Cascaded Geothermal Systems Primer

From Energy Production To Heating And Cooling Homes

Geothermal is Always On❤

New Zealand Geothermal Association

egg geo
expertise
education
engineering
Defining the Future of Geothermal

2024 New Zealand Geothermal Association Keynote Address

July 03, 2024

Outline

Outline for PPT:

1. Costs of Residential and Commercial Systems for Hi, Med, & Low temperatures
2. Limitations of Geothermal heat. Localized solutions using gas infrastructure
3. What are the possibilities of geothermal heating for industrial applications?
    a) NZ has 18 geothermal plants. They want to reduce emissions. One plant is saving $8million per year from reduced emissions.
    b) Use heat for wood panel drying, vegetable and horticultural pursuits.
    c) 6X more transportation capable with LH2

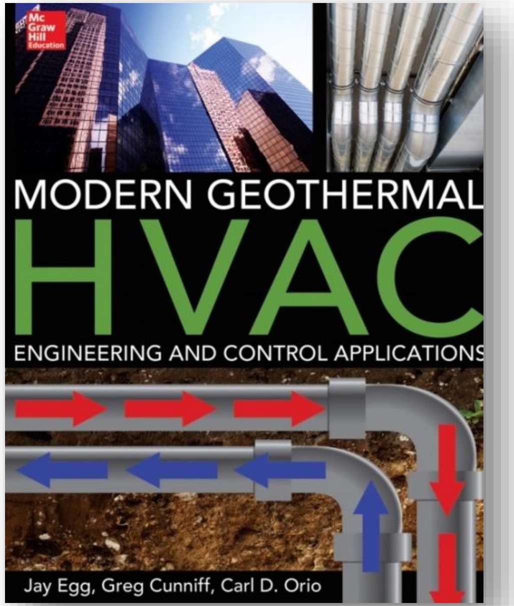
Egg Geo's part and a short history -

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

In Full Swing

Early Contracting Days

Now:
Consulting & Education



A Passion for Sharing Knowledge

egg geo
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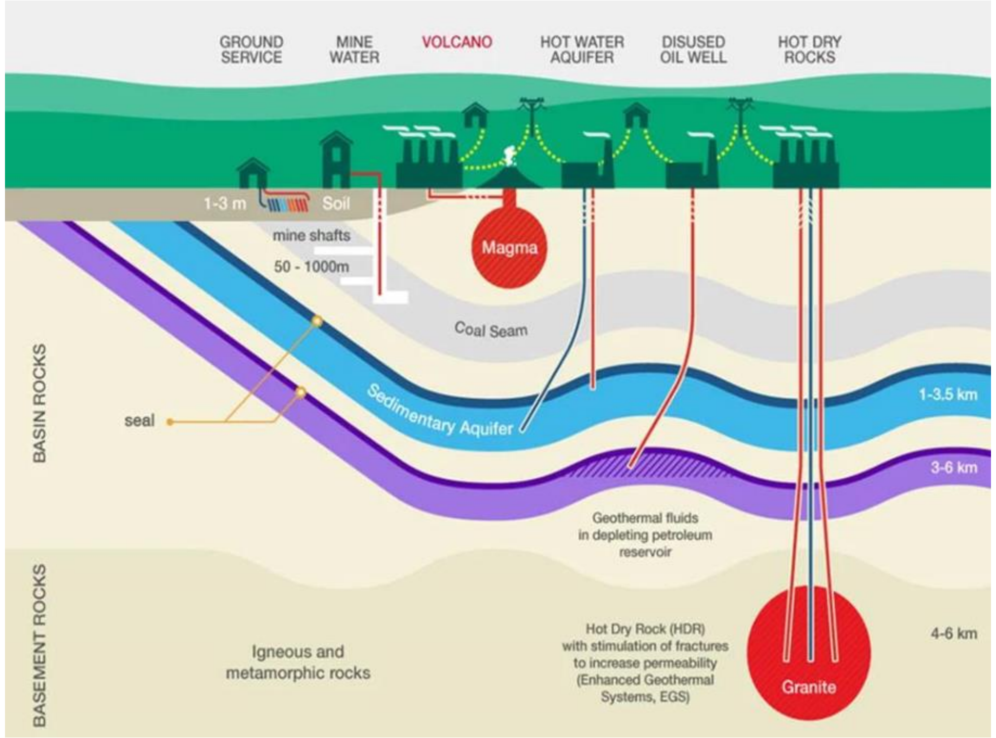
education
engineering
Defining the Future of Geothermal

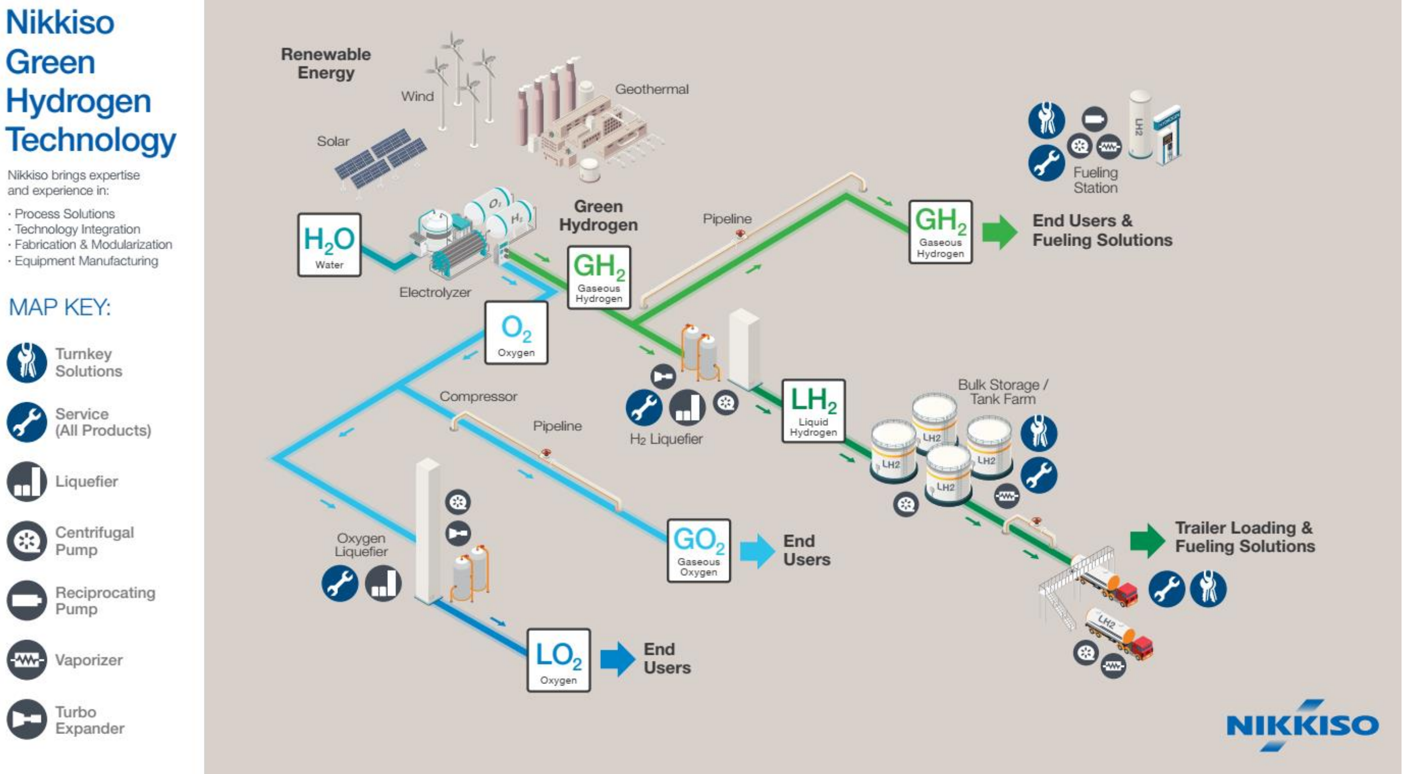
Plenary session at the 2022 GR Conference in Reno

What We Do Now

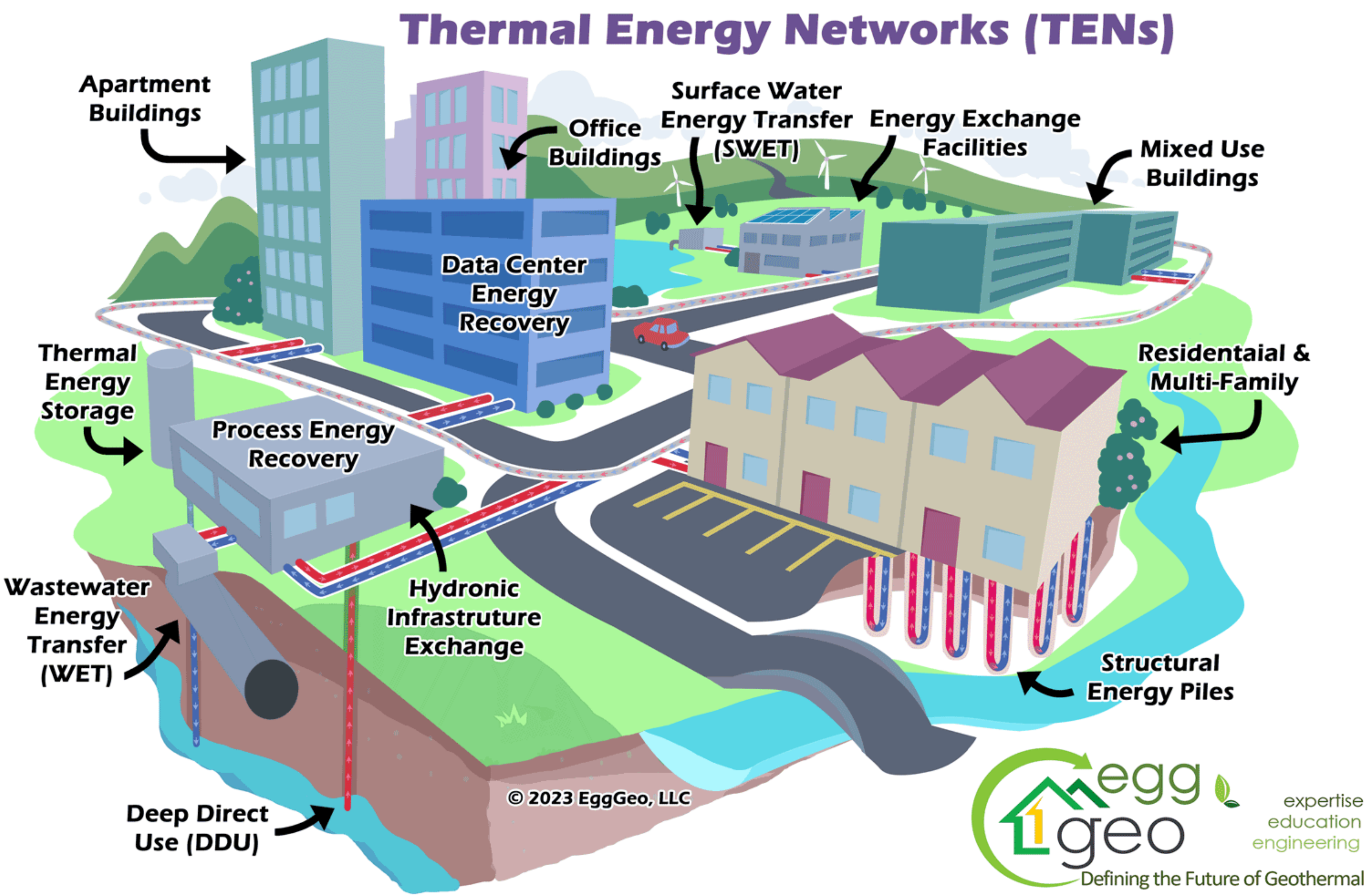
- Validation
- Consulting
- Guidance
- Education
- Code Compliance
- Program Writing
- Technical Steering
- Studies, Implementation, & Water Conservation Efforts

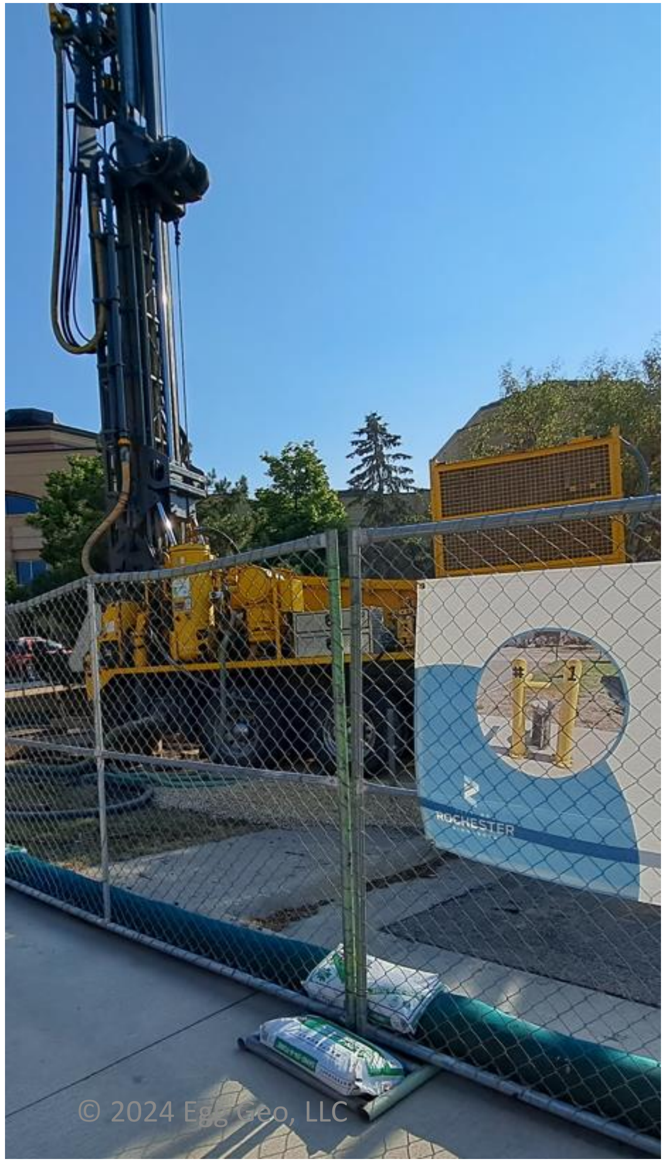
Geothermal Resources from Low-Temp to EGS



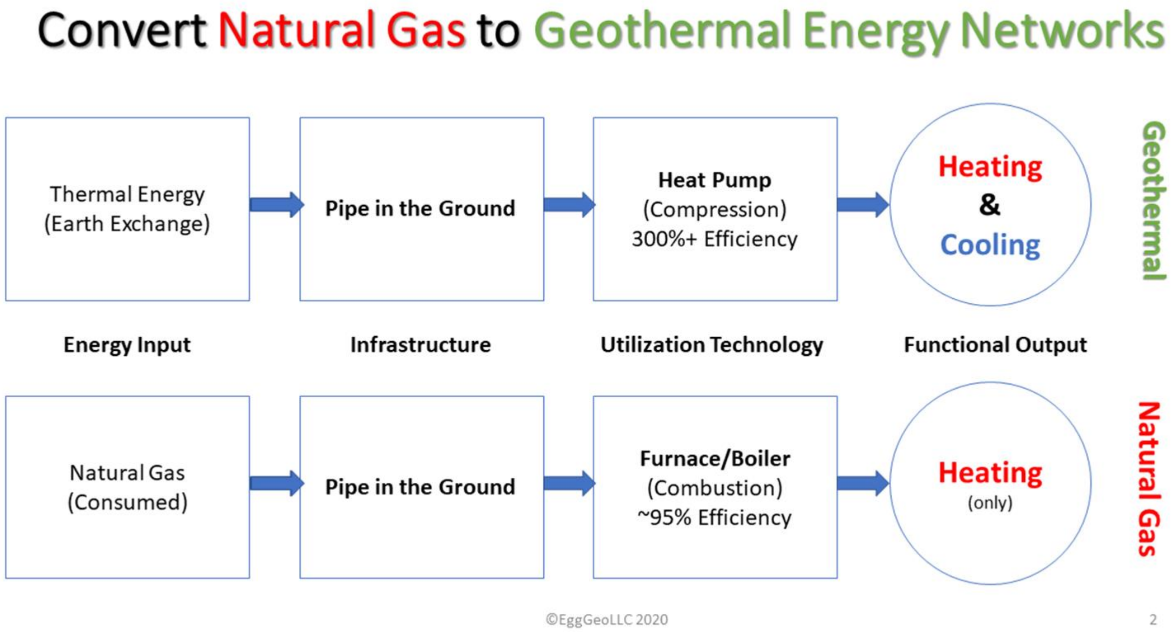


Cascaded Utility Thermal Energy Network (TEN) Design

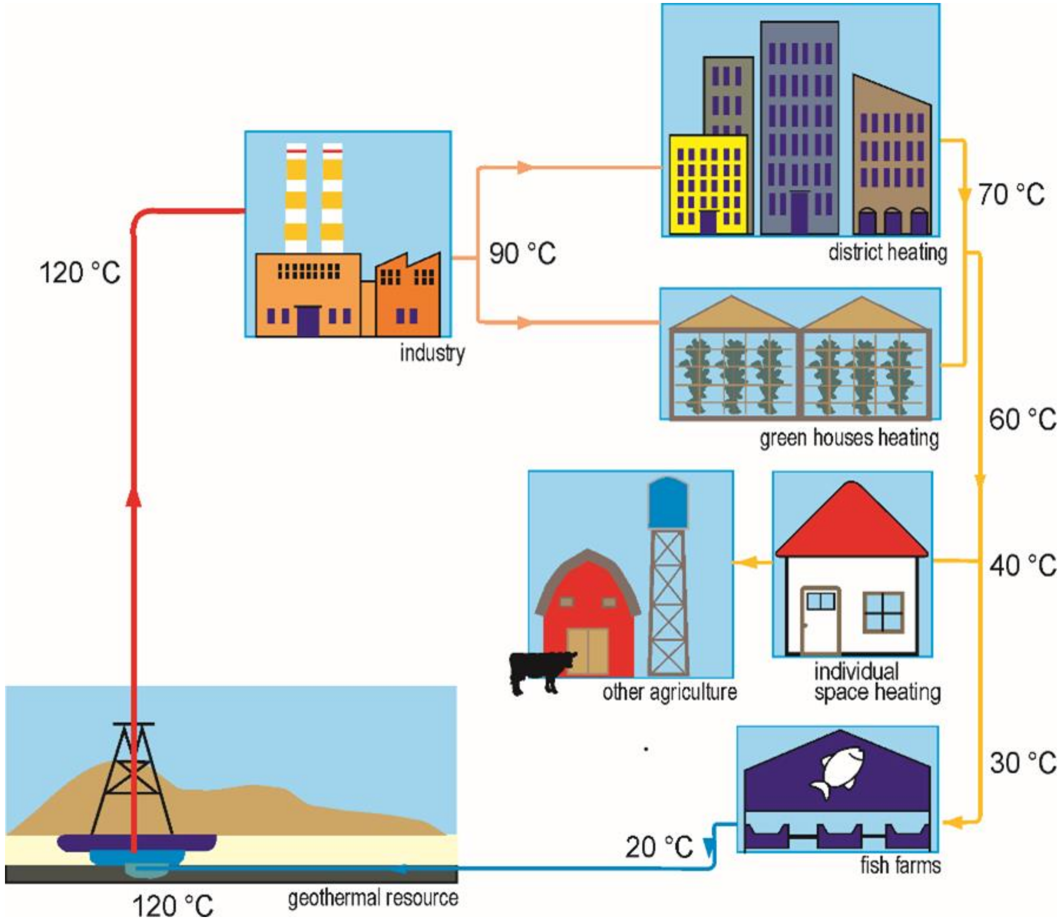


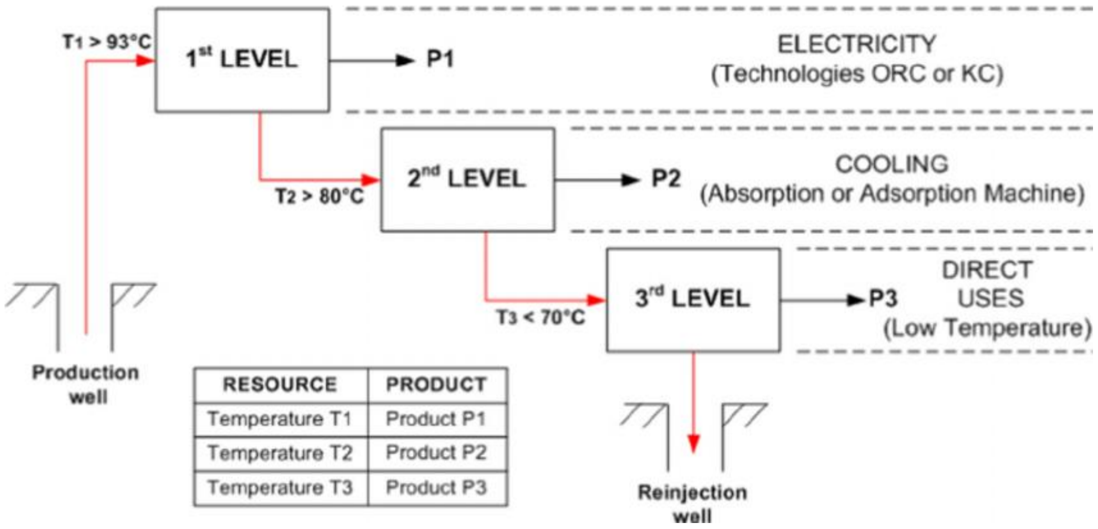


A Cascaded Geothermal Energy Network involves piped thermal infrastructure



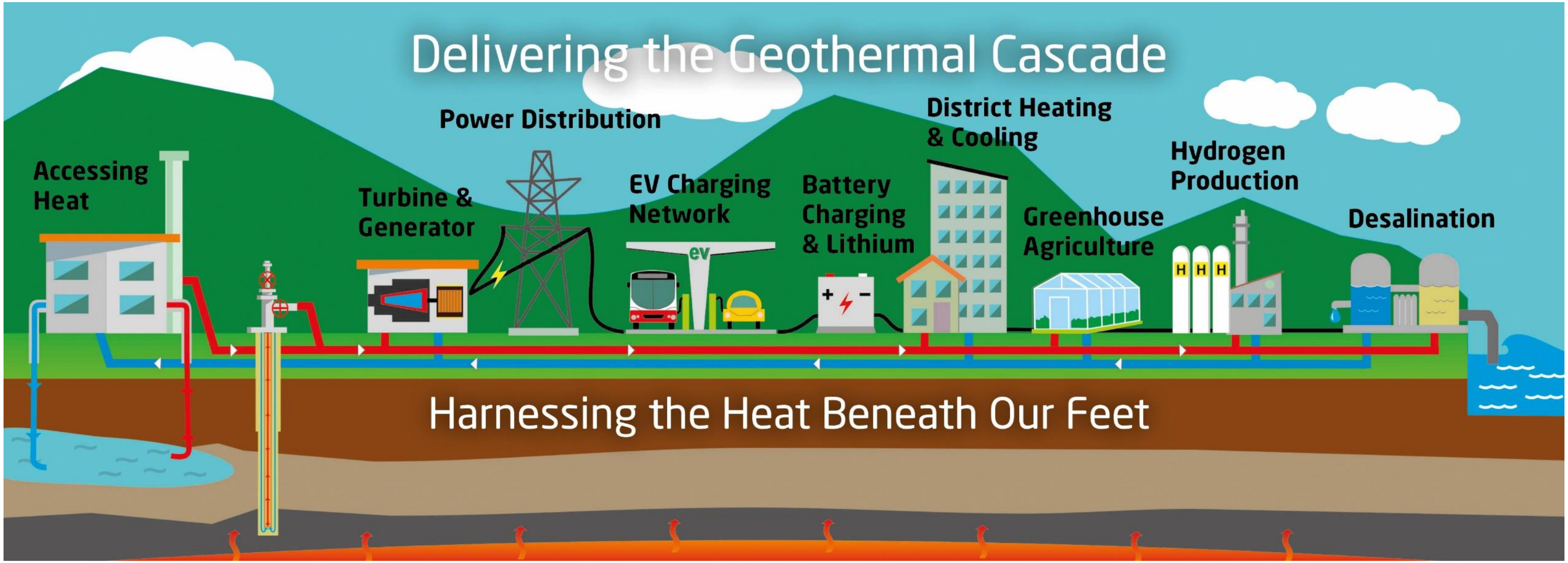
Cascaded Geothermal Opportunities





RESOURCE	PRODUCT
Temperature T1	Product P1
Temperature T2	Product P2
Temperature T3	Product P3

NZGA; Helping to fully utilize our Geothermal Resources



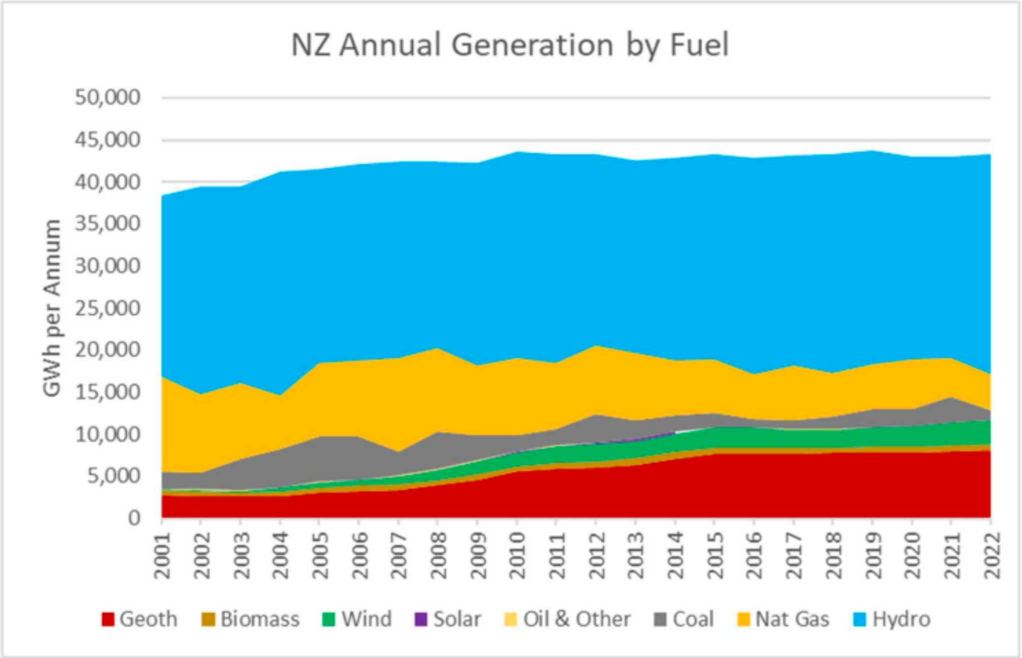
NZ Geothermal Fields

Geothermal systems occur in many parts of New Zealand.

NZ Geothermal Fields

The Taupō Volcanic Zone extends from White Island in the Bay of Plenty southwest to Mt Ruapehu. Geothermal fields are associated with young and active rhyolitic volcanism.

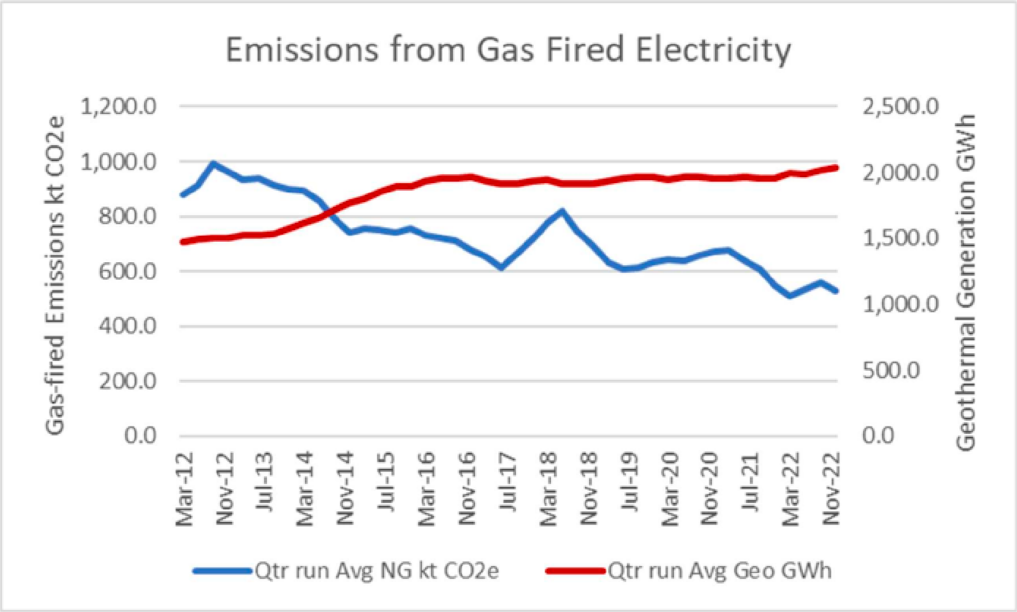
Figure 1.1: Aotearoa New Zealand Annual Generation by Fuel (calendar years)



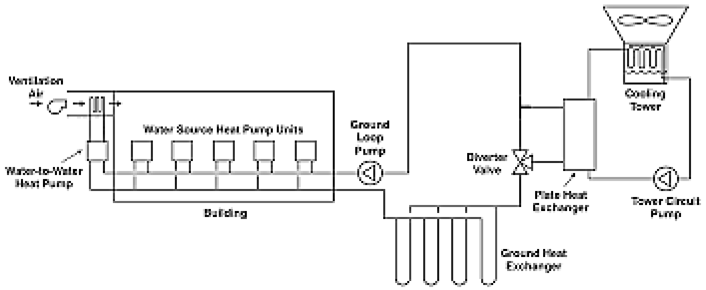
Decarbonizing the Aotearoa New Zealand Electricity Market

In 2014, geothermal electricity generation overtook natural gas as the second largest source of electricity supply after hydro generators.

Figure 2.1: NZ gas fuelled electricity emissions (running quarterly average) vs geothermal generation (same basis).

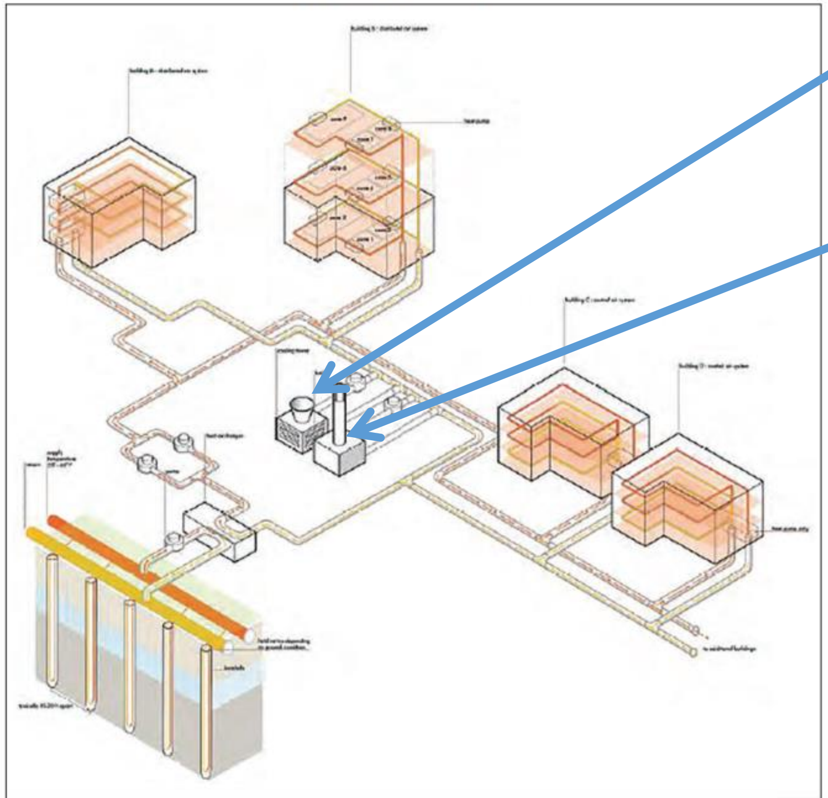


Hybrid System Configurations



- The most significant advantage of a hybrid systems is the ability to economically meet a building load that, if designed with a ground loop alone, would be more costly.
- For this reason, a hybrid system is sometimes the better choice for a short-term investment ROI

Figure 2.2d Hybrid GHX



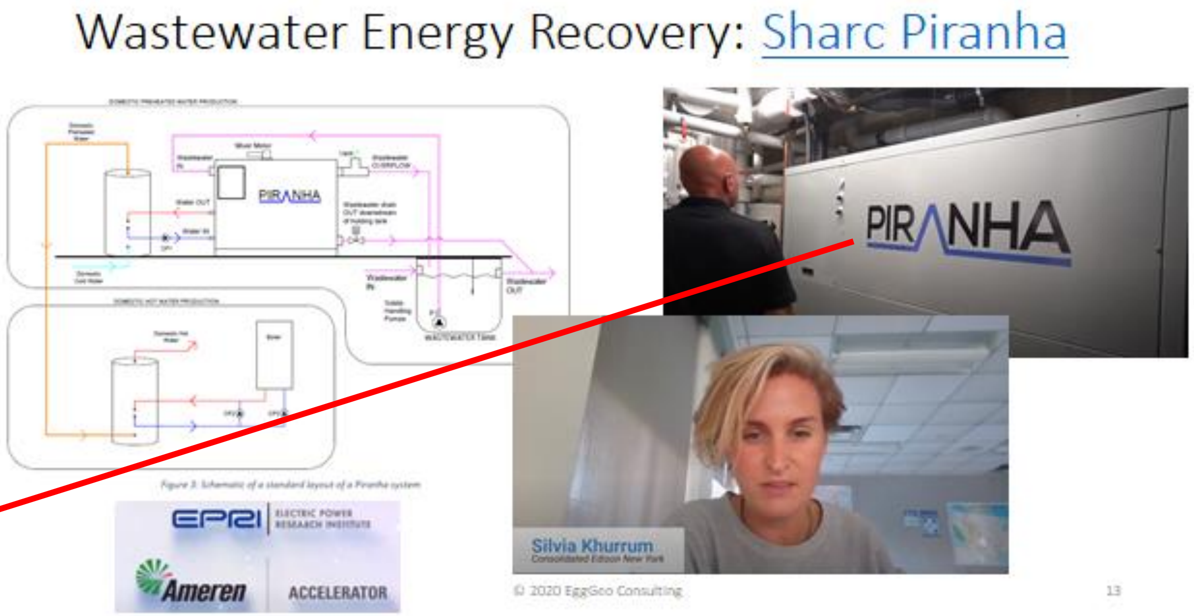
Heat exchanged through one of the GHX options above (Tables 3.2a-c) in concert with other heat sources and sinks that are not ground-coupled, e.g., boiler, cooling tower, boiler or solar collector; can serve unbalanced seasonal loads, reduce land area and cost of GHX, and take advantage of other available heat sources and sinks.

Hybrid Configuration

With all these building types, peak loads can be managed with “peaker” plants

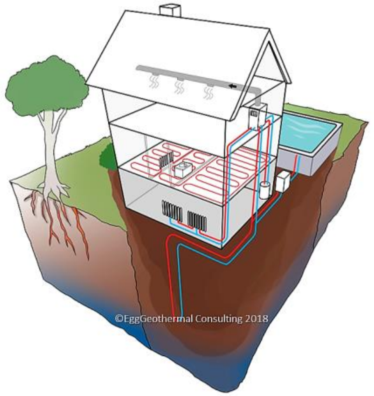
- These could be Hydrogen Fired End Use Facilities
- Designed to provide Needs +1
- Could provide a boost of needed heat on extended cold snaps
- Provides a heat source when other heat sources and sinks are out of commission for any reason

Other great resources include Wastewater Energy Recovery; can reduce loads by 40% to 60%



As Geothermal Energy Networks are built up, there will be a need to supplement heat periodically, and as back-up for unforeseen weather events and load conditions

CEATI INTERNATIONAL DEMAND SIDE ENERGY MANAGEMENT PROGRAM



Homes and buildings will come off of individual loops, and onto the 'Geo-Thermal Energy Grid"

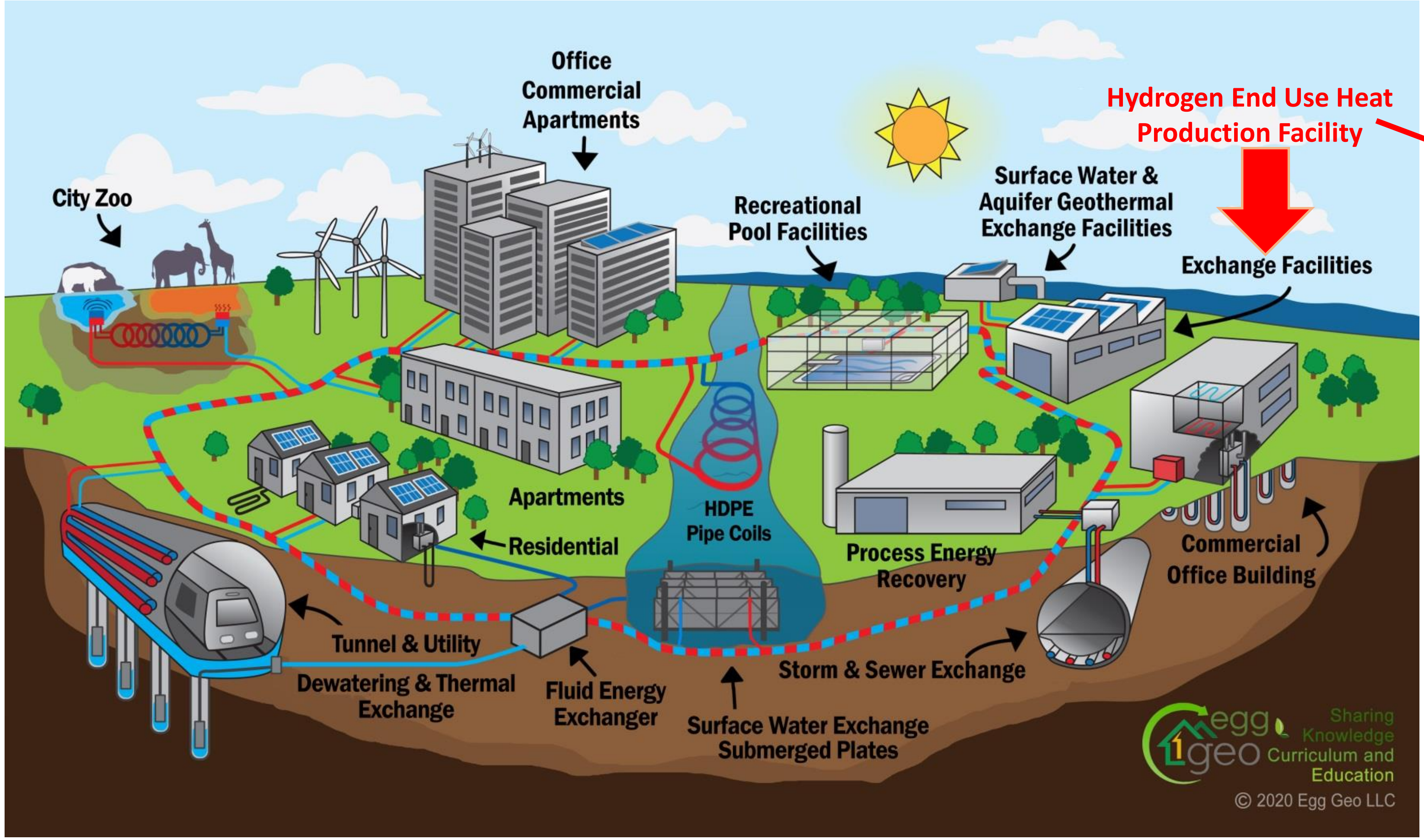
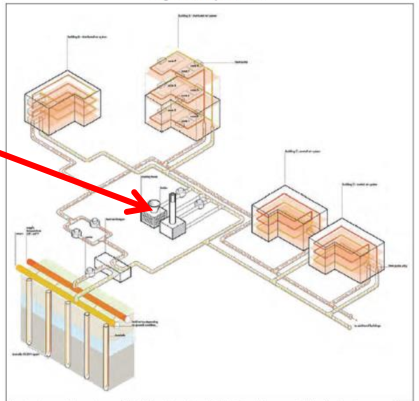


Figure 2.2d Hybrid GHX



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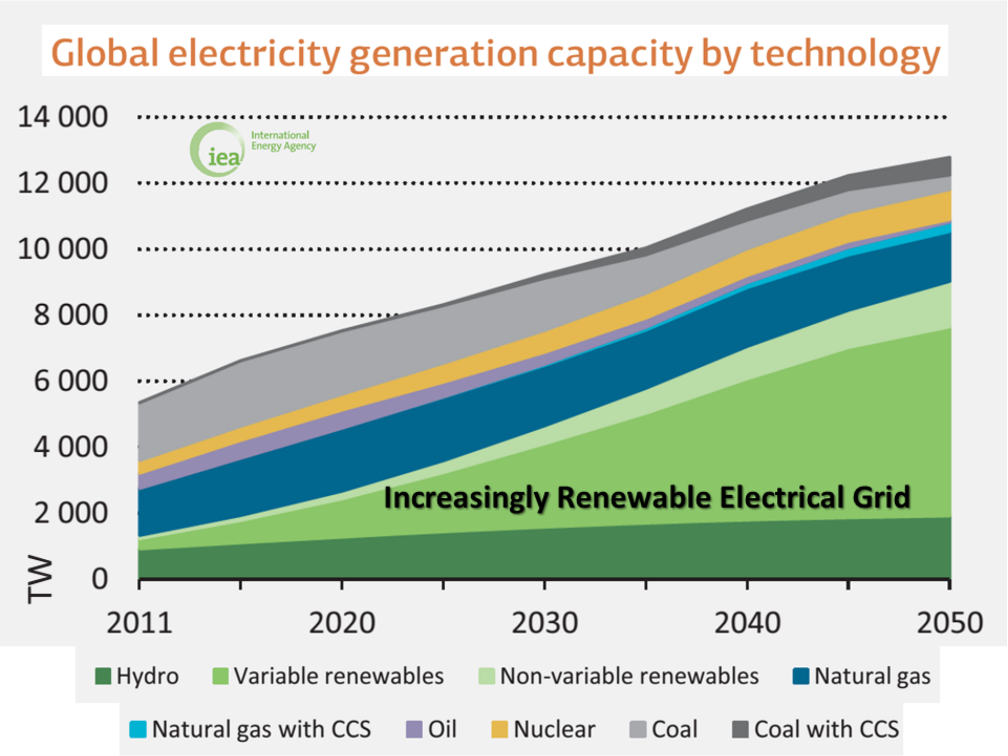
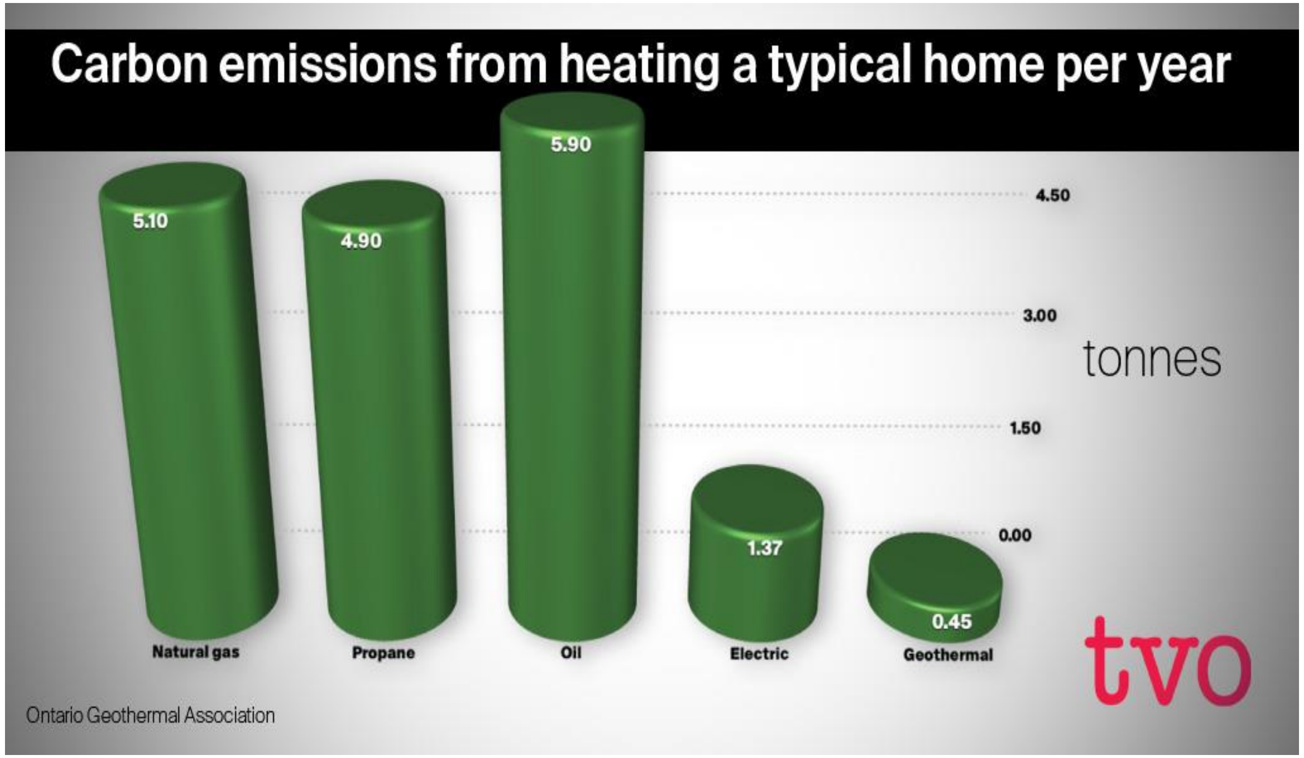
Hybrid Configuration

Emissions Comparison Between Combustion and Electric Heat Pumps (Geothermal & Air)



The Electric Grid is "Greening" Continuously



All Electric Heat Pumps result in Low Emissions

Measuring Performance Thresholds Coefficient of Performance (COP)

- Electric Resistance Heating
- Engages when temperatures outside are cold
- Efficiency (COP = 1)

1 kW of Electricity = 1 kW of Heat=

COP of 1

Efficiency Ratings: EER and COP

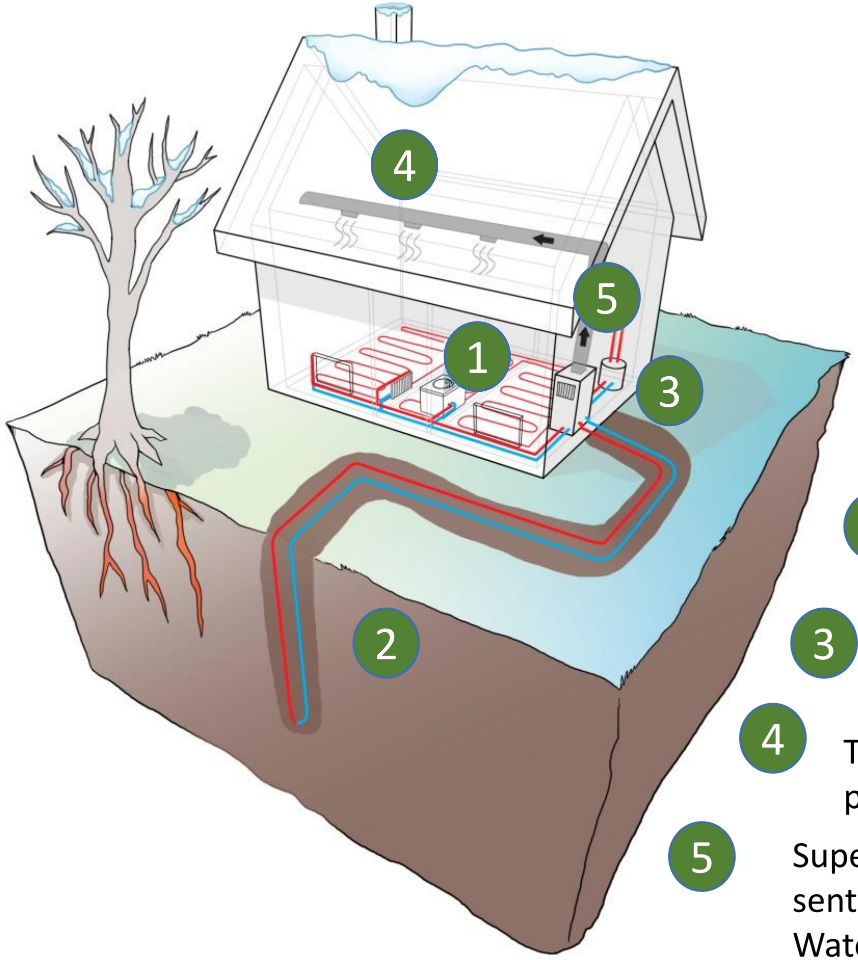
- Energy Efficiency Rating (EER) is often used for Cooling Efficiency
- EER is the is the Net Cooling Capacity/Applied Energy in watts

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

EER = COP x 3.412

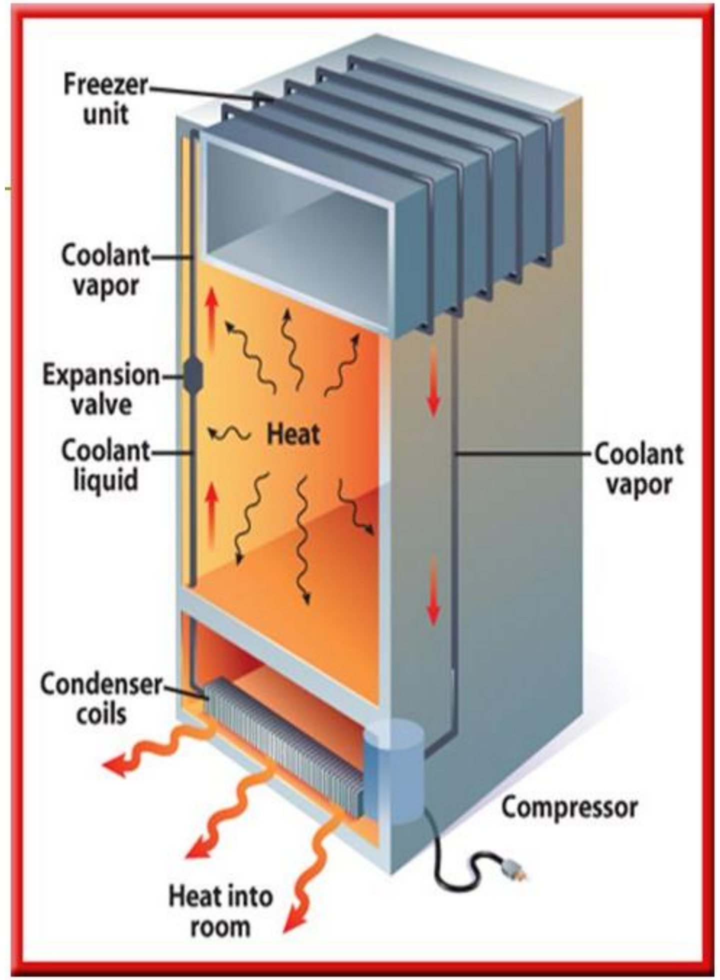
1 watt of electricity = 3.412 BTU

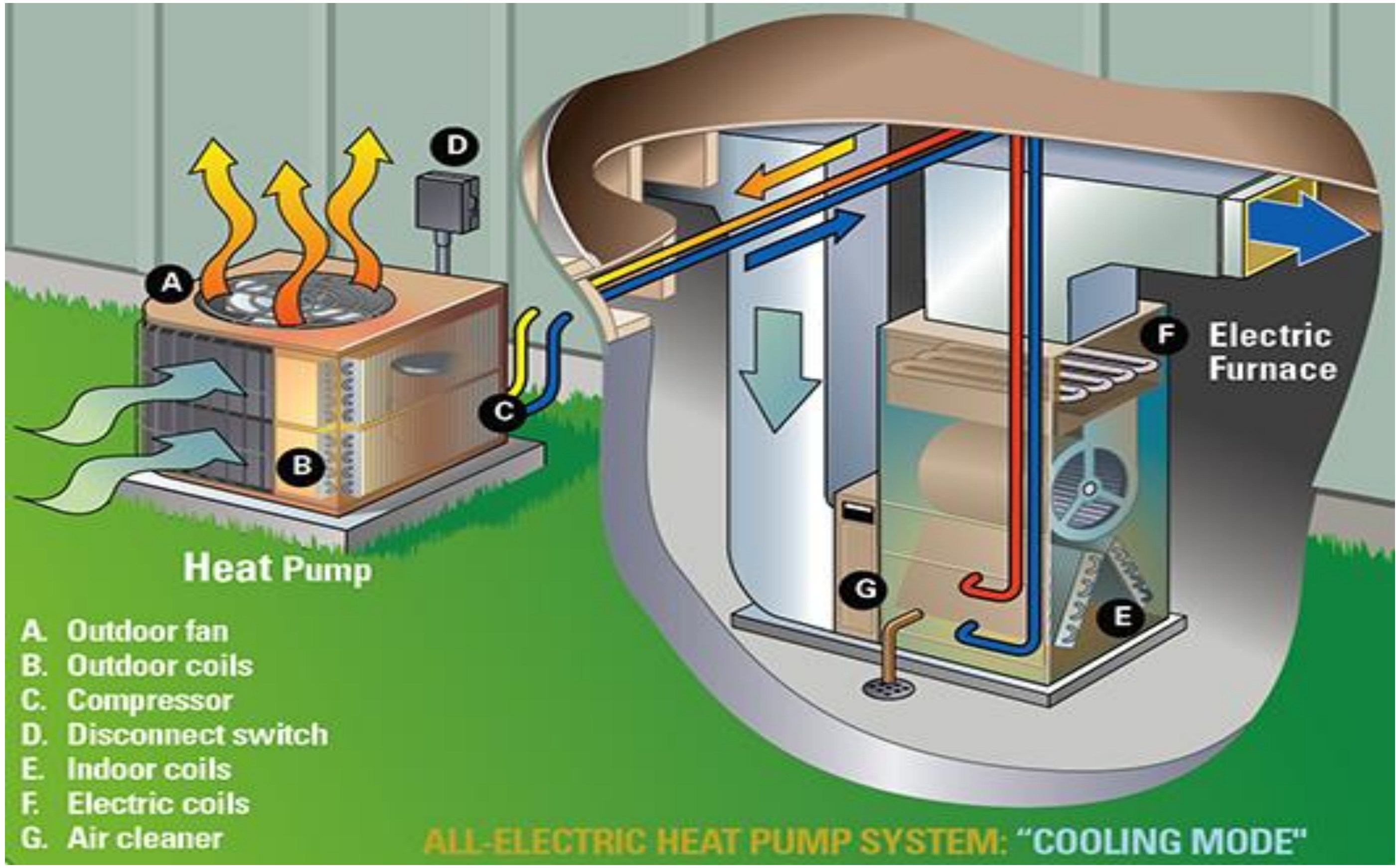
Both GSHP & ASHP use a refrigerant system



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

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

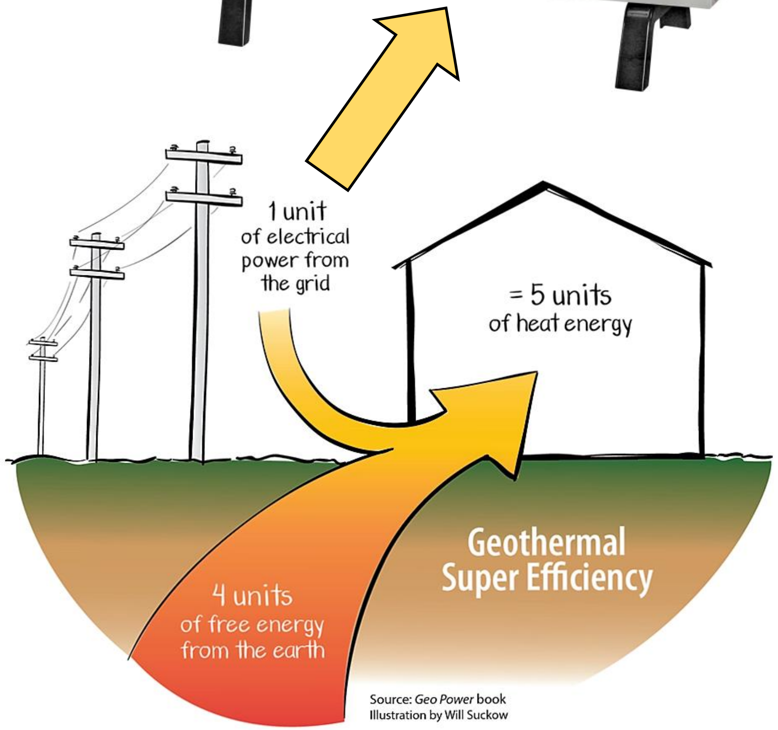




Heat Pump = about 3.0 to 5.0 + COP

1 kW of Electricity = 3412 BTUs

= 3,412 BTUs of heat (Space Heater)

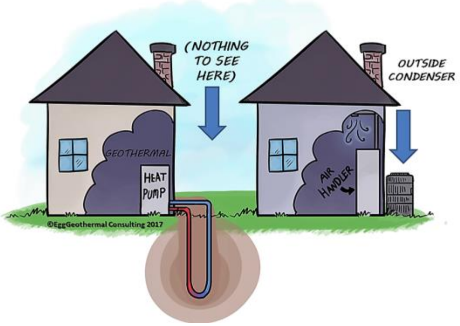


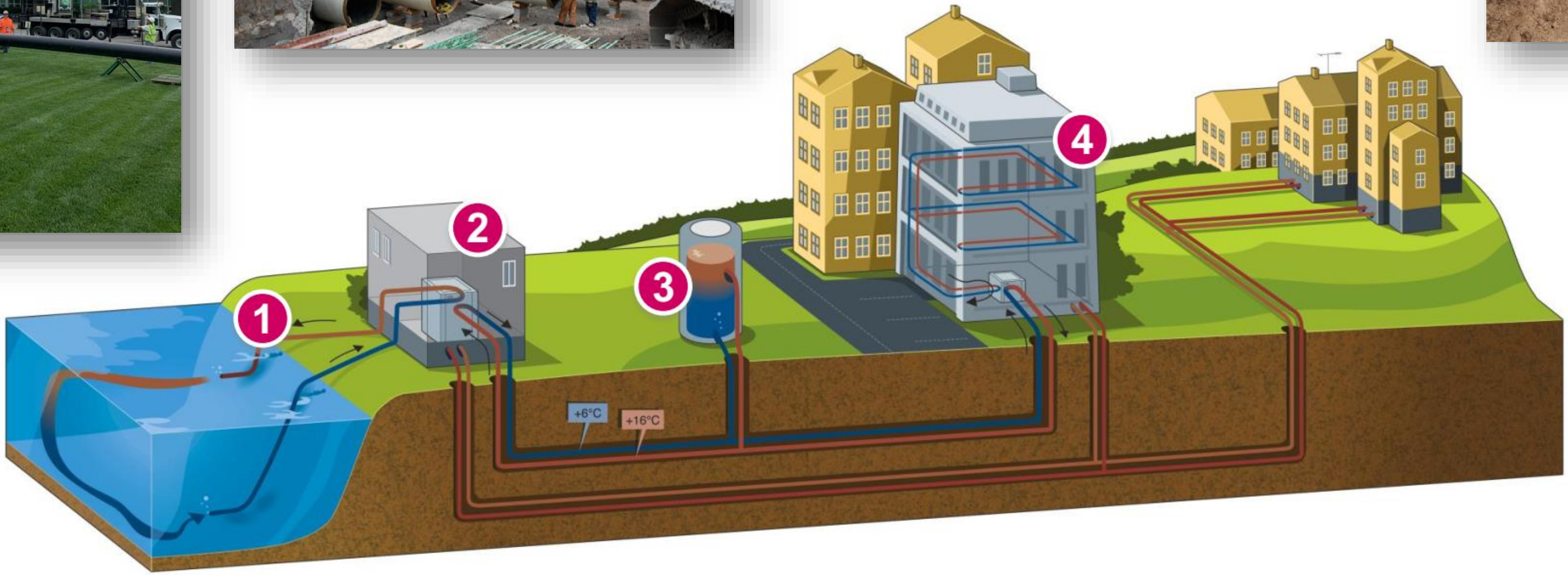
= 17,060 BTUs of heat* (Thermal Loop Heat Pump)

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

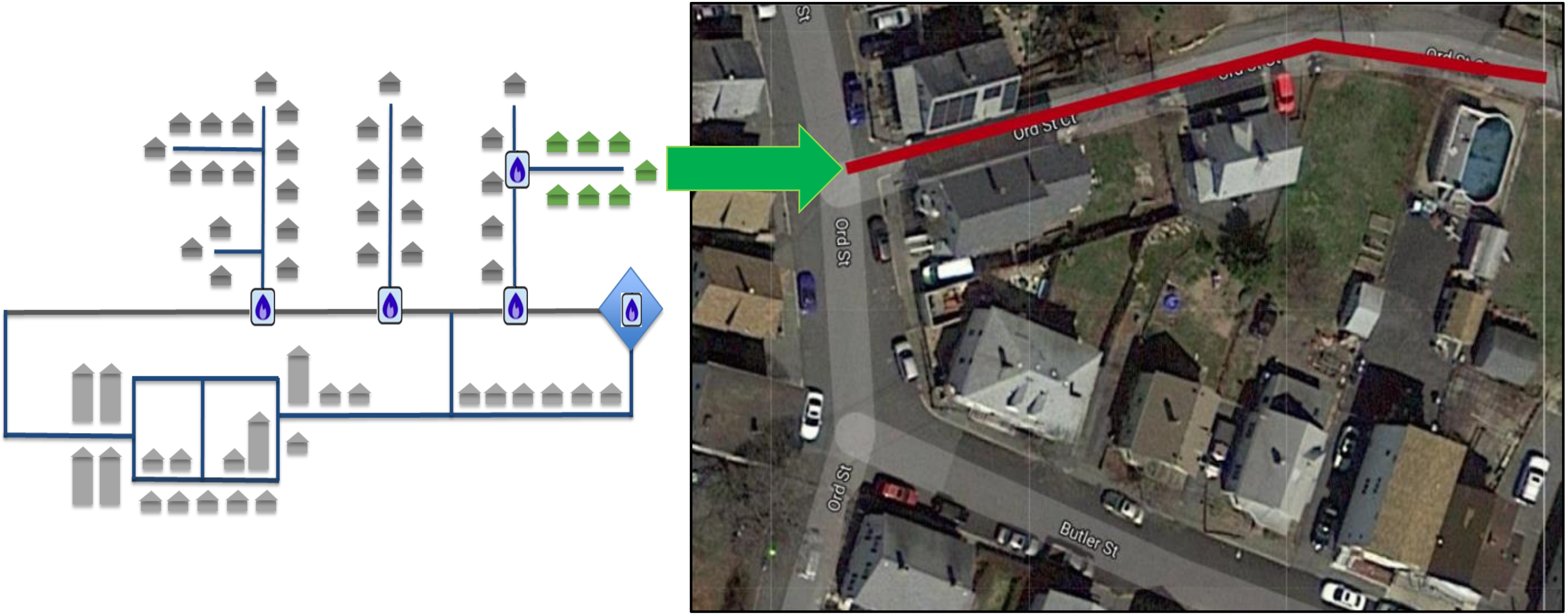
*@ 5.0 COP

Thermal Energy Networks share energy between structures using pipes between buildings and their Geothermal Heat Pumps



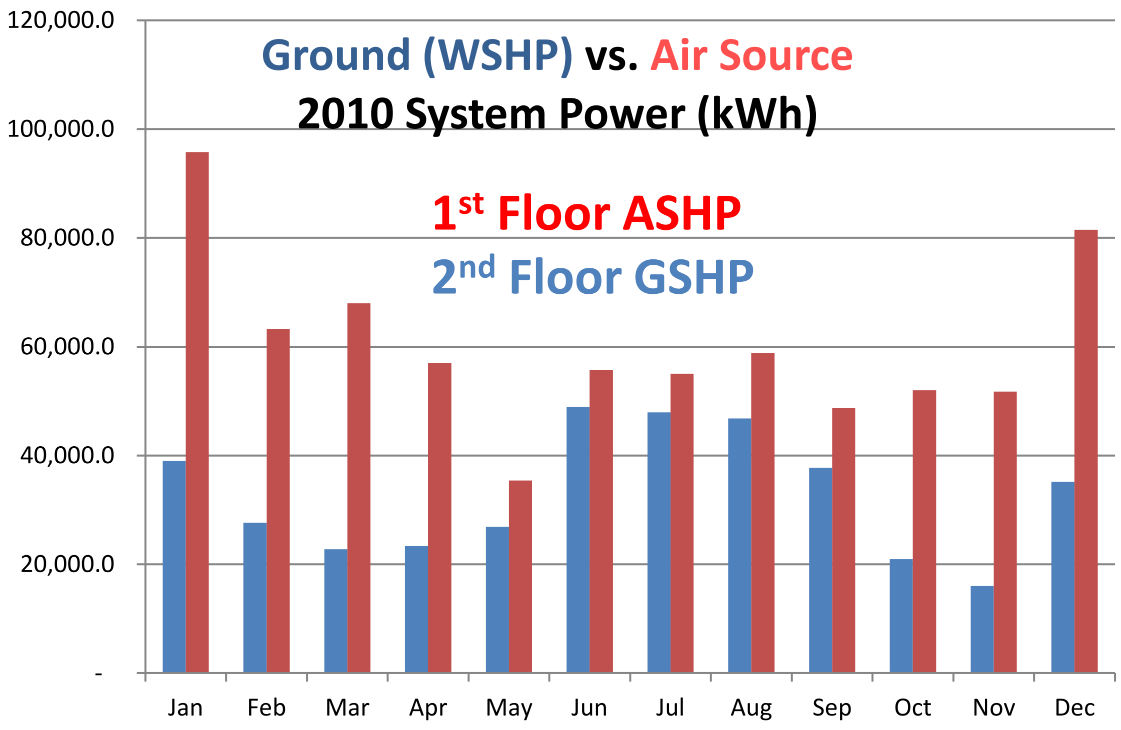


Replacing Old Gas Networks with Geothermal



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

Building Electrification Promotes Load Sharing / Diversification of Energy Resources

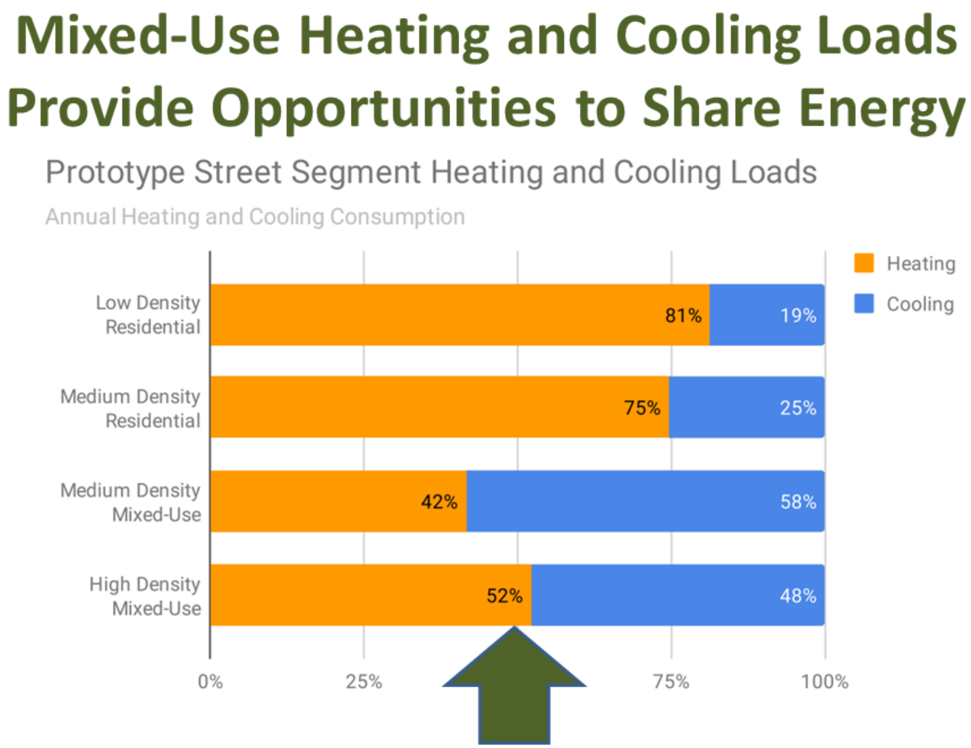


Figure III-5: Comparison of residential and commercial peak heating demand patterns

Figure III-2: Medium density residential PSS

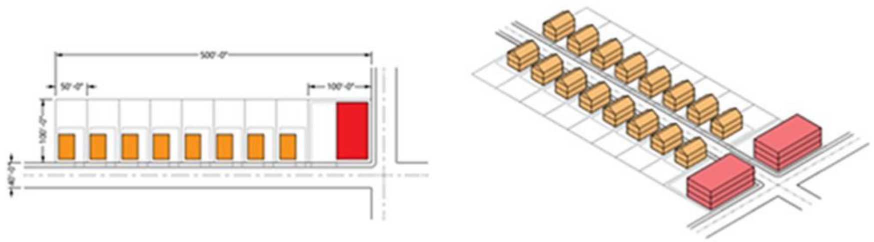


Figure III-3: Medium density mixed-use PSS

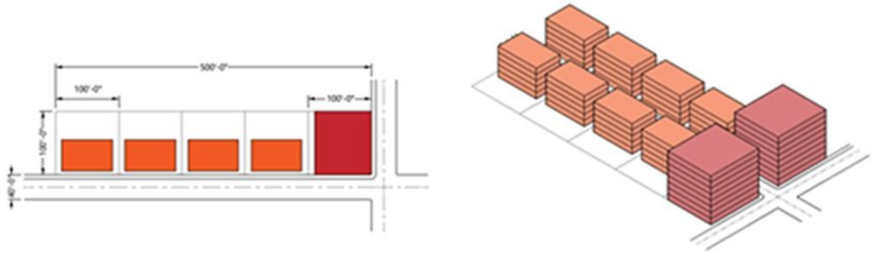
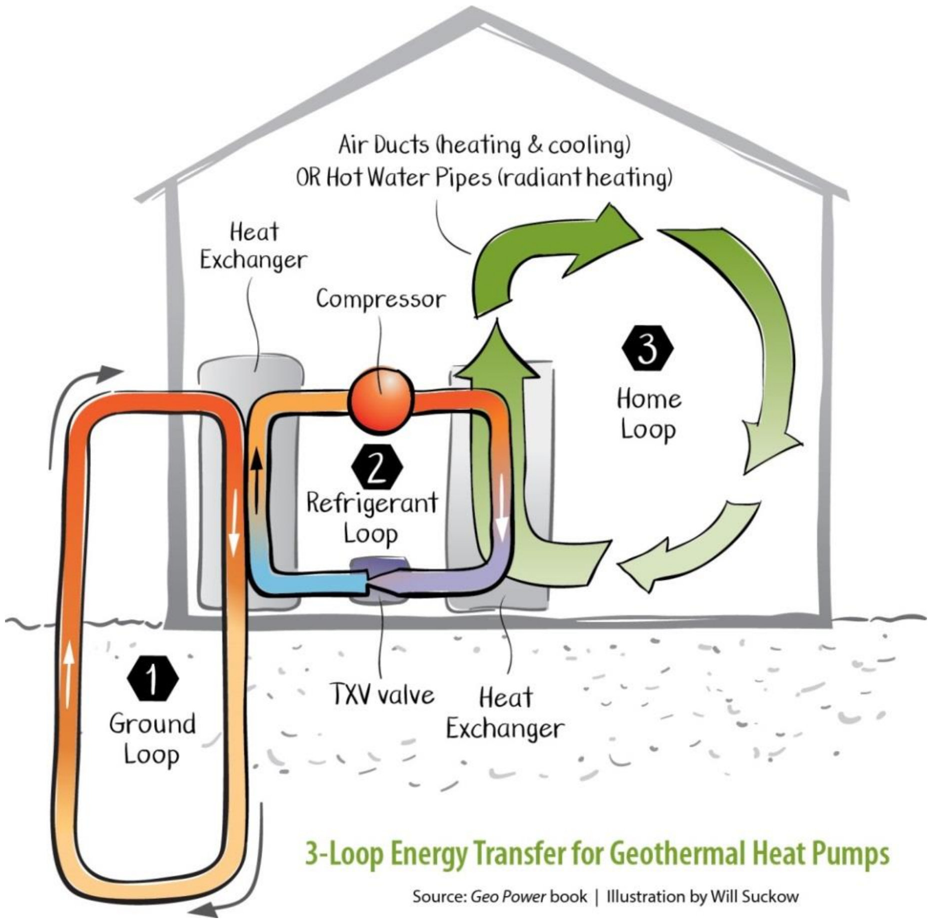
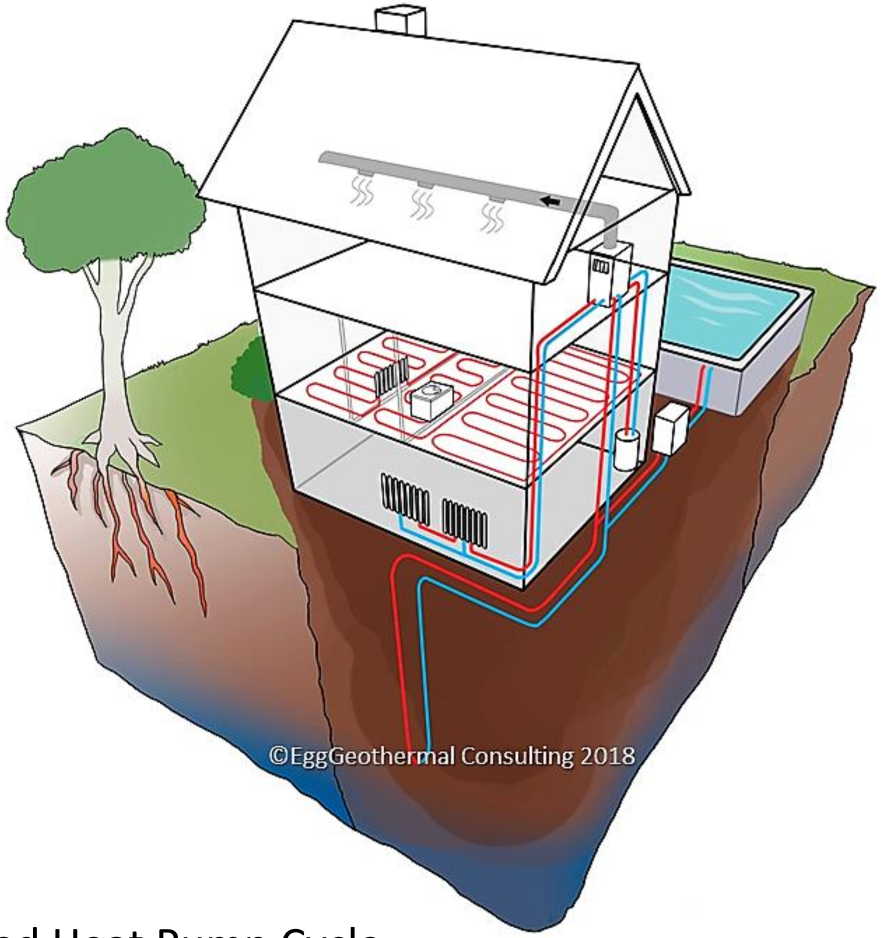


Figure III-4: High density mixed-use PSS

Understanding the refrigeration cycle in a water source, or Geothermal Heat Pump (GHP)





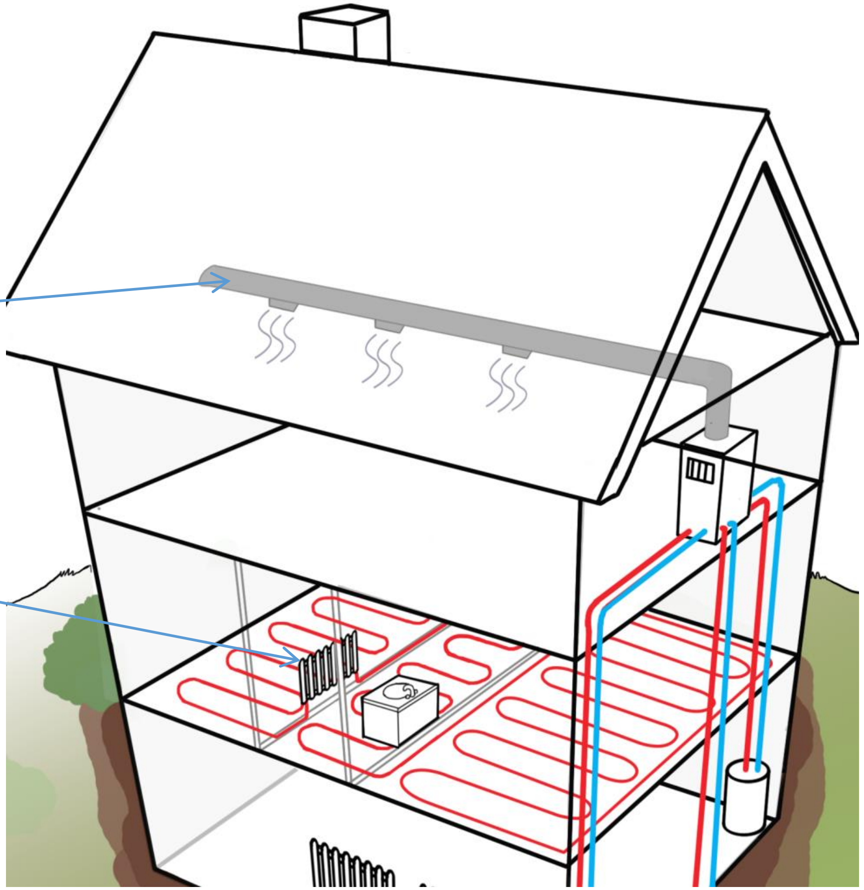
Animated Heat Pump Cycle
https://youtu.be/cGyEUZVGpxw

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*

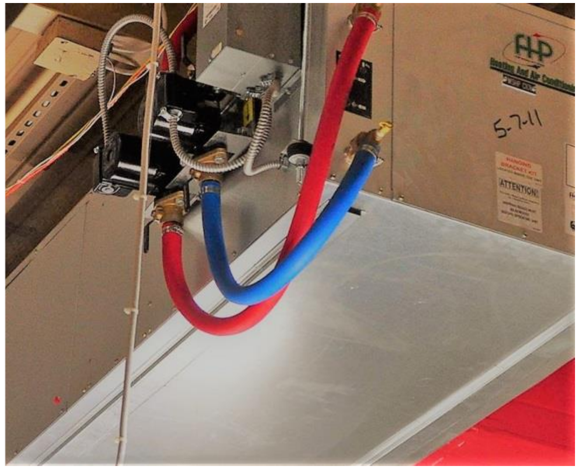
*refrigerant based distribution circuits are also used

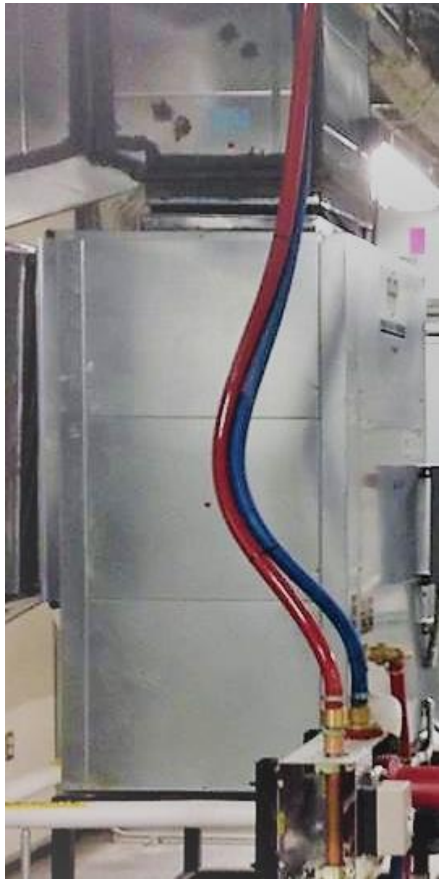


Like ASHPs GSHPs are also designed to fit every type of structure







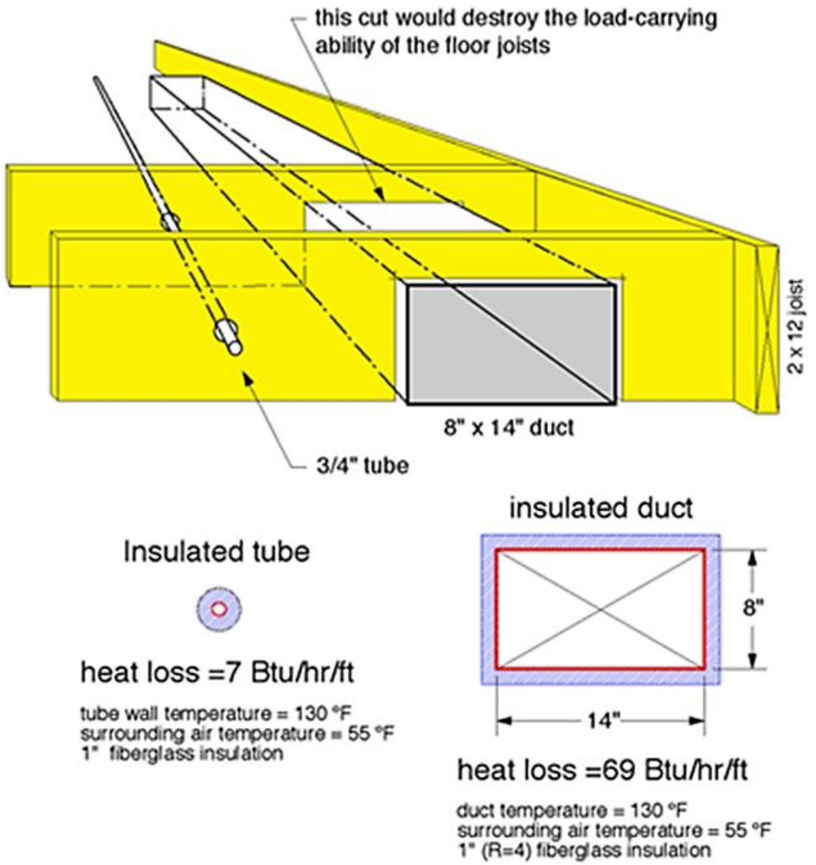



GHPs to fit every type of building, even roof tops

Replacement Roof Top GHPs

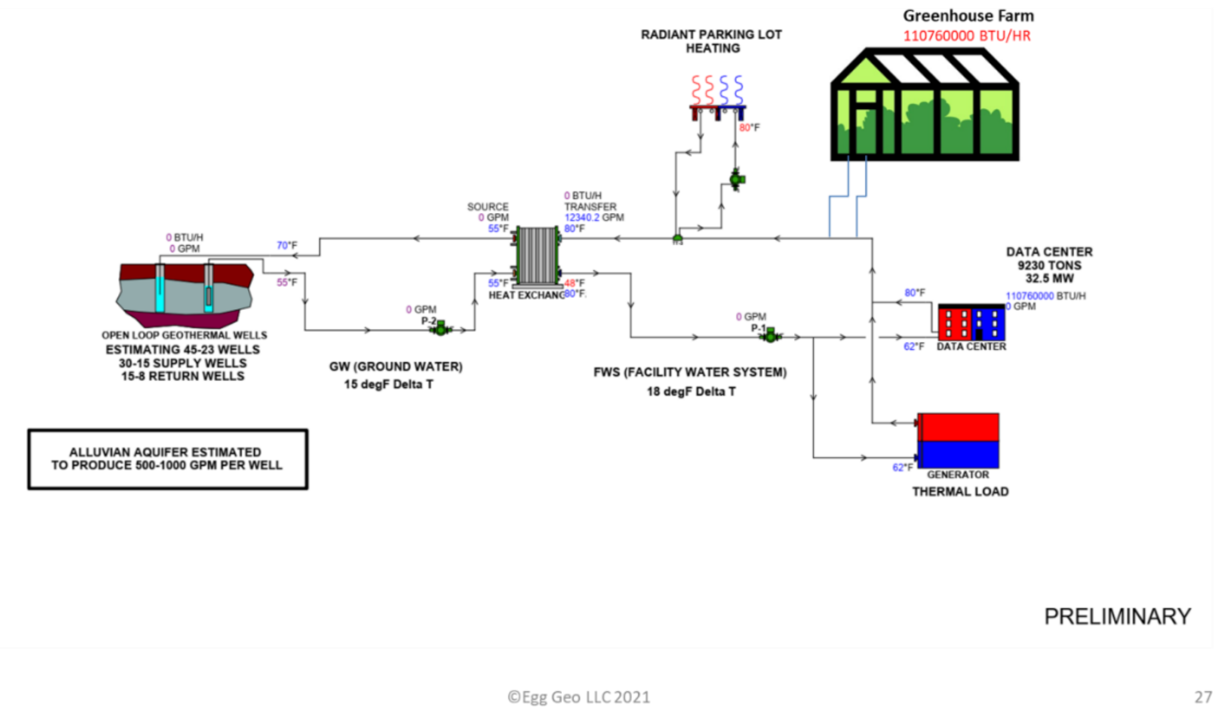
All Inside 100% Fresh Air (DOAS)

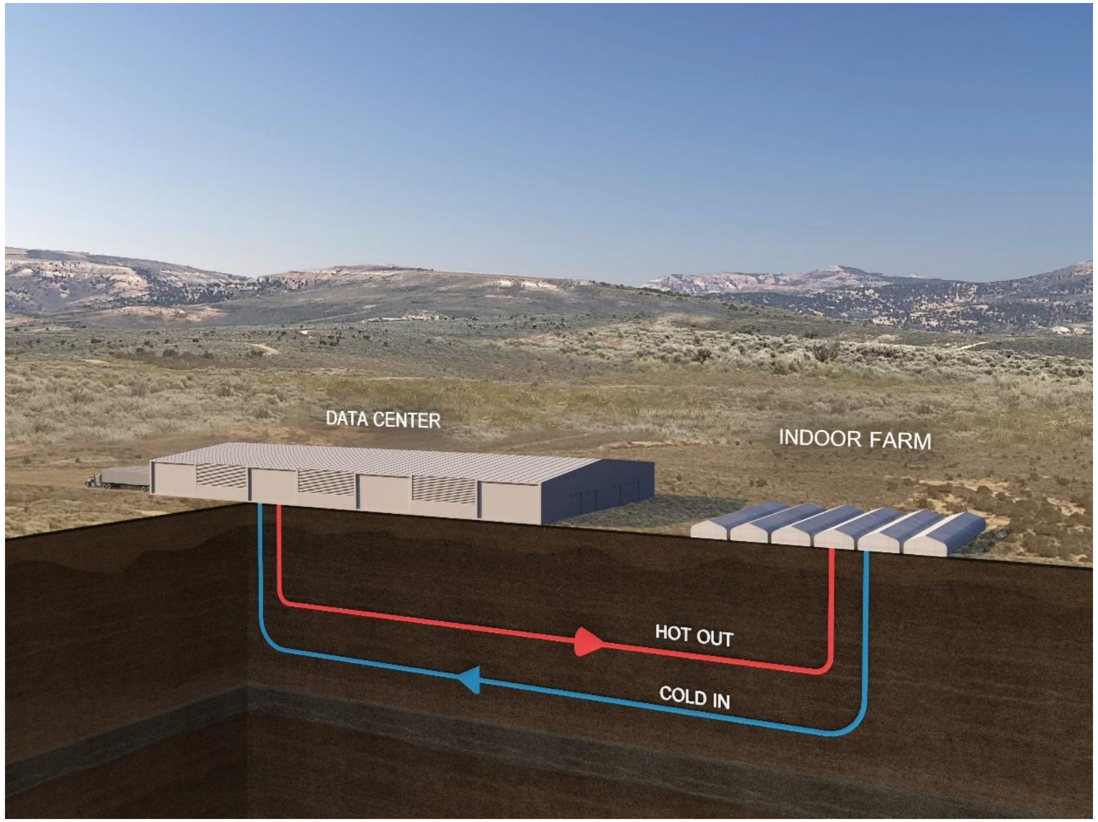
Less Energy is required to move BTUs in Water/Fluid compared to Forced Air



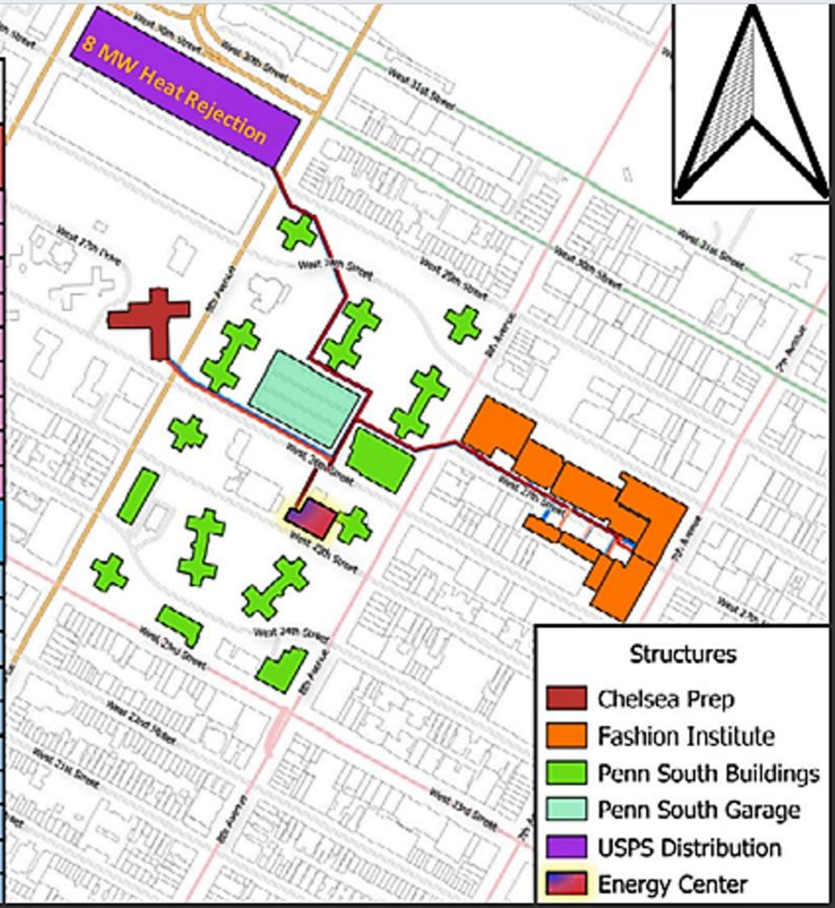
- A ¾" pipe can effectively carry the same cooling and heating energy as an 8" X 14" air duct
- Construction is simplified and space is optimized
- Energy is saved in pumping vs. fan power
- Almost 10x more energy is lost through the walls of the duct

Cascaded Energy to various resources





One Way Pipe Catalog	
Heating	
PS(in.)	Length(ft)
1 1/4	23
2	16
2 1/2	24
4	79
5	728
6	115
8	2145
10	413
Cooling	
PS(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

EGG GEO

TASK 3

FLOW DIAGRAM

WELL DATA TO BE VERFIED
BY HYDRGEOLOGICAL TESTING
-
WELL CONFIGURATION
SUBJECT TO CHANGE

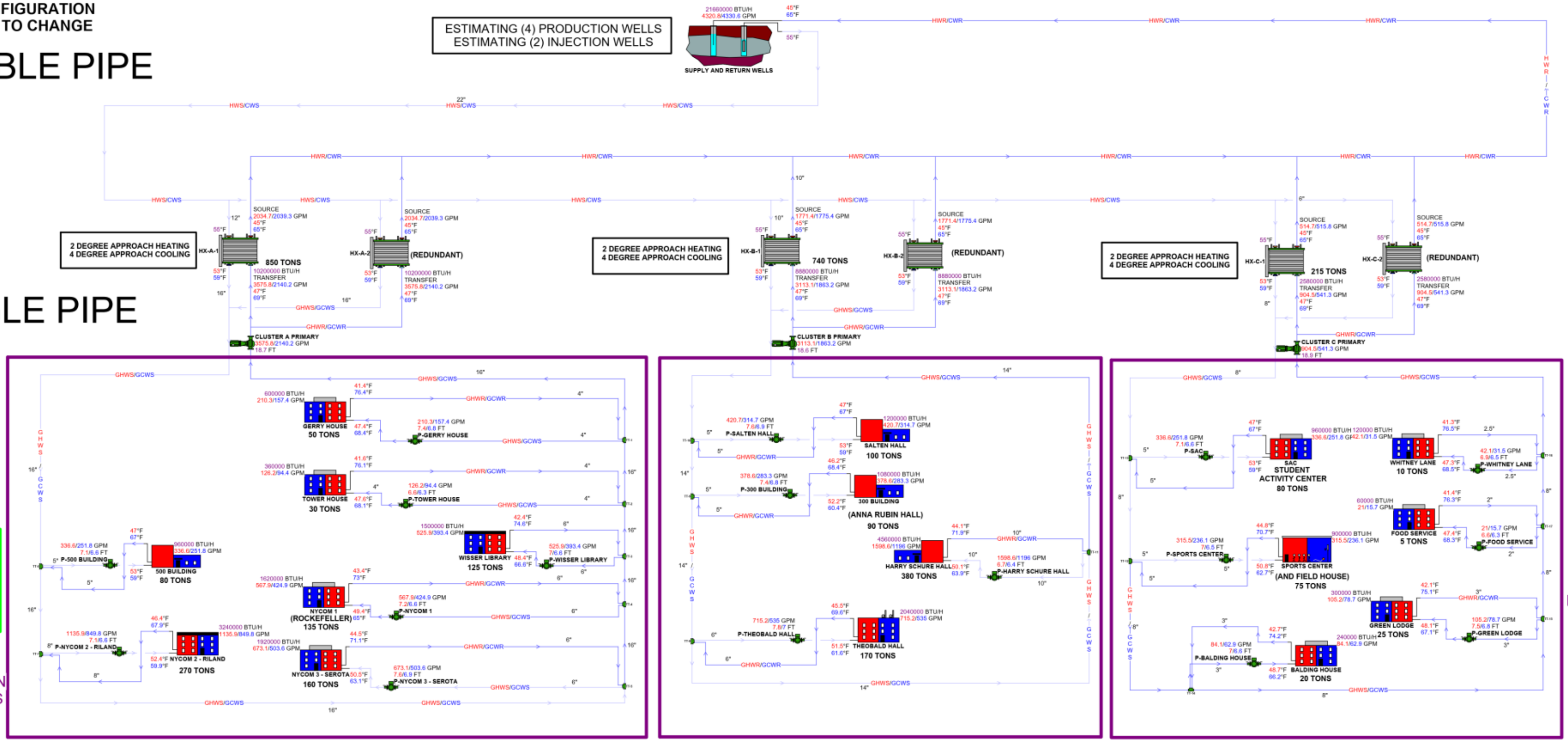
DOUBLE PIPE

SINGLE PIPE

2,580 TOTAL TONS

1,805 CONNECTED TONS

4,330 GPM



DE SEVERSKY AND COMMUNICATION ARTS - 160 TONS LOCATED APPROX. 2,000 FEET FROM OTHER BUILDINGS

MEDICAL BUILDINGS = 850 TONS

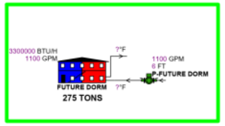
A CLUSTER

TECHNICAL BUILDINGS = 740 TONS

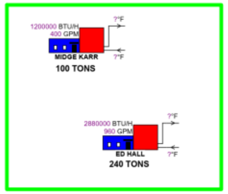
B CLUSTER

UTILITY BUILDINGS = 215 TONS
(40 TONS OF MISC HEATING FOR SHOPS NOT INCLUDED)

C CLUSTER

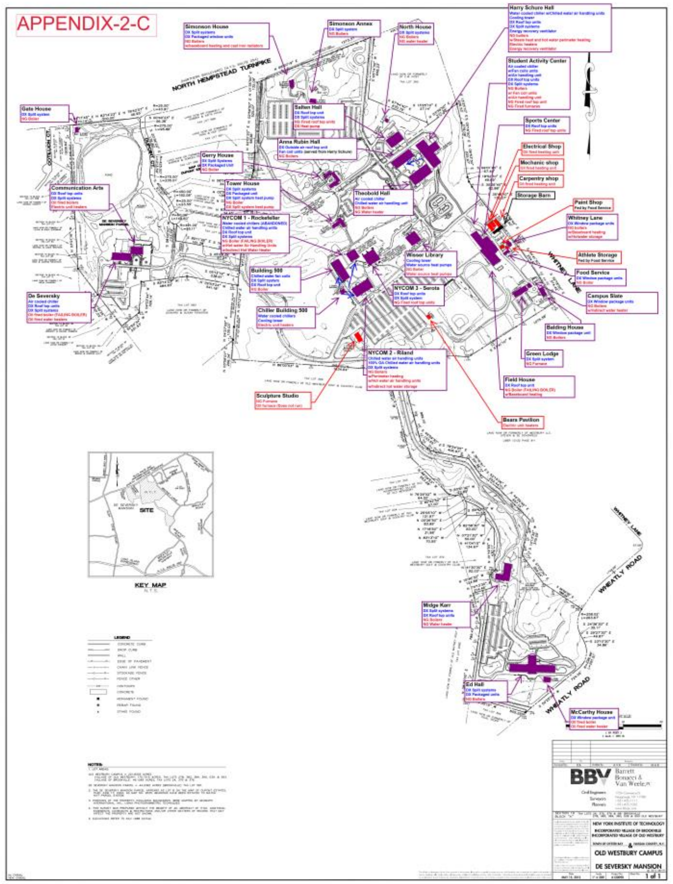


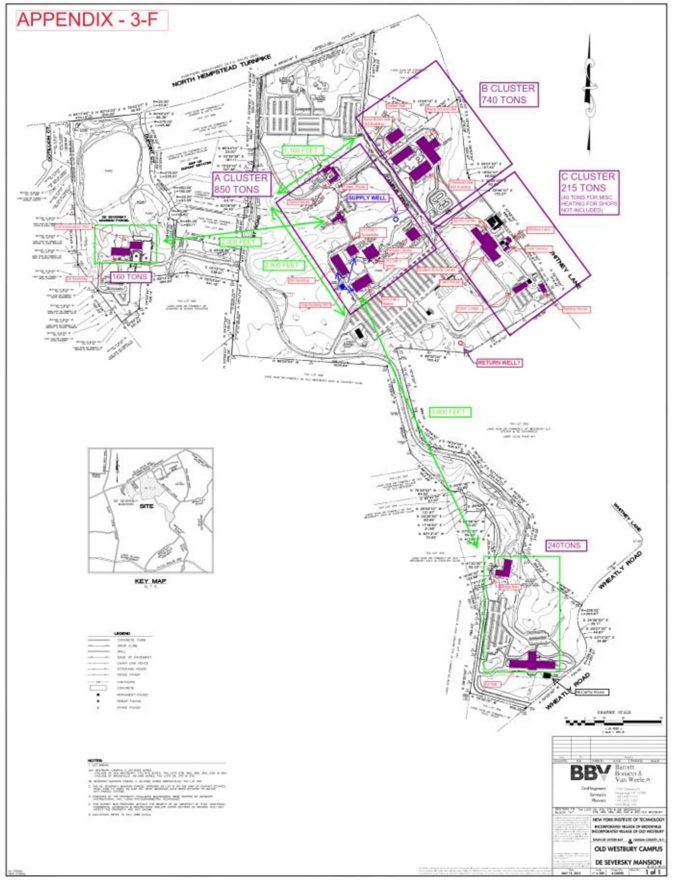
FUTURE DORM - 275 TONS



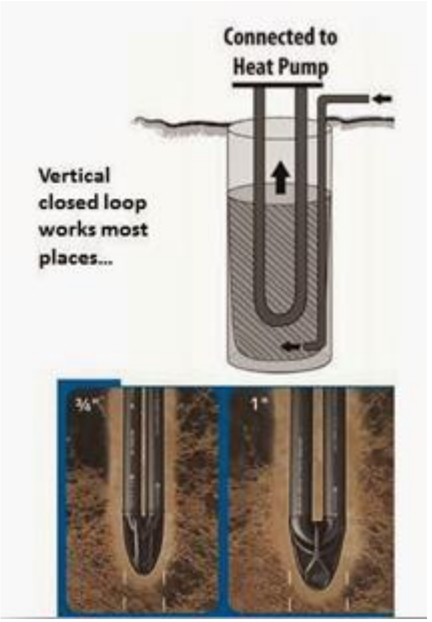
MIDGE KARR AND ED HALL - 340 TONS
LOCATED APPROXIMATELY 3,000 FEET FROM OTHER BUILDINGS

Modeling and Inventory of Data for Heating and Cooling the NYIT Campus

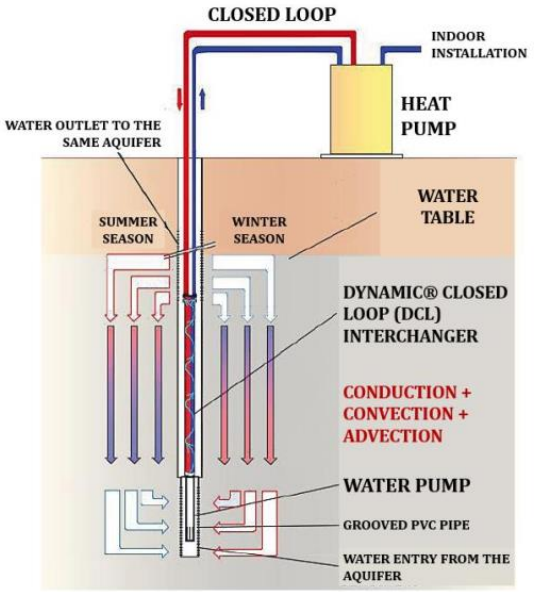




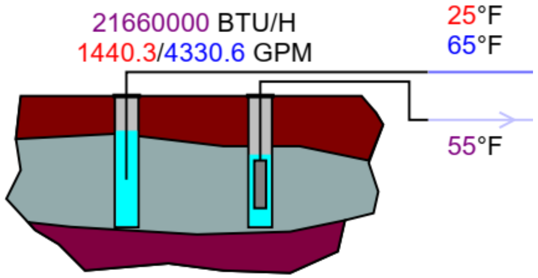
Some Economics:
Vertical Exchangers for Geothermal Heat Pumps: Average costs-$



1.Closed Loop Vertical



2. Downhole Exchanger

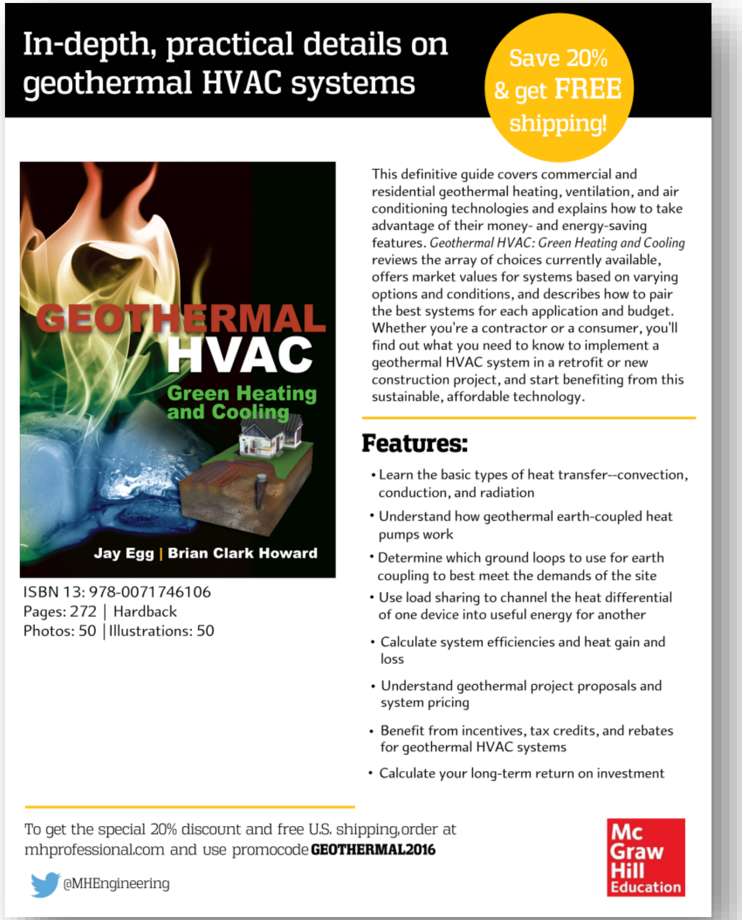


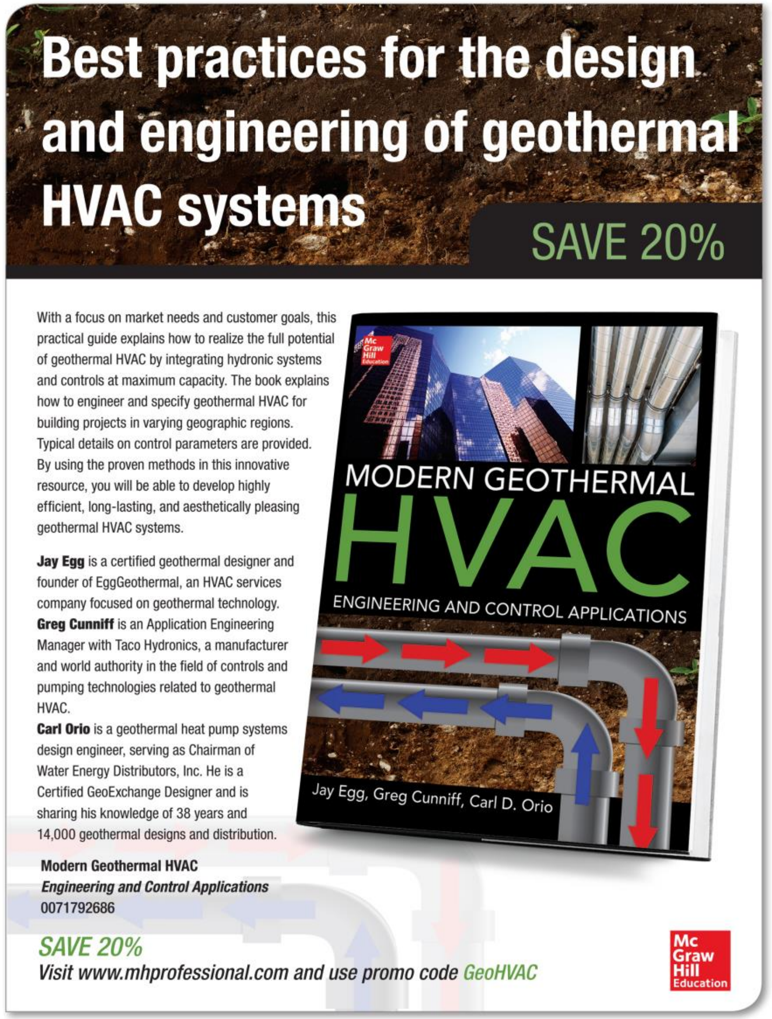
3. Open Well Pair (Doublet)

Three Vertical Geothermal Exchangers (Focus):

1. ***Closed Loop Vertical***
   - ***~$11k/ton***
2. ***Downhole Exchanger (aka DCL; Darcy)***
   - ***~$9k/ton***
3. ***Open Well Pair (aka Doublet, ATET, Open)***
   - ***~$7k/ton***

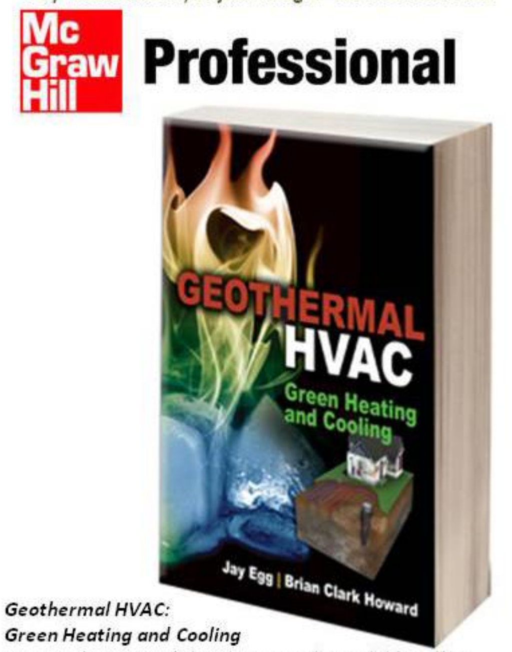
Diversity of Writings to support Curriculum and Geothermal Education



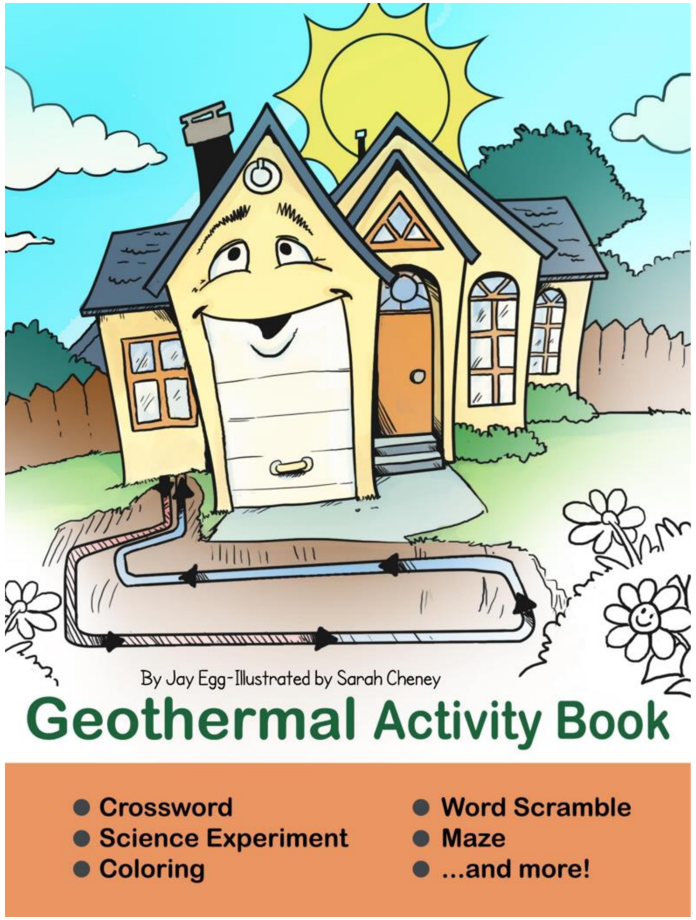


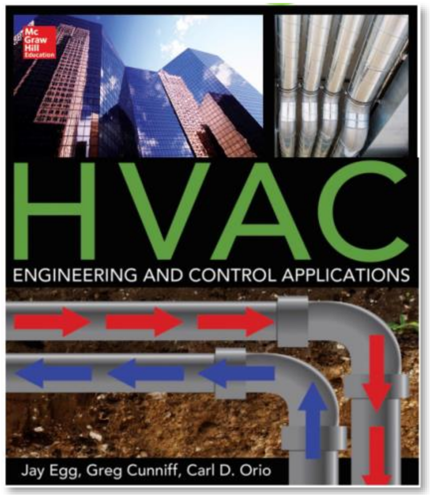
Diversity of Writings to support Curriculum and Geothermal Education

Buy it on Amazon, or just Google "Geothermal HVAC"



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.

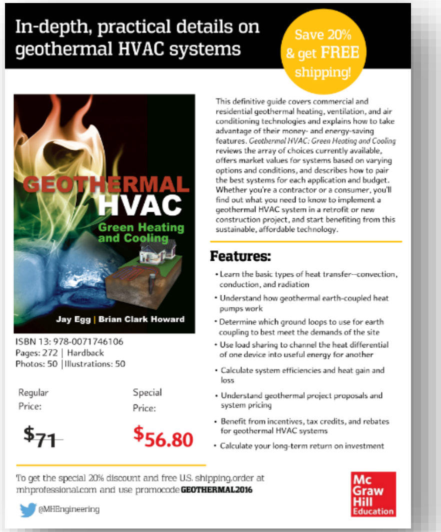




egg geo

expertise
education
engineering

Defining the Future of Geothermal


In-depth, practical details on geothermal HVAC systems

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This definitive guide covers commercial and residential geothermal heating, ventilation, and air conditioning technologies and explains how to take advantage of their money- and energy-saving features. *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.

GEOTHERMAL HVAC Green Heating and Cooling

Jay Egg | Brian Clark Howard

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Pages: 272 | Hardback
Photos: 50 | Illustrations: 50

Regular Price: ~~$71~~

Special Price: $56.80

Features:

- Learn the basic types of heat transfer--convection, conduction, and radiation
- Understand how geothermal earth-coupled heat pumps work
- Determine which ground loops to use for earth coupling to best meet the demands of the site
- Use load sharing to channel the heat differential of one device into useful energy for another
- Calculate system efficiencies and heat gain and loss
- Understand geothermal project proposals and system pricing
- Benefit from incentives, tax credits, and rebates for geothermal HVAC systems
- Calculate your long-term return on investment

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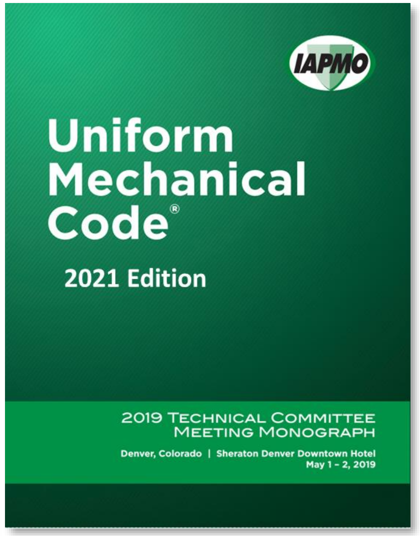
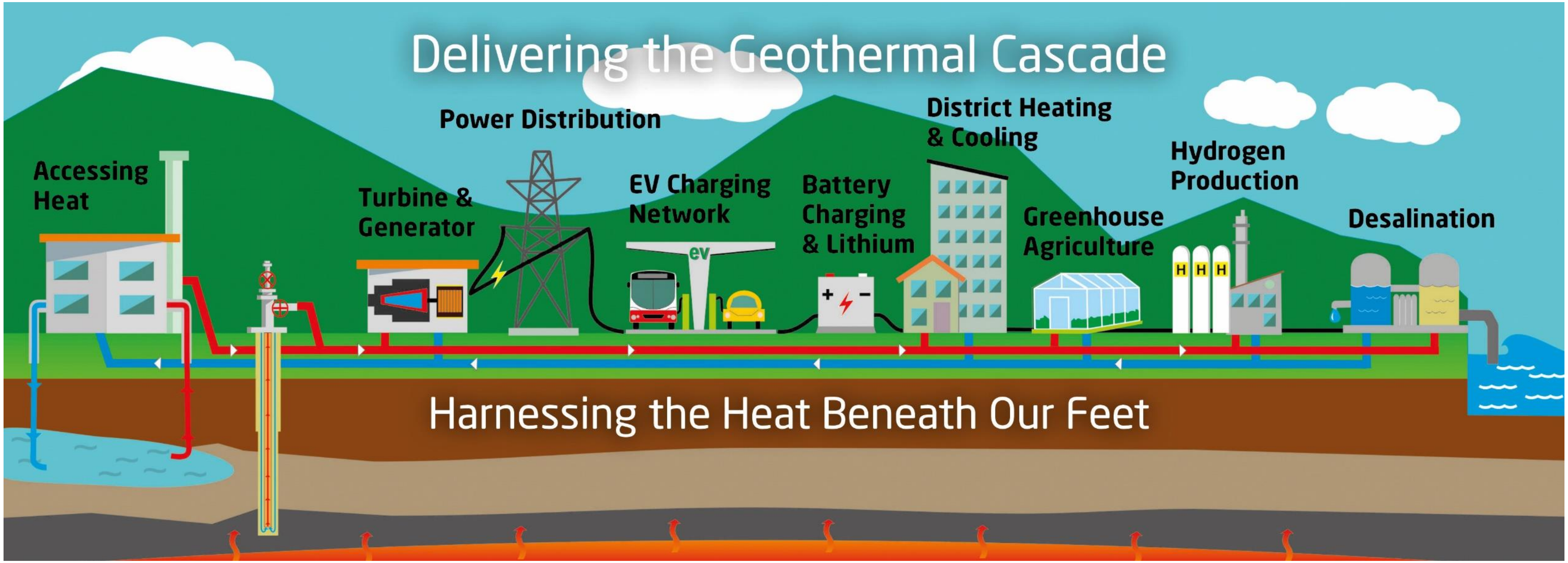
Mc Graw Hill Education



NZGA; Helping to fully utilize our Geothermal Resources



Cascaded Geothermal Systems Primer

From Energy Production To Heating And Cooling Homes

Geothermal is Always On

New Zealand Geothermal Association

nzga

2024 New Zealand Geothermal Association Keynote Address

July 03, 2024

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expertise
education
engineering

Defining the Future of Geothermal

Defining the Future of Geothermal

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Main Website

End of Slide Show

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