Heat Pumps 101: An Introduction to Heat Pump Technologies

Jay Egg / *Egg Geothermal*

Presented Live at the NY-GEO 2023 Conference Albany, New York on April 26, 2023

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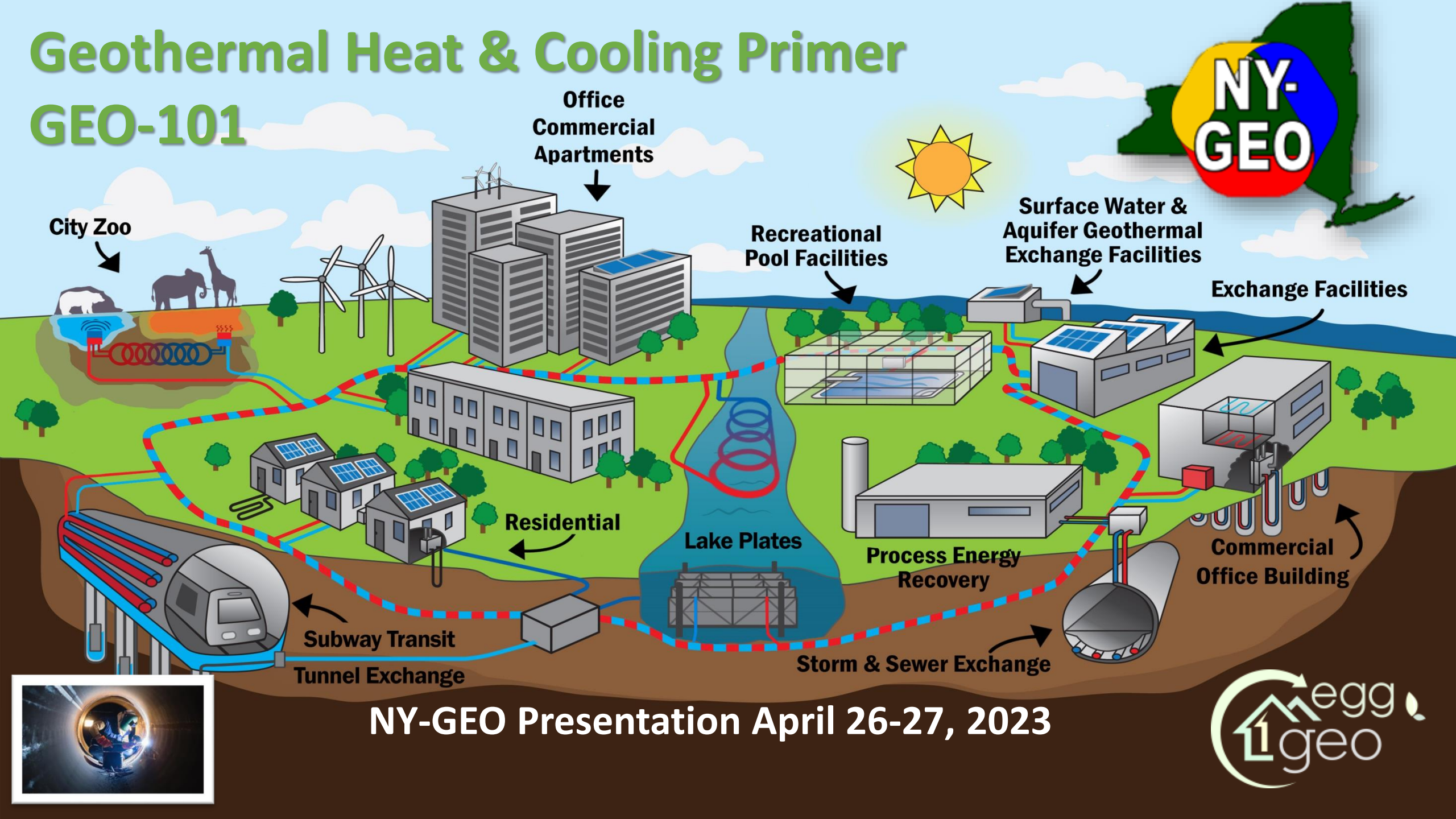
Geothermal Heat & Cooling Primer

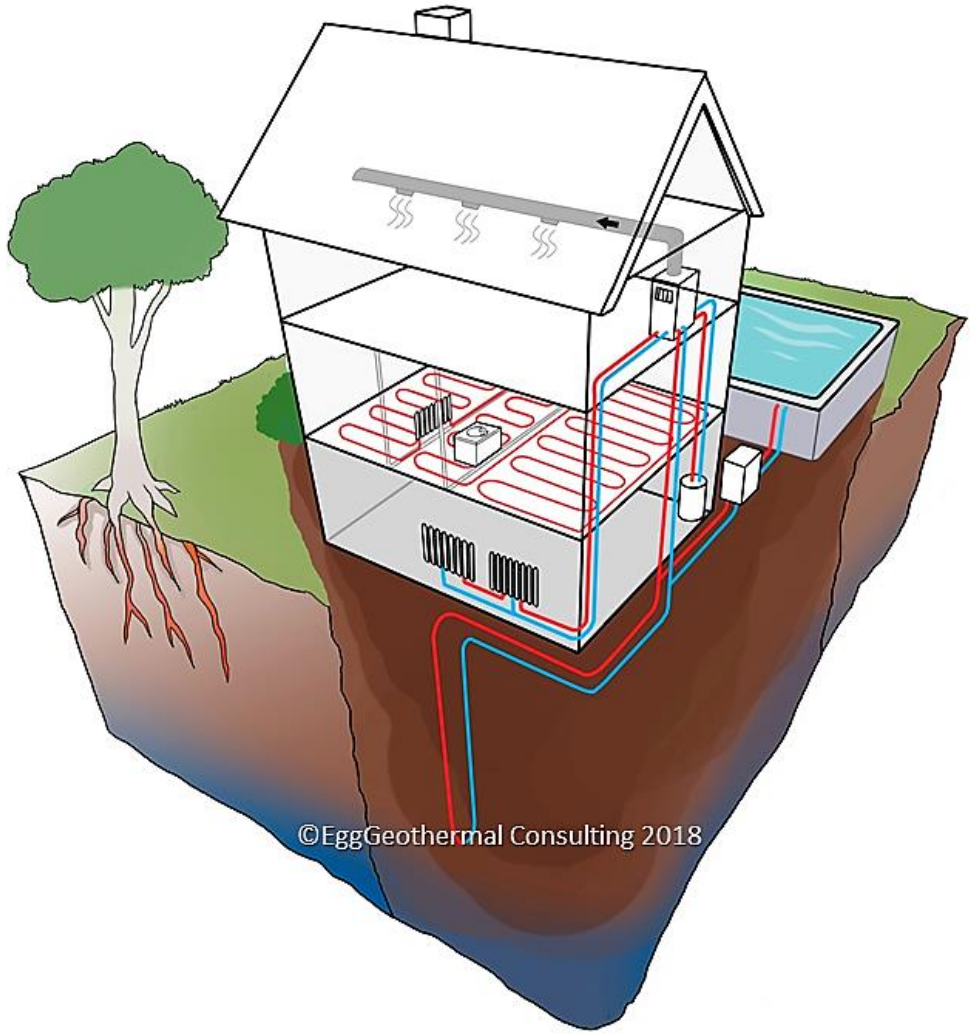
GEO-101



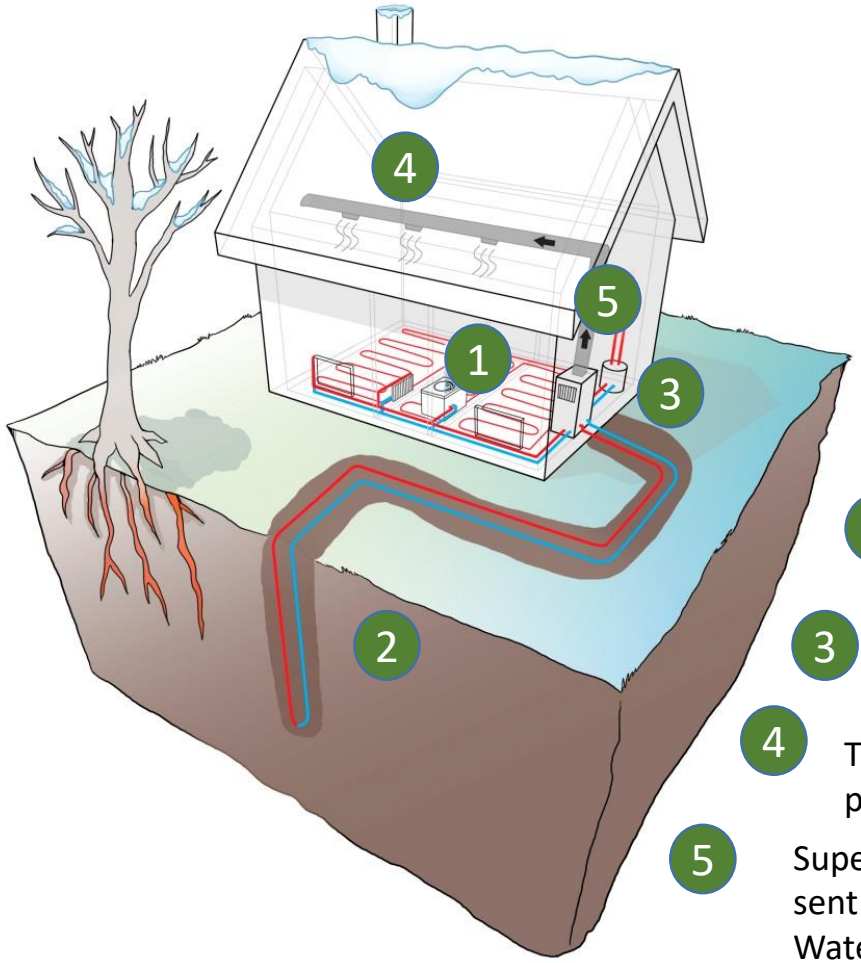
NY-GEO Presentation April 26-27, 2023

Learning Objectives for Attendees

1. Understand the context and verbiage of heat pumps in clean heating and cooling technology
2. Identify the importance, adaptability, and benefits of the technology as vital to infrastructure and building construction
3. Understand why the technology is important to health, human safety, and imperative industry goals
4. Understand existing barriers to geothermal adoption and how to manage them
5. Internalize our collective capability and responsibility to make these changes
6. Leave with the intent to properly study, specify, & apply heat pump technology & safe building in every application going forward



Both GSHP & ASHP use a refrigerant system



1. Cold air goes to the heat pump
2. The heat pump processes heat from the ground
3. Heat is conducted through ducts or pipes
4. The home is warmed the Heat pumps
5. Superheat from the heat pump is sent into the DHW (Domestic Hot Water) System

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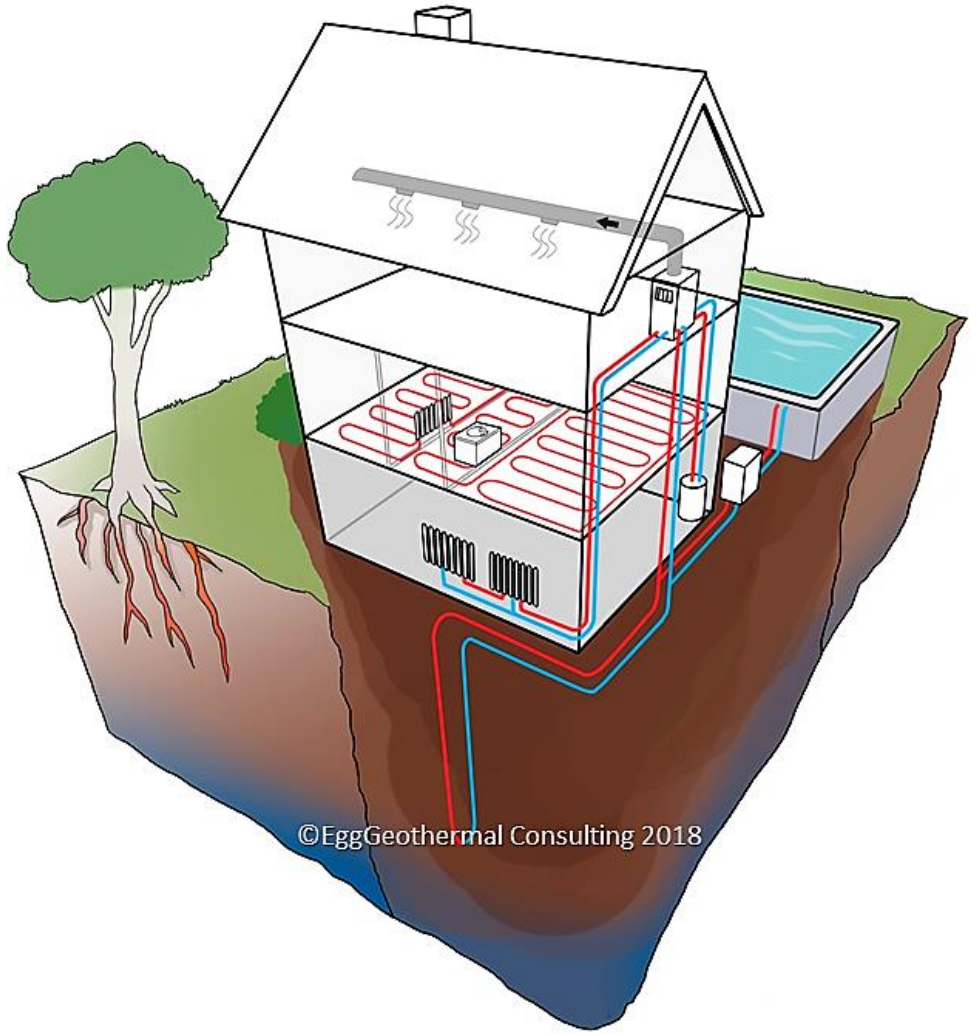
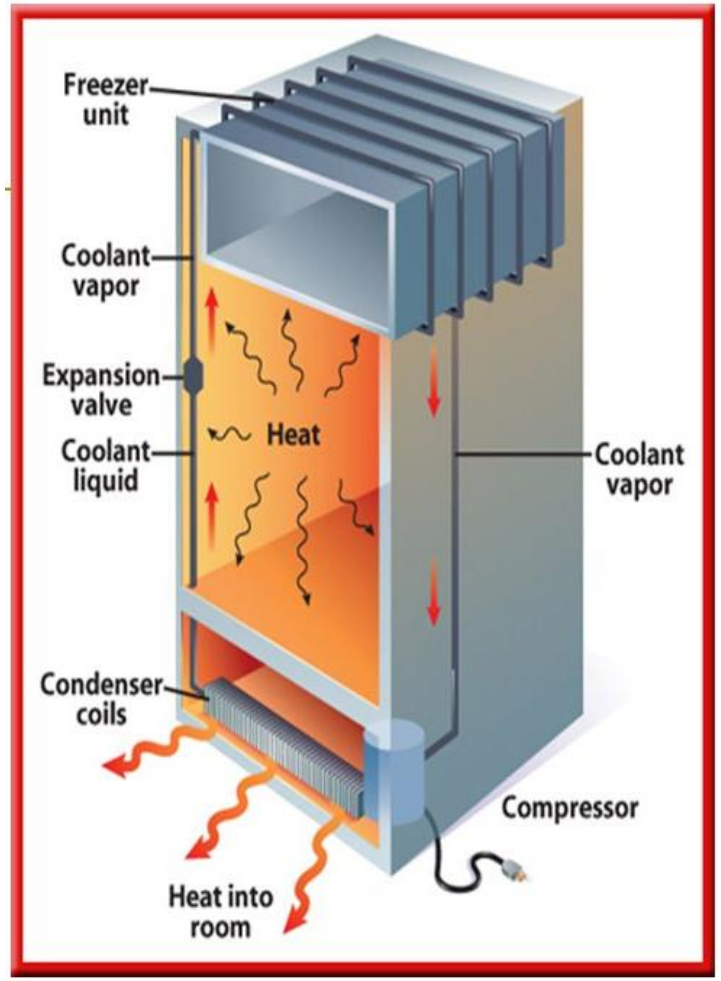
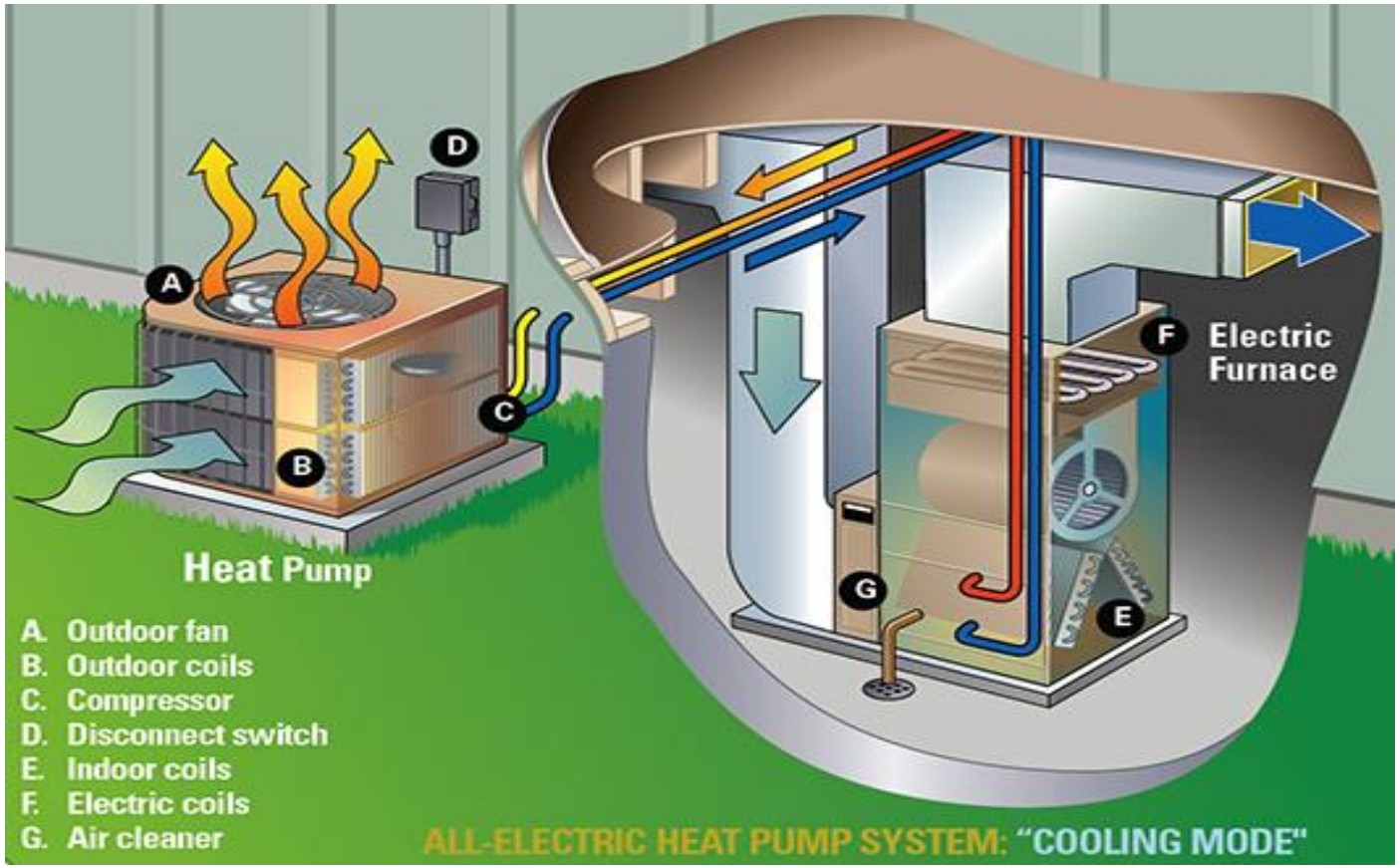


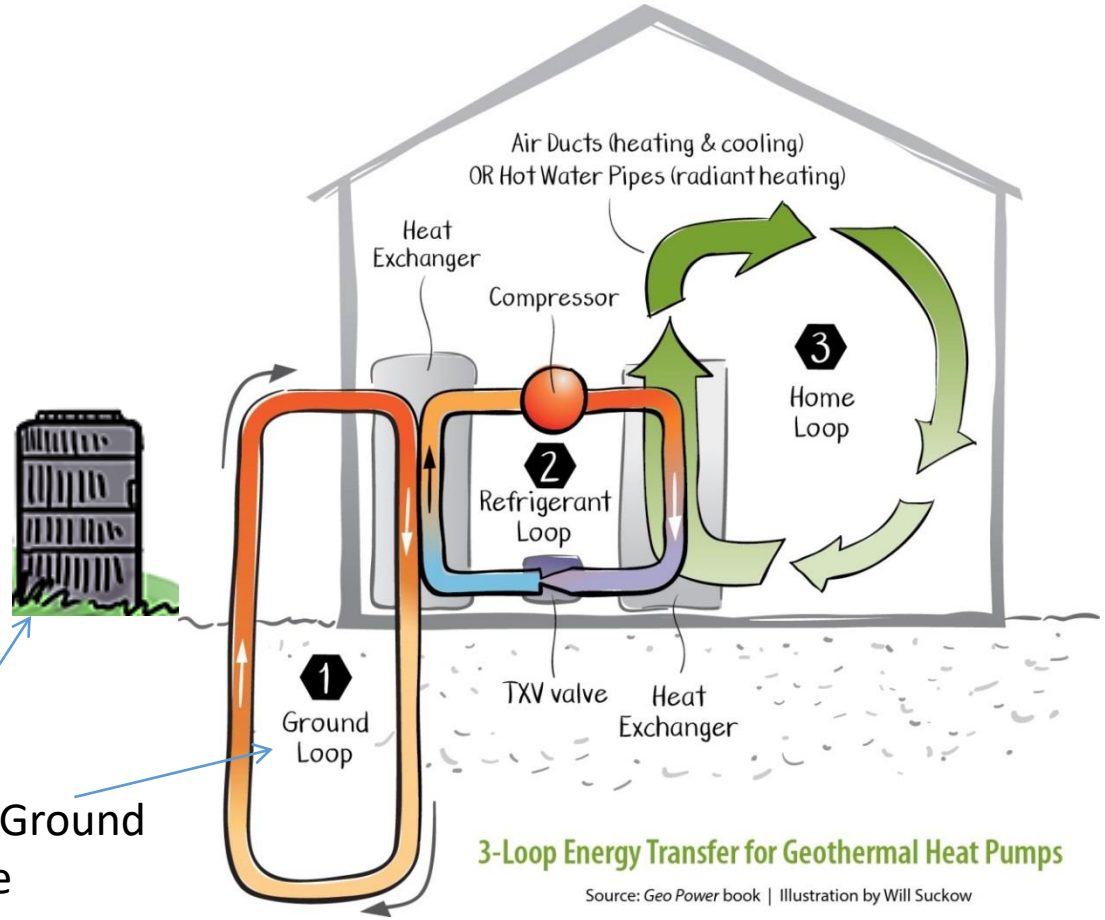
How to cool & heat spaces by "pumping heat"- exactly like a refrigerator



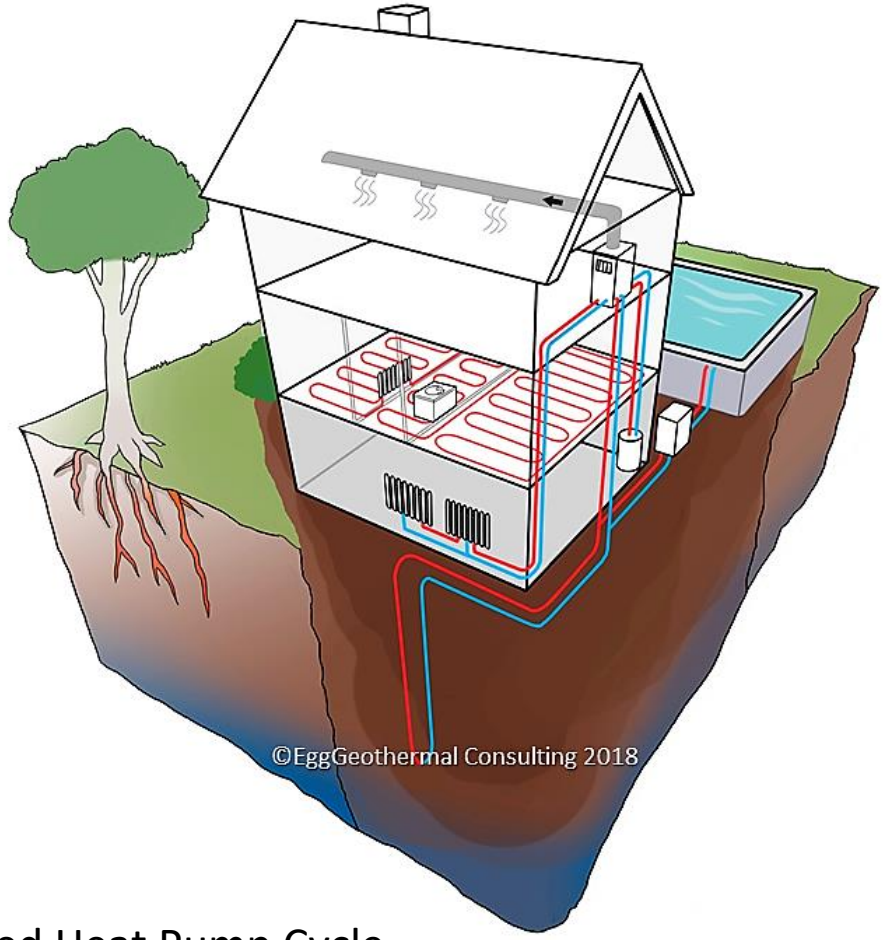


Heat Pump = about 3.0 to 5.0 + COP

Understanding the refrigeration cycle in a Heat Pump



Air or Ground Source



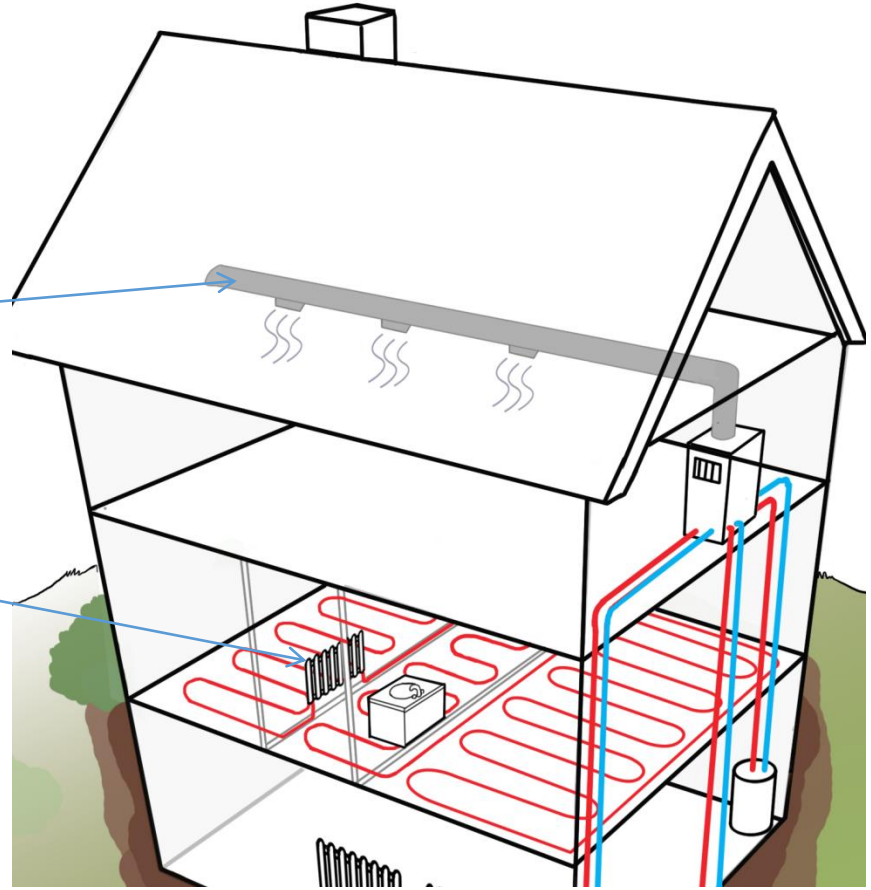
Animated Heat Pump Cycle
https://youtu.be/cGyEUZVGpxw

Forced Air & Hydronic Distribution

There are generally two ways to get the heating and cooling to the areas served

- Forced air: usually through ducted systems
- Hydronic distribution: usually through water-based heat transfer fluids*

*refrigerant-based distribution circuits are also used



Efficiency Ratings: EER and COP

- Energy Efficiency Rating (EER) is often used for Cooling Efficiency
- EER is the is the Net Cooling Capacity/Applied Energy in watts

- Coefficient of Performance (COP) is often used for Heating Efficiency
- COP is the BTUs delivered/BTUs consumed

EER = COP x 3.412

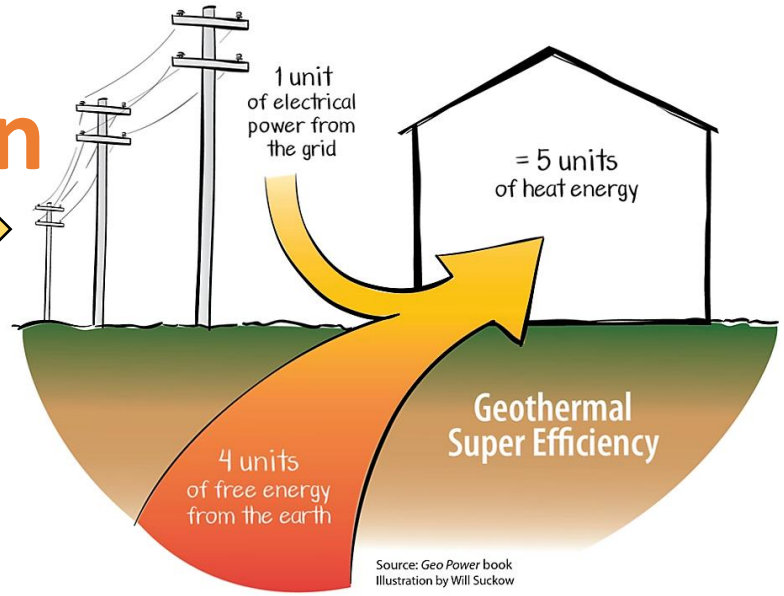
1 watt of electricity = 3.412 BTU

1 kW of Electricity = 3412 BTUs/Hr

1 kW in

= 3,412 BTUs/Hr of heat (Electric Space Heater)

1 kW in



= 17,060 BTUs/Hr of heat* (Geothermal Heat Pump)

- ***It takes 20% of the kW to do the same heating with a geothermal heat pump***

*@ 5.0 COP

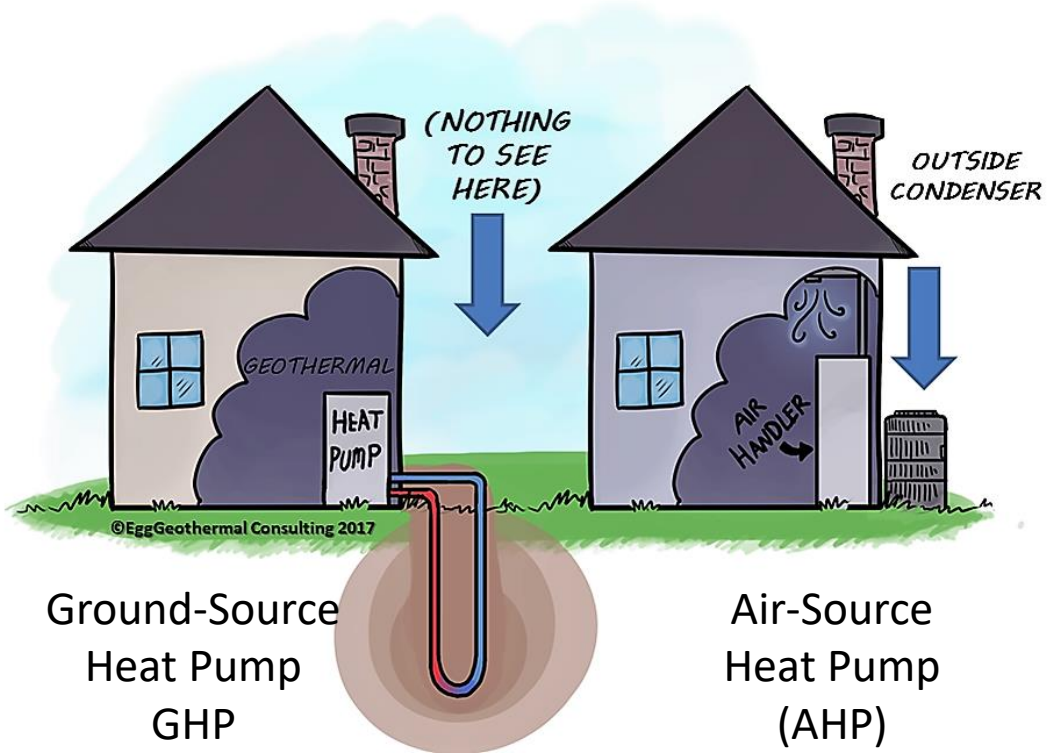
egg geo Sharing Knowledge Engineering and Education

Both Air Source & Ground Source Heat Pump are All Electric

They use renewable energy (from the air & the earth) to help heat and cool buildings

Nothing outside

Both use “Renewable Energy”

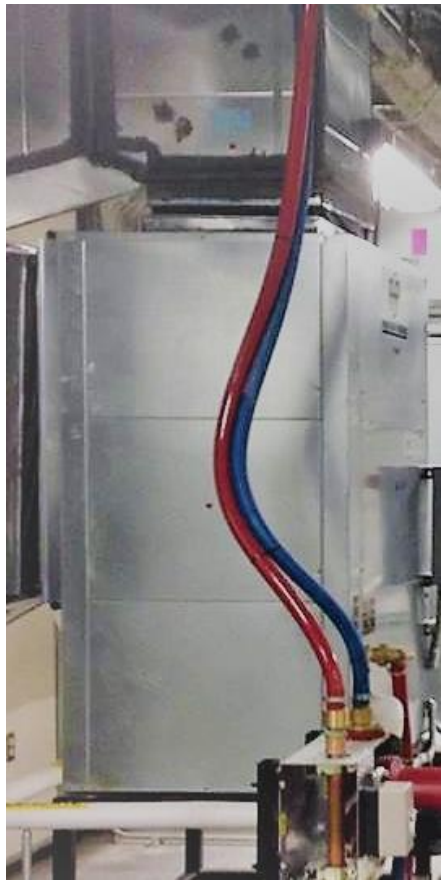


Ground-Source Heat Pump GHP

Air-Source Heat Pump (AHP)

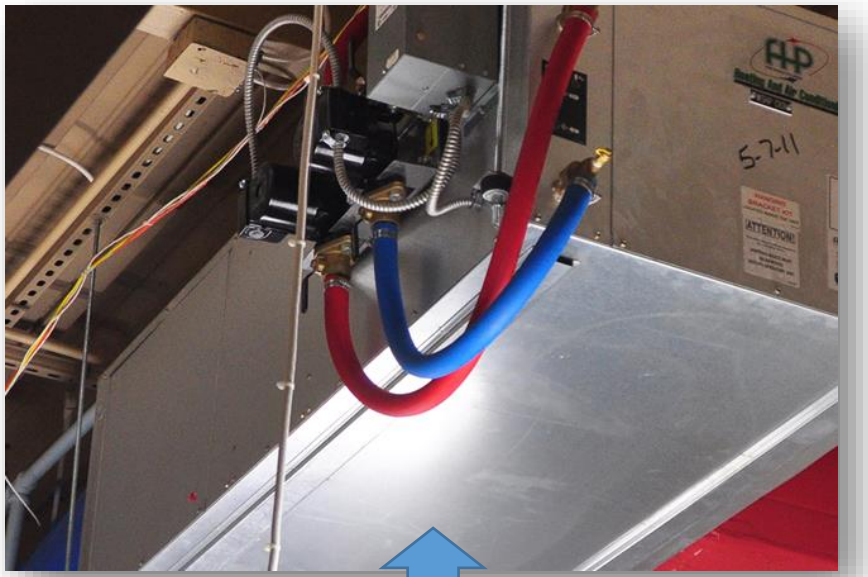
Remote Outside Condenser

Like ASHPs GSHPs are also designed to fit every type of structure

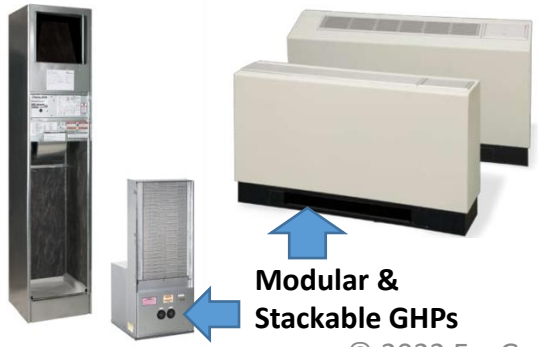


Various Types of Geothermal Heat Pumps (GHPs)

Vertical GHP (**water-to-air** GHP)



Horizontal; GHP (**water-to-air** GHP)



Modular & Stackable GHPs

Pool or Dedicated Hot Water GHP; (**water-to-water** GHP)

GHPs to fit every type of building, even roof tops

Replacement Roof Top GHPs

All Inside 100% Fresh Air (DOAS)

District Thermal Energy Networks

…making thermal network heat pumps a reality for all

- No more outdoor equipment to replace
- More hurricane and storm resilient (no HVAC equipment outside)
- HVAC system longevity (a benefit of having equipment inside)
- No combustion boilers, cooling towers or furnaces (Decarbonization)
- Noticeably superior comfort in heating and cooling modes
- Remarkable system efficiency at standard equipment pricing
- Thermal Energy Network Wells /Piping are permanent infrastructure

Thermal Energy Networks will be installed by our Nation's Skilled Trades

Photo: piping installation in progress along Serra Mall.

Merlin Dunt, Mayor of West Union from 1998-2011 said, ***"...as long as we're tearing up the streets and sidewalks to put in new water mains, we might as well improve the energy infrastructure at the same time."*** From that came the downtown thermal energy loop. Consider the number of infrastructure projects that take place, and this is a great model for our nation.

“Beneficial Electrification” was a real thing in 1958 - Some history, and the logic behind it.

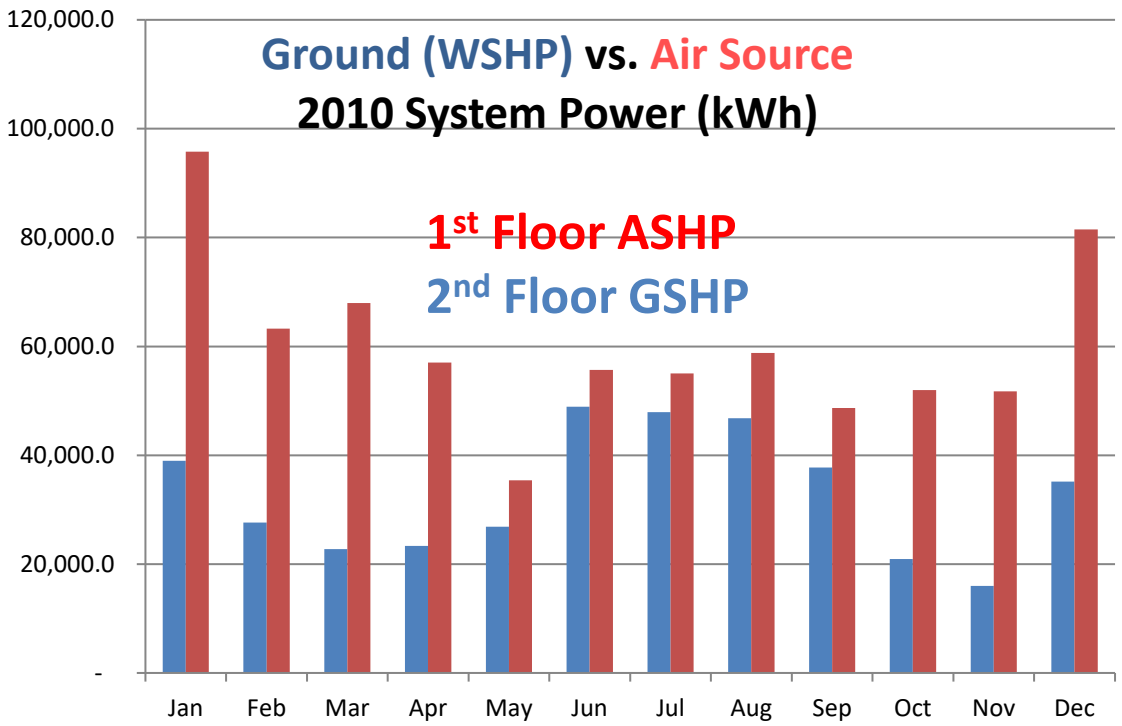
These homes received “Total Electric” medallions indicating the home was inspected & safe.

Decarbonization = Electrification

In 1958 the National Electric Manufacturers Association (NEMA) provided medallions for homes that were all electric. This effort could be renewed, and for many of the same advantages cited as advantages for homes built between 1957 and the mid-1970s.

Understanding efficiency; the ASHRAE Building in Atlanta

Thermal Energy Heat Pumps consume less energy than air-source heat pumps



Power Consumption at ASHRAE Bldg, Atlanta

Electrical Load is "**leveled out**" using WSHPs

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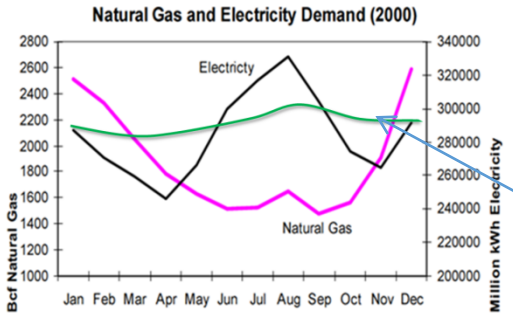
- Utility Benefits
  - Highly efficient heating and cooli systems.
  - Potentially a cost-effective optior to defer capital commitment for utility gas and electric infrastructure.
  - Reduces electric peak demand, improves load factor and improves the efficiency of the electric delivery system.
  - Gas peak load reductions.



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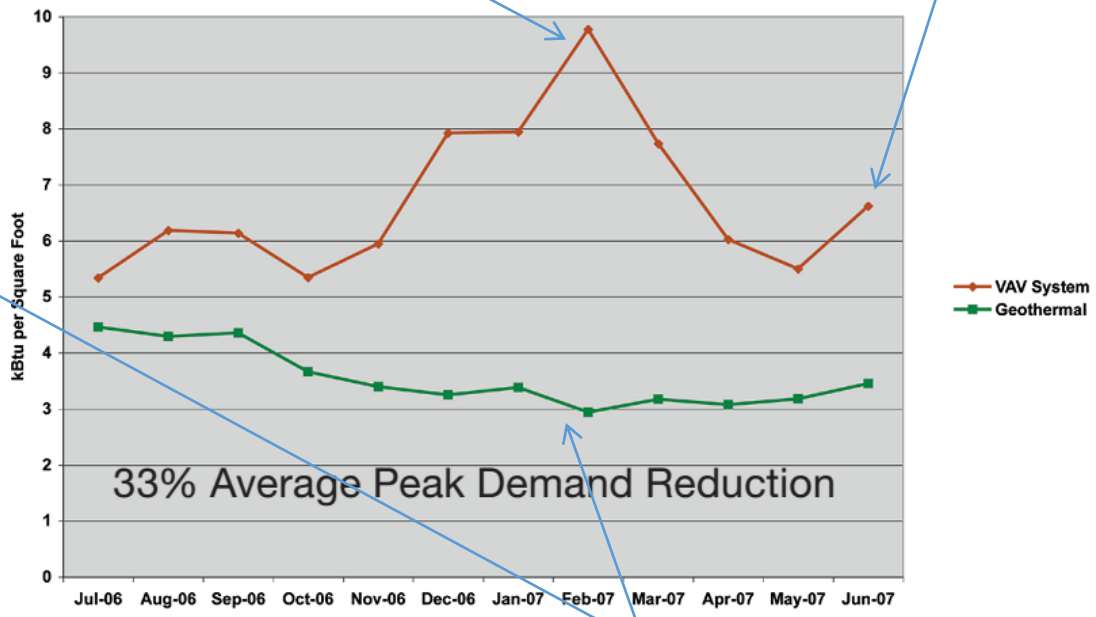
Combination Gas-Heat & Electric-Cooling Peaks in the Summer

Air Source Heat-Pumps tend to "peak" in the winter, as well as the summer



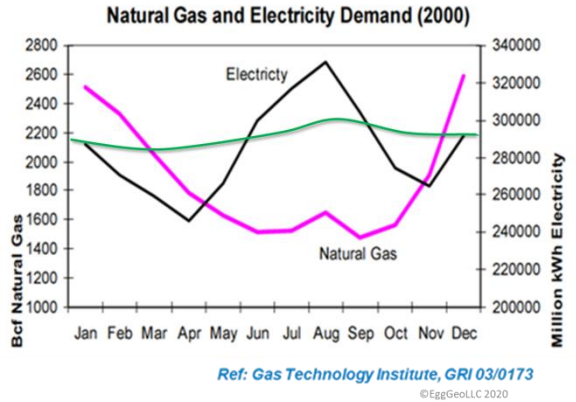
Ground Source Heat-Pumps Shave Both Summer and Winter Peaks

Assessment of National Benefits from Retrofitting Existing Single-Family Homes with Ground Source Heat Pump Systems

Table E-1. Potential Benefits of Retrofitting Existing U.S. Single-Family Homes with State-of-the-Art GHP Systems at Various Market Penetration Rates

Estimated national benefits	Market penetration rate of GHP retrofit				
	20%	40%	60%	80%	100%
Primary energy savings [quad BTU]	0.8	1.7	2.5	3.3	**4.2**
Percentage savings	9.0%	18.0%	27.1%	36.1%	**45.1%**
CO2 emissions reduction [MM ton]	54.3	108.7	163.0	217.3	**271.7**
Percentage savings	9.1%	18.1%	27.2%	36.2%	**45.3%**
Summer peak electrical demand reduction [GW]	43.2	86.4	129.5	172.7	**215.9**
Percentage savings	11.2%	22.4%	33.6%	44.9%	**56.1%**
Energy expenditures savings [Billion $]	10.4	20.9	31.3	41.7	**52.2**
Percentage savings	9.6%	19.3%	28.9%	38.5%	**48.1%**

Notes: (MM ton, million metric ton).

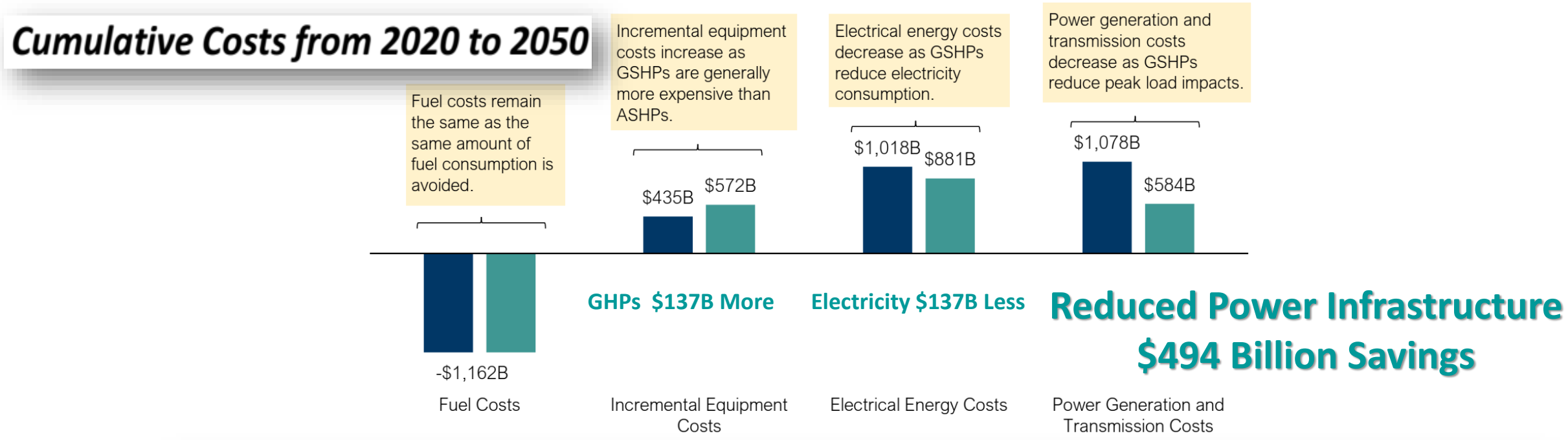


45.3% Reduction in Carbon Emissions

56.1% Reduction in Summer (& Winter) Peak Electrical Demand

The Benefits of Ground Source Heat Pumps for Beneficial Electrification

Figure 5. Cumulative Costs from 2020 to 2050 by Cost Component Under Renewables-Only Generation Scenario (Scenario 1) Assuming 100% of Buildings Electrify with ASHPs vs. 100% GSHPs ($Billions)



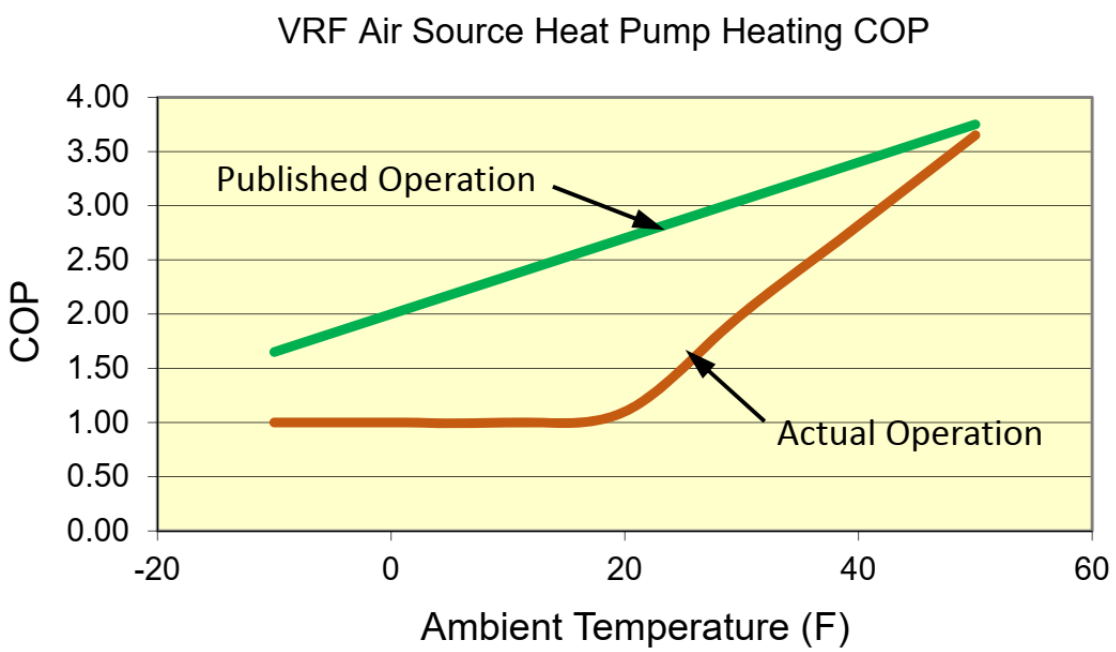
Geothermal Energy Networks
…*eliminate Outdoor Equipment and related hazards*

Thermal Energy Networks

…eliminate Outdoor Equipment and related hazards

Air Source Heat Pumps Naturally Lose COP in Cold Weather

- The constant speed COPs are the published COPs. However, the units are operated in the variable speed mode, but there is no published data on the lower COPs. This can be misleading because only the constant speed COPs are published yet the unit is operated at the lower variable speed COP's.



CONSTANT SPEED

OVER SPEED HYPER HEAT

Annual Field Performance of Inverter-Driven Heat Pumps in Cold Climates (DOE)

According to the US DOE report on Cold Climate referenced:

> *"While the measured COPs of systems in this study are lower than those of other studies… …none of the ASHPs monitored would have provided operating cost savings over an efficient natural gas heating system."*

Table 8. Overall COP With and Without Defrost Cycles Included

Site	Overall COP	COP w/o Defrost	Days Monitored
1	1.61	1.69	204
2	1.99	2.01	141
4	2.31	2.44	142
5	1.71	1.73	28
8	2.33	2.41	44
9	1.11	1.12	57
10	2.06	2.11	51

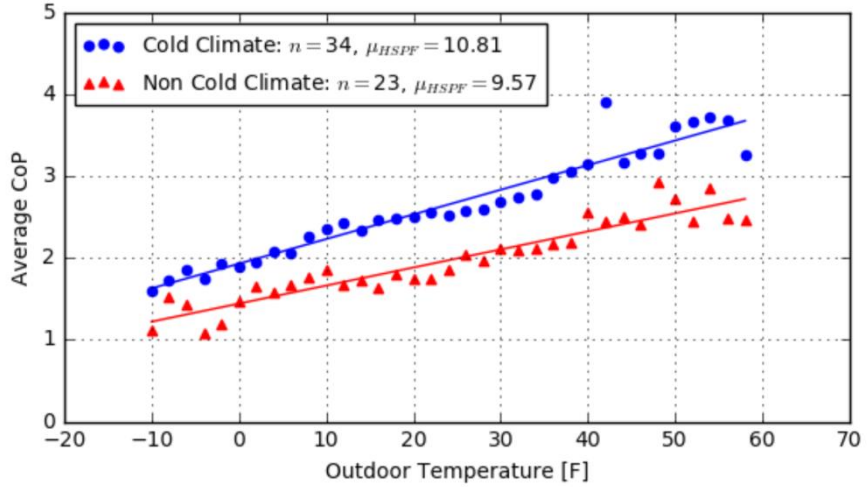
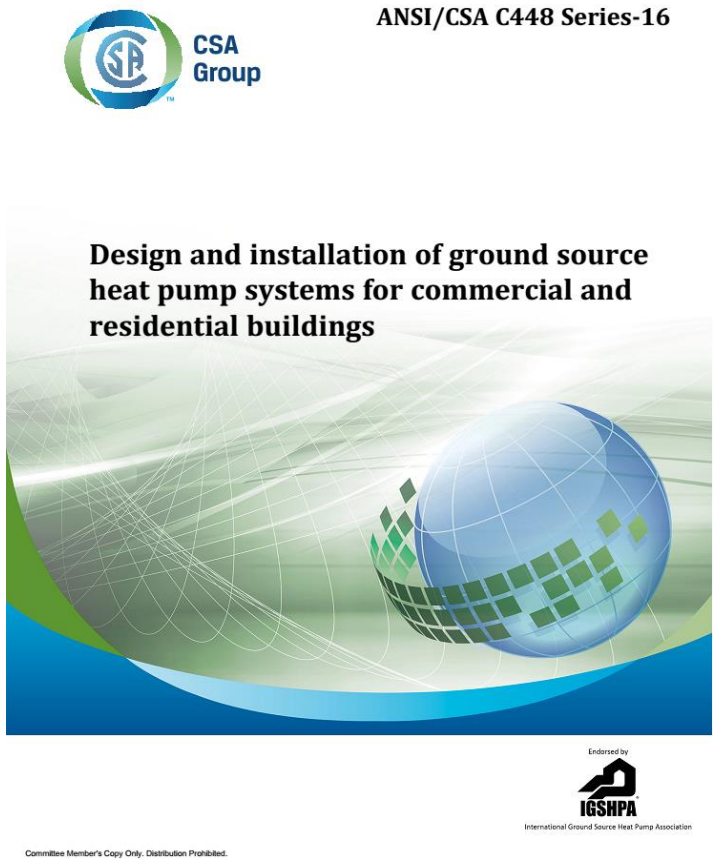
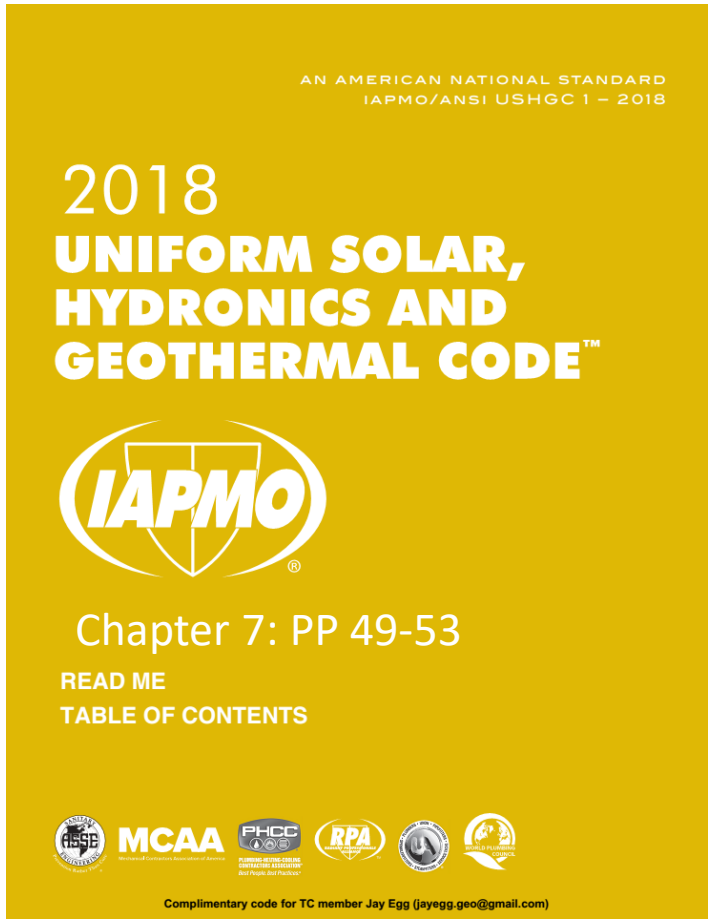


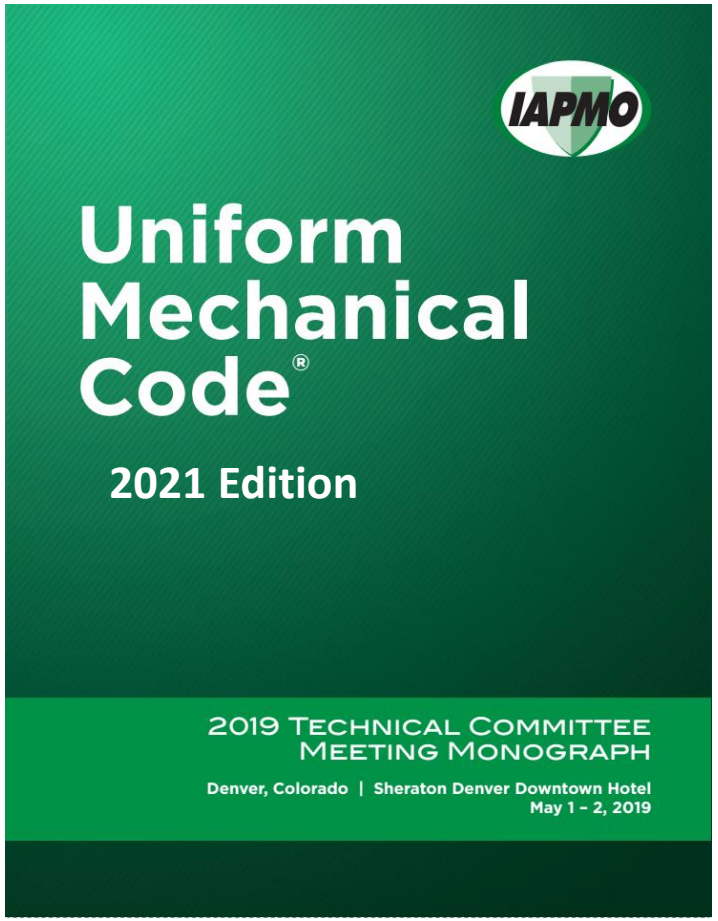
Figure 14. Average DHP Efficiency vs Outdoor Temperature

Evaluating Cold Climate Heat Pumps: Understanding How and Where Cold Climate Heat Pumps Can Displace Less Efficient Heating Sources RI & MA 2017 Report

Thermal Energy Codes are aligning

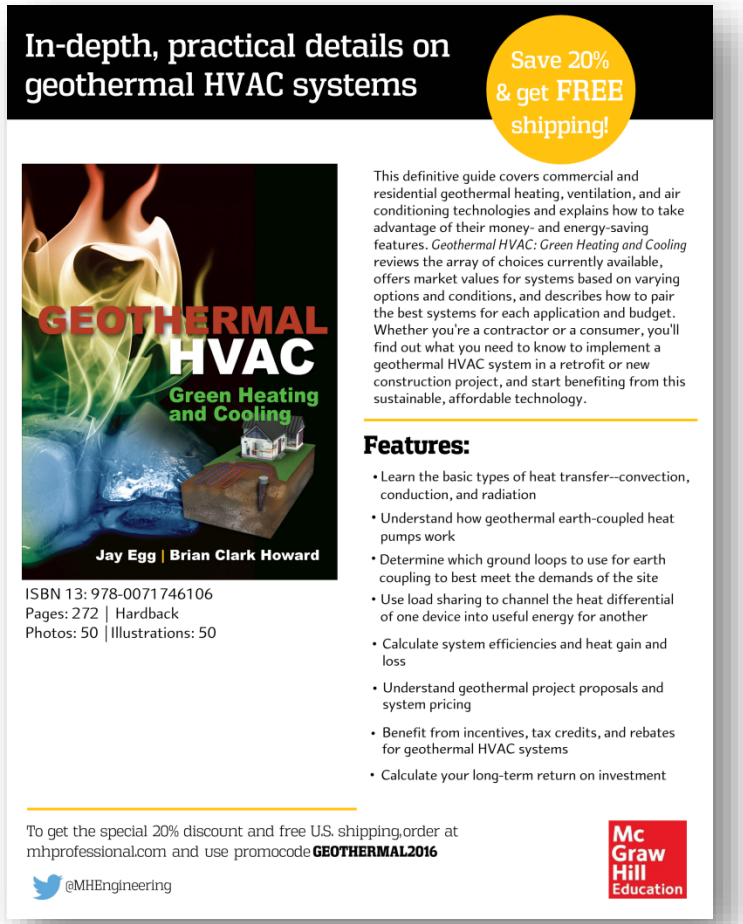


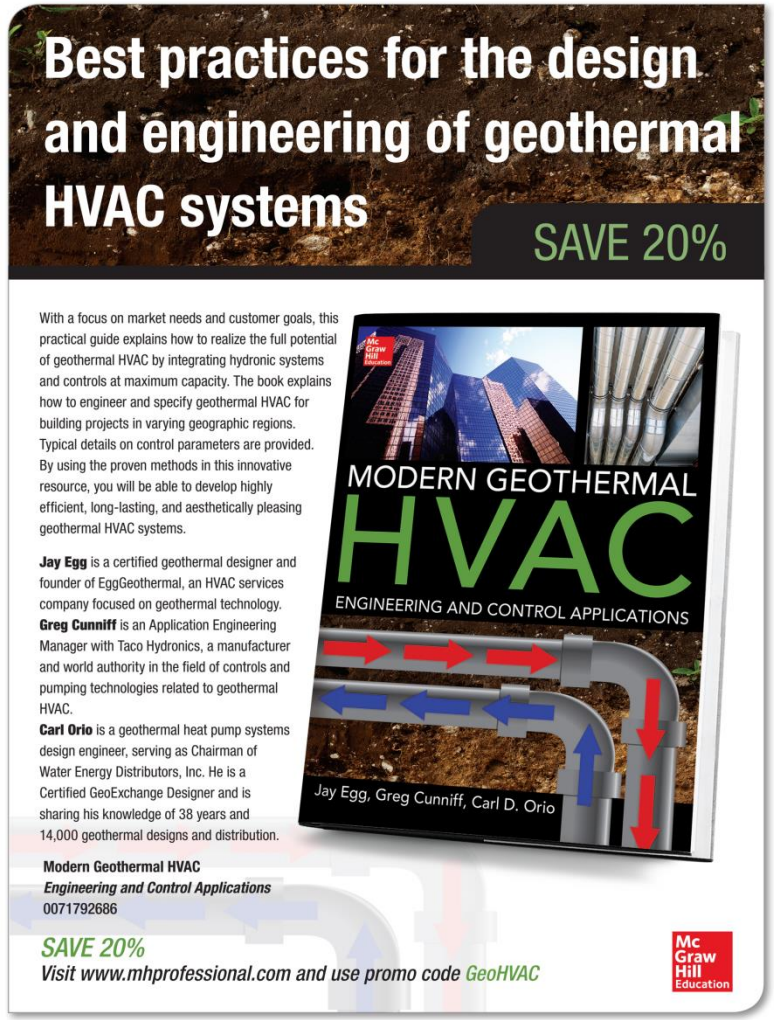




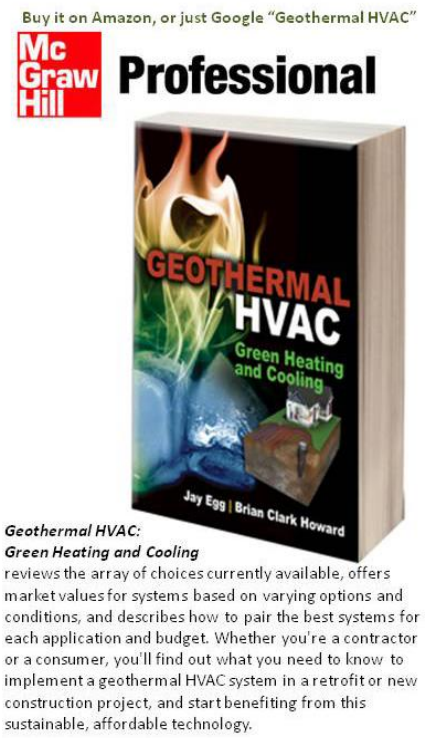
Egg Geo is on the IAPMO USHGC and the UMC 2021 Tech Committee

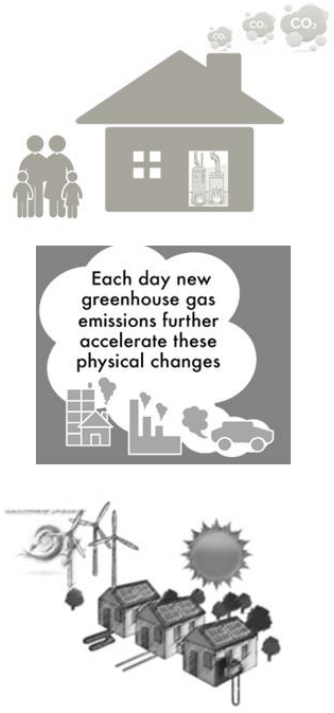
Diversity of Writings to support Curriculum and Thermal Education Trades and Designers

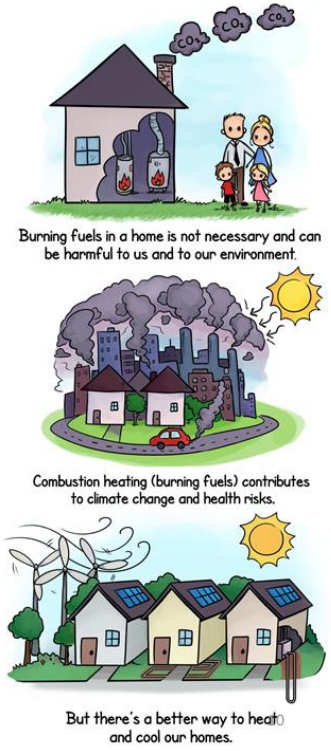


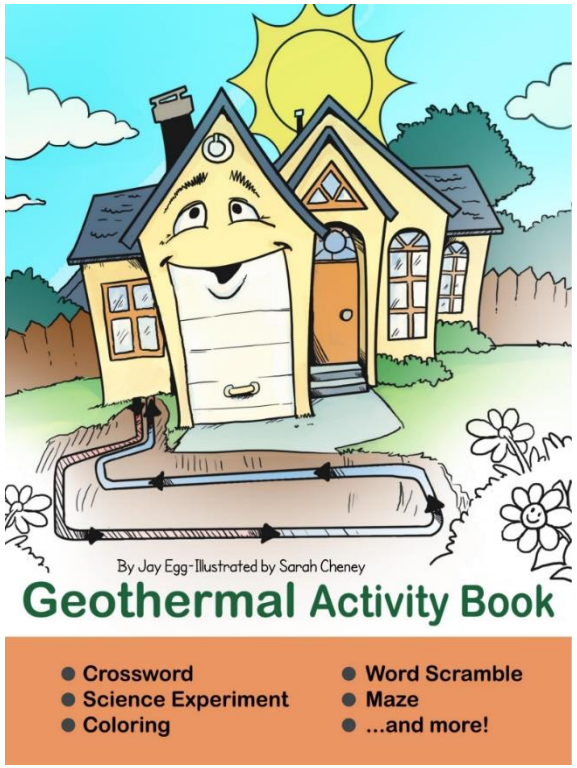


Diversity of Writings to support Curriculum and Thermal Loop Education (STEM)









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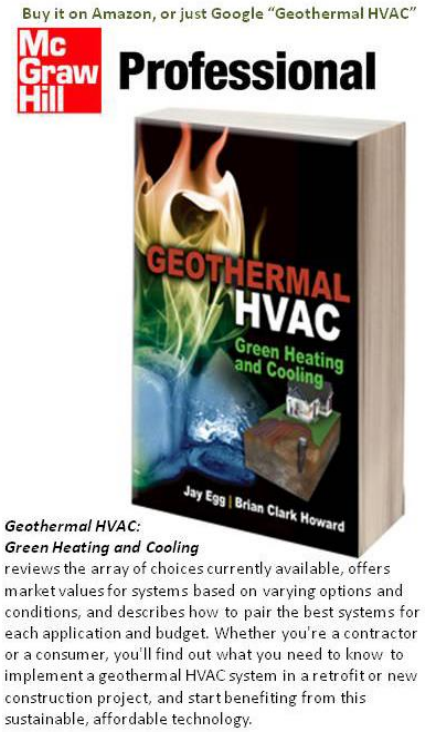
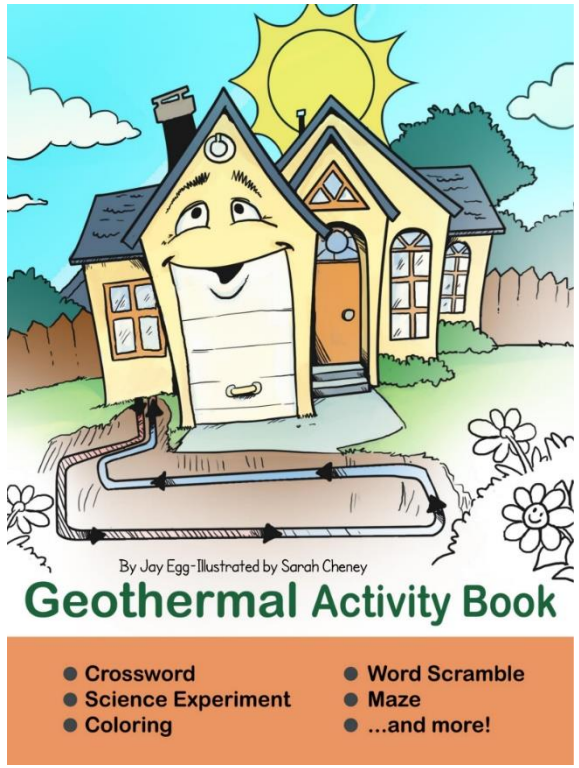


Geothermal HVAC:
Green Heating and Cooling
reviews the array of choices currently available, offers market values for systems based on varying options and conditions, and describes how to pair the best systems for each application and budget. Whether you're a contractor or a consumer, you'll find out what you need to know to implement a geothermal HVAC system in a retrofit or new construction project, and start benefiting from this sustainable, affordable technology.



Current Educational Projects…

Events

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June 8, 2021

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Every month on 2nd Tuesday

Instructors:

Jay Egg, CMC

Kristy Egg, RN, BSPH

learn more and register:

https://www.eventbrite.com/e/module-1-introduction-to-clean-heating-and-cooling-tickets-153843789917

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- **Introduction to Clean Heating and Cooling**
- **Installation Scenarios for Heat Pumps**
- **Air Source Heat Pumps & Ground Source Heat Pumps.**
- **The Nuts & Bolts of Heat**
- **Digging Deep into Ground Source Heat Pumps**
- **So, you're getting a Heat Pump. What now?**
- **Who Else Has These Heat Pumps?**
- **What Have We Learned about Clean Heating & Cooling?**

Sponsored by SUNY and the New York State Energy Research and Development Authority

EVENTS

GEOTHERMAL HEATING AND COOLING EDUCATION

learn more and register:
ny-geo.org/pages/earn-ceu-credits-learning-about-geothermal-with-jay-egg

Jay Egg

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  Central Hudson Gas & Electric Auditorium
- **Albany**
  September 14, 2017
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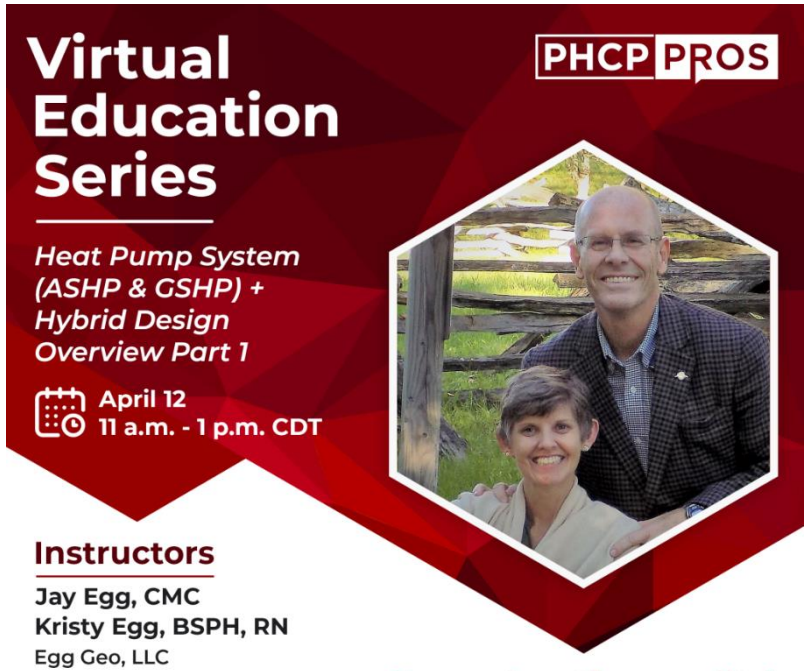
- **New York City**
  October 17, 2017
  Clean Energy Hub
- **Farmingdale, Long Island**
  October 19, 2017
  Renewable Energy & Sustainability Center
- **Buffalo and Syracuse**
  Week of November 13
  Location TBD

Egg Geo has been contracted to provide an 8 module training series for the State University of New York (SUNY) focusing on Geothermal and Air Source Heat Pump systems. Each of the 8 modules are 4 hours in length and are accredited by the AIA for Continuing Education Units. The courses have received high approval and other New York State agencies are interested in engaging in the training series for their employees.



Current Educational Projects for Union Plumbers and Pipefitters Skilled Trades Cross training

“Plumbing Clean Heating and Cooling”

40% of the energy we use is for heating, hot water, and air-conditioning

- The key to clean heating and cooling is in our plumbing infrastructure.

PHCP PROS
YOUR PROFESSIONAL PLUMBING, HEATING, COOLING & PIPING COMMUNITY

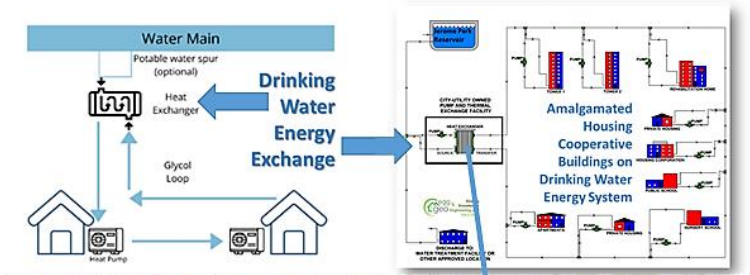
The key to clean heating and cooling is in our plumbing infrastructure.

April 2, 2021 *Jay Egg* *No Comments*

Water infrastructure under our streets and in our buildings is useful for a lot more than potable water and sanitary sewer. Water is necessary to sustain life, but it’s also the best conductor of thermal energy available. Moving BTUs around a building or a city hydronically (a system of heating or cooling that involves transfer of heat by a circulating water-based fluid in a closed piping system) is the most efficient and effective way to move thermal energy.

“As I was writing this column, I got a call from John Murphy, international representative of the United Association, about the uptake in thermal energy networks….”

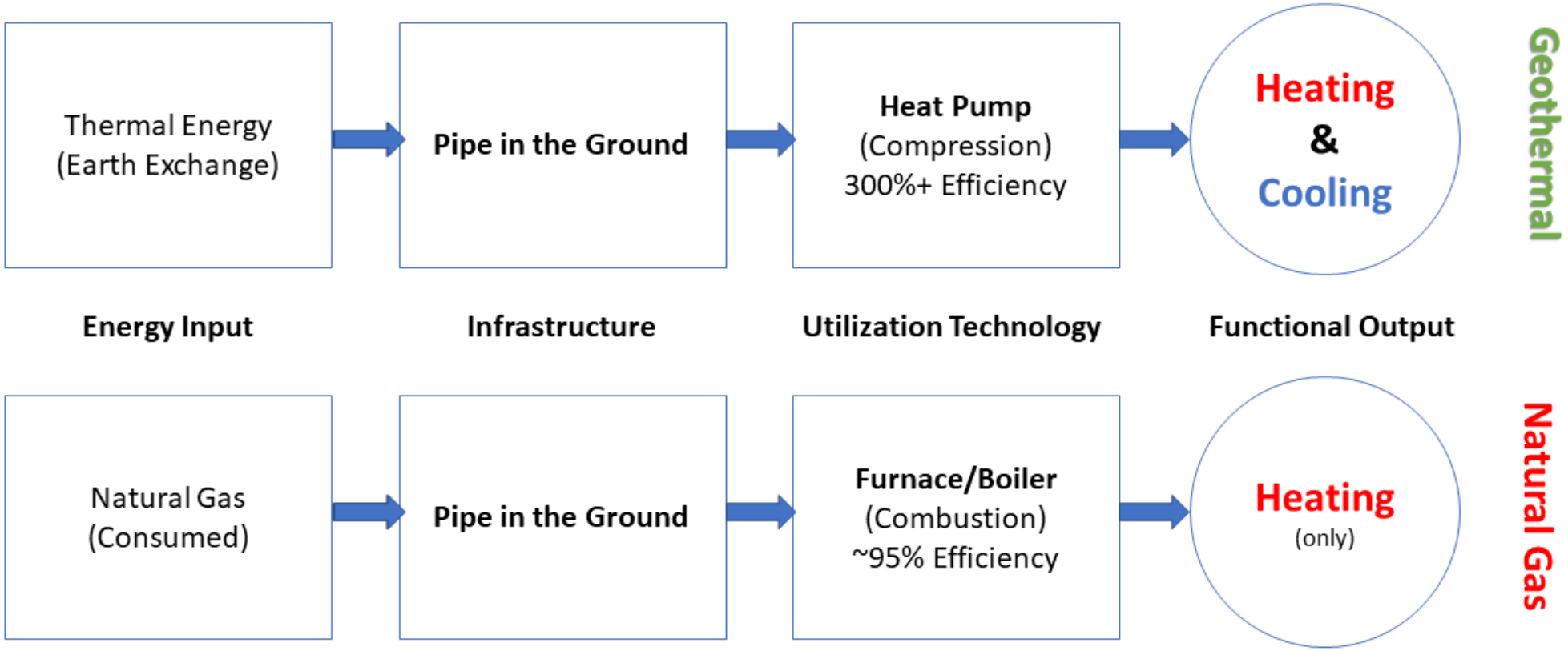
Amalgamated Housing Campus, plus several schools and neighborhoods can operate from one Drinking Water Energy facility



Utility Thermal Energy Network

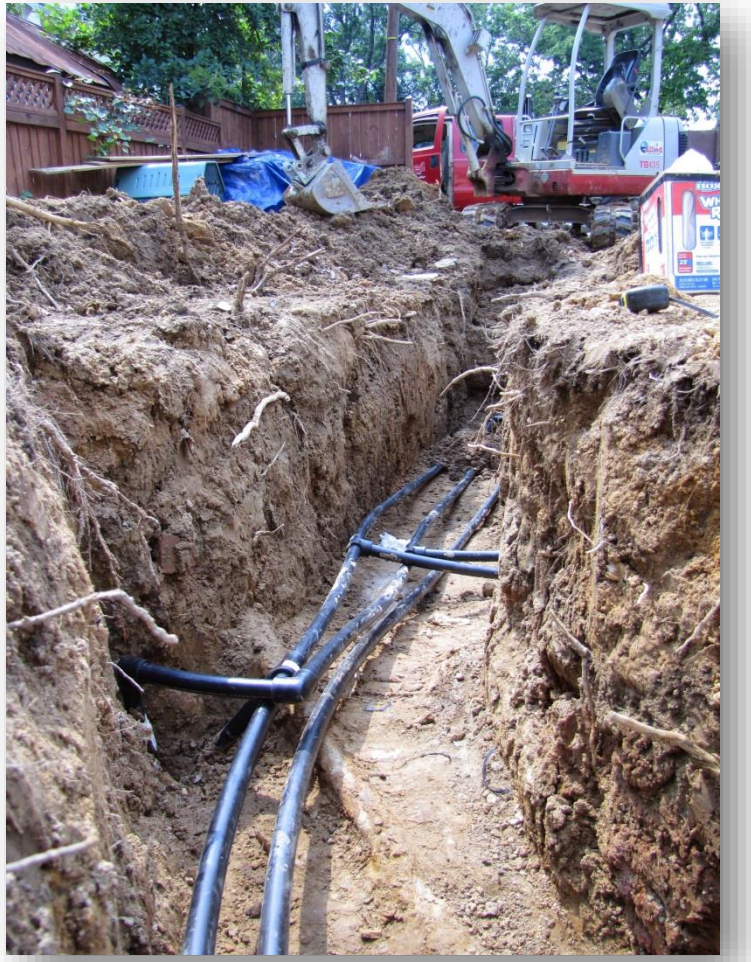
Simplified Schematic View of Thermal Energy vs. Natural Gas for Heating and Cooling Systems

Convert Natural Gas to Geothermal Energy Networks



A typical vertical installation on a small plot

Vertical Closed Loops (tight spot)



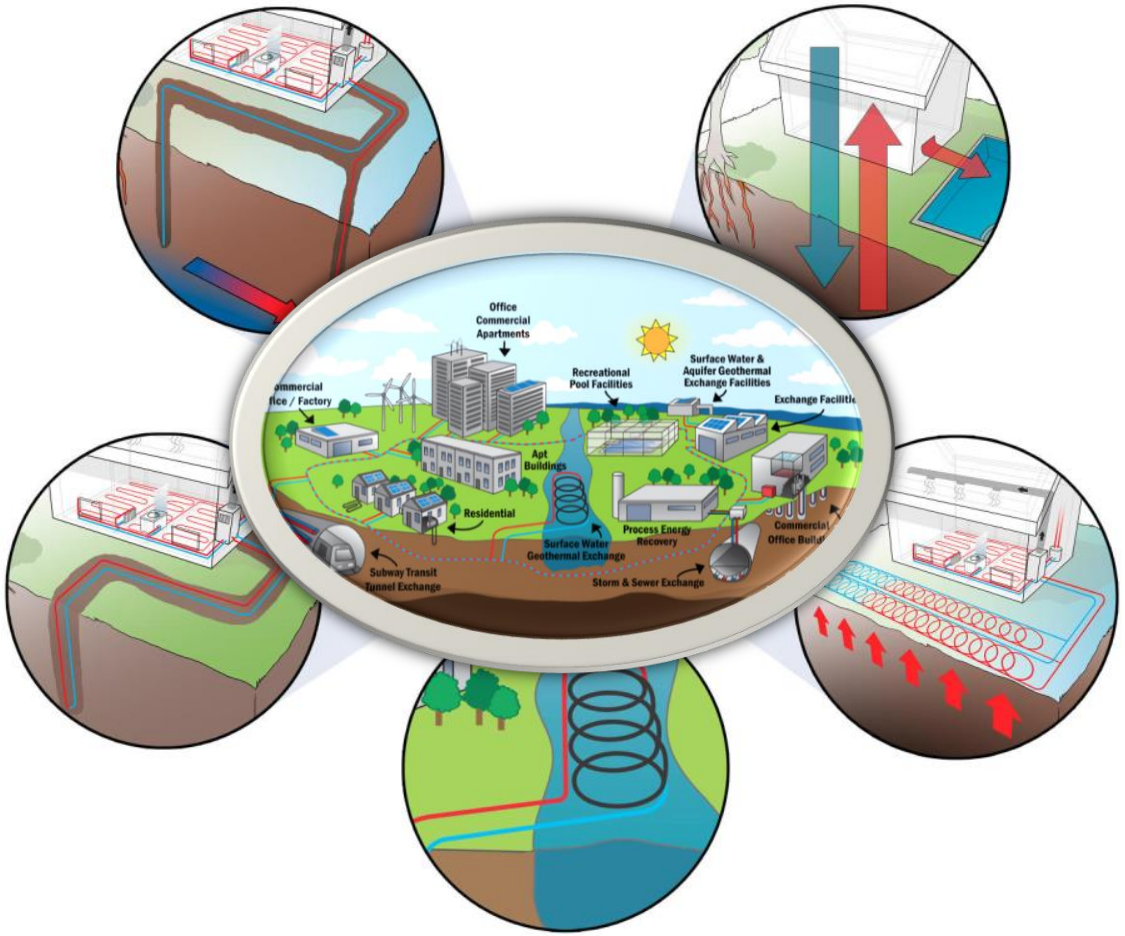
Residence After Boreholes are Completed

Net Zero Energy Application

Equipment is All-Inside and out of the weather

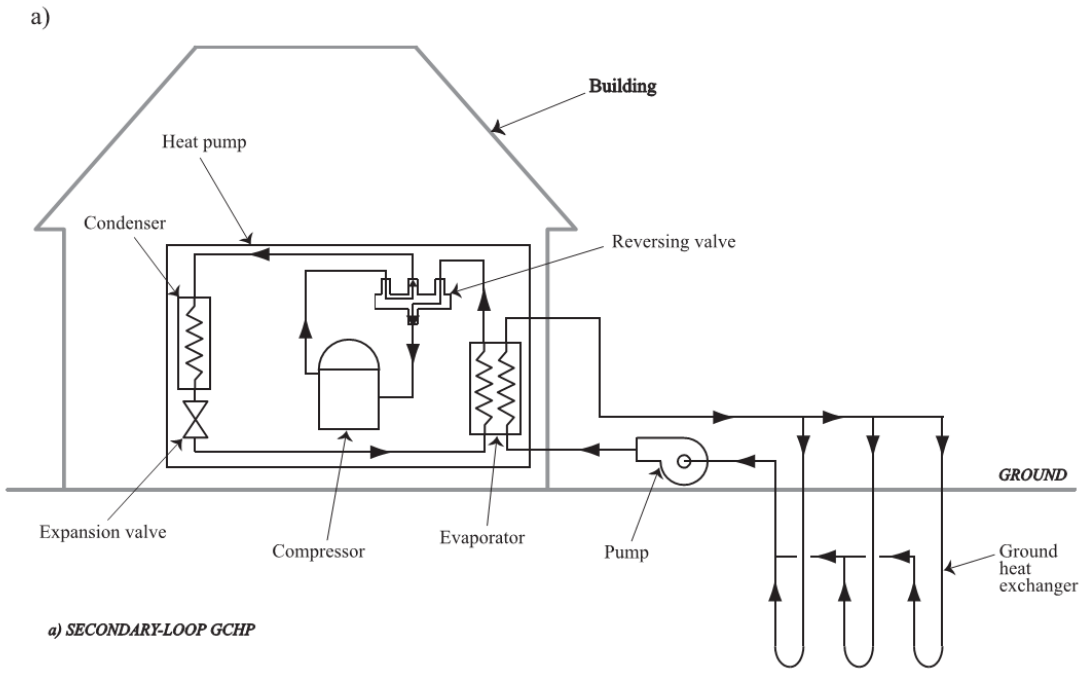
- No more outdoor equipment to replace
- More hurricane and storm resilient (no HVAC equipment outside)
- HVAC system longevity (a benefit of having equipment inside)
- No combustion or electric strip heating
- Noticeably superior comfort and heating and cooling modes
- Remarkable system efficiency at standard equipment pricing
- Geothermal Wells are permanent infrastructure

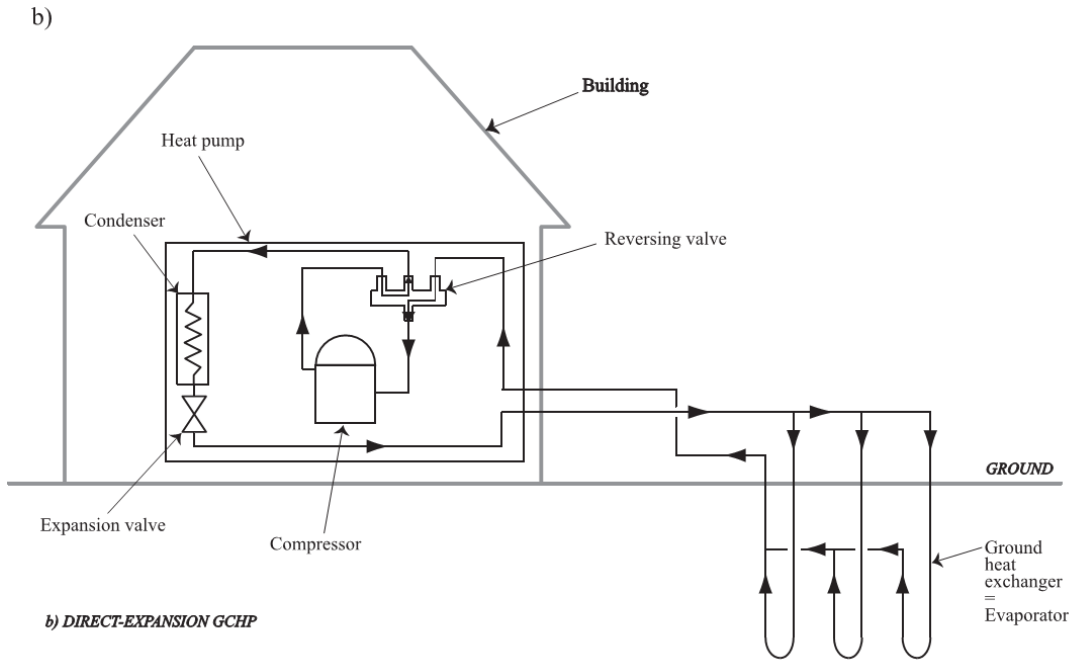
Variations in Earth Loop Systems



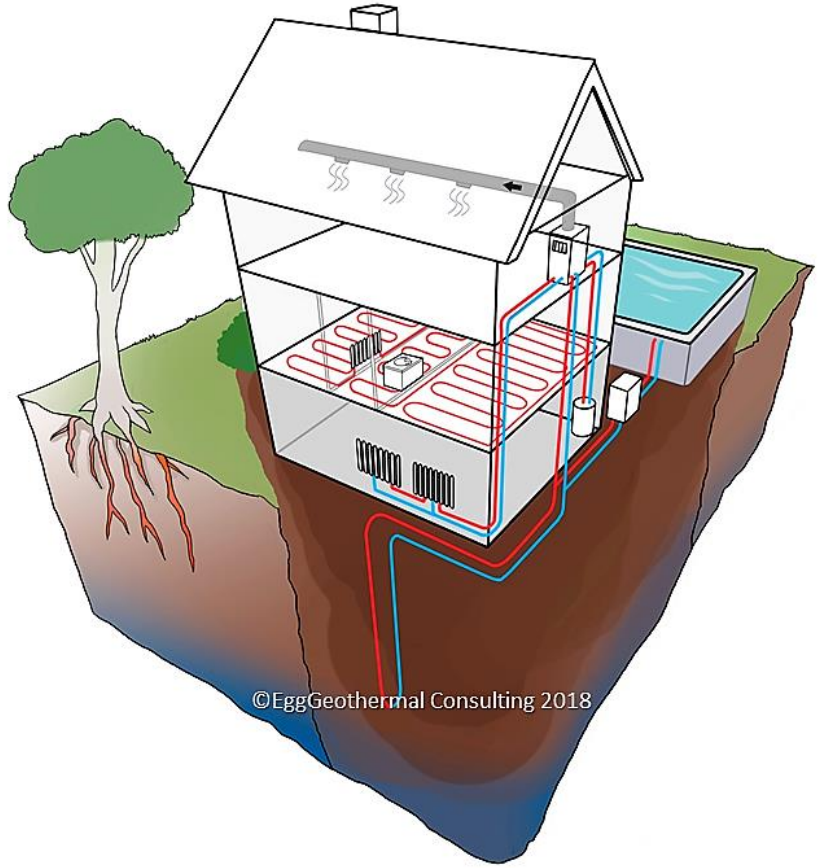
There are numerous geothermal exchange methods. One of these will be right for your project.

Types of Geothermal: Closed Loop Water, and Direct Expansion (DGX)





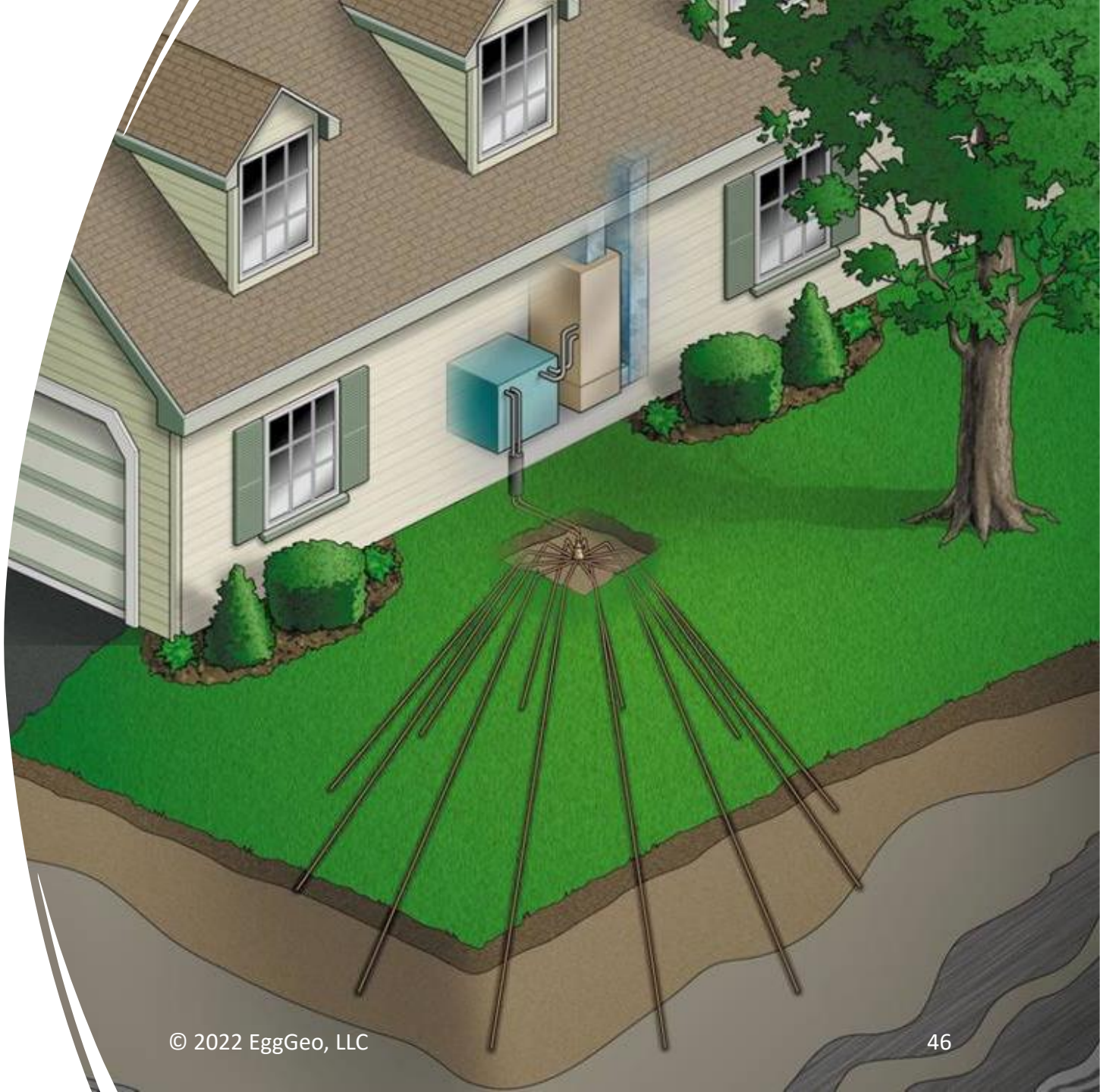
Types of Geothermal: Closed Loop Water, and Direct Expansion (DGX)



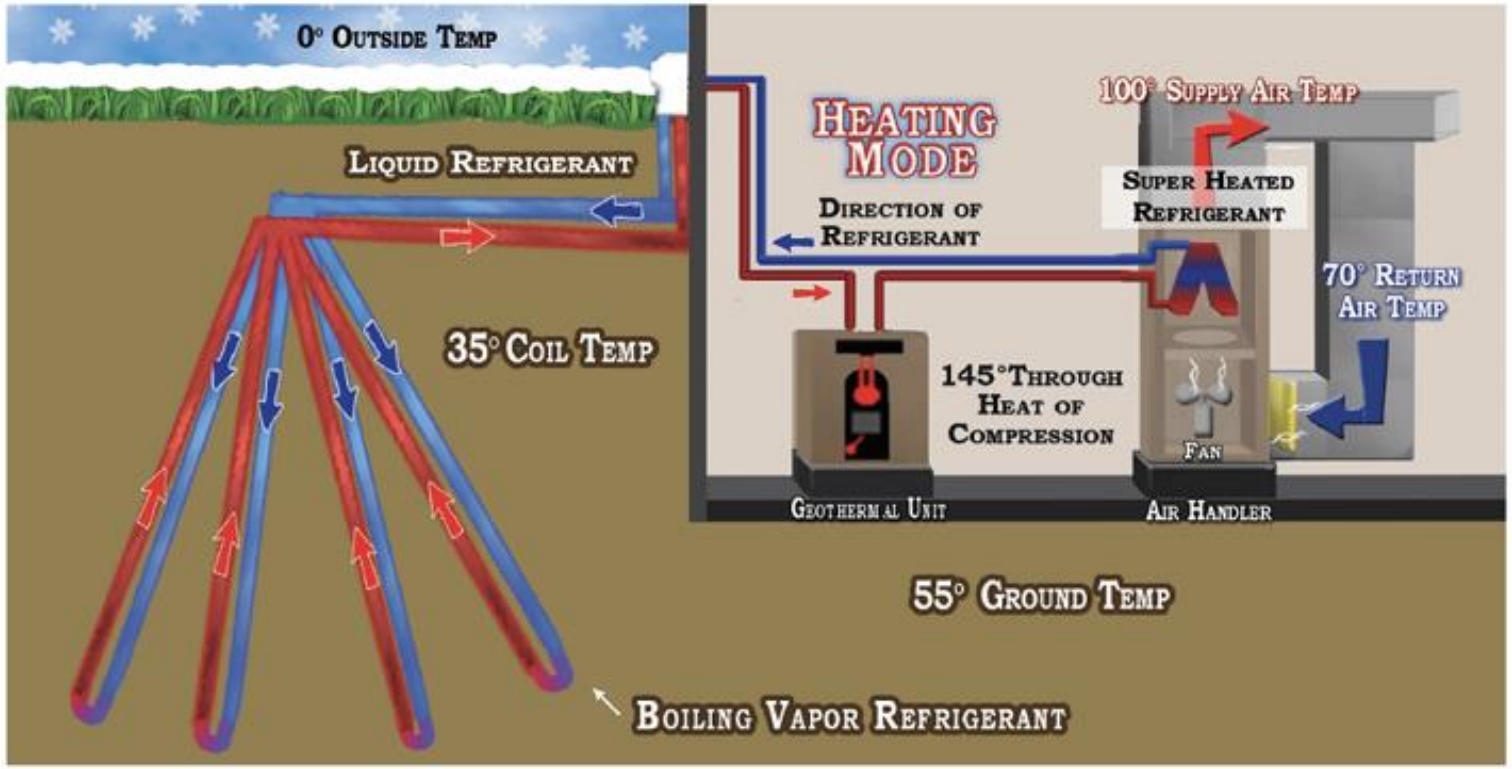
Low disturbance and impact area for DGX systems

Direct Exchange (DGX) also reduces borehole size & length

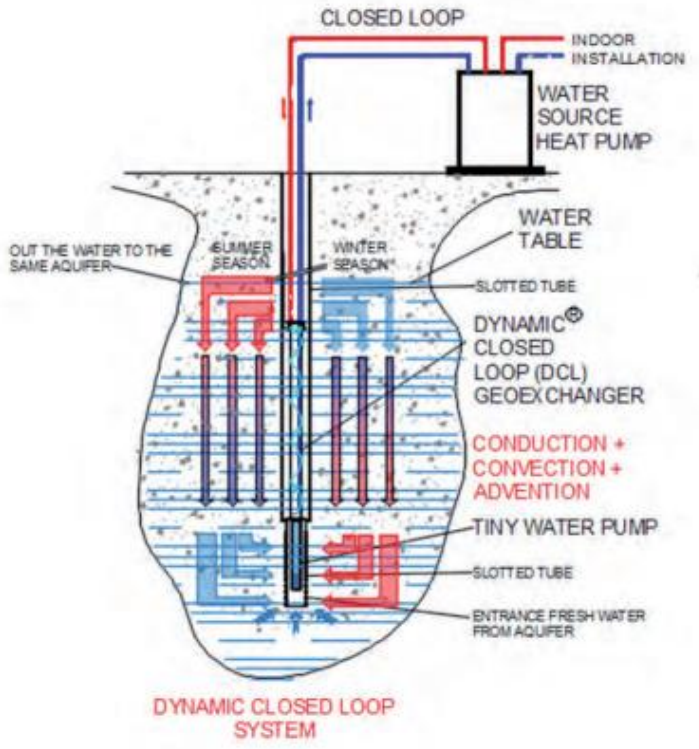
- Refrigerant Piping goes into the earth
- Utilizes less borehole per ton than water based closed loop
- Require specialized training
- NYSERDA Provides Incentives
- Federal Gov’t provides tax credits
- Excellent for basements and tight spaces; Halco Statement



The Logic of Direct Exchange; Heat Transfer



The Dynamic Closed Loop (DCL) Concept



ENVIRONMENTAL SUSTAINABILITY

- HEAT-EXCHANGE INSIDE THE WELL:
- LESS PUMP ENERGUY NEEDED
- ZERO WATER EXTRACTION FROM THE WELL
- ZERO GROUND THERMAL AFFECTION

Aquifer Based Thermal Exchange: Dynamic Closed Loop & Open Exchange Wells

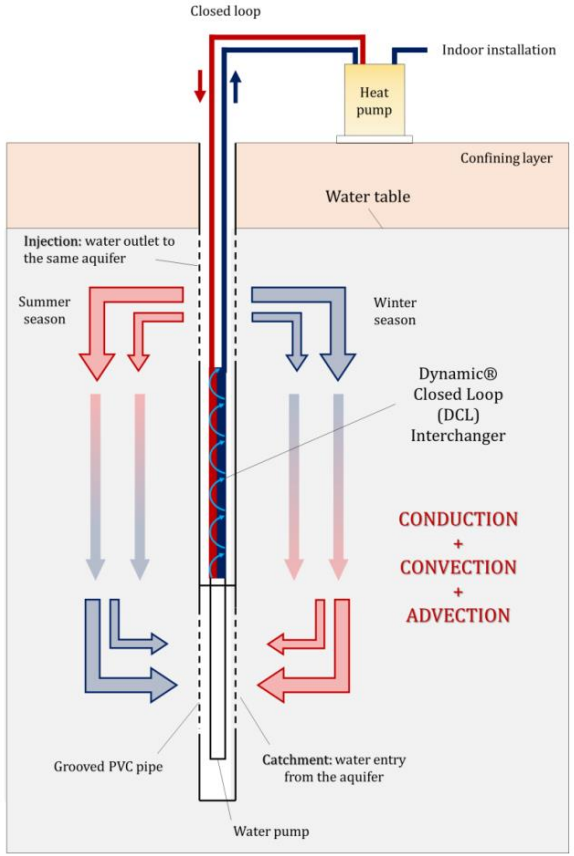
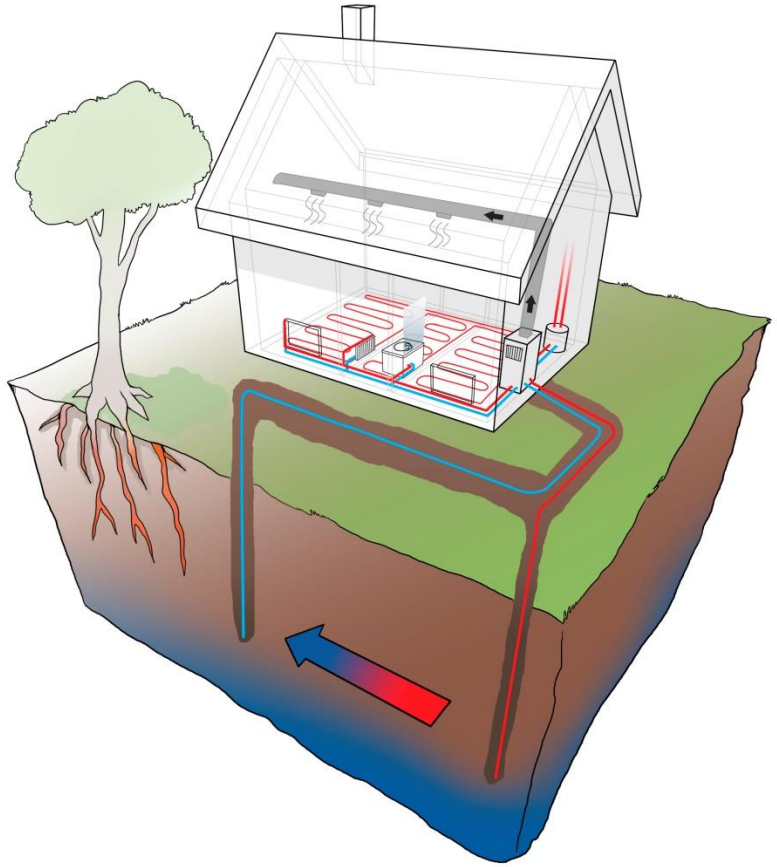
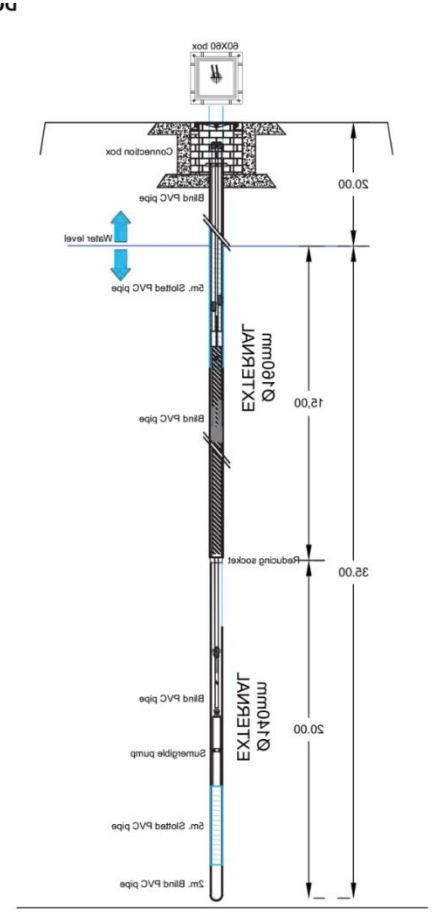


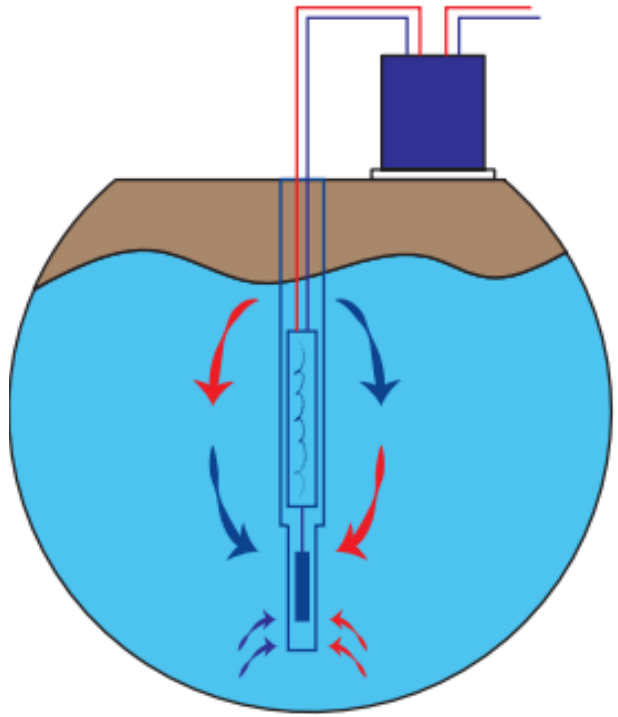
FIG. 1-1. *Operation diagram of the DCL® geothermal probe*

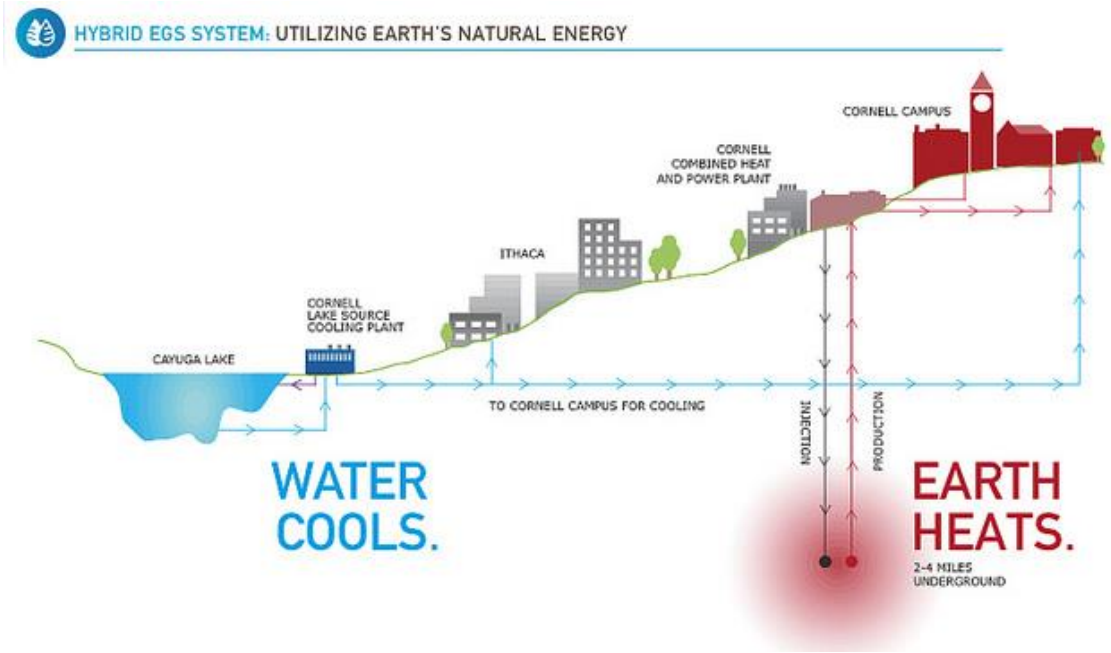


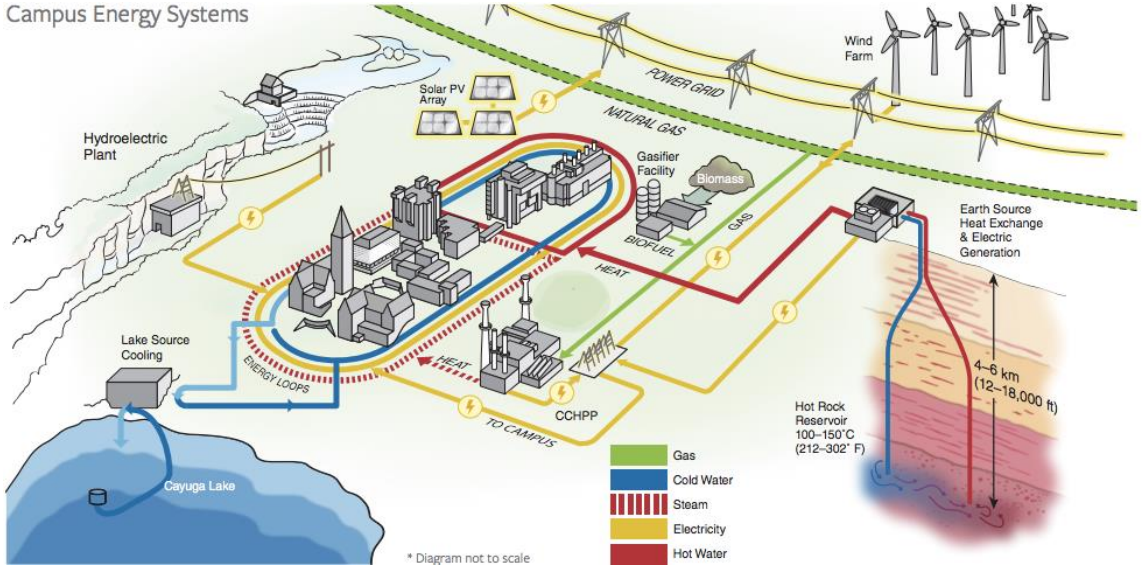
DCL & THERMAL EXCHANGE

HTTPS://YOUTU.BE/ISVP2BUCIY4



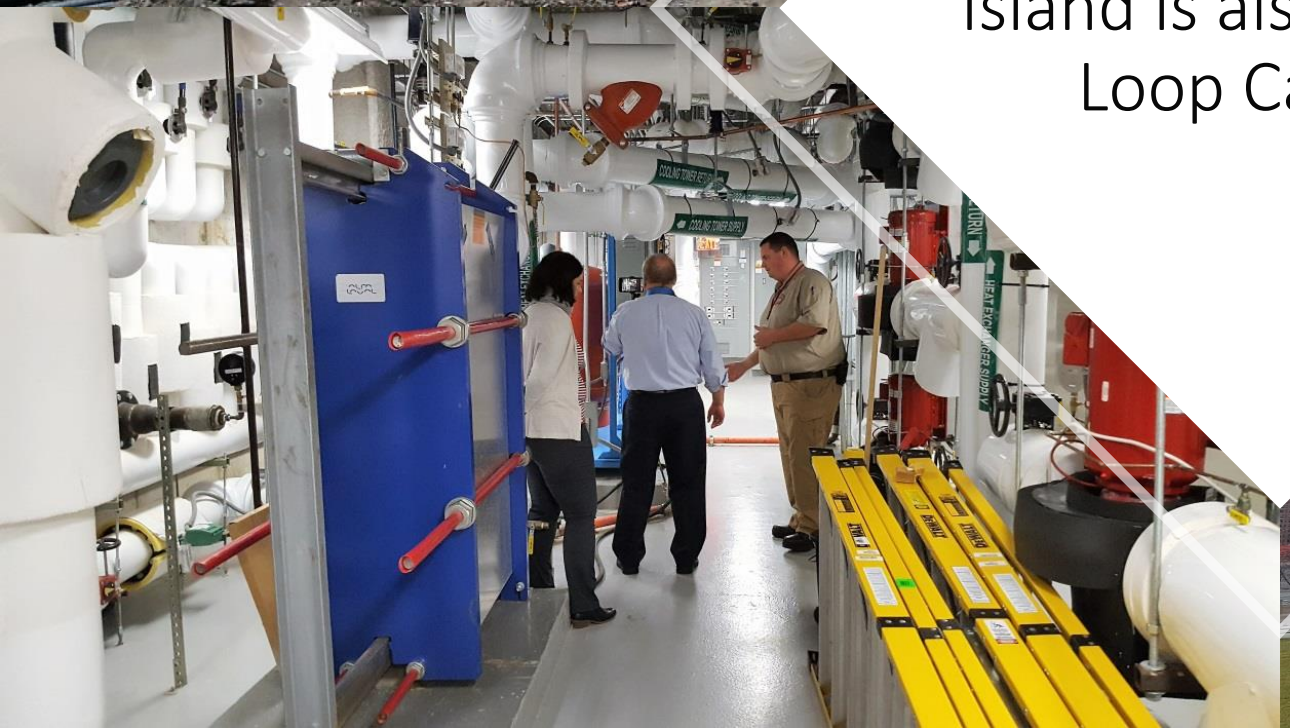


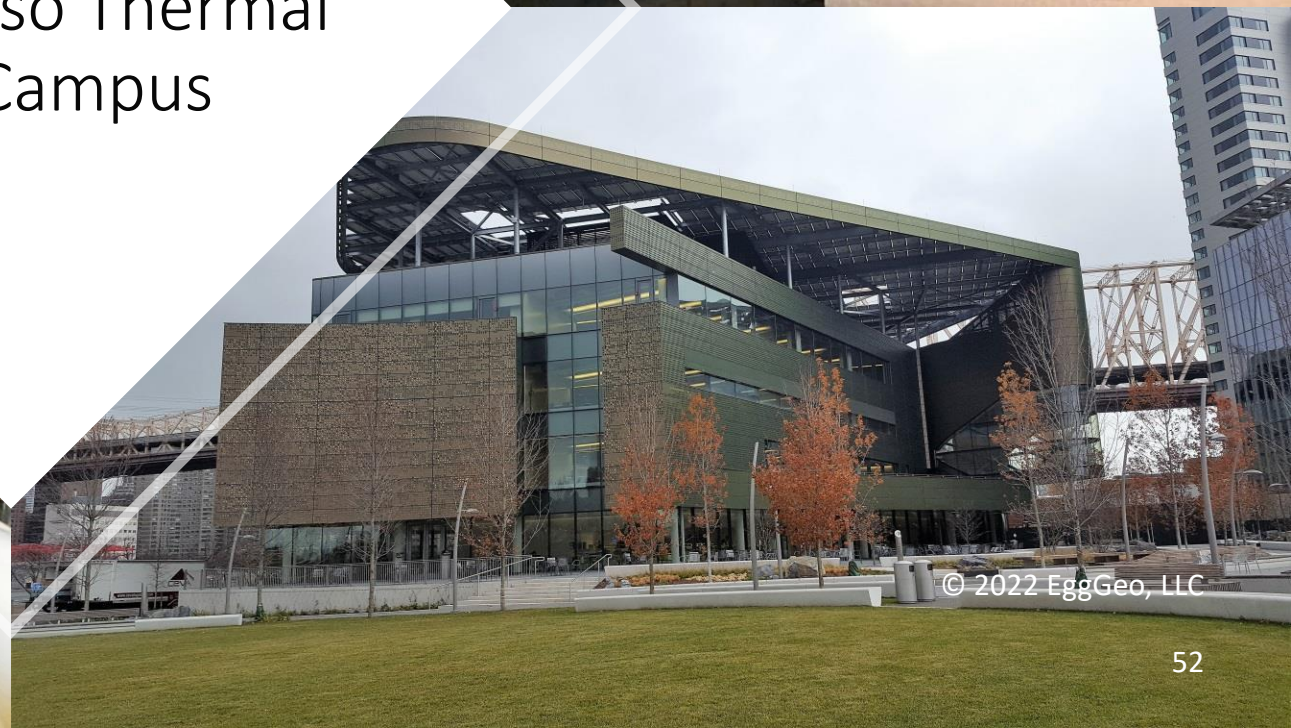




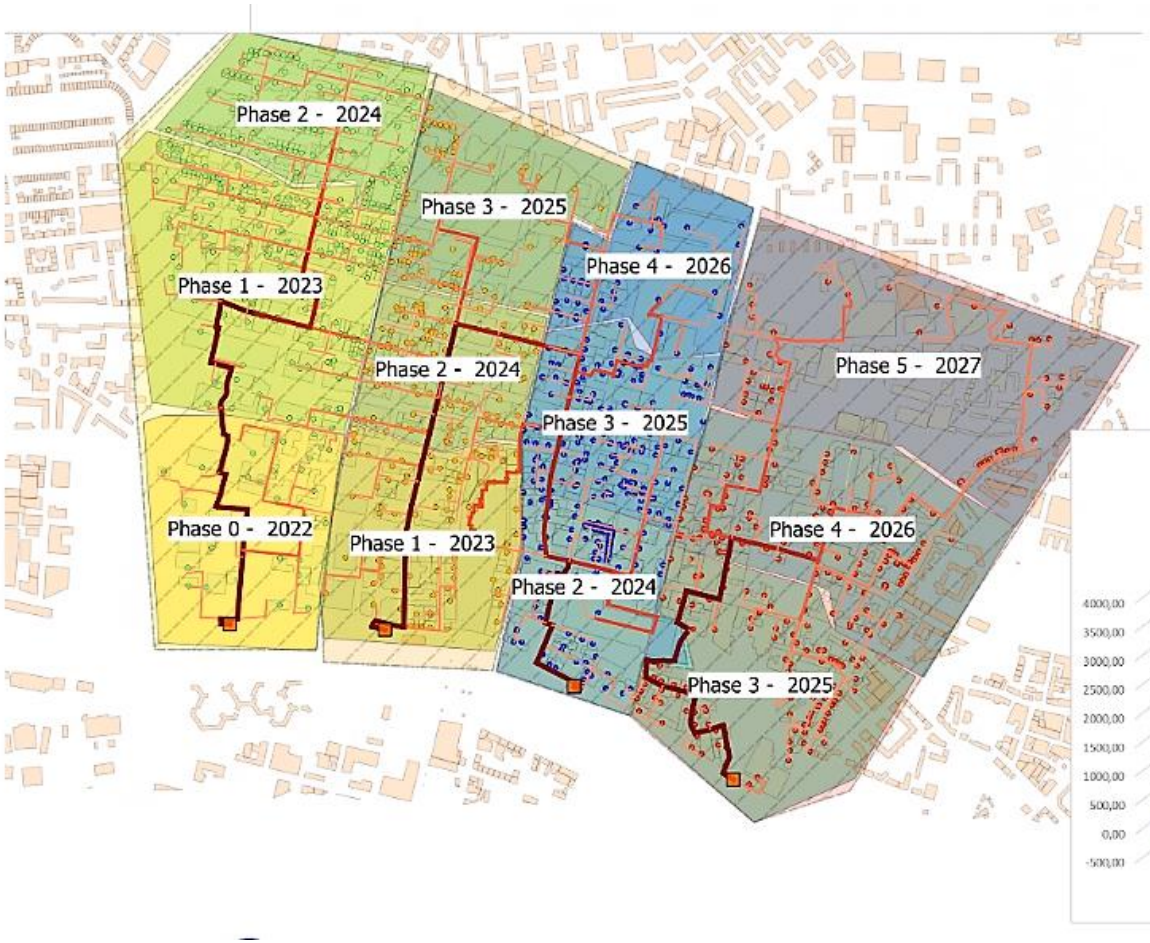
Cornell's Ithaca Campus has a Thermal Energy Network

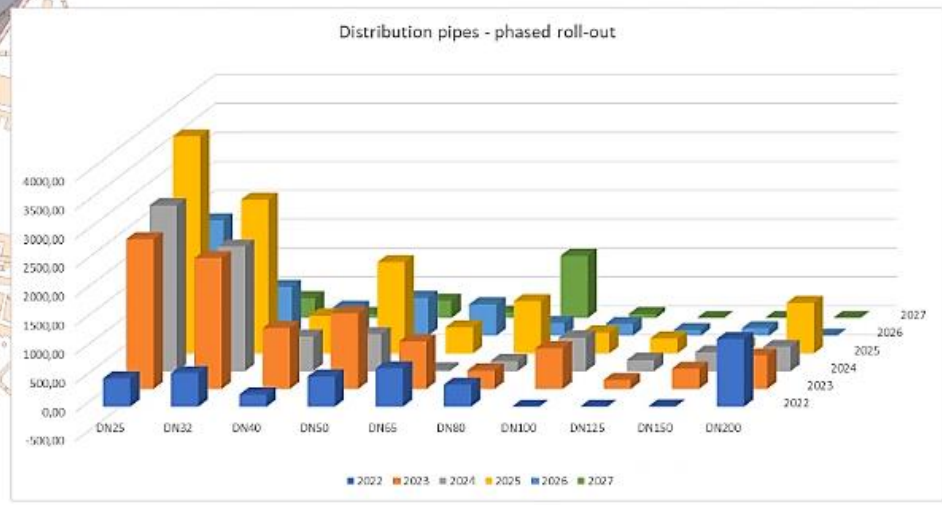
Cornell's Roosevelt Island is also Thermal Loop Campus



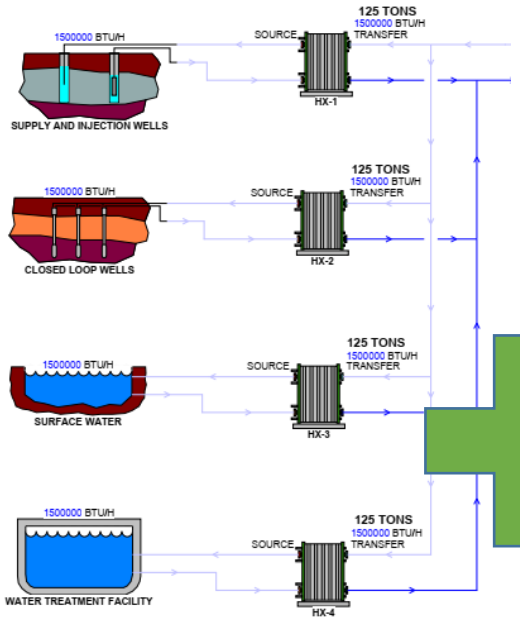


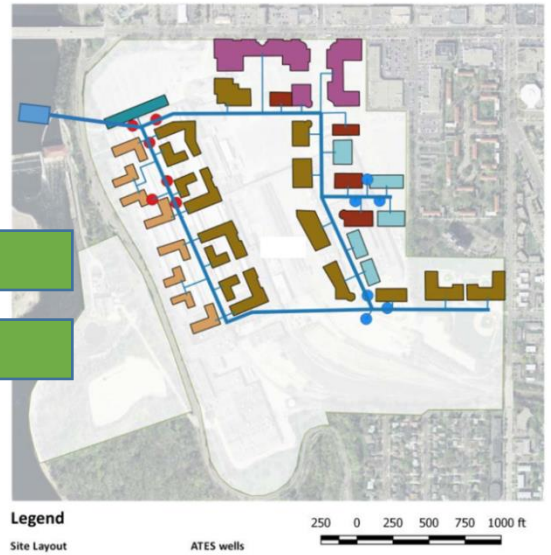
Layout Using GIS Data & Local Pricing for Labor and Materials

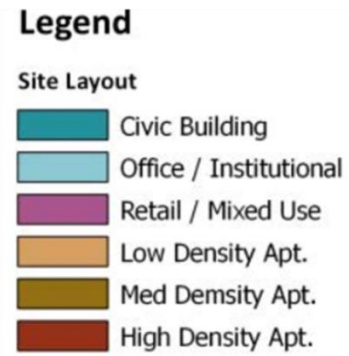




Creation of Thermal Energy Networks







Infrastructure Sources + Horizontal Piping Infrastructure = Thermal Networks

(Skilled Labor Unions)

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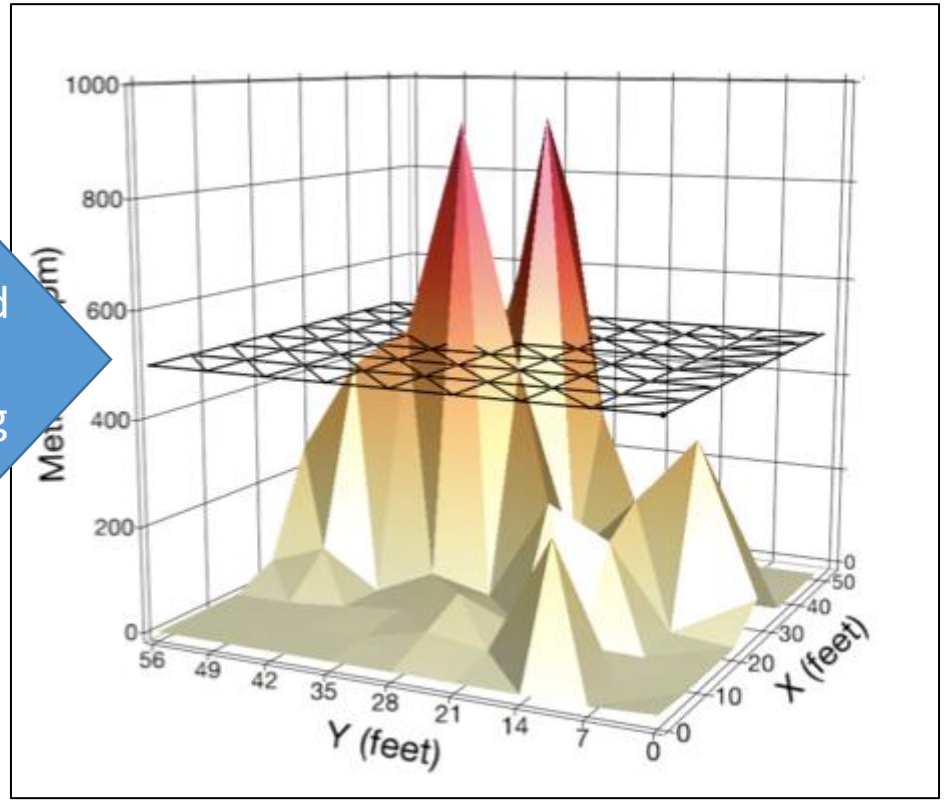
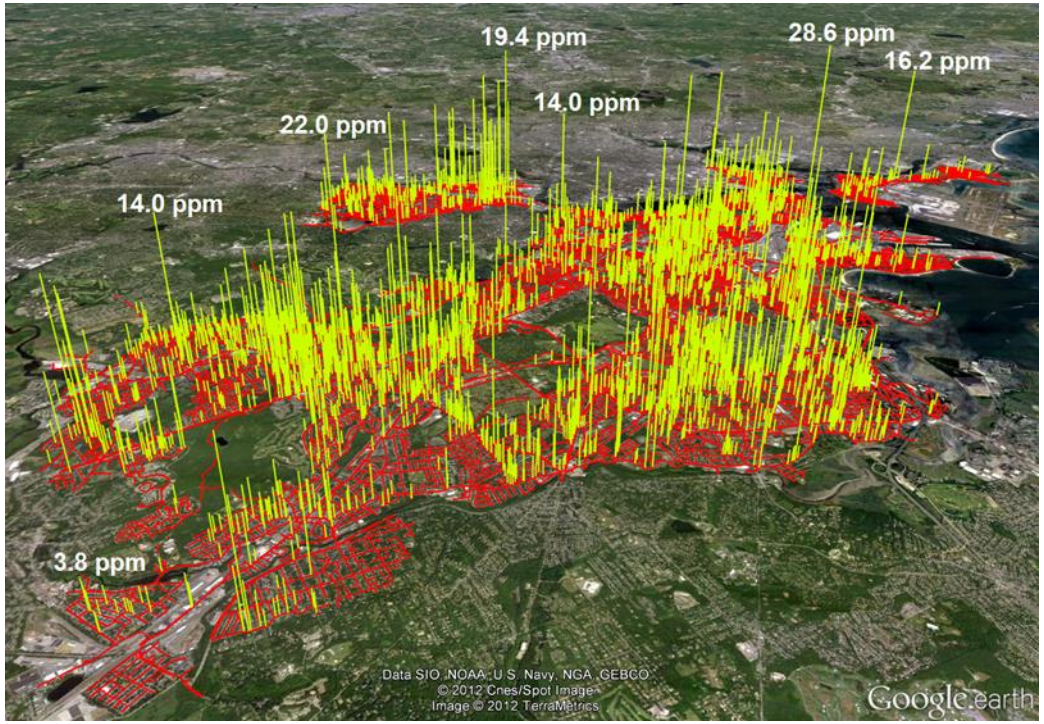
expertise
education
engineering
Defining the Future of Geothermal

$9 Billion* Question; Stranded Assets (Gas Pipe) or Thermal Micro Districts (Water Pipe)

Unburned natural gas, or methane is a more potent greenhouse gas than we could have imagined; it has 84 times the impact of CO2

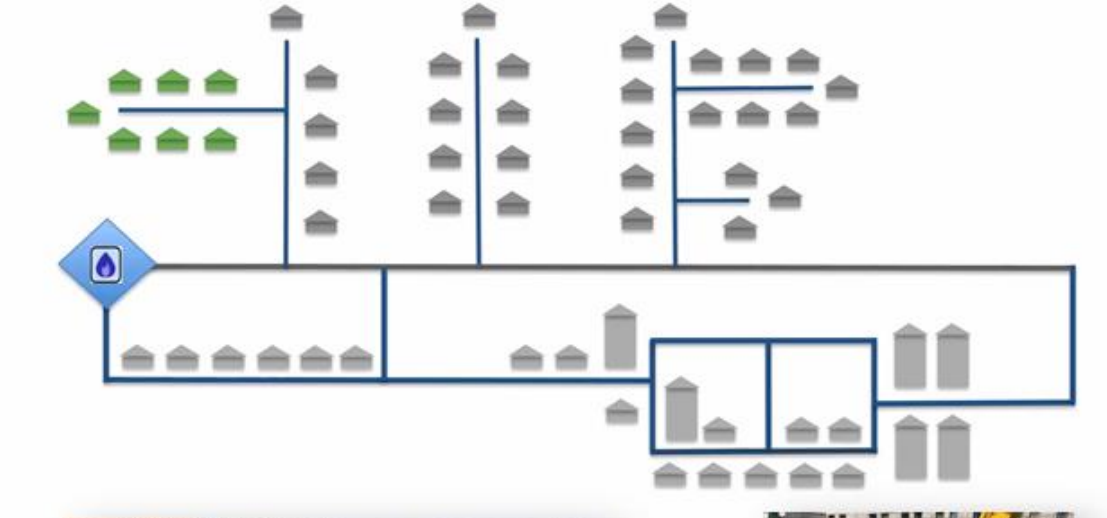
Threshold for Reporting

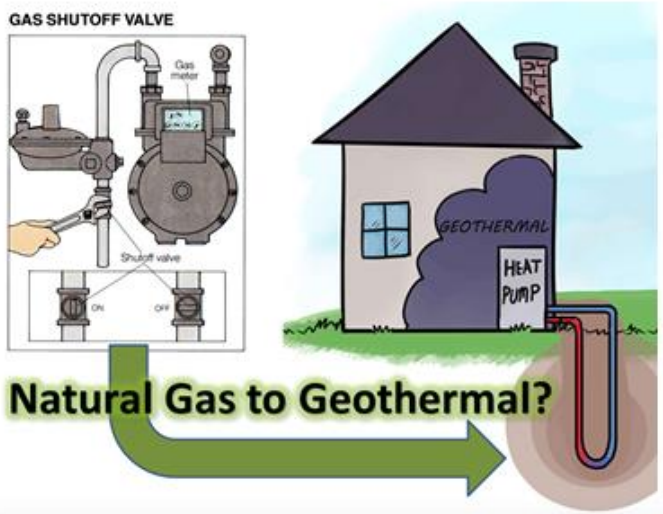


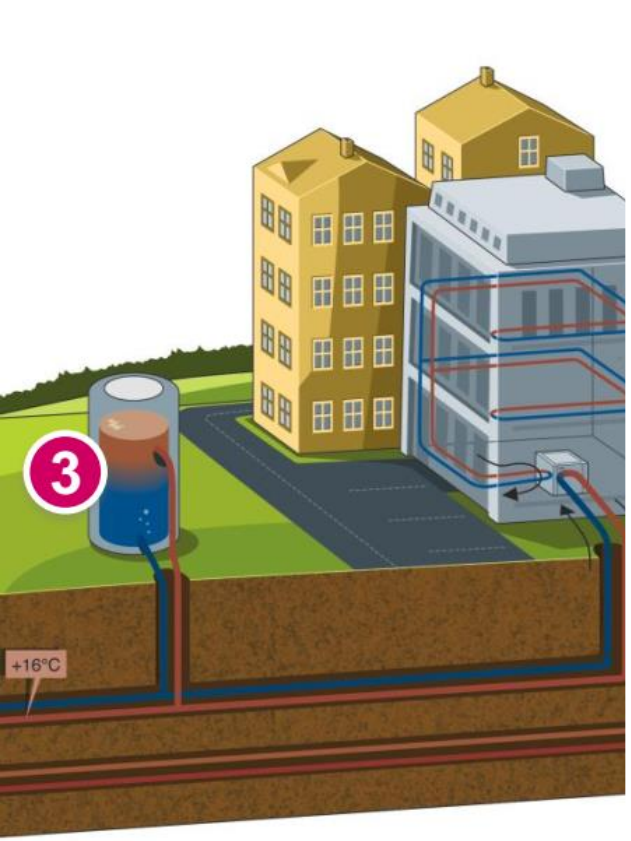


Most of the Natural Gas leakage is below the 500-ppm threshold

Industry Goals are to convert Aging NG Systems to “Thermal Micro Districts”

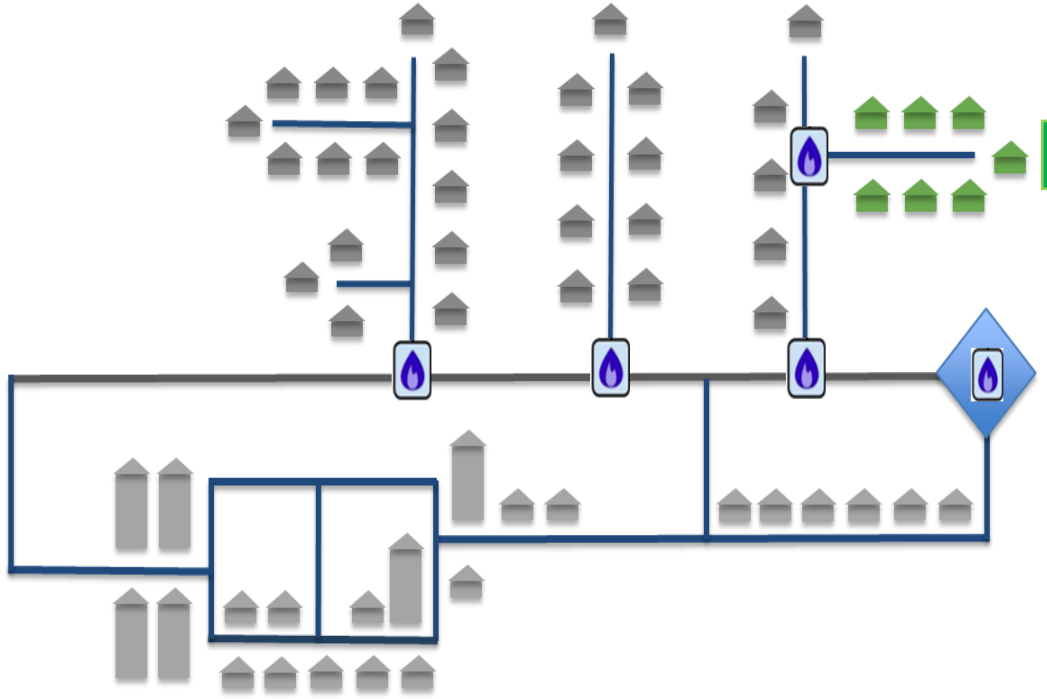




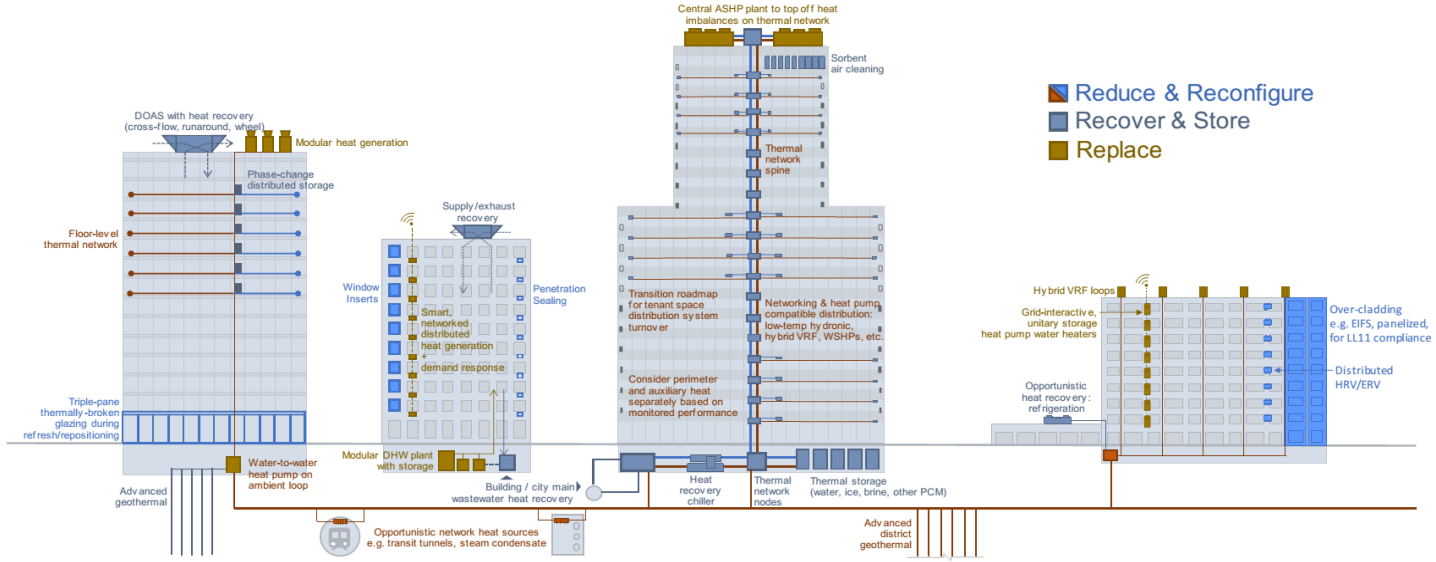


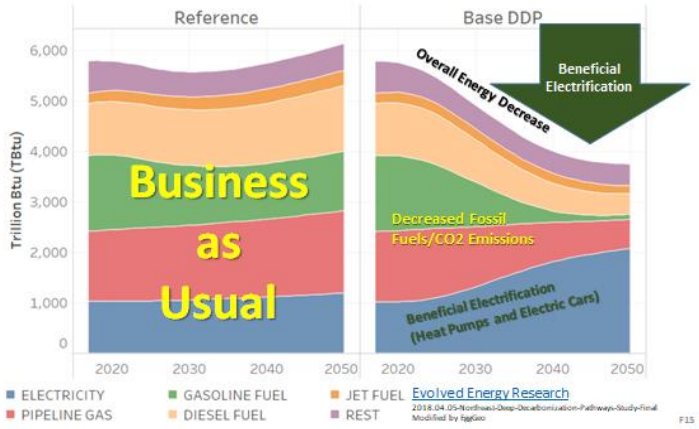
Allows Gas Utilities to bill for BTUs and gives them a path to become renewable energy companies.

Replacing Old Gas Pipe with Thermal Energy Pipelines



Replacing Natural Gas with Thermal Energy Networks





Electrification Promotes Load Sharing / Energy Diversification (re-use of BTUs)

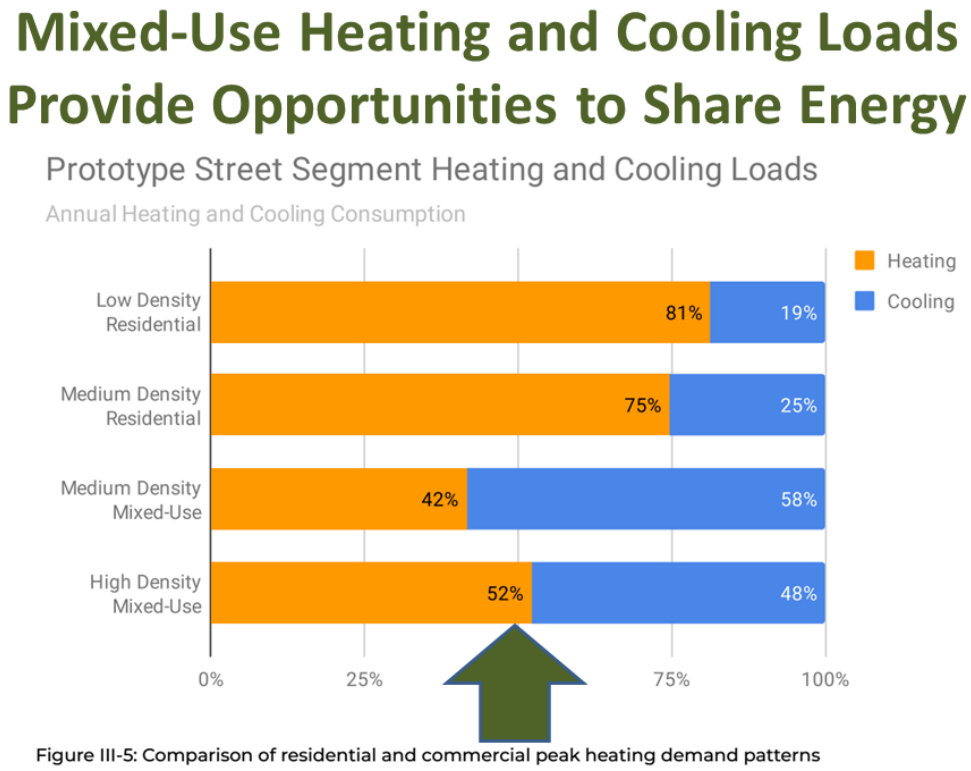


Figure III-5: Comparison of residential and commercial peak heating demand patterns

Figure III-2: Medium density residential PSS

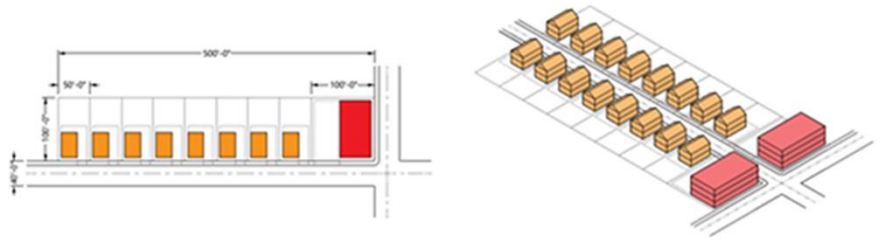


Figure III-3: Medium density mixed-use PSS

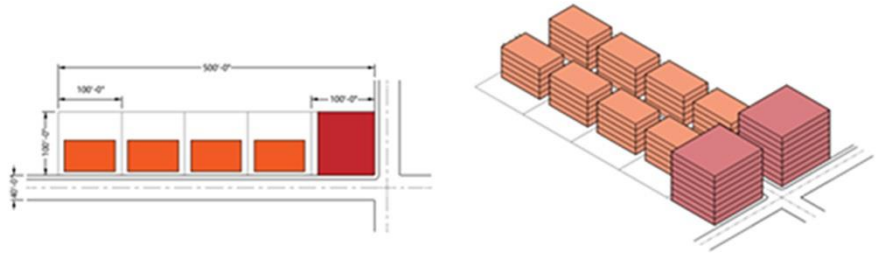
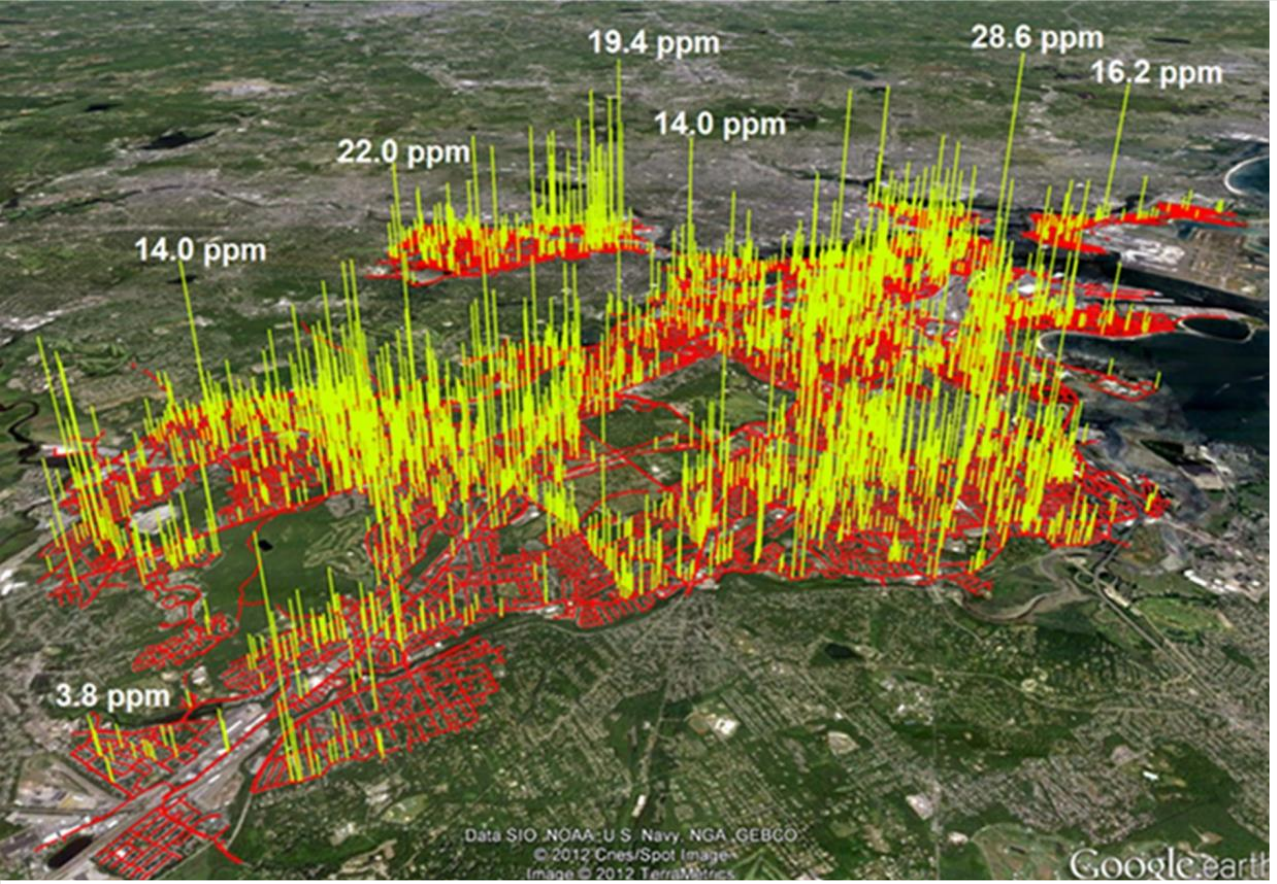
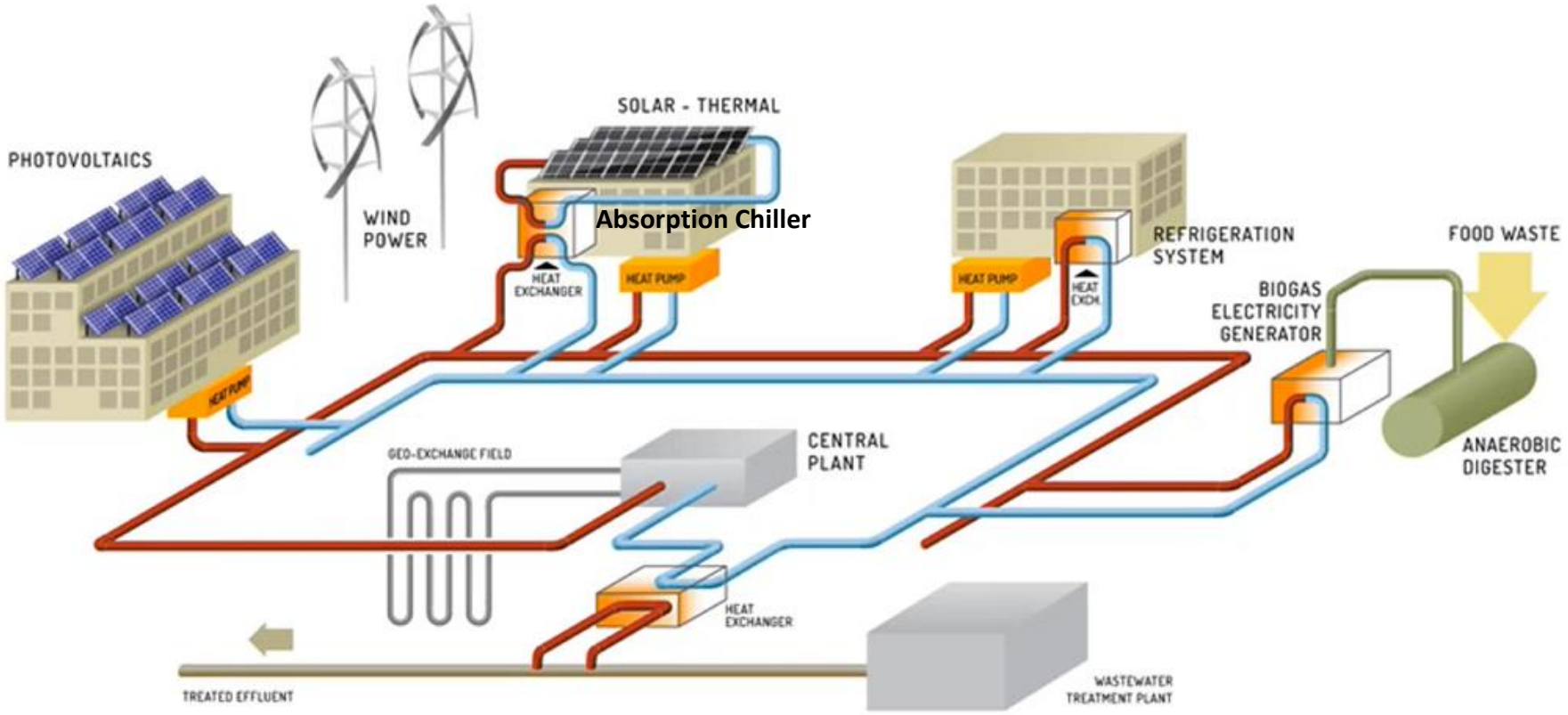


Figure III-4: High density mixed-use PSS



Health and Human Safety are Enhanced by Beneficial Electrification. Building Codes Protect the Public (UMC)

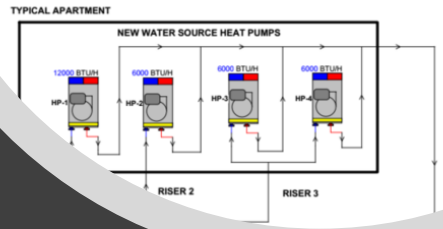
Community Thermal Energy Networks



offer load diversity, or the ability to share energy between units that are heat and cooling. For example, one heat pump in cooling mode's waste heat can be used by another unit in heating mode for more efficient operation (or vice versa). The existing fan coils are electrically powered from breakers within the apartment. The voltage of the service to each GHP will need to be upsized to match the requirements of the nameplate rating (208V, single phase, various amperage ratings) Estimated cost are to replace (316 apartments x ~4 units each) = 1200 GHPs (package terminal HPs) $2,040,000.

DISTRIBUTED GEOTHERMAL HEAT PUMP OPTION

F5



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Amalgamated Housing Corporation

August 14, 2019
Via Email to:

Charles M. Zsebedics, ARM
General Manager
Amalgamated Housing Corporation
Park Reservoir Housing Corporation
H. Consumers Society, Inc.

HLZA HOWARD L. ZIMMERMAN ARCHITECTS PC

GEOTHERMAL UPGRADE OPTI
ELECTRICAL IMPACT

FOR AMALGAMATED HOUSING CORP
3975 Sedgwick & 3965 sedgwick ave
BRONX, N.Y 10463

Issue Date:
March 9th, 2020

Reference:
N/A

Prepared For:
3975 Sedgwick & 3965 Sedgwick Ave
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NY 10463

C/O
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Bronx, N.Y. 10463

Prepared by:
Jurgen Gjoka, Project Associate
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New York, NY 10805

TABLE OF CONTENTS:

11 West 30th Street 3rd Floor New York NY 10001 | p. 212.564.9393 | f. 212.564.9032 | www.hlzimmerman.com

Educational Modules, Textbooks, and Trades Curriculum
Using Case Studies and Real-World Examples

→ Cheapest Upgrade Option ☆RECOMMENDED

Water Source Heat Pumps →
Mechanical Work Estimated = $2,904,800
Electrical Work Estimated = $1,315,000
Geothermal Work Estimated= $2,800,000
TOTALL WORK ESTIMATED= $7,019,800

*Contingency for replacing all existing piping infrastructure not included in above price.
* Estimated price for full piping replacement: $3,000,000 + $7,019,800 = $10,019,800

Option #2 → Intermediate Upgrade Option

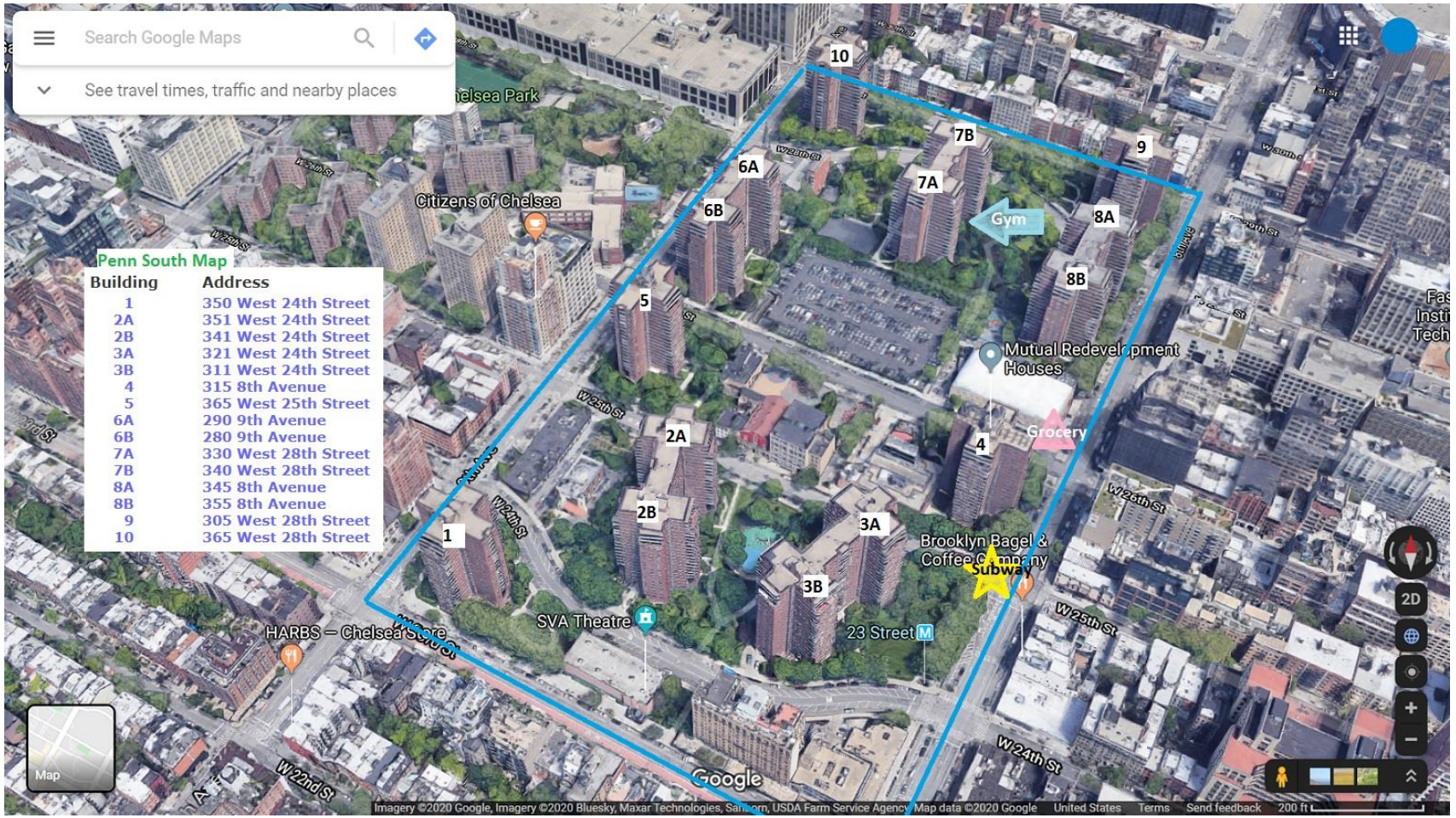
Modular Heat Pump Chiller→
Mechanical Work Estimated = $4,250,000
Electrical Work Estimated = $200,000
Geothermal Work Estimated= $2,800,000
TOTALL WORK ESTIMATED= $7,200,000

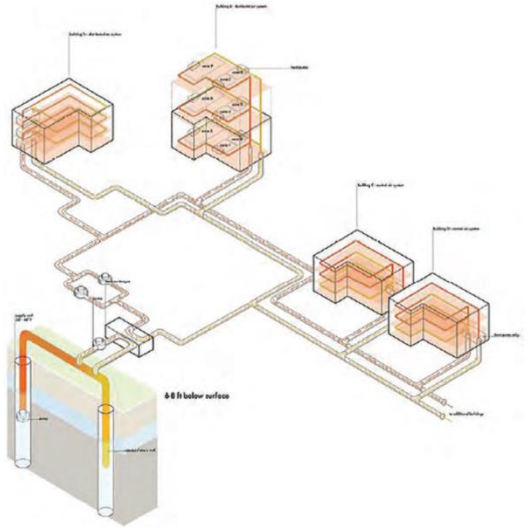
*Contingency for replacing all the existing piping infrastructure not included in above price.
* Estimated price for full piping replacement: $3,000,000 + 7,200,000 = 10,200,000

Option #3 → Most Expensive Upgrade Option

Water Cooled VRF/VRV →
Mechanical Work Estimated = $
Electrical Work Estimated = $1,915,000
Geothermal Work Estimated= $2,800,000
TOTALL WORK ESTIMATED= $9,970,000

Infrastructure Studies, Coordination & Validation





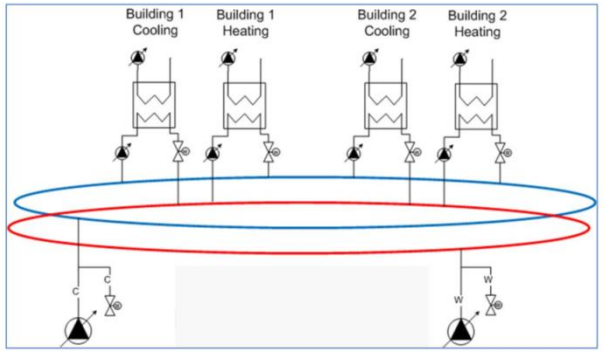
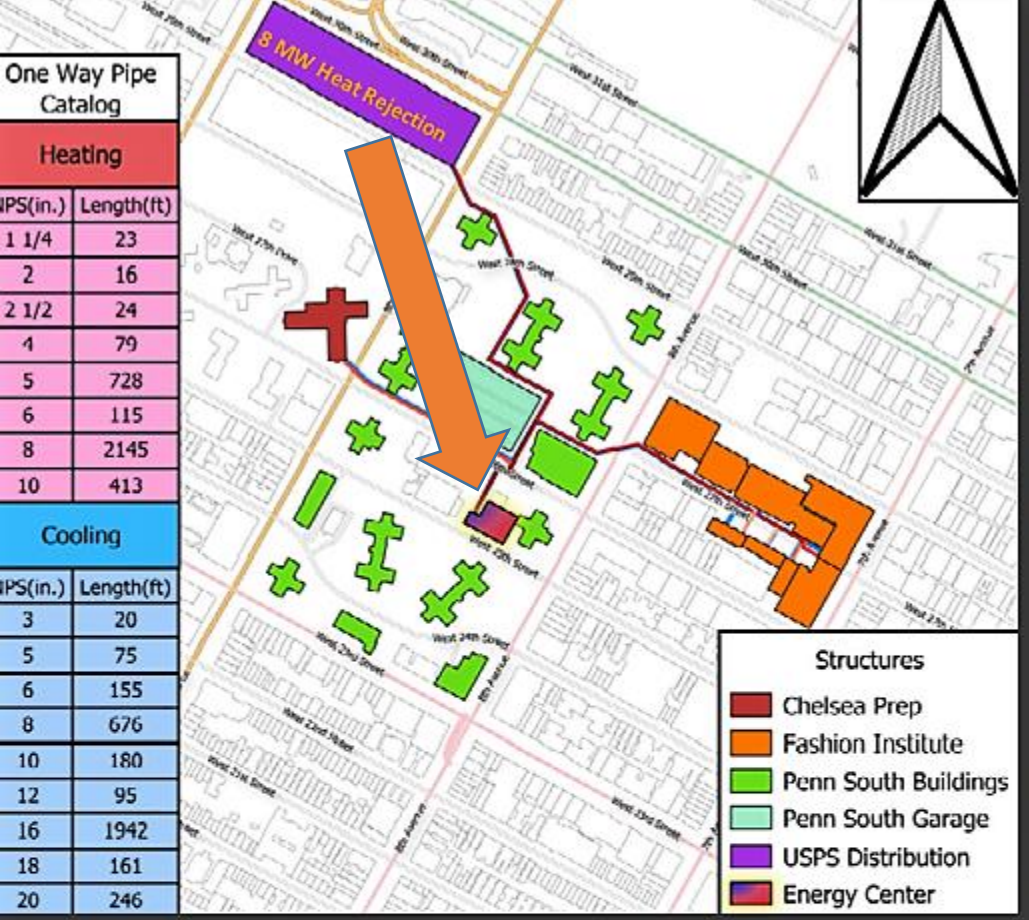


Figure 10 - Two-pipe groundwater distribution, active building connections

Energy Exhausted from Commercial Buildings is piped to Residential Structures



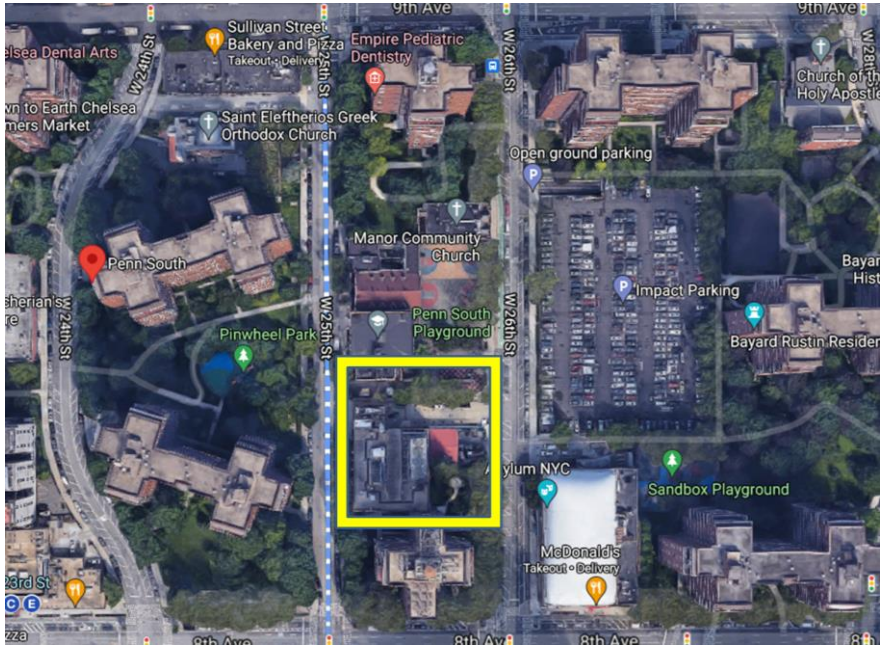
One Way Pipe Catalog

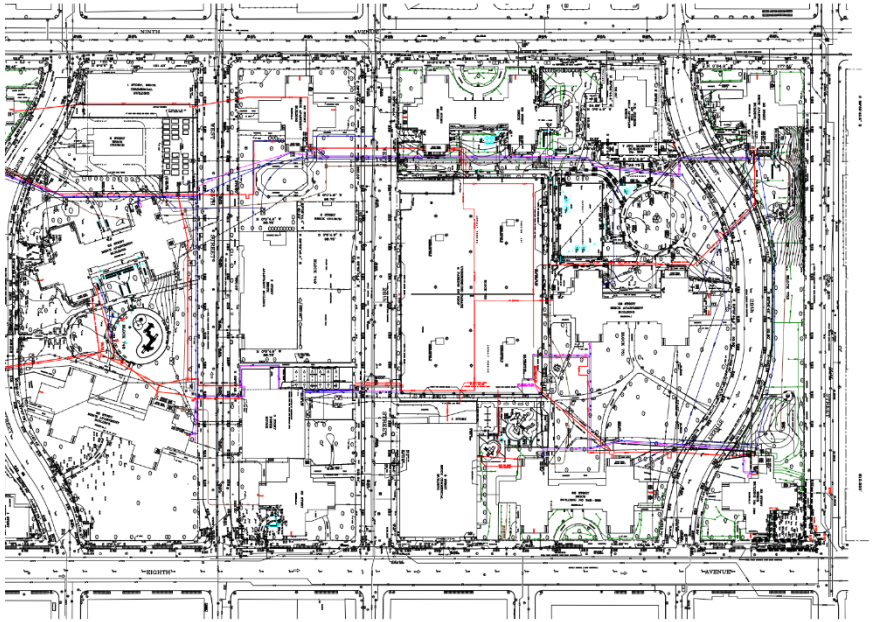
Heating	
NPS(in.)	Length(ft)
1 1/4	23
2	16
2 1/2	24
4	79
5	728
6	115
8	2145
10	413

Cooling	
NPS(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

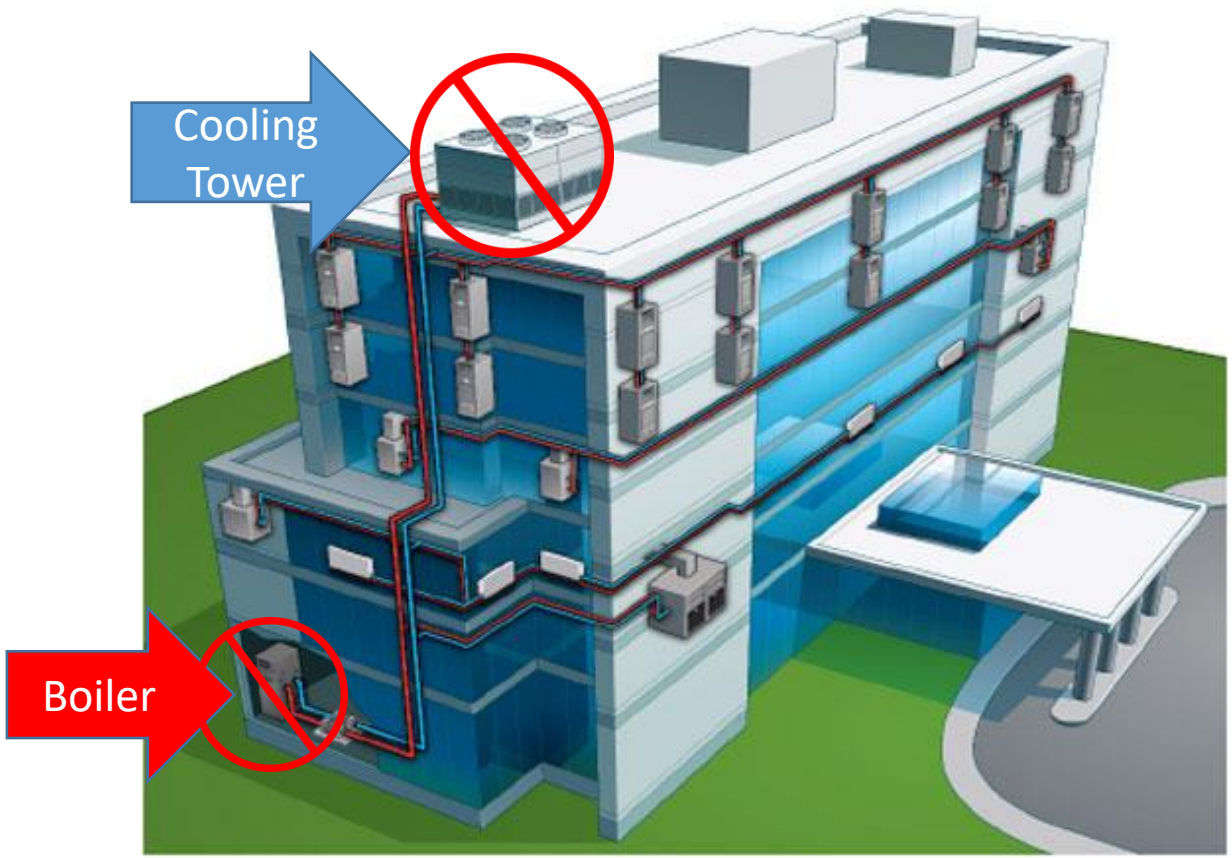
Penn South Campus and Adjoining Properties

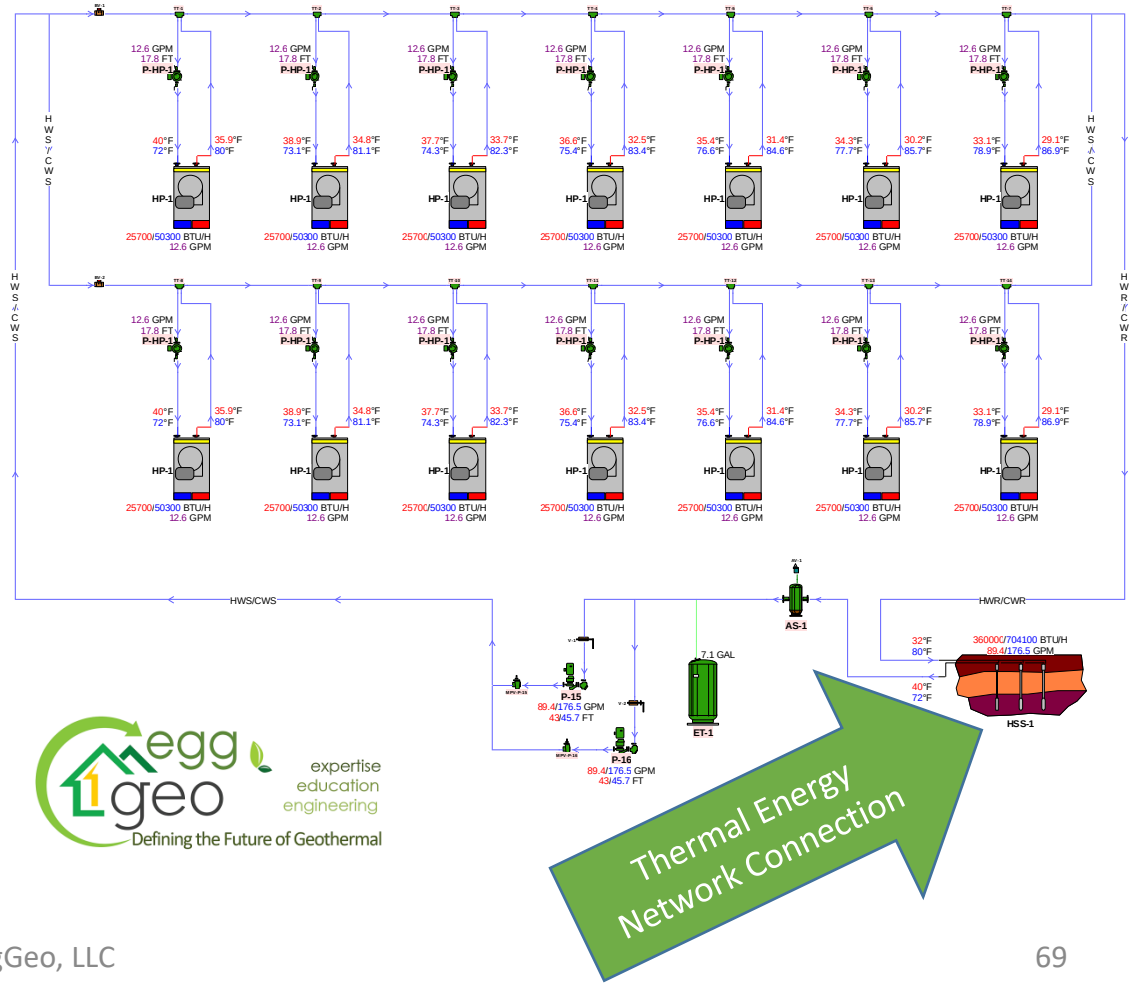




Penn South in Manhattan needs Miles of Pipe

Thermal Energy Networks Eliminate Cooling Towers and Boilers





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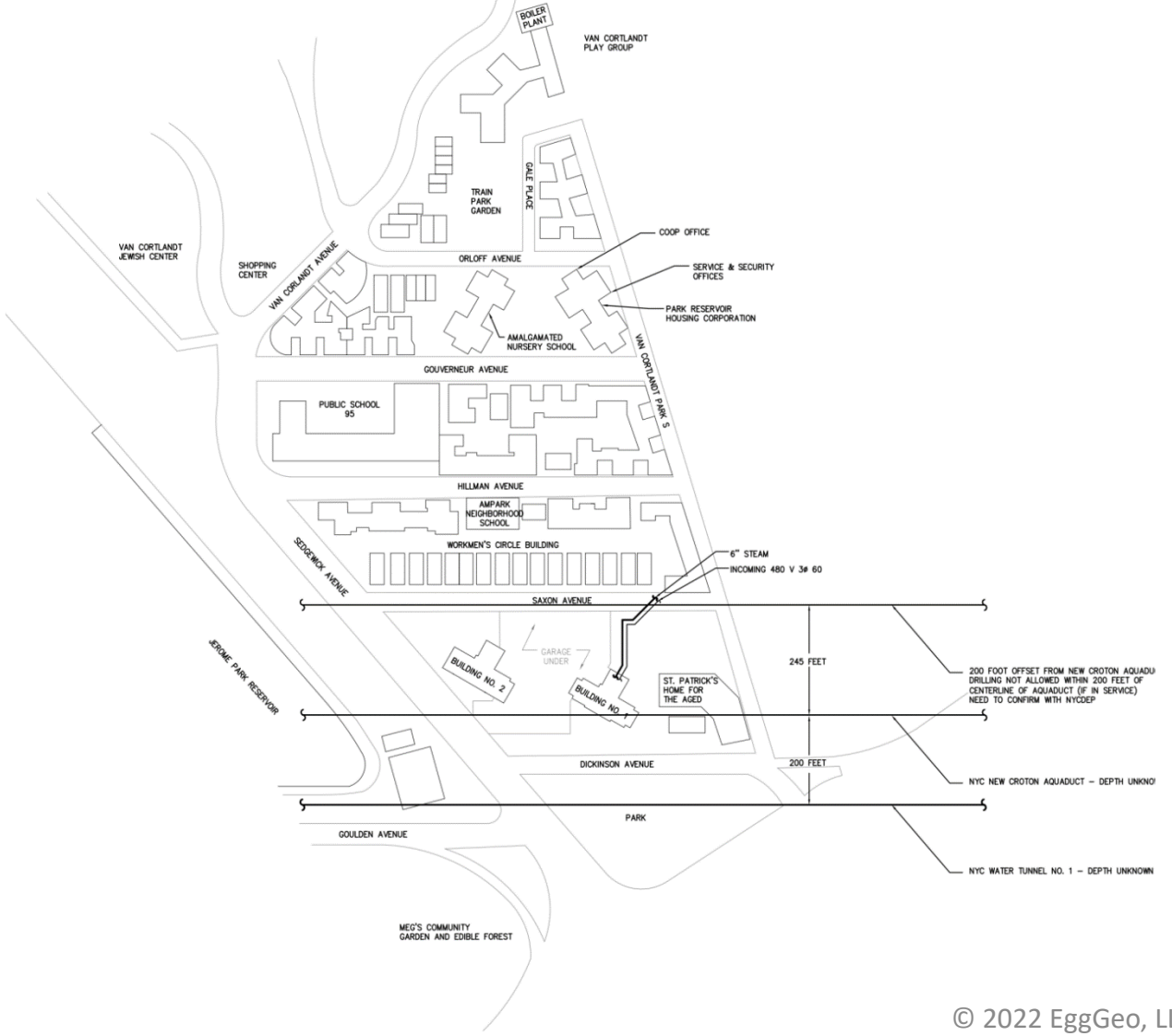
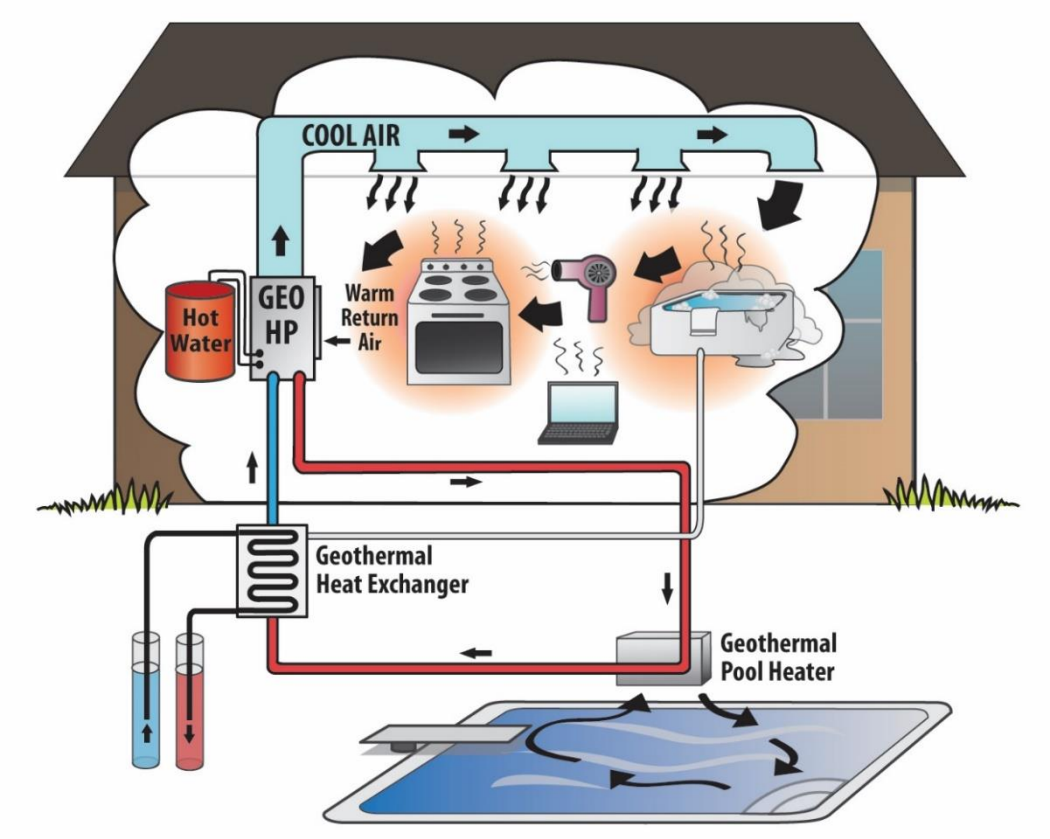
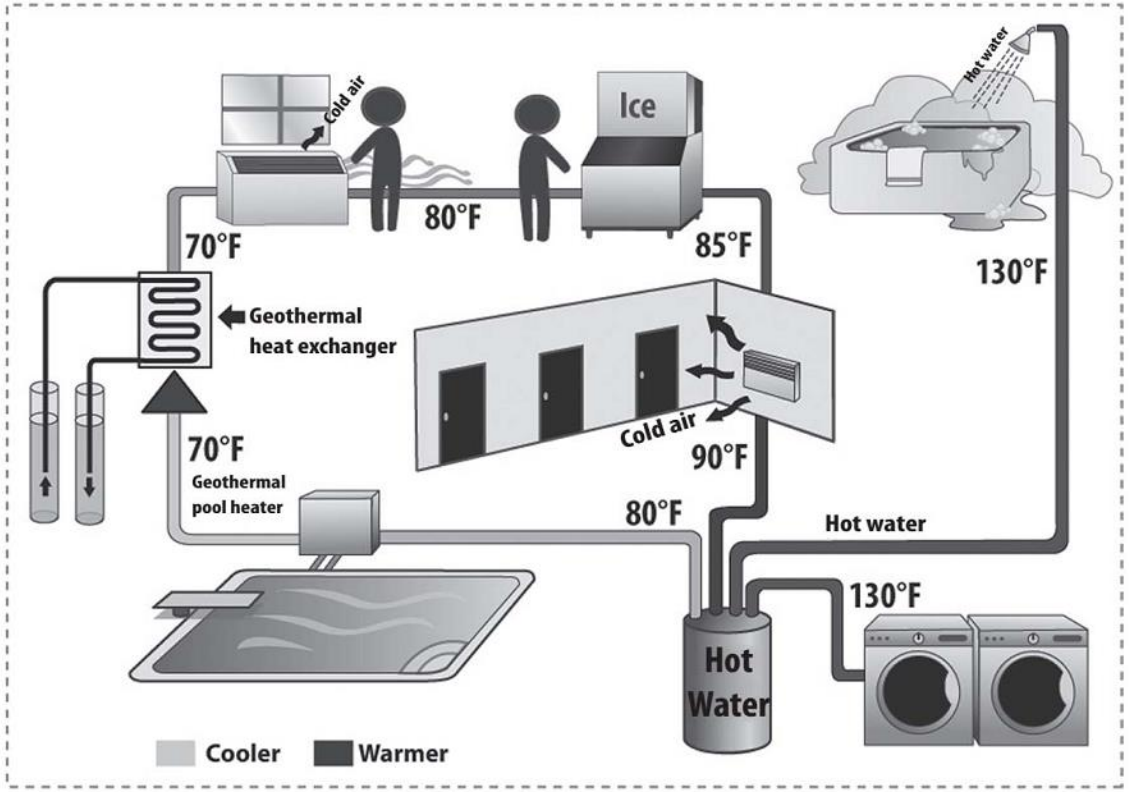
education
engineering
Defining the Future of Geothermal

Preparation of Hands-On Modules; Pipe Details, Construction Documents



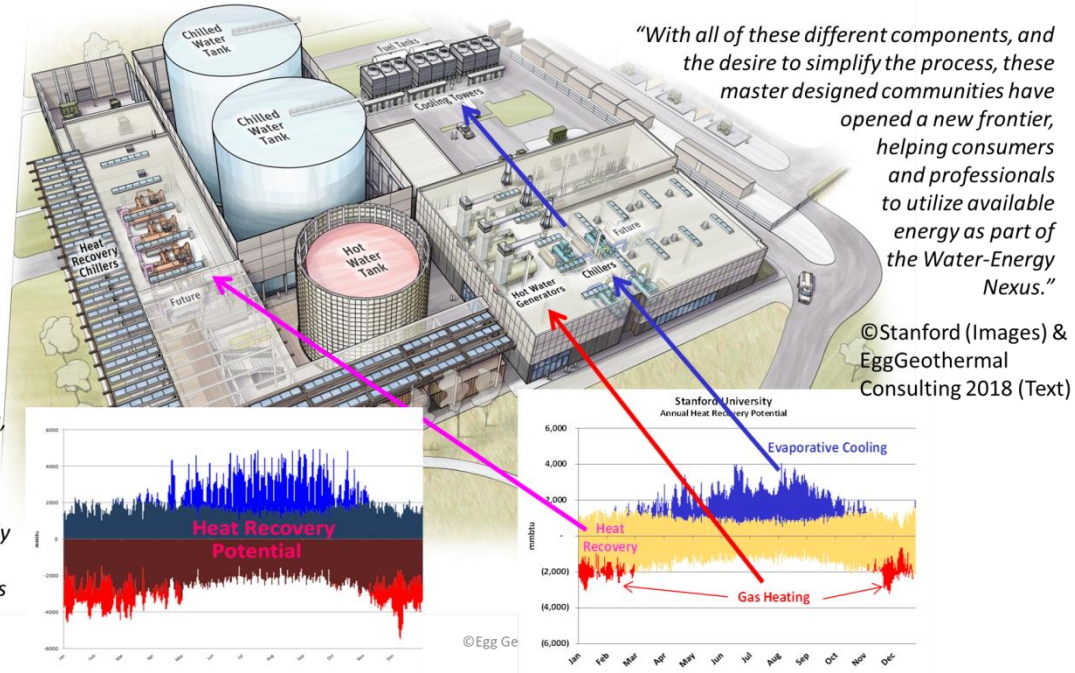
PRELIMINARY Geothermal Drilling Locations - Amalgamated Housing Corp., Bronx, NY





Perpetual BTUs: How Many Times Can We Re-use the same BTU? Follow the Energy…

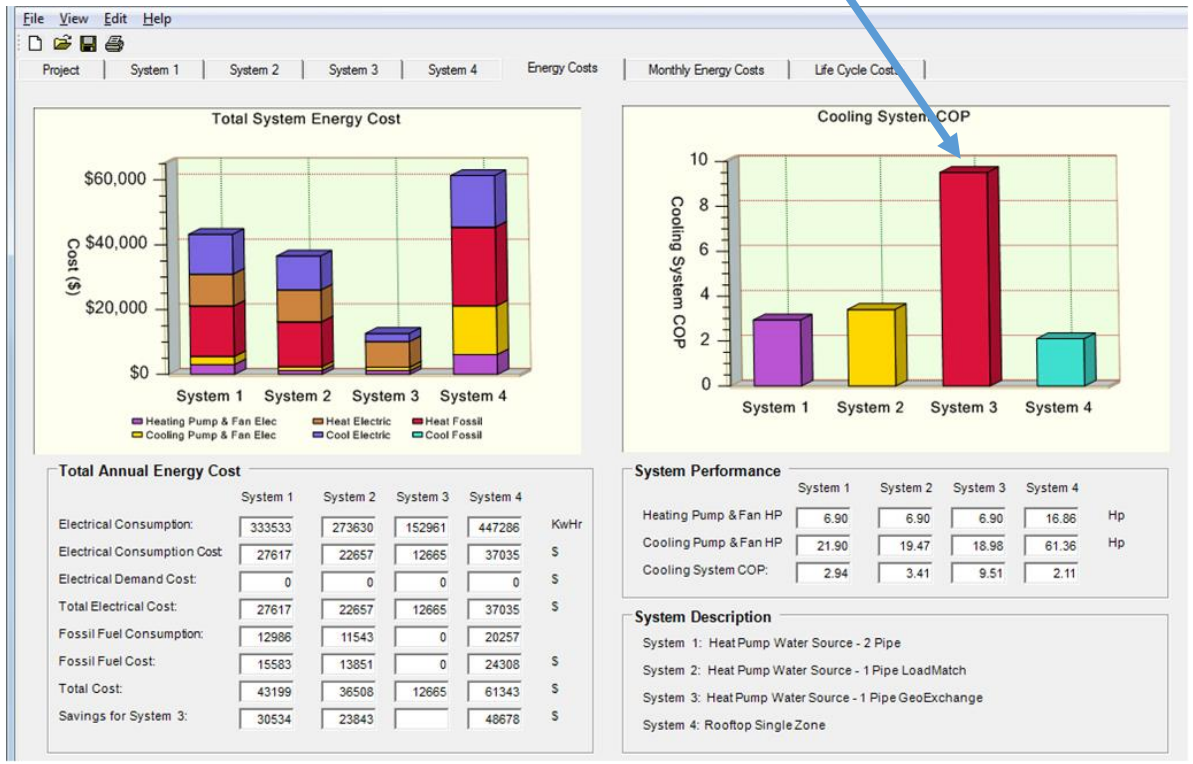
Building Efficiency System Tool (BEST) Software Illustrates Combined COP



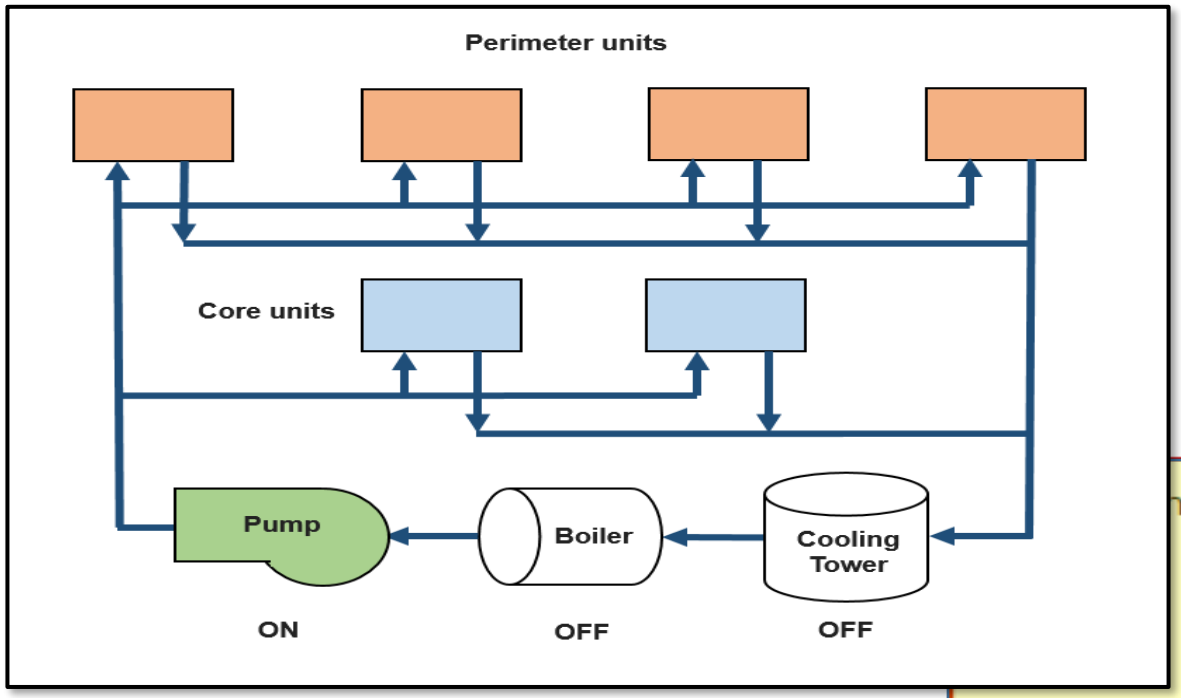
"With all of these different components, and the desire to simplify the process, these master designed communities have opened a new frontier, helping consumers and professionals to utilize available energy as part of the Water-Energy Nexus."

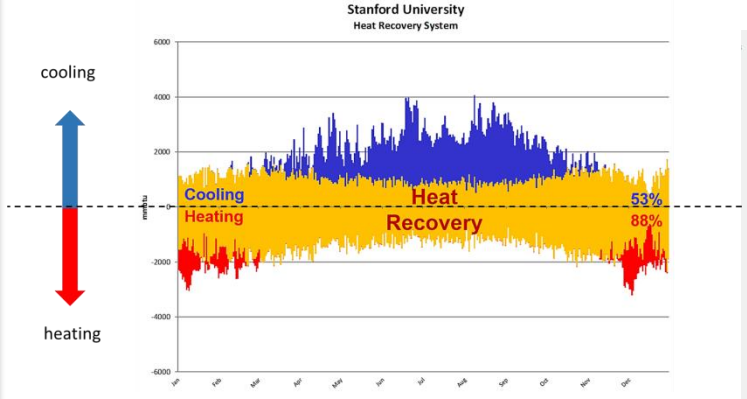
©Stanford (Images) & EggGeothermal Consulting 2018 (Text)

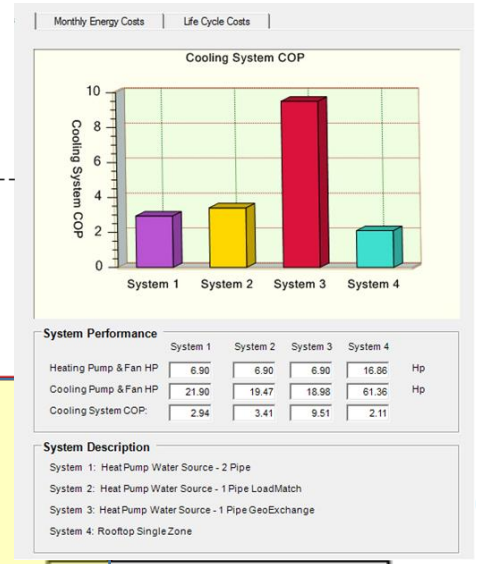
"In our homes, offices and buildings, we are paying to simultaneously heat and cool different areas and systems."

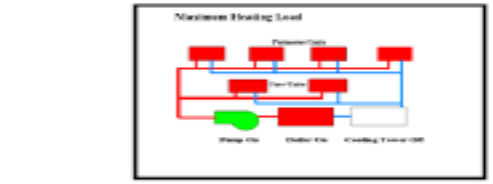


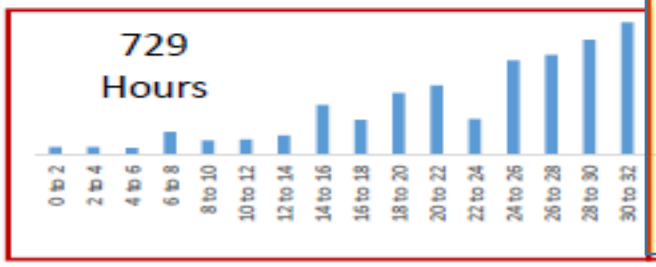
Bin Data 8760 hours

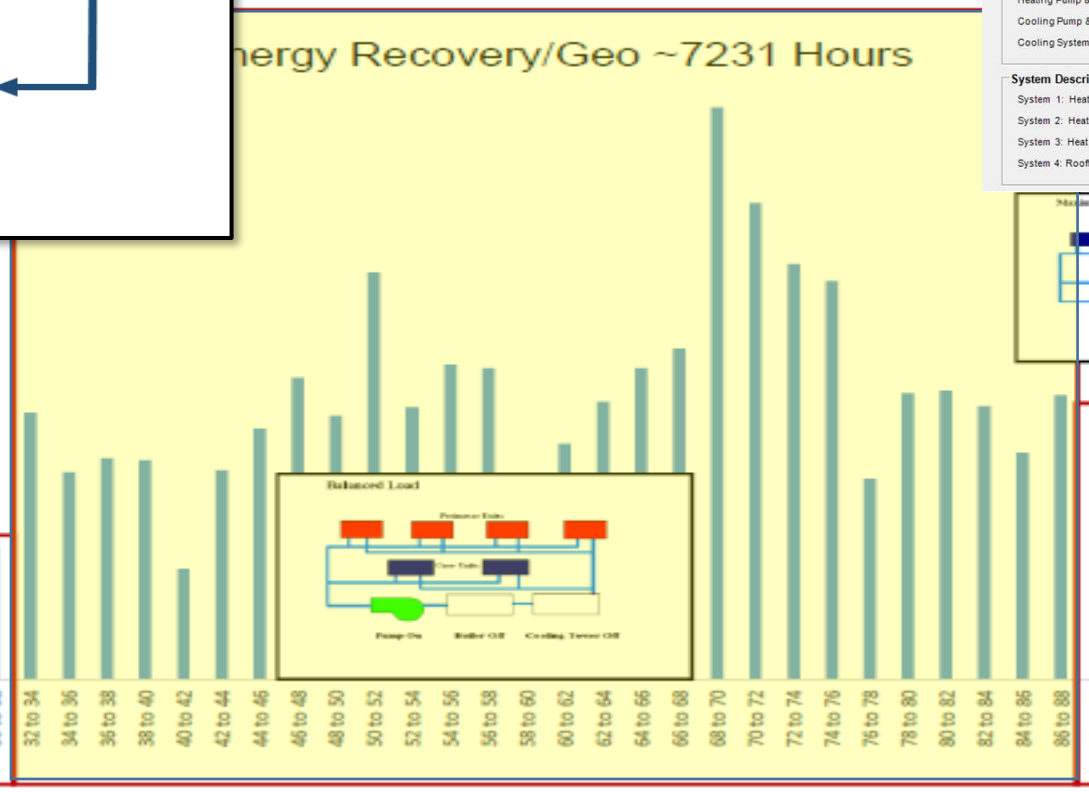


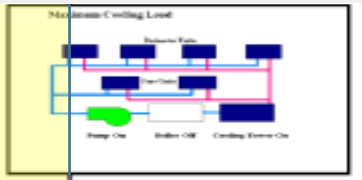


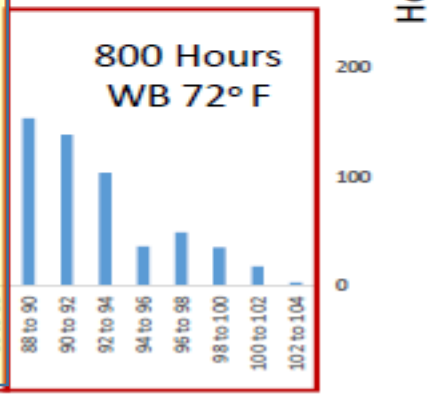


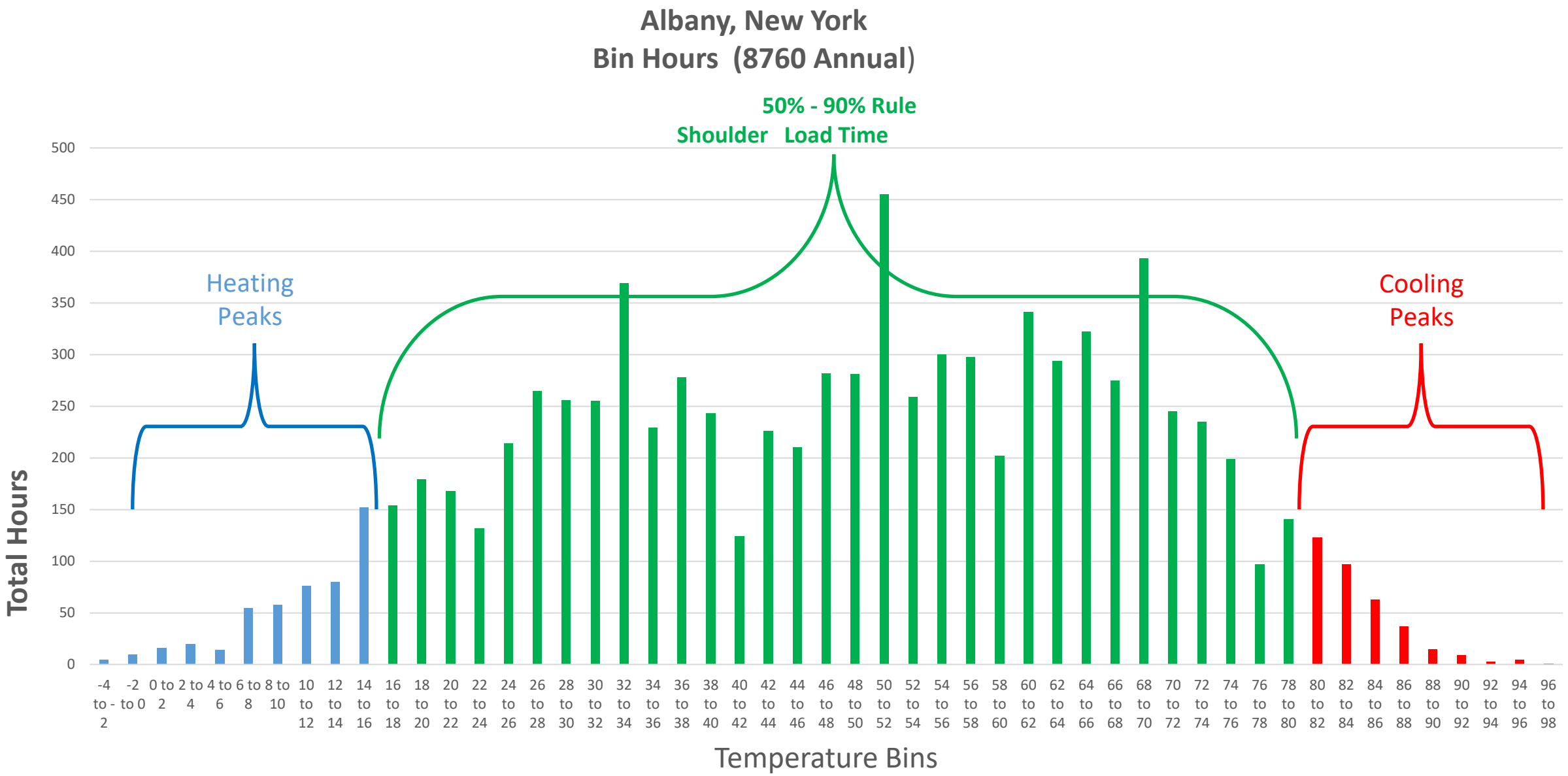






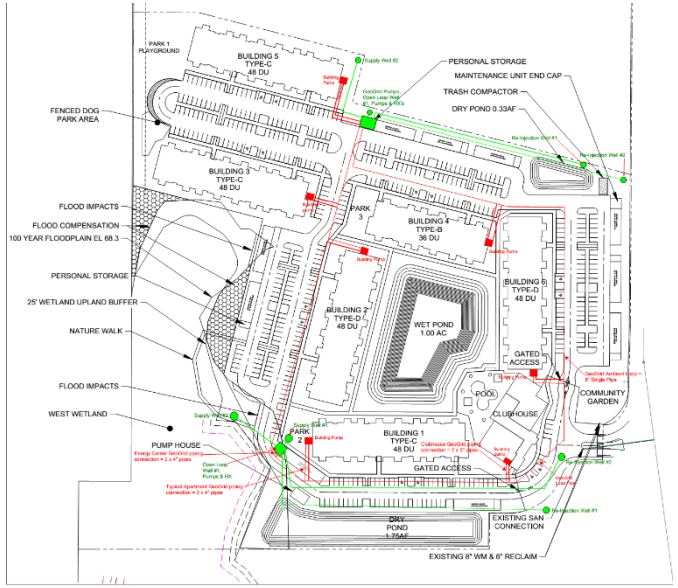


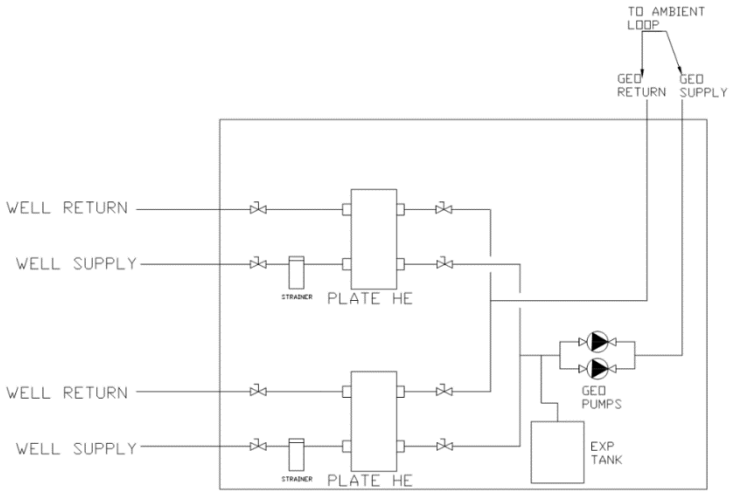


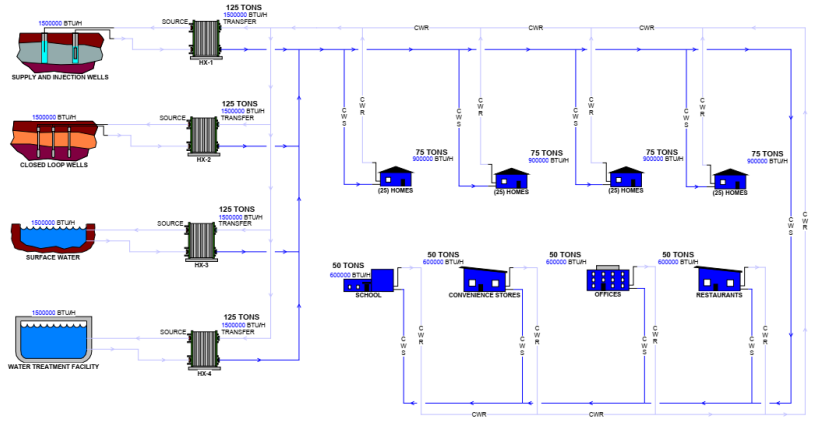


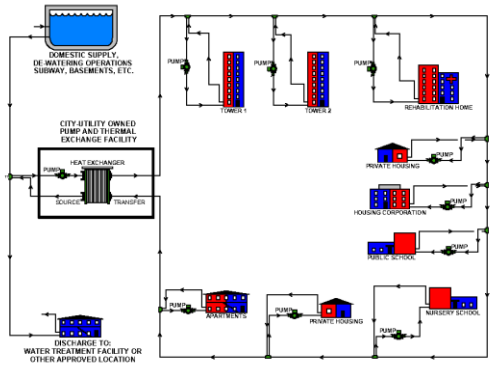
C. Smith, Sound Geothermal Corporation

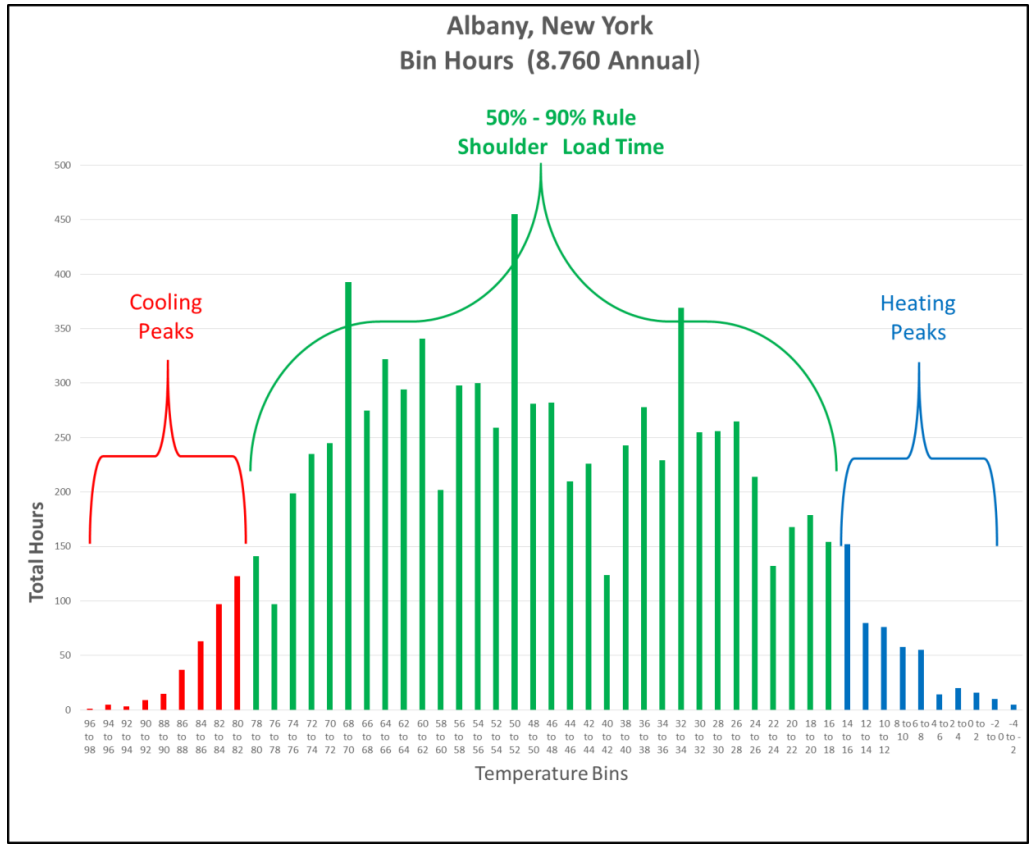
Project Construction Drawings

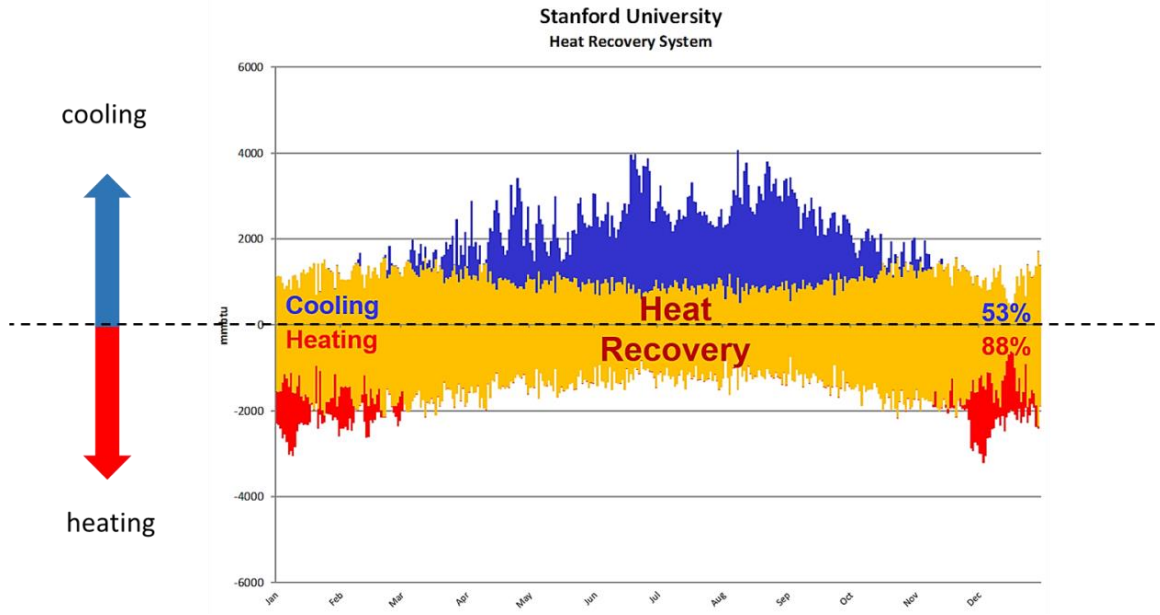








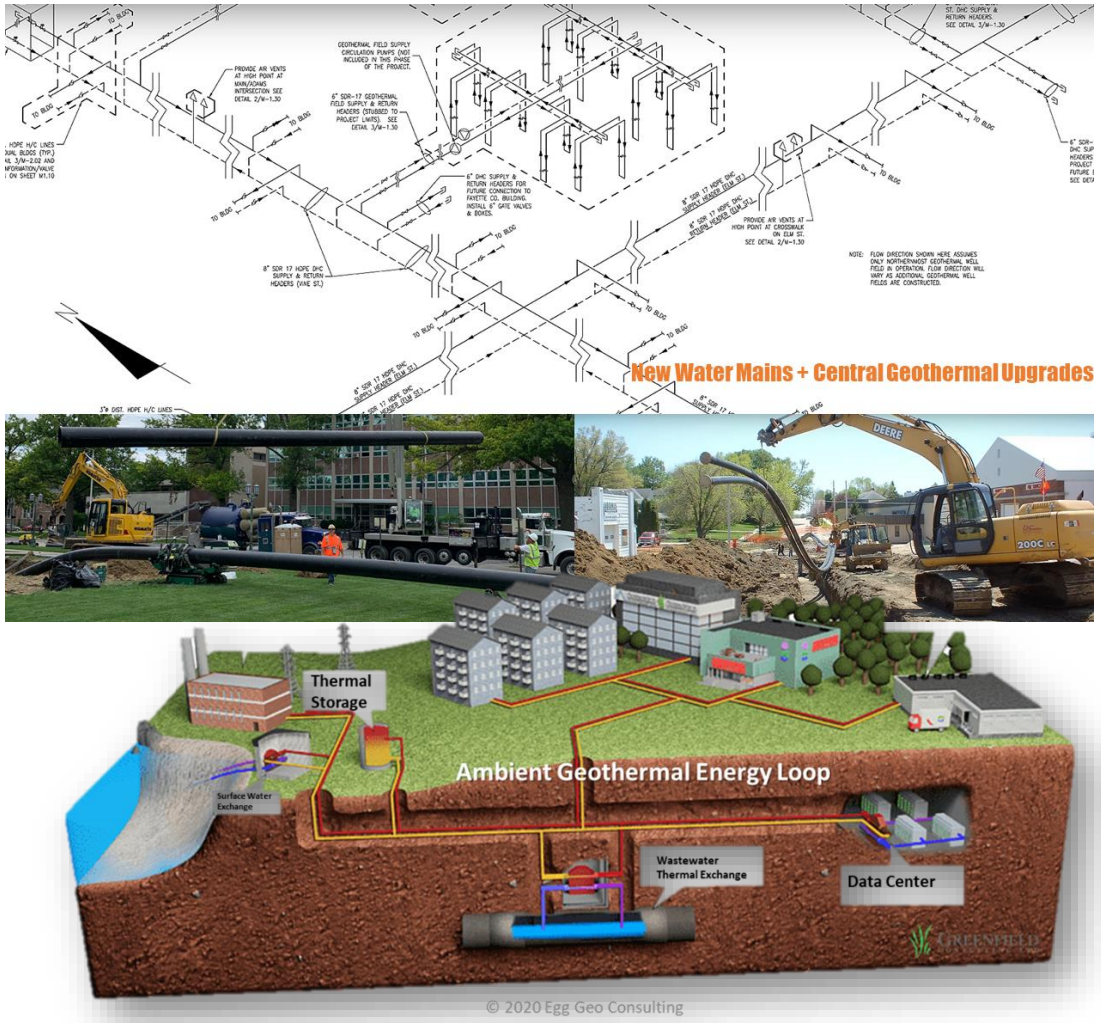




Using BTUs Over & Over Again

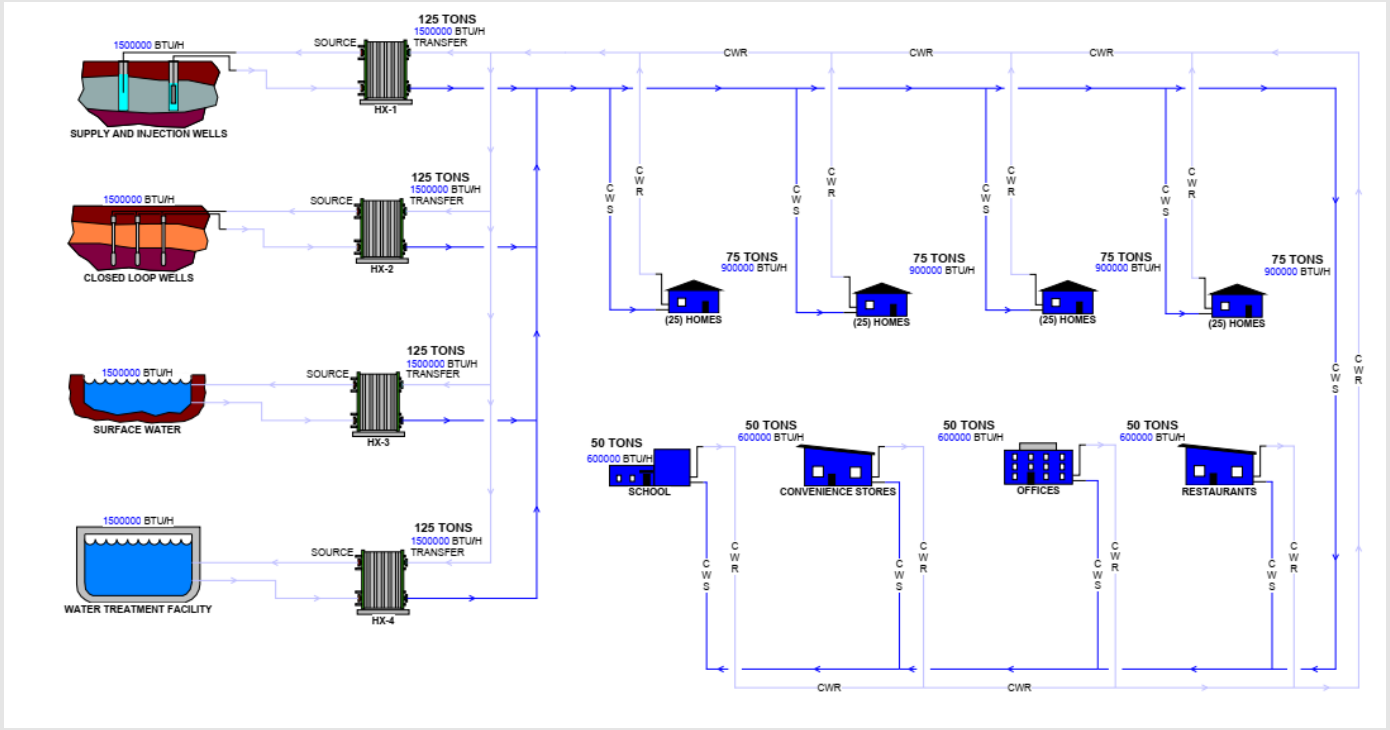
Greenfield and Brownfield Thermal Energy Network Curriculum; Bridging Silos

Horizontal Design + Skilled Union Labor & Thermal Energy Network Curriculum



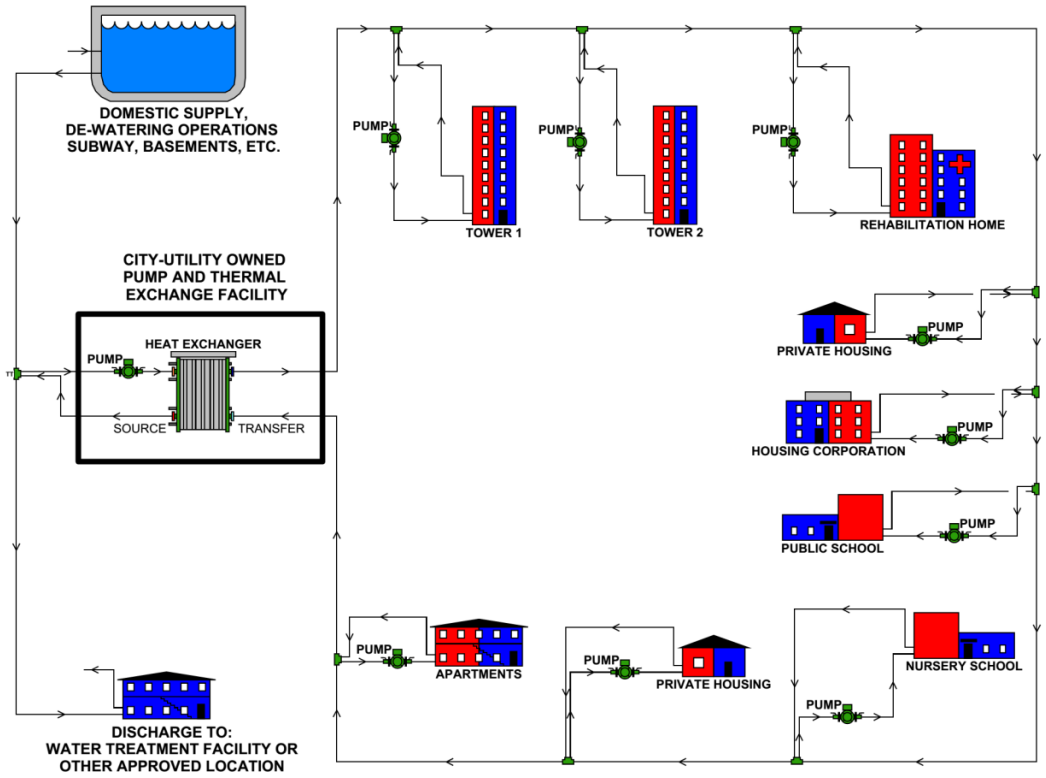
Local Construction and Contractors execute these projects

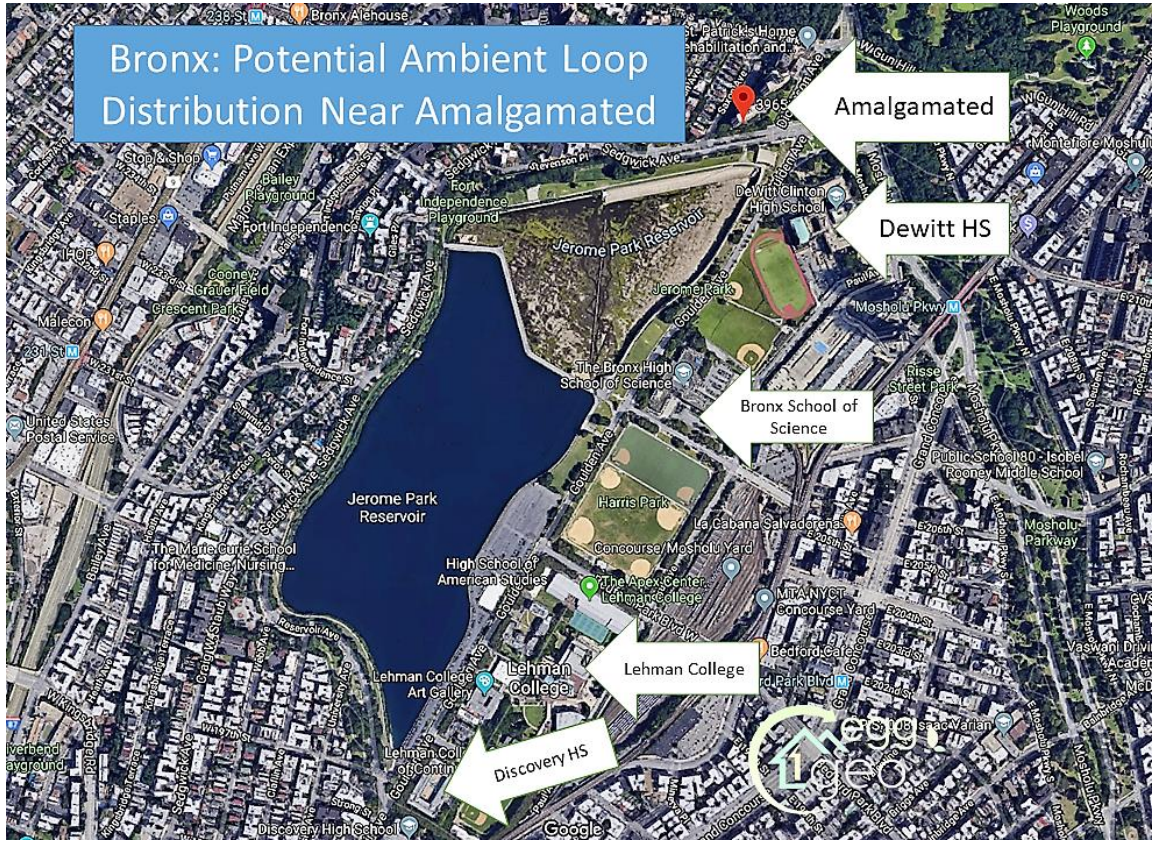
Types of Thermal Exchange Networks Between Buildings and Blocks in Communities



- **Utility & Infrastructure Fluid Energy Sources**
- Raw Water (pre-Drinking Water Treatment)
- Wastewater (Dirty)
- Wastewater Effluent (Cleaned)
- Irrigation Water (Greywater)
- Dewatering Operations (Subways, Subgrade Parking Garages, etc.)
- Drinking Water Energy
- Data Centers

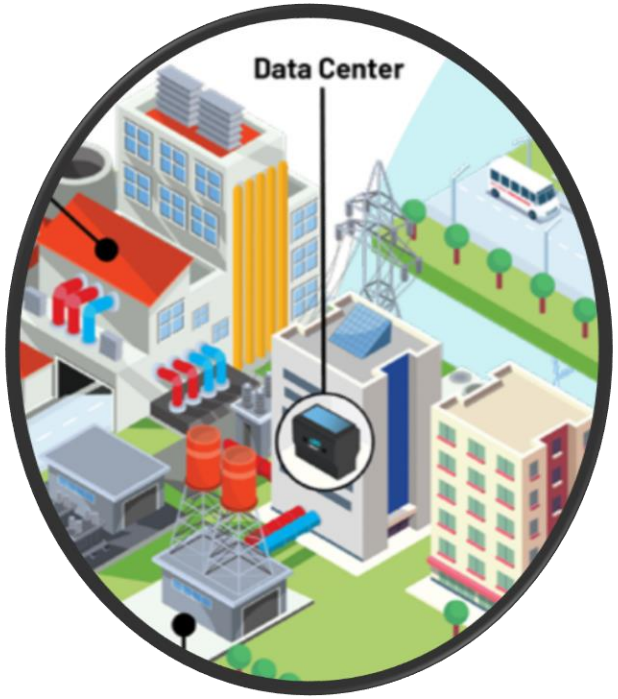
Thermal Energy Network Infrastructure Will Be Installed by Plumbers and Pipefitters

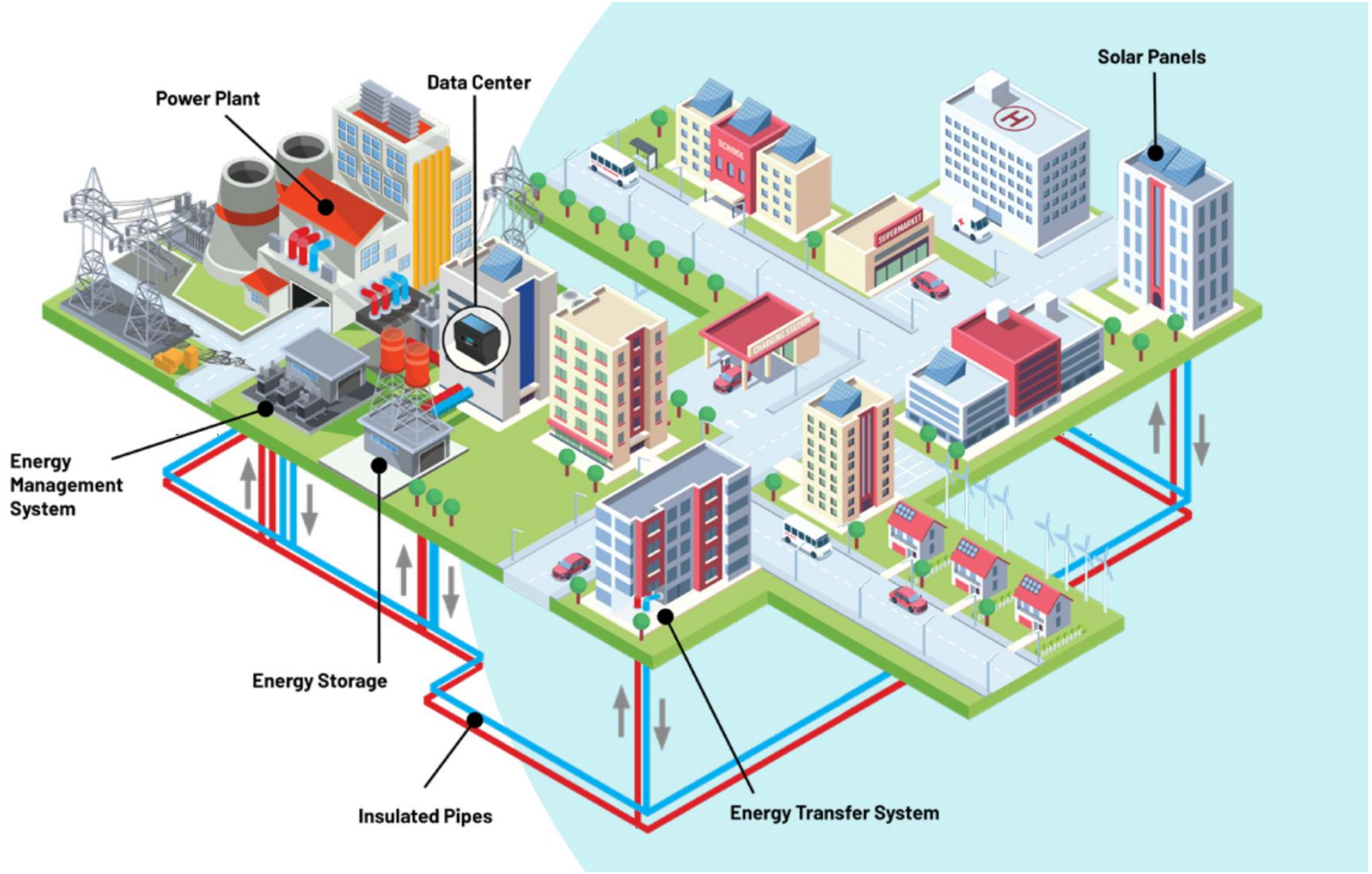


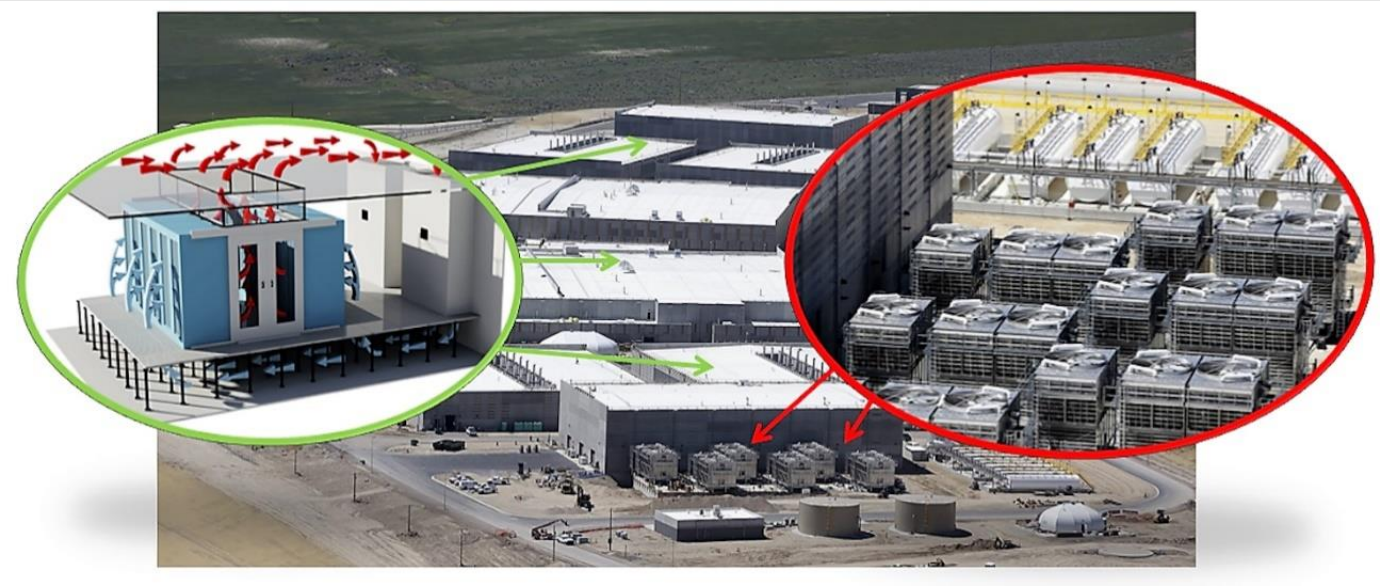


City Layout with Hydronic Software

Thermal Network Integration for Data Centers

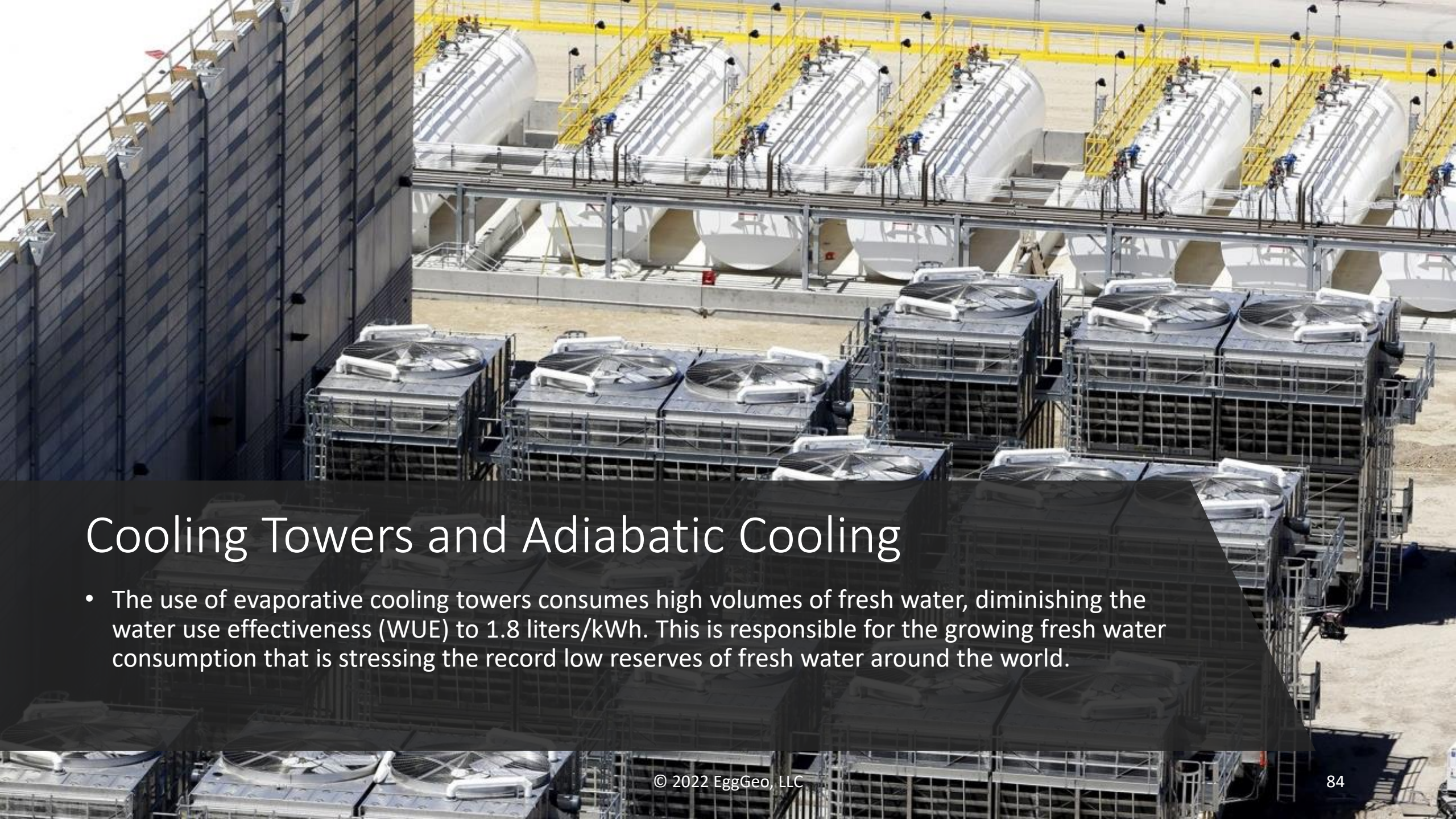






Understanding Water and Energy Consumption

- Cooling tower-coupled cooling systems are generally favored because they can improve the power use effectiveness (PUE) of the data center. That's because the efficiency of air-cooled equipment can be increased dramatically by evaporative cooling, which drives down the effective heat transfer temperature from outside dry-bulb to the more favorable wet-bulb temperature. Depending on the relative humidity, this can improve cooling PUE substantially.

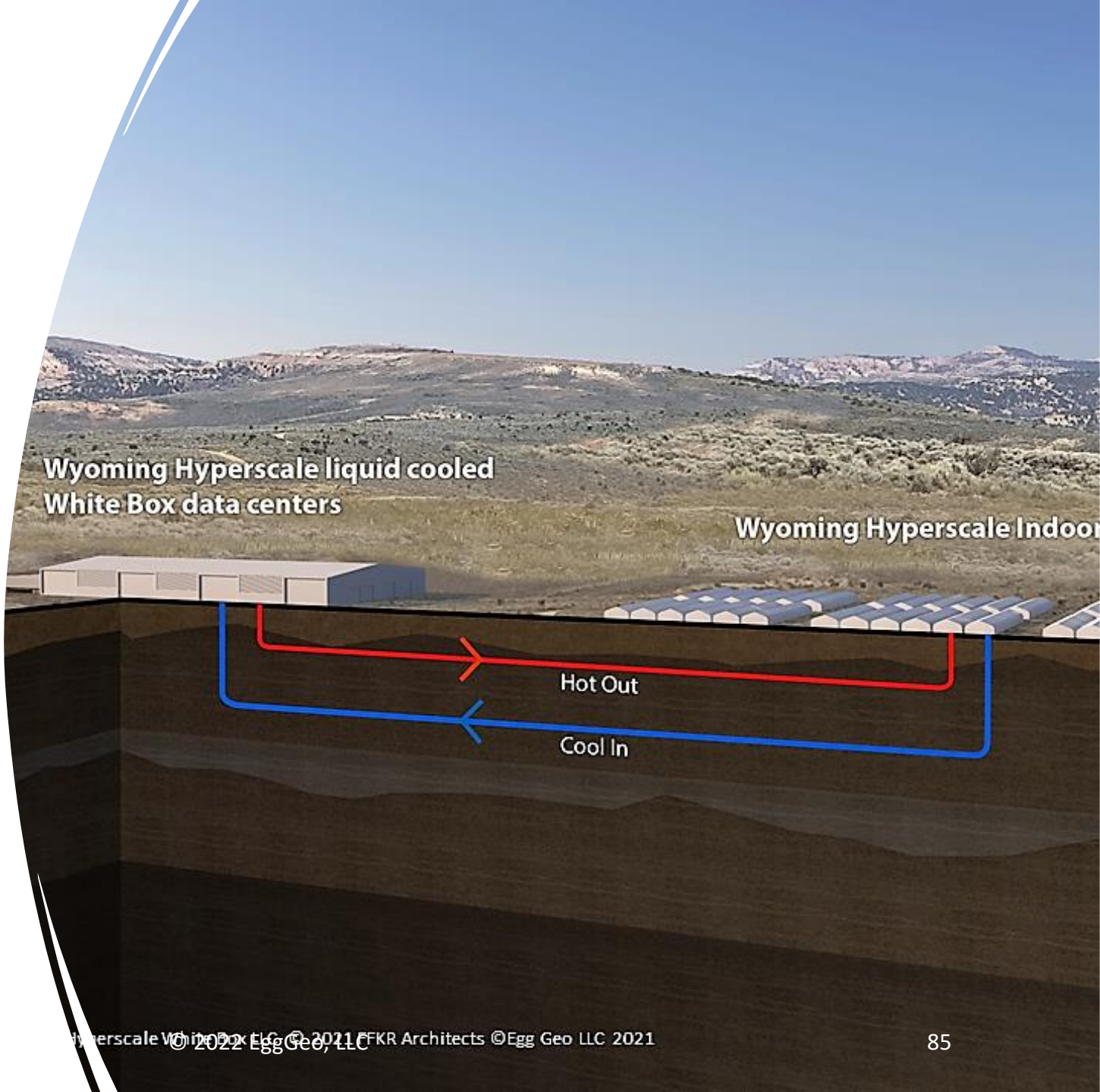


Cooling Towers and Adiabatic Cooling

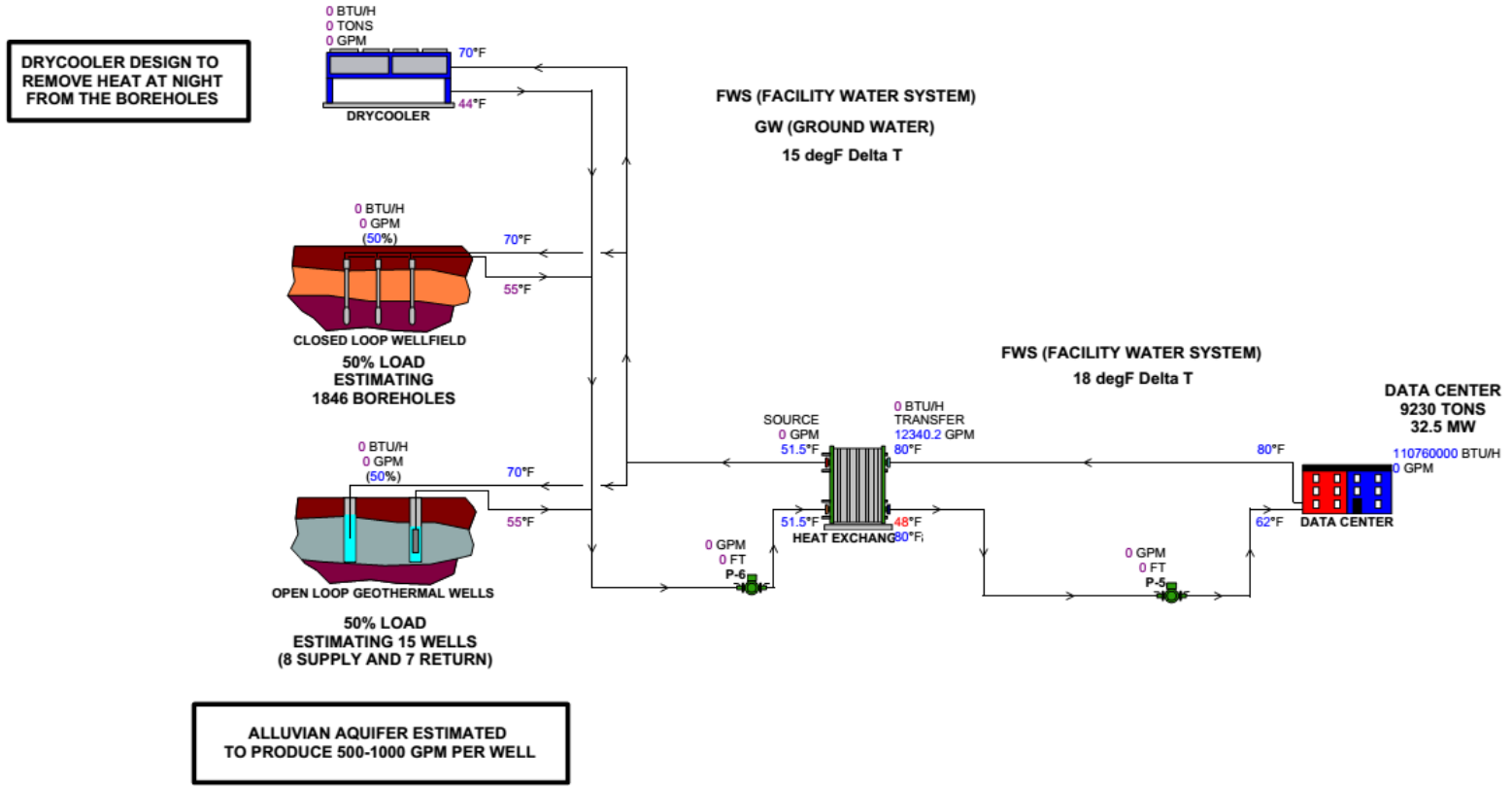
- The use of evaporative cooling towers consumes high volumes of fresh water, diminishing the water use effectiveness (WUE) to 1.8 liters/kWh. This is responsible for the growing fresh water consumption that is stressing the record low reserves of fresh water around the world.

Data Center Heat “Off-Takers”
https://bit.ly/GeoDataCentersSaveEnergyWater

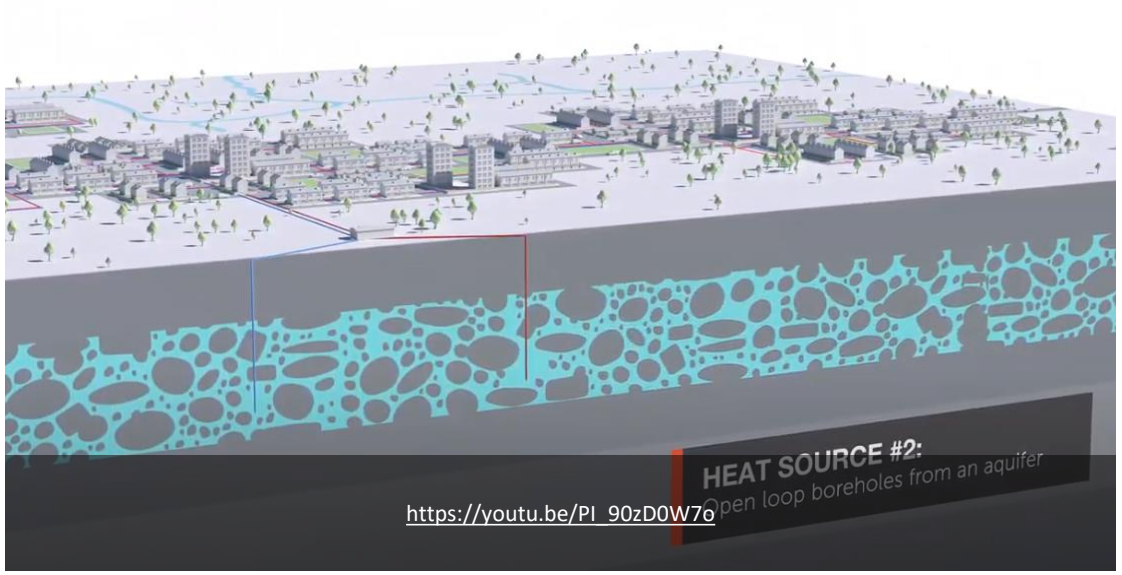
- 120 MW of heat rejection is the equivalent of 40,000 tons of cooling capacity. Since the data center is located in a remote area, what can be done with all that heat? That's the brilliant part. They are co-developing a project called “Wyoming Hyperscale Indoor Farms, LLC.”



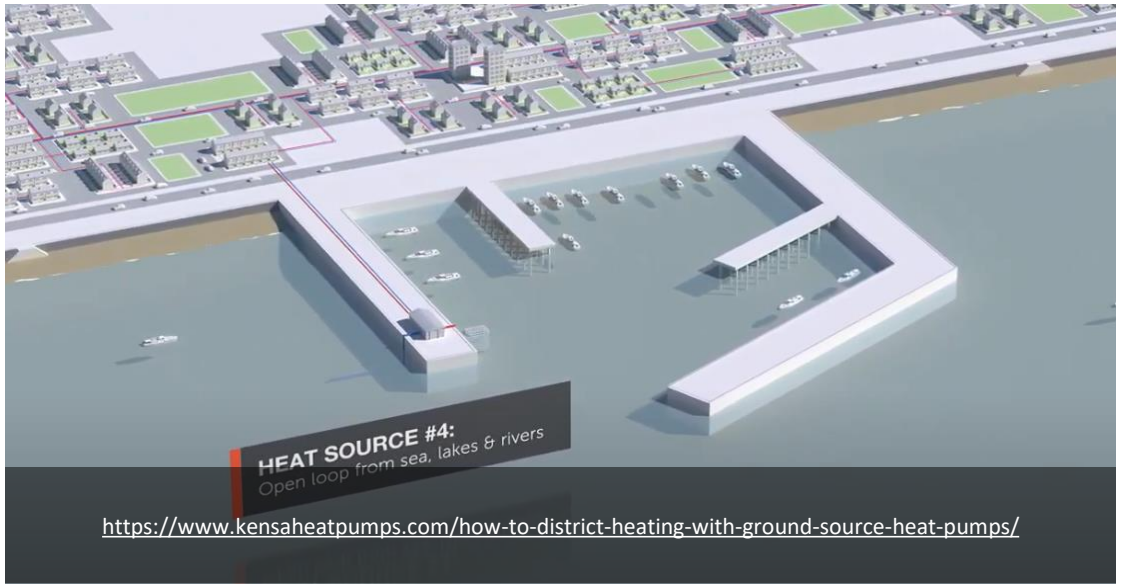
Data Center Variations for Thermal Energy Network Load Shedding



Application throughout North America & the World



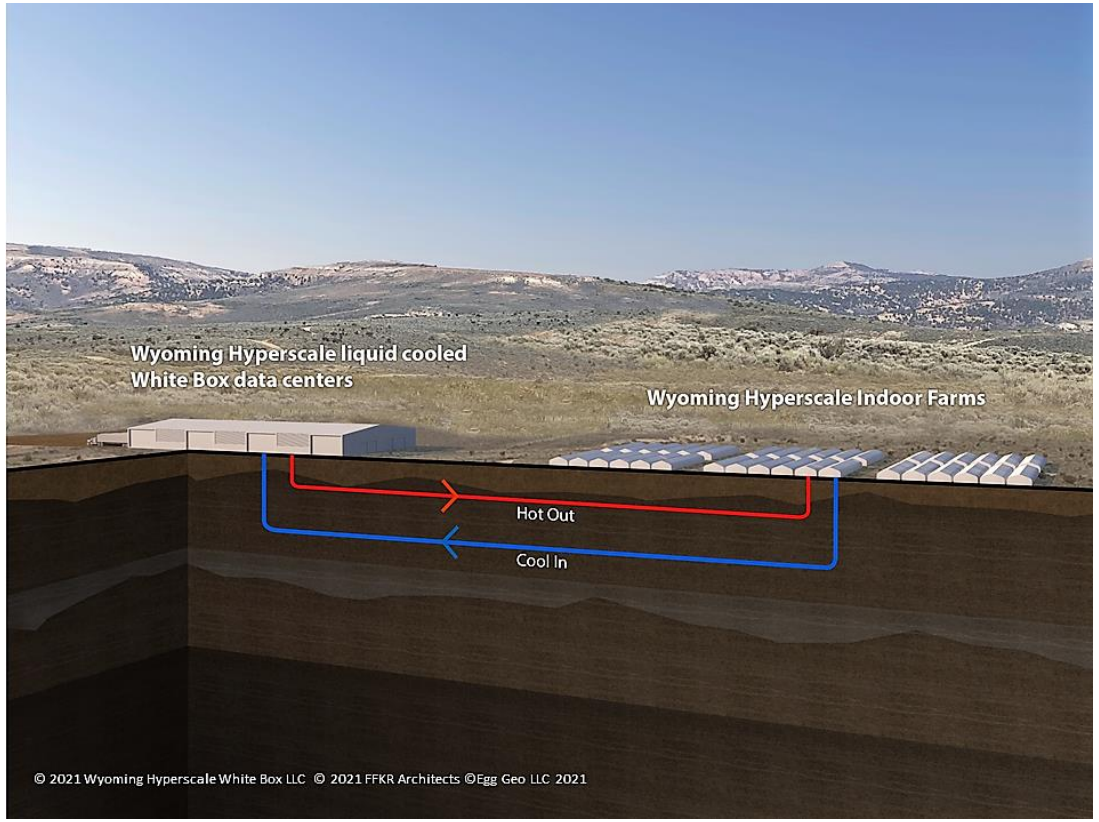
https://youtu.be/PI_90zD0W7o



https://www.kensaheatpumps.com/how-to-district-heating-with-ground-source-heat-pumps/

Data Center Heat Off Takers

https://bit.ly/GeoDataCentersSaveEnergyWater



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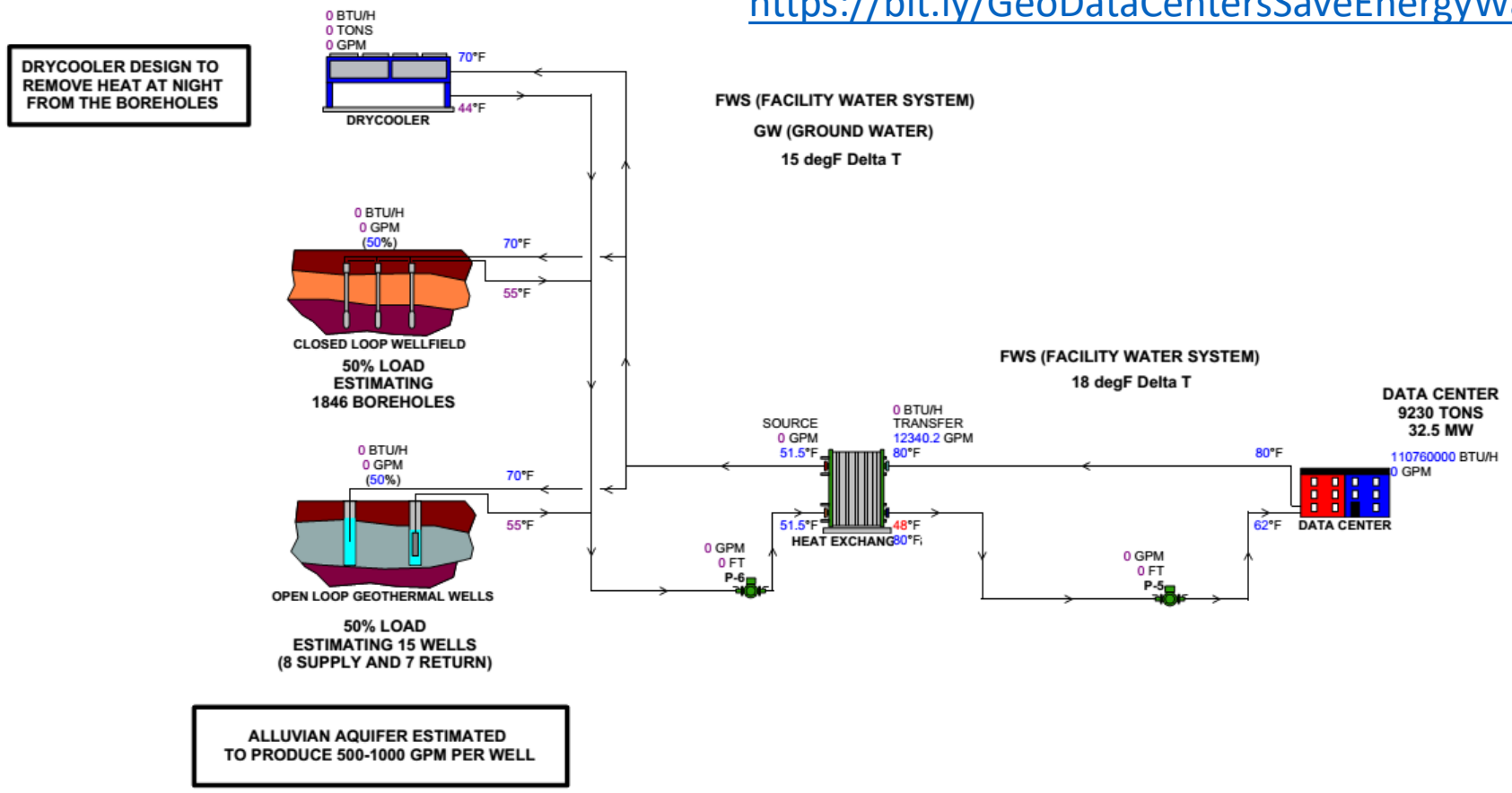
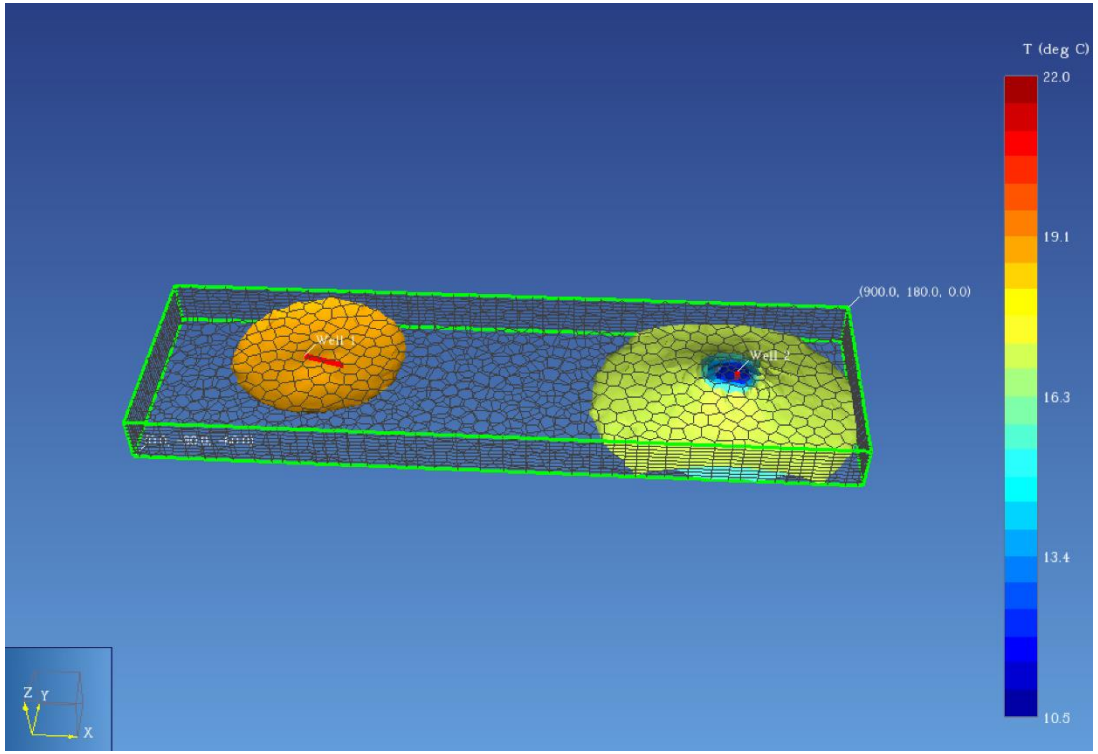
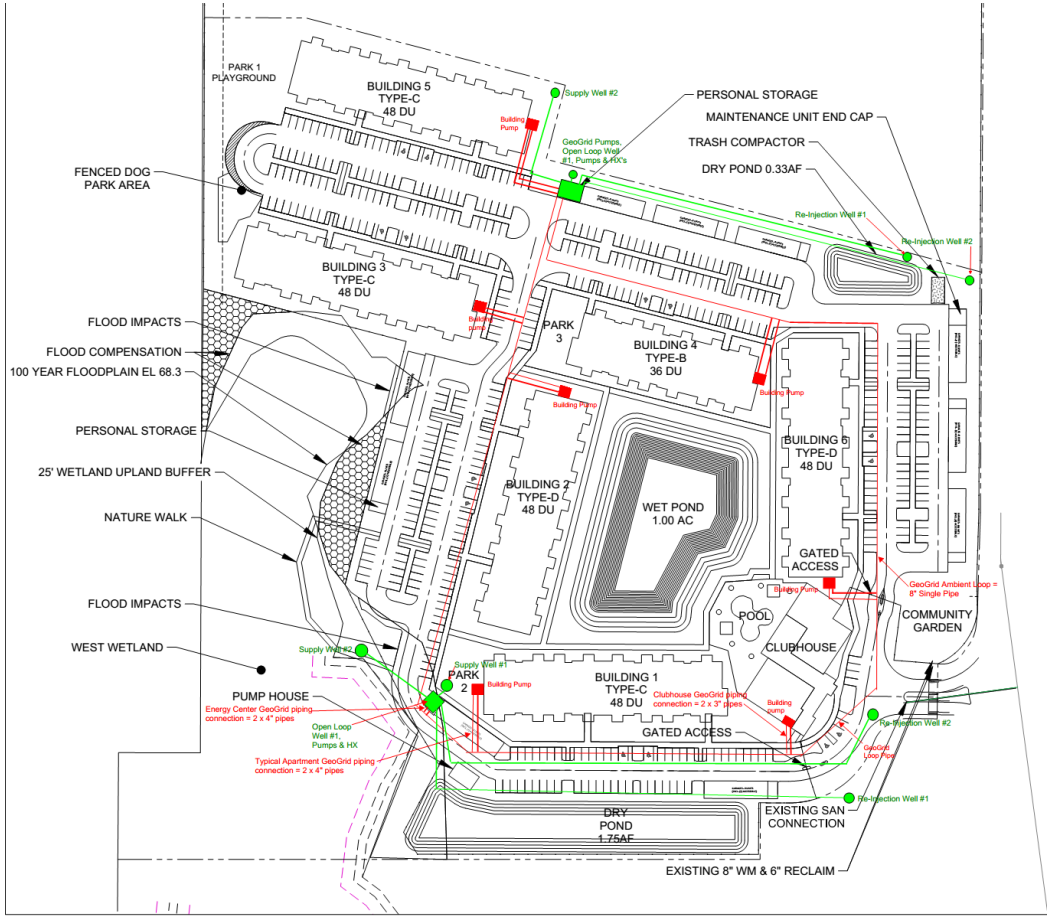
Data Center Variations for geothermal and hybrid exchange in immersion cooling to eliminate mechanical refrigeration

https://bit.ly/GeoDataCentersSaveEnergyWater

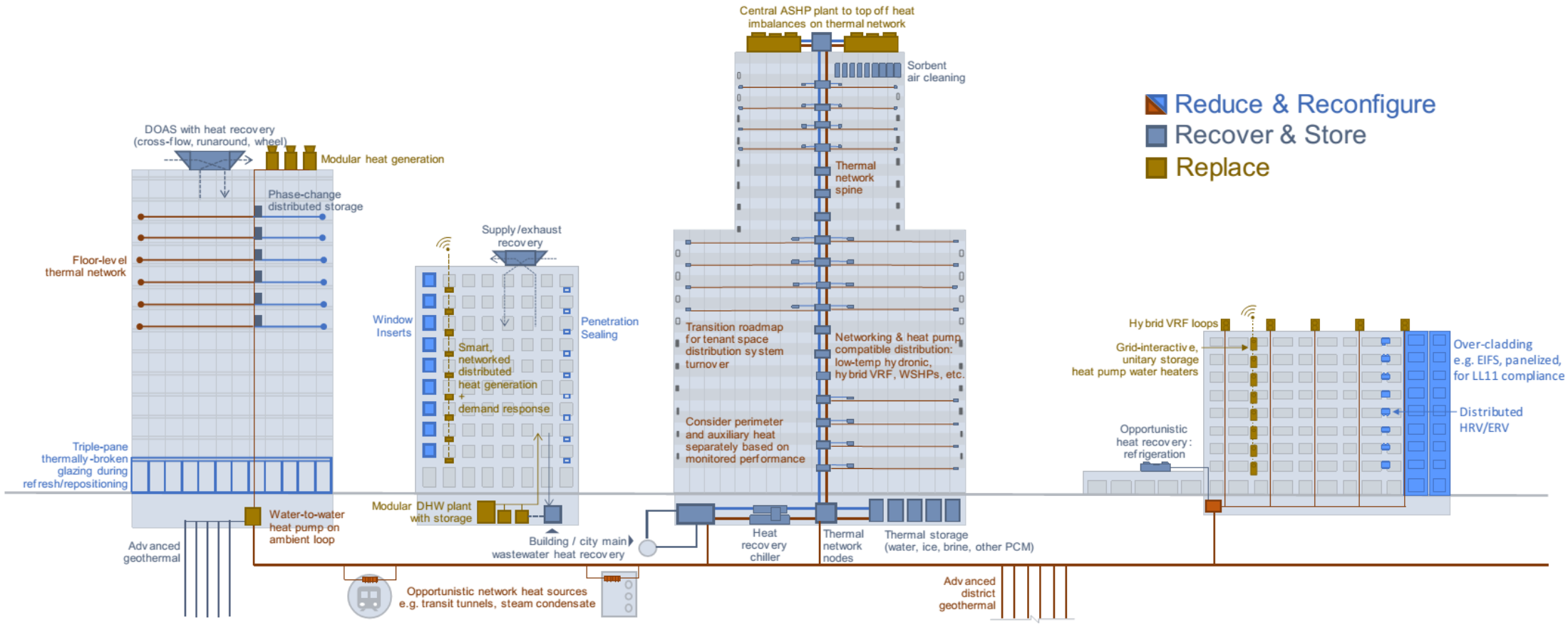


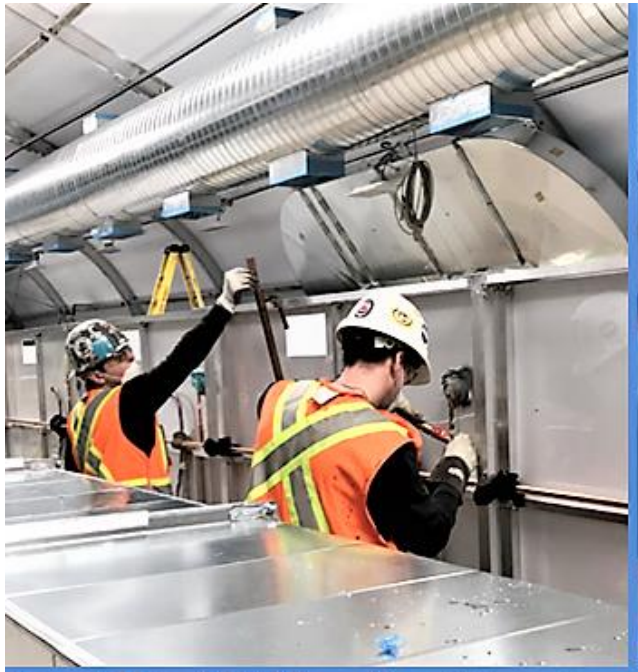
Thermal influence in aquifers (ATET)

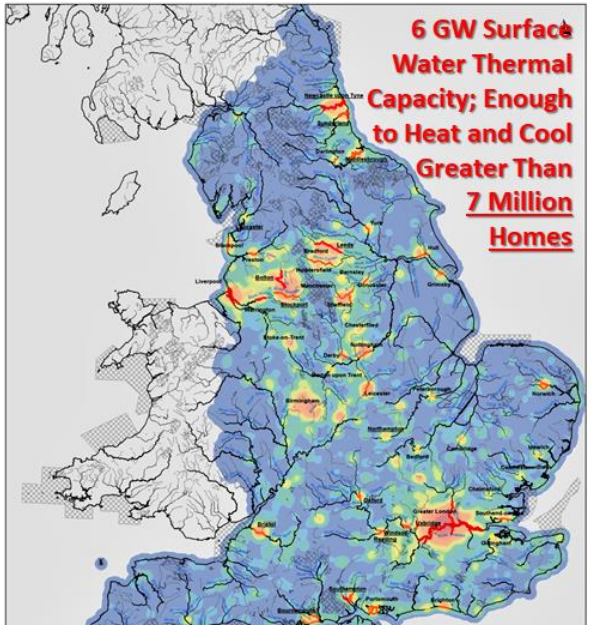


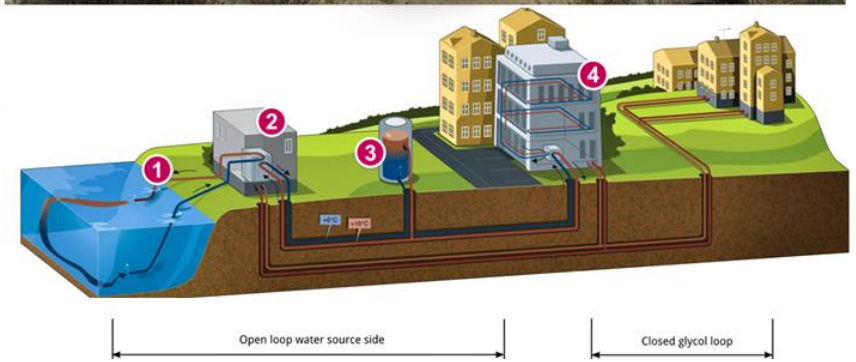


Thermal Energy Networks - Empire State; Developed for NYSERDA

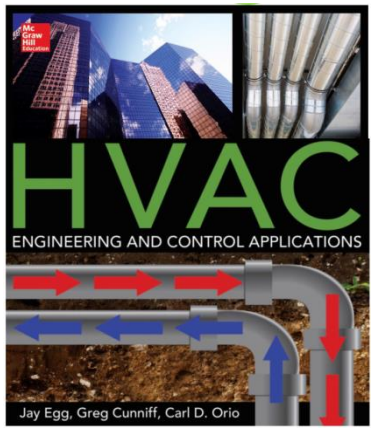




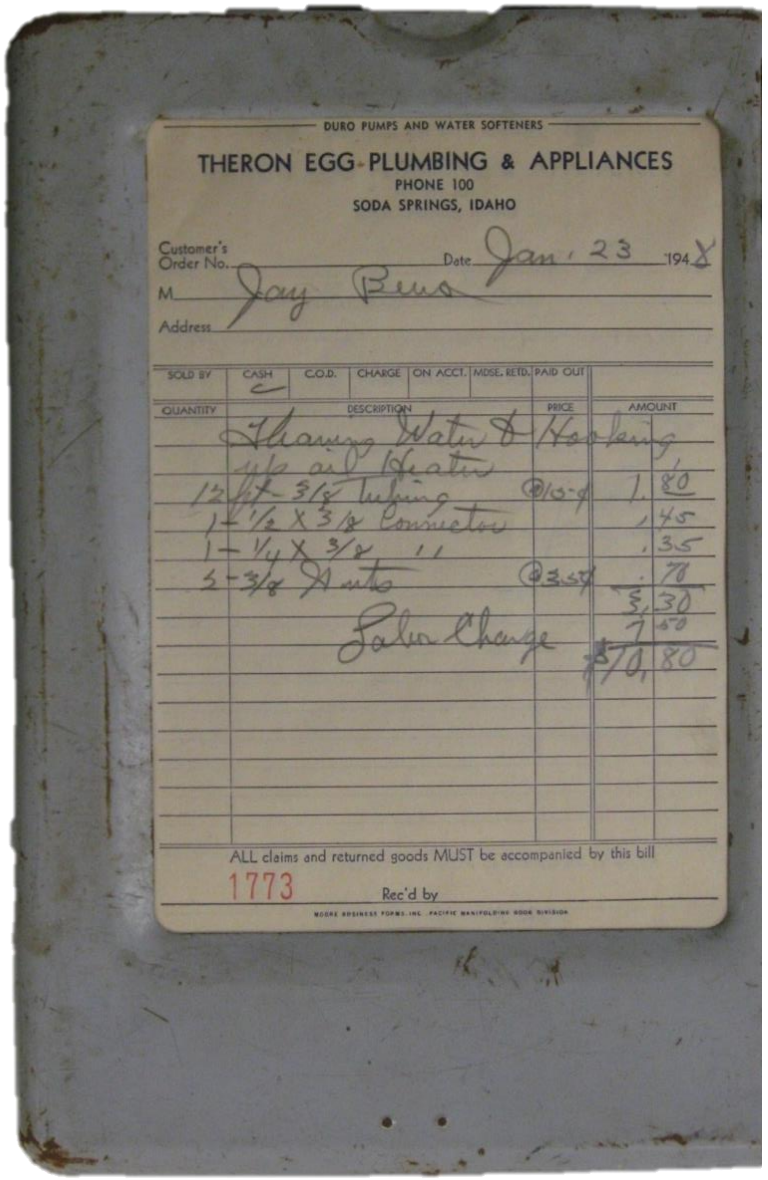




Union Jobs in Thermal Energy Network Infrastructure


HVAC
ENGINEERING AND CONTROL APPLICATIONS
Jay Egg, Greg Cunniff, Carl D. Orio


egg
geo
Sharing Knowledge
Curriculum and Education


DURO PUMPS AND WATER SOFTENERS

THERON EGG PLUMBING & APPLIANCES
PHONE 100
SODA SPRINGS, IDAHO

Customer's Order No. Date Jan. 23 194X
M Jay Rees
Address

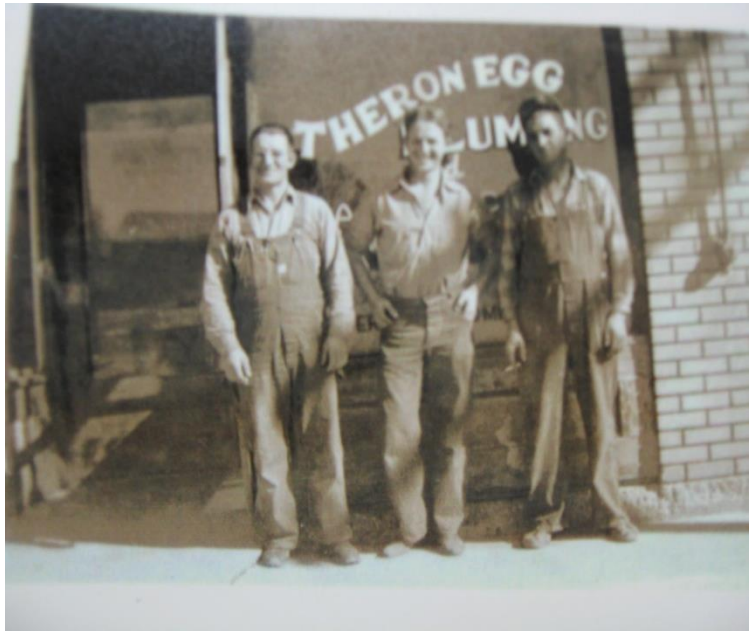
SOLD BY	CASH	C.O.D.	CHARGE	ON ACCT.	MDSE. RET'D.	PAID OUT
	C					

QUANTITY	DESCRIPTION	PRICE	AMOUNT
	Thawing Water & Heating		
	up oil Heater		
12 ft	3/8 Tubing	@10¢	1. 80
1	1/2 X 3/8 Connector		.45
1	1/4 X 3/8 "		.35
3	3/8 Nuts	@3.5¢	.78
			$3.30
	Labor Charge		7.50
			$10.80

ALL claims and returned goods MUST be accompanied by this bill

1773 Rec'd by

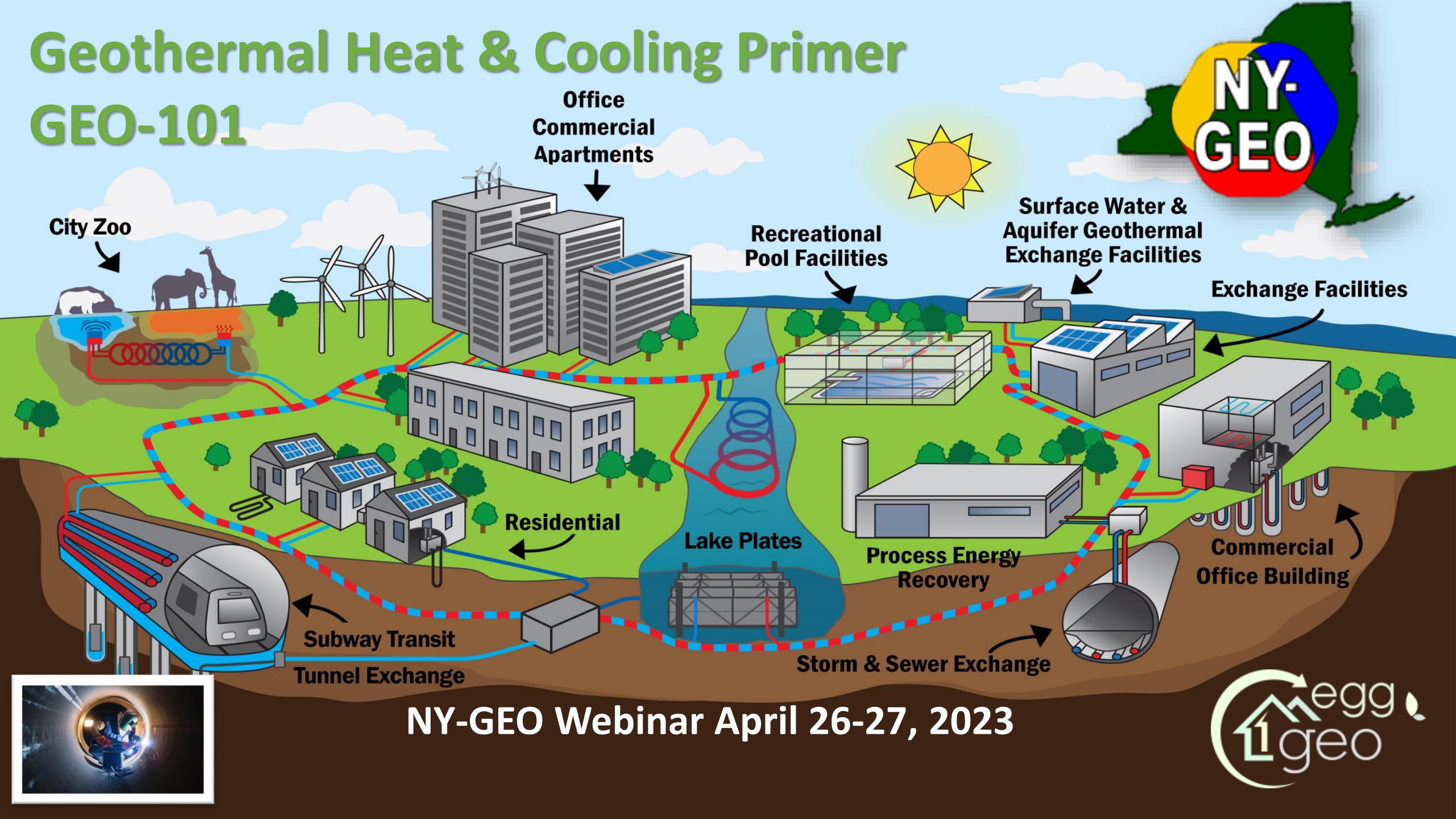
MOORE BUSINESS FORMS, INC. PACIFIC MANIFOLDING BOOK DIVISION



Theron Egg Plumbing, Circa 1948

Geothermal Heat & Cooling Primer

GEO-101



NY-GEO Webinar April 26-27, 2023