BUILDINGENERGY BOSTON

How Building Professionals Can Harness Geothermal Energy for New Climate-Resilient Housing at Scale

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About Dandelion

Founded out of Google X
Dandelion spun out of Google X in 2017 with a mission to deploy the world's most efficient heating and cooling method, cost-effectively, at scale, for residential homes.

Leading Expertise
We have industry-leading expertise in ground-loop system designs and best-in-class geothermal design engineers who have designed over 15,000 residential geothermal systems.

Over 1500 Homes Installed
by our 6th year of operation; and we are now bringing this turnkey solution to production developers.

Prominent Investors
Strategic investors Lennar, NPG, BEV are betting on geothermal and recently invested $30M in Dandelion to fund expansion and R&D

Goals for today

01. High-level overview of geo, what are the benefits, etc.
02. Describe best practices and identify challenges of incorporating geothermal into a build schedule.
03. Discuss the financial landscape surrounding geothermal HVAC, including costs, incentives, tax credits, and the impact of legislation on the adoption of this technology.
04. Calculate life cycle costs of geothermal system (using a case study).
05. Evaluate historical monitoring performance data of a real system (mine!).

Society is pushing toward electrified clean energy

There are many incentives to build electrified homes but it won't be a choice before long.

1. NY All Electric Building Act: New buildings < 8 stories must be fully electric if permitted after 12/31/2025.
    - All buildings are included starting in 2029 (including single family homes).
2. MA: Mass Save incentives increasingly require electrification to qualify or earn highest tier incentives and all new programs will require electrification to receive incentives.
    - 270 municipalities in MA have adopted the stretch code.
    - Even more are expected to adopt it throughout 2024.

Adopting geothermal now as part of your build package will prepare your company for the future.

Geothermal is a proven technology

50 years of geothermal installations in the US.

1,000,000+ geothermal heat pumps installed in the US today.

~50,000 residential installations every year.

https://www.energy.gov/energysaver/geothermal-heat-pumps
https://www.waterfurnace.com/residential/about-geothermal/

What makes geothermal great for your projects

Premium HVAC systems

Lowest operating & maintenance costs, most comfortable, longest lasting HVAC system available.

Electrified Clean Energy

Geothermal has lower energy use and carbon emissions than any other HVAC on the market today and is the best way to future proof your buildings to meet emerging energy regulations.

Clean and quiet communities

No outdoor equipment or refrigerant to install, look at, listen to, or maintain. Geo also eliminates the risk of theft or damage.

Competitive Incentives

Federal and local incentives specific to geothermal make it much more cost-effective for builders to implement geothermal.

Why geothermal is the best financial choice for your project

	Savings
Competitive Day 1 pricing	• With incentives, all markets can install geo for less than a 20% premium than conventional HVAC on day one. • In many markets, geothermal can even be the cheapest up front option to build.
Cheapest cost of ownership	• Energy costs will be 25-60% lower with Geothermal than any conventional alternative in all markets. • Ground loops last the life of the building and geothermal heat pumps have twice the life expectancy of ASHP or other conventional systems, dramatically reducing maintenance and replacement costs over time.

Federal Geothermal Financial Benefits

	Savings
Investment Tax Credit	• Developers who maintain ownership can receive a 30-40% tradeable investment tax credit. • Homeowners are able to claim a tax credit of 30% through 2032.
45L Tax Credit	• 45L Tax Credit Provides developers with a tax credit of $2,500 for Energy Star New Homes through 2032. • Zero Energy Ready Homes (ZERH) Tax Credit (45L) Provides developers with a tax credit of $5,000 for ZERH through 2032. GSHPs help reduce the Energy Rating Index to meet the higher ZERH requirements.
Income Eligible funding	• Developers of properties meeting income-eligible criteria qualify for federal home electrification rebates of up to $8,000

State and Other Financial Benefits

	Savings

State specific rebate programs	• NYS Clean Heat is prescriptive ($/ton)
	• CT and MA are HERS score-based.
	  ○ The range varies from $100's to $1000's, depending on tier.
	  ○ Performance based incentive programs have prescriptive requirements to qualify. Rebates aren't geo specific, but the inclusion of geo makes it much easier to meet the requirements.
	• (Note: Geo reduces HERS score by 7-9 points compared to gas with AC and/or air source heat pumps)

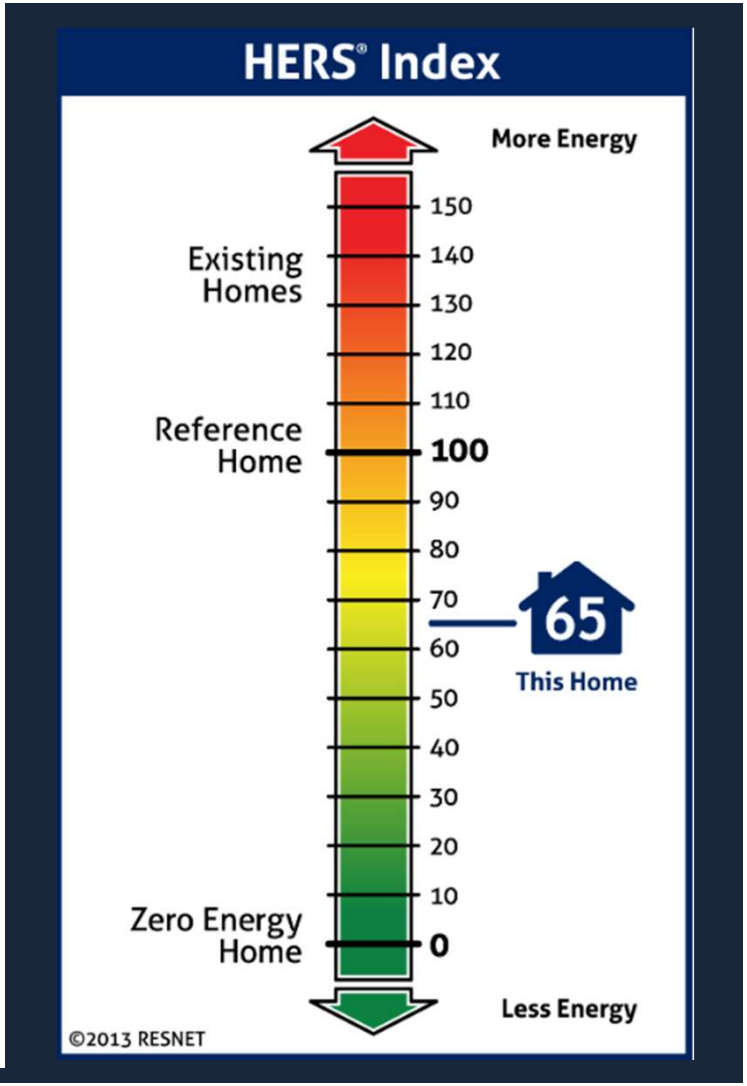
Construction offsets	• Potential for increased density with less utility easement requirements • Possible Non-Pipeline Alternative (NPA) grant money from utility provider • Reduces size of PV system (if net zero is the goal) • Eliminates the need for concrete pad (and space associated) for outdoor condenser • Eliminates the need for lineset runs and field-charged refrigerant circuits

HERS Study

Home Energy Rating System (HERS) Index is used to measure a home's performance from an energy efficiency perspective. The lower the score, the better

Study of Multiple Markets /w Lennar

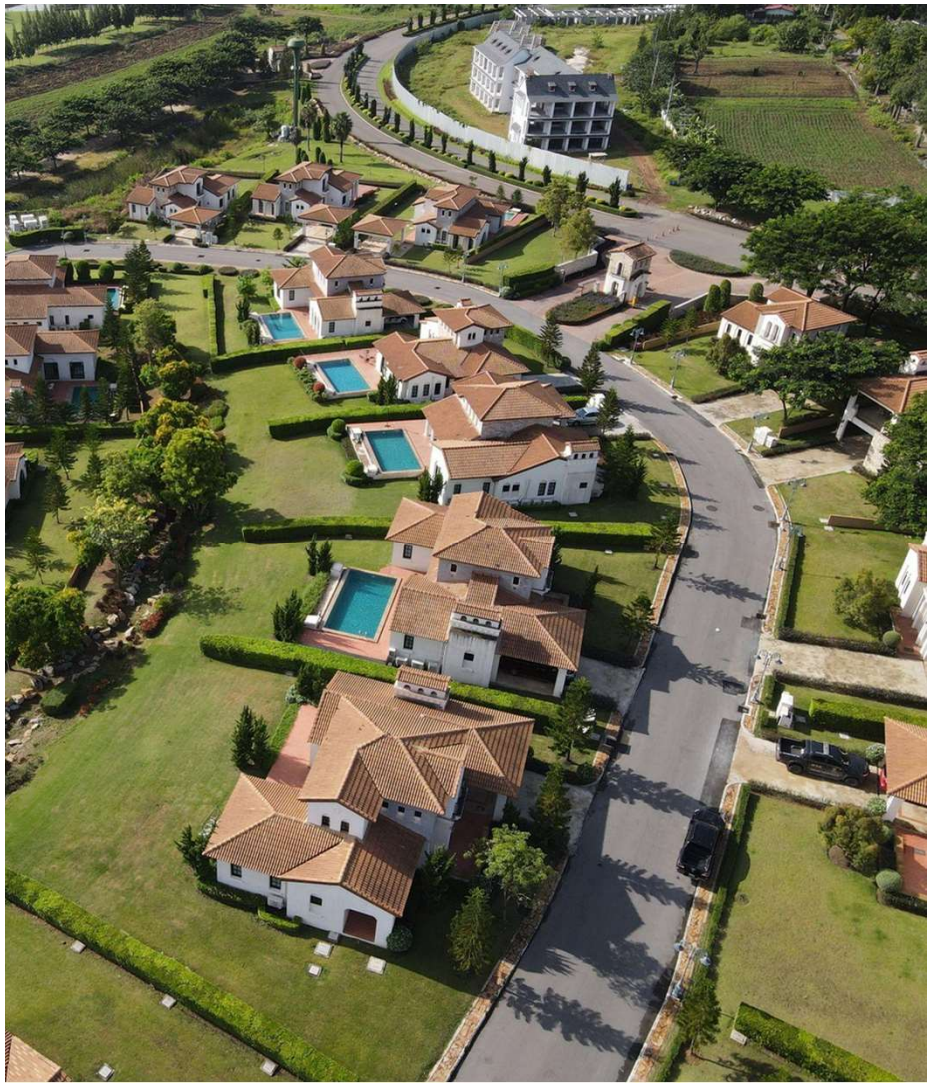
- Looked at 1,000 homes they built across 5 major markets
- Modeled the homes two ways:
  - As-designed (with gas furnaces)
    - 17.9% of homes qualified for EnergyStar 45L
  - After substituting geo for the HVAC system without changing anything else
    - 78.0% of homes qualified for EnergyStar 45L
    - Avg HERS score reduction in cold climates: 9.1
    - Avg HERS score reduction in warm climates: 3.2
  - Same exercise using air source heat pumps...
    - Resulted in minimal change to HERS score or EnergyStar 45L qualification rate.
    - In some markets, HERS score increased slightly



Geothermal for your community

Tips for Success

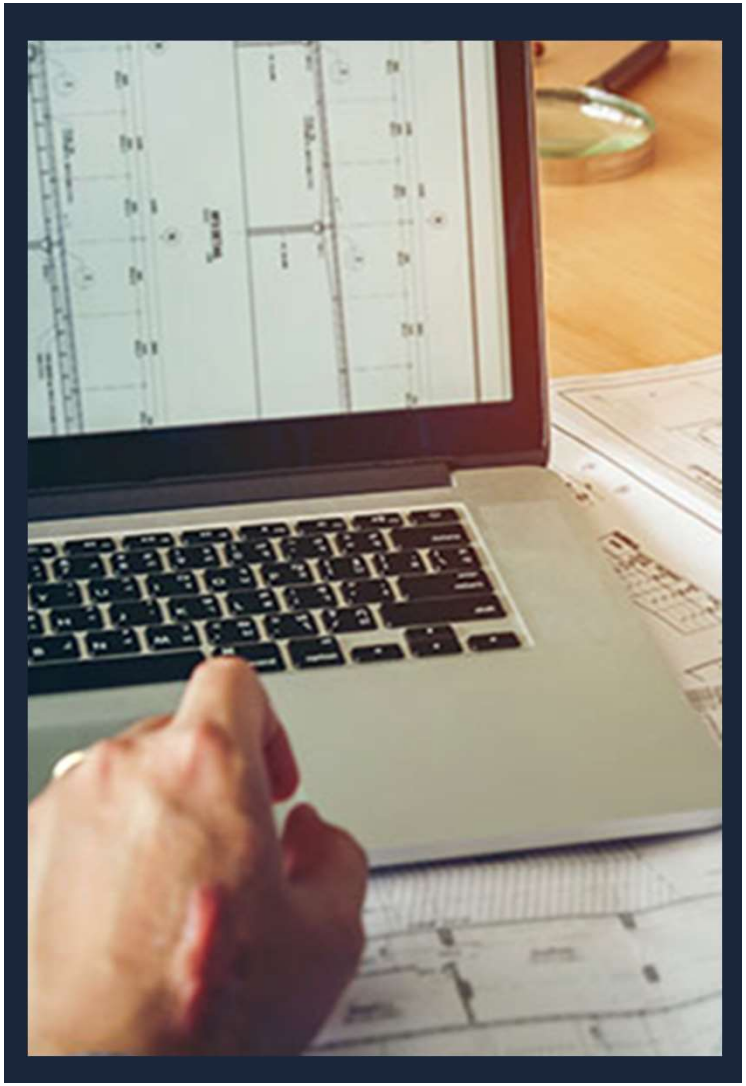
- **Proper design**
- **Planning and coordination**
- **Keep it simple!**
- **Sales training**



#1 Don’t use rules of thumb

Proper design is critical

- Rule of thumb is very common HVAC practice that leads to oversizing
- Unlike a furnace, AC or ASHP, the cost for geo is linear with system capacity
    - Pay per ft for drilling or trenching
- Incentive programs required Manual Js
    - NYS Clean Heat: system sizing must be between 90-120% of calculated load to qualify for rebates
- Oversizing can lead to comfort issues due to short cycling and poor dehumidification
    - Can be especially problematic with unitary equipment in heating dominant climates
    - (i.e. when sized for the heating load, capacity will be much bigger than the cooling load)



#2 Planning & coordination are key

Planning should start early

- Geothermal requires an extra trade that isn't typically part of construction.
- This is easy to do, but builders aren't used to thinking about HVAC before vertical construction

Drill within our outside of the footprint?

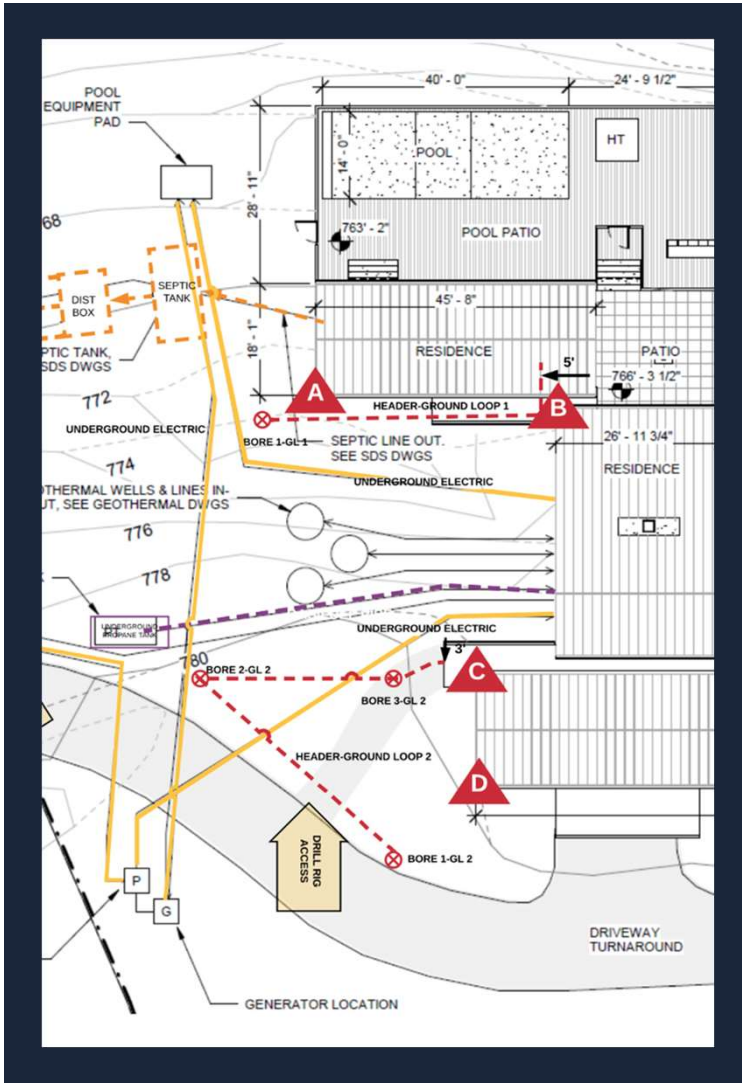
- Pro's of drilling within the footprint
  - Lower cost (eliminates the need for the excavator)
  - Protects against future damage (under the house, no other work will take place)
- Con's of drilling within the footprint
  - Timing is everything.

#3 Keep it simple

In most cases, the simplest solution is the best value and the best performing.

- Simple systems are easier to execute on at every stage of the project (design, installation, service) and are the easiest to own and operate
  - 1- or 2-stage equipment with basic thermostat controls
  - Individual loop for each home coupled with a residential flow center / circulators

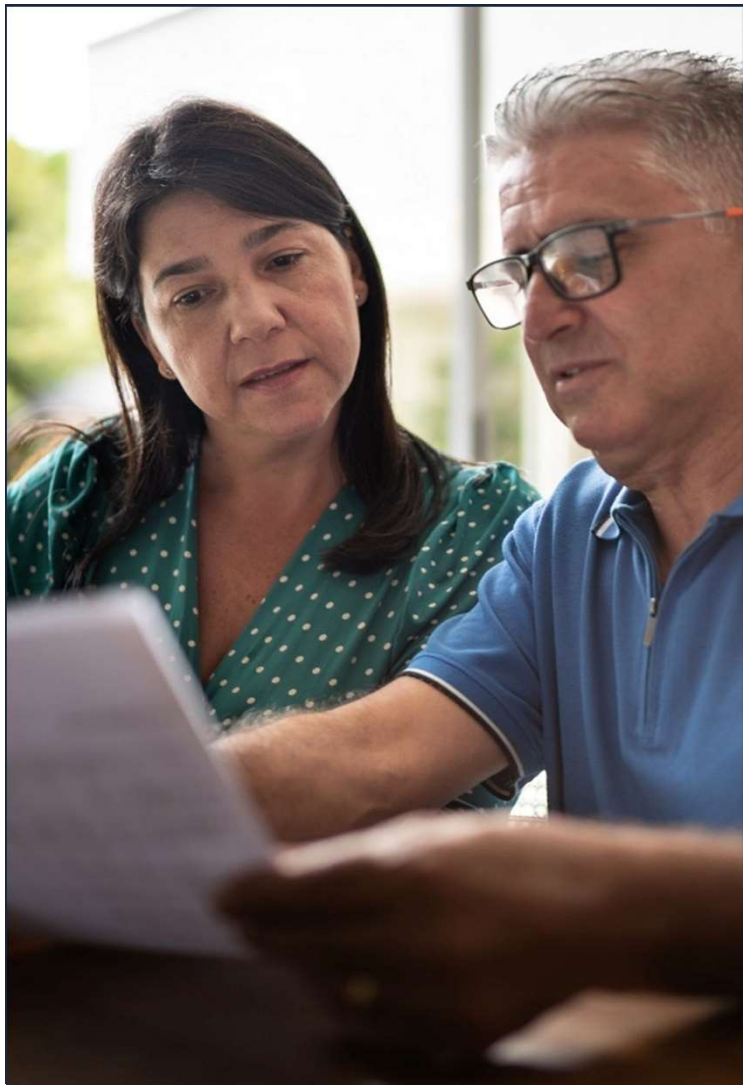
- Complicated examples (require higher level of expertise, more specialized equipment, etc)
  - Variable speed systems
  - Proprietary controls
  - District-style loops



#4 Don’t forget sales training

The sales team will need to know how to speak to potential homebuyers about geo

- The things that they need to know
  - How to change filters
  - How to use their thermostat
  - Who to call for service
  - How to collect the 30% federal ITC (other rebates reduce contract price directly, the ITC needs to be collected by the eventual system owner)

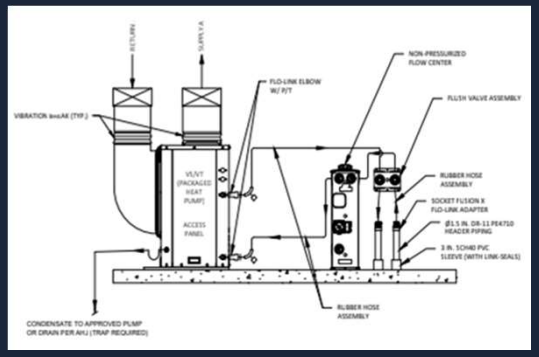


Case Study: Landing at Esopus Icehouse (Saugerties NY)

Project Overview

- 11 for-sale townhomes currently under construction (complete this summer)
- Options for space conditioning were (1) propane with AC (2) air source heat pumps or (3) geothermal heat pumps

Case Study: Landing at Esopus Icehouse (Saugerties NY)



Project Overview

- Implementation plan – construction schedule
  - Drill outside of the footprint, before other utilities, landscaping etc.
  - Sleeves in foundation walls to eliminate need to core drill
- Each unit consisted of:
  - 1 x 4T forced-air (packaged) 2-stage heat pump with two ducted zones
  - 1 x 450ft vertical borehole w/ 1.25” loop piping and 1.20 grout TC
- Mechanical rough in schedule exactly the same…except simpler
  - Airflow rates & duct design did not change with switch to geo (air source heat pumps were originally spec’d)
  - Install bypass valves at time of lateral tie in to allow for full ground loop commissioning (flush/purge and antifreeze fill).
  - No pad, no lineset run, no brazing
  - Very little left to do when time comes to install the interior equipment (electrical, thermostat, duct tie in, condensate)

Case Study: Landing at Esopus Icehouse (Saugerties NY)

Financial Overview

Landing at Esopus Icehouse (Saugerties, NY)		
Geothermal System Cost Summary		
	Per Unit	**Entire Project (x11)**
Geothermal System Cost	$40,248	$442,728
Central Hudson Geothermal Rebate	-$7,660	-$84,260
Base 45L	-$2,500	-$27,500
DOE zero energy ready (45L bonus)	-$2,500	-$27,500
Net cost per unit	**$27,588**	**$303,468**
Conventional System Cost Summary (vs Air Source Heat Pumps)		
	Per Unit	**Entire Project (x11)**
ASHP System Cost	$33,500	$368,500
Central Hudson ASHP Rebate	-$1,915	-$21,065
Net Cost to Developer	-$3,997	-$43,967
Homeowner Cost Summary (vs Air Source Heat Pumps)		
	Per Unit	**Entire Project (x11)**
ITC (30%) - (Diff between Geo and Air Source)	-$7,776	-$85,540
NYS State Income Tax Credit (25% up to $5k) - Geo Only	-$5,000	-$55,000
Construction Cost Delta	-$3,997	-$43,967
Homeowner Net Purchase Price	**-$16,773**	**-$184,507**
Homebuyer Operation and Ownership Savings (vs Air Source Heat Pumps)		
	Per Unit	**Entire Project (x11)**
Operating Cost Savings (Year 1)*	-$2,035	-$22,390
Projected 20-Year Operating Cost Savings**	-$54,692	-$601,614
Avoided Replacement Costs	-$15,000	-$165,000
Total Homebuyer 20-Year Ownership Delta	**-$86,466**	**-$951,122**

**assumes 0.22/kWh avg electric rate*

***assumes 3% annual electric increase*

Case Study: Landing at Esopus Icehouse (Saugerties NY)

Energy Savings & Emissions Reduction

Landing at Esopus Icehouse (Saugerties, NY)			
Heating and Cooling Energy Use Summary (vs Air Source Heat Pumps)			
	Per Unit	**Entire Project (x11)**	
Geo Heating Energy Use (kWh/yr)	7,096	78,056	
Geo Cooling Energy Use (kWh/yr)	1,571	17,281	
Geo Total Energy Use (kWh/yr)	8,667	95,337	
ASHP Heating Energy Use (kWh/yr)	15,307	168,377	
ASHP Cooling Energy Use (kWh/yr)	2,443	26,873	
ASHP Total Energy Use (kWh/yr)	17,750	195,250	
Total Savings with Geo (kWh/yr)	**9,083**	**99,913**	(48.8% savings)
Heating and Cooling CO2 Emissions Summary (vs Air Source Heat Pumps)			
	Per Unit	**Entire Project (x11)**	
Geo Heating Emissions (lb/yr)	1,657	18,227	
Geo Cooling Emissions (lb/yr)	367	4,037	
Geo Total Emissions (lb/yr)	2,024	22,264	
ASHP Heating Emissions (lb/yr)	3,575	39,325	
ASHP Cooling Emissions (lb/yr)	570	6,270	
ASHP Total Emissions (lb/yr)	4,145	45,595	
Total Savings with Geo (lb/yr)	**2,121**	**23,331**	(48.8% savings)

**Emissions for all electric heating and cooling systems are estimated from EPA data, based on the generation mix for the region*

***Annual reduction of 23,331 lb of CO2 is equivalent to removing 2.4 cars from the road every year (27,129 miles not driven every year)*

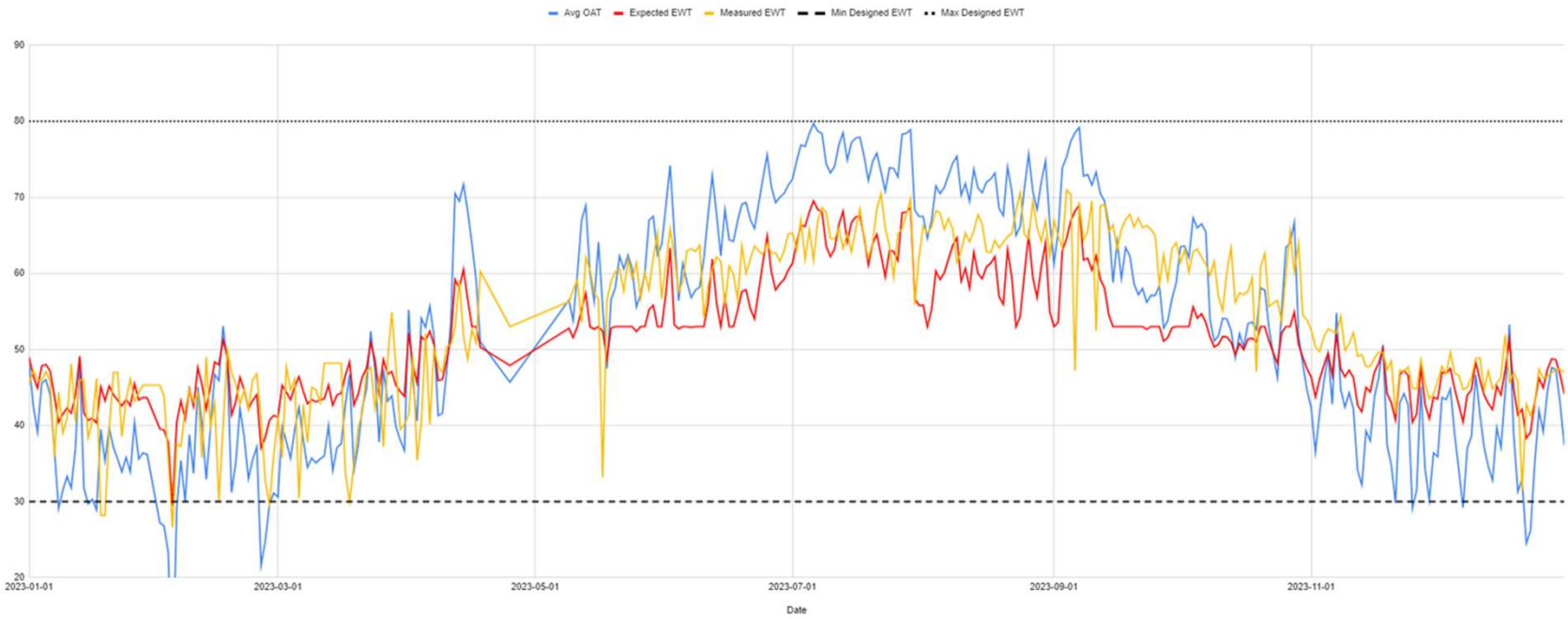
Monitoring Data Review: Carda Residence (New Paltz NY)

Project Overview

- 1.5 story single family home in New Paltz NY
- Built in 2021
- Code minimum construction
  - Batt insulation (R21 walls, R38 ceilings)
  - Average air sealing (<3 ACH 50)
- Conditioned area: 3,900 sf
  - First floor: 1,700 sf
  - Second floor: 1,000 sf
  - Basement: 1,200 sf
- Geothermal system summary
  - Calculated peak loads:
    - Heating: 54,198 Btu/hr
    - Cooling: 24,787 Btu/hr (+2,707 Btu/hr latent)
  - Single 5-ton forced-air 2-stage system (w/ 2 zones):
    - Zone 1: Main floor + basement
    - Zone 2: Second floor
    - w/ desuperheater
  - Ground loop:
    - 1 bore x 500 ft deep
    - Designed for 30/80 (min/max) EWTs

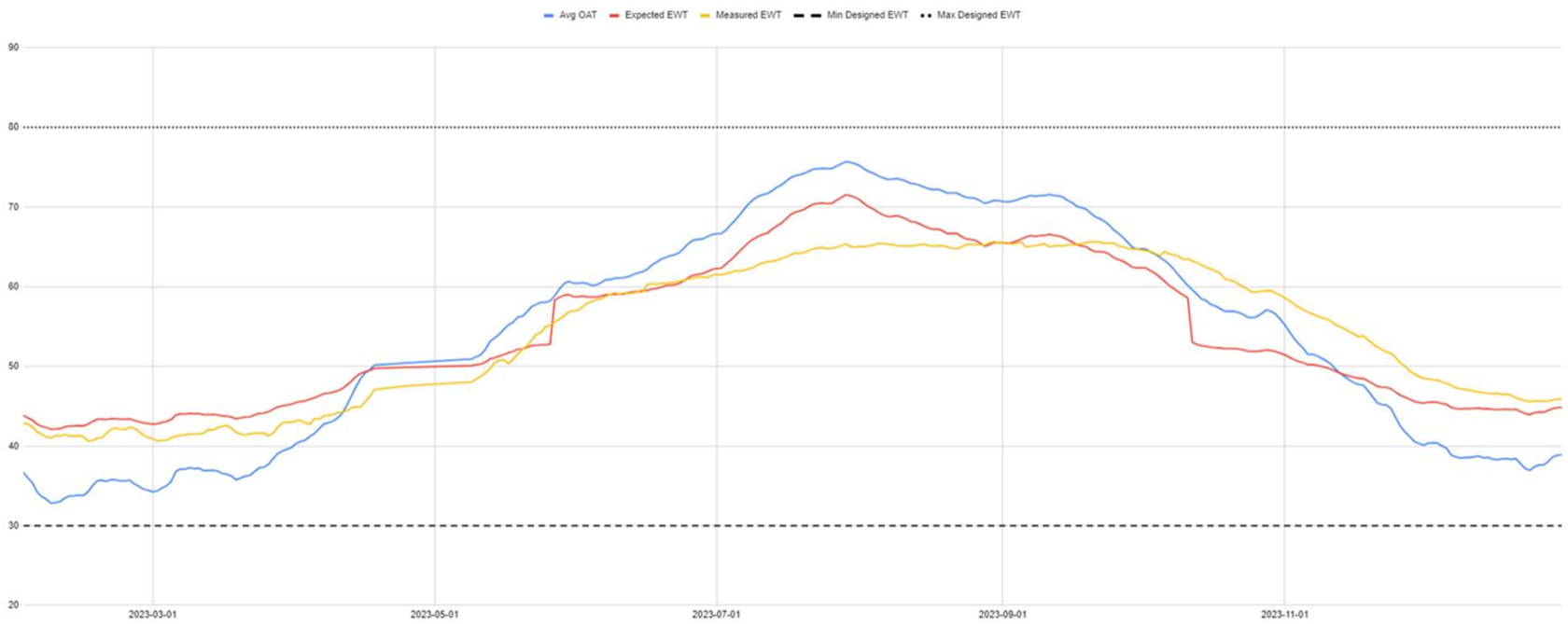
Measured vs Expected EWT - 2023

Daily Averages



Measured vs Expected EWT - 2023

30-Day Moving Average [Dashboard View]



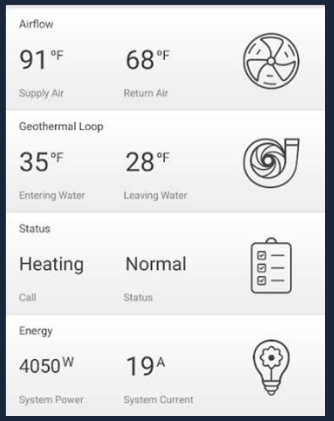
Performance on a cold day

Jan 19, 2024

- Heat of extraction (HE)
  - HE = 485 x 14 gpm x (EWT-LWT)
  - HE = 47,530 Btu/hr
- Heating capacity (HC)
  - HC = HE + 3.412 x Watts
  - HC = 61,349 Btu/hr
- Heating COP
  - COP = HC / (3.412 x Watts)
  - COP = 4.44
- Notes on performance data:
  - Power consumption includes everything - blower, pumps, compressor, etc
    - 10kW aux installed but disabled (at the tstat)

Weather:

Monitoring Data:



Performance during a cold week!

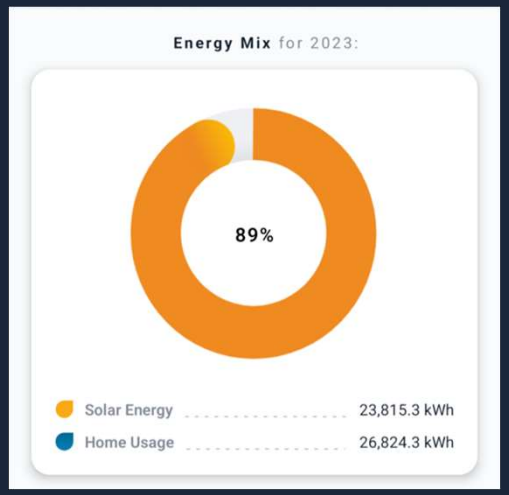
Jan 21 - Jan 28, 2024 (Avg COP = 4.5)

Monitoring Data Review: Carda Residence (New Paltz NY)

Geo + Solar PV = (Nearly) Net Zero

- All electric home
  - Laundry
  - Hot water
  - Cooking
  - Pool pump + heat pump
  - Geothermal heat pump!
- Added 21 kW solar PV system in 2022 to (nearly) cover 100% of the energy load of the house
  - Approx 50:50 split for base electricity load vs HVAC
  - Installed 58 panels (would have needed more than 70 panels with air source)
- Covers 90% of elec load (about 4-5 panels short)
  - Pool was added later
- Projected annual electric use:
  - Base load: 12,000 kWh/yr
  - Geothermal: 8,000 kWh/yr
  - Pool + heat: 5,000 kWh/yr

Monitoring Data Review: Carda Residence (New Paltz NY)



Financial Overview of PV System

- Cost to install:
  - $67,690
- NYS state income tax credit:
  - $5,000
- Federal ITC (30%):
  - $18,807
- Out of pocket cost:
  - $43,883
- Purchase financed with 20-year loan
  - Monthly loan payment: $300/month (directly applied the 30% ITC to loan balance)
  - Monthly electric bill savings: $420/month

Monitoring Data Review: Carda Residence (New Paltz NY)

End Result = Gold!

Certificate No. DH-000000

Pearl CERTIFIED

Certification Date: July 14, 2022

High-Performing Home

108 Le Fevre Ln, New Paltz, NY 12561-2683

Gold

This home's high-performing asset specifications can be found in the Pearl Certification Report and Appraisal Institute's *Residential Green and Energy Efficient Addendum* that accompany this certificate.

W. Casey Murphy
Pearl VP of Quality Management

Pearl Certification Services
Certifying Contractor

SOLAR

Thank You!

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cell: (605) 695-4026

High-efficiency homes sell easier, and for more

9/10 homebuyers would choose a house with energy efficient features over a cheaper, less efficient home*

5%+ Premium price for high-efficiency homes, according to a study by Pearl Certification**

63% of Realtors said that energy efficiency promotion in listings was very or somewhat valuable*** Geothermal is the best bang for the buck of all your options.

*NAHB Study,
** Pearl Appraisal Study,
***National Association of Realtors

How does geothermal work?

1. **Ground Loop**
   Ground loops absorb heat from the constant underground earth temperature.

2. **Heat Pump**
   Heat exchangers transfer heat from the ground loop to a refrigerant, which runs through our compressor, boosting the temperature.

3. **Distribution System**
   The hot refrigerant exchanges heat with air in the house via distributed through traditional ductwork.*

*Process is reversed in cooling mode