CALIFORNIA GEO
California Geothermal Heat Pump Association

The California Buyers Guide to Geothermal Heat Pump Systems

- An Information Survival Kit for the Prospective Geothermal Heat Pump Owner

by K Penning, Director, California Geo

If you are curious enough to open this document, you are researching the possibility of installing a geothermal heat pump in your home, and you may have questions like:

- How do geothermal or ground source heat pumps work?
- Do geothermal heat pumps work in California?
- How much do geothermal heat pumps cost?
- Can I replace my old furnace/air-conditioner with a ground source heat pump?
- Who can I contact to help me with my home heating and cooling project?
- Where can I learn more about tax credits, rebates, and incentives?

As an experienced contractor selling, designing, installing, and servicing geothermal heating and cooling systems in northern California, I want to share some basic information with homeowners like you, which I have learned over the past 30 years. This article is by no-means intended to be the complete resource regarding this subject - so be sure to see the "For More Information" at the end of this article. Let's start by answering these first six questions.

How do geothermal or ground source heat pumps (GSHP) work?

The following link will take you to the US Department of Energy website where you can obtain a description of these systems, how they work, and get a quick primer of the different ways these systems can be designed. https://www.energy.gov/energysaver/geothermal-heat-pumps

Do geothermal heat pumps work in California?

Ground source heat pumps work in every climate zone in California except climate zone 16, which is where the earth temperatures are too warm due to geothermal (hot water and steam) activity. California has diverse geology, from beaches to granite mountains, and earth temperatures that are colder up in the Sierras than the earth temperatures in the Central Valley. Because California is part of the Pacific Rim, there are some pockets of geothermal activity close

to the surface outside of climate zone 16 which can contribute to warmer than expected earth temperatures.

(1)Inspired by "*An Information Survival Kit for the Prospective Geothermal Heat Pump Owner,"* by K. Rafferty, P.E, Geo-Heat Center, Oregon Institute of Technology, 2021.

What does a geothermal heat pump installation cost?

The total installed cost for a geothermal heat pump will be more than a conventional system. My experience is that a geothermal system installation can cost 2 to 3 times the cost of a conventional system.

The geothermal ground loop heat exchanger and corresponding labor is a costly component of the installation. For a conventional 1500 – 2500 sq. ft home, this item can easily be in the $20,000 to $40,000 range. A horizontal trench is typically cheaper than the vertical bores which require a drilling rig.

The geothermal HVAC equipment costs more also. Since the geothermal equipment provides higher efficiencies, is manufactured in significantly less volume, and has more components, (circulation pump, expansion tank, etc..), it is easy to see that this equipment will cost more than a conventional system.

Most residential and commercial air conditioners in the United States are oversized by 25 to 50%. (https://www.aceee.org/files/proceedings/2008/data/papers/1_692.pdf)

This means that an over-sized system will need to have a larger ground loop. This condition has a multiplying effect, as significant, unneeded costs will be added to the project by installing an oversized ground heat exchange loop.

This is why a "design" is recommended, so that the HVAC equipment and the ground heat exchanger loop are properly sized and keep the installation costs in check.

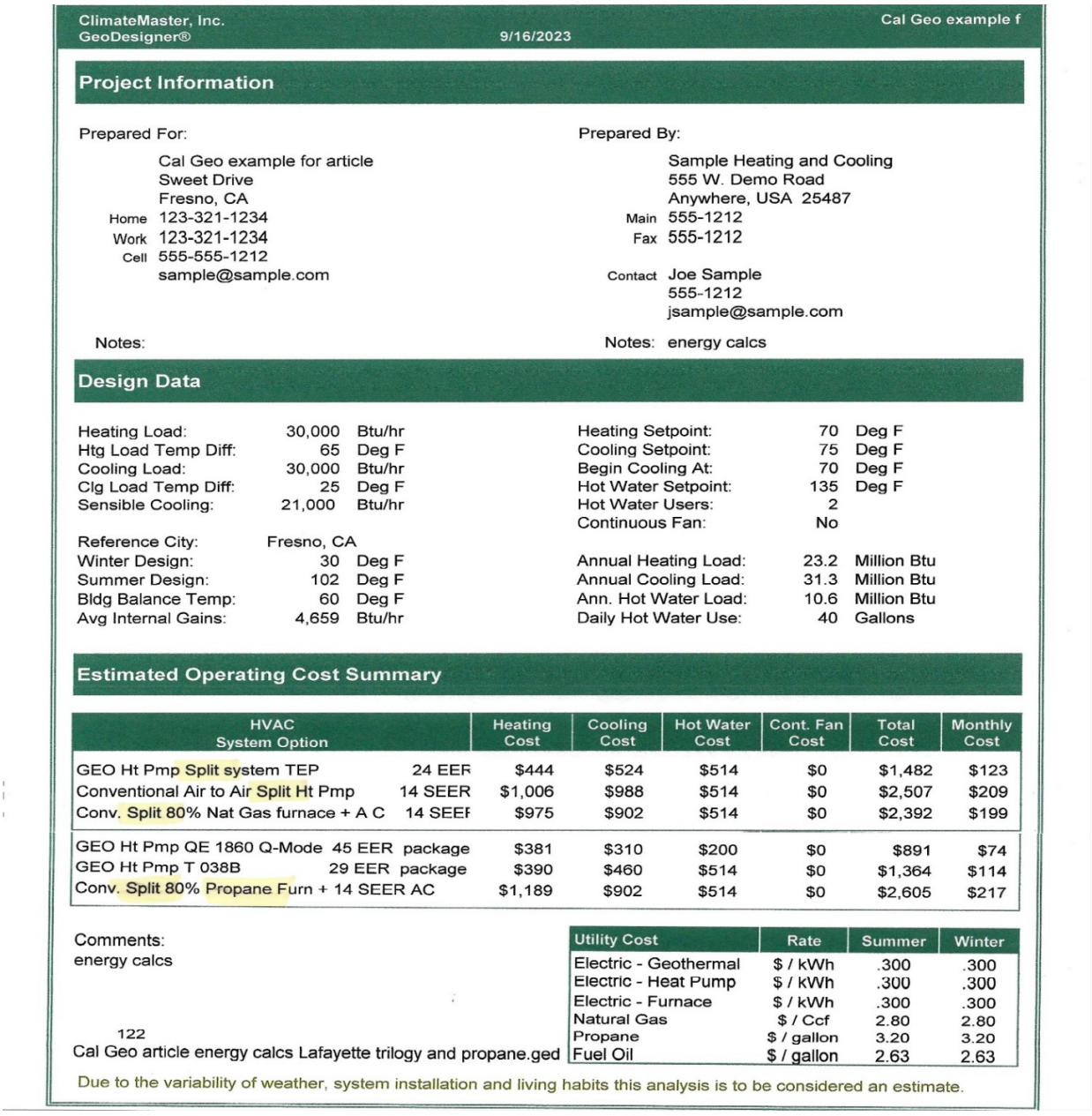
System energy costs and $ savings.

Energy costs for geothermal heat pumps are typically 25 to 50 percent less than other HVAC systems, depending on the home, geographical location, and homeowner consumption patterns.

A properly designed and installed geothermal heat pump has the best and fastest payback in cold, heating-dominant climates. This means that a geothermal system will pay for itself faster in Minnesota, Indiana, New York, etc. faster than most places in California, (except perhaps the Sierras). This is part of the reason that other states have significantly more geothermal heat pumps installed than California.

In California, a geothermal heat pump has the best payback when compared to propane furnaces on properties above 3,000 feet elevation. When propane is the heating fuel, the estimated paybacks I have generated are in the 8–13-year range in the Bay Area in northern California, excluding the tax credit which can cut the payback time nearly in ½.

In the Bay Area of California, a geothermal heat pump will have a 15-20 year pay back when compared to heating with natural gas or an air source heat pump. Again, this excludes the tax credits which will reduce the payback time.



ClimateMaster, Inc.
GeoDesigner®
9/16/2023
Cal Geo example f

Project Information

Prepared For:
Cal Geo example for article
Sweet Drive
Fresno, CA
Home 123-321-1234
Work 123-321-1234
Cell 555-555-1212
sample@sample.com

Notes:

Prepared By:
Sample Heating and Cooling
555 W. Demo Road
Anywhere, USA 25487
Main 555-1212
Fax 555-1212

Contact Joe Sample
555-1212
jsample@sample.com

Notes: energy calcs

Design Data

Heating Load:	30,000	Btu/hr	Heating Setpoint:	70	Deg F
Htg Load Temp Diff:	65	Deg F	Cooling Setpoint:	75	Deg F
Cooling Load:	30,000	Btu/hr	Begin Cooling At:	70	Deg F
Clg Load Temp Diff:	25	Deg F	Hot Water Setpoint:	135	Deg F
Sensible Cooling:	21,000	Btu/hr	Hot Water Users:	2	
			Continuous Fan:	No	
Reference City:	Fresno, CA				
Winter Design:	30	Deg F	Annual Heating Load:	23.2	Million Btu
Summer Design:	102	Deg F	Annual Cooling Load:	31.3	Million Btu
Bldg Balance Temp:	60	Deg F	Ann. Hot Water Load:	10.6	Million Btu
Avg Internal Gains:	4,659	Btu/hr	Daily Hot Water Use:	40	Gallons

Estimated Operating Cost Summary

HVAC System Option	Heating Cost	Cooling Cost	Hot Water Cost	Cont. Fan Cost	Total Cost	Monthly Cost
GEO Ht Pmp Split system TEP 24 EER	$444	$524	$514	$0	$1,482	$123
Conventional Air to Air Split Ht Pmp 14 SEER	$1,006	$988	$514	$0	$2,507	$209
Conv. Split 80% Nat Gas furnace + A C 14 SEEF	$975	$902	$514	$0	$2,392	$199
GEO Ht Pmp QE 1860 Q-Mode 45 EER package	$381	$310	$200	$0	$891	$74
GEO Ht Pmp T 038B 29 EER package	$390	$460	$514	$0	$1,364	$114
Conv. Split 80% Propane Furn + 14 SEER AC	$1,189	$902	$514	$0	$2,605	$217

Comments:
energy calcs

Utility Cost	Rate	Summer	Winter
Electric - Geothermal	$ / kWh	.300	.300
Electric - Heat Pump	$ / kWh	.300	.300
Electric - Furnace	$ / kWh	.300	.300
Natural Gas	$ / Ccf	2.80	2.80
Propane	$ / gallon	3.20	3.20
Fuel Oil	$ / gallon	2.63	2.63

122
Cal Geo article energy calcs Lafayette trilogy and propane.ged

Due to the variability of weather, system installation and living habits this analysis is to be considered an estimate.

Figure 1: Operating Cost Summary of various HVAC system Options for an Example Home

An example estimated operating cost summary is provided in Figure 1. Of course, these are just examples which are based on my utility rates. Utility rates, weather data, home size, home insulation, etc. will all be different for your home and location. The value of these example reports is that the same engine is providing the numbers from a common input.

Can I replace my old furnace/air-conditioner with ground source heat pump?

It depends. The first thing to determine is whether there is sufficient land on your home or building site to install a vertical or horizontal ground heat exchanger. For 3 projects with small lots, we placed the loop field under the driveway. If you happen to have a pond or lake on your property, this might be used instead of a ground heat exchanger.

If there is sufficient land for a ground heat exchanger, the next step is to have a qualified contractor or designer should look at your existing equipment to see how challenging it will be to replace the equipment in the same place and to run pipe from the ground heat exchanger into the location where the mechanical equipment will be located.

Who can I contact to help me with my home heating and cooling project?

One way to answer this question is to suggest the avoidance of the following consultants:

- Those that will not personally come out to your home for an evaluation.
- Those that will not perform heat gain and loss calculations and preliminary design work.
- A contractor that is a significant distance from your home is not a good bet for future service work.
- An installation firm that does not have a service department.
- Those parties, on the internet, just want to sell equipment and offer advice.
- Firms that use a standard bore depth per ton.
- A firm doing their first installation. (Everyone has their first time for something, just make sure the firm has experienced mentors to back them up.)

Who should design and specify a geothermal system?

A successful and reliable installation starts with a good plan. I have found that every retrofit and new installation is unique. Rarely does a cookie cutter design work for the many different sizes and floor plans of homes. The person designing a system should be trained or certified by organizations such as IGSHPA, ASHRAE, a manufacturer or other state certification program.

Contractors or mechanical engineering firms are good sources of design. Expect to pay for the design work.

One of the benefits of using a designer is that they will perform building loads which calculate your home's heat loss and gain to correctly size of the equipment and ground loop. This is commonly referred to as a Manual J calculation. See an example of a Manual J calculation attached to this article. Designers are a neutral party and are interested in finding the right equipment for your special situation. Be sure that you pay enough to get the energy usage comparisons, installation drawings of the ground loop, equipment schedule, floor plan, installation details, etc. Once the plans are completed, contractors can be contacted.

A contractor will know that you are serious when a current floor plan for a retrofit project or a complete set of plans for a remodel or new build are available.

Who should do the installation of the geothermal heat pump system?

The installing contractor needs to be a heating and air conditioning contractor with the appropriate equipment (flush cart, fusion tools), certifications and training. The HVAC contractor should be the quarterback to integrate the various specialty trades. Specialty contractors are typically brought in for drilling the geothermal bores or trenching. With larger projects, a clear scope of work and responsibility are a best practice to avoid forgotten task(s), change orders and disagreements.

A geothermal heating and cooling installation is not a do-it-yourself project. (An exception is the talented, construction-oriented property owners that own their own backhoe. In many circumstances these owners have been proven capable of doing the trenching for a horizontal ground loop. These owners also had a professional design and plans to follow.)

Where can I learn more about tax credits, rebates, and incentives?

https://www.dsireusa.org/

The current Federal tax credit is 30% of ALL the geothermal heat pump system related installation costs. Aggressive home owners have gotten restorative landscaping, updated electrical panel, new drive way, etc. "On Sale" (by using the tax credit) for the legitimate % of those costs that are related to the geothermal installation. Obviously, consult with your trusted tax professional.

One example of a local incentive is from the City of Sunnyvale. They allow homeowners to have a higher lot coverage (bigger house) when a geothermal heat pump is installed. This meant that one of our clients was able to have a larger home installed on the lot than normally permitted

For more information about tax credits, please visit any of these websites:

https://www.climatemaster.com/homeowner/up-links/tax-incentives

https://blog.enertechusa.com/claim-your-geothermal-tax-credit

https://www.waterfurnace.com/literature/collateral/br1507mw-tax-credit-residential.pdf

https://www.irs.gov/credits-deductions/residential-clean-energy-credit

To help you get to ***why*** in your decision-making process regarding whether a geothermal heat pump system is right for you and your home, please read on.

Why should one consider the installation of a geothermal heat pump heating and cooling system in one's home?

Geothermal is the most energy-efficient, environmentally clean, and cost-effective space conditioning system according to the Environmental Protection Agency.

The environment.

A geothermal heating and cooling (heat pump) system will lower the homeowner's carbon footprint. A heat pump consumes electricity, so fossil fuels (natural gas, propane, and fuel oil) are not consumed on site.

When the electricity generated to operate your geothermal heat pump system comes from a renewable source, the system becomes even greener.

A geothermal heat pump is more efficient than other heating and cooling systems because it:

- is all electric and uses less electrical energy during the cooling season than traditional air conditioning or air source heat pump. A geothermal heat pump also uses less electrical energy in the winter than an air source heat pump.
- eliminates the use of fossil fuels, helping to protect the environment for your kids, grand kids, and future generations by using fewer natural resources.

Geothermal heat pumps have a long service life.

A geothermal heat pump is a close relative of the water source heat pump (which is the commercial version). As a contractor, I was replacing these water source heat pumps after 30-40 years of service in several local condominium complexes.

Typical air source heat pumps in the Bay Area of northern California have a service life in 10-15 years. A properly designed and installed geothermal heat pump system can be expected to operate twice as long as this.

Geothermal heat pumps eliminate the noise of outdoor equipment.

Since a geothermal heat pump does not have a noisy outdoor condenser fan motor, like a typical air conditioning or heat pump condensing unit, unwanted noise is avoided. A home owner can now use that outdoor patio without that obnoxious droning of air conditioning condensing unit.

Geothermal heat pumps are more flexible, compatible with hydronic radiant and forced air systems.

Geothermal heat pump systems are available as *"water to air"* systems or *"water to water"* systems.

A water to air heat pump is the same delivery method as a typical furnace and air conditioner. Water to air Geothermal heat pumps are available as a typical split system, (2 pieces), or a package unit (1 piece). This equipment can be in the basement, a closet, or the attic.

Figure 2: Typical geothermal heat pump split system. The air flow can be configured by the installer to be vertical up-flow, downflow, or horizontal.

Figure 3: Water-to-air geothermal heat pump package unit.

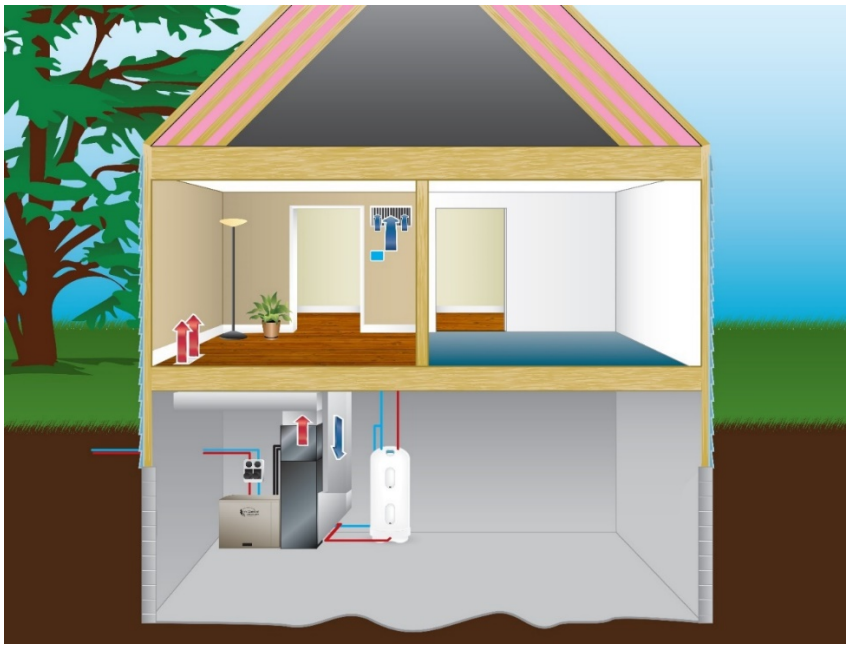


Figure 4: The above graphic illustrates a possible geothermal HVAC installation.

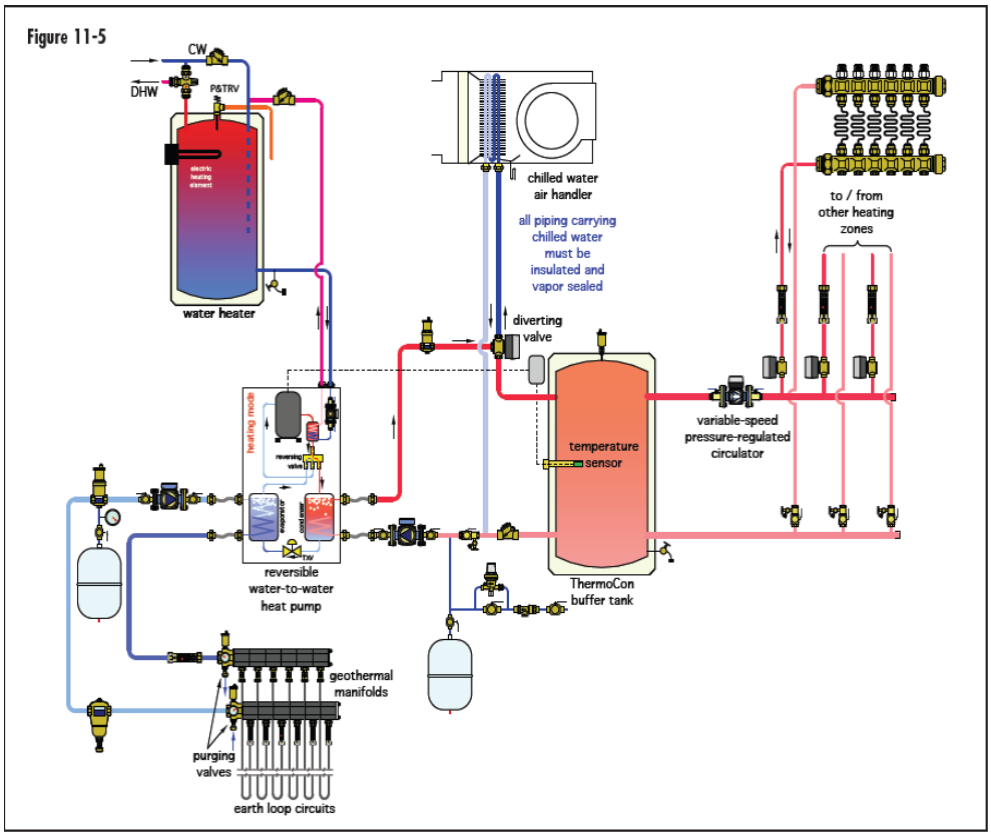


Figure 5: Diagram of a water-to-water geothermal heat pump (hydronic) system

A water-to-water geothermal heat pump replaces a low temperature boiler for radiant heating systems. A water-to-water geothermal heat pump will also do the job of a "chiller." (A chiller makes cold water which is used to cool a building). Water-to-water heat pumps are the "engine" that drives a radiant/hydronic heating/cooling system.

In addition to why you might want to install a geothermal heat pump in your home, here is some additional information or questions you may have as you go through my article.

What are the most important items for a successful geothermal heat pump installation?

Based on my experience those items are:

1. The design of system. This encompasses many items, properly sized heat pump and ground loop, appropriate "system" for the application
2. A properly installed system
3. Local equipment support
4. Realistic expectations from the completed project

What brand of equipment should I consider?

The reality is that all the major brands are quality products.

All the brands are aggregators of common components, most use the same compressor brand, in concert with various brands of fan motors, blower wheels, heat exchangers, coils, electrical components, etc.

The unique items that each manufacturer brings to the table are the research + development, engineering + design, component matching, circuit boards, operating software, control algorithms, business philosophy, sheet metal panels, packaging, paint and finishing, sales, distribution, reliability testing, advertising, etc.

My personal criteria when shopping for new equipment and machinery is - what brands are popular in my area and which brand has the best local support.

What type of ground loop should I request, vertical bores, horizontal, lake or pond loop?

This is a question best left to the designer or geothermal heat pump contractor. My experience in the bay area was predominately with vertically bored ground loops. This was dictated by the small lots of sub-division homes.

Who are the homeowners in California that are currently having geothermal heating and cooling system installed?

My experience is the current purchasers of geothermal heat pumps are environmentally conscious, successful, trendsetters, leaders, and long-term thinkers who want to do the “right” thing.

When should I have a system installed?

Keep an eye on the rebates that are available and their expiration dates. As this is being written, there is a 30% Federal tax credit on all the installation costs associated with a geothermal heat pump. Utilities in various areas have had incentives. Hopefully more utility and regional incentives will become available.

The geothermal heat pump installation process is much more involved than replacing a traditional cooling and heating system. We have had replacement projects executed as fast as 4 months. The crew was on site for only 1 + weeks. The rest of this time was spent waiting for the equipment and the drillers schedule. Scheduling the driller is typically “the” critical path task. Other installations have taken much longer when the geothermal heat pump installation was part of a home remodel as we had to wait on the other trades to finish the rest of the building.

The underground work is best performed in dry seasons. It was not a lot of fun when we were having to deal with wet weather and the mud. Keeping the dirt and mud out of the ground loop piping is much easier when it is dry.

Most successful heating and cooling contractors are very busy during the summer. This leaves the spring and fall as the times when the contractor will be most focused on your project.

How does one pay for geothermal heat pump installation?

Most of our clients have had enough savings to write a check for each phase of the project. Financing is available.

- A home equity line of credit is a good choice.
- Some manufacturers offer their contractors vetted financing programs.
- Leasing

  Loop leasing is provided by utilities in a few areas. The electrical utility will install the geothermal heat exchange loop and "lease" it back to the home owner over 30 years. The Plumas-Sierra Rural Electrical Co-operative has a very successful program in place.

  https://www.psrec.coop/energy/energy-savings-products/geoexchange-program/

  There are many similar programs in other states.

  In order for this type of program to become readily available at the larger California utilities, smaller California utilities such as Santa Clara's Silicon Valley Power, City of Palo Alto Utilities need to offer these types of programs. Then John Q. Public needs to loudly demand it from the bigger players.

  In my opinion, this financing vehicle is key element to increasing the number of installations in California.

  The solar P V business has done a great job with providing leases to customers. On a couple of occasions, I worked with a solar/electrical contractor with the goal being to add the geothermal installation costs in with the solar system lease. Those projects ended up being scaled back and did not proceed.

- Another financing option called PACE (Property Assessed Clean Energy) is available in select Counties of California. The unique thing about this program is the payments are lumped in with the property taxes. The way it was explained to me, is that additional cost is now a part of the part of the property taxes and is now deductible for those itemizing deductions. https://www.energy.gov/scep/slsc/property-assessed-clean-energy-programs

- Other home improvement financing firms and programs are out there, but please be careful, some are very predatory. I occasionally offered clients the “no money down, same as cash” programs – BEWARE – miss one payment and the financing firm will go back to contract date and hit the homeowner with an exorbitant interest expense.

For More Information

https://www.californiageo.org/geothermal-basics-ground-heat-exchangers/

https://www.californiageo.org/learning-more/

https://igshpa.org/

https://www.youtube.com/watch?v=onmLrUh2cHU

The above video is well done, however there a few minor things to point out.

a) The earth temperature is warmer than 50 degrees, especially in California.

b) Industry professionals have settled on the correct term being “Ground Loop Heat Exchanger” without the word “well”.

A special thanks to:

- Climate Master Inc. for permission to publish the Geo Designer report
- Enertech for the equipment pictures
- Caleffi Hydronic Solutions for the water-to-water piping diagram
- **Attachment:** Manual J Report example

Project Report

General Project Information

Project Title:	Cal Geo Example
Designed By:	Kent P
Project Date:	Monday, September 18, 2023
Client Name:	Cal Geo Example
Client Address:	Sweet Drive
Client City:	Lafayette, CA

Design Data

Reference City:		Concord, California
Building Orientation:		Front door faces South
Daily Temperature Range:		High
Latitude:	38	Degrees
Elevation:	23	ft.
Altitude Factor:	0.999	

	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	27	25.2	n/a	n/a	70	n/a
Summer:	97	68	22%	50%	75	-9

Check Figures

Total Building Supply CFM:	775	CFM Per Square ft.:	0.644
Square ft. of Room Area:	1,204	Square ft. Per Ton:	682
Volume (ft³):	10,234		

Building Loads

Total Heating Required Including Ventilation Air:	33,006	Btuh	33.006	MBH
Total Sensible Gain:	21,210	Btuh	100	%
Total Latent Gain:	-34	Btuh	0	%
Total Cooling Required Including Ventilation Air:	21,210	Btuh	1.77	Tons (Based On Sensible + Latent)

Notes

Rhvac is an ACCA approved Manual J, D and S computer program.
Calculations are performed per ACCA Manual J 8th Edition, Version 2.50, and ACCA Manual D.
All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

Total Building Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
1D-cv-o: Glazing-Double pane, operable window, clear, vinyl frame, U-value 0.57, SHGC 0.56	158	3,872	0	4,189	4,189
11D: Door-Wood - Solid Core, U-value 0.39	21	352	0	229	229
12B-0bw: Wall-Frame, R-11 insulation in 2 x 4 stud cavity, no board insulation, brick finish, wood studs, U-value 0.097	790	3,295	0	1,126	1,126
12B-0bw: Part-Frame, R-11 insulation in 2 x 4 stud cavity, no board insulation, brick finish, wood studs, U-value 0.097	238	923	0	346	346
16CR-11: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Vented Attic with Radiant Barrier, Dark Asphalt Shingles or Dark Metal, Tar and Gravel or Membrane, R-11 insulation, U-value 0.081	1204	4,194	0	4,096	4,096
19A-0cp: Floor-Over enclosed crawl space, No insulation on exposed walls, sealed or vented space, passive, no floor insulation, carpet or hardwood, U-value 0.295	1204	5,737	0	2,935	2,935
Subtotals for structure:		18,373	0	12,921	12,921
People:	3		600	690	1,290
Equipment:			0	0	0
Lighting:	200			682	682
Ductwork:		6,167	-52	4,422	4,370
Infiltration: Winter CFM: 0, Summer CFM: 0		0	0	0	0
Ventilation: Winter CFM: 100, Summer CFM: 100		4,726	-582	2,418	1,836
Hot Water Piping, 200 ft. Total:		3,740	0	0	0
AED Excursion:		0	0	78	78
Total Building Load Totals:		33,006	-34	21,210	21,177

Check Figures

Total Building Supply CFM:	775	CFM Per Square ft.:	0.644
Square ft. of Room Area:	1,204	Square ft. Per Ton:	682
Volume (ft³):	10,234		

Building Loads

Total Heating Required Including Ventilation Air:	33,006	Btuh	33.006	MBH
Total Sensible Gain:	21,210	Btuh	100	%
Total Latent Gain:	-34	Btuh	0	%
Total Cooling Required Including Ventilation Air:	21,210	Btuh	1.77	Tons (Based On Sensible + Latent)

Notes

Rhvac is an ACCA approved Manual J, D and S computer program.
Calculations are performed per ACCA Manual J 8th Edition, Version 2.50, and ACCA Manual D.
All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

Building Pie Chart