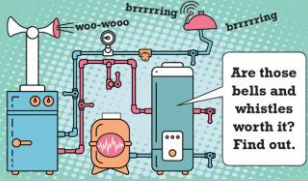


Introducing HVAC to Architects

Heating
Ventilating
Air-Conditioning

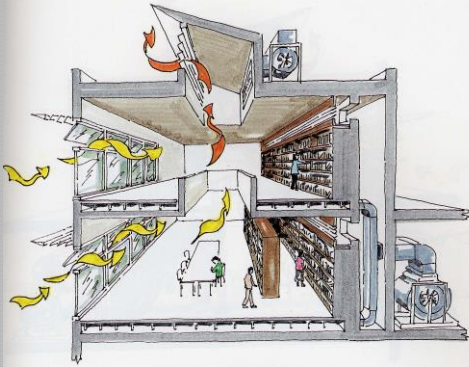


Sponsored by ASHRAE
American Society of Heating, Refrigeration and Air-Conditioning Engineers



1

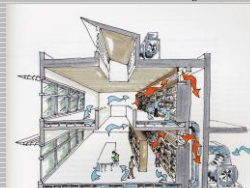
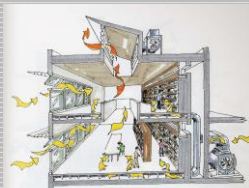
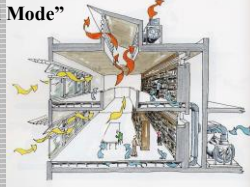
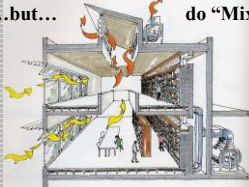
Design buildings for this:



2

...but...

do "Mixed Mode"



3

Battle of Yom Kippur (w/the ME)

An air-conditioned sanctuary for Dead Sea Scrolls sounded embarrassingly contradictory. Functionally speaking, it is simply this: the air of Jerusalem (unlike that of Tel Aviv and Haifa) is sparkling dry, like champagne; the sanctuary is half underground, partially buried in rock, earth and fill. That provides for natural cooling in summer and warming in winter. Furthermore, the dome is open at the top and so shaped that the warm air is pressed upward by the cool ground. In addition, we have provided a circular spray of fountains over the upper part of the dome; they provide continuous cooling which can be diminished or strengthened as the summer heat demands. To add mechanized dehydration and frigidity to the air would be a sheer waste of equipment and money, and, worst of all, artificial in this atmosphere of antiquity. Churches, synagogues, mosques—domes of any sort throughout the ages in the East, the West, North and South, these man-built caves have been the very natural refuges from the confinement by summer heat.

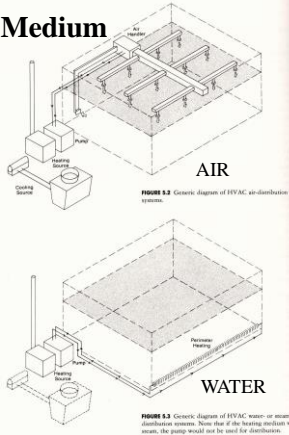
From Fredrick Kessler's journal *Inside the Endless House*, 11 Oct 1959

The decision not to air-condition the shrine artificially was made yesterday. Today was another victory in the making. It concerns 338

4

Classified by Delivery Medium

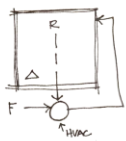
Effective Air
vs.
Wonderful Water
+
Combo?



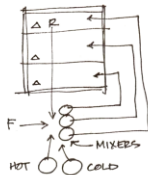
5

MEDIUM SCALE ALL-AIR SYSTEMS

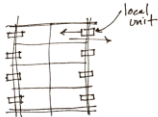
① CENTRAL SIMPLE SYSTEM



② MULTISENSE SYSTEM



③ INDIVIDUAL LOCAL UNITS



F = Fresh air supply R = Return air supply
Δ = Thermostat

6

① CENTRAL SIMPLE SYSTEM

For medium-sized one zone bldgs.
(or one for each big zone)

1 thermostat
1 air mixture

Also known as Direct Expansion (DX)

Uses: warehouses, factories, big box retail, bowling alleys, the Eden Project...

7

DX Heating and Cooling
Eden Project, Cornwall

8

② MULTISENSE SYSTEM

For multizone zone bldgs

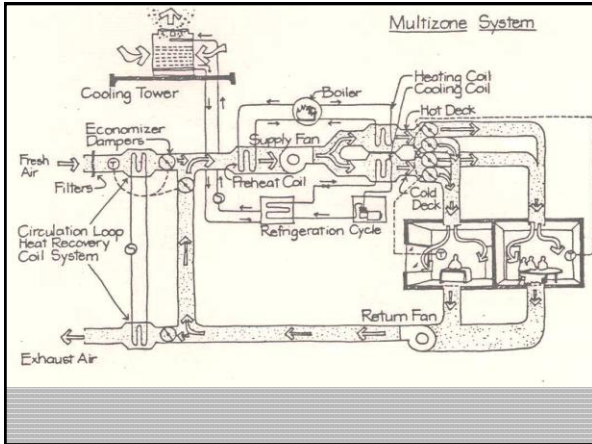
1 thermostat/zone
1 air mixer/zone
1 supply duct/zone
Common return

Also known as Multizone

Can heat and cool simultaneously

Uses: simple buildings that need both heating and cooling...
IDL/SDL mixed use...

9



10

③ INDIVIDUAL LOCAL UNITS

For individual units

- 1 thermostat/unit
- 1 air mixture/unit
- 1 supply duct/unit
- No shared resources

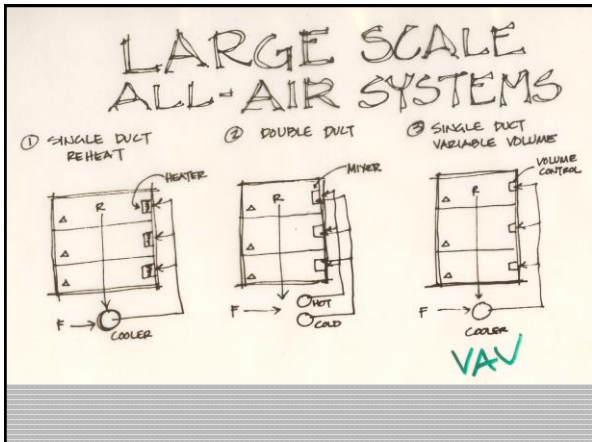
Can heat and cool simultaneously
Each unit can be metered separately

Uses: cellular buildings—hotels, apartment blocks, condos...

Pictured: mini-splits in an apartment building

Courtesy CNN

11



12

① SINGLE DUCT REHEAT

For large IDL bldgs

- 1 thermostat/zone
- 1 re-heater/zone
- 1 supply duct/zone
- Common return and fresh air

Lowest first cost system

Idea is to cool for biggest load, reheat for all others...

“From an energy point-of-view can you imagine a more stupid system?”
--John Reynolds

13

Fan coil units to reheat cool air...

Write the words in the correct places to label the hair dryer!

- fan
- heating coil
- motor
- electricity
- hot air

Hand-held Fan coil heater

- The hot air is pushed out by the fan.
- The energy source is electricity.
- The hot coil heats the air in the tube.
- Electrical energy is converted to heat energy when it passes through the coil of wire.

14

Reheat System

Reheat System

Labels in diagram: Cooling Tower, Economizer Dampers, Fresh Air, Circulation Loop Heat Recovery Coil System, Exhaust Air, Boiler, Cooling Coil, Preheat Coil, Heating Coil, Reheat Coil, Refrigeration Cycle, Warm Water, Cool Water, Return Fan, Supply Fan.

15

② DOUBLE DUCT

For large multi-use bldgs

- 1 thermostat/zone
- 1 mixer/zone
- 2 supply ducts/zone
- Common return and fresh air

Mercedes of HVAC systems

Costs both more money and space...

To solve space problem use perimeter or exterior duct work.

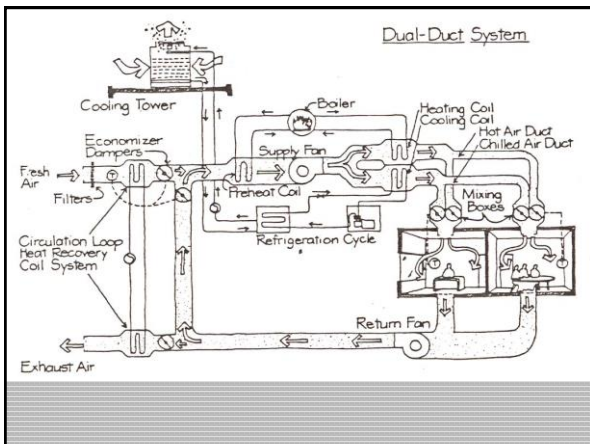
16

40% of the building cost is the HVAC

Blue Cross Blue Shield, Boston
Paul Rudolph

Fig. 7.8 Dual-duct, high-velocity distribution ducts and return duct integral with the facade of the Blue Cross Blue Shield building. Photo shows building in construction.

17



18

① SINGLE DUCT VARIABLE VOLUME

VOLUME CONTROL

F

COOLING

VAV

For large IDL bldgs

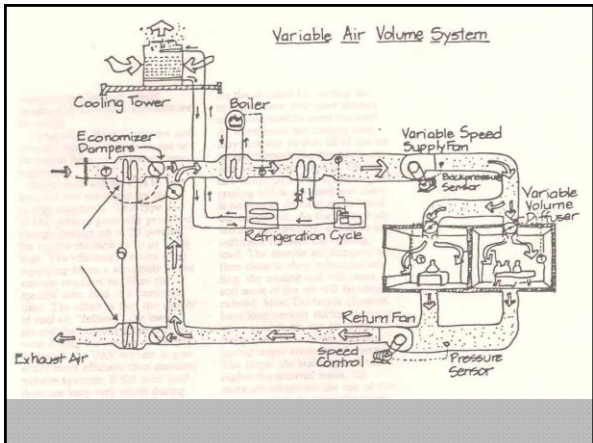
1 thermostat/zone
1 volume control/zone
1 supply duct/zone
Common return and fresh air

For buildings that never need heating

Most common HVAC in large buildings...

Solves problem of not whether to cool, but how much to cool...

19



20

Mixing in unoccupied zone generated by convection currents

Temperatures gradient within space

Screen with low level perforation

Occupied zone

Driving convection air flows generated by heat sources such as people & office machines

Perimeter heating

Summer 20°C 24°C 26°C 18°C / 22°C / 0.3m/s Supply air slightly below room air temperature

Winter 19°C 21°C 25°C Displacement supply air terminal (100% outside air at very low velocity)

Exhaust air

A. Air flow.

Early (1984) Displacement Ventilation System
Arup Bristol Office

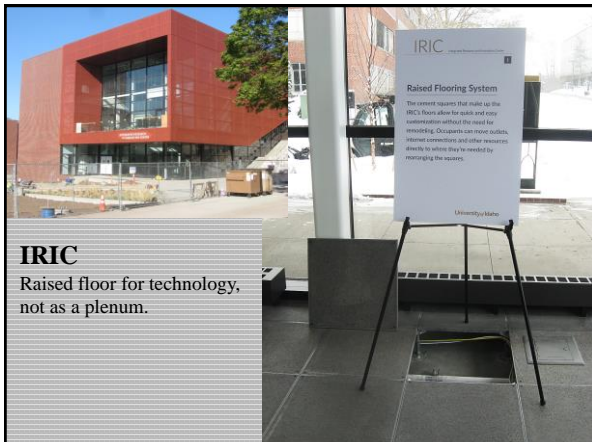
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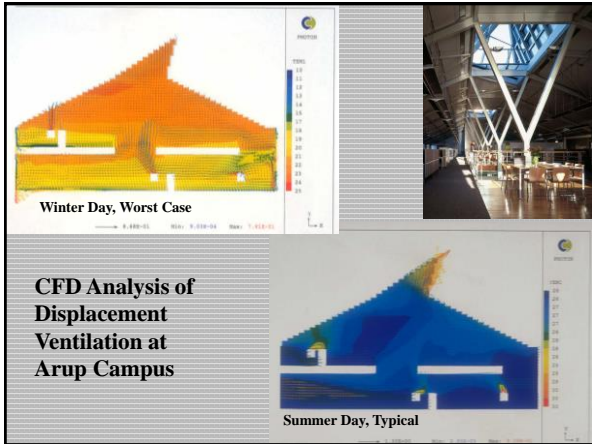
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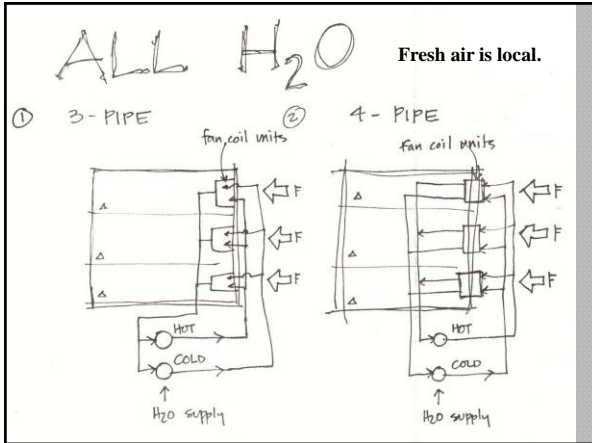
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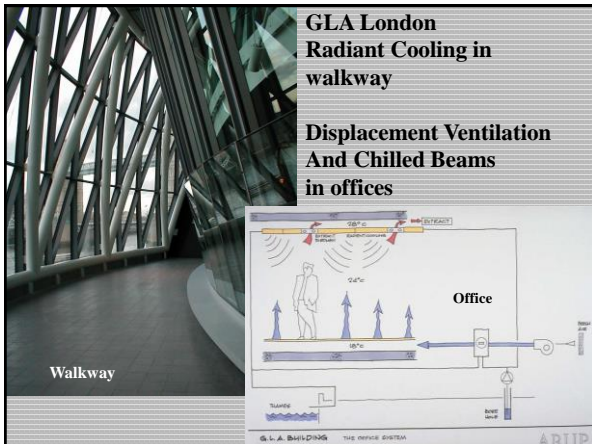
24



25



26



27

**John Hope Gateway, RBGE
Radiant Cooling via
Chilled Beam**



Chilled Beam



28

AIR/H₂O

① DUAL DUCT, HIGH VELOCITY

Hybrid system

- 1 thermostat/zone
- 1 fan coil/zone
- 2 supply pipes/zone
- 1 supply duct/zone
- Common return and fresh air

Identical to 4-pipe + high speed air supply

Smaller air ducts...fresh air control

29

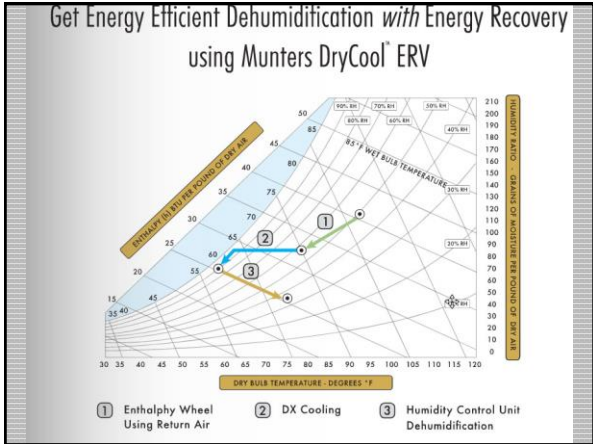
Energy Wheel
Exchanges both heat and humidity

Summer mode: cools fresh air and removes moisture

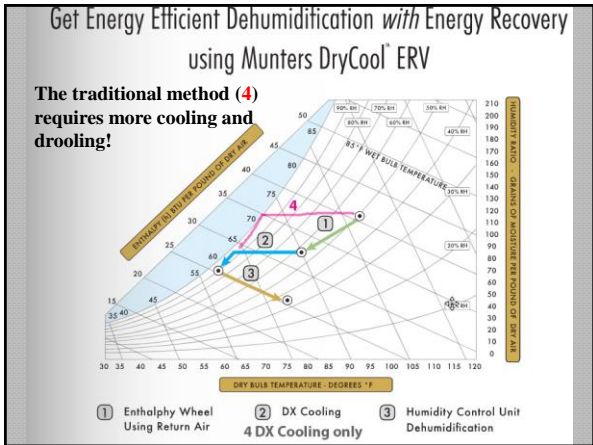
Winter mode: warms fresh air and adds moisture

L. J. Wang Mfg. Co., Div. of Aero-Flow Dynamics, Inc.

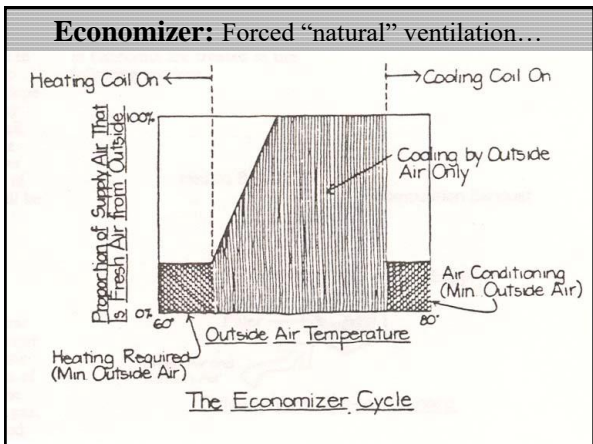
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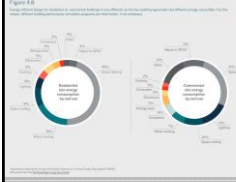


32

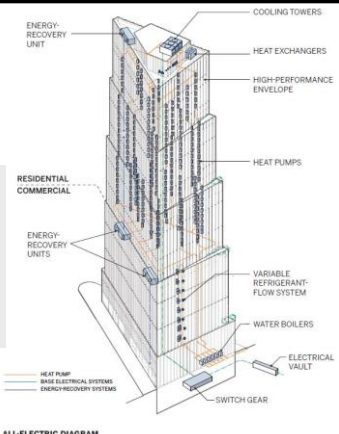


33

A large mixed-use building may use different systems for different uses.



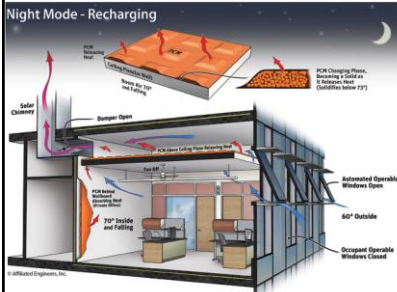
Commercial and residential loads in the same climate differ!



34



Advanced buildings may be passive/active hybrids... at UW this building is almost purely passive: natural ventilation + phase change material.



University of Washington's Molecular Engineering & Sciences Building
ZGF
Seattle, Washington
A PQE helped ZGF understand the effectiveness of a phase-change material used at the University of Washington's Molecular Engineering & Sciences Building. For the project's second phase, which is now under construction, the firm has modified the ceiling design to boost the material's performance.
Image courtesy Affiliated Engineers Inc.
[View Related Story](#)

35



In a benign climate no HVAC!

**1111 Lincoln Road
Miami Beach, FL
Herzog & de Meuron**

36

Multiple Building Heating and Cooling Systems

Examples:

❖ Community Scale **BedZED Central Heat and Power CHP**

❖ District Scale **Architecture 2030 District Seattle**

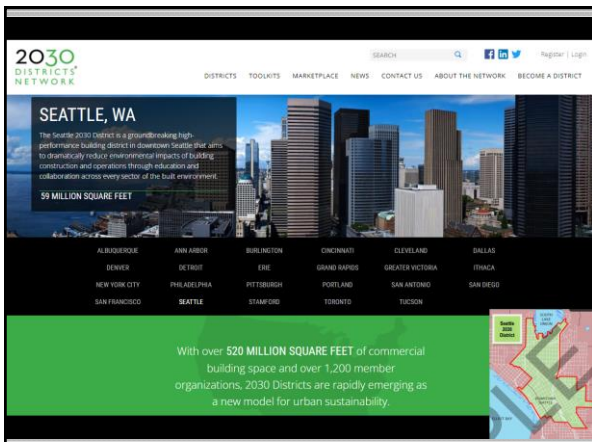
❖ City Scale **Toronto Deep Lake Water Cooling**



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38



39

What is the Seattle 2030 District?

The Seattle 2030 District (SD2030) is a membership organization that bridges the gap between the private and public sectors to reduce the environmental impact of buildings in Seattle. Our 140 members have made the commitment to significantly reduce water and energy use, pollution from construction, and carbon emissions from transportation by the year 2030.

The impacts from buildings and transportation emissions are the two leading contributors to climate change in the Pacific Northwest. Our unique relationships with the community, private sector, public officials, and building owners positions us as an important new resource for dramatically improving the health and environment of the region.

260 Buildings Committed
58.9M Committed Sq. Ft.
7.2%+ of Buildings
24.3%+ of Sq. Footage

Making a Difference

Our leaders create shared market solutions to developing and operating high-performance buildings by transforming the way buildings are designed and constructed, as well as the operations and codes governing their ongoing performance. The organization also works to directly build environmental

- Providing a voice for high-performance real estate developers and operators.
- Convening shared collaborations in diverse forums.
- Identifying opportunities to improve building design and operations.
- Developing strategic partnerships that benefit membership.
- Advocating for state policies that encourage high performance.

Working directly with real estate owners and developers, as well as architects, engineers, and contractors, the District provides proven strategies and solutions to transition to high performance. Projects focus on building availability, programmatic, and economically viable strategies to reducing environmental impacts, increasing resilience to current and future challenges, lowering operating costs, and increasing property values.

Some examples of projects we have worked on include:

- Piloted the Smart Buildings Initiative, which aims to deploy advanced software to run smarter, more efficient buildings.
- Promoted the use of rooftop gardens, rainwater collection, permeable pavement, and other alternative technologies that produce a range of 220 water gallons of stormwater annually by 2020.
- Created a network of electric vehicle charging stations to utilize Seattle's clean hydroelectric power for transportation through Liberty Health.
- Created policies and transactions, such as the 2020 Challenge Pilot and Pay for Performance, to make a greater return on investment in building upgrades.

40

Toronto is home to the world's largest lake-powered cooling system. Here's how it works.

Deep lake water cooling (DLWC) is used to cool over 100 buildings in the city. It saves enough electricity to power a town of 25,000 — and it's so popular the city is pursuing an expansion.

©2017 Energy Canada. All rights reserved. Credit to Toronto. The cover design, the layout of the text, some headlines and graphics are the property of Energy Canada.

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1. Three pipes pull water

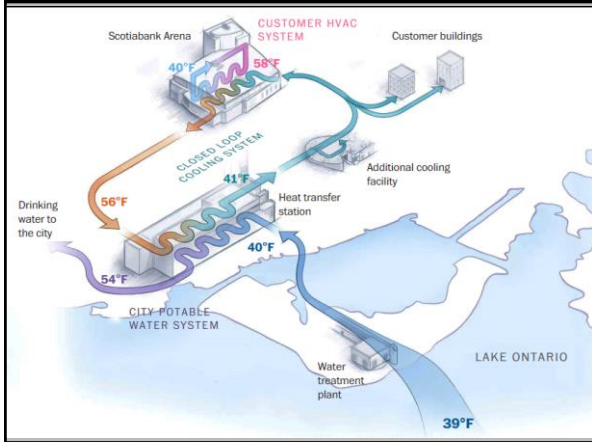
2. Lake water makes its way to the city through a heat transfer station

3. Pipelines carry cooled water to buildings in downtown Toronto.

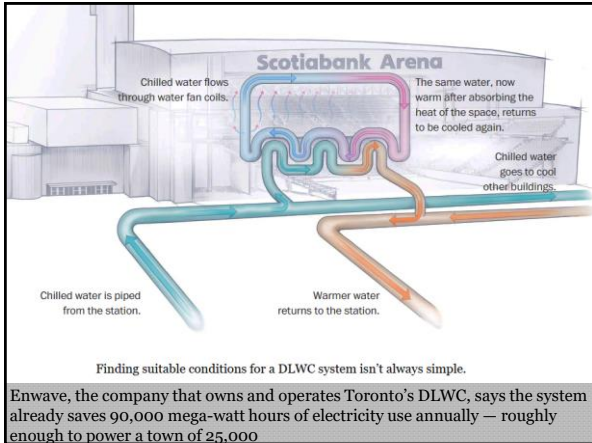
Map labels: CANADA, Toronto, Lake Ontario, INNER HARBOR, Water treatment plant, Scotiabank Arena, TORONTO, N.Y., Vt., N.H., Mass., Conn., N.J., Phila.

500 M / 1000 FEET

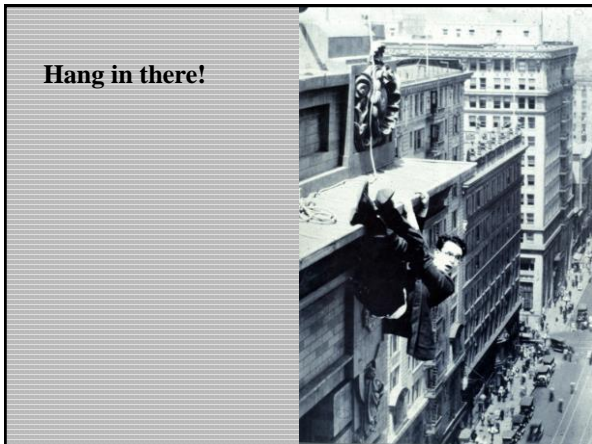
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