Future District Systems in Daegu

Propose a high-performance, low-carbon district system

Juye Kim. MS-BPD

juyek@andrew.cmu.edu

Daegu,
the third-largest
metro city
in South Korea.

Population: 2.5Million

Winter Temperature:
L: -2.9C (26.8F) H: 5.9 (42.6)
Summer Temperature:
L: 23.1 (73.6) H: 40.0 (104.0)

Graphic: Carbon Brief. © Esri

Energy Stats of Daegu

Energy Mix by Sources (%)

Total yearly energy consumption: 4.3M TOE

Oil/Petroleum	Electric	LNG	Coal	Renewable
39.2	29.90	21.9	4.2	4.8

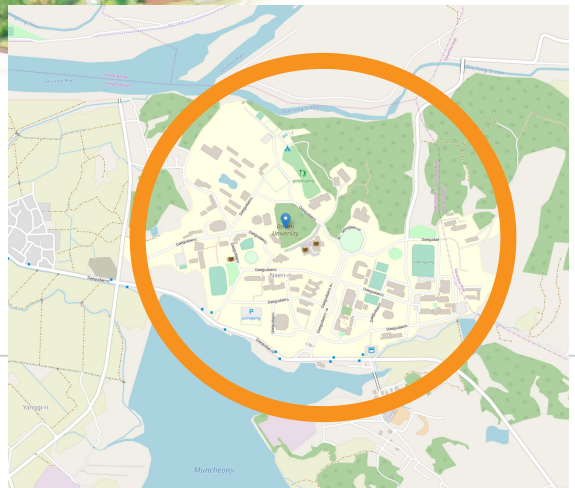
Electricity Generation by Sources (MW)

Total	Coal	LNG	Renewable	Oil	etc
587.5	72.9	370.7	90.5	43.5	9.9

Daegu University

Number of students: 20,000
Established: 1946
Campus lot size: 900 acre
Number of buildings: 50

No district system exists in the campus



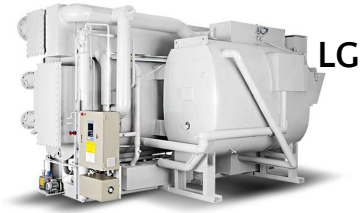
Current Building HVAC System

Buildings in the campus use LG's VRF HVAC system, with electricity as main fuel

LG Multi V Super 5 (outdoor unit)

- Variable Refrigerant Flow (VRF) system
- Include Inverter Compressor

LG Multi V Indoor units



LG Chiller: provide cold water

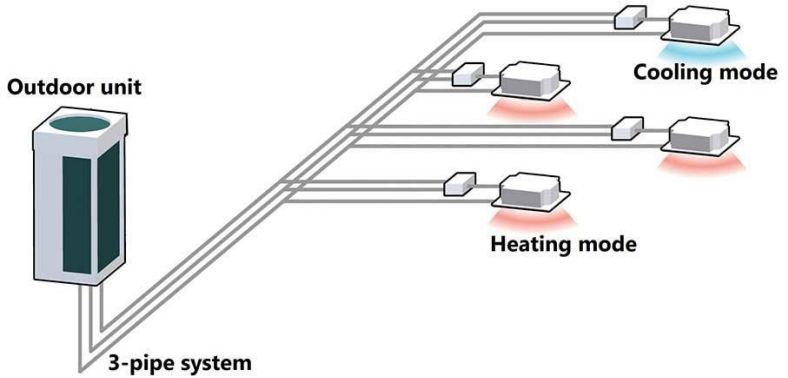
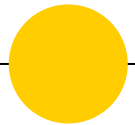


Figure: Engineering Systems
https://www.esmagazine.com/articles/99646-vrf-technology-the-missing-link-to-lower-utility-bills

Proposal



Interesting Fact!

The campus is located
between “Muncheonji” lake and “Gumho” river

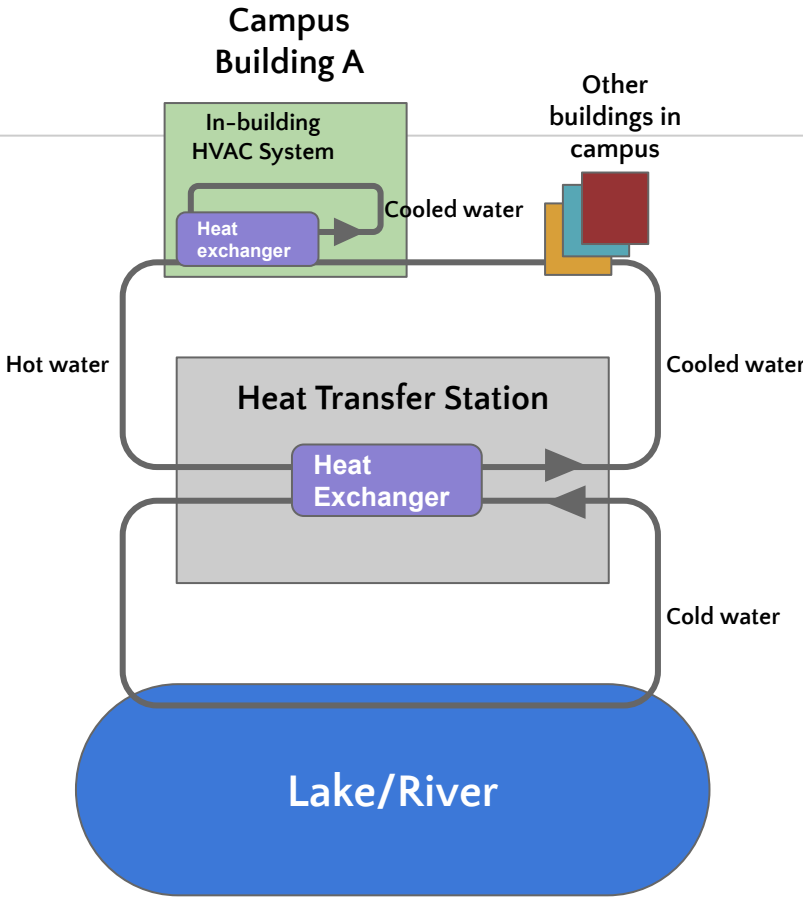
Proposing New District System

- Propose **Lake/River-powered Cooling System**

- The campus is located in **perfect place** to utilize water to operate cooling system
- We can source water from both lake and river
- It will dramatically reduce overall cost currently used for cooling (electricity)

How it works?

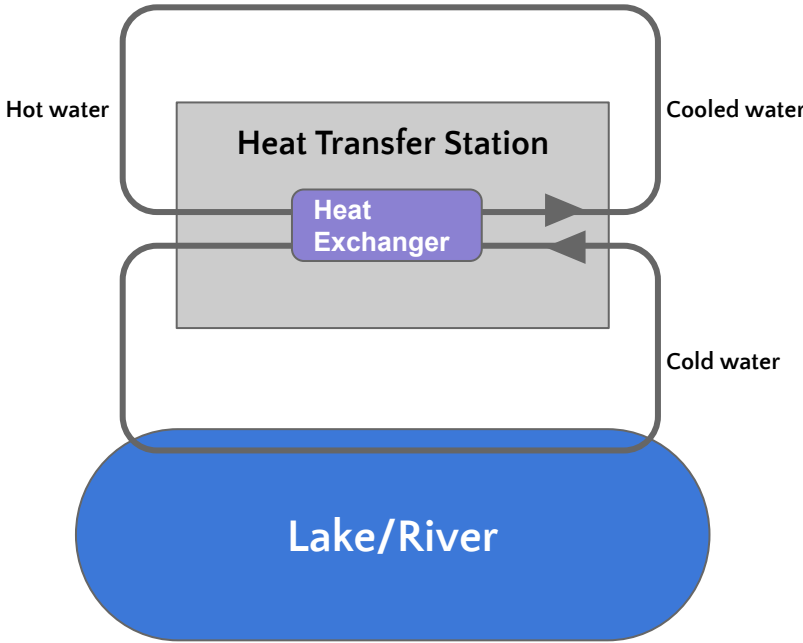
- Use naturally cold water from lake/river as a heat sink.
  - The water is pumped through one side of a heat exchanger.
  - Another side, cooled water is generated.
- Advantage: **efficiency**
  - Only 1/10 of average energy is needed than conventional cooling system



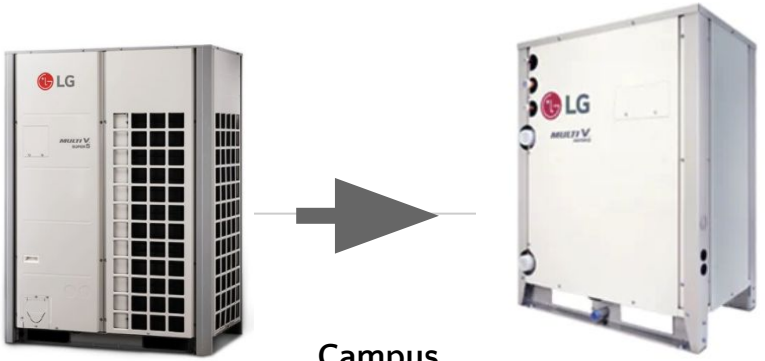
Project Overview

Water Sourcing side

- We will build heat transfer station
  - Heat exchanger will be housed
- We will install pipes from lake and river to heat transfer station

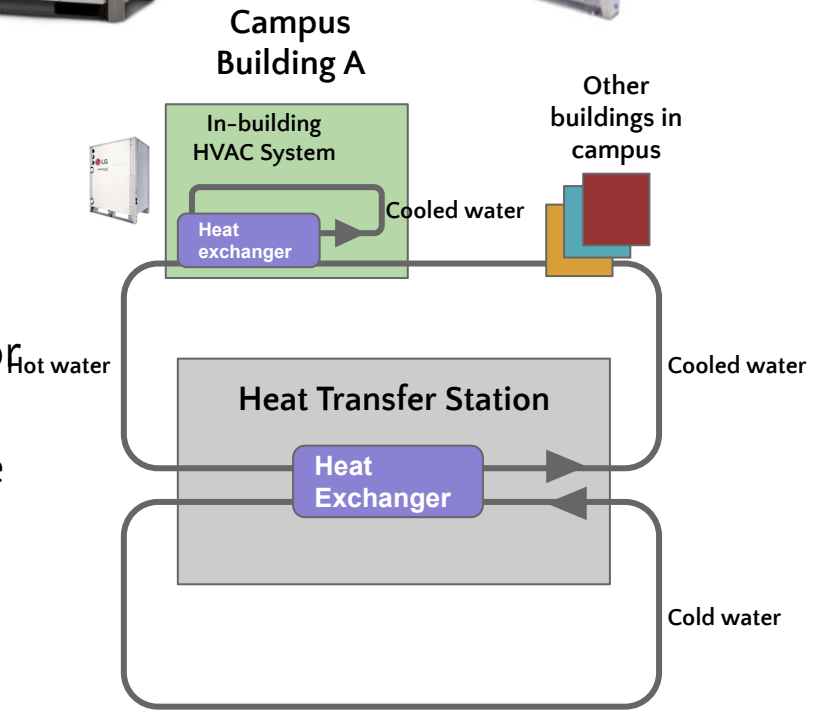


Project Overview



Individual Building side

- Water loop will be built along with in-building heat exchanger
- Water-sourcing outdoor units will get the chilled water
- Existing electricity-based HVAC VRF outdoor units will be replaced to **water-sourcing LG Multi V outdoor units,** which are compatible to existing indoor units already installed in the building




LG
MULTI V WATER IV
LG
MULTI V WATER IV

Benefits

- **Huge energy savings for cooling**
  - Case studies show that **30-70% electricity cost is reduced** by moving to the proposed cooling. [Root 2021, Cornell 2021, Choi 2021]]
- **Use fully renewable, local energy source**
  - It can Drastically lower carbon footprints
  - 85% of electricity in Daegu is from non-renewable sources, **and we contribute to reduce the usage of the electricity which results in many carbon footprints.** [Daegu 2021]
- **Remove potential health issue from cooling towers**
  - Evaporative cooling towers often have fatal bacterium Legionella pneumophila. The proposed method totally removes cooling towers. [Wiki 2021]
- **Don't need to install heating and cooling installation on the roof**
  - While reducing the installation costs, noise of operating and urban heat island effects can also be reduced

Challenges & Ideas for overcoming this challenge

- **1. High Upfront Cost**
  - Setting-up new infrastructure has high bill
  - E.g., Cornell University project costed $58.5M [Cornell 2021]
- **Solution/Idea**:
  - **1. Apply subsidiary programs** from regional/national government. Catch: lower carbon footprint.
    - If we succeed, it will be Daegu's first kind of lake/river powered cooling project
  - **2. Reuse HVAC infrastructure:** Current HVAC infra can be reused only except outdoor unit, which currently is electricity-based.

Challenges & Ideas for overcoming this challenge

- **2. Possible Opposition from Local Community**
  - Cornell had strong opposition from community for its potential environmental effects such as lake water temperature increase, water quality issues, etc. [Cornell 2021]
- **Solution/Idea :**
  - **1. Scientific Advocacy & Communication**: We can continuously measured its environmental effects with governmental authorities and shared the results with local community, and assured its safety. Cornell did this approach and local community embraced it.[Research Foundation 2011]
  - **2. Joint-Program for local community**: For those live nearby to campus, and want to participate the lake/river-powered cooling system, welcome them to join in the system. Ask them for minimal cost (e.g., pipeline cost from nearby campus infra to their home).

Case Studies

1. Toronto, Canada
2. Cornell University
3. Lotte Tower, Seoul

Case 1 : Toronto, Canada

- The world's largest lake-powered cooling system
- Gets water from Lake Ontario
- Cools 150 buildings
- Cooling load: 75,000RT (Refig.Ton)

Benefit/Effect:

- **Saves 900MW hours annually in the city for cooling**
- E.g., Scotiabank Arena building, one exemple building that uses the cooling system, **reduced electricity 70%.**

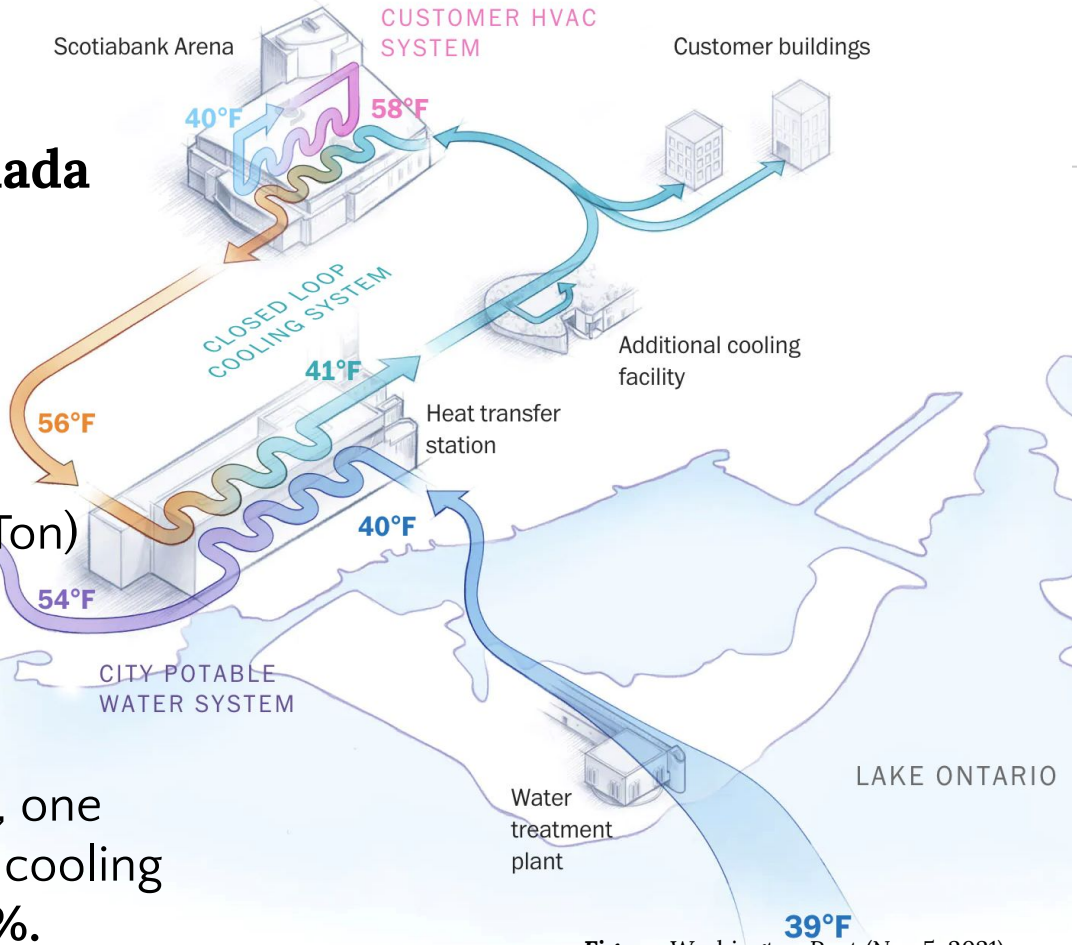
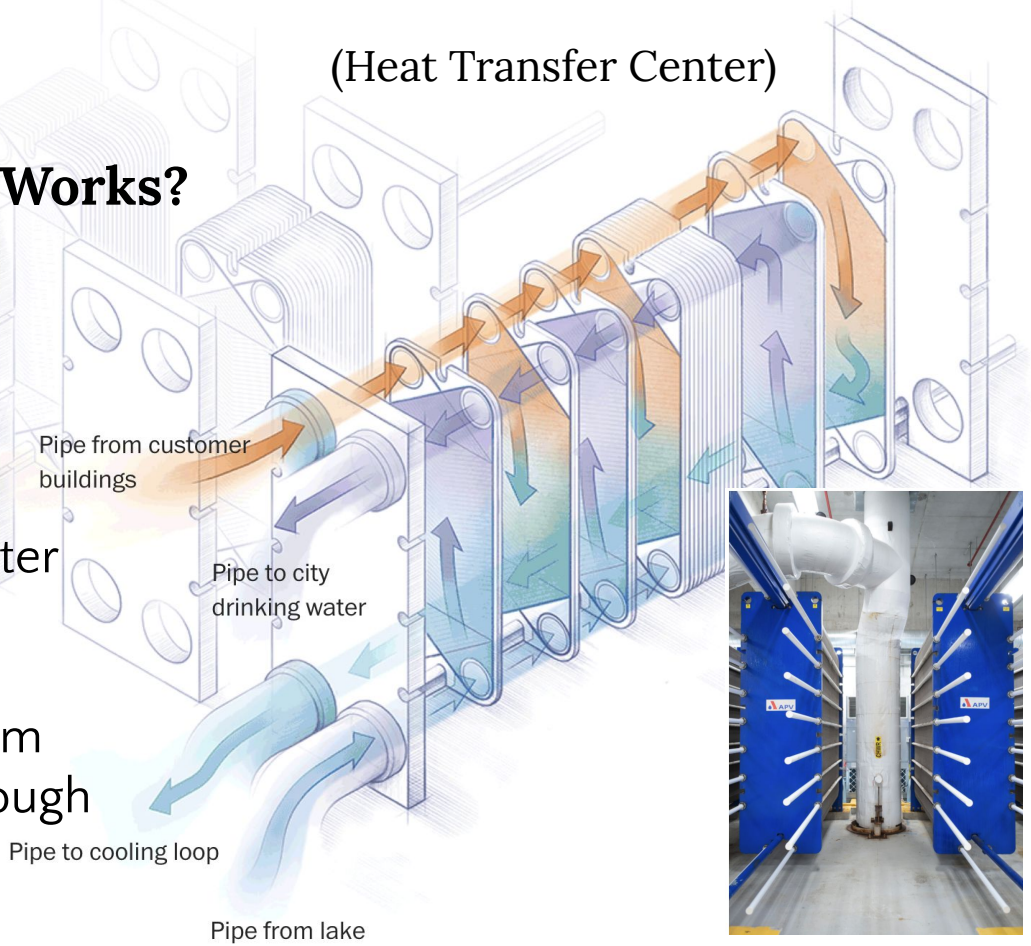


Figure: Washington Post (Nov 5, 2021)
https://www.washingtonpost.com/climate-solutions/interactive/2021/toronto-deep-latke-water-cooling-raptors/

(Heat Transfer Center)

How Heat Exchanger Works?

- Large passive heat exchangers are installed in heat transfer center and individual buildings
- Water from lake cools water from (heatted) customer building through passive heat exchangers



Figures: Washington Post (Nov 5, 2021)
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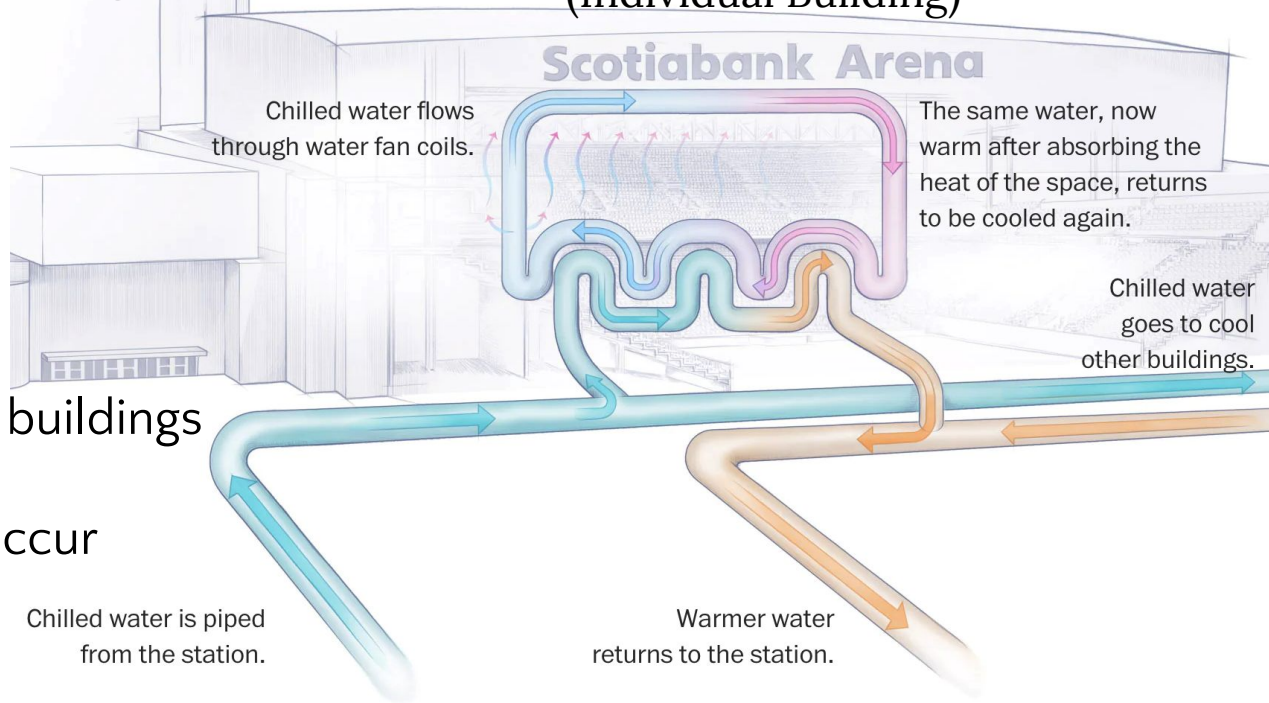
How Heat Exchanger Works?

(Individual Building)



- Cooled water are delivered to individual buildings
- Same heat exchange occur in each building

Figure: Washington Post (Nov 5, 2021)
https://www.washingtonpost.com/climate-solutions/interactive/2021/toronto-deep-latke-water-cooling-raptors/

LSC Facility

Case 2 : Cornell University

- Built in 2000, first major system in United States. “Lake Source Cooling”
- Pull water from Cayuga Lake and cool buildings in the campus
- **Cooling load: 20,000RT**
- Project cost: $58.5M

Benefit/Effect:

- **Reduced 85% of electricity used for cooling. (20M kWh per year)**

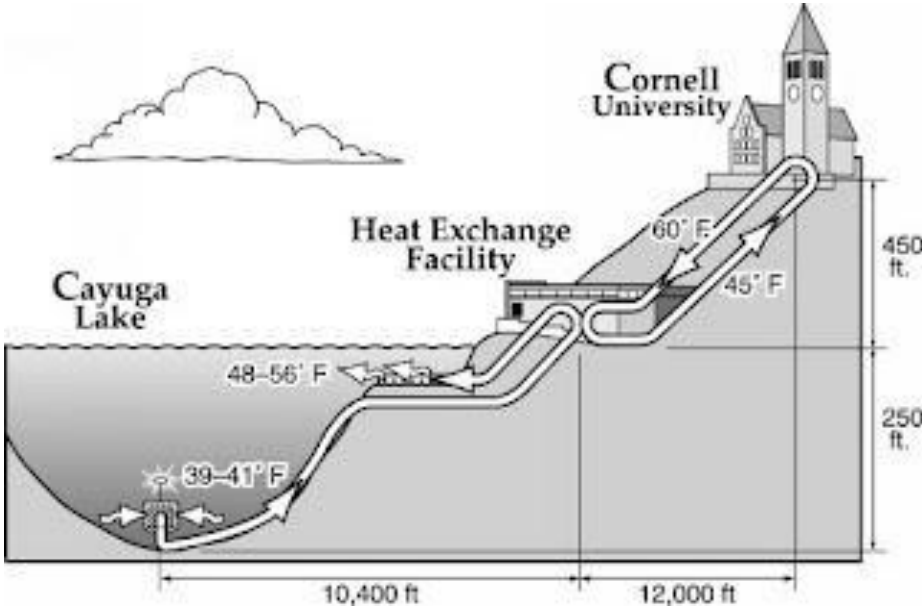


Figure: bilmes.blogspot.com
http://bilmes.blogspot.com/2009/07/lake-source-cooling-debate-heats-up.html

Heat pump system
in Lotte Tower

Case 3: Lotte Tower in Seoul, Korea

- Lotte Tower is the tallest building in SK, world's fifth. First water-based cooling in SK
- Floors: 123, Floor area: 3.2 M sq ft
- **Gets 50,000 tons of water** daily from Han river

Benefit/Effect:

- Cooling load: **3000RT (10% of building RT)**
- **Saves 36% of energy for HVAC**
- World's first building, taller than 100 floors, with LEED GOLD

Reference (Citation)

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Toronto, Canada

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