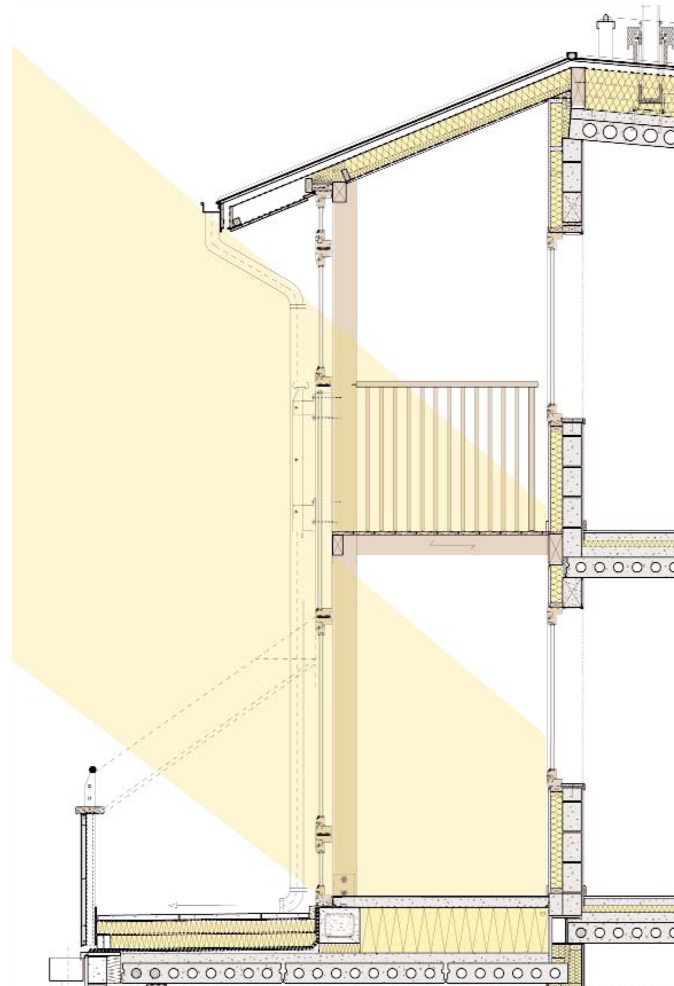


Image credits: ZEDfactory

Jubilee Wharf:
Key Strategies List | Energy and Systems

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

Being passive it uses no electricity.

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

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

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

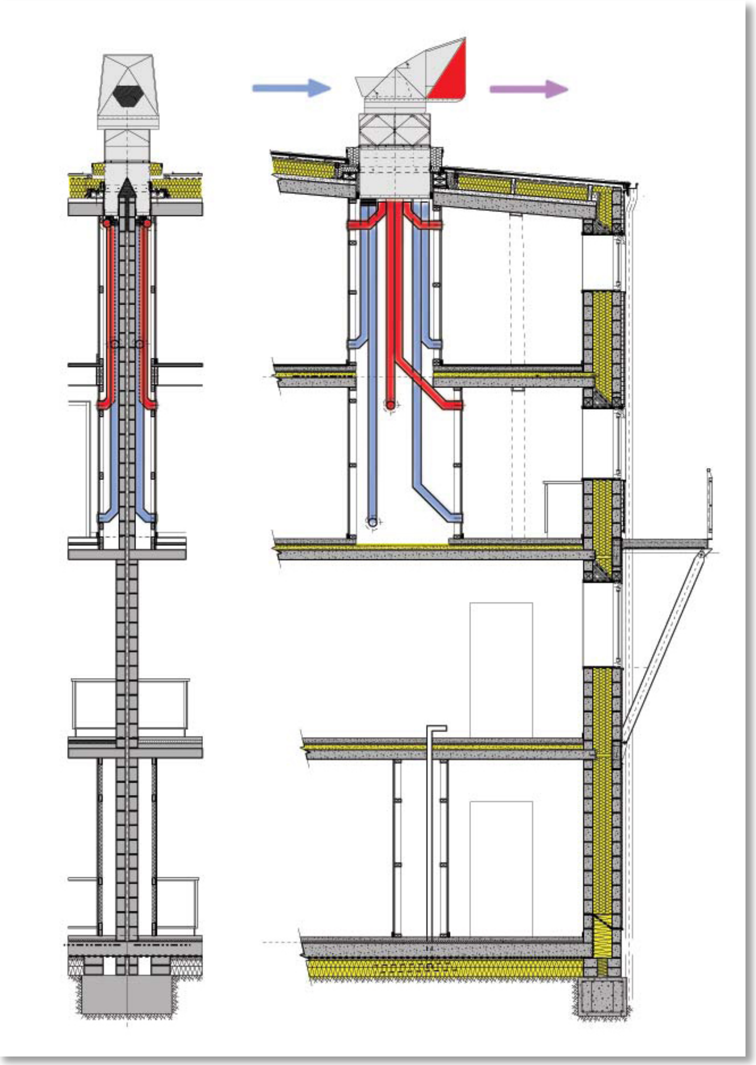
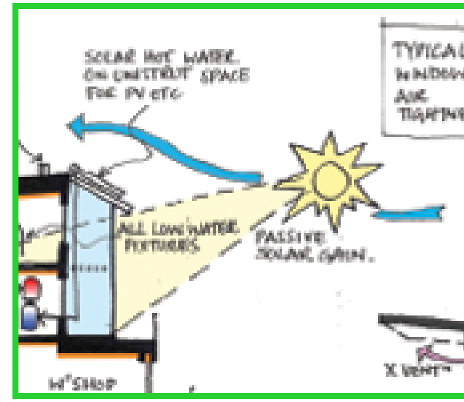


Image credit: ZEDfactory

Jubilee Wharf:

Key Strategies List | Energy and Systems



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

Photovoltaics –

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

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

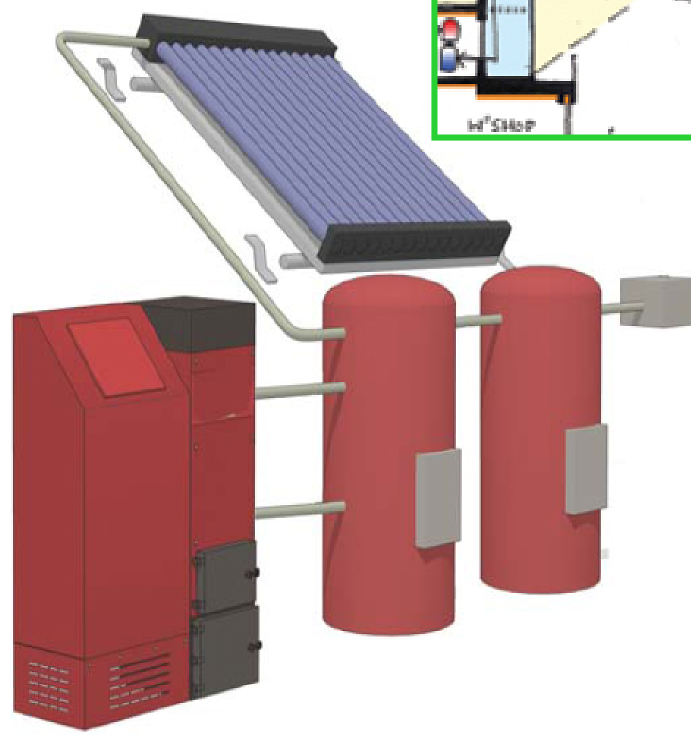


Image credits: ZEDfactory

Jubilee Wharf:

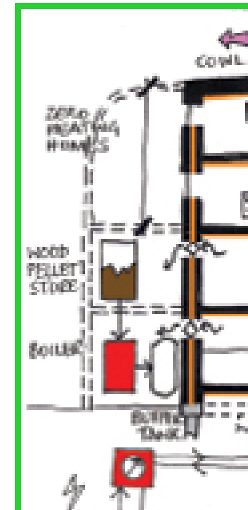
Key Strategies List | Energy and Systems

Biomass heating –

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

Onsite micro generation –

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



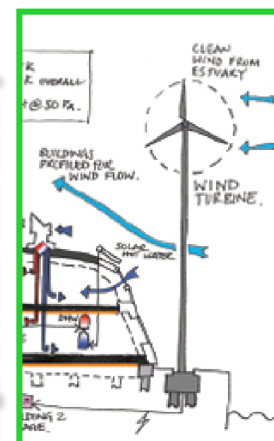


Image credits: ZEDfactory

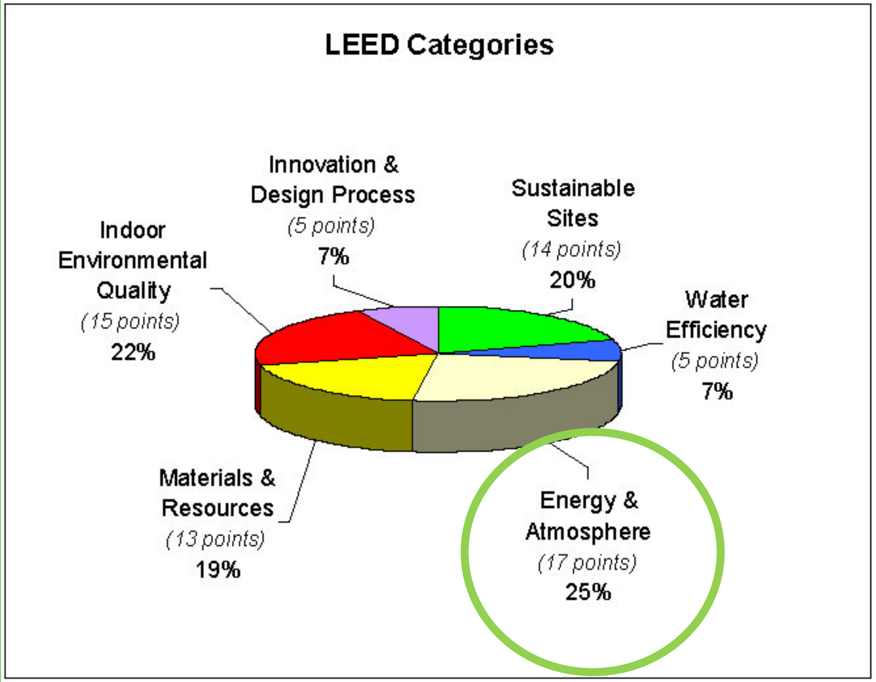
Carbon Neutral – Operating Energy

Comparing Carbon Neutral to LEED™

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

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

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



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

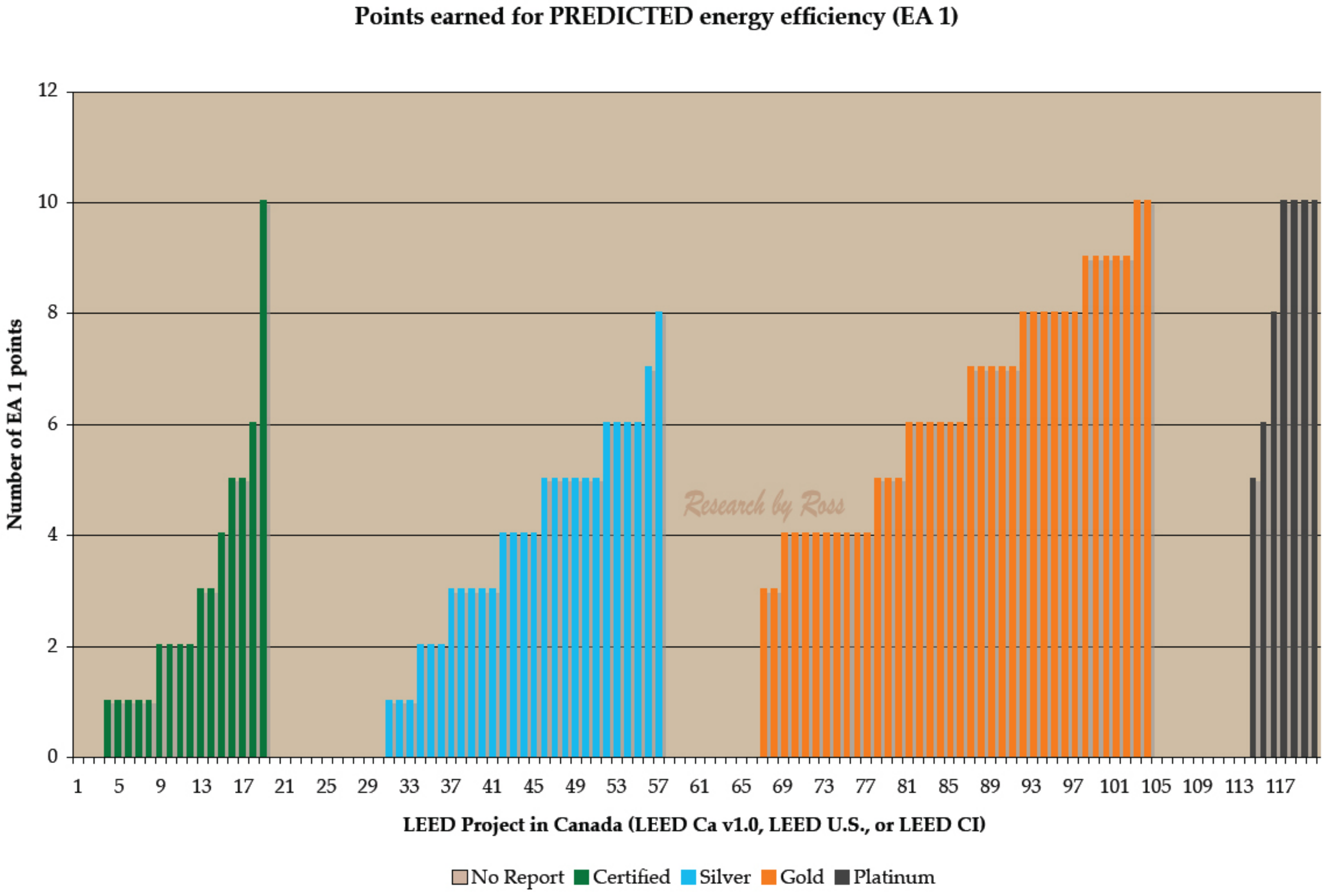
- Most LEED buildings earn less than 5 of these credits…..

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

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

Scorecard for National Works Yard in Vancouver, LEED™ Gold

LEED and Predicted Energy Credits



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

2030 Targets - Commercial

2030 CHALLENGE Targets: National Averages

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

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

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

Reduction over MNECB
kBtu/sf/yr

123	5%
109	10%
96	15%
82	20%
68	25%
61	30%
54	35%
48	40%
41	45%
34	**50%**

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

LEED™ 2009 and Operating Energy

OPTIMIZE ENERGY PERFORMANCE

EA	
NC	Credit 1
CS	Credit 1

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

INTENT

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

REQUIREMENTS: NC & CS

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

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

EITHER

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

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

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

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

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

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

Reduction over MNECB

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

LEED™ 2009 and Operating Energy: ASHRAE 90.1 - 2007

OR

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

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

LEED™ 2009 and Operating Energy: ASHRAE 90.1 - 2007

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

LEED™ 2009 and Renewable Energy

NEW CONSTRUCTION:

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

CORE AND SHELL:

PERCENTAGE RENEWABLE ENERGY	POINTS
0.5%	2
1%	4

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

Towards Zero Energy \ Zero Carbon:

LEED[TM] Gold

IslandWood

Early ZED

BEDZed

case studies

Jubilee Wharf

ZED

Aldo Leopold Legacy Center

Carbon Neutral

IslandWood – Mithun Architects and Planners

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

Team members (too numerous to fully list):

Mithun Architects

KEEN Engineering (Stantec)

Berger Partnership Landscape

Western Sun

2020 Engineering

Browne Engineering

IslandWood – Using the LEED^{TM} System

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

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

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

IslandWood – Sustainable Sites
(9/14 possible points)

SS Prerequisite 1, Erosion & Sedimentation Control

SS Credit 1, Site Selection

SS Credit 4.1, Alternative Transportation, Public Transportation Access

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

SS Credit 4.4, Alternative Transportation, Parking Capacity

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

SS Credit 5.2, Reduced Site Disturbance, Development Footprint

SS Credit 6.2, Stormwater Management, Treatment

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

SS Credit 8, Light Pollution Reduction

Inference of reduced carbon emissions from personal transportation

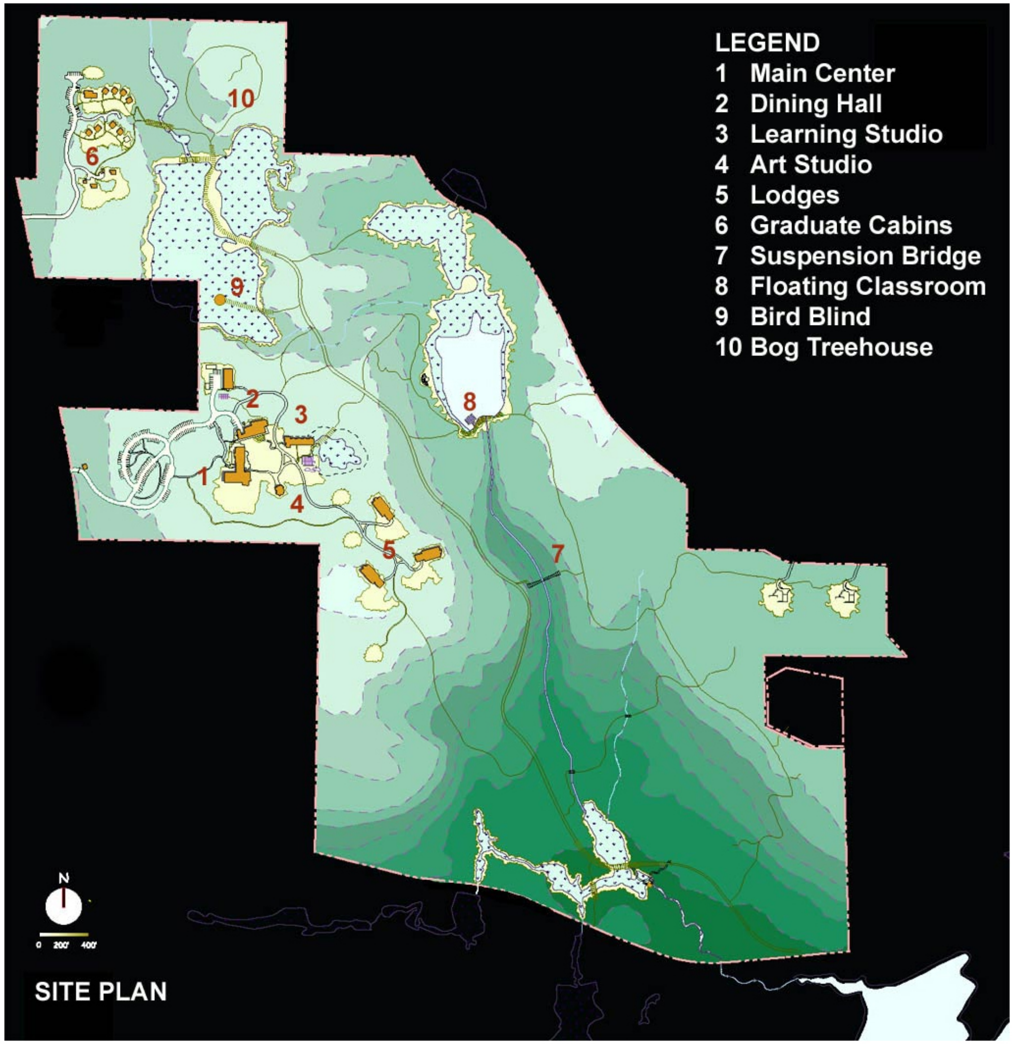
People, "Use" + Transportation

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

Landscape + Site

IslandWood – Sustainable Sites
(9/14 possible points)

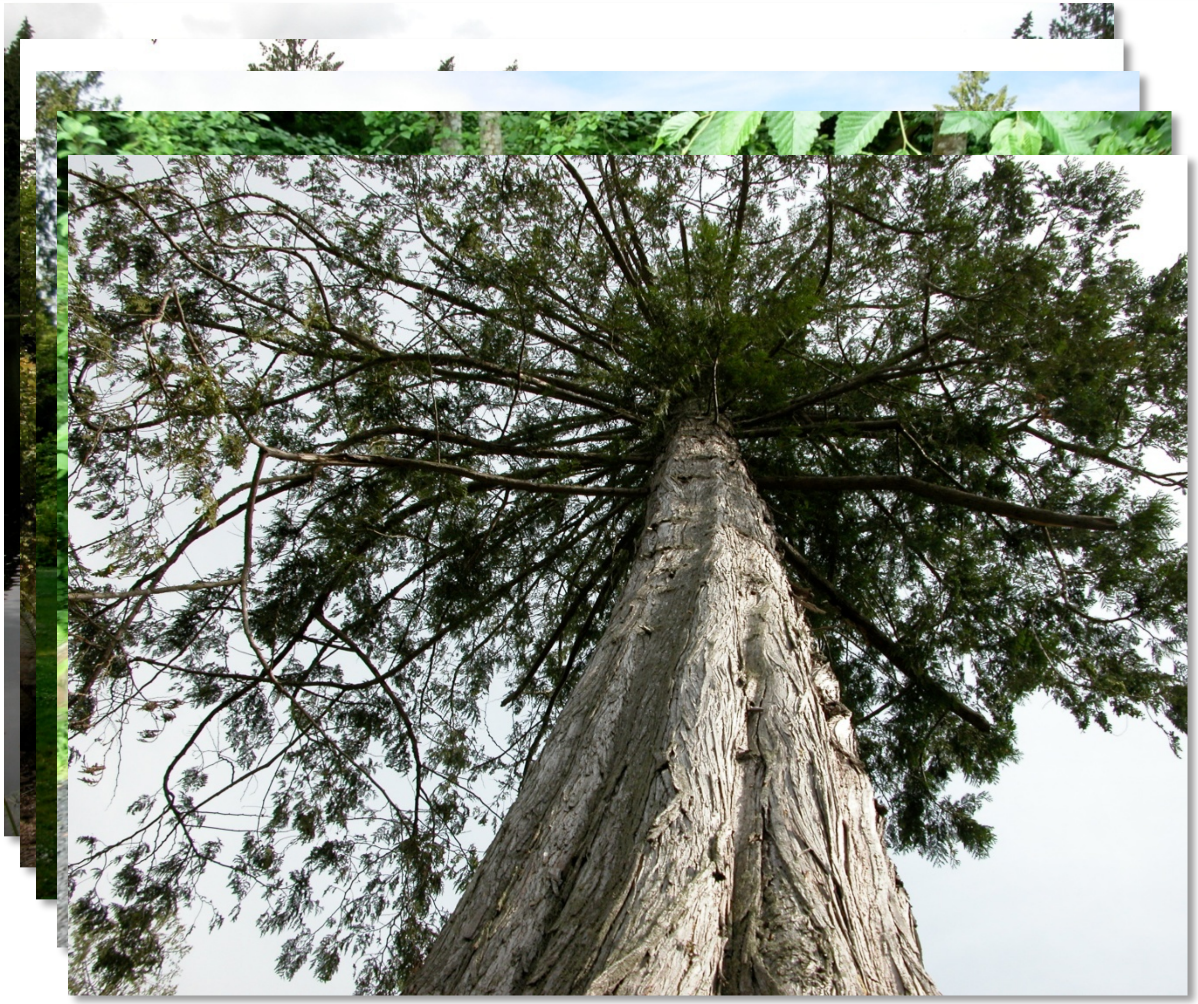
Overview map of the development showing topography and building clustering to ensure the minimum disruption and impact on the land.



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

IslandWood – Sustainable Sites
(9/14 possible points)

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



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

EA Prerequisite 1, Fundamental Building Systems Commissioning

EA Prerequisite 2, Minimum Energy Performance

EA Prerequisite 3, CFC Reduction in HVAC&R Equipment

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

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

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

Operating energy

EA Credit 4, Ozone Depletion

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

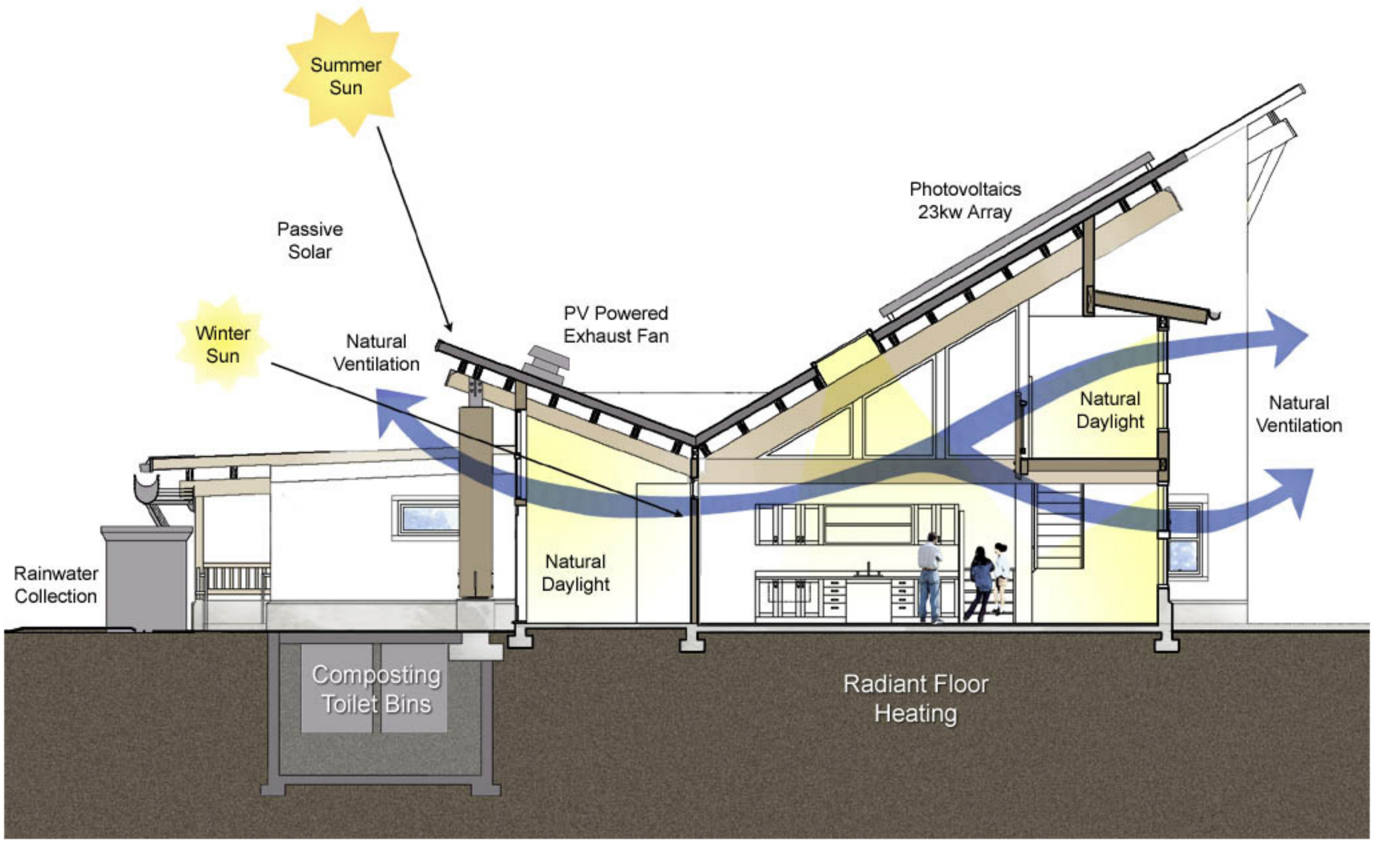
Although there is PV on the building, it is not enough to earn any of these credits, so obviously not enough to satisfy a carbon neutral state

Renewables + Site Generation

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

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

IslandWood –
Passive Design Strategies: Heating and Cooling



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

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

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

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

IslandWood – Water Efficiency
(5/5 possible points)

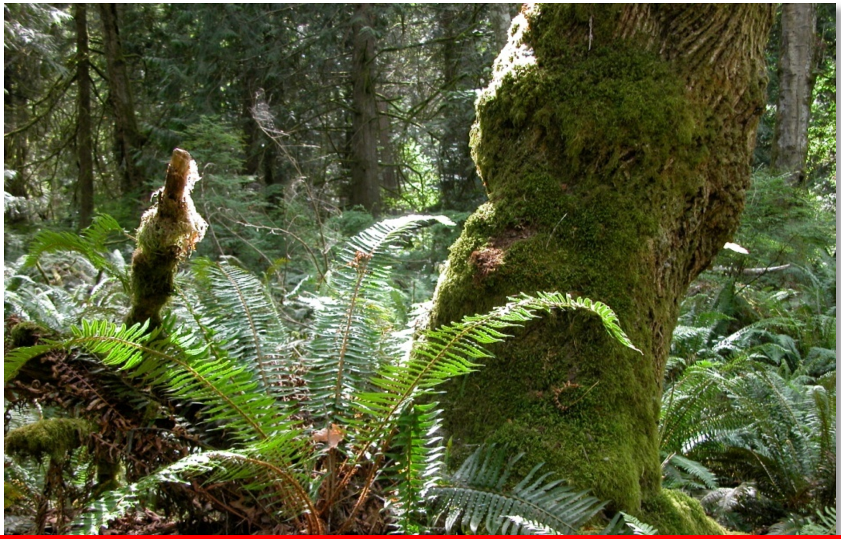
WE Credit 1.1, Water Efficient Landscaping, Reduce by 50%

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

WE Credit 2, Innovative Wastewater Technologies

WE Credit 3.1, Water Use Reduction, 20% Reduction

WE Credit 3.2, Water Use Reduction, 30% Reduction



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

IslandWood – Water Efficiency
(5/5 possible points)

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

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

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

MR Prerequisite 1, Storage & Collection of Recyclables

MR Credit 2.1, Construction Waste Management, Divert 50%

MR Credit 2.2, Construction Waste Management, Divert 75%

MR Credit 3.1, Resource Reuse, Specify 5%

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

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

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

MR Credit 7, Certified Wood

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

Embodied Carbon in Building Materials

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

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

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

EQ Prerequisite 1, Minimum IAQ Performance

EQ Prerequisite 2, Environmental Tobacco Smoke (ETS) Control

EQ Credit 1, Carbon Dioxide (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 7.1, Thermal Comfort, Comply with ASHRAE 55-1992

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

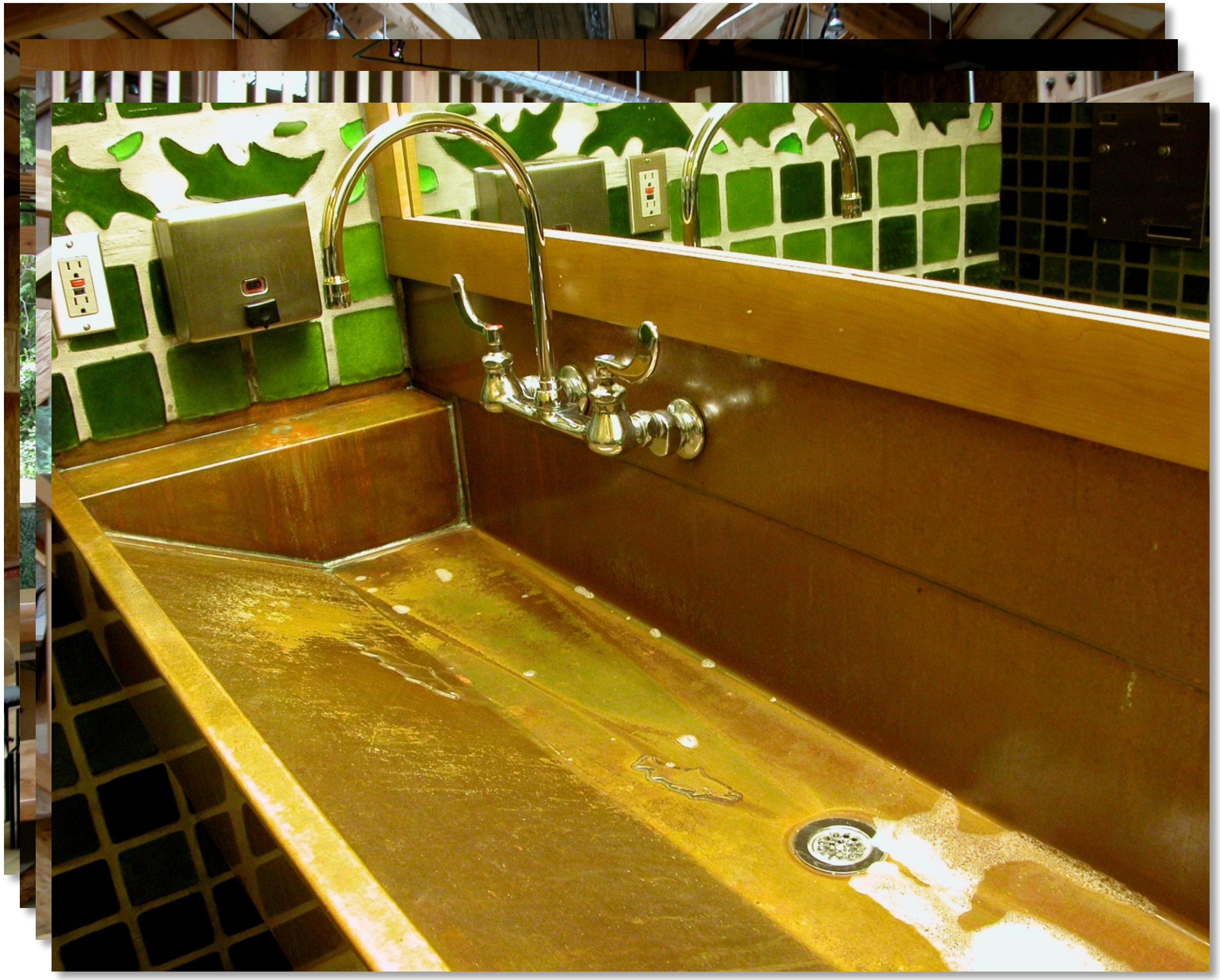
Operating energy

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

Daylit spaces at Islandwood

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

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



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

ID Credit 1.1, Innovation in Design "Environmental Education"

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

ID Credit 2, LEED® Accredited Professional

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