keen green : sustainable innovation

LOWER BUILDING ENERGY USAGE WITH RADIANT HEATING AND COOLING

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Presented by:

Blair McCarry, P.Eng.

LEED™ Accredited Professional,

ASHRAE Fellow

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RADIANT SYSTEMS

- Opportunity for very low energy heating and cooling using radiant systems
- Application ideas and examples

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SIZE OF AIR SYSTEM

- Dedicated Outdoor Air Supply (DOAS)
- DOAS provides dehumidified, conditioned supply air
- Dehumidification prevents condensation on cool surfaces
- DOAS can be smaller if perimeter is improved
- Can be significantly smaller than conventional systems

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SUPPLY WATER TEMPERATURES ARE MODERATE

- Cooling
  - for radiant cooling, temperature can be ~15-17°C (59-63°F)
  - much warmer (ie. less chiller work) than usual 7°C (44°F) temperature off chiller
  - still may need 7°C (44°F) chilled water for DOAS
- Heating
  - for radiant heating, temperature is ~40°C (104°F)

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WHY IMPROVE ENVELOPE?

Envelope	Standard Design	Improved
Internal loads	100%	100%
Perimeter loads	400-500%	150-250%

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THERMAL SLABS BETTER WITH STEADY LOADS

- Have to control fluctuating perimeter loads!
- For low energy building, prevent perimeter loads from coming into building
- Thermally active radiant systems do not respond quickly to large load shifts like solar. Larger than minimum air systems may be needed to smooth out peak loads.

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OPPORTUNITIES FOR LOW ENERGY BUILDINGS

- Many sources of water/air at moderate temperature
  - ground water with recharge
  - seawater, lakewater
  - river water, piped water
  - ground source heat pumps
  - ground source piping
  - evaporative cooling in dryer areas
  - night cooling
  - heat recovery from internal cooling loads
  - Condensing boilers
  - Lower kW/Ton chillers

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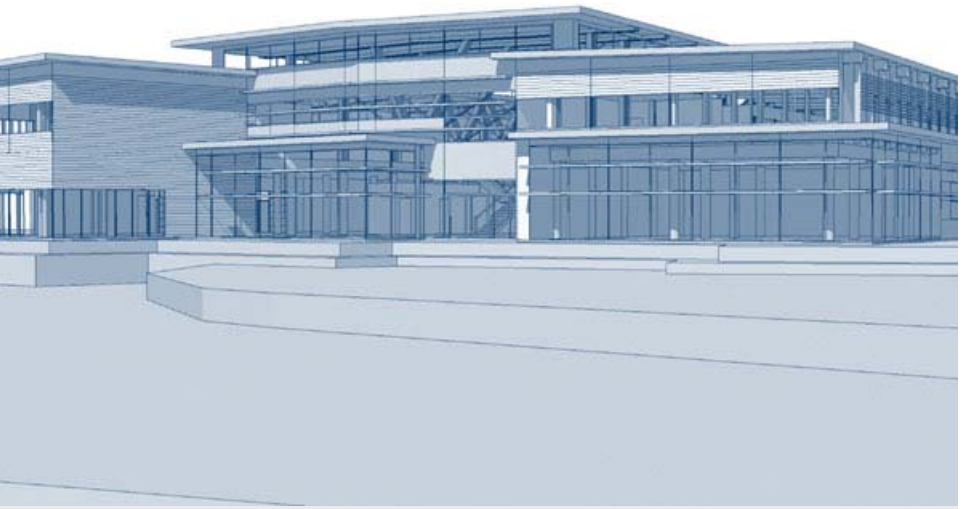
GROUND WATER WITH RECHARGE



Architect: Larry McFarland Architects

- North Cariboo Community Campus, Quesnel
- 45,000 sf
- Two well water pumps
- 22.7 l/s, 8.6ºC (360 gpm, 46ºF) ground water
- Supplies cooling coils and in-floor cooling
- Also used with water-to-water heating heat-pumps - hope to avoid having boilers
- Injection system returns water to groundwater

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GROUND WATER

Architect: Boxwood Architecture

- Joint Training Facility, City of Seattle
- Site has a water spring
- Water flows through building
- Walls of trench functions as chiller
- Radiant floor heating and cooling with natural ventilation.

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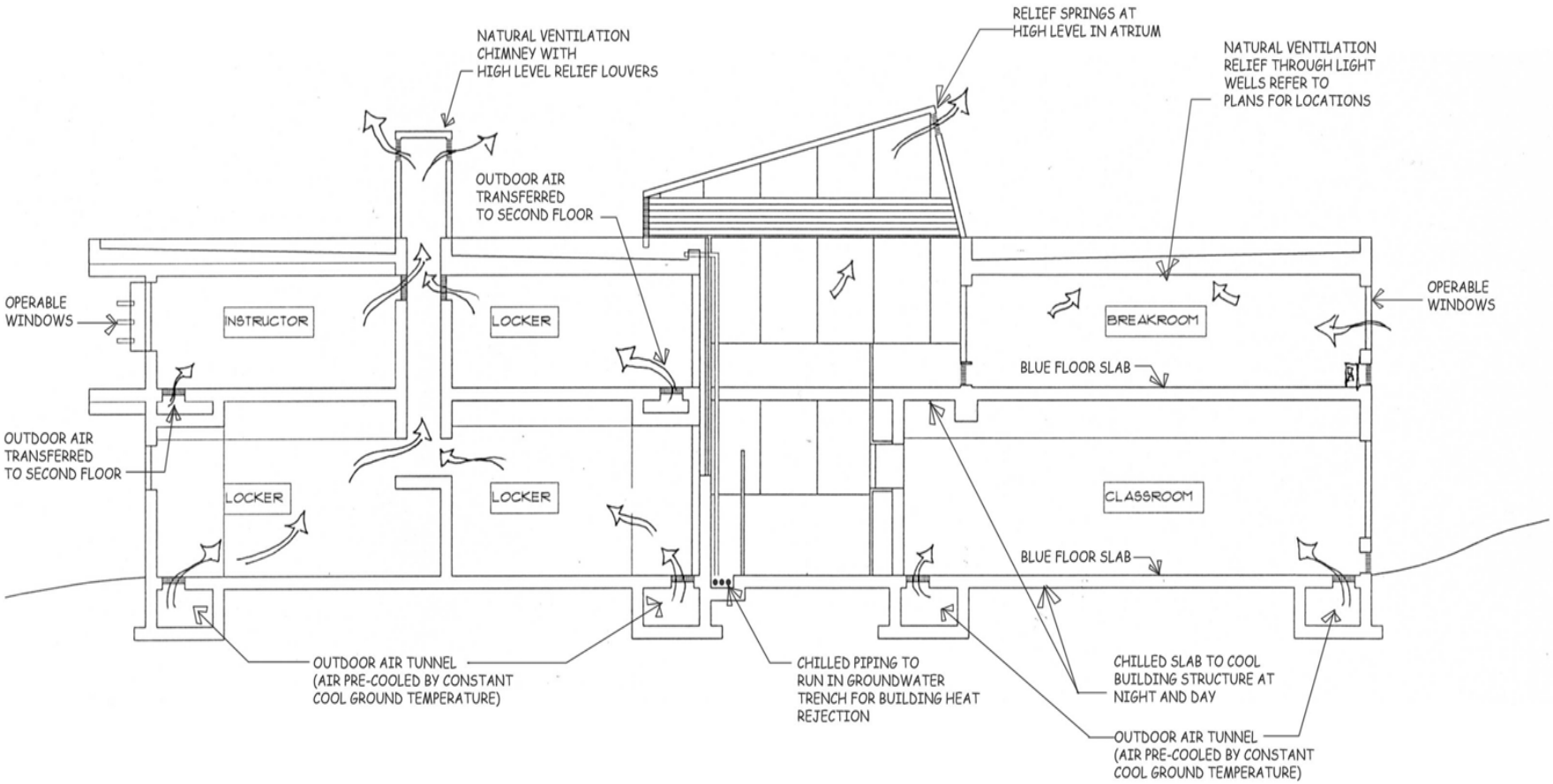
GROUND WATER



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GROUND SOURCE HEAT PUMP & DIRECT GROUND COOLING

- Husky Guest House, Toronto with Transsolar, Germany
- Winter:
  - geothermal heat pump runs a low temperature radiant heating system, heat recovery
- Summer:
  - geothermal well provides direct cooling for slabs

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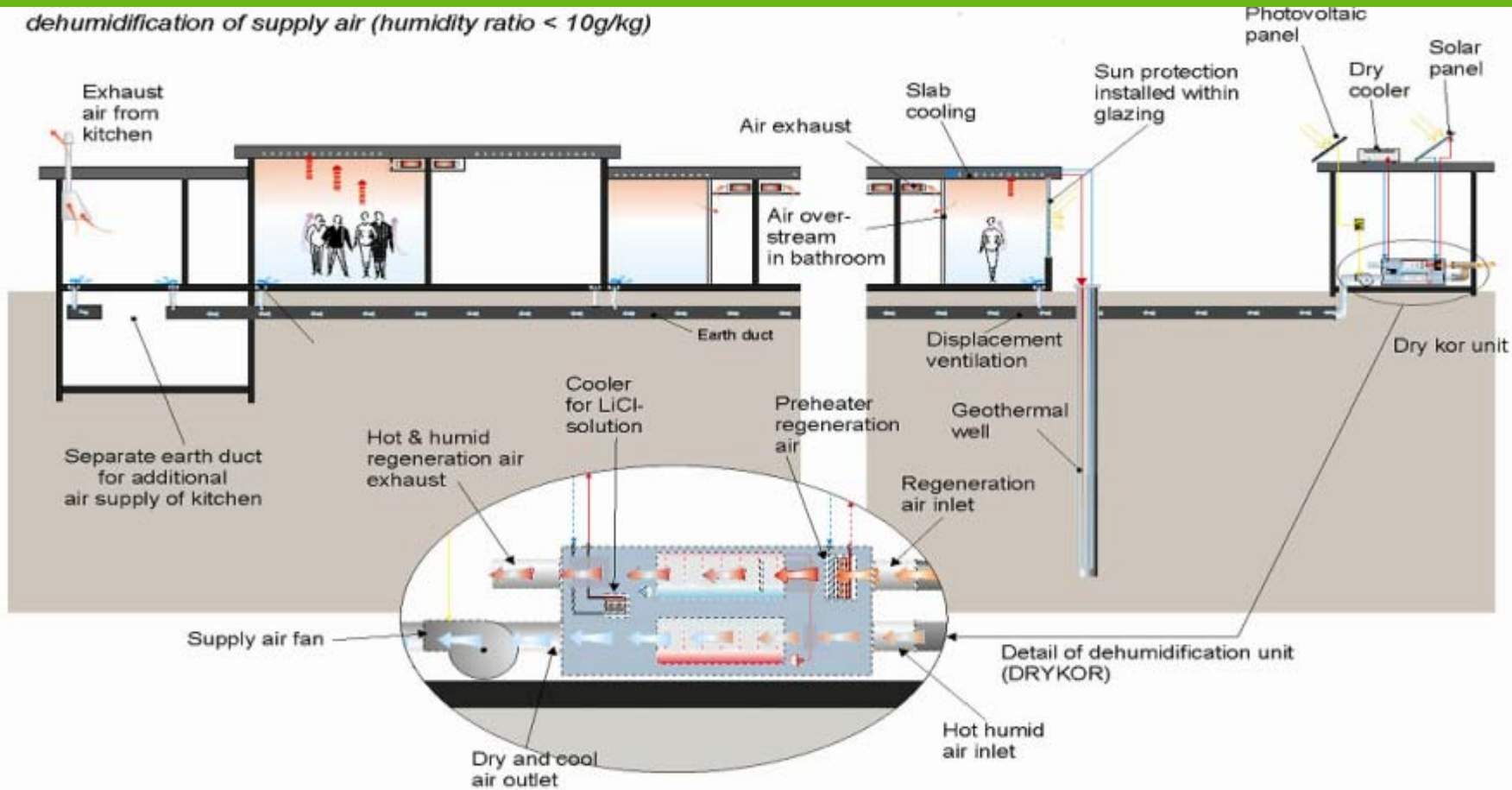
DIRECT GROUND COOLING SUMMER



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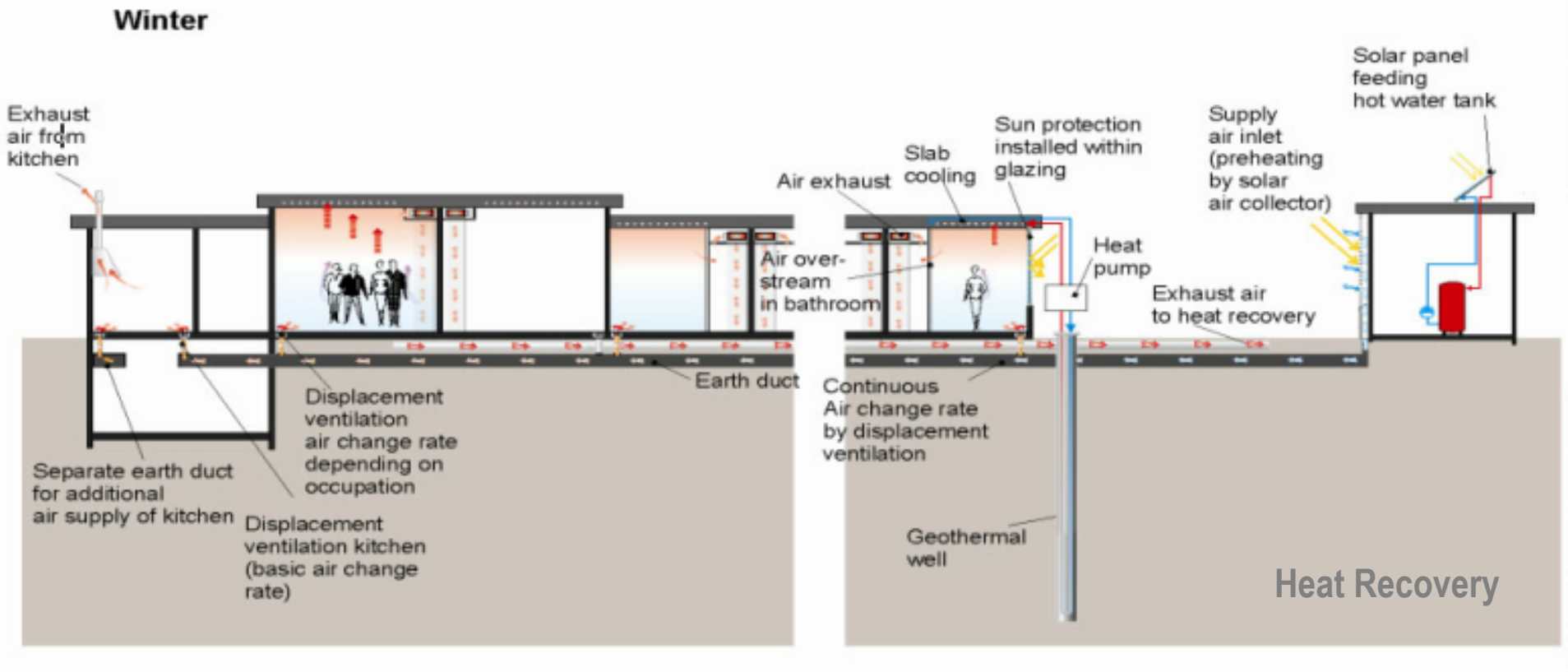
GROUND SOURCE HEAT PUMP WINTER



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DIRECT AIR COOLING

DOW Office Building, Horgen, Switzerland

- 4/5 level office building, ≈15,000m^2
- Completed 1992
- First multi storey building radiant slab cooling project
- Some PV cells on roof

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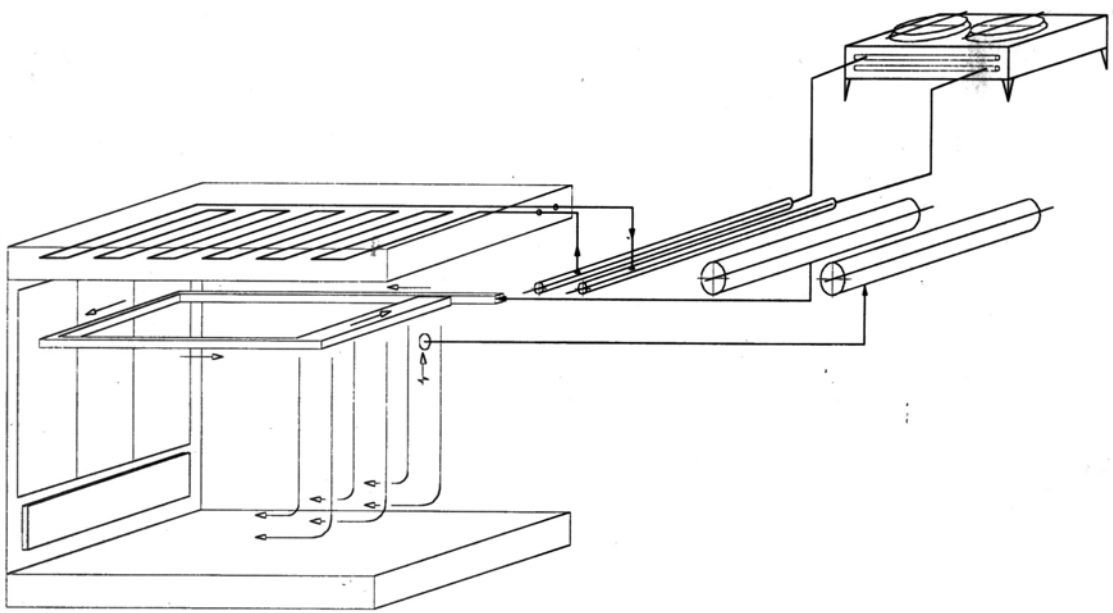
DIRECT AIR COOLING



Rooftop radiators cool chilled water at night to 18ºC (65ºF)

Only night time cooling for radiant slab

Ceiling displacement supply air

Small chiller for supply air cooling and dehumidification

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NIGHT COOLING

- For areas with high diurnal temperatures, in conjunction with thermal mass

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BC Cancer Research Centre

HEAT RECOVERY FROM INTERNAL COOLING LOADS

- Heat recovery
  - chillers cooling interior equipment areas
  - providing heat for skin loss and ventilation
  - Radiant slab in office end of building
  - Radiant slab for heating and cooling

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ICICS

- Computer Research Building
- Energy study predicts
  - 39% of MNECB
  - 45% of ASHRAE 90.1(est)
- Slab option has
  - lowest capital cost
  - lowest operation cost
  - lowest maintenance cost
- Higher temperature chilled water and heat recovery from chillers

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GSHP wells under grass

AMSTEIN + WALTHERT OFFICE BUILDING, ZURICH

Direct Ground Water Cooling

- 15.5ºC (60ºF) CHWS at beginning of summer
- 20.5ºC (69ºF) CHWS at end of summer
- 25.5ºC (78ºF) maximum room temperature
- Direct ground piping cooling 220 m (720 ft) deep
- Heat Pump heating

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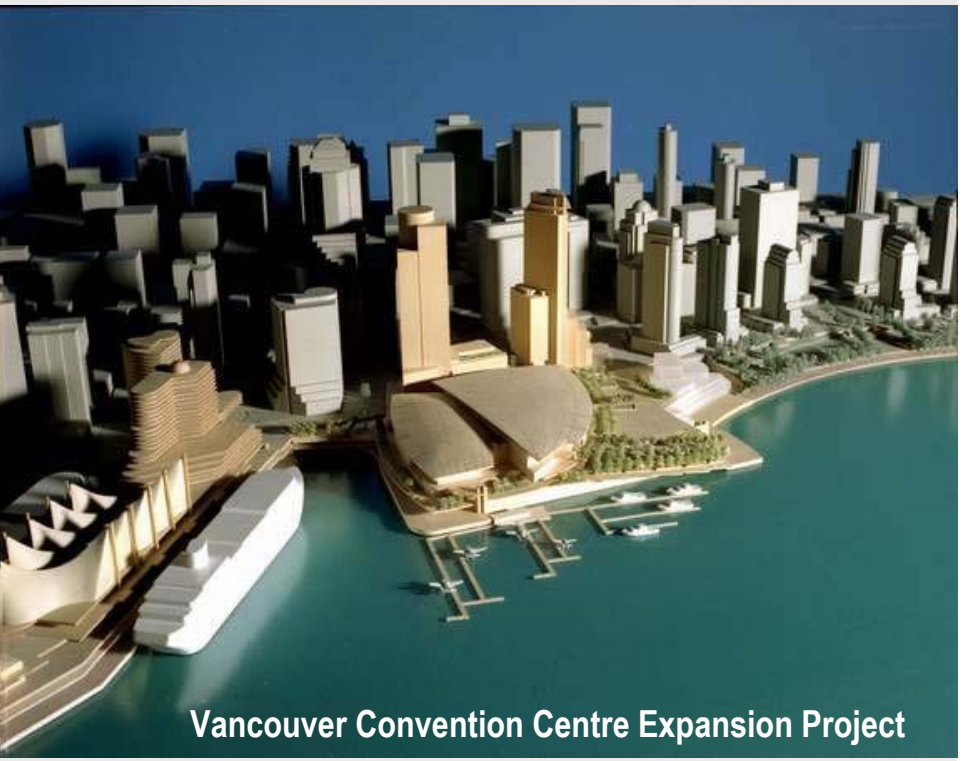
SEA WATER COOLING AND HEAT PUMP


Vancouver Convention Centre Expansion Project

- Thermal mass can mean smaller chillers with load shift with radiant cooling
- Sea water cooled/heat pump chillers
- Direct sea water cooled radiant slabs
- Heat Recovery from chillers
- Radiant Heating and Cooling in perimeter areas

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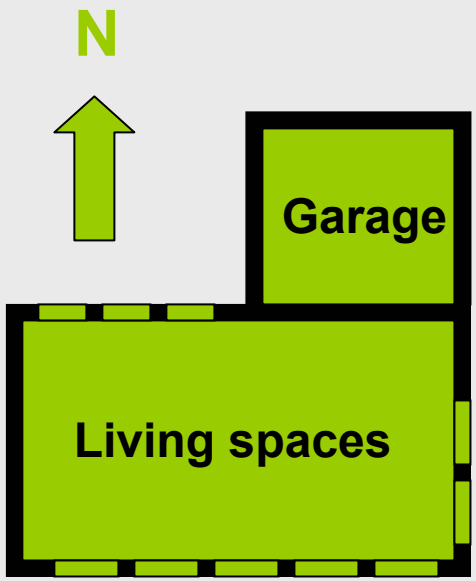

EVAPORATIVE COOLING

- Radiant ceiling uses water from cooling tower
- Reduces load on conventional system in all climates
- Simple house modeled

COOLING LOADS

Richard K. Strand, U of IL, 2003 ASHRAE Presentation

Climate	Location	Conventional only	Radiant/Forced Air
Mild, Dry	Spokane WA	1570 kWh	5 kWh
Mild, Wet	Peoria IL	2450 kWh	300 kWh
Hot, Dry	Phoenix AZ	9480 kWh	1400 kWh
Hot, Wet	Key West FL	6020 kWh	3140 kWh

THE BRIDGES

Architects: Busby & Associates

- 60 kW Microturbine/Cogen
- Absorption cooling for retail
- Radiant heating/cooling in residential
- Groundwater with recharge for cooling residential

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HINTON TOWN HALL, HINTON, ALBERTA

- No Chiller
- Cooling from Heat Exchanger on domestic water mains
- Mains continue out to industrial user
- Has been applied to civic projects

Architects: Manasc Isaac Architects

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CHILLER SAVINGS USING HIGHER CHILLED WATER SUPPLY TEMPERATURE (Screw Chiller Example)

Water-cooled (incl. aux.)

44 / 85ºF	0.65 kW/ton
60 / 85ºF	0.50 kW/ton

Air-cooled

44 / 95ºF	1.20 kW/ton
60 / 95ºF	0.96 kW/ton

20% to 25% reduction

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CONDENSING BOILERS AND WATER HEATERS

- Standard Boilers 80% Efficient
- Mid Efficiency Boilers 84%
- Condensing Boilers ~92%
- Direct Contact Water Heaters ~95%
- Radiant heating temperatures work well with the most efficient boilers

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CENTRAL PLANTS (Campus)

Set supply heating and cooling mains temperatures

Can benefit plant with higher ΔT's (lower cost?)

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OTHER OPPORTUNITIES

Lake Water Cooling

Evaporative with night sky radiant cooling and water storage

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