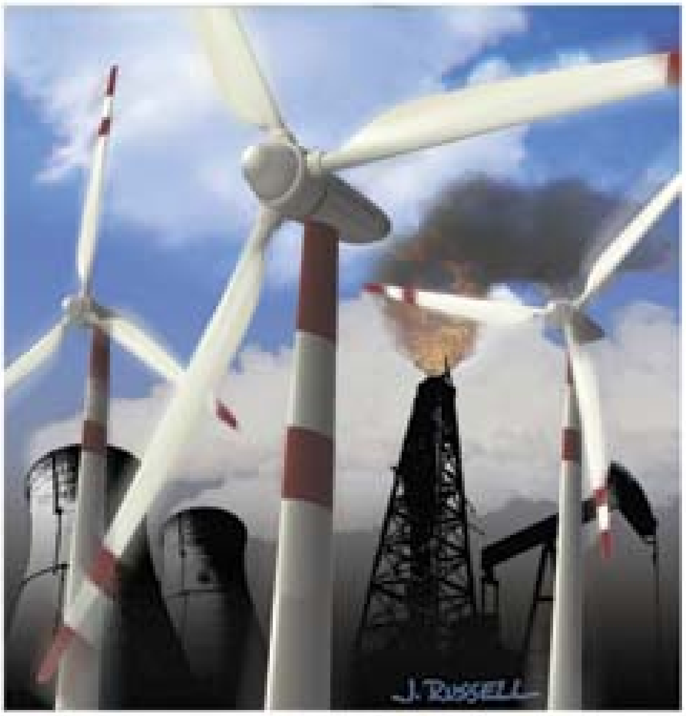
Can We Achieve "ZERO"?
SEFC Olympic Village



"The quality of one's life is dependant on the quality of one's environment & one's relationship to that environment."

Presented by
Albert T. Bicol, P. Eng.
LEED® Accredited Professional
January 11, 2007

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Cobalt Engineering – We Bring Life to Buildings

Vision:
“Global Recognition”

Mission:
“Engineering Ideas Beyond Sustainability”

Added Value:

- Advanced Energy, Building, Comfort Modeling
- Passive Design
- Microclimate Analysis/Modeling
- Daylighting Analysis
- Façade Design
- Sustainable Master Planning
- External Airflow Analysis
- LEED Consulting

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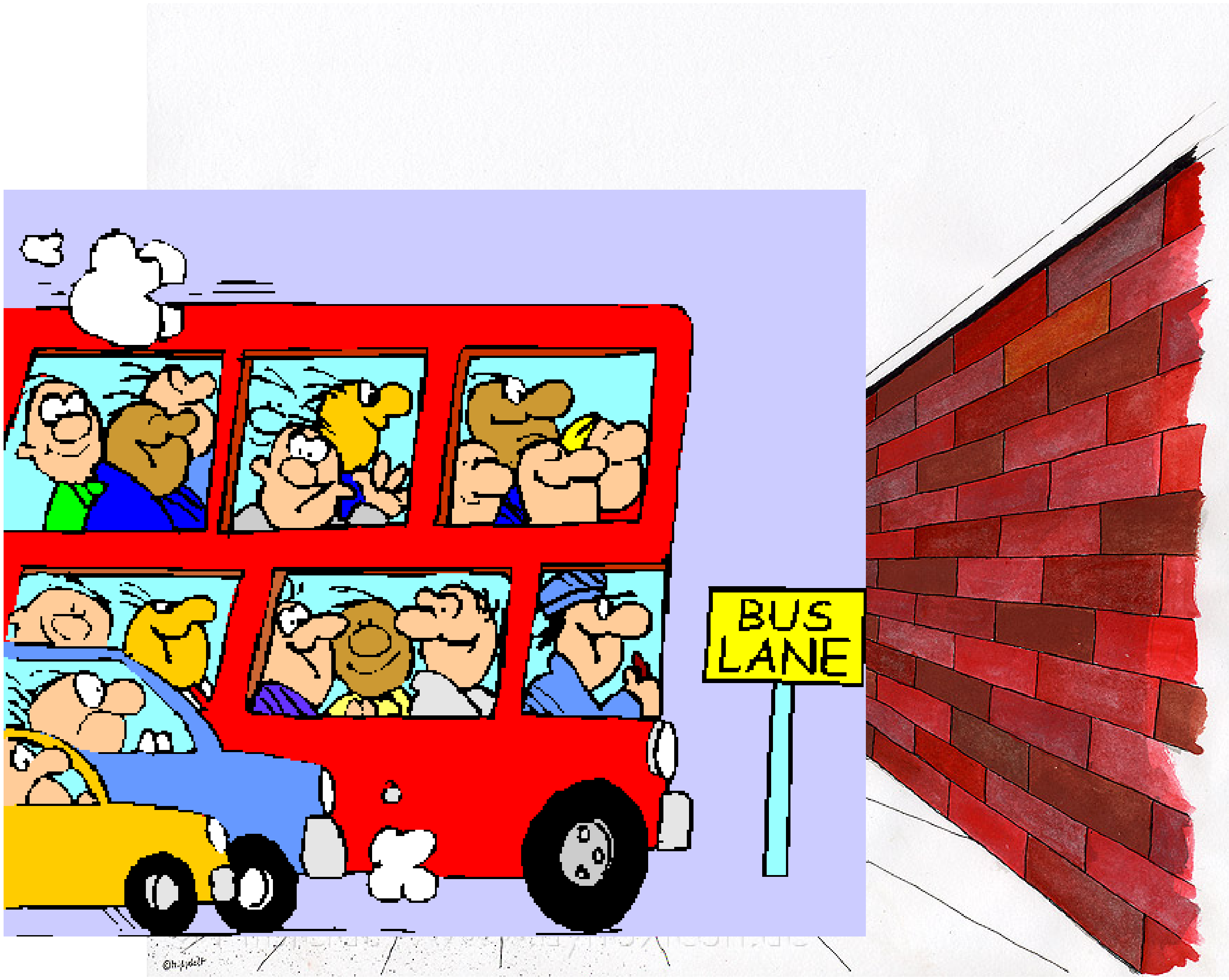
Doubt?



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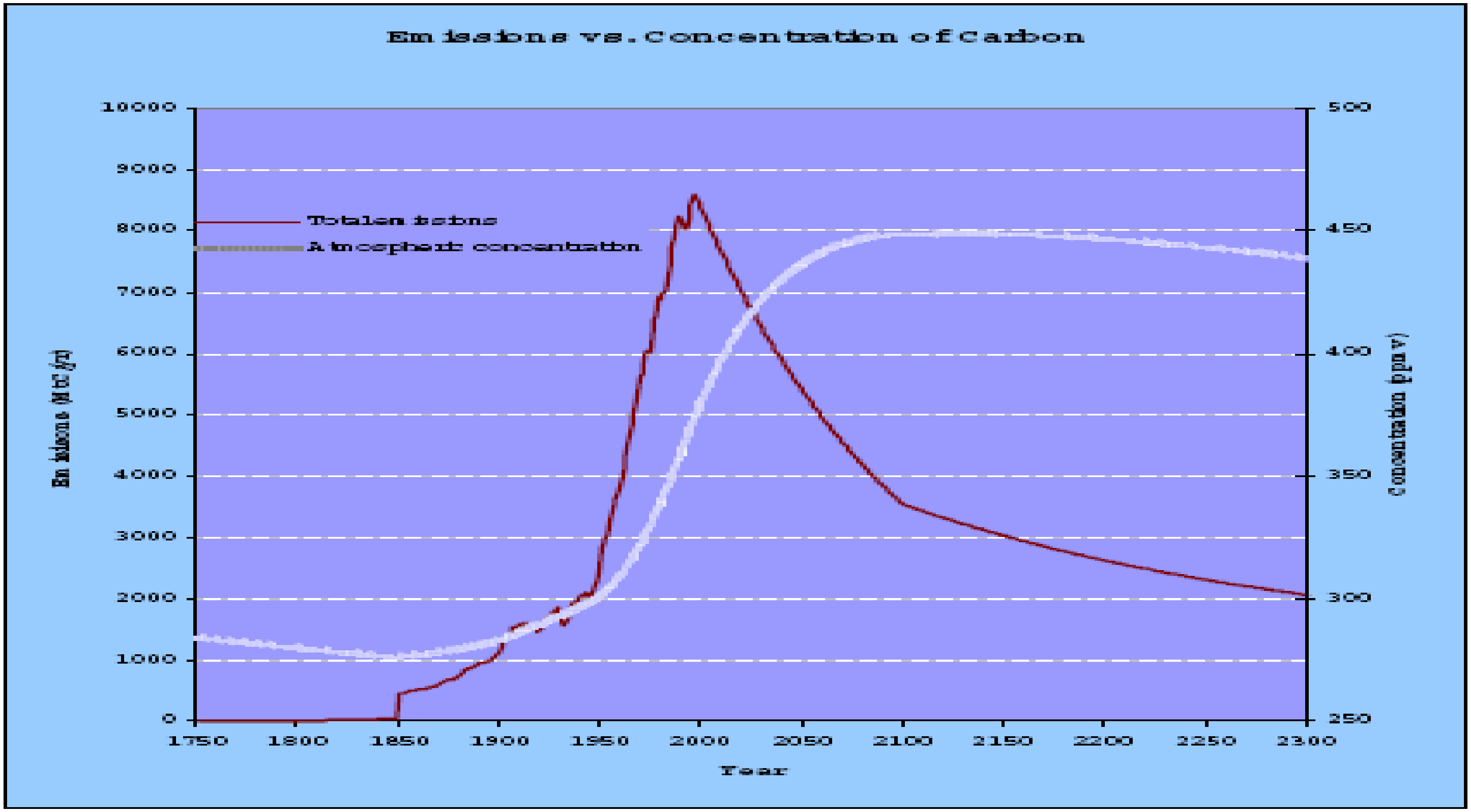
Strive for ZERO & Beyond



Atmospheric concentrations of carbon dioxide will only stabilize around 450ppm (about double pre-industrial averages) if we take early & dramatic action to reduce our absolute global emissions.

Souce: http://www.leiss.ca/climate-change/73?download .

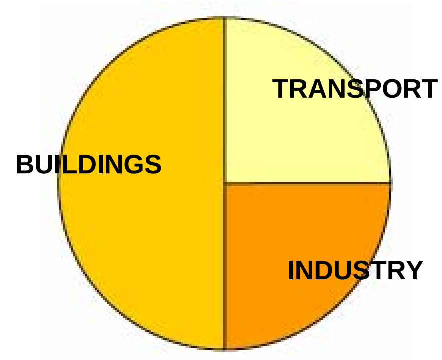
Buildings & Climate Change Facts

Burning Fossil Fuels = GHG ($C0_2$) = Climate Change

Cause & Effect – We are all interconnected

Energy Use in Buildings

- 40%-50% of Worldwide Energy Use
- 50% for HVAC and Lighting
- 65% for Energy Transport – “Parasitic Losses”



Global Energy Use

Hong Kong

“We do not inherit the earth from our ancestors; we borrow it from our children.” - Haida

Non-Traditional Design Approach

- Need to change design mentality
  - Subjective & Objective
- Reduce vs. efficiency
- Back to basics and basic principles
- Passive vs. Hi-Tech
- KISS principle
- Less is better
- 50% of 100 is still greater than 50% of 50

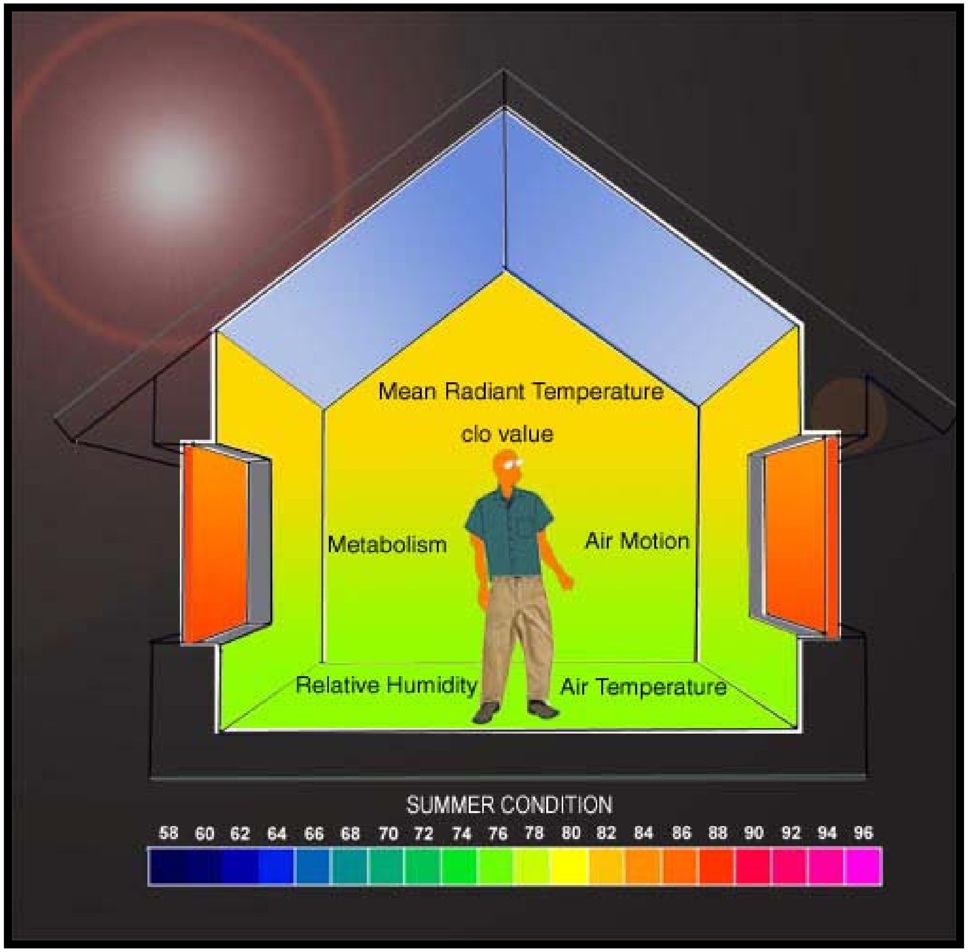
"We have enough people who tell it like it is - now we could use a few who tell it like it can be" – Robert Orben

Order of Priorities

Conventional Design

Sustainable Design

Thermal Comfort



Graphic courtesy of Prof. David Scheatzle, ASU

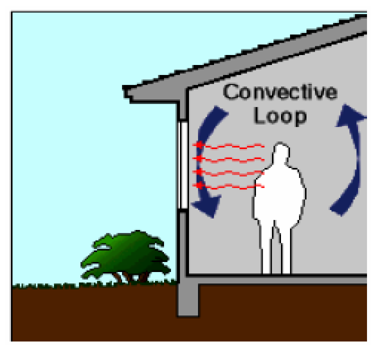
Human comfort:

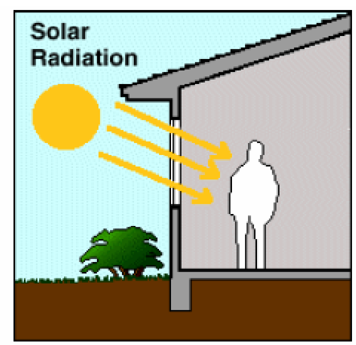
- 50% Radiation
- 30% Convection
- 20% Evaporation

Operative/resultant temp

Relative humidity

Air movement





Need to consider mean radiant temps

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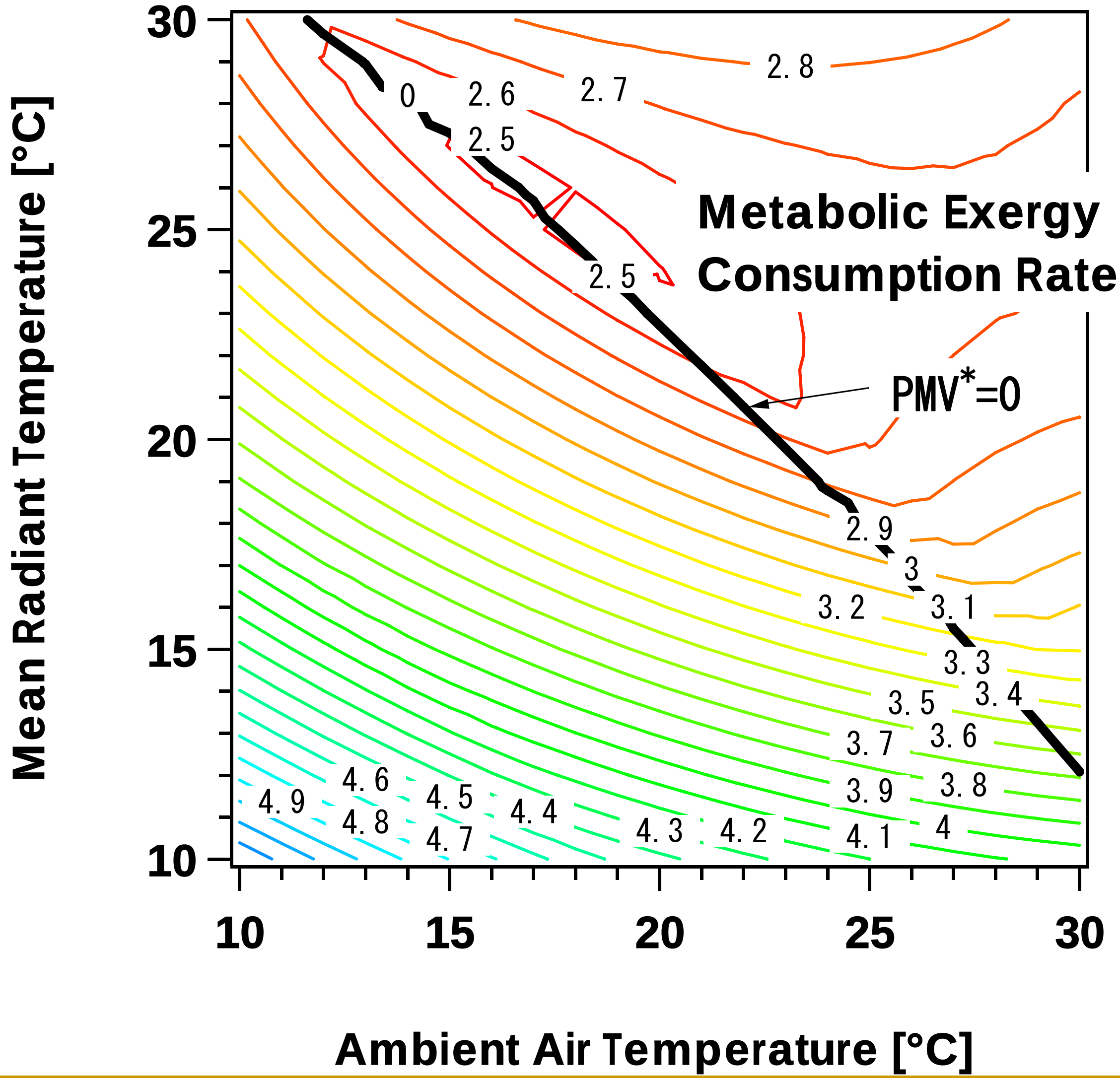
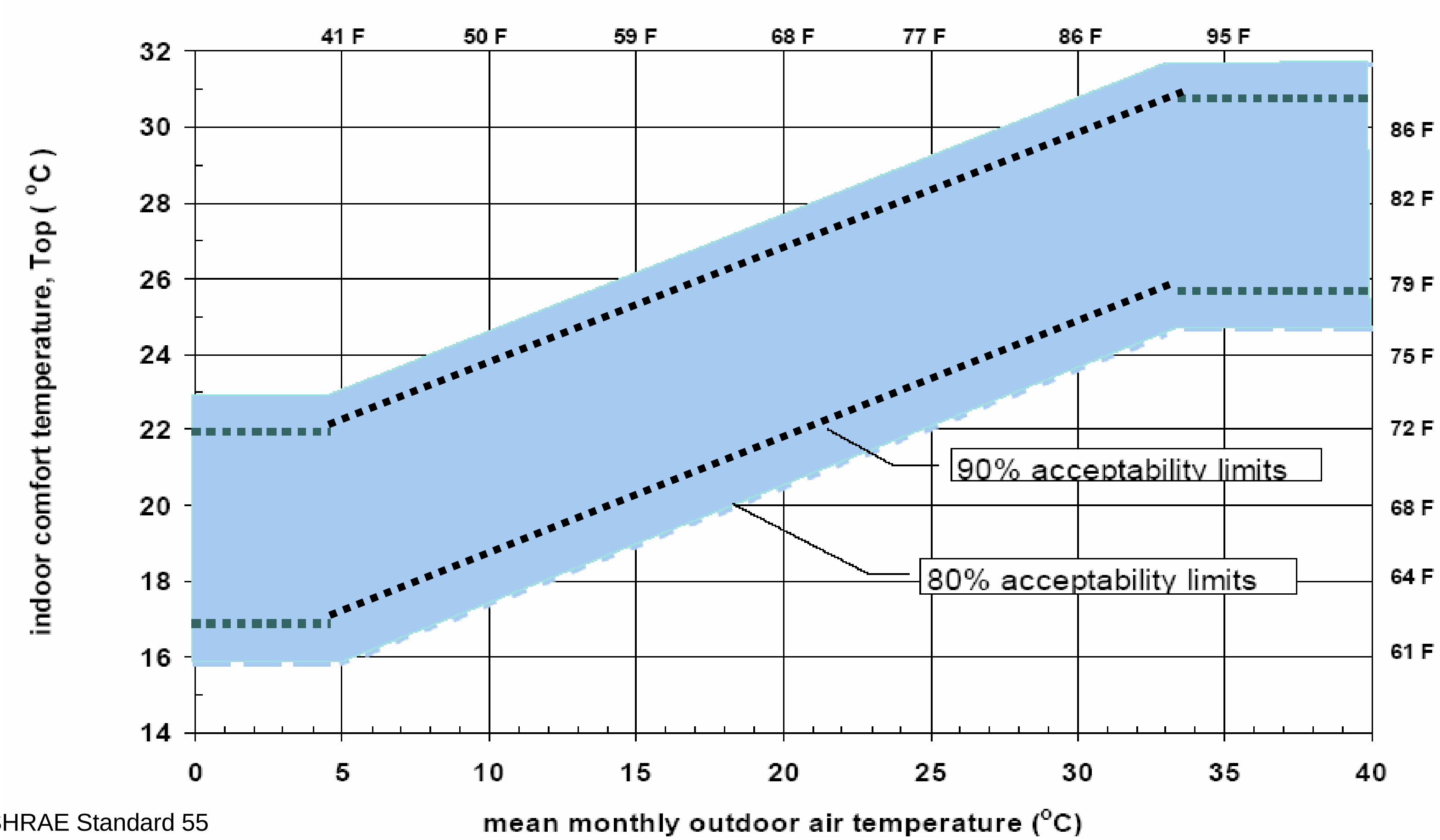
Thermal Comfort & Exergy



Courtesy of M. Shukuya, Musashi Institute of Technology

Thermal Comfort Adaptability



Source: ASHRAE Standard 55

Thermal Comfort Range In Naturally Ventilated Building

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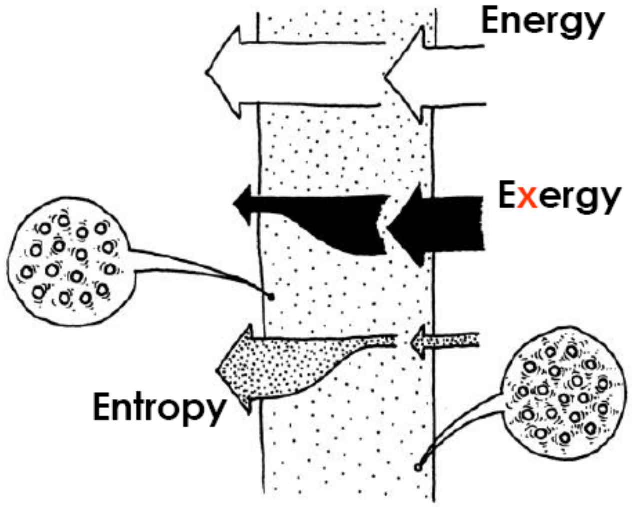
Energy - Exergy- Entropy

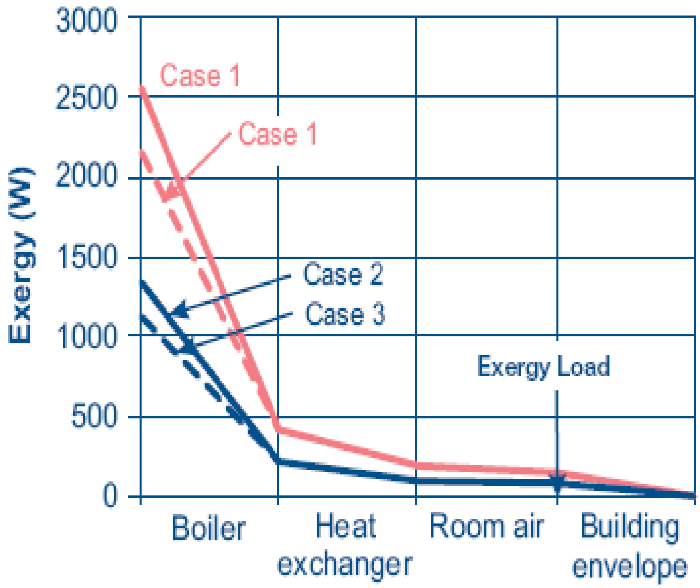
- Laws of Thermodynamics
- Do we really need to conserve energy?
- Exergy – the quality and usable portion of energy
- Entropy – qualitative degradation of the energy flow

Energy, Entropy, and Exergy Flow through a Building Wall

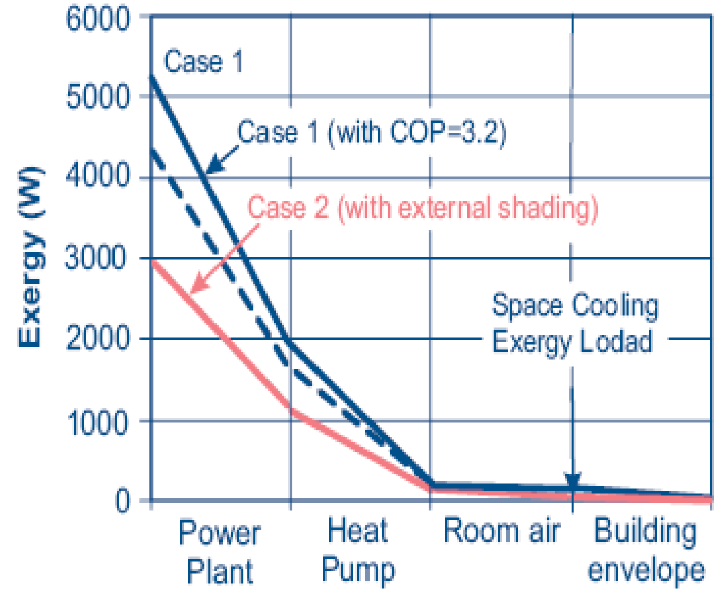


Souce: Shukaya, Manasori (2003).

Exergy System Analysis



Heating



Cooling

Case 1 - Standard envelope, mid-efficiency boiler
Case 1b - Standard envelope, condensing boiler
Case 2 - Improved envelope, mid-efficiency boiler
Case 3 - Improved envelope, condensing boiler

Case 1 - Standard glazing SHGC=0.7, A/C COP=2.7
Case 1b - Standard glazing SHGC=0.7, A/C COP=3.2
Case 2 - Improved glazing SHGC=0.35, A/C COP=2.7

Source: Low Exergy Systems for Heating and Cooling of Buildings Guidebook – IEA ECBCS Annex 37 (available at http://www.lowex.net/)

High-Exergy Building: A real example

Ski Resort in Dubai

Source: http://urbanlegends.about.com/library/n_dubai_ski_resort5.htm

Source: http://urbanlegends.about.com/library/n_dubai_ski_resort2.htm

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Building Energy Standards

- North America - ASHRAE 90.1 (US), MNECB (Canada)
  - Energy Codes are a moving target
  - Energy performance measured in non energy units
- European Union – "EPB Directive 2002/91/ES"
  - Provides clear & measurable target
  - Energy Intensity in (kWh/m2. year)

ZERO Strategies

Recognize

Design options early

Reduce

Conserve fuel, energy, water use, low exergy

Remember

Laws of physics/nature, return back to basics building science

Recycle

Fuel, energy, water, materials

Renewable

Solar & its Derivatives:

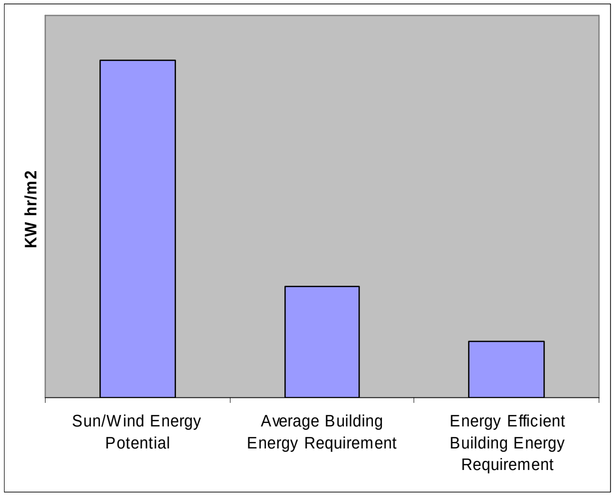
Regenerate

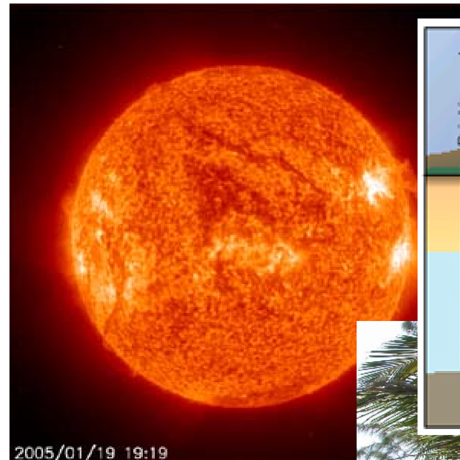
Energy

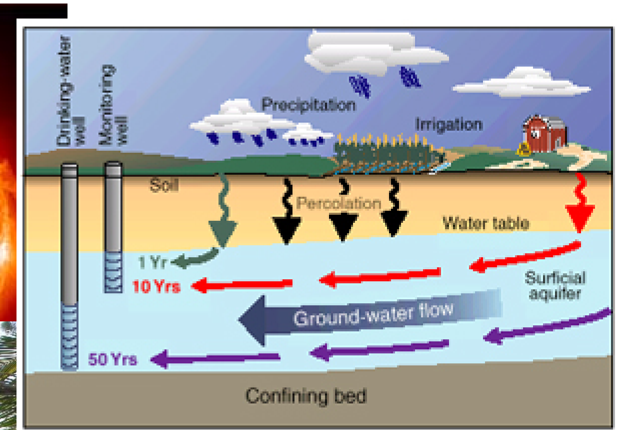
Real Costs

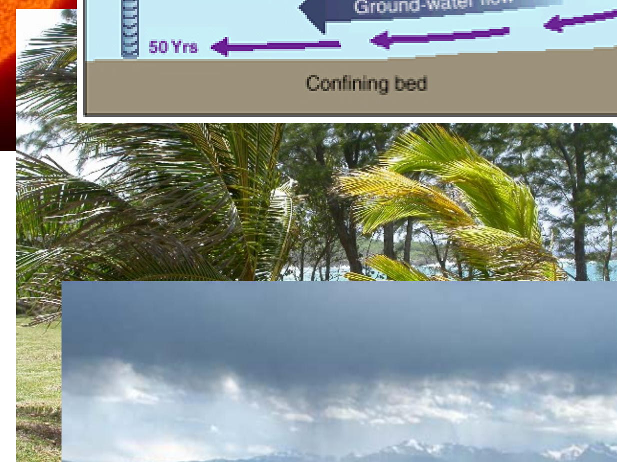
LCC, Soft Costs, green funding

Microclimate Analysis









- Discovering environmental energy potential
- Full utilization of landscaping
- True assessment of renewable energy
- Do not rely on climate data miles away
- Data required for passive design
- Relationship of buildings to its surroundings
- Environment energy – has potential to be balanced
- Recognize, utilize & be resourceful

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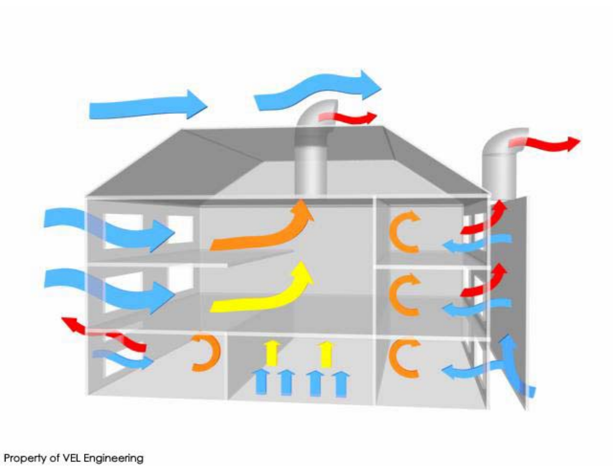
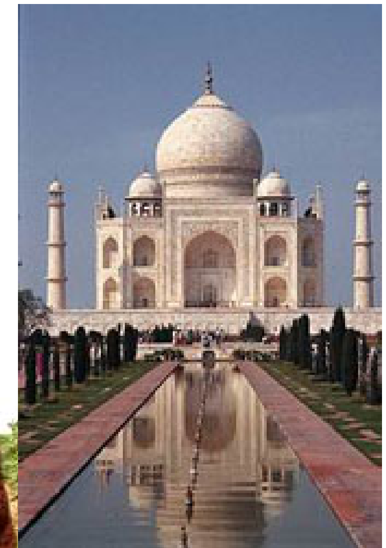
Where is the Highest Potential for Energy Savings in a Building?

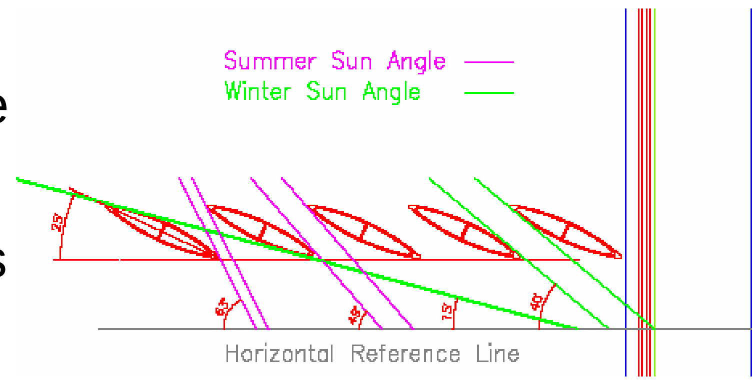




Building Energy – Passive:

- Design Obey Laws of Physics & Nature
- Thermal Mass
- The building is the engineering systems

"Ultimate goal – No mechanical systems"



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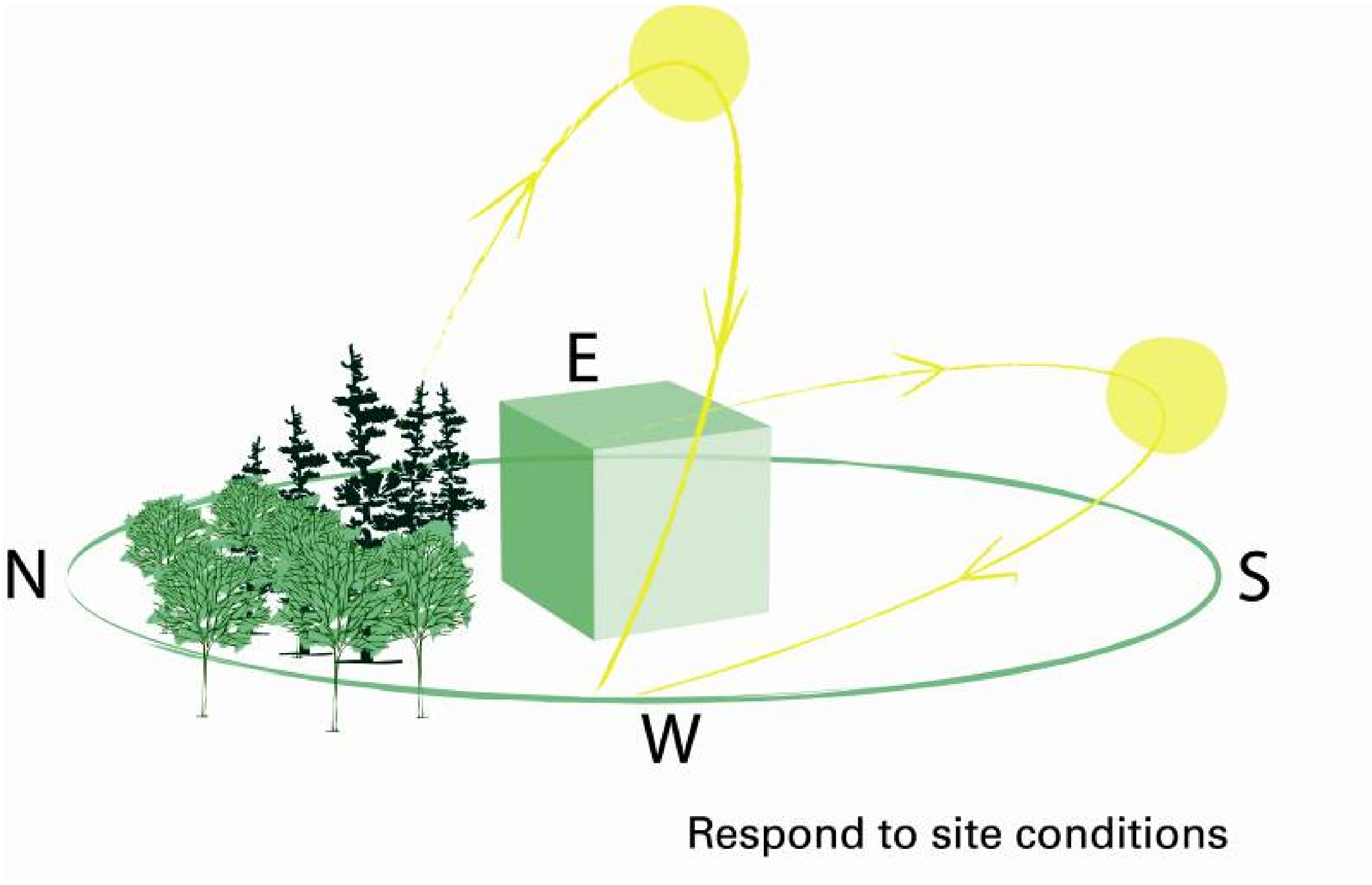
Building Orientation / Form



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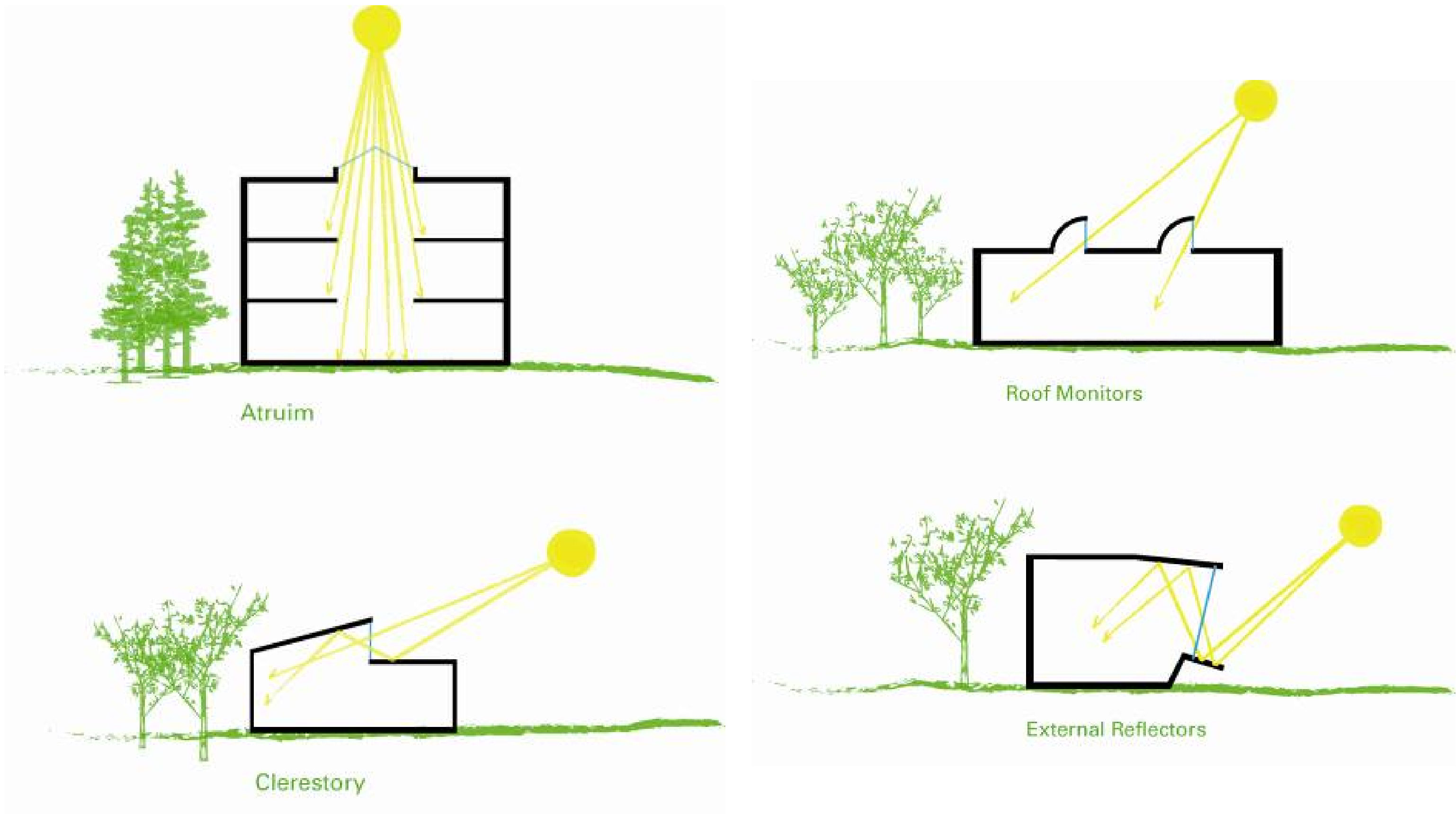
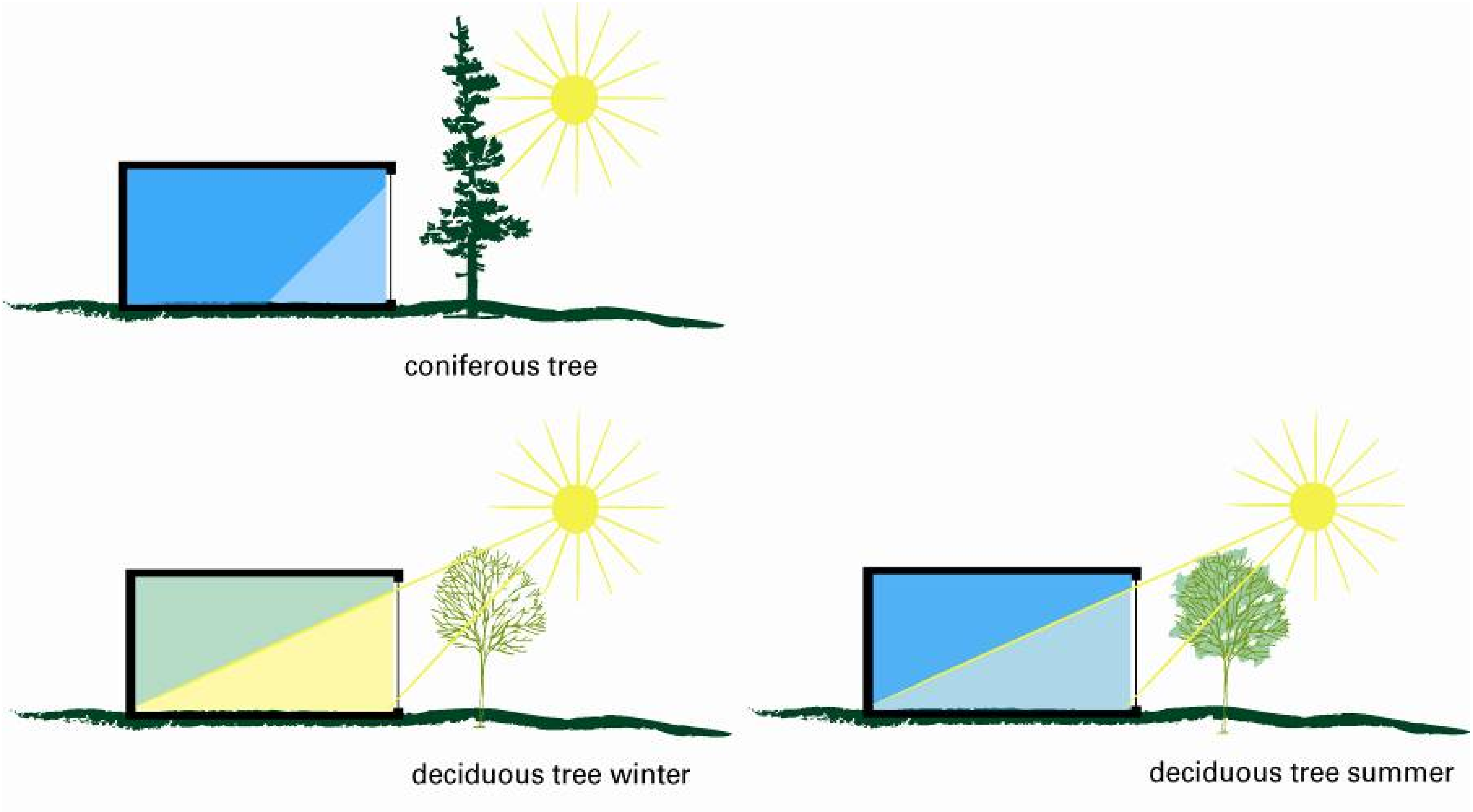
Daylighting and Solar Gain

Possible ways to introduce daylighting into building design



Courtesy Hughes Condon Marler : Architects

Full Utilization of Landscaping



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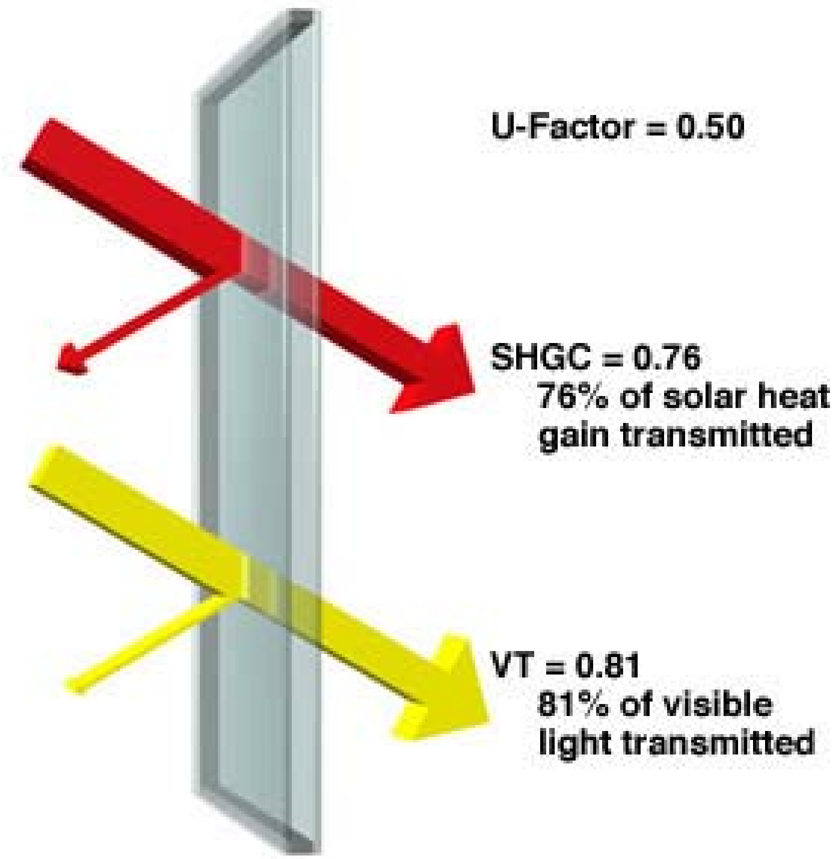
Building Envelope Design

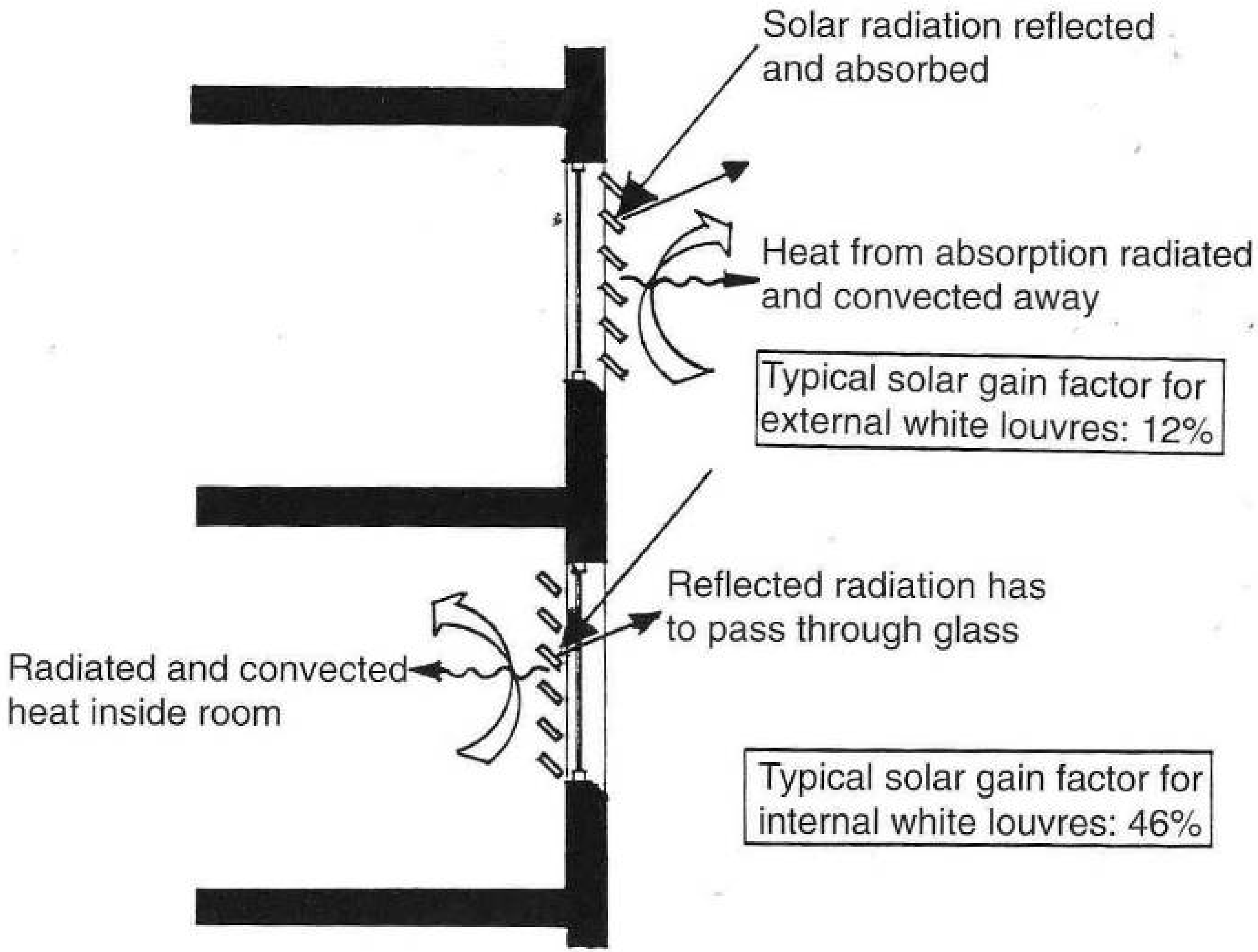
- Glazing Performance
  - Thermal
  - Solar
- Thermal Bridging
- Building Fabric
  - Lightweight
  - Heavyweight
- Envelope Type
  - Translucent
  - Transparent
  - Opaque

Glazing Performance

- Heat transfer coefficient (U-factor)
- Solar heat gain coefficient (SHGC)
- Shading Coefficient (SC)
- Visible light transmittance (VLT)



Daylighting & Solar Gain Control



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Building Mass - Light vs. Heavy

- Assuming identical R & U values
- Is there a difference in performance?
- What makes the difference?

Courtesy Earthtech

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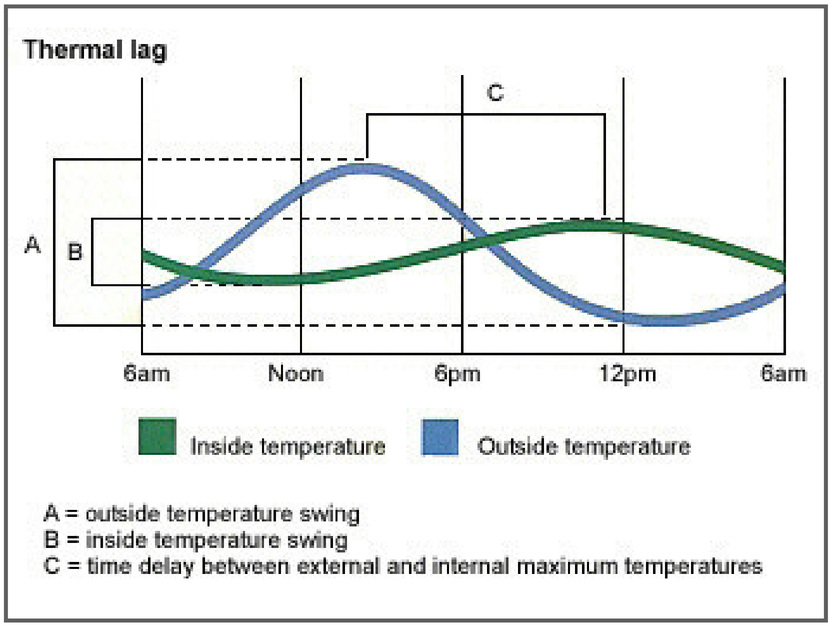
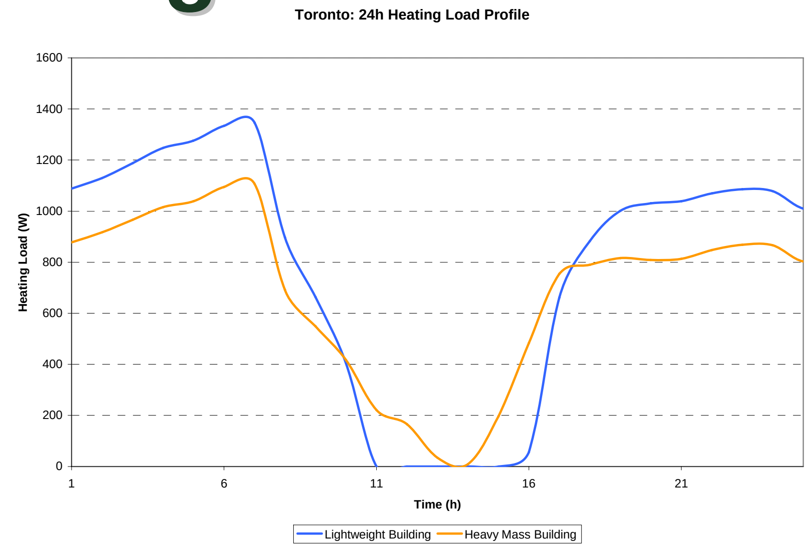
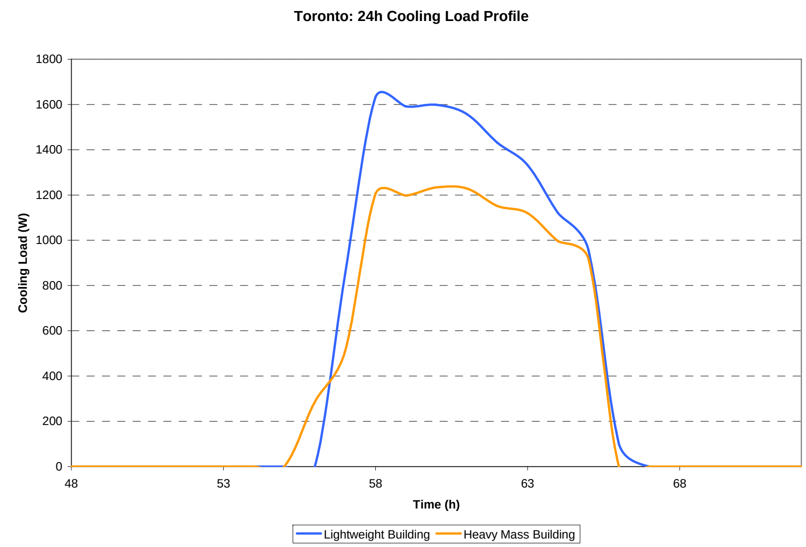
Benefits of Building Mass



Courtesy Thermodeck





Courtesy Cobalt Engineering

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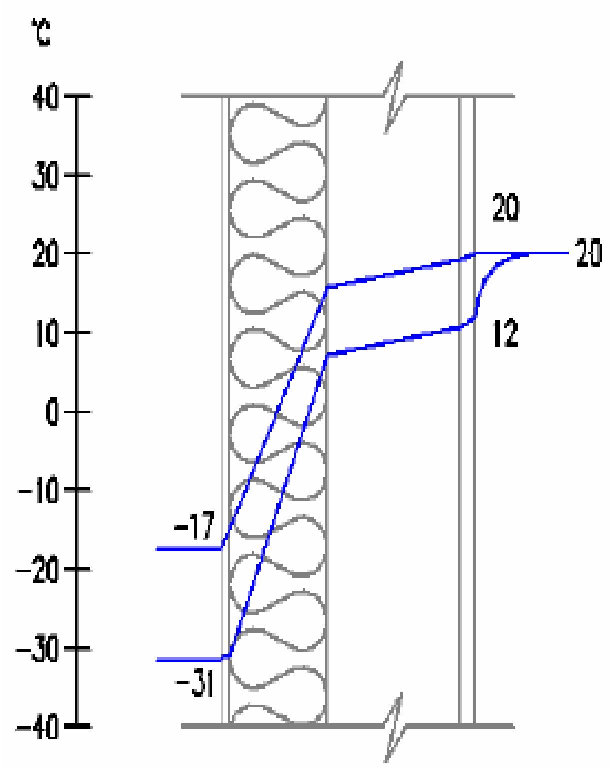
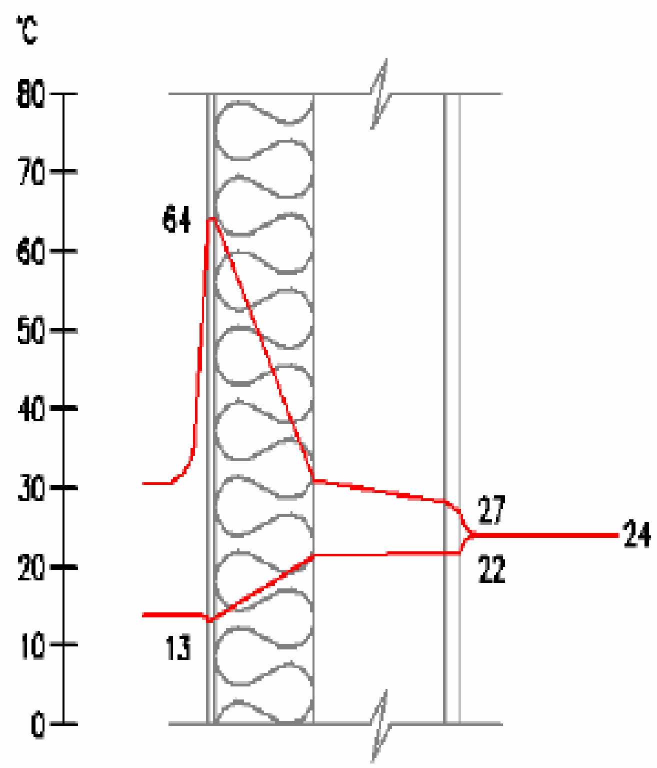
Building Envelope Performance

Regina – light weight curtain wall

Courtesy Cobalt Engineering



Winter



Summer

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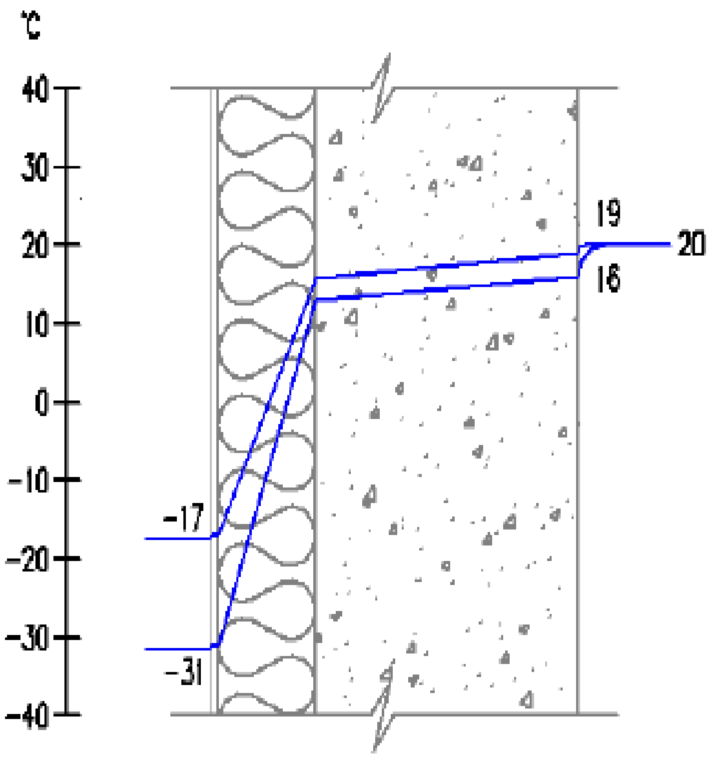
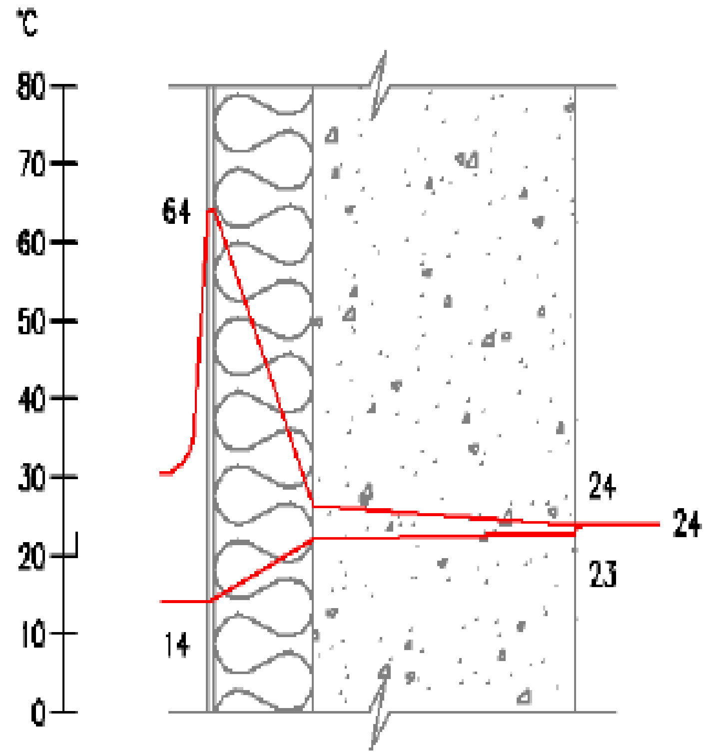
Building Envelope Performance

Regina – heavy weight concrete wall

Courtesy Cobalt Engineering



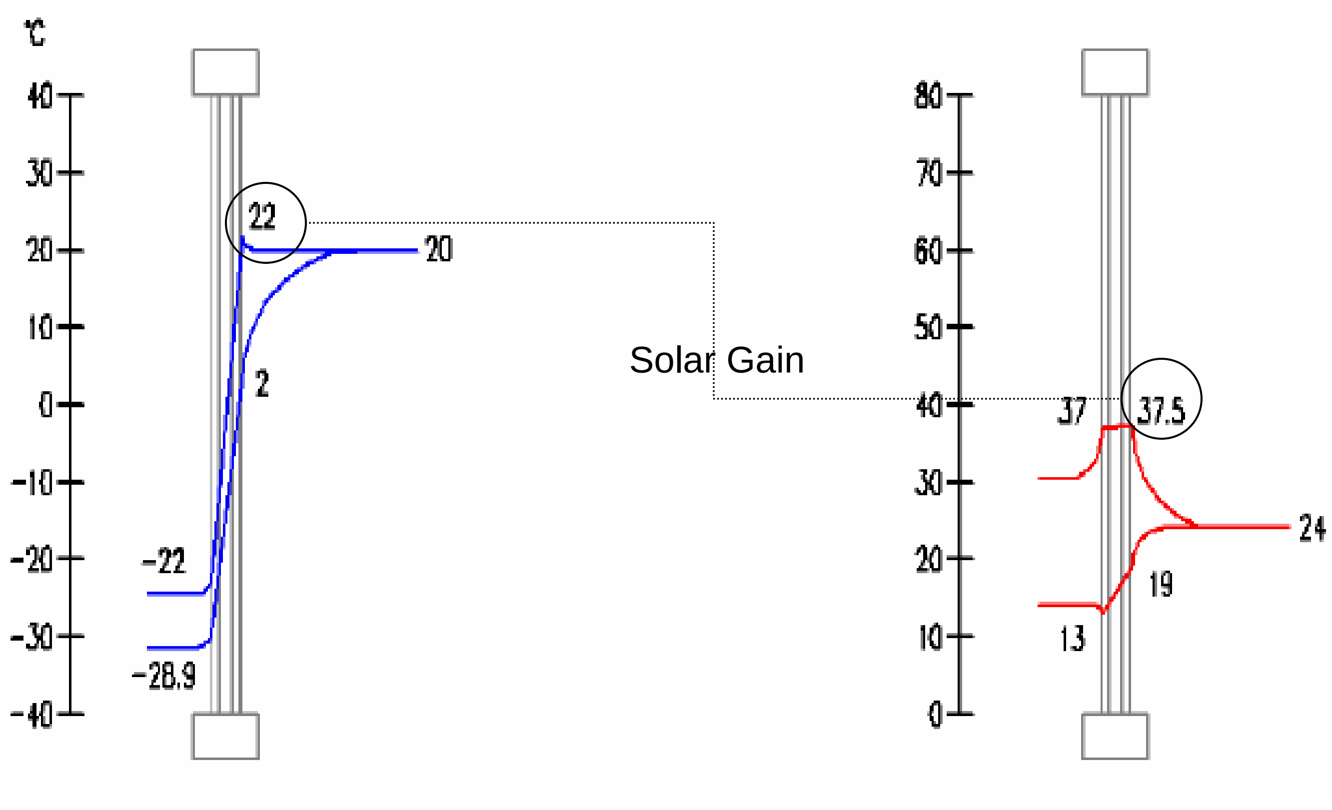
Winter



Summer

Glazing Surface Temperatures

Courtesy Cobalt Engineering



Glazing:
6mm clear low-e
10 mm air
6mm clear float
SC =0.78
SHGC =0.68

U = 2.118 W/m^{2}K

Winter Summer

Glazing surface temperatures during design conditions (Regina)

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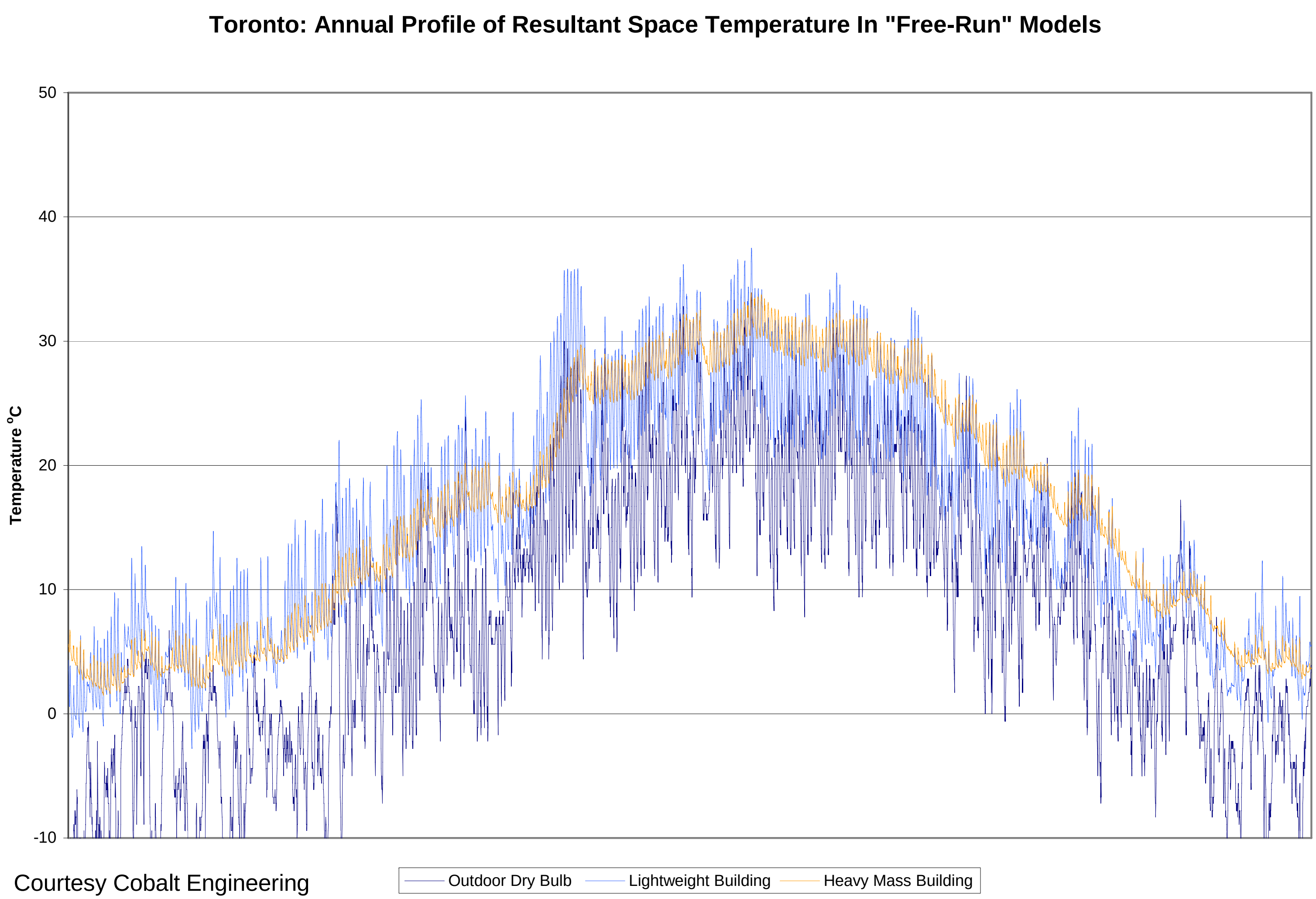
Free Run Temperature



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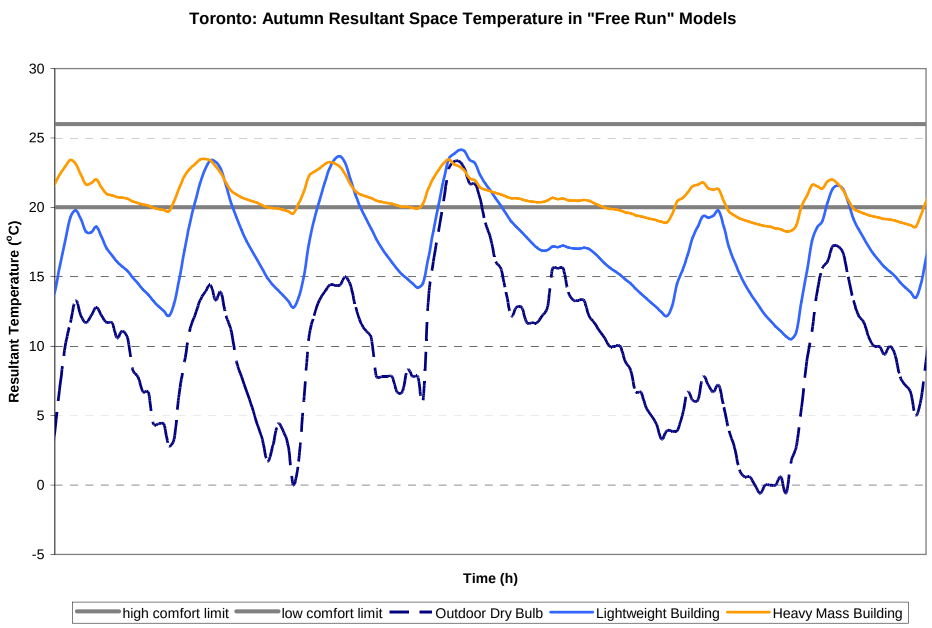
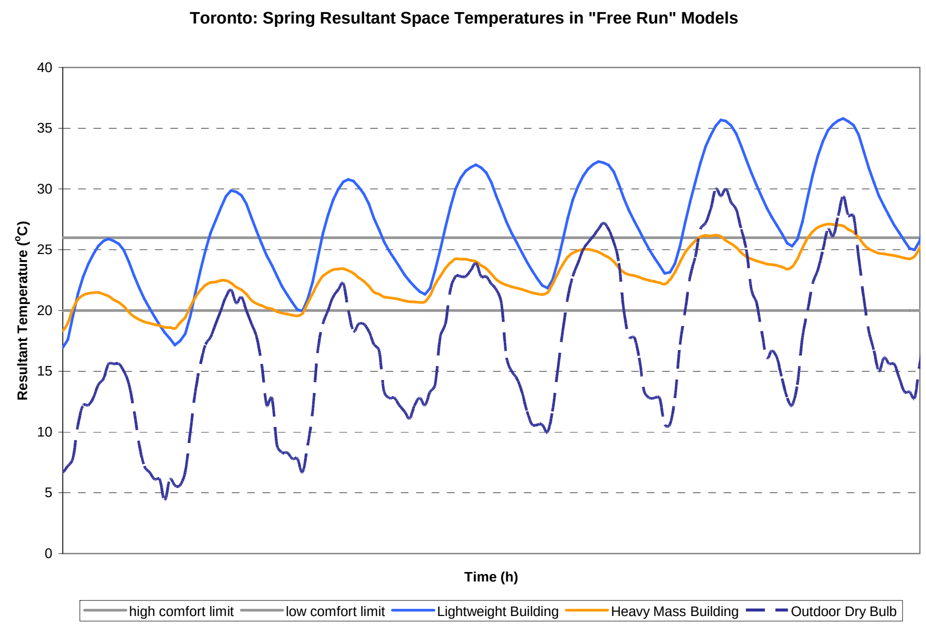
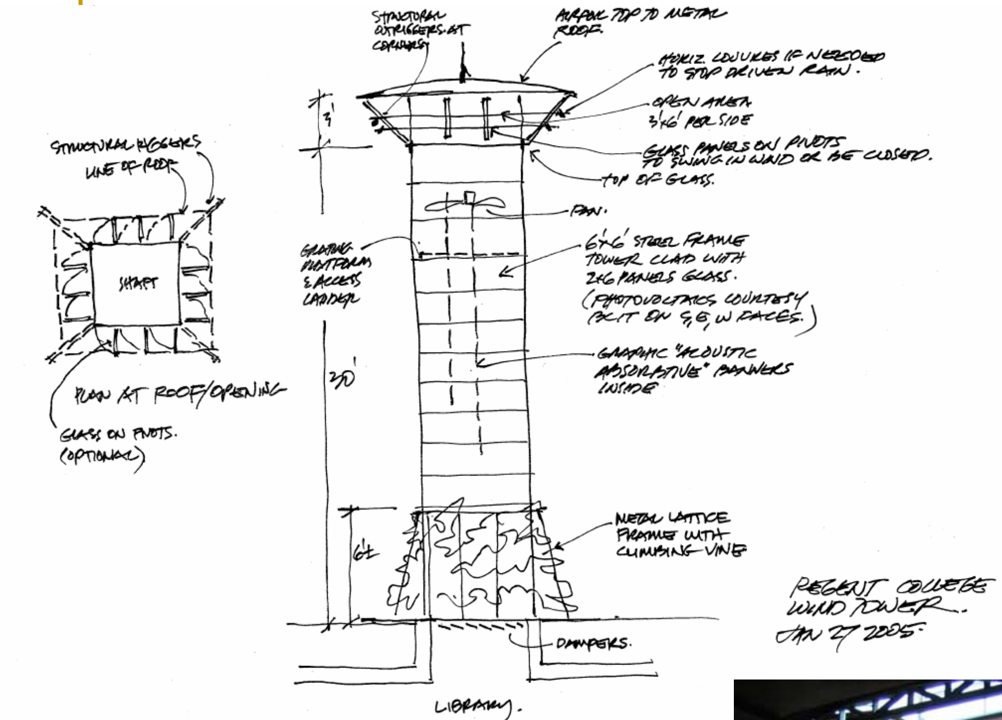
Free-Run Temperature





Courtesy Cobalt Engineering

Natural Ventilation/Wind Towers



Yazd, Iran: Wind Towers

Dubai: Wind Towers

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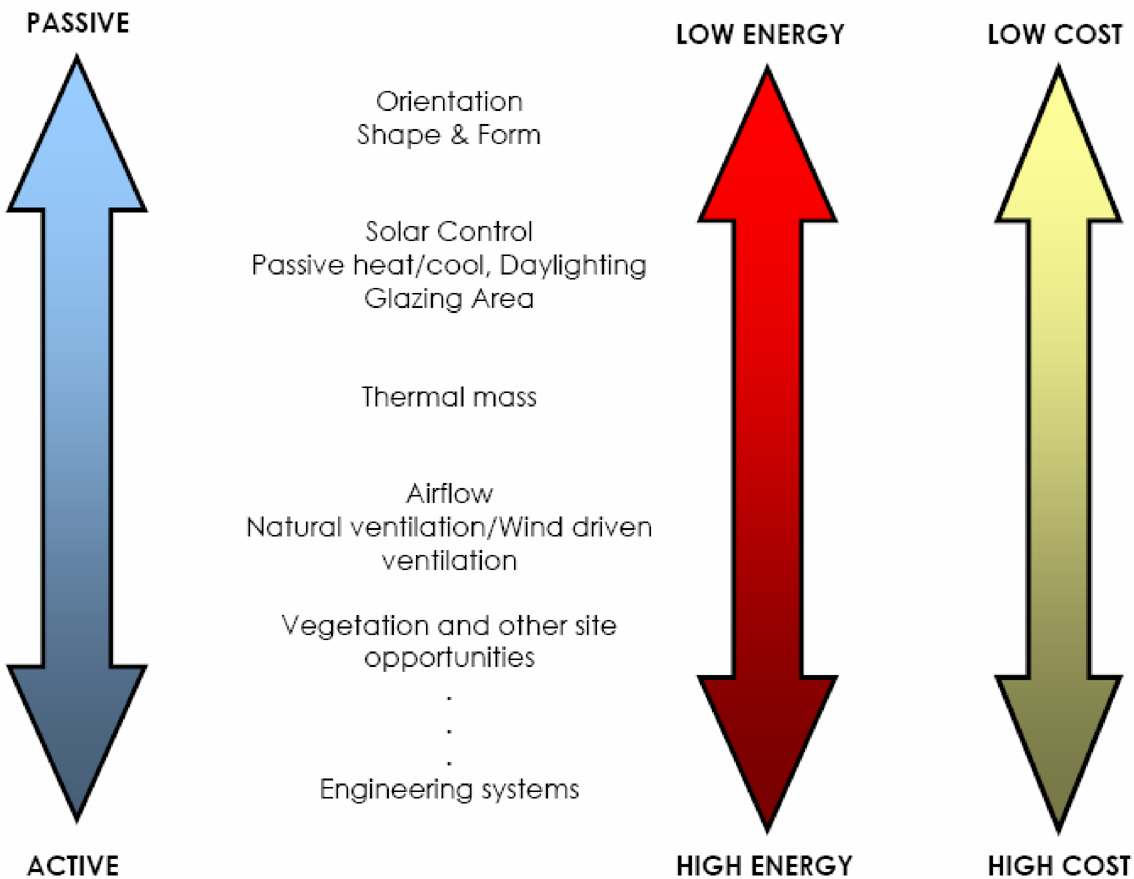
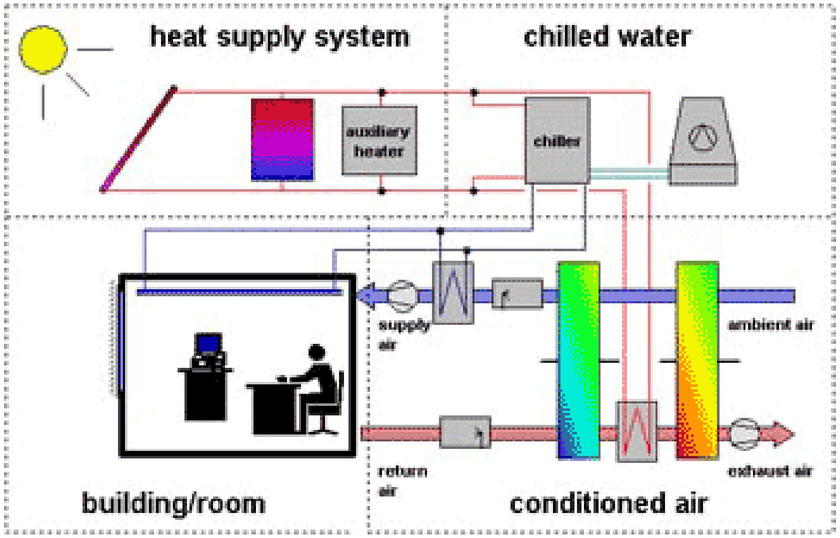
Passive Design Approach

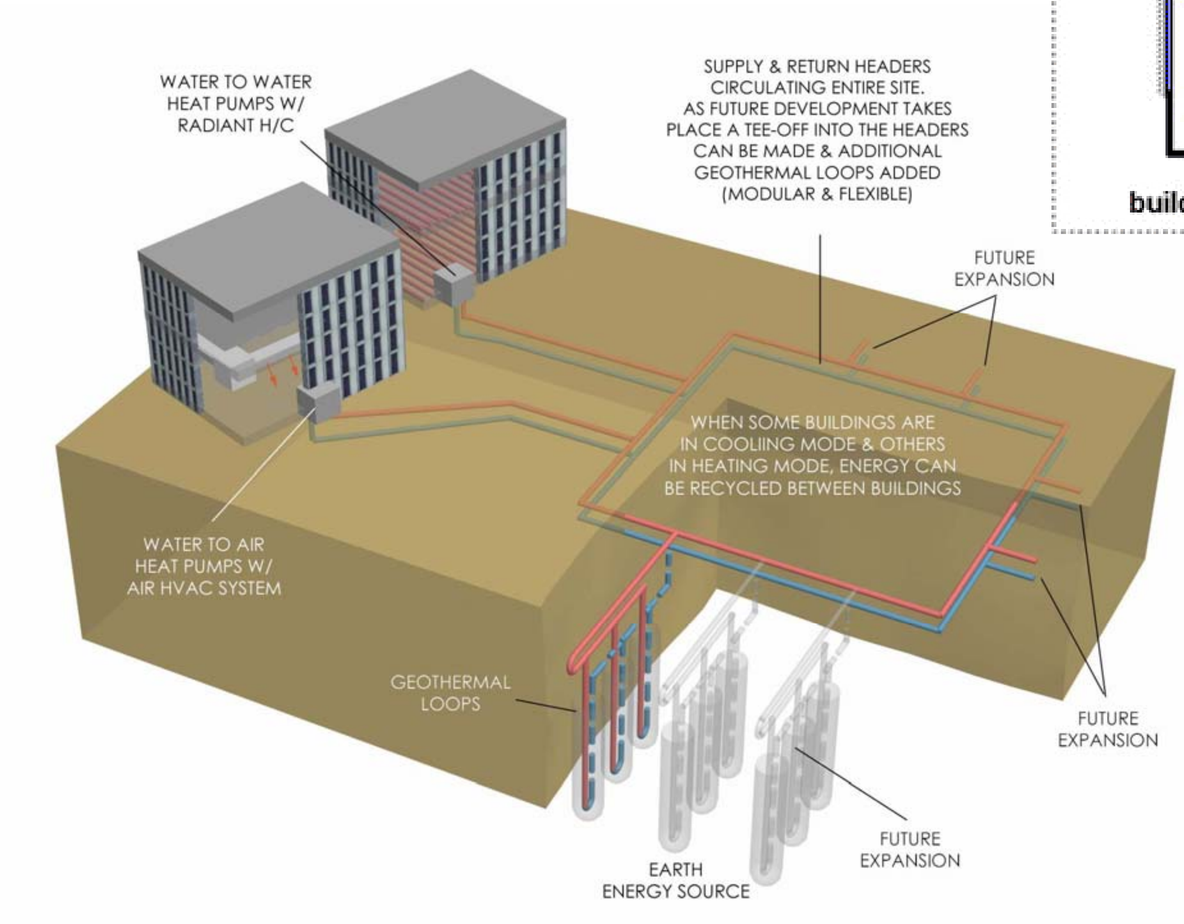


Goals:

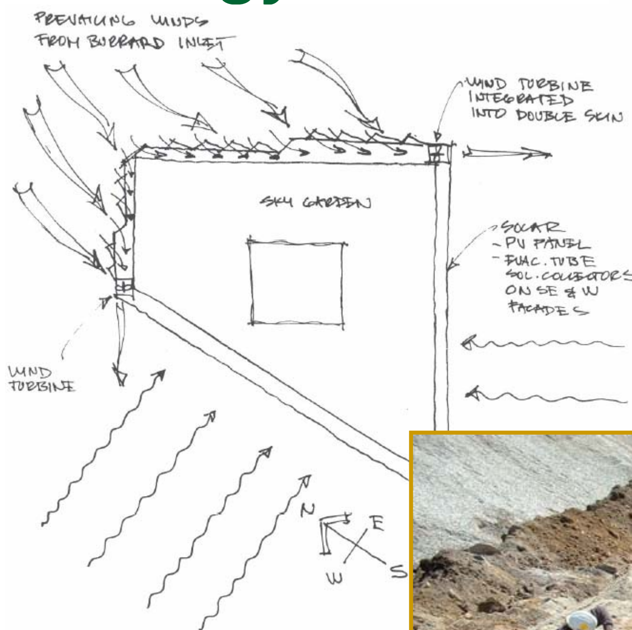
- Human well being
    - Comfort
    - Daylighting
    - Noise
    - Indoor air quality
- Energy

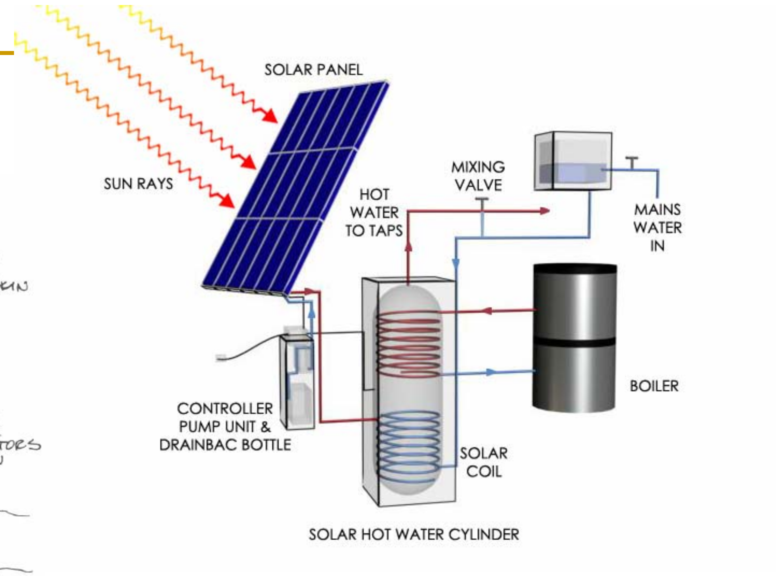
Plant Energy





Renewable Energy





- Tidal/Wave
- Wind/Solar
- Biomass
- Geothermal
- Greatest challenge on achieving ZERO energy
- Ideal application – Low grade energy building systems
- Renewable – basic form of energy

News Flash! Wal-Mart Deploys Solar, Wind, Sustainable Design

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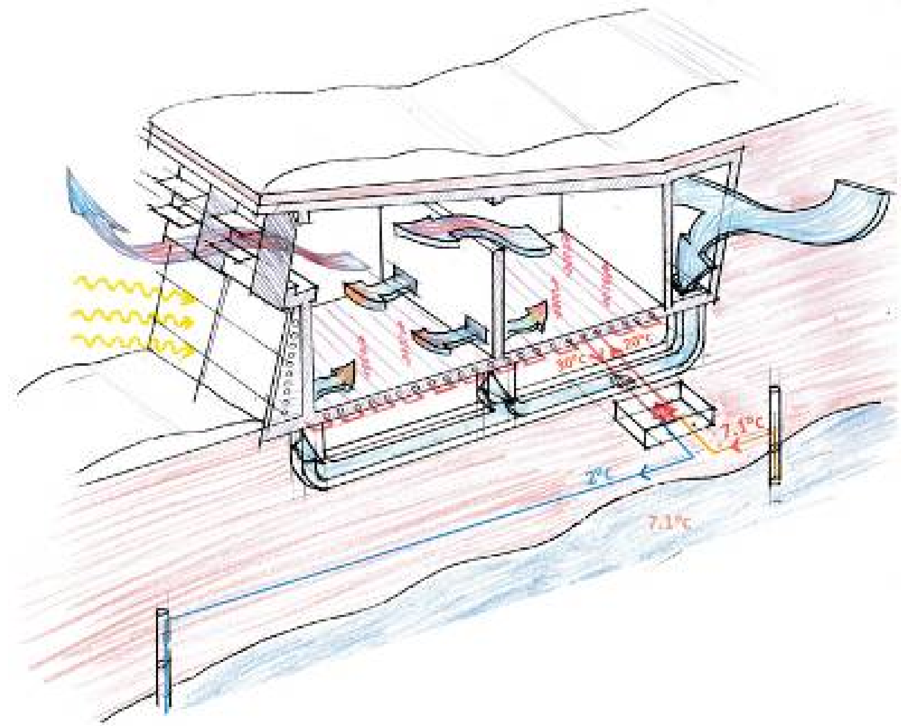
Active Low Exergy Systems



- Separate H&C from ventilation
- Low temperature difference
- Large heat emission surfaces
- Use water instead of air
- Natural or mixed mode ventilation
- Low-grade renewable energy sources

Courtesy Cobalt Engineering

Air vs. Water

Volumetric Heat Capacity = $\rho.c_p$ [J/m^3.K]

measure of material's ability to store thermal energy

- Air $\Rightarrow \rho.\ c_p$ = 1,395 J/m^3.K
- Water $\Rightarrow \rho.\ c_p$ = 4,200,000 J/m^3.K

Radiant System Configurations

Low-Mass → Heavy-Mass

Low- Inertia → High Inertia

More Passive → High Exergy

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Benefits of Radiant Systems

Superior Thermal Comfort

Maximum Energy Efficiency

Courtesy Karo Capillary Mats

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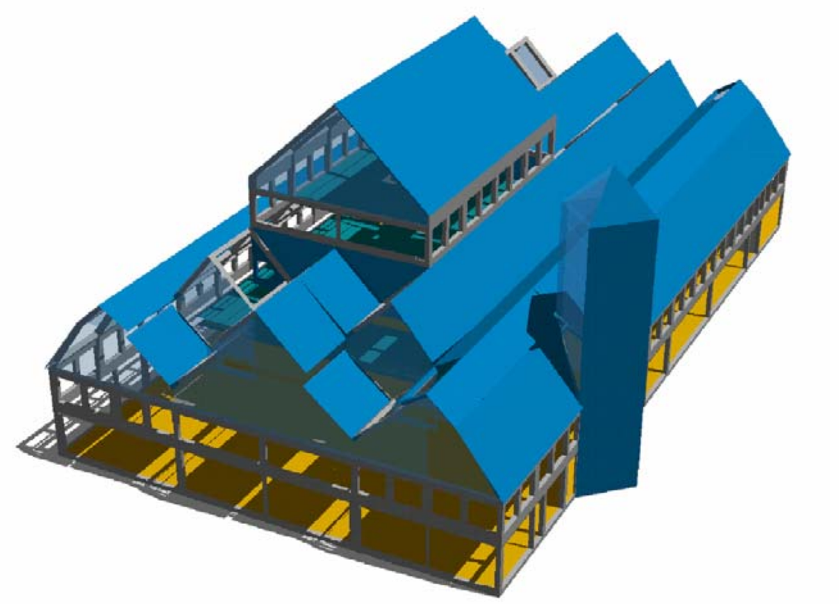
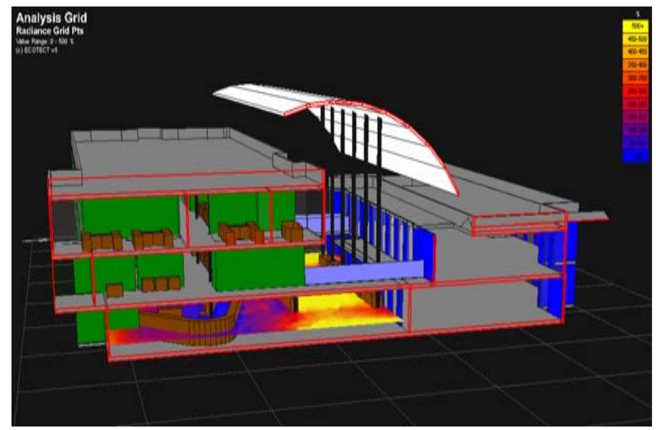
Simulation Tools



"Use the right tool for the job!"

Passive Building performance

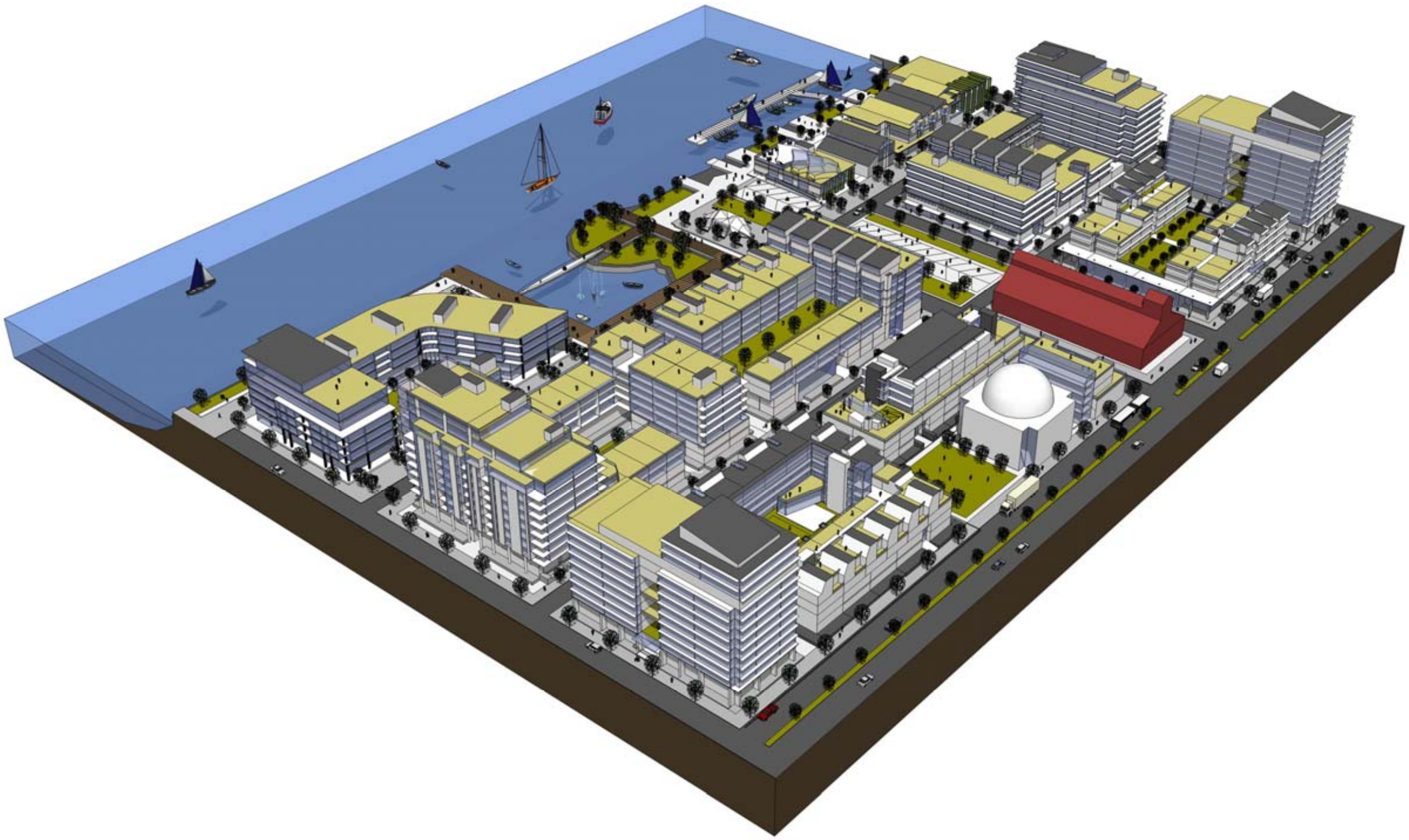
- Building physics
  - Building Energy & Comfort
  - Radiant Heat Transfer
  - Effects of Building Mass
  - Air-Flow Dynamics (CFD)
  - Wind & Buoyancy Driven Air-Flows
  - External/internal Shading
  - Day-lighting



Active Systems Performance

- Building systems
  - Peak loads & System energy

SE False Creek – Olympic Athlete's Village



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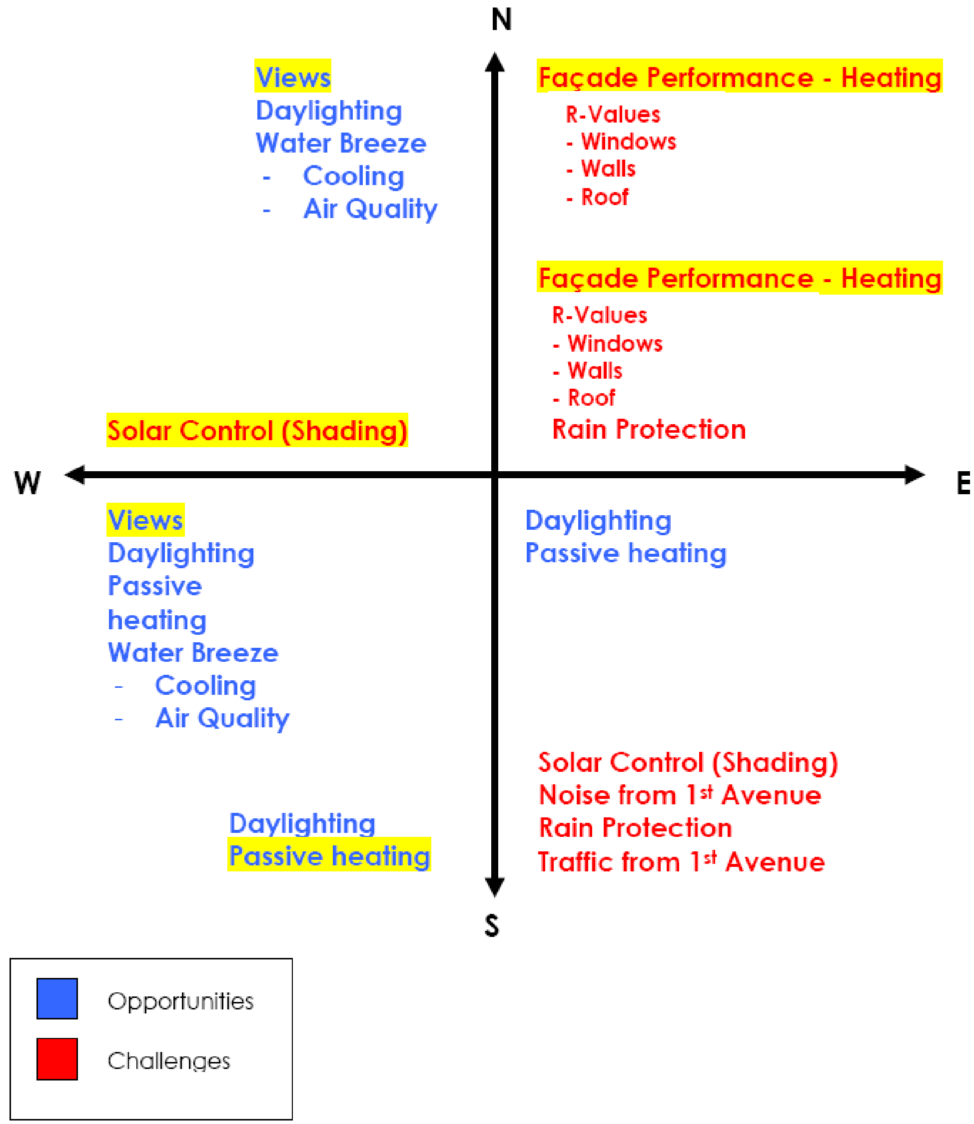
SE False Creek

Microclimate Analysis

Note: for this site only



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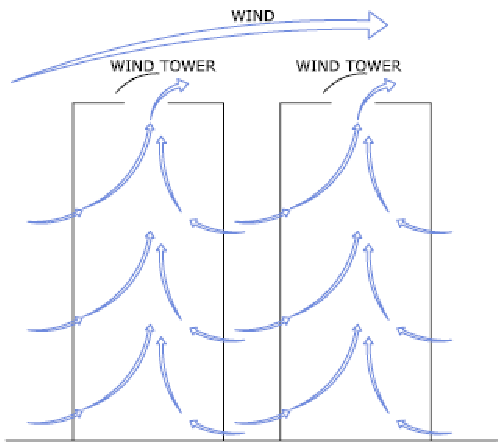
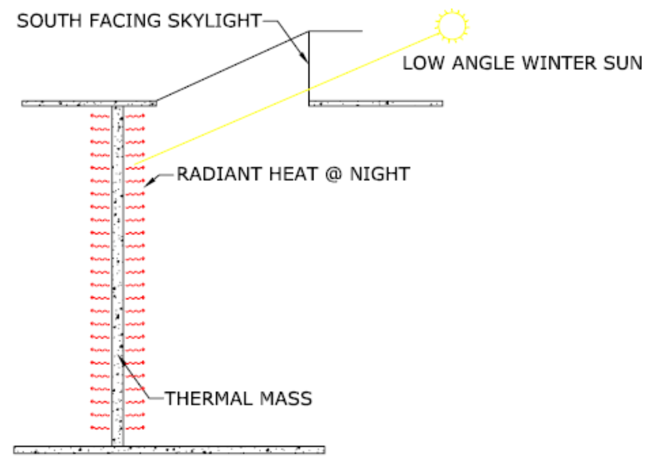
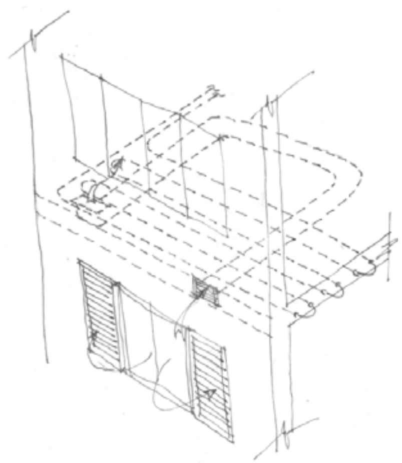
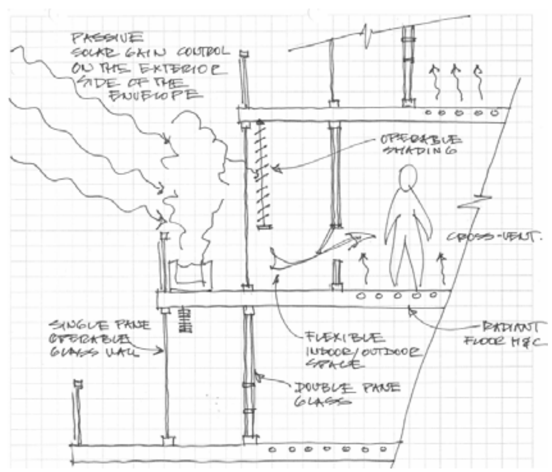
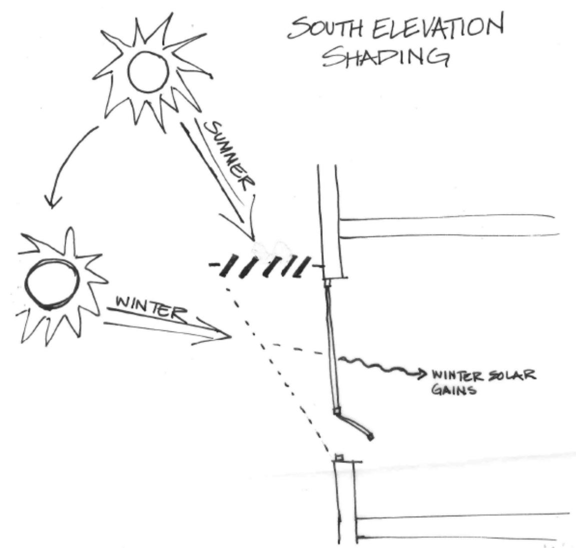
SE False Creek – Passive Design Options











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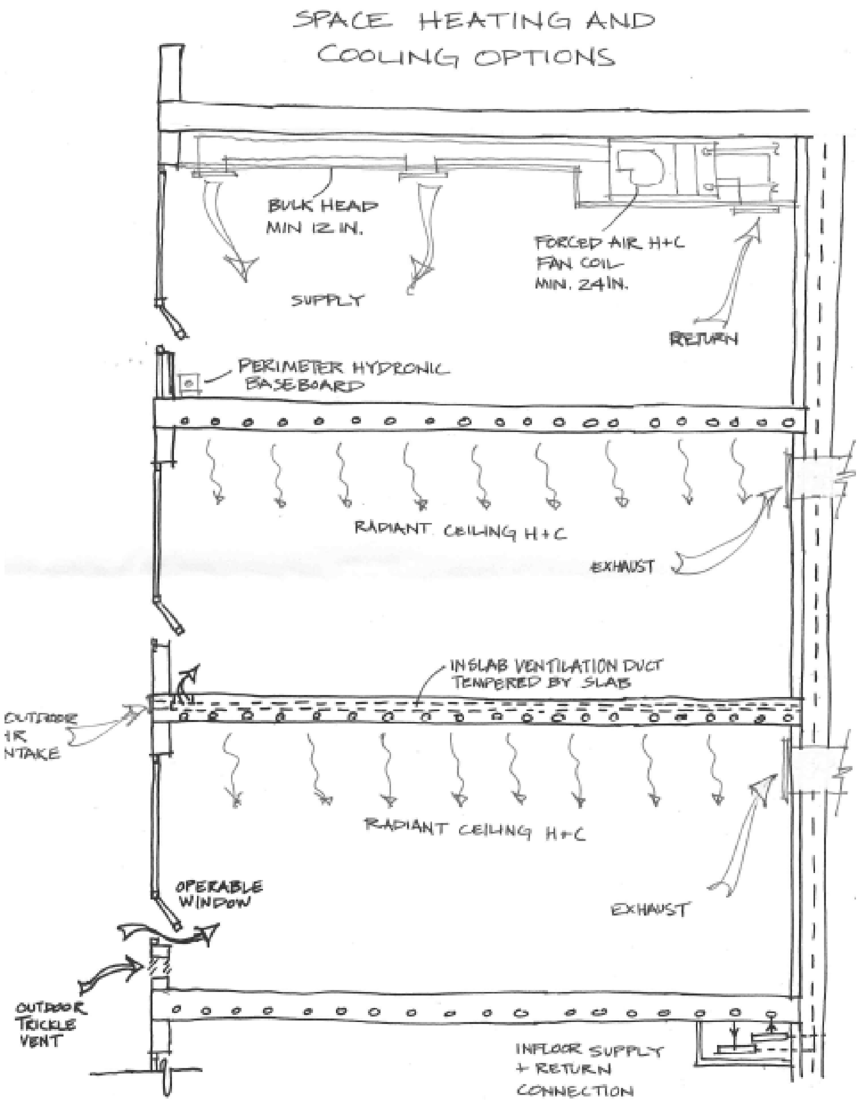
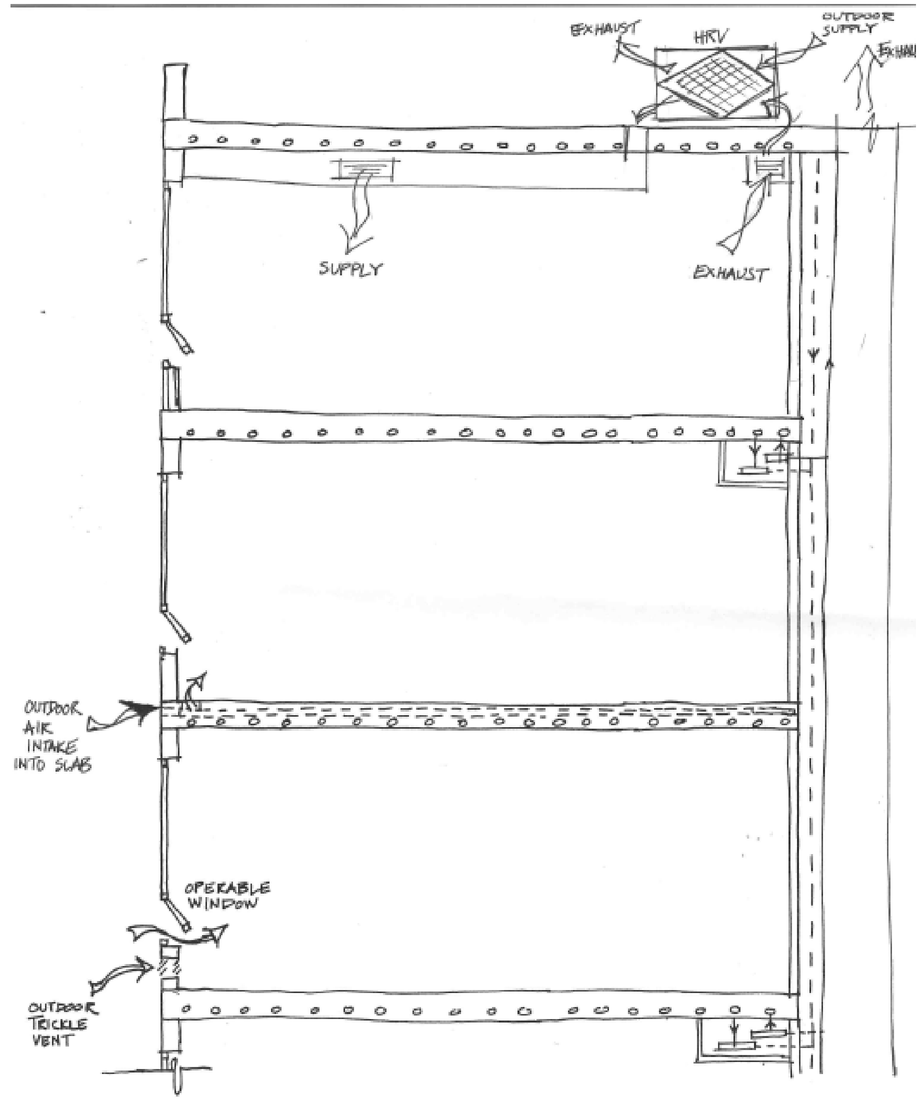
SE False Creek – HVAC Options





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SE False Creek – Capillary Tube Radiant H/C

Mats Ready For Plaster. Headers in Corridor

Plaster Applied Over Mats – Header Connection to Distribution Piping

Plaster Finishing

Mat Headers Routed to Control Centre

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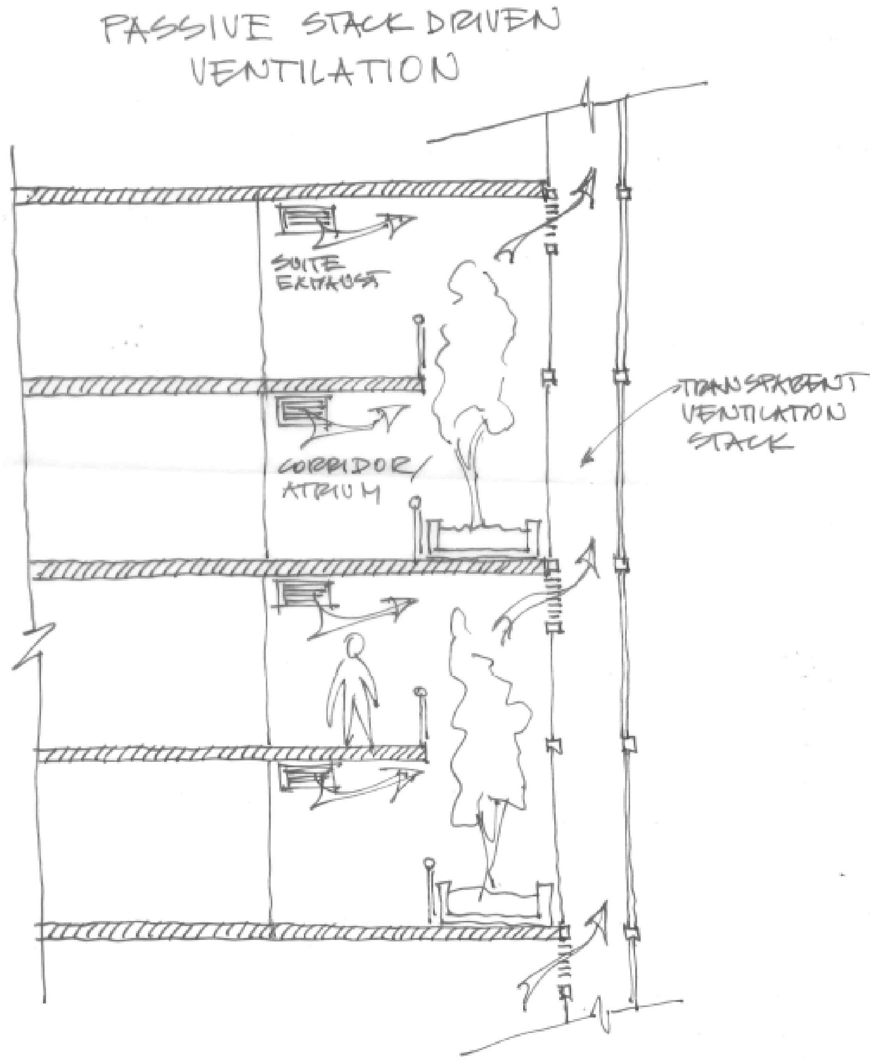
SE False Creek – HVAC Options



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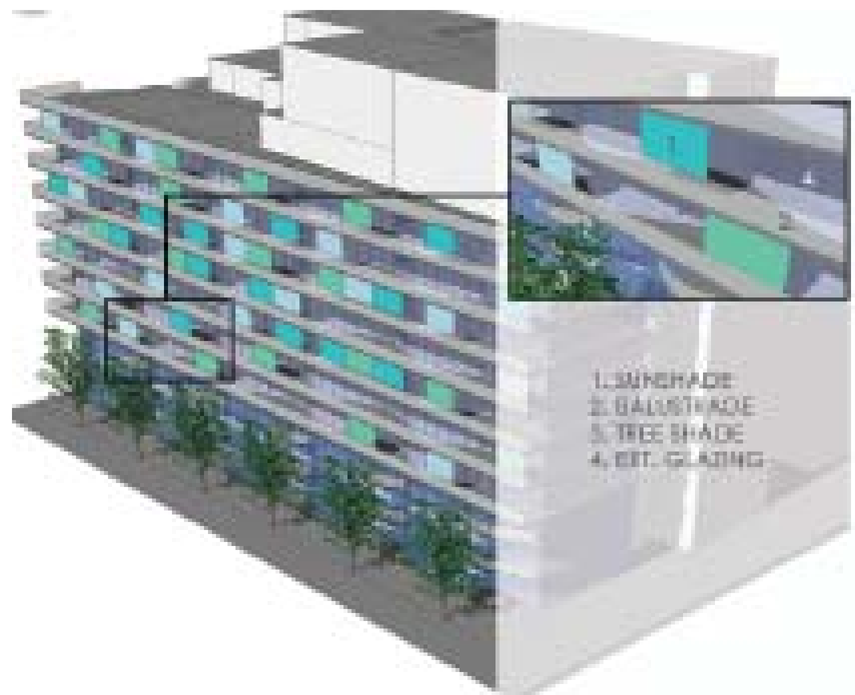
Façade Design – Shading/Window Performance



- Min glazing performance and % Glazing is critical for both energy and comfort

Parcel #9 – Net Zero Housing

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Thank You!

"Beyond sustainability, blossoming with new ideas."

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