Water Saving Legislation

# HOW TO CONSERVE WATER AND MAXIMIZE NON-CONSUMPTIVE USE OF GROUNDWATER BY DEVELOPING COOLING SYSTEMS BASED ON GEOTHERMAL TECHNOLOGY

## Geothermal HVAC Systems:

## Cooling Tower Conversion to Geothermal Sources Saves Precious Water

Jay Egg, CMC

May 14-15
6th Biennial
2024 EWTS
EMERGING WATER TECHNOLOGY SYMPOSIUM
Scottsdale, AZ

egg geo
expertise
education
engineering
Defining the Future of Geothermal

# Presentation Objectives

- Understand the context and verbiage of the (geothermal) technology
- Identify the importance, adaptability, and benefits of the technology as vital to water savings, infrastructure and building construction
- Understand why the geothermal is important to health, human safety, and imperative industry goals
- Internalize our collective capability and responsibility to make these changes
- Leave with the intent to offer, incentivize, specify, & apply the technology in every reasonable application going forward

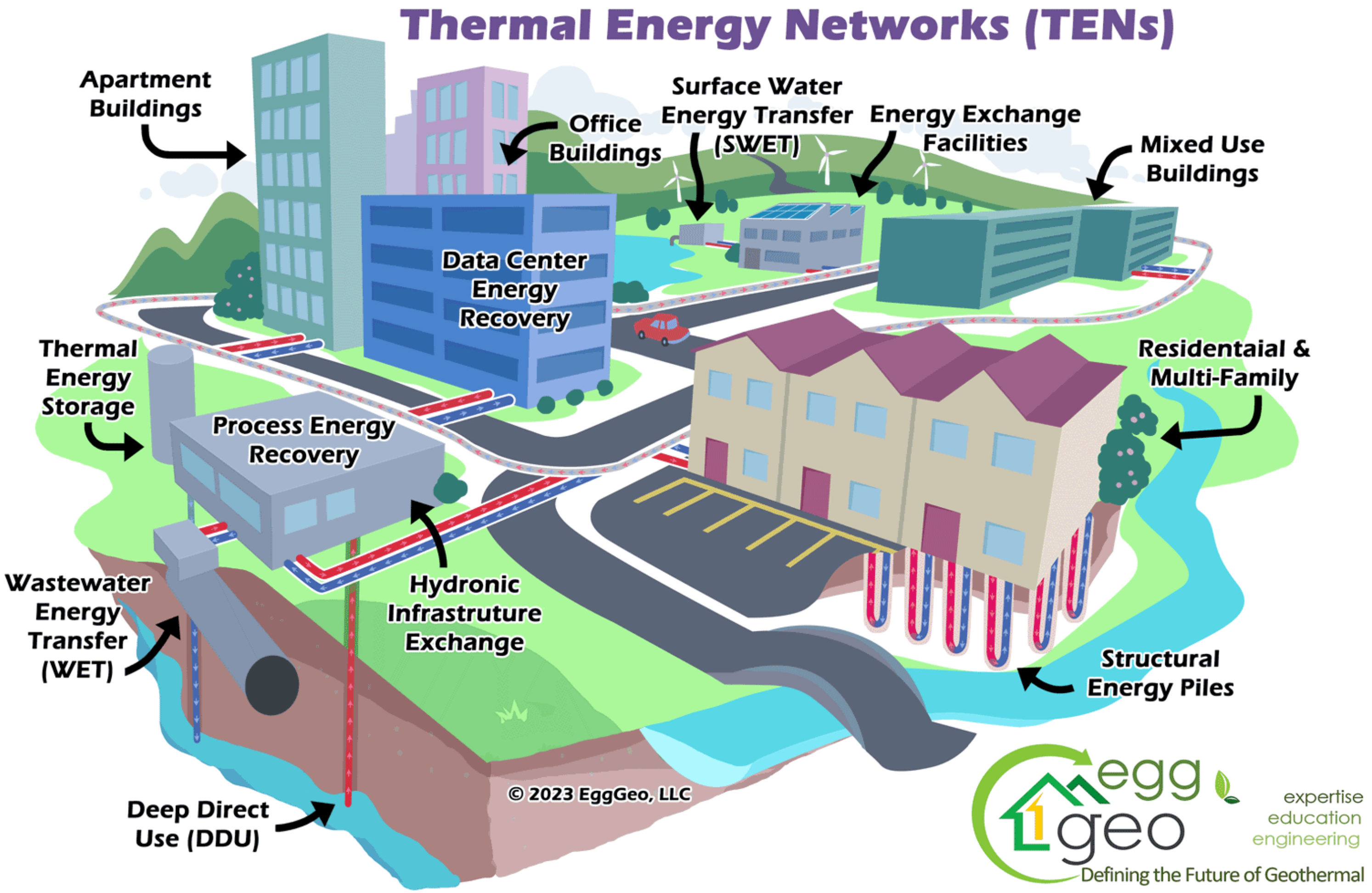
Egg Geo and the Water Savings space in HVAC technologies

- Types of water/energy reduction measures
  - heat recovery,
  - geothermal,
  - wastewater heat sinks,
  - cold water storage (TES)

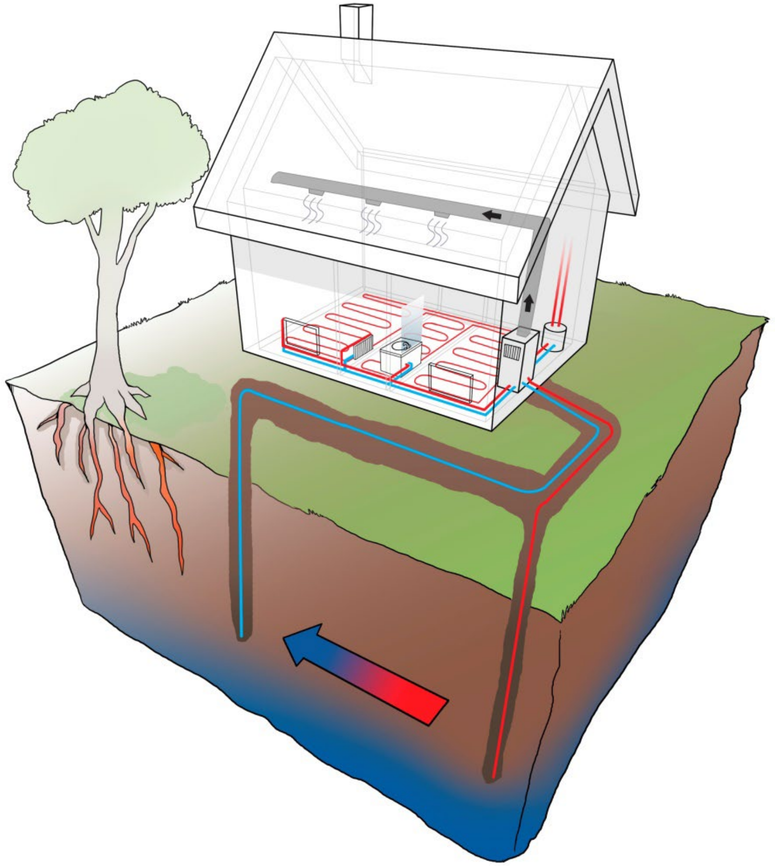
One size doesn't fit all. Your building design will to a large extent dictate what is feasible

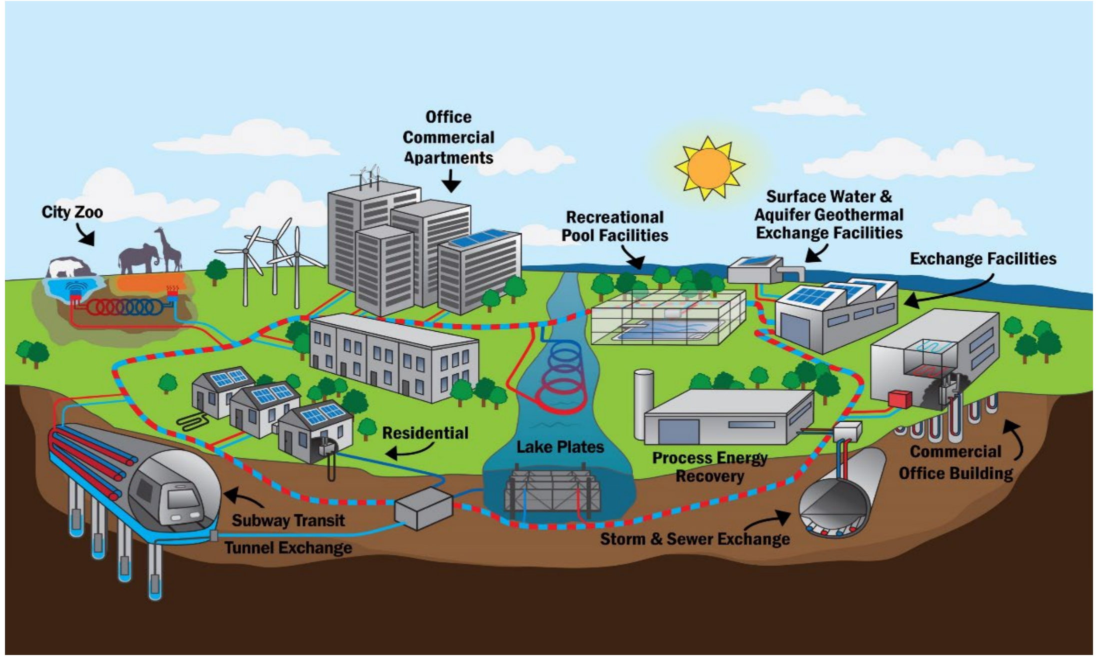
Expand our thinking. Resorts are inclined to save water, but ONLY to the extent they can do it without significantly adding to their energy load.

# Aquifer Thermal Energy Transfer Eliminates Cooling Towers



# Geothermal fundamentals & some history





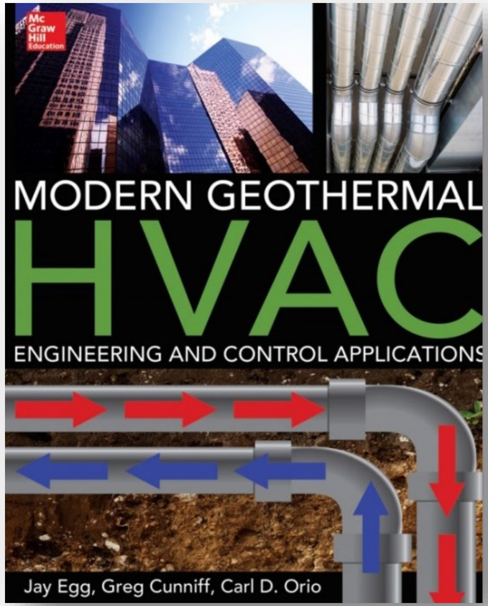
# Egg Geo’s part and a short history -

## In the business since the 1930s; Authored two McGraw Hill Textbook on the subject

Early Contracting Days


In Full Swing

Now:
Consulting & Education



# A Passion for Sharing Knowledge

egg geo
expertise
education
engineering
Defining the Future of Geothermal


Plenary session at the 2022 GR Conference in Reno

# What We Do Now

- Validation
- Consulting
- Guidance
- Education
- Code Compliance
- Program Writing
- Technical Steering
- Studies, Implementation, & Water Conservation Efforts


# Capabilities: Expertise, Engineering, Education Application of 35 years of geothermal experience

<u>Expertise</u>

- Internal Client Studies
- Thought leadership
- Articles
- Textbooks
- Seminars
- Code writing

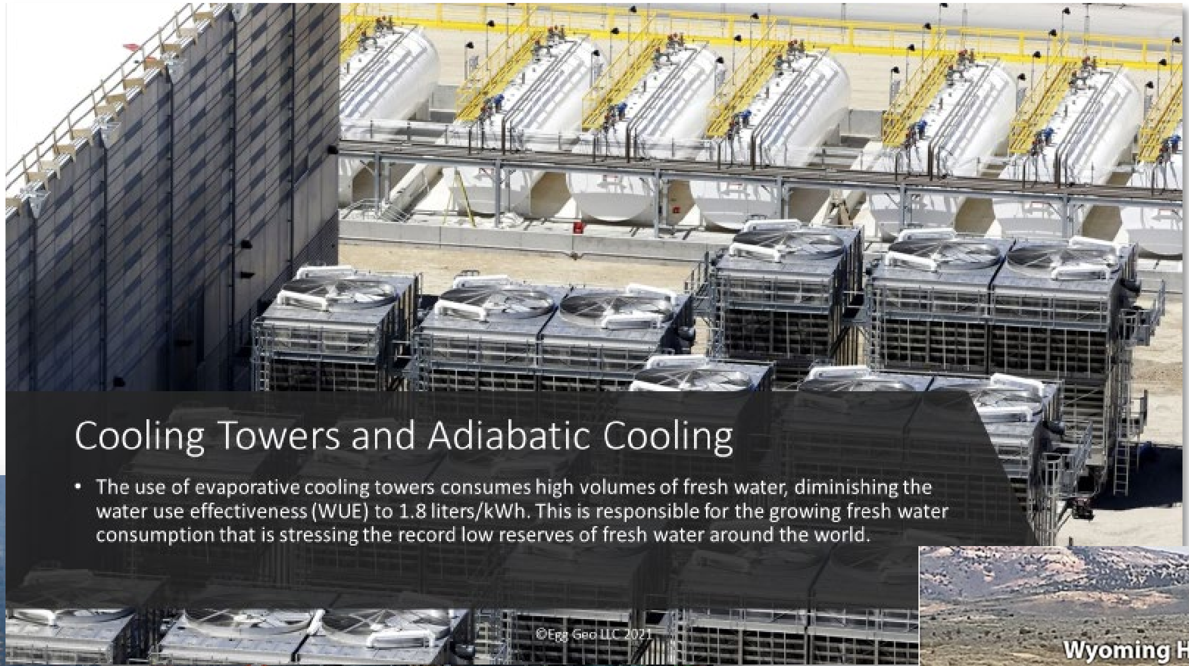
<u>Education</u>

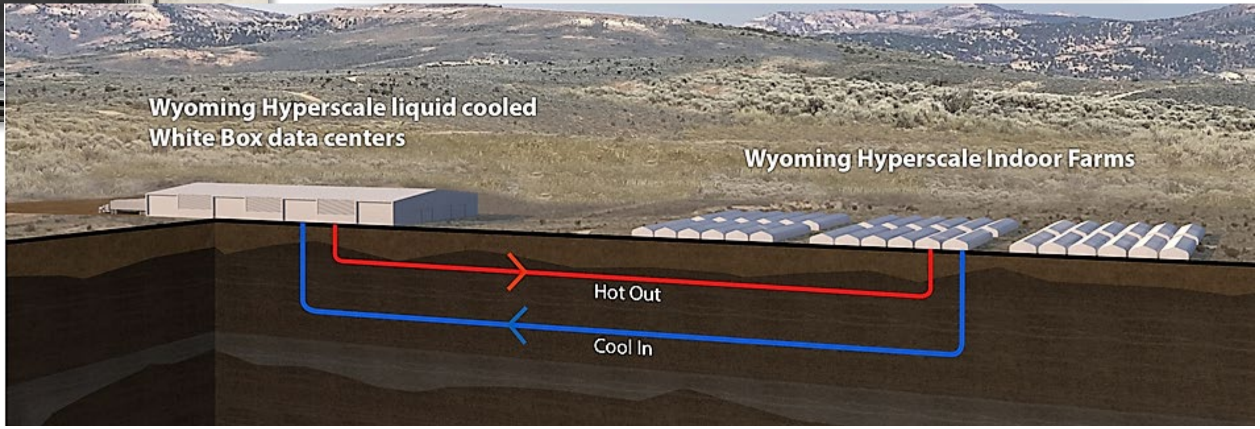
- Transferring knowledge to engineering teams about geothermal methods models and techniques
- Advocacy about technologies and solutions
- Curriculum writing for specific trade groups and professional organizations

<u>Engineering (Consulting)</u>

- Feasibility Studies
  - Design
  - Thermal loads of community
  - Thermal bandwidth of piping
  - Layout of infrastructure
  - Needs +1
  - Costs of material and labor
  - Incentives from federal, local and utilities
- Owners Rep Services
  - Validation
  - RFPs
  - Construction oversight
  - Commissioning

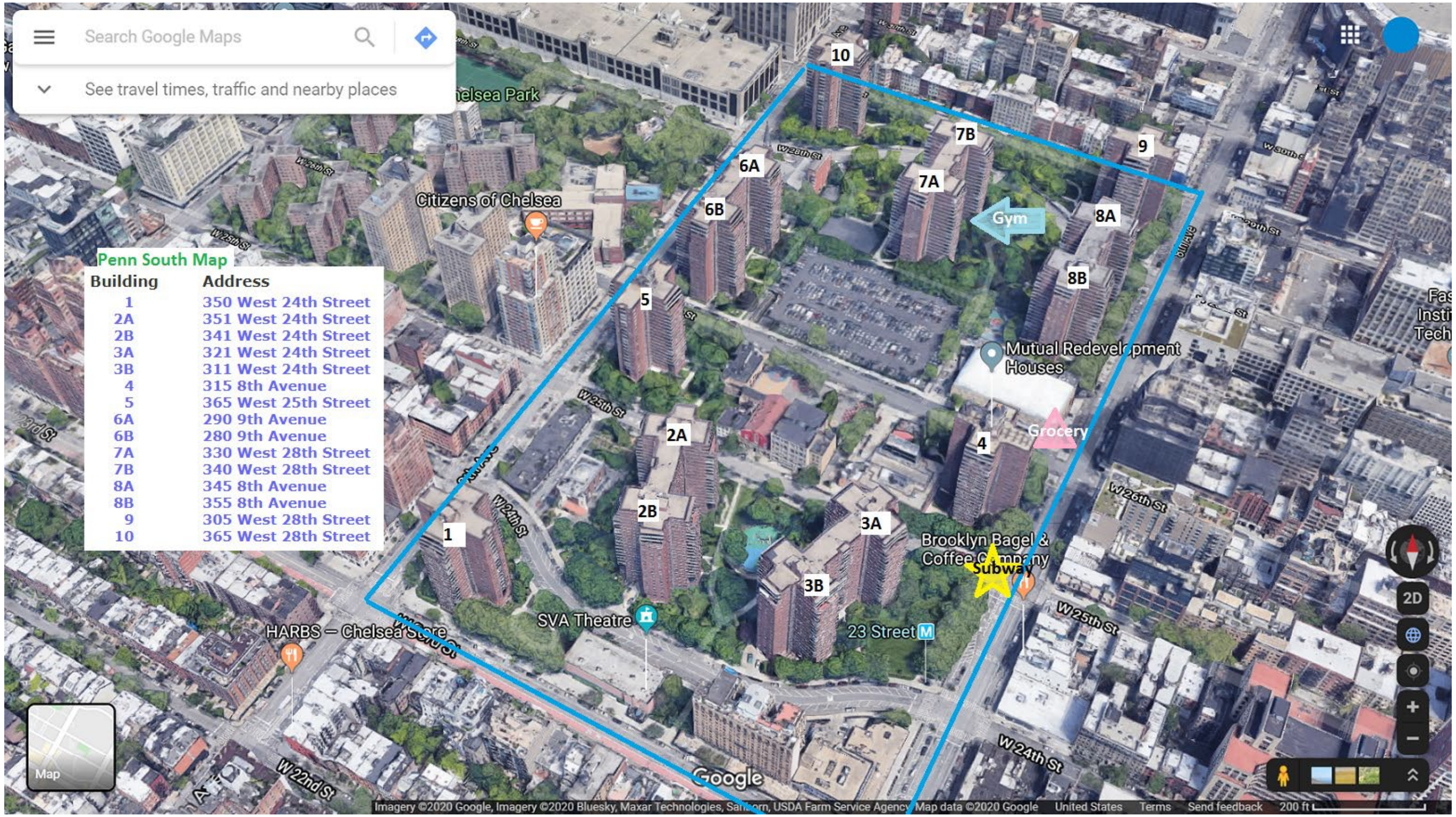
# Providing Infrastructure Level Guidance

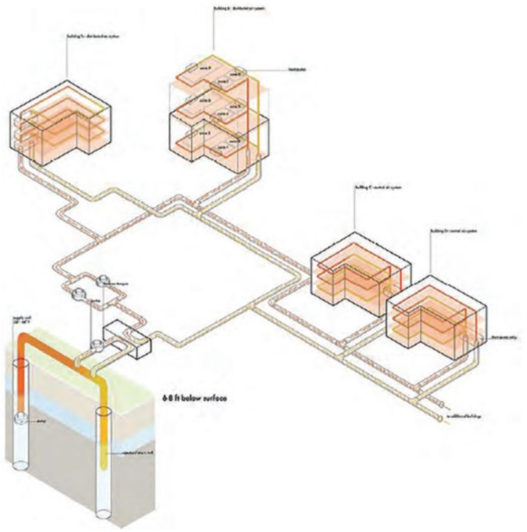



Moving Energy Instead of Evaporating Water;  a "Win-Win"

# Infrastructure Studies, Engineering & Implementation



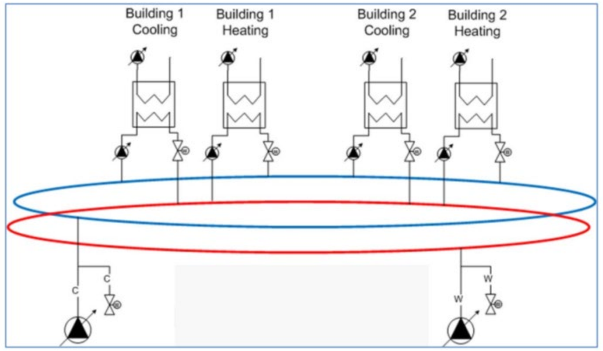



Figure 10 - Two-pipe groundwater distribution, active building connections

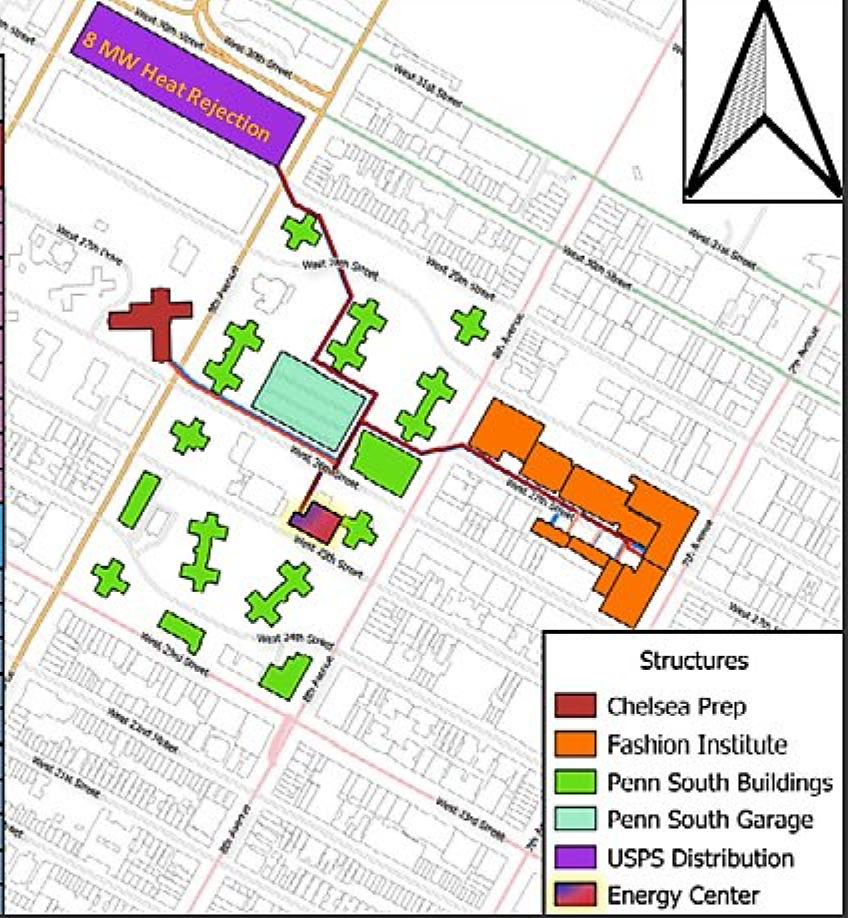
One Way Pipe Catalog

Heating

| IPS(in.) | Length(ft) |
|---|---|
| 1 1/4 | 23 |
| 2 | 16 |
| 2 1/2 | 24 |
| 4 | 79 |
| 5 | 728 |
| 6 | 115 |
| 8 | 2145 |
| 10 | 413 |

Cooling

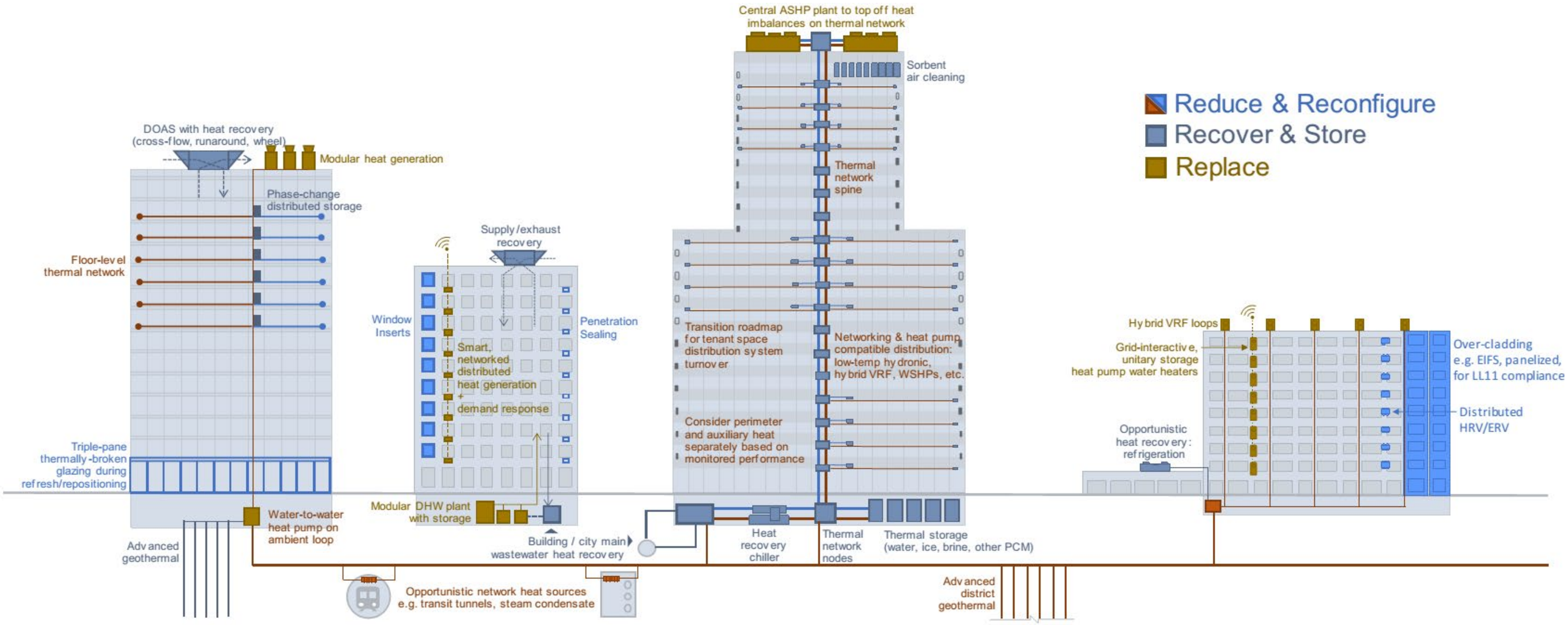
| IPS(in.) | Length(ft) |
|---|---|
| 3 | 20 |
| 5 | 75 |
| 6 | 155 |
| 8 | 676 |
| 10 | 180 |
| 12 | 95 |
| 16 | 1942 |
| 18 | 161 |
| 20 | 246 |



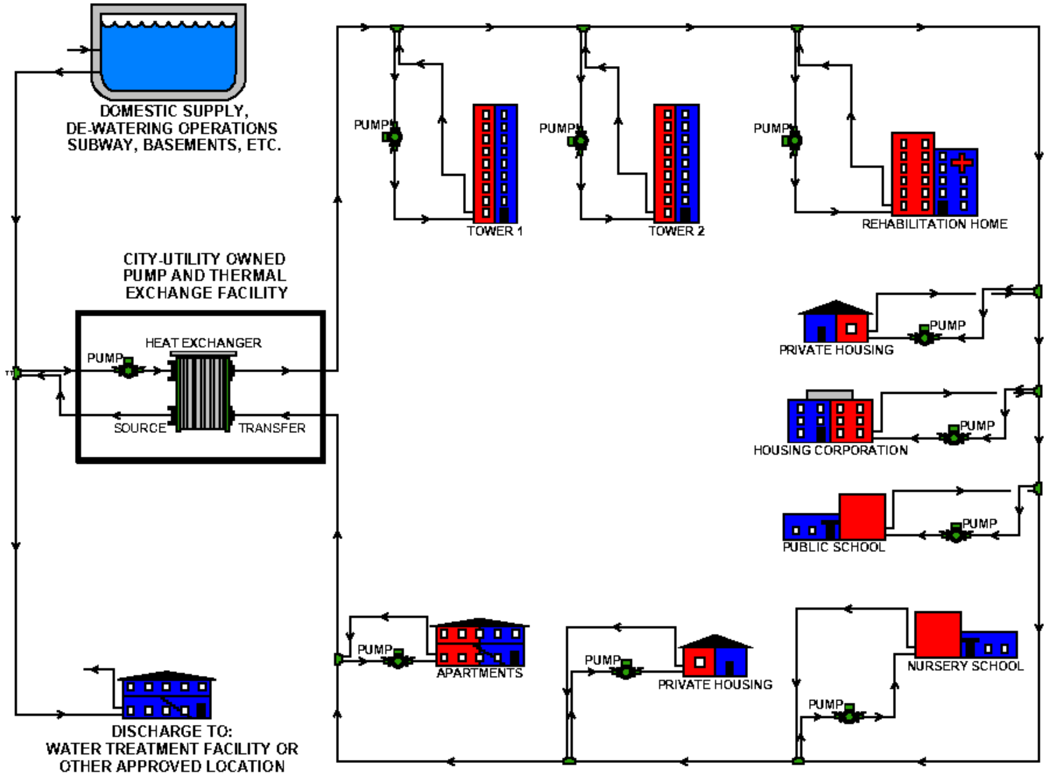

# *Thermal Energy Network Modeling*

# Penn South Campus and Adjoining Properties

# Thermal Energy Networks - Empire State; Developed for NYSERDA



# Sharing Energy within Resorts and Communities -Elimination of Cooling Towers and Boilers

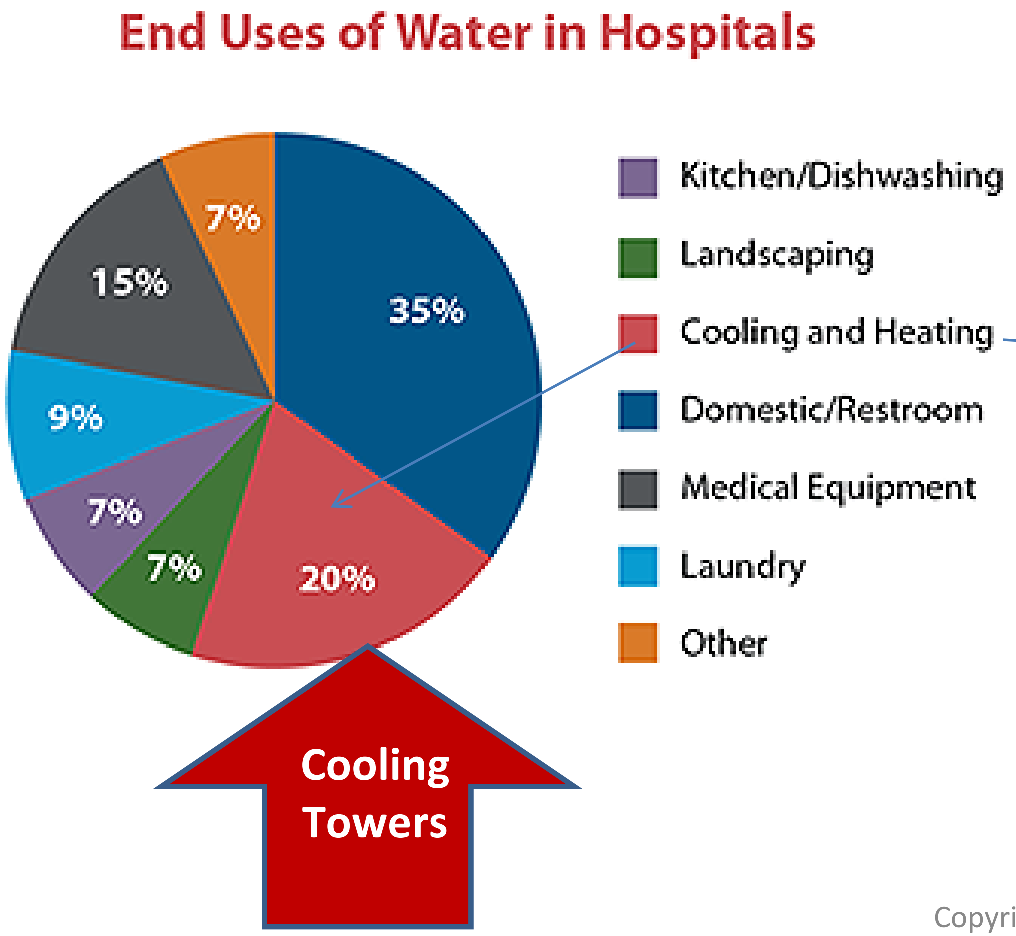


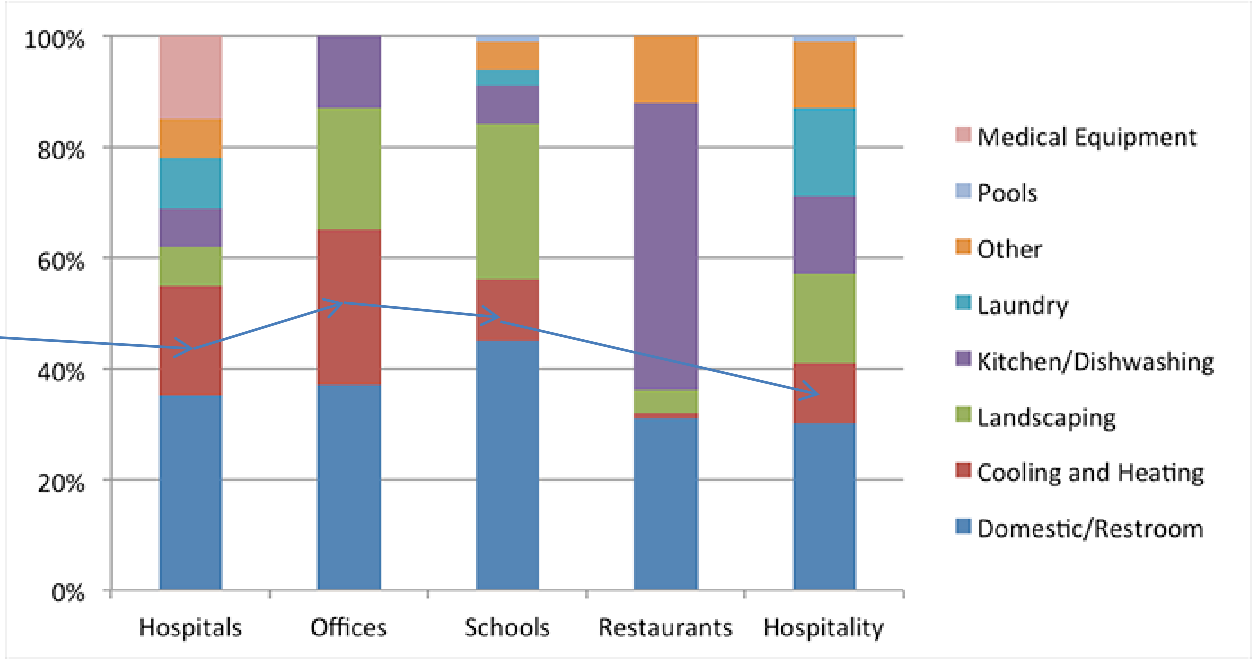
# Cooling Towers: Functions & Purpose

A cooling tower usually is part of a recirculated water system that has been incorporated into a building’s cooling system, industrial processes, refrigeration or energy generators. They use the principle of evaporative cooling to increase the cooling effectiveness of a building's systems.

# Water Conservation = New Water
# Let's Understand: Where is our water going?

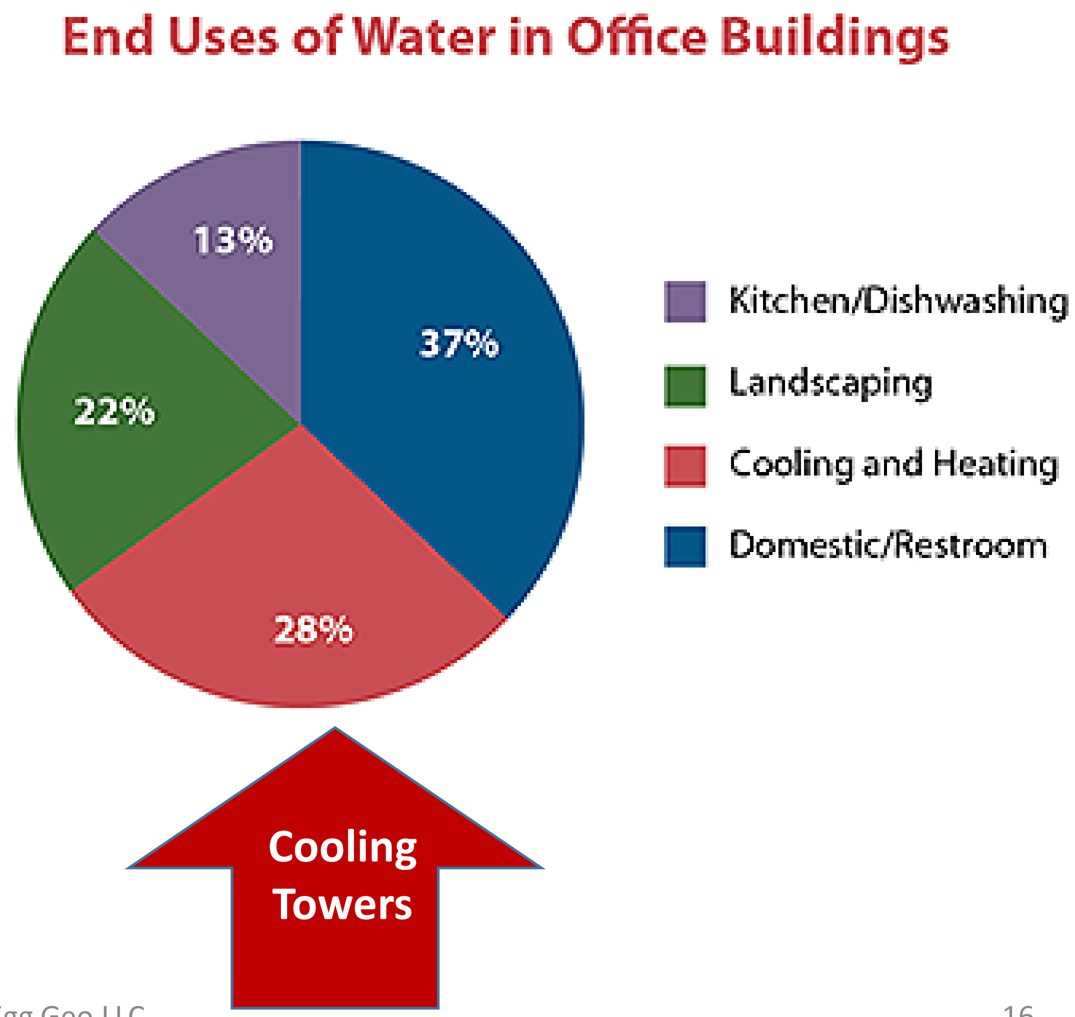
https://www.epa.gov/watersense/types-facilities



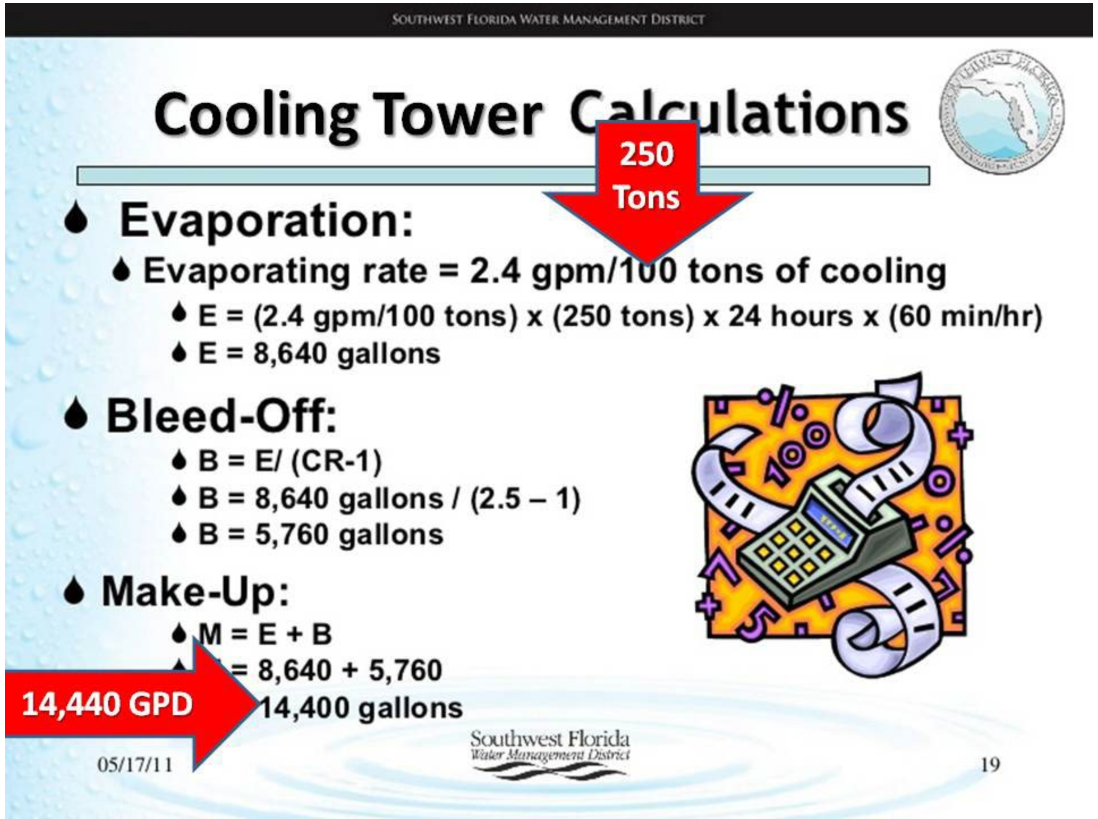
# Where is our water use in Office Buildings?

- In many commercial buildings, cooling towers (CTs) are among the highest consumers of water
- They (CTs) consume more water that landscaping or kitchens in office buildings.

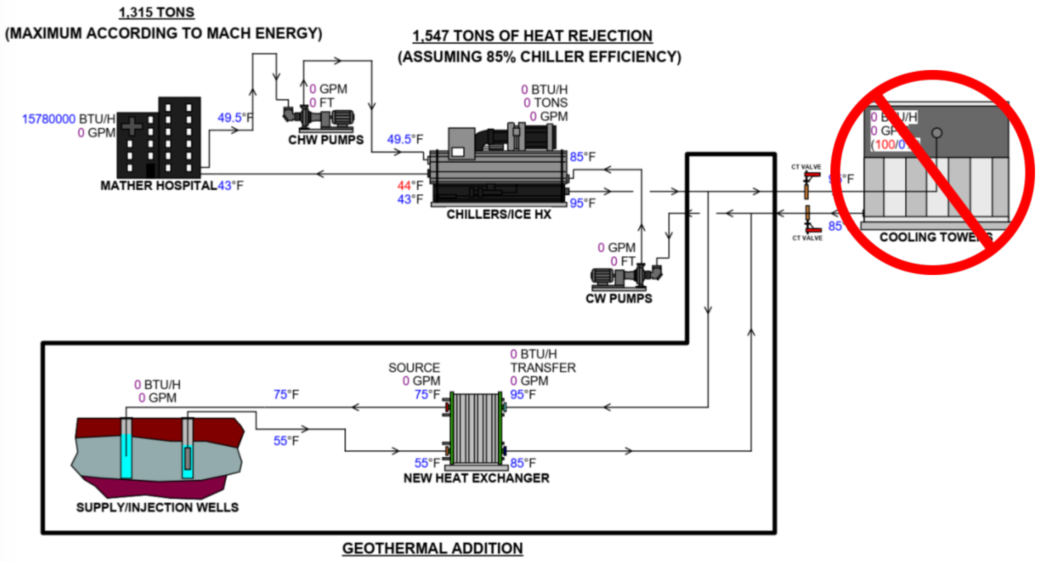


# Elimination of Cooling Towers = New Water

A Small (250Ton) C/T can use ~15,000 GPD

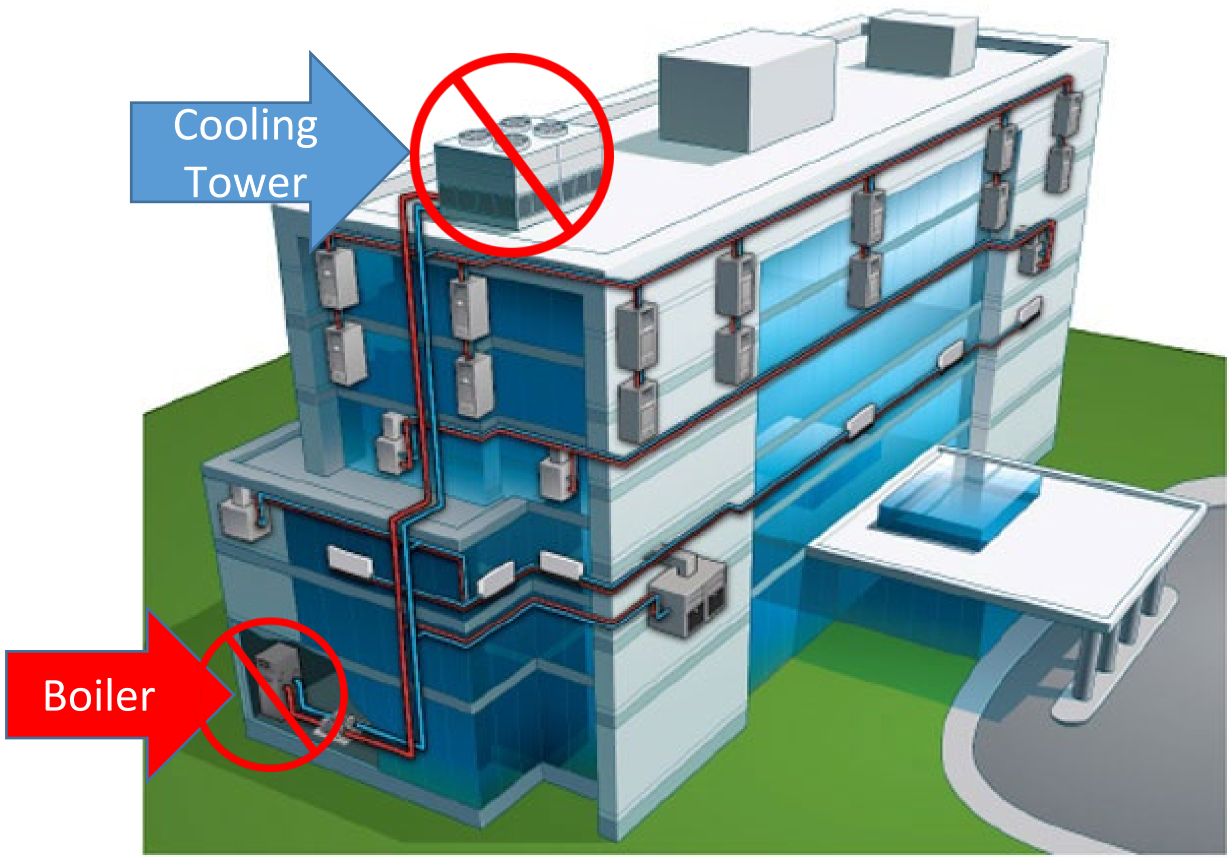


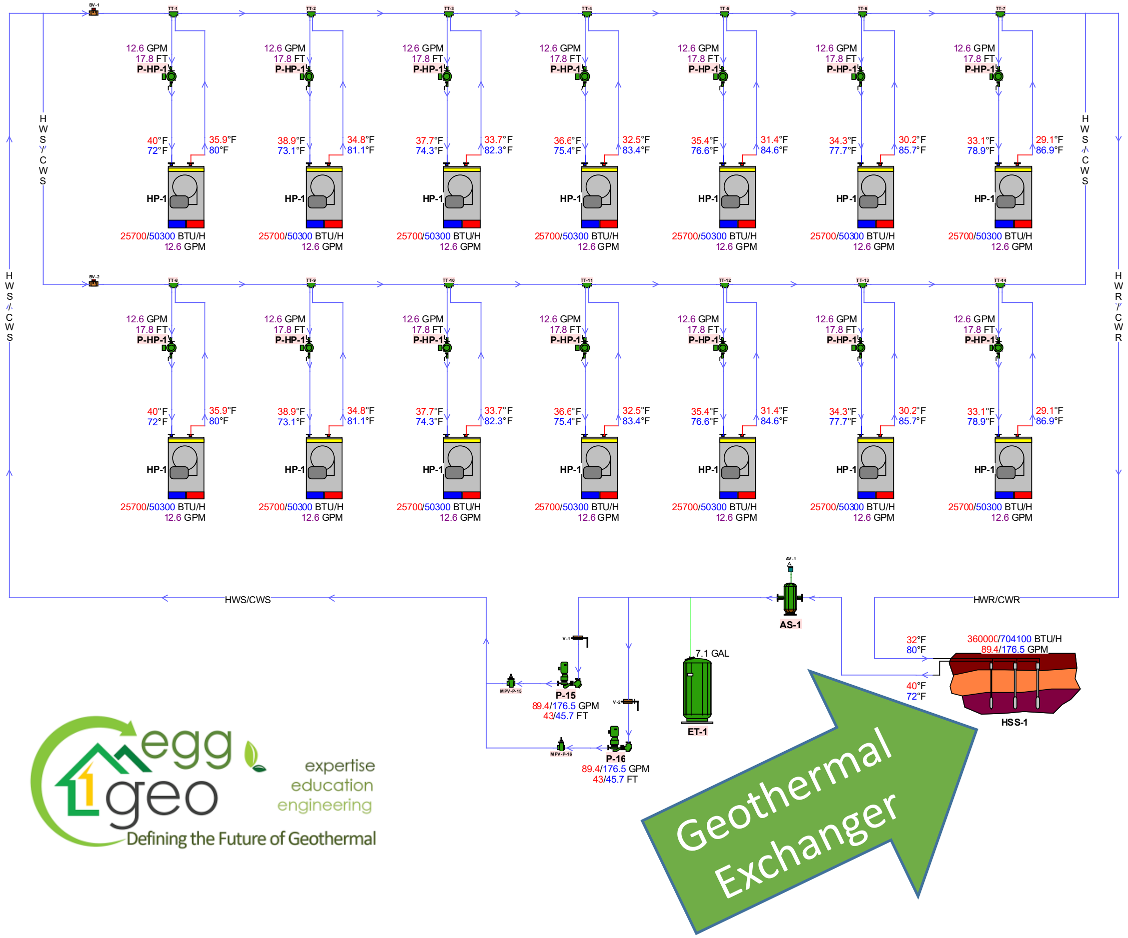
# Aquifer Coupled Thermal Exchange Reduces First Cost, and Eliminates Cooling Towers


**SIMPLIFIED FUTURE FLOW DIAGRAM**

# Building Mechanical Design and Upgrades

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# Some Permanent Solutions Provided by Geothermal Upgrades Include:


# Wastewater & SkyCool Technologies

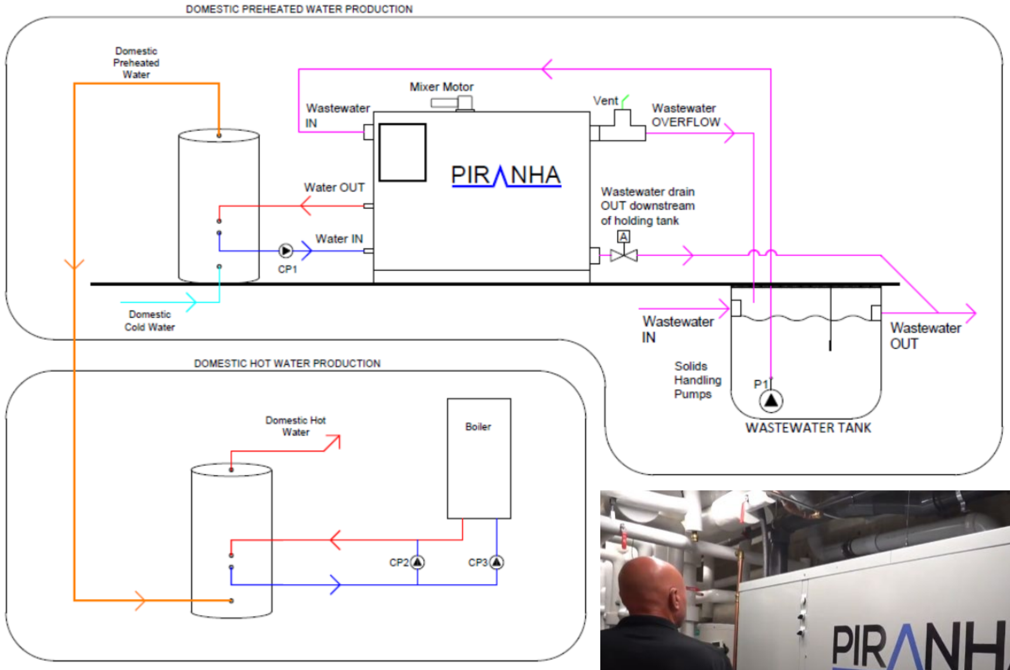
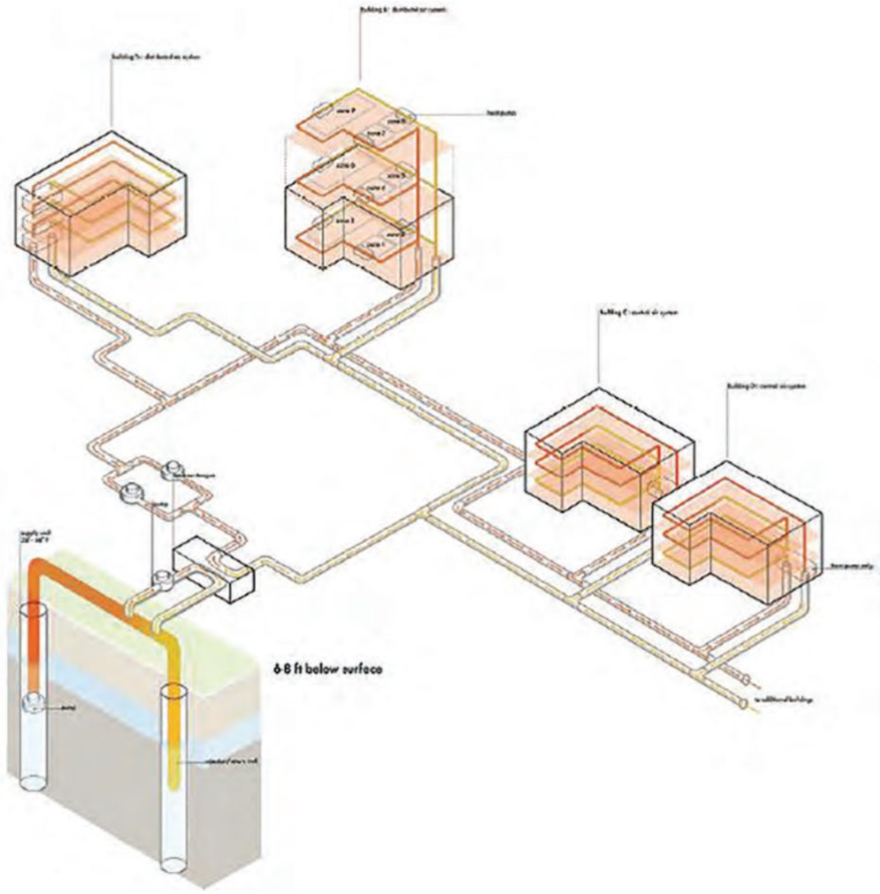



*Figure 3: Schematic of a standard layout o*

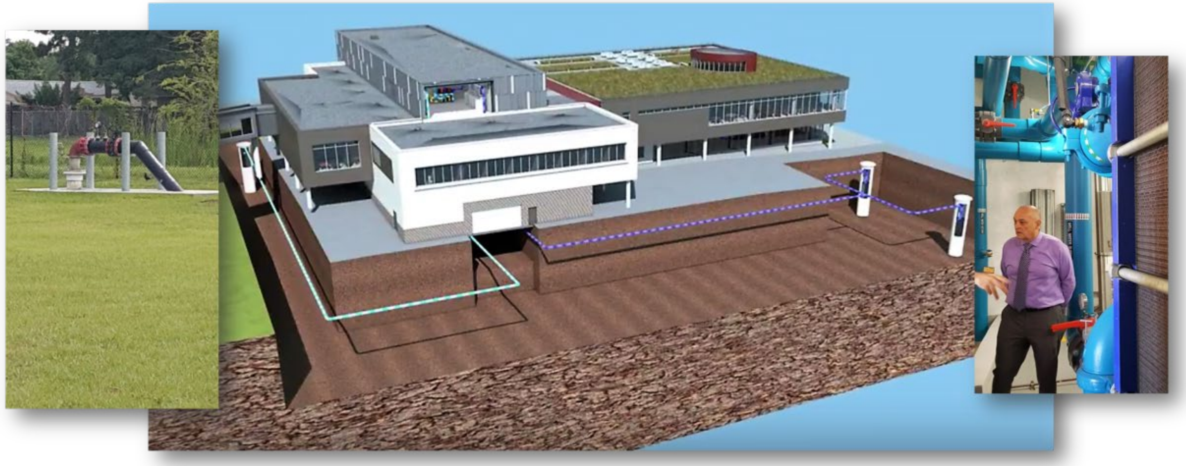

Wastewater Energy Exchange

SkyCool Radiant Panels

# Recommended Legislation: "Cooling Towers Shall Not Be Supplied from Aquifers or Potable Water"

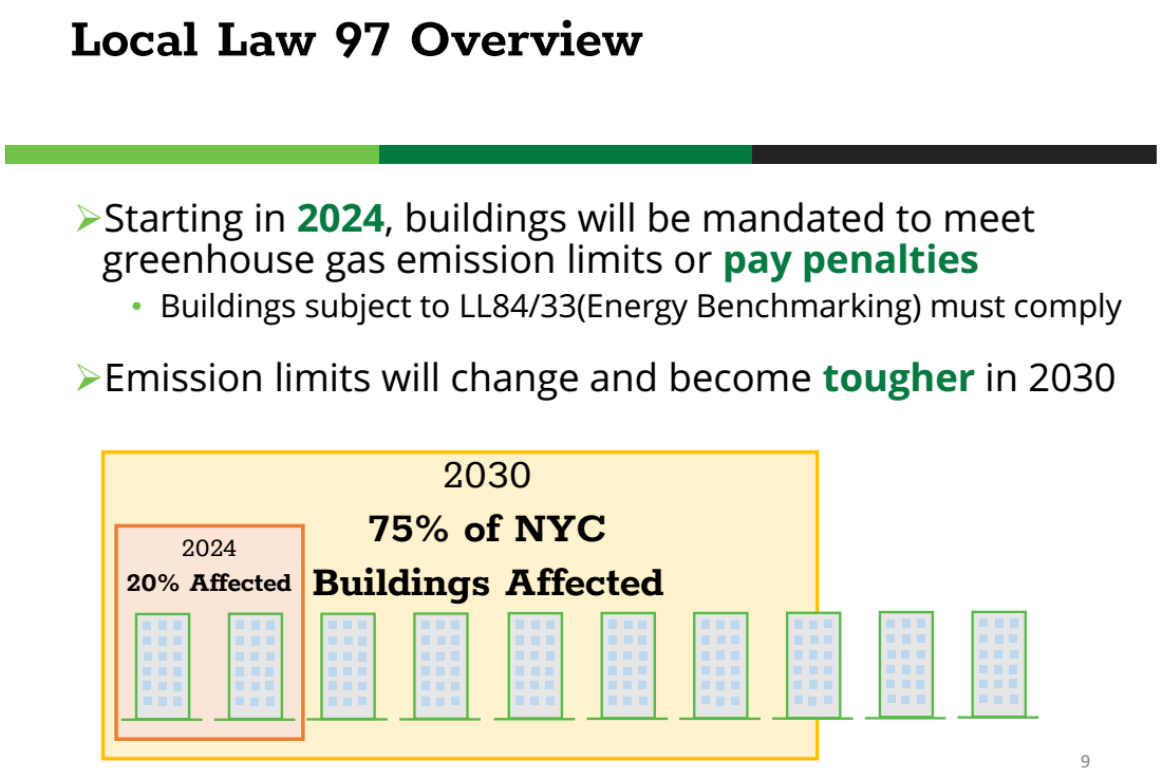



- ❑ ***Cooling Tower Elimination:***
  - ❑ Water Savings
  - ❑ Energy Savings
  - ❑ Improvement in Infrastructure



# End Game: Can Las Vegas implement like NYC Local Law 97?

This ends up being best described as a sort of Cap & Trade method. In NY, they want to reduce greenhouse gas (GHG) emissions, in Nevada, you want to reduce water consumption (from evaporative cooling towers).



# Similarly, Las Vegas could pass regulations…

**NYC Climate Mobilization Act**

What is it?

- The New York City Council recently passed a package of bills that
  - directly impacts NYC buildings
  - aims to significantly reduce the City's greenhouse gas emissions
- The key bills passed were:
  - **Local Law 95** – Adjusts energy letter grade ranges
  - **Local Law 96** – Establishes new financing options including the Property Assessed Clean Energy (PACE) Program
  - **Local Law 97** – Mandates emission limits and establishing financial penalties

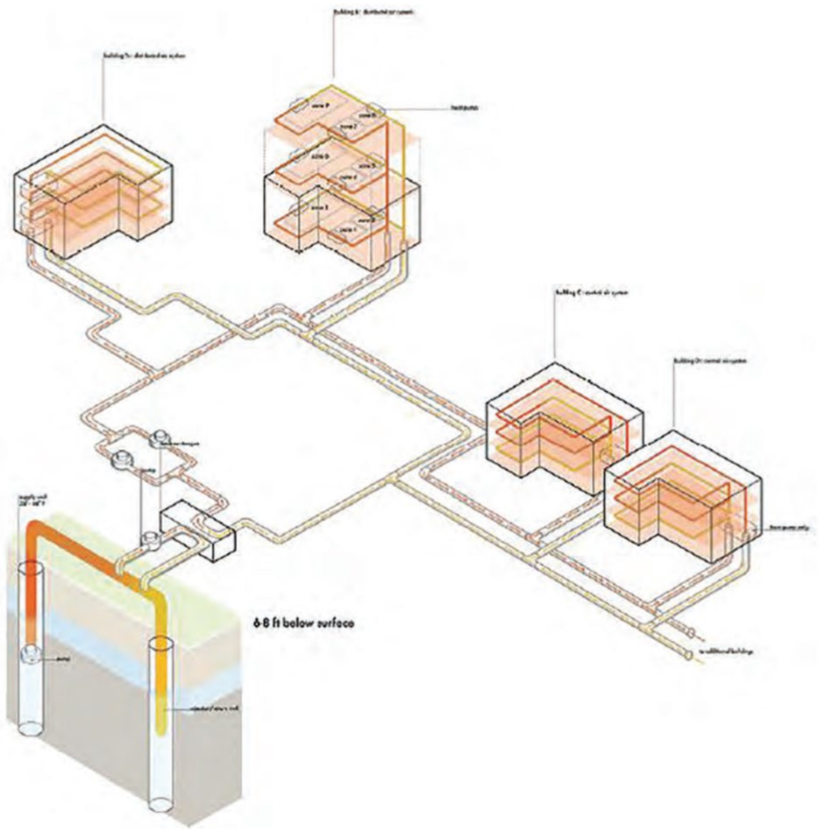
7

- Las Vegas Water Mobilization Act
- Aims to significantly reduce water evaporation/waste
- Mandates water consumption limits (for Cooling Towers) and establishes financial penalties

# Economics and Energy Savings

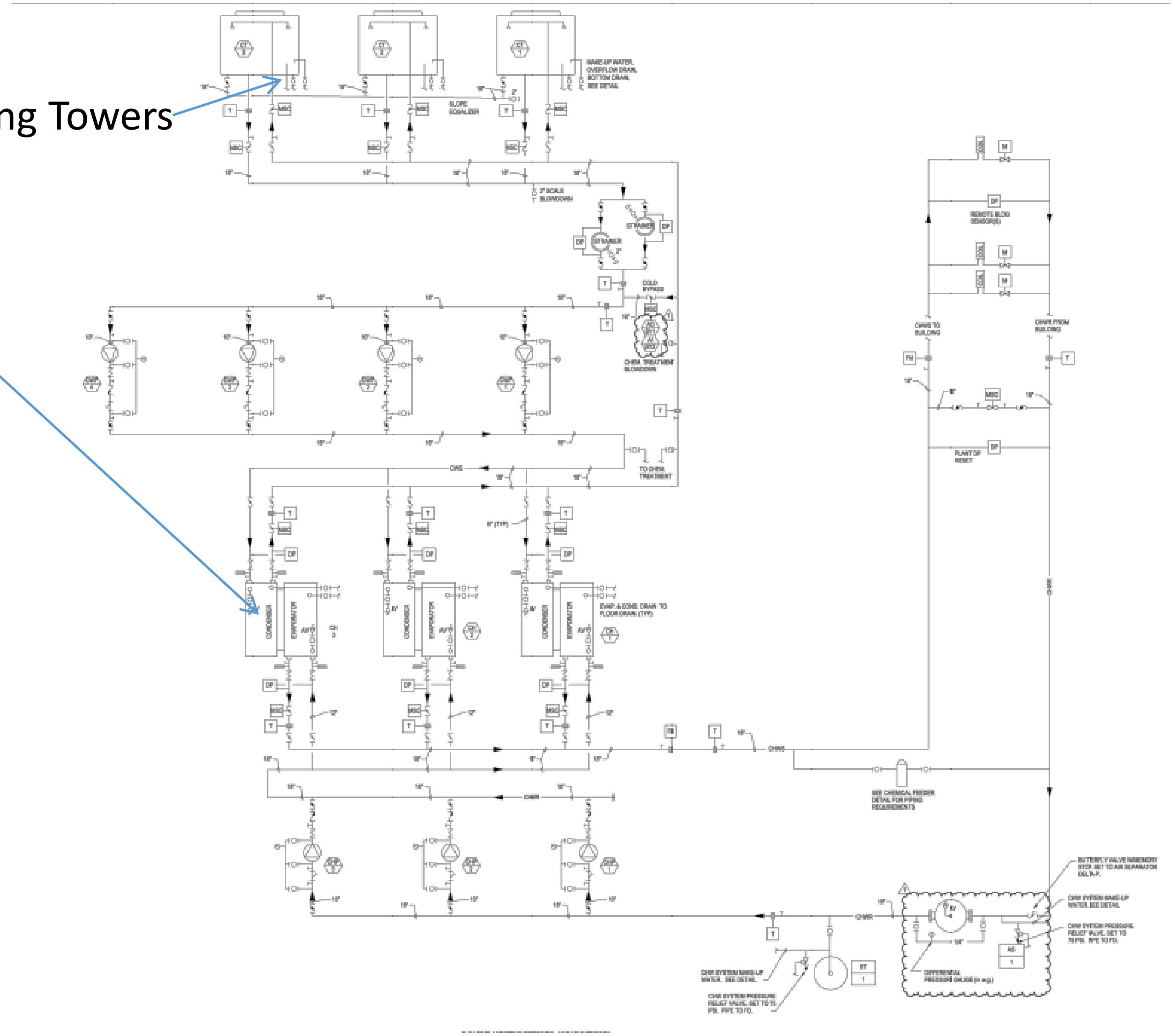
Geothermal Systems are economically attractive because they:

- Are highly energy efficient
- Eliminate C/T related freshwater consumption
- Provide storm-proofing (All indoor system lowers first cost in certain instances)
- Clears up valuable roof space and other real estate
- Has great longevity (no C/Ts to weather-away; Geo wells are permanent)



# Typical CHW Flow Diagram

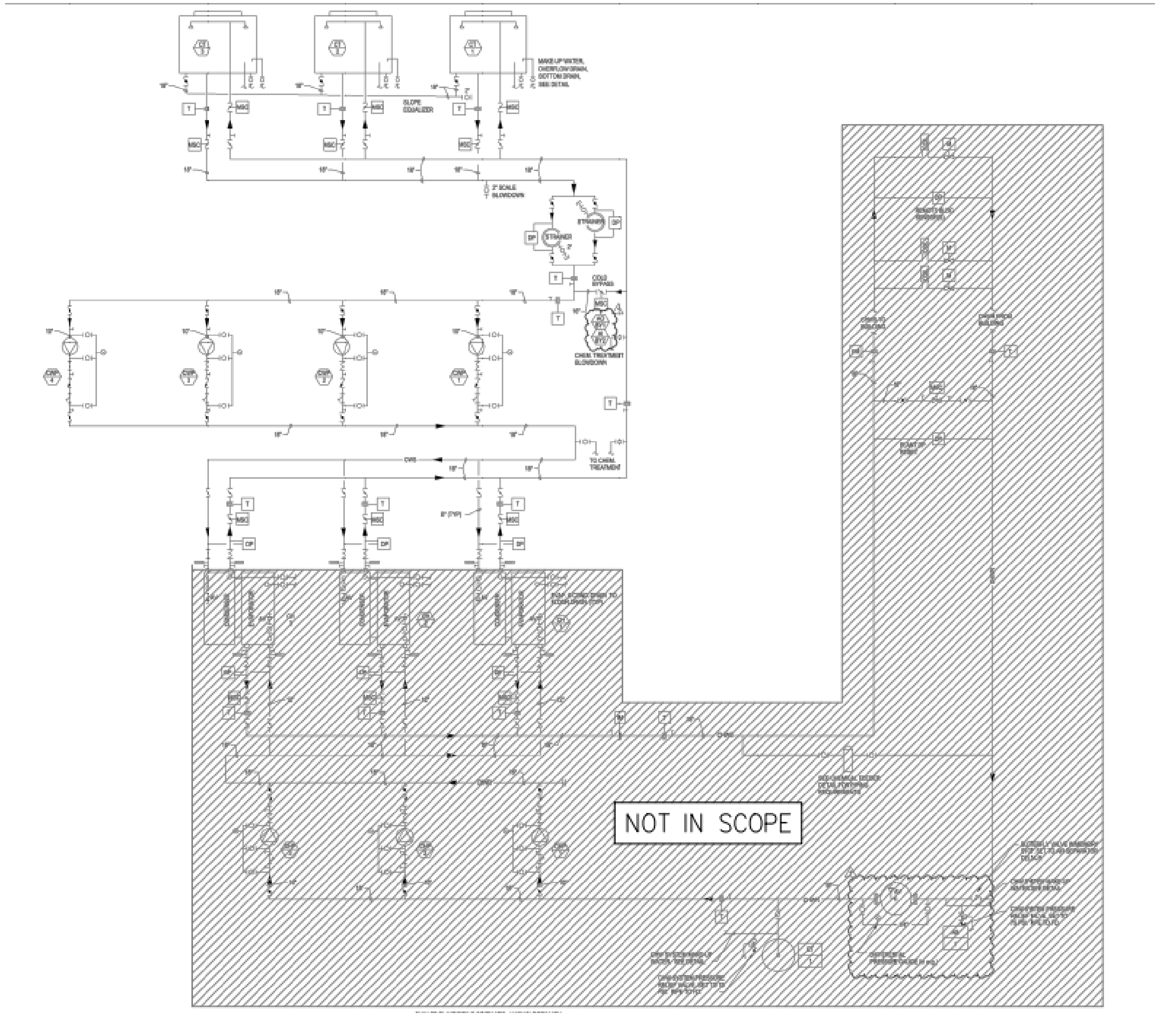
Typical Chillers with Cooling Towers



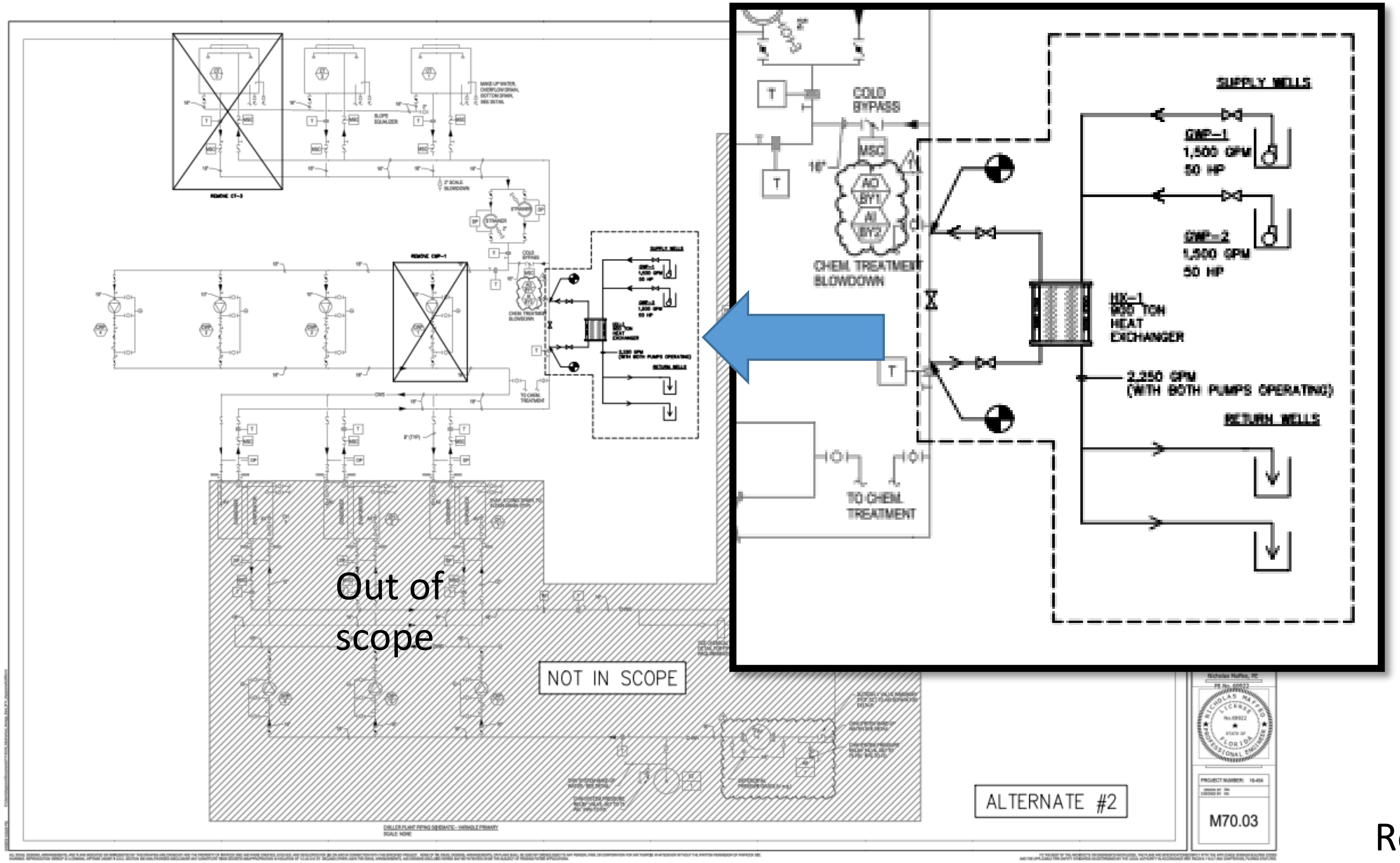
# Affected Scope of Work Area

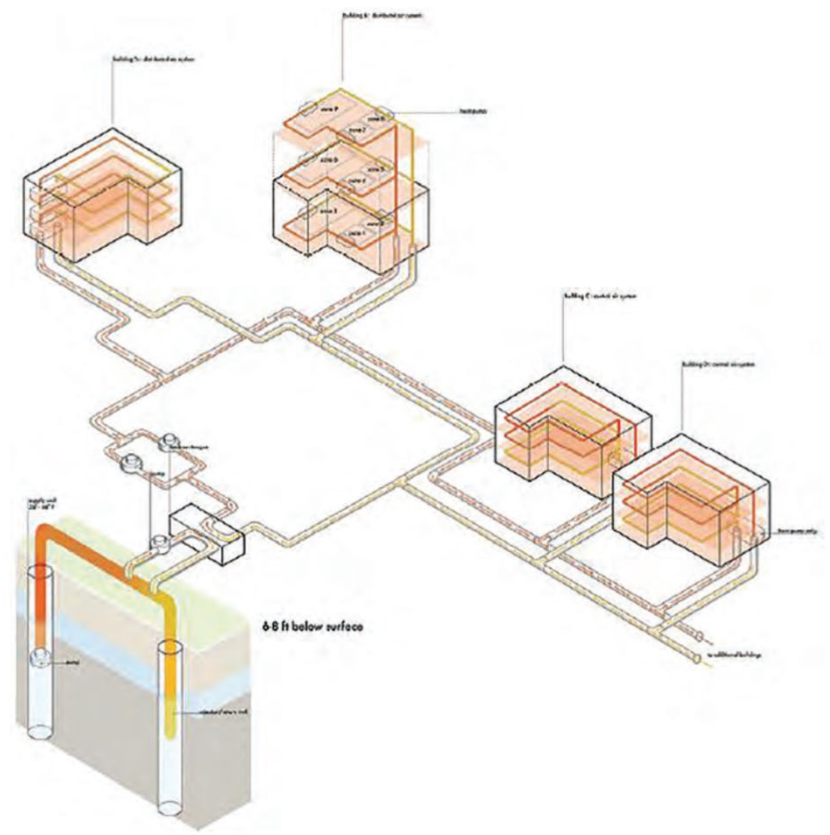
- Minimal changes need to be made to the existing design

- NOTE: Potential for greater system improvement with new construction/earlier adoption



# Pump & Injection (Class V UIC Wells) – Ground Water for Base-Load; Leave Cooling Tower (N+1)




Rotate and Sequence Towers

# Snapshot of Results of Alt 2 (Turn Off One C/T)

TRACE p 4

**Alternative 2 vs Alternative 1**

| | |
|---|---|
| First Cost Difference | 1,300,000.00 |
| Down Payment Difference | 1,300,000.00 |
| Net Present Value of Incremental Cash Flows | 3,403,316.80 |
| Life Cycle Cost Difference | 3,403,316.80 |
| Revenue Penalty Difference | 0.00 |
| Simple Payback on Investment | 4.8 years |
| Life Cycle Payback on Investment | 1.9 years |
| Internal Rate of Return | 39.0 % |
| Cost of capital (%) | 8.3 |

| Year | Cash Flow Difference | Cumulative Cash Flow Difference | Present Value of Flow Difference | Net Present Value |
|---|---|---|---|---|
| 0 | -1,300,000.00 | -1,300,000.00 | -1,300,000.00 | -1,300,000.00 |
| 1 | 268,529.66 | -1,031,470.34 | 248,064.35 | -1,051,935.65 |
| 2 | 1,341,863.29 | 310,392.94 | 1,145,123.89 | 93,188.24 |
| 3 | 284,883.11 | 595,276.05 | 224,586.17 | 317,774.41 |
| 4 | 293,429.59 | 888,705.64 | 213,693.99 | 531,468.39 |
| 5 | 302,232.49 | 1,190,938.13 | 203,330.09 | 734,798.48 |
| 6 | 311,299.44 | 1,502,237.57 | 193,468.81 | 928,267.29 |
| 7 | 320,638.43 | 1,822,876.00 | 184,085.79 | 1,112,353.08 |
| 8 | 330,257.58 | 2,153,133.59 | 175,157.85 | 1,287,510.93 |
| 9 | 340,165.31 | 2,493,298.90 | 166,662.90 | 1,454,173.83 |
| 10 | 260,738.36 | 2,754,037.26 | 118,011.93 | 1,572,185.76 |
| 11 | 360,881.38 | 3,114,918.65 | 150,889.00 | 1,723,074.76 |
| 12 | 750,986.55 | 3,865,905.20 | 290,066.35 | 2,013,141.11 |
| 13 | 382,859.04 | 4,248,764.24 | 136,608.03 | 2,149,749.14 |
| 14 | 394,344.80 | 4,643,109.04 | 129,982.69 | 2,279,731.83 |
| 15 | 406,175.16 | 5,049,284.20 | 123,678.69 | 2,403,410.52 |
| 16 | 418,360.39 | 5,467,644.59 | 117,680.41 | 2,521,090.93 |
| 17 | 430,911.23 | 5,898,555.82 | 111,973.05 | 2,633,063.98 |
| 18 | 443,838.55 | 6,342,394.37 | 106,542.48 | 2,739,606.46 |
| 19 | 457,153.71 | 6,799,548.08 | 101,375.30 | 2,840,981.76 |
| 20 | 361,607.58 | 7,161,155.66 | 74,076.34 | 2,915,058.10 |
| 21 | 484,994.36 | 7,646,150.02 | 91,780.58 | 3,006,838.68 |
| 22 | 499,544.17 | 8,145,694.19 | 87,329.33 | 3,094,168.01 |
| 23 | 514,530.51 | 8,660,224.70 | 83,093.95 | 3,177,261.96 |
| 24 | 1,010,983.24 | 9,671,207.94 | 150,825.36 | 3,328,087.32 |
| 25 | 545,865.41 | 10,217,073.35 | 75,229.48 | 3,403,316.80 |

RUN 421
$100k CT Credit / 10% EPA Tax Credit

# Water Savings:

**MONTHLY UTILITY COSTS**

By ENGINEERING MATRIX, INC.

TRACE pp 24-25 (Switched from Gallons to $'s on consolidated report)

------- Monthly Utility Costs -------

| Utility | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alternative 1** | | | | | | | | | | | | | |
| Electric | | | | | | | | | | | | | |
| On-Pk Cons. ($) | 5,322 | 6,852 | 7,927 | 11,402 | 13,566 | 15,102 | [illegible] | 15,930 | 14,532 | 12,154 | 7,872 | 7,616 | 133,898 |
| Off-Pk Cons. ($) | 2,227 | 5,556 | 4,857 | 8,353 | 11,232 | 12,012 | [illegible] | 12,545 | 11,552 | 8,901 | 11,715 | 10,828 | 112,322 |
| Mid-Pk Cons. ($) | 9,402 | 11,931 | 14,557 | 7,160 | 8,940 | 10,116 | [illegible] | 10,759 | 9,775 | 7,677 | 4,486 | 5,032 | 110,268 |
| On-Pk Demand ($) | 7,765 | 8,330 | 9,402 | 9,993 | 11,391 | 12,380 | [illegible] | 12,380 | 12,120 | 10,385 | 9,993 | 8,808 | 125,196 |
| Total ($): | 24,716 | 32,669 | 36,743 | 36,908 | 45,128 | 49,610 | [illegible] | 51,614 | 47,979 | 39,117 | 34,067 | 32,285 | 481,683 |
| Water | | | | | | | | | | | | | |
| On-Pk Cons. ($) | 15,131 | 22,770 | 24,657 | 25,171 | 31,483 | 32,559 | 33,710 | 34,067 | 31,890 | 25,769 | 24,406 | 24,004 | 325,616 |
| Monthly Total ($): | 39,847 | 55,439 | 61,400 | 62,079 | 76,611 | 82,169 | 84,557 | 85,681 | 79,869 | 64,886 | 58,473 | 56,289 | 807,298 |

Building Area = 1 ft²

Utility Cost Per Area = 807,298.48 $/ft²

| Utility | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alternative 2** | | | | | | | | | | | | | |
| Electric | | | | | | | | | | | | | |
| On-Pk Cons. ($) | 5,297 | 6,819 | 7,874 | 11,100 | 12,893 | 14,120 | [illegible] | 14,838 | 13,519 | 11,458 | 7,794 | 7,594 | 127,874 |
| Off-Pk Cons. ($) | 2,230 | 5,569 | 4,874 | 8,307 | 10,957 | 11,121 | [illegible] | 11,466 | 10,852 | 8,451 | 11,594 | 10,793 | 107,678 |
| Mid-Pk Cons. ($) | 9,335 | 11,849 | 14,364 | 7,023 | 8,562 | 9,391 | [illegible] | 9,928 | 9,047 | 7,261 | 4,404 | 4,986 | 105,765 |
| On-Pk Demand ($) | 7,557 | 8,083 | 8,945 | 9,563 | 10,352 | 11,763 | [illegible] | 11,763 | 11,515 | 9,530 | 9,483 | 8,526 | 118,717 |
| Total ($): | 24,419 | 32,320 | 36,058 | 35,993 | 42,763 | 46,396 | [illegible] | 47,995 | 44,933 | 36,700 | 33,275 | 31,899 | 460,035 |
| Water | | | | | | | | | | | | | |
| On-Pk Cons. ($) | 4,497 | 6,113 | 6,858 | 7,220 | 11,275 | 11,760 | 12,397 | 12,591 | 11,529 | 7,639 | 6,847 | 6,408 | 105,134 |
| Monthly Total ($): | 28,916 | 38,433 | 42,915 | 43,213 | 54,038 | 58,155 | 59,681 | 60,585 | 56,462 | 44,339 | 40,122 | 38,307 | 565,169 |

Saving up to $21,000 in water & 6MM Gallons/month

Building Area = 1 ft²

Utility Cost Per Area = 565,168.86 $/ft²

# Alt #1 & #2; Plant Operation Details/Sequence

TRACE pp 27-30

*(Change-Savings in C/T kWh Operations)*

**EQUIPMENT ENERGY CONSUMPTION**
By ENGINEERING MATRIX, INC.

Alternative: 1 (3)775T WCC, (3)CT

------- Monthly Consumption -------

| Equipment - Utility | Jan | Feb | Mar | Apr | May | June | July | Au |
|---|---|---|---|---|---|---|---|---|
| Bsu 1: Finfrock Project 801 load profile | | | | | | | | |
| Proc. Chill Water (ton-hrs) | 379,091.8 | 570,314.2 | 617,001.1 | 629,656.2 | 788,824.9 | 816,285.1 | 845,296.7 | 854,3 |
| Peak (tons) | 1,298.5 | 1,376.0 | 1,472.9 | 1,550.4 | 1,783.0 | 1,938.0 | 1,918.6 | 1,93 |
| Cpl 1: Cooling Plant - 001 [Sum of dsn coil capacities=1,938 tons] | | | | | | | | |
| Water-Cooled Chiller 01 [Clg Nominal Capacity/F.L.Rate=775 tons / 449.5 kW] (Cooling Equipment) | | | | | | | | |
| Electric (kWh) | 122,116.2 | 196,980.3 | 209,581.5 | 209,606.5 | 213,708.8 | 218,345.7 | 221,243.6 | 222,2 |
| Peak (kW) | 432.0 | 432.0 | 415.9 | 440.7 | 387.5 | 440.7 | 387.5 | 38 |
| _Project 801 Cooling Twr 3-Cell [Design Heat Rejection/F.L. | | | | | | | | |
| Electric (kWh) | 6,032.5 | 9,535.1 | 13,2 | | | 68,299.8 | 74,361.3 | 75,9 |
| Peak (kW) | 54.6 | 75.0 | 108. | | | 176.9 | 176.9 | 17 |
| _Project 801 Cooling Twr 3-Cell | | | | | | | | |
| Make Up Water (1000gal) | 4,089.4 | 6,154.1 | 6,66 | | | 8,799.8 | 9,110.8 | 9,2 |
| Peak (1000gal/Hr) | 14.0 | 14.8 | 15 | | | 20.9 | 20.6 | 20 |
| _Project 801 Var Vol CHW Pump [F.L.Rate=74.57 kW] (Misc Accessory Equipme | | | | | | | | |
| Electric (kWh) | 15,159.4 | 23,033.1 | 23,795.0 | 24,308.4 | 23,251.6 | 25,585.3 | 25,196.7 | 25,6 |
| Peak (kW) | 70.0 | 70.0 | 65.9 | 72.2 | 58.0 | 72.2 | 58.0 | 58 |
| _Project 801 Var Vol CW Pump [F.L.Rate=149.1 kW] (Cooling Plant Circulation Pump) | | | | | | | | |
| Electric (kWh) | 11,427.5 | 16,967.0 | 18,993.6 | 20,040.5 | 28,337.6 | 31,846.4 | 33,036.6 | 34,1 |
| Peak (kW) | 42.1 | 46.9 | 53.5 | 59.4 | 80.3 | 97.0 | 94.8 | 97 |
| Water-Cooled Chiller 02 [Clg Nominal Capacity/F.L.Rate=775 tons / 449.5 kW] (Cooling Equipment) | | | | | | | | |
| Electric (kWh) | 91,057.6 | 124,434.8 | 140,522.7 | 139,696.5 | 152,482.1 | 157,593.7 | 158,466.6 | 160,4 |
| Peak (kW) | 357.6 | 381.1 | 415.9 | 440.7 | 387.5 | 440.7 | 375.0 | 37 |
| _Project 801 Var Vol CHW Pump [F.L.Rate=74.57 kW] (Misc Accessory Equipment) | | | | | | | | |
| Electric (kWh) | 11,187.1 | 14,938.6 | 17,587.9 | 17,887.4 | 17,333.0 | 19,627.3 | 19,040.2 | 19,6 |
| Peak (kW) | 49.1 | 56.1 | 65.9 | 72.2 | 58.0 | 72.2 | 54.3 | 54 |
| Water-Cooled Chiller 03 [Clg Nominal Capacity/F.L.Rate=775 tons / 449.5 kW] (Cooling Equipment) | | | | | | | | |
| Electric (kWh) | 0.0 | 0.0 | 0.0 | 8,736.9 | 77,189.5 | 80,884.8 | 92,692.5 | 94,4 |
| Peak (kW) | 0.0 | 0.0 | 0.0 | 291.2 | 328.5 | 355.8 | 352.2 | 35 |

Project Name: Finfrock Project 801
Dataset Name: PROJECT801.TRC

RUN 421
$100k CT Credit / 10% EPA Tax Credit

**EQUIPMENT ENERGY CONSUMPTION**
By ENGINEERING MATRIX, INC.

Alternative: 2 (3)775T WCC, (2)CT, (1)898T HX

------- Monthly Consumption -------

| Equipment - Utility | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bsu 1: Finfrock Project 801 load profile | | | | | | | | | | | | | |
| Proc. Chill Water (ton-hrs) | 379,091.8 | 570,314.2 | 617,001.1 | 629,656.2 | 788,824.9 | 816,285.1 | 845,296.7 | 854,308.2 | 799,425.1 | 644,636.6 | 610,469.6 | 600,779.0 | 8,156,088.0 |
| Peak (tons) | 1,298.5 | 1,376.0 | 1,472.9 | 1,550.4 | 1,783.0 | 1,938.0 | 1,918.6 | 1,938.0 | 1,899.2 | 1,550.4 | 1,531.0 | 1,434.1 | 1,938.0 |
| Cpl 1: Cooling Plant - 001 [Sum of dsn coil capacities=1,938 tons] | | | | | | | | | | | | | |
| Water-Cooled Chiller 01 [Clg Nominal Capacity/F.L.Rate=775 tons / 449.5 kW] (Cooling Equipment - Cooling Mode) | | | | | | | | | | | | | |
| Electric (kWh) | 122,116.2 | 196,980.3 | 209,581.5 | 209,606.5 | 213,708.8 | 218,345.7 | 221,243.6 | 222,262.7 | 213,773.6 | 209,525.3 | 206,636.1 | 209,549.9 | 2,453,330.0 |
| Peak (kW) | 432.0 | 432.0 | 415.9 | 440.7 | 387.5 | 440.7 | 387.5 | 387.5 | 423.8 | 432.0 | 440.7 | 432.0 | 440.7 |
| _Project 801 Cooling Twr 2-Cell [Design Heat Rejection/F.L. | | | | | | | | | | | | | |
| Electric (kWh) | 3,085.3 | 4,661.2 | 6,3 | | | 25,858.0 | 25,624.3 | 26,861.9 | 19,232.9 | 12,033.4 | 7,415.4 | 5,223.8 | 160,117.5 |
| Peak (kW) | 28.4 | 37.8 | 4 | | | 118.0 | 118.0 | 118.0 | 118.0 | 118.0 | 47.6 | 31.0 | 118.0 |
| _Project 801 Cooling Twr 2-Cell | | | | | | | | | | | | | |
| Make Up Water (1000gal) | 1,215.4 | 1,652.1 | 1,8 | | | 3,178.3 | 3,350.5 | 3,402.9 | 3,116.0 | 2,064.7 | 1,850.6 | 1,731.9 | 28,414.7 |
| Peak (1000gal/Hr) | 4.8 | 5.1 | 5 | | | 9.6 | 9.5 | 9.6 | 9.4 | 7.7 | 5.7 | 5.3 | 9.6 |
| _Project 801 Var Vol CHW Pump [F.L.Rate=74.57 kW] (Misc Accessory Equipment) | | | | | | | | | | | | | |
| Electric (kWh) | 15,159.4 | 23,033.1 | 23,795.0 | 24,308.4 | 23,251.6 | 25,585.3 | 25,196.7 | 25,625.8 | 24,482.8 | 23,360.2 | 24,078.4 | 24,096.3 | 281,972.8 |
| Peak (kW) | 70.0 | 70.0 | 65.9 | 72.2 | 58.0 | 72.2 | 58.0 | 58.0 | 67.9 | 70.0 | 72.2 | 70.0 | 72.2 |
| _Project 801 Var Vol CW Pump [F.L.Rate=99.4 kW] (Cooling Plant Circulation Pump) | | | | | | | | | | | | | |
| Electric (kWh) | 7,618.4 | 11,311.3 | 12,662.4 | 13,360.3 | 18,891.7 | 21,231.0 | 22,024.4 | 22,749.7 | 20,388.5 | 13,708.0 | 12,806.8 | 12,188.6 | 188,941.1 |
| Peak (kW) | 28.1 | 31.3 | 35.7 | 39.6 | 53.5 | 64.7 | 63.2 | 64.7 | 61.7 | 39.6 | 38.6 | 33.9 | 64.7 |
| Var vol geothermal loop pump [F.L.Rate=119.3 kW] (Plant Geothermal Pump) | | | | | | | | | | | | | |
| Electric (kWh) | 5,516.5 | 9,162.6 | 10,071.3 | 9,807.0 | 10,178.8 | 9,923.1 | 10,235.1 | 10,234.9 | 9,889.9 | 10,087.4 | 9,759.9 | 10,047.7 | 114,914.2 |
| Peak (kW) | 14.4 | 14.4 | 14.4 | 14.5 | 14.3 | 14.5 | 14.3 | 14.3 | 14.4 | 14.4 | 14.5 | 14.4 | 14.5 |
| Water-Cooled Chiller 02 [Clg Nominal Capacity/F.L.Rate=775 tons / 449.5 kW] (Cooling Equipment) | | | | | | | | | | | | | |
| Electric (kWh) | 91,057.6 | 124,434.8 | 140,522.7 | 139,696.5 | 152,482.1 | 157,593.7 | 158,466.6 | 160,415.3 | 154,521.8 | 138,907.5 | 140,743.8 | 130,812.6 | 1,689,655.0 |
| Peak (kW) | 357.6 | 381.1 | 415.9 | 440.7 | 387.5 | 440.7 | 375.0 | 375.0 | 423.8 | 432.0 | 440.7 | 401.1 | 440.7 |
| _Project 801 Var Vol CHW Pump [F.L.Rate=74.57 kW] (Misc Accessory Equipment) | | | | | | | | | | | | | |
| Electric (kWh) | 11,187.1 | 14,938.6 | 17,587.9 | 17,887.4 | 17,333.0 | 19,627.3 | 19,040.2 | 19,628.1 | 18,755.1 | 16,995.7 | 18,289.2 | 16,282.7 | 207,552.4 |
| Peak (kW) | 49.1 | 56.1 | 65.9 | 72.2 | 58.0 | 72.2 | 54.3 | 54.3 | 67.9 | 70.0 | 72.2 | 61.9 | 72.2 |

Project Name: Finfrock Project 801
Dataset Name: PROJECT801.TRC

TRACE® 700 v6.3.2 calculated at 05:23 PM on 08/24/2018
Alternative - 2 Equipment Energy Consumption report page 3 of 6
08.24.2018

# Represents Energy Dissipated to Ground Water

TRACE p 13

**RUN 421**
**$100k CT Credit / 10% EPA Tax Credit**

## Geothermal Energy Transfer Summary

By ENGINEERING MATRIX, INC.

### Geothermal Plant - Ground-Source Heat Transfer

**Alternative: 3 - (3)775T WCC, (1)CT, (2)898T HX**
**Plant: Cooling Plant - 001**

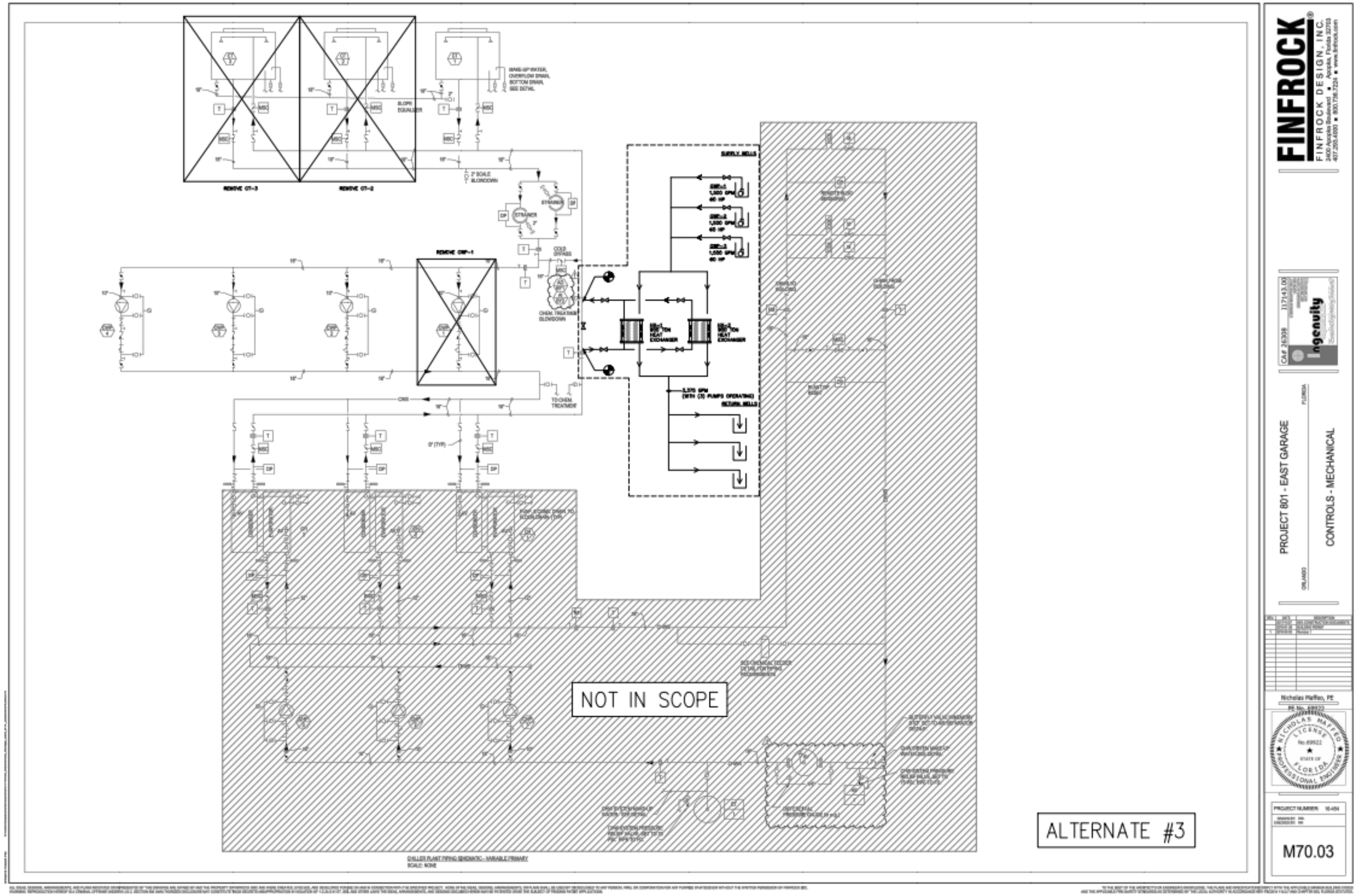
Year: 1

| | QExtracted from Geothermal Loop | | | QRejected to Geothermal Loop | | | Heat Rejected to Auxiliary Cooling | | | | Heat Supplied from Supplemental Boiler | | | | Compressor Energy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | ton-hrs | kBtu | kWh | ton-hrs | kBtu | kWh | peak tons | ton-hrs | kBtu | kWh | peak MBH | ton-hrs | kBtu | kWh | kWh |
| Jan | 0 | 0 | 0 | -439,723 | -5,276,676 | -1,546,052 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 213,174 |
| Feb | 0 | 0 | 0 | -661,731 | -7,940,775 | -2,326,626 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 321,415 |
| Mar | 0 | 0 | 0 | -716,575 | -8,598,900 | -2,519,455 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 350,104 |
| Apr | 0 | 0 | 0 | -713,499 | -8,561,989 | -2,508,640 | 600 | 17,989 | 215,867 | 63,249 | 0 | 0 | 0 | 0 | 358,039 |
| May | 0 | 0 | 0 | -754,394 | -9,052,729 | -2,652,426 | 688 | 160,534 | 1,926,406 | 564,432 | 0 | 0 | 0 | 0 | 443,380 |
| Jun | 0 | 0 | 0 | -776,695 | -9,320,339 | -2,730,835 | 747 | 169,518 | 2,034,214 | 596,019 | 0 | 0 | 0 | 0 | 456,824 |
| Jul | 0 | 0 | 0 | -785,675 | -9,428,096 | -2,762,407 | 740 | 193,981 | 2,327,770 | 682,030 | 0 | 0 | 0 | 0 | 472,402 |
| Aug | 0 | 0 | 0 | -792,126 | -9,505,507 | -2,785,089 | 747 | 197,899 | 2,374,792 | 695,808 | 0 | 0 | 0 | 0 | 477,177 |
| Sep | 0 | 0 | 0 | -760,566 | -9,126,794 | -2,674,127 | 732 | 166,184 | 1,994,202 | 584,296 | 0 | 0 | 0 | 0 | 447,679 |
| Oct | 0 | 0 | 0 | -711,694 | -8,540,324 | -2,502,292 | 600 | 37,177 | 446,126 | 130,714 | 0 | 0 | 0 | 0 | 366,489 |
| Nov | 0 | 0 | 0 | -709,269 | -8,511,229 | -2,493,768 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 347,380 |
| Dec | 0 | 0 | 0 | -697,584 | -8,371,006 | -2,452,683 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 340,363 |
| Annual | 0 | 0 | 0 | -8,519,530 | -102,234,368 | -29,954,400 | 747 | 943,281 | 11,319,377 | 3,316,548 | 0 | 0 | 0 | 0 | 4,594,425 |

Energy Moved Out of the Building & Into Earth

Remainder to C/T

# Alternate #3: Turn Off 2 Cooling Towers



# Economic Comparison Summary

RUN 421
$100k CT Credit / 10% EPA Tax Credit

## Economic Summary

### Project Information

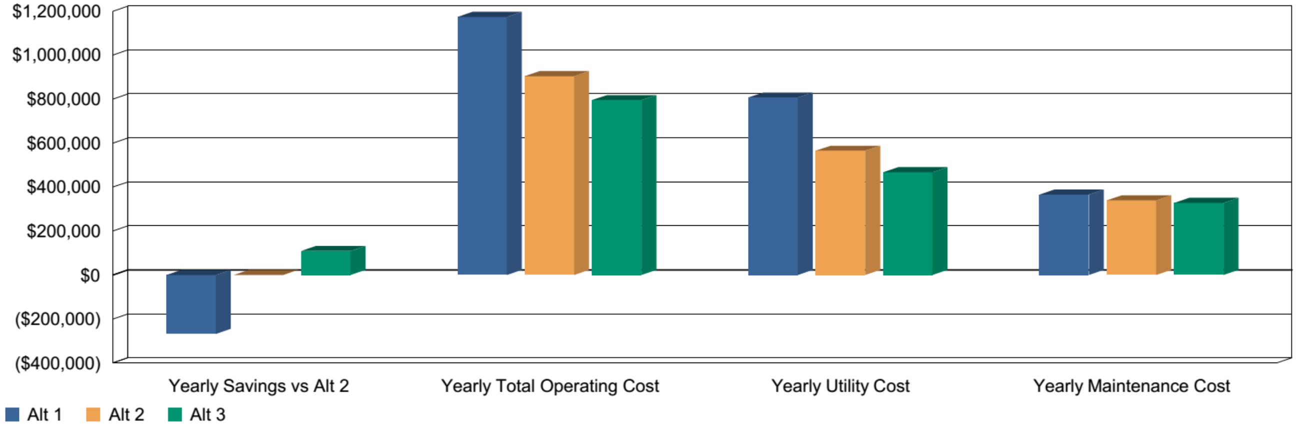
| | | | |
|---|---|---|---|
| Location | South East | Study Life: | 25 years |
| Project Name | Finfrock Project 801 | Cost of Capital: | 8.25 % |
| User | CJM | Alternative 1: | (3)775T WCC, (3)CT |
| Company | Engineering Matrix | Alternative 2: | (3)775T WCC, (2)CT, (1)898T HX |
| Comments | Alterantives analysis of New CEP at Project 801 | Alternative 3: | (3)775T WCC, (1)CT, (2)898T HX |

### Economic Comparison of Alternatives

| | Yearly Savings ($) | First Cost Difference ($) | Cumulative Cash Flow Difference ($) | Simple Payback (yrs.) | Net Present Value ($) | Life Cycle Payback (yrs.) | Internal Rate of Return (%) | Life Cycle Cost Difference |
|---|---|---|---|---|---|---|---|---|
| Alt 2 vs Alt 1 | 268,530 | 1,300,000 | 10,217,070 | 4.8 | 3,403,317 | 1.9 | 39.0 | 3,403,317.00 |
| Alt 3 vs Alt 1 | 377,625 | 1,800,000 | 14,407,030 | 4.8 | 4,580,533 | 2.5 | 35.1 | 4,580,533.00 |
| Alt 3 vs Alt 2 | 109,096 | 500,000 | 4,189,953 | 4.6 | 1,177,216 | 5.0 | 26.9 | 1,177,216.00 |

TRACE P 3

### Annual Operating Costs




| | Yearly Savings vs Alt 2 | Yearly Total Operating Cost ($) | Yearly Utility Cost ($) | Yearly Maintenance Cost ($) | Plant kWh/ton-hr |
|---|---|---|---|---|---|
| Alt 1 | -268,530 | 1,173,099 | 807,299 | 365,800 | 0.717 |
| Alt 2 | 0 | 904,569 | 565,169 | 339,400 | 0.687 |
| Alt 3 | 109,096 | 795,473 | 467,173 | 328,300 | 0.686 |

RUN 421
$100k CT Credit / 10% EPA Tax Credit

# Calculating Water Savings:

**MONTHLY UTILITY COSTS**

By ENGINEERING MATRIX, INC.

TRACE pp 24-25 (Switched from Gallons to $'s on consolidated report)

------- Monthly Utility Costs -------

| Utility | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alternative 1** | | | | | | | | | | | | | |
| Electric | | | | | | | | | | | | | |
| On-Pk Cons. ($) | 5,322 | 6,852 | 7,927 | 11,402 | 13,566 | 15,102 | [illegible] | 15,930 | 14,532 | 12,154 | 7,872 | 7,616 | 133,898 |
| Off-Pk Cons. ($) | 2,227 | 5,556 | 4,857 | 8,353 | 11,232 | 12,012 | [illegible] | 12,545 | 11,552 | 8,901 | 11,715 | 10,828 | 112,322 |
| Mid-Pk Cons. ($) | 9,402 | 11,931 | 14,557 | 7,160 | 8,940 | 10,116 | [illegible] | 10,759 | 9,775 | 7,677 | 4,486 | 5,032 | 110,268 |
| On-Pk Demand ($) | 7,765 | 8,330 | 9,402 | 9,993 | 11,391 | 12,380 | [illegible] | 12,380 | 12,120 | 10,385 | 9,993 | 8,808 | 125,196 |
| Total ($): | 24,716 | 32,669 | 36,743 | 36,908 | 45,128 | 49,610 | [illegible] | 51,614 | 47,979 | 39,117 | 34,067 | 32,285 | 481,683 |
| Water | | | | | | | | | | | | | |
| On-Pk Cons. ($) | 15,131 | 22,770 | 24,657 | 25,171 | 31,483 | 32,559 | 33,710 | 34,067 | 31,890 | 25,769 | 24,406 | 24,004 | 325,616 |
| Monthly Total ($): | 39,847 | 55,439 | 61,400 | 62,079 | 76,611 | 82,169 | 84,557 | 85,681 | 79,869 | 64,886 | 58,473 | 56,289 | 807,298 |

Building Area = 1 ft²

Utility Cost Per Area = 807,298.48 $/ft²

| Utility | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alternative 2** | | | | | | | | | | | | | |
| Electric | | | | | | | | | | | | | |
| On-Pk Cons. ($) | 5,297 | 6,819 | 7,874 | 11,100 | 12,893 | 14,120 | [illegible] | 14,838 | 13,519 | 11,458 | 7,794 | 7,594 | 127,874 |
| Off-Pk Cons. ($) | 2,230 | 5,569 | 4,874 | 8,307 | 10,957 | 11,121 | [illegible] | 11,466 | 10,852 | 8,451 | 11,594 | 10,793 | 107,678 |
| Mid-Pk Cons. ($) | 9,335 | 11,849 | 14,364 | 7,023 | 8,562 | 9,391 | [illegible] | 9,928 | 9,047 | 7,261 | 4,404 | 4,986 | 105,765 |
| On-Pk Demand ($) | 7,557 | 8,083 | 8,945 | 9,563 | 10,352 | 11,763 | [illegible] | 11,763 | 11,515 | 9,530 | 9,483 | 8,526 | 118,717 |
| Total ($): | 24,419 | 32,320 | 36,058 | 35,993 | 42,763 | 46,396 | [illegible] | 47,995 | 44,933 | 36,700 | 33,275 | 31,899 | 460,035 |
| Water | | | | | | | | | | | | | |
| On-Pk Cons. ($) | 4,497 | 6,113 | 6,858 | 7,220 | 11,275 | 11,760 | 12,397 | 12,591 | 11,529 | 7,639 | 6,847 | 6,408 | 105,134 |
| Monthly Total ($): | 28,916 | 38,433 | 42,915 | 43,213 | 54,038 | 58,155 | 59,681 | 60,585 | 56,462 | 44,339 | 40,122 | 38,307 | 565,169 |

Saving up to $21,000 in water & 6MM Gallons/month

Building Area = 1 ft²

Utility Cost Per Area = 565,168.86 $/ft²

# Calculating savings and cost (Hotel/Campus)

**PROJECT 801 MODEL (Series 400 Runs) RESULTS: SCENARIO #3: (EPA TAX CREDIT Only; NO IRS MACRS TAX BENEFIT; NO UTILITY REBATES) - $0 CREDIT for CTs** — SCENARIO #3: WORST CASE w/ EPA TAX Credit — RUN 420

| | UTILITY COSTS | | | MAINTENANCE COST | ANNUAL OPERATING COST | ANNUAL OPERATING SAVINGS | CONSTRUCTION COSTS | | | | | | | FINANCIALS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (A) | (B) | (C)= (A) + (B) | (D) | (E) = (C) + (D) | (F) | (G) | (H) | (I) | (J) | (K) = (G) + (H) + (I) + (J) | | (L) | (M) = (L)/(P) | | |
| | Annual Cost of Electricity | Annual Cost of Water | Annual UTILITY Cost (Elec & Water) | Annual MAINTENANCE Cost | TOTAL OPERATING Cost (UTILITY plus MAINTENANCE) | TOTAL OPERATING SAVINGS (UTILITY plus MAINTENANCE) | Estimated HVAC System Cost (less Ductwork and CTs) | CT Cost | CT CREDIT Received | GEO System Cost | TOTAL Construction Cost | FEDERAL EPA TAX CREDIT of 10% of HVAC System Cost Rec'd in Year 2 (less Ductwork) | Construction PREMIUM to Add Geothermal | Simple Payback (Years) * | Life-Cycle Payback (Years) | IROR |
| Alt 1 BASE CASE (3 CTs) | $ 481,683 | $ 325,616 | $ 807,298 | $ 365,800 | $ 1,173,098 | N/A (Base Case) | $ 8,561,750 | $ 581,250 | $ - | $ - | $ 9,143,000 | N/A (Base Case) | N/A (Base Case) | N/A | N/A | N/A |
| Alt 2 Remove 1 CT Add HX Equivalent | $ 458,712 | $ 105,134 | $ 563,846 | $ 342,700 | $ 906,546 | $ 266,552 | $ 8,561,750 | $581,250 | $ - | $ 1,400,900 | $ 10,543,900 | $ 1,054,390 | $ 346,510 | 1.30 | 2.00 | 35.8% |
| Alt 3 Remove 2 CTs Add HX Equivalent | $ 440,469 | $ 11,168 | $ 451,638 | $ 334,300 | $ 785,938 | $ 387,161 | $ 8,561,750 | $581,250 | $ - | $ 2,000,900 | $ 11,143,900 | $ 1,114,390 | $ 886,510 | 2.29 | 3.00 | 32.0% |

TOTAL LIFE CYCLE COST OF OWNERSHIP in Present Worth Dollars for ALT 1: $ 25,695,654
TOTAL LIFE CYCLE COST OF OWNERSHIP in Present Worth Dollars for ALT 2: $ 22,410,427
TOTAL LIFE CYCLE COST OF OWNERSHIP in Present Worth Dollars for ALT 3: $ 21,168,498

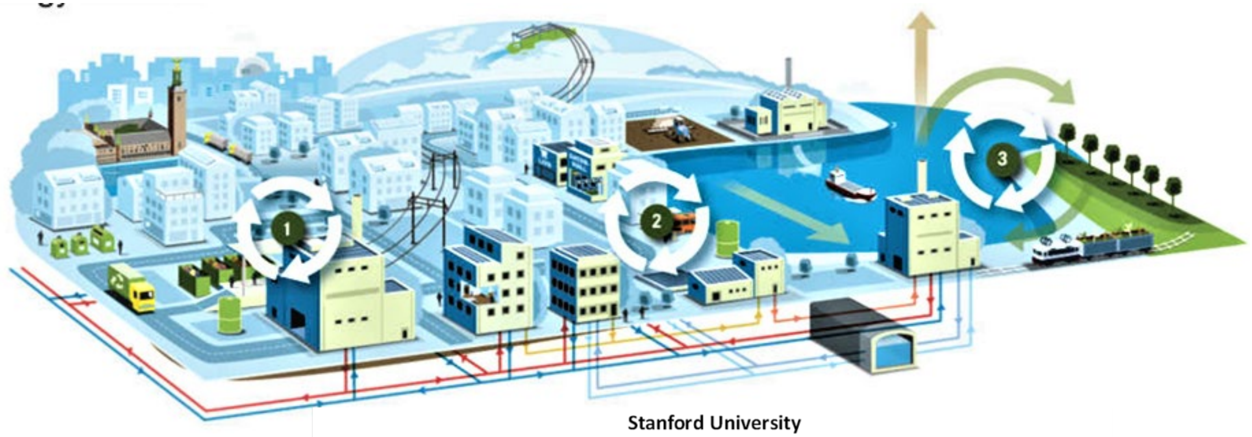
* Calculated on PWV; Building Model uses Year 0 only

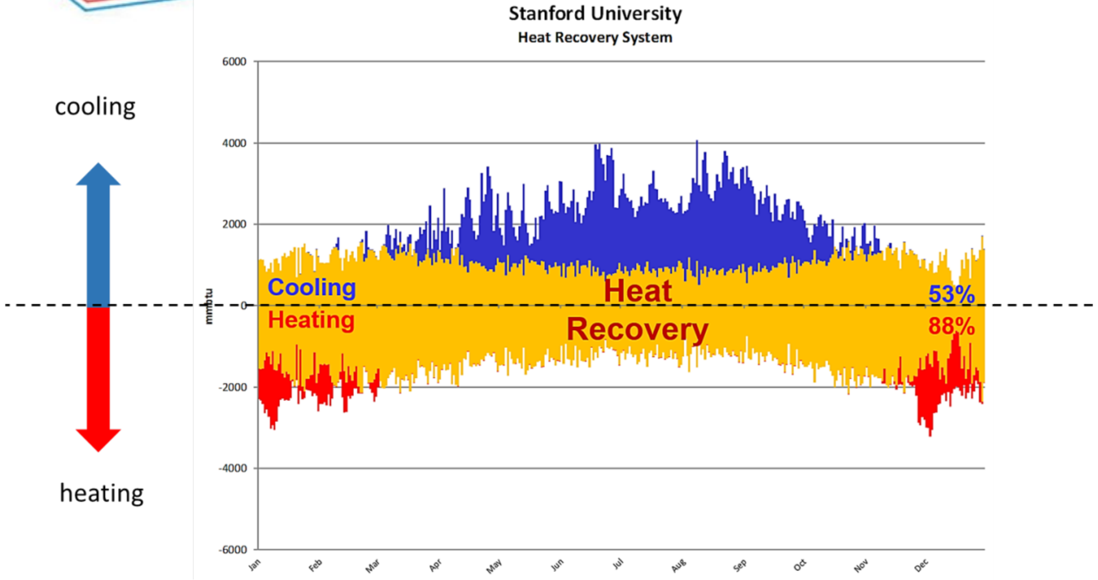
**PROJECT 801 MODEL (Series 400 Runs) RESULTS: SCENARIO #4: (EPA TAX CREDIT; NO IRS MACRS TAX BENEFIT; NO UTILITY REBATES) - $100,000 CREDIT for CTs** — SCENARIO #4: MOST REALISTIC — RUN 421

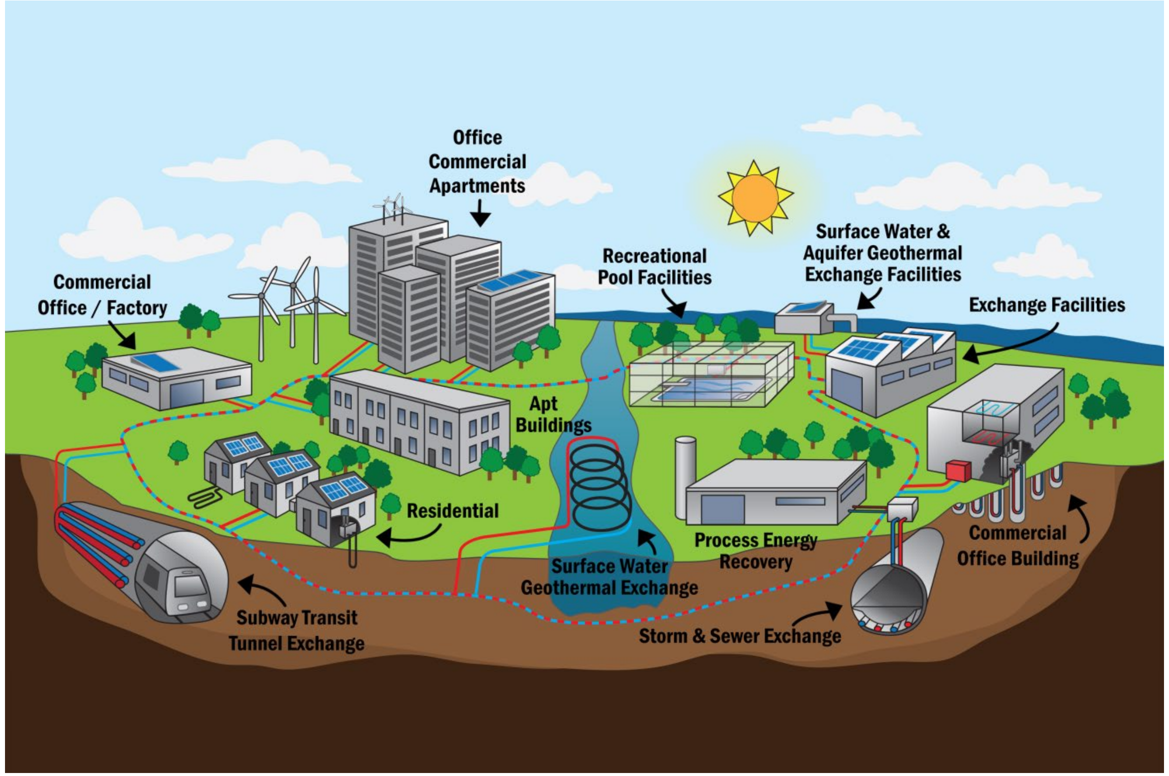
| | UTILITY COSTS | | | MAINTENANCE COST | ANNUAL OPERATING COST | ANNUAL OPERATING SAVINGS | CONSTRUCTION COSTS | | | | | | | FINANCIALS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (A) | (B) | (C)= (A) + (B) | (D) | (E) = (C) + (D) | (F) | (G) | (H) | (I) | (J) | (K) = (G) + (H) + (I) + (J) | | (L) | (M) = (L)/(P) | | |
| | Annual Cost of Electricity | Annual Cost of Water | Annual UTILITY Cost (Elec & Water) | Annual MAINTENANCE Cost | TOTAL OPERATING Cost (UTILITY plus MAINTENANCE) | TOTAL OPERATING SAVINGS (UTILITY plus MAINTENANCE) | Estimated HVAC System Cost (less Ductwork and CTs) | CT Cost | CT CREDIT Received | GEO System Cost | TOTAL Construction Cost | FEDERAL EPA TAX CREDIT of 10% of HVAC System Cost Rec'd in Year 2 (less Ductwork) | Construction PREMIUM to Add Geothermal | Simple Payback (Years)* | Life-Cycle Payback (Years) | IROR |
| Alt 1 BASE CASE (3 CTs) | $ 481,683 | $ 325,616 | $ 807,298 | $ 365,800 | $ 1,173,098 | N/A (Base Case) | $ 8,561,750 | $ 581,250 | $ - | $ - | $ 9,143,000 | N/A (Base Case) | N/A (Base Case) | N/A | N/A | N/A |
| Alt 2 Remove 1 CT Add HX Equivalent | $ 460,035 | $ 105,134 | $ 565,169 | $ 339,400 | $ 904,569 | $ 268,529 | $ 8,561,750 | $581,250 | $100,000 | $ 1,400,900 | $ 10,443,900 | $ 1,044,390 | $ 256,510 | 0.96 | 1.90 | 39.0% |
| Alt 3 Remove 2 CTs Add HX Equivalent | $ 456,005 | $ 11,168 | $ 467,173 | $ 328,300 | $ 795,473 | $ 377,625 | $ 8,561,750 | $581,250 | $200,000 | $ 2,000,900 | $ 10,943,900 | $ 1,094,390 | $ 706,510 | 1.87 | 2.50 | 35.1% |

TOTAL LIFE CYCLE COST OF OWNERSHIP in Present Worth Dollars for ALT 1: $ 25,695,654
TOTAL LIFE CYCLE COST OF OWNERSHIP in Present Worth Dollars for ALT 2: $ 22,292,337
TOTAL LIFE CYCLE COST OF OWNERSHIP in Present Worth Dollars for ALT 3: $ 21,115,122

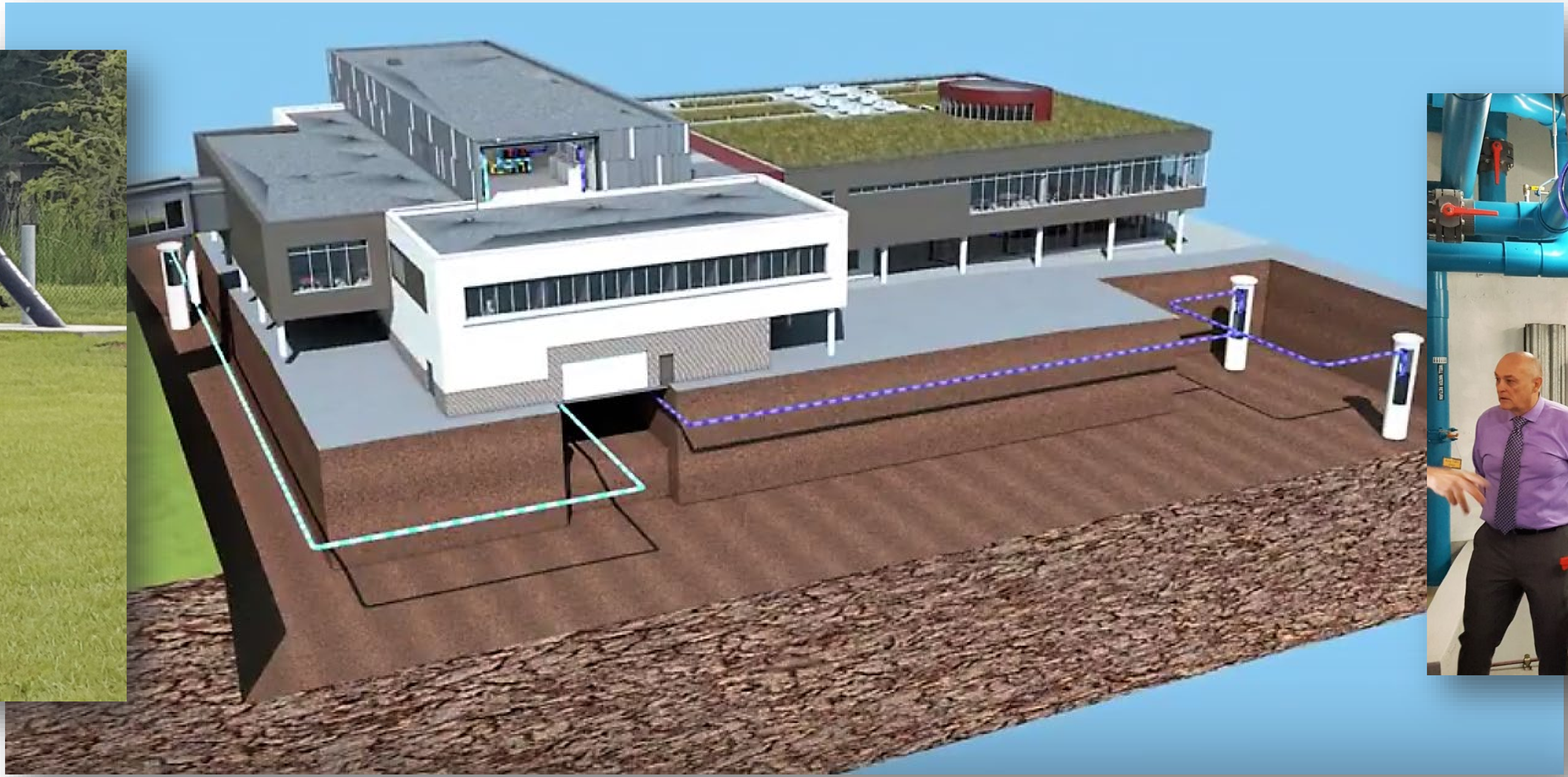
# The opportunities for load diversity and hybrid applications are vast



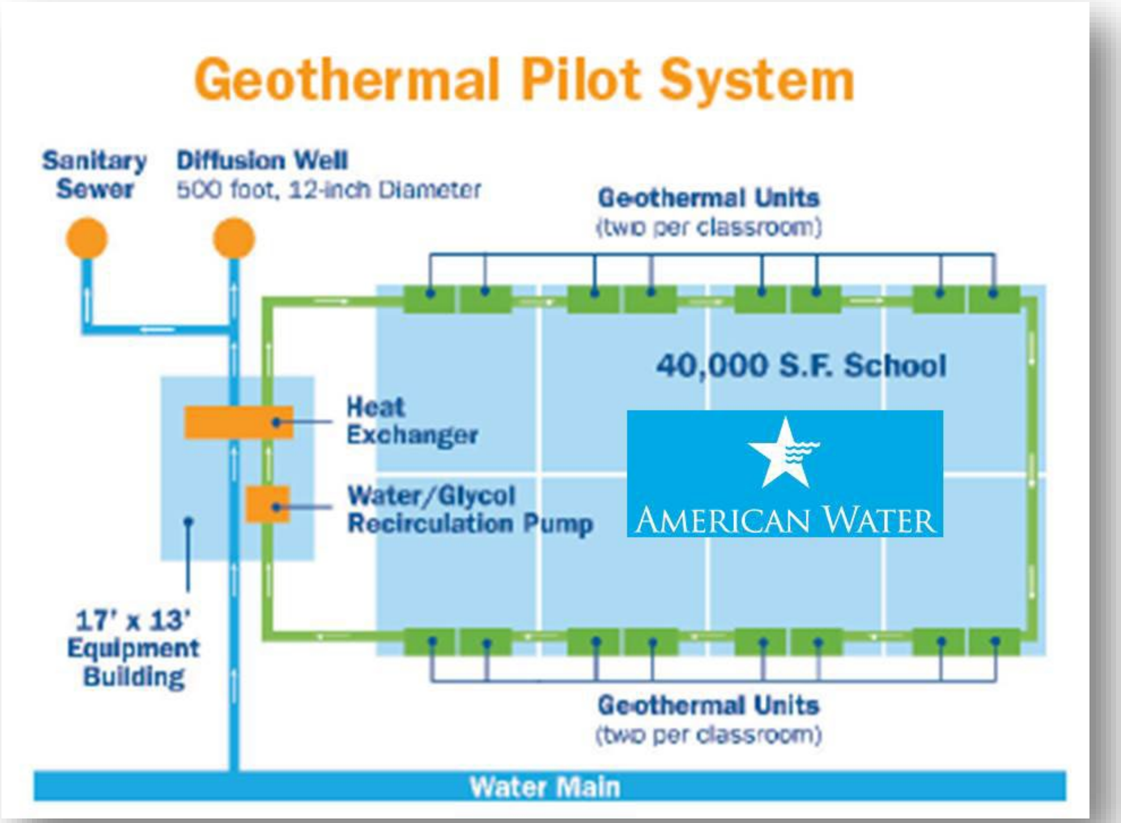


# Commercial: Ground Water Sourced of Class V UIC Geothermal



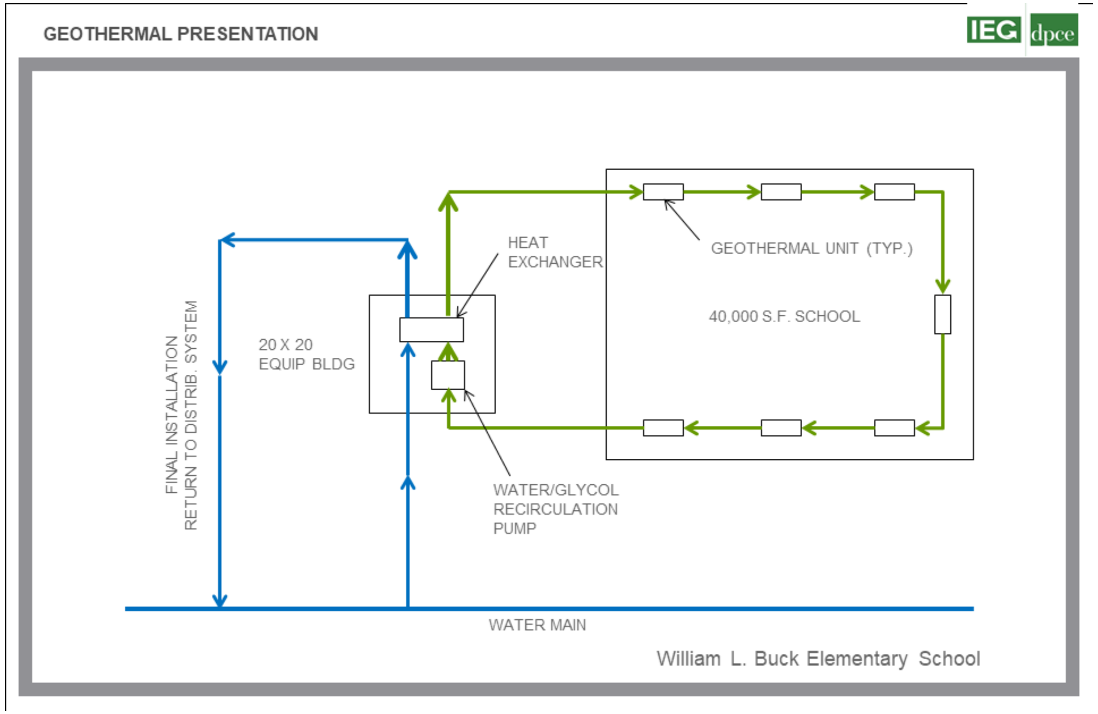
# There are more ways than we think: New Developments are using drinking water:




Valley Stream Middle School entered a project that was a collaboration between a manufacturer, American Water, and the New York Public Service Commission.

The 40,000 square-foot school was outfitted with new geothermal heat pumps, and the heat pumps were fed by the existing water main

# Use of Water-Mains as a Geothermal Source



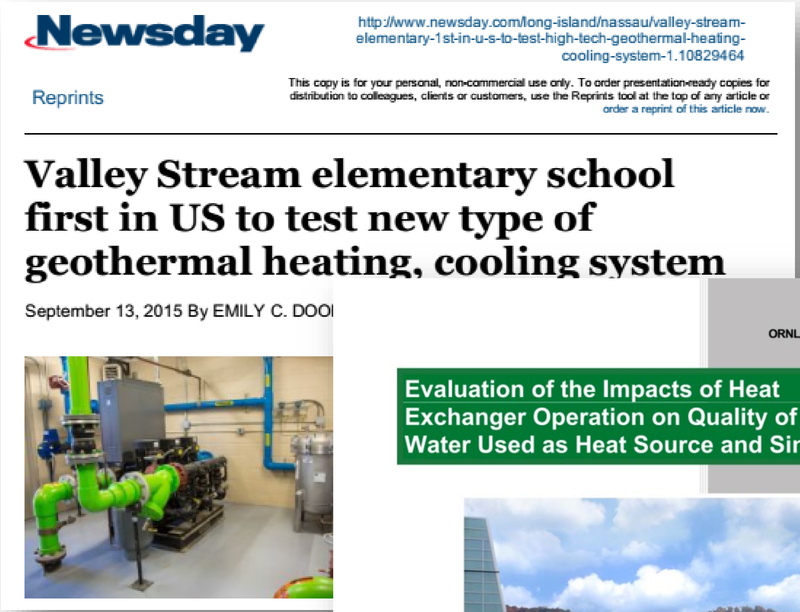

The ultimate goal of this configuration will result in the piping as depicted here. The water will be returned to the water main, certified as clean and safe for human consumption.

This project has been under test and certification for almost two years. Once approved by the PSC for public use, government building will be able to apply for permits to use water-mains as their geothermal source.

# Valley Stream Elementary in New York

Geothermal Heat Pump (Left) and Exchanger Room (Above)

# ORNL: Evaluation of the Impacts of Heat Exchanger Operation on Quality of Water Used as Heat Source and Sink


Newsday
http://www.newsday.com/long-island/nassau/valley-stream-elementary-1st-in-u-s-to-test-high-tech-geothermal-heating-cooling-system-1.10829464
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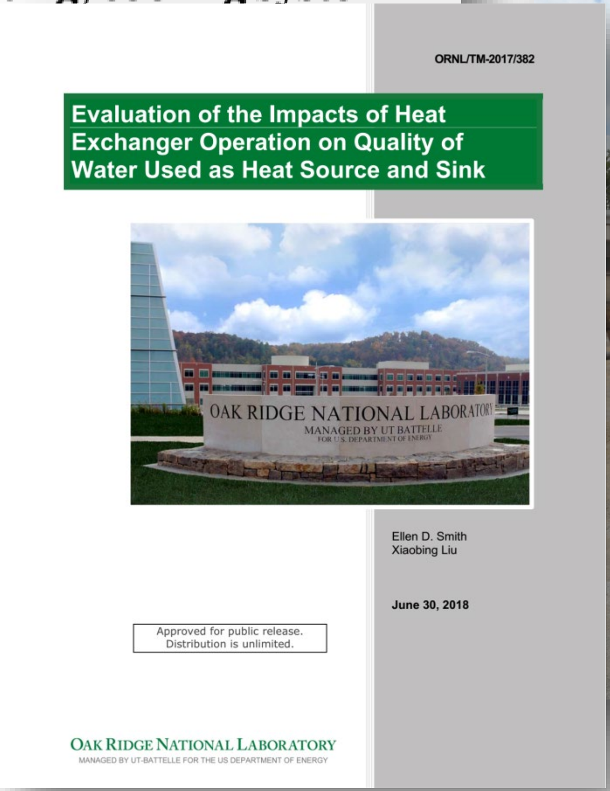
Valley Stream elementary school first in US to test new type of geothermal heating, cooling system

September 13, 2015 By EMILY C. DOO


ORNL/TM-2017/382

Evaluation of the Impacts of Heat Exchanger Operation on Quality of Water Used as Heat Source and Sink



Ellen D. Smith
Xiaobing Liu

June 30, 2018

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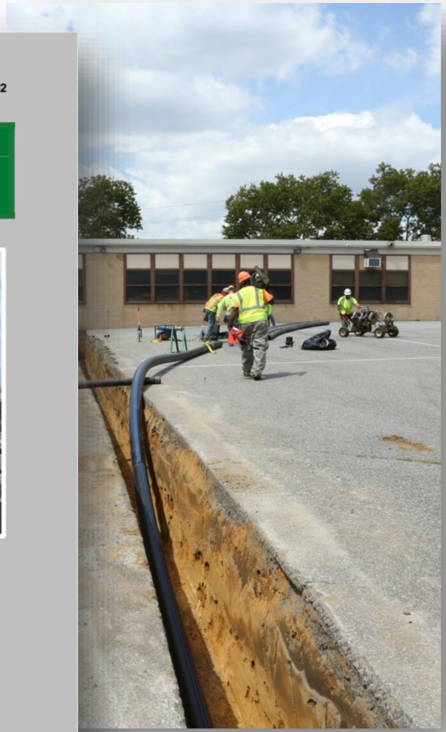
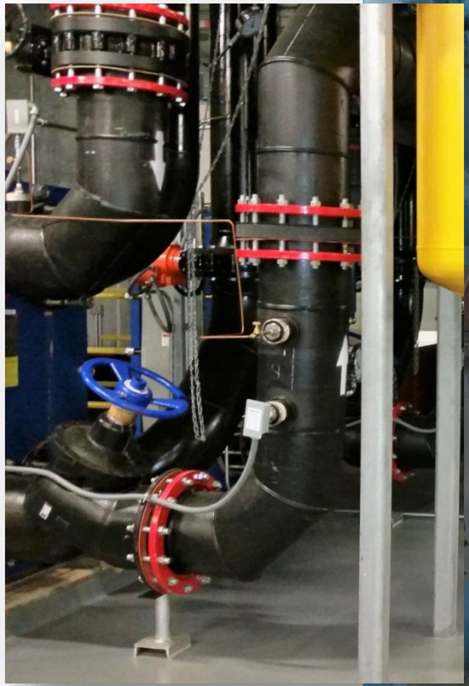
OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY



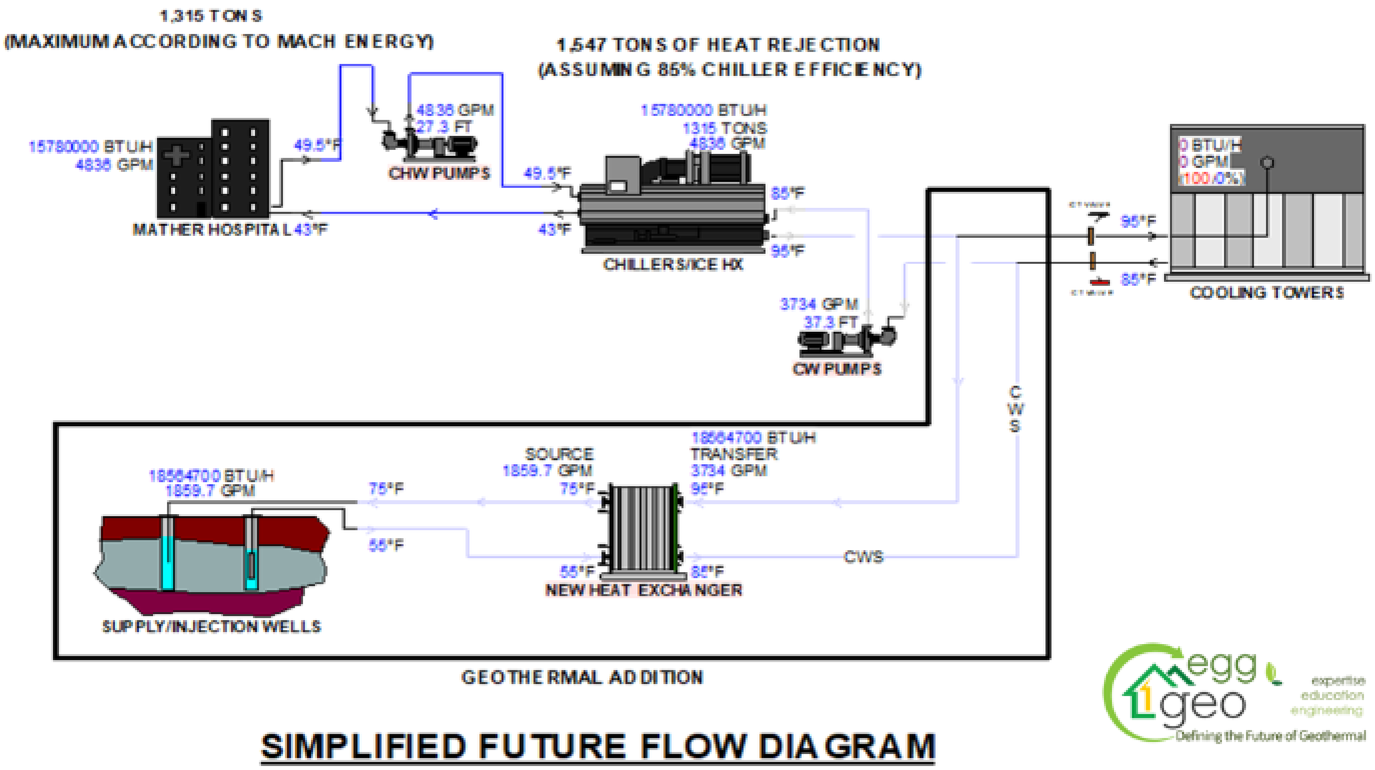
**From the ORNL Study:**

- *"Data were compared with regulatory standards and inflow and outflow data were compared to identify changes occurring in the water resulting from its passage through the heat exchanger. Review of the data identified no conditions that would prevent the use of heat exchange outflow water for water supply.* ***Inflow and outflow water quality conforms with applicable regulatory standards.****"*

# Commercial: Ground Water Sourced of Class V UIC Geothermal In Practice for Decades. Out of Sight; Out of Mind




# Cooling tower to Geothermal Example

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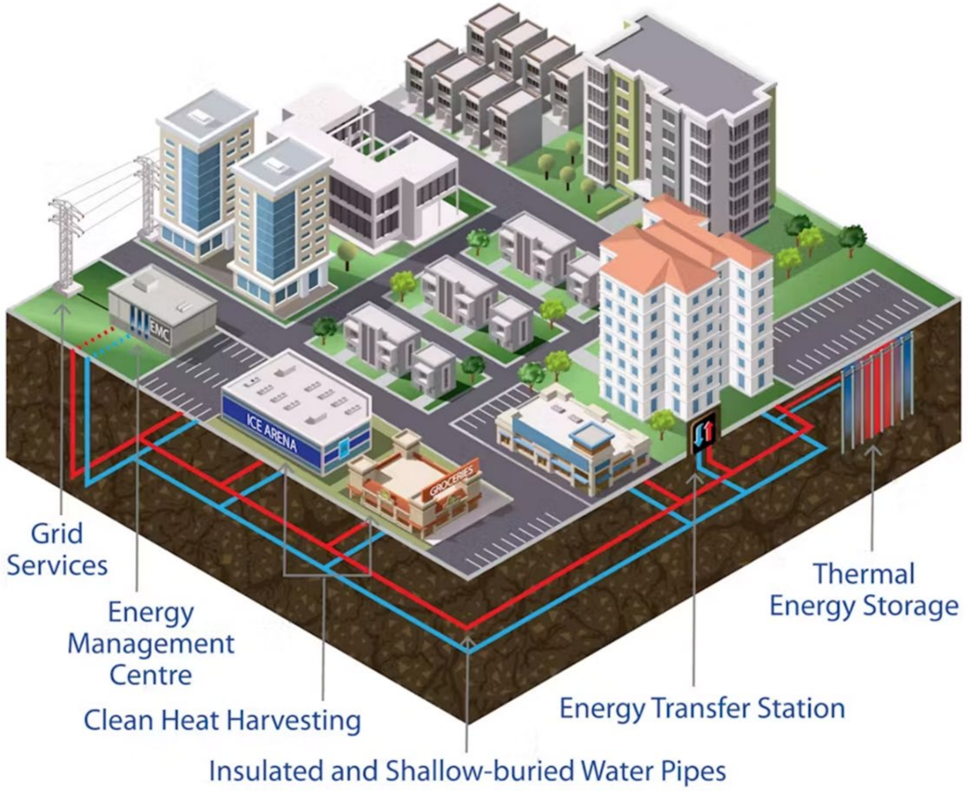
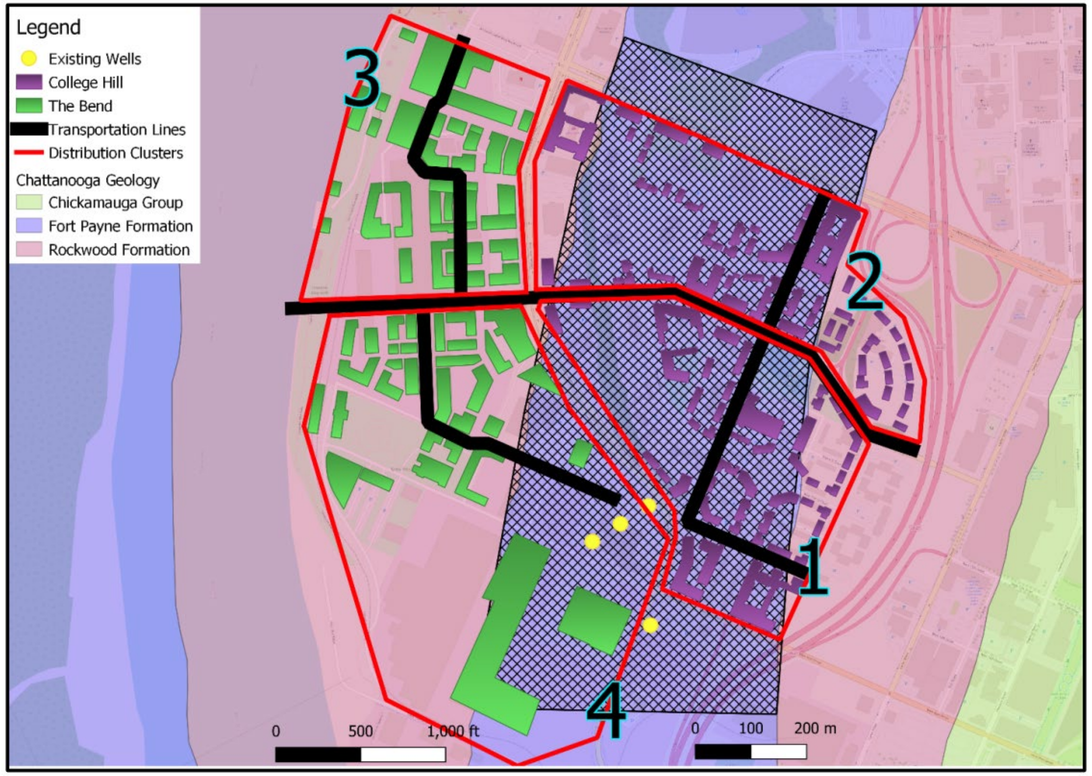
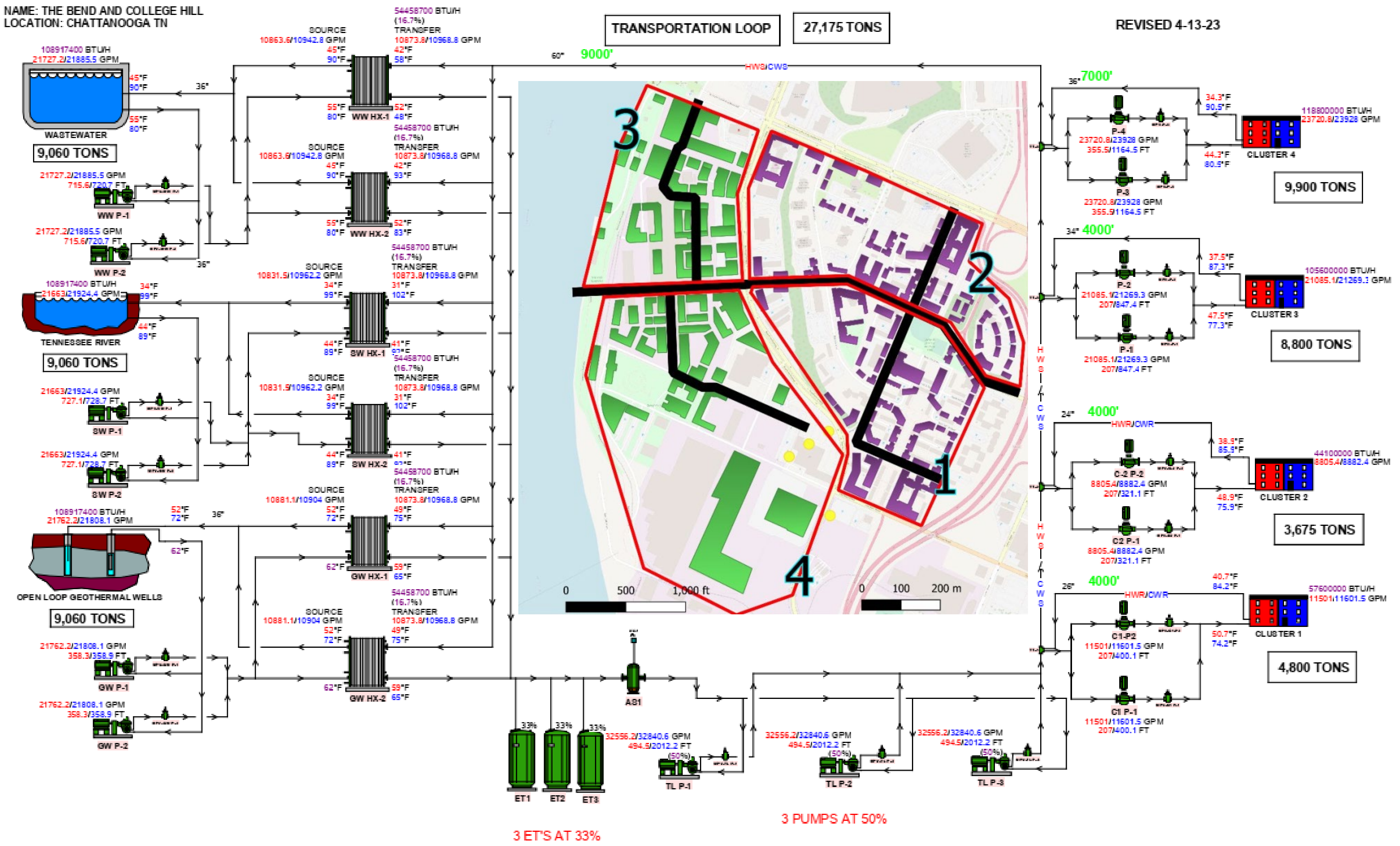
# Thermal Network Integration for City Centers



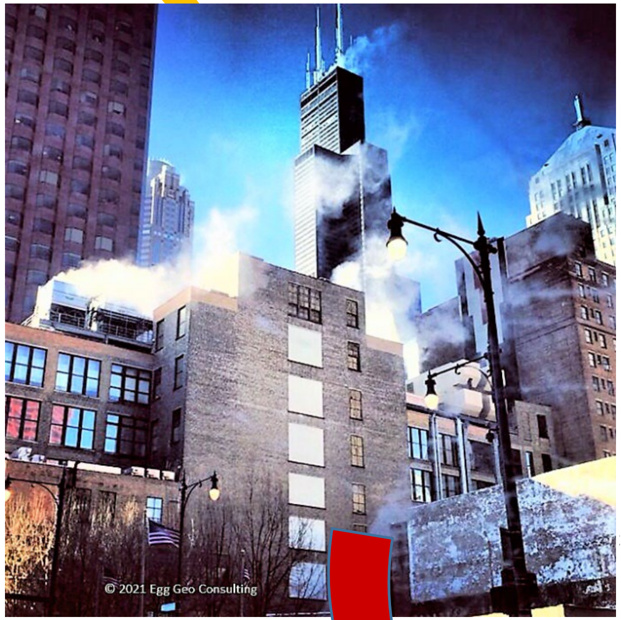
# Thermal Network Integration for City Centers

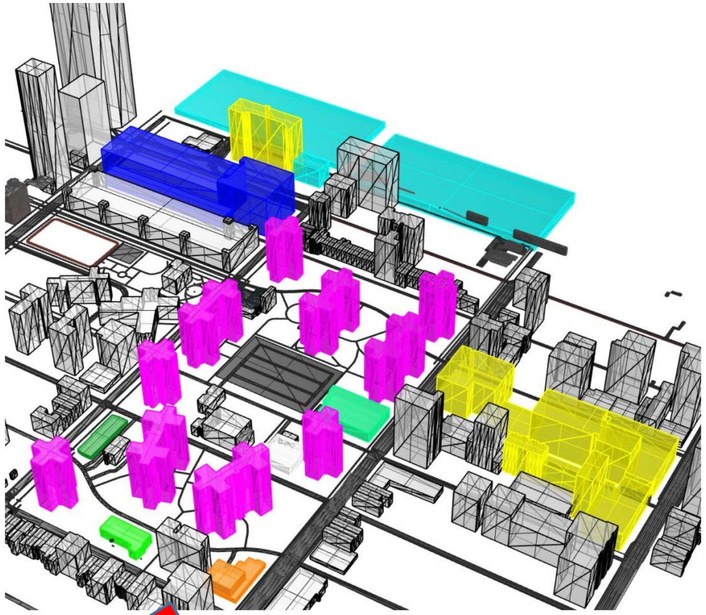


# Heat Energy Expelled from Cooling Towers is Piped to the Residential Apartments

**Thermal Energy Network** Concept:

“TEN”





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# Beyond Financial Benefits

**Beyond financial benefits** of geothermal heating and cooling technologies lies an impressive list of environmental benefits; many of which are not considered at first.

Energy efficiency investments may have a payoff or return on investment longer than a company's typical hurdle rate. Some of the value that is not always measured when considering sustainable initiatives such as geothermal HVAC include:

- Reduced reliance on fossil fuels
- Reduced price risk
- Easier planning due to stability of fuel sources
- "Eco-Immunity"
- Increased likelihood to be the vendor of choice
- Increased attractiveness to valuable talent


Public Relations

As stated above, companies that make the shift to renewable energy sources such as geothermal sourced chiller plants fit a model for a growing consumer base that may include tourism.

Sustainable Advancements

Sustainability initiatives are met favorably through the elimination of cooling towers and reductions in chemical consumables, labor, and energy and water consumption, along with an increase in usable space normally reserved for the footprint of a cooling tower.
Renewable Energy employment (Direct use geothermal)

# Some Important Points to Recap:

- Water Conservation = New Water
- Public Health & Safety
  - Do Nevada statutes empower the Water Management Districts within the WMD and DEP rules?
- Can Las Vegas implement like NYC Local Law 95-97?
- Storm Resistance & Hardening
- Economics and Energy Savings
  - Lifecycle (longevity) and reduced maintenance and chemicals
  - Green Benefits
- **Develop a precedent with Egg Geo studies, implementation, and validation efforts.**

# Geothermal Provides **Water Savings**.
# Geothermal Provides **New Water.**

Take-A-Ways:

1. **Geothermal systems enable water savings (= New Water)**
2. **Geothermal systems improve building performance**
3. **Geothermal systems increase Public Health & Safety**
4. **Geothermal systems provide greater energy–efficiency**
5. **Geothermal systems increase longevity of equipment**

# Thermal Energy Networks (TENs)




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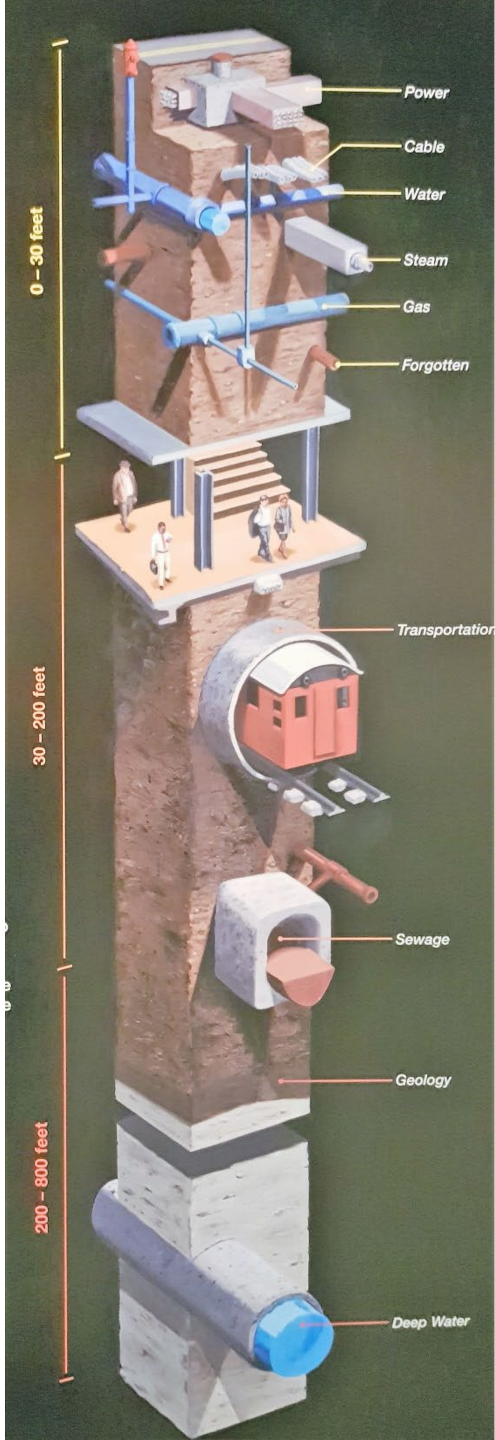

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# Water Saving Legislation

## HOW TO CONSERVE WATER AND MAXIMIZE NON-CONSUMPTIVE USE OF GROUNDWATER BY DEVELOPING COOLING SYSTEMS BASED ON GEOTHERMAL TECHNOLOGY

### Geothermal HVAC Systems:

## Cooling Tower Conversion to Geothermal Sources Saves Precious Water

Jay Egg, CMC

# End of Water Saving Presentation