# Sustainable Energy Resources for Consumers Webinar on Residential Geothermal Heat Pump Retrofit Transcript

The following is a transcript of a Webinar recording on residential geothermal heat pump retrofits, which was presented on Dec. 14, 2010 for Sustainable Energy Resources for Consumers Grantees and sponsored by the U.S. Department of Energy. Watch the video recording.

*Liz:* Thanks very much. This is Liz Doris. I'm with the National Renewable Energy Lab. I coordinate technical assistance here at the lab. I wanna thank everybody for joining us today in our SERC webinar series. In this series, we're trying to help give a baseline to people on different renewable energy technologies, and we're really excited today that we have Erin Anderson with us to talk about geothermal heat pumps. This is one that we get a lot of questions about.

So I'm gonna hand it over to her in a minute, but before I do that I just wanted to let you know that we have muted the other lines because we're recording. But you can contact us through the Q&A mechanism. If you look at the buttons across the top of the webinar, there's one that says Q&A, and if you click on it you can type in a question, and at the end of Erin's talk, we'll answer as many of those as we can, and we might try to answer them over email afterwards.

Also if you have further questions or if you have questions at all on SERC, DOE is supporting us to answer technical assistance questions. So you can feel free to email us at SERC_TA@NREL.gov. And so we wanna thank DOE for supporting that, and hopefully that can be helpful to you as you move forward with your projects. So – and also just so you know, we're not – we usually do these every two weeks if you've been following this series.

We're not doing one on December 30th. We're gonna resume on January 11th at the same time, and there'll be a registration page sent out to you. Amy Hollander is going to talk about community marketing, and so I think that will be a really good one as well. We hope to see you then, and we hope you have a great, safe holiday. So with that, I will hand it over to Erin Anderson, who's an NREL expert in geothermal. And she comes to us fresh from the field this morning, so she's got a lot of field experience.

She also has a master's degree in geothermal science, an MBA and then a degree in civil engineering as well. So with that, I will hand it over to her, and thank you very much, Erin, for coming down.

*Erin:* Thank you for having me. So morning, everyone. This is gonna be a talk about residential geothermal heat pump retrofits, and hopefully – so I'm just gonna go over – I was asked to go over several topics, which the first is just what is the technology. What are the options out there? How is this applicable, and what are the applications on residences? What are the costs? And this is gonna be a rough cost estimate.

It really varies from region to region based on how many geothermal heat pump installers are out there and what I've called a mature and an immature market. Use and availability – how is it you find certified designers, installers, contractors? What are some of the financing options out there? There isn't a lot, and I'm not sure if you're all government entities, if you can actually apply for tax credits, but we'll go over that.

Some key information for RFPs. We'll look at project Q&A and how is it you can monitor projects and know that things are going smoothly. And the last part will be what types of tools and what information is out there in geothermal heat pumps that you can kind of get more knowledgeable than just this webinar. So first are the technology options – geothermal energy in and of itself is just below the ground.

It's a fact about 47 percent of the sun's heat is absorbed in the shallow parts of the ground, and this graph that I have in the upper right-hand corner kind of shows a variation of the temperatures as you go a little bit deeper. The deeper you go, until about 30 feet, you actually see average throughout the year that equate to the average air temperatures.

So sometimes when you're limited with space, and I'll go into this in the next slides, vertical bore holes actually have a little bit better of a time because the temperature is more consistent. But if you do a shallow geothermal well six feet below you'll actually see that there's a lead in the lag, so there's still an advantage over something like an air source heat pump.

So why are geothermal heat pumps – why are they being talked about? Why are they being looked at? And it's first and foremost; they're highly efficient for providing both heating, cooling and actually supplemental or total hot water heating for residences. It works that using the ground temperature as the renewable resource

– even if you're in the south, there's people that say, "Well, we're cooling dominated, so we're rejecting too much heat."

It comes down to how adequate are your designers and installers at knowing what geothermal is and designing the heat exchanger, which is the pipes that are in the ground, efficiently. So in theory in a place like Colorado, you're taking heat in the winter from the ground, you're absorbing it. In the summer time, you take heat from your house and you reject it into the ground. It's highly cost effective, and you have environmental benefits. It's cost effective both in terms of the end user – the maintenance costs, operational costs – and the utility costs.

So this is just a schematic. And when I first introduced to this, you're thinking, "Okay, the average temperature around the U.S. in the underground is between 60 and – well, let's say 55 degrees Fahrenheit is the average temperature across the U.S., and you're saying, "How am I gonna get that 55 degrees and bring it up to 72 if I wanna heat my house?" And it just works the same way that a refrigerator does.

What it does is you're circulating fluid in the ground anywhere between 34 to 60 degrees. It comes into what is called an evaporator that evaporates liquid at a much lower temperature than what water is. So you're not trying to boil water at 212 degrees Fahrenheit. It actually boils at – like a refrigerant would – at 32 or sometimes 16 degrees Fahrenheit. So you boil this off and then as you compress it you actually increase pressure. You increase the heat capacity of something.

So you end up compressing this gas, and it released heat, and it's this heat that heats your house. And in the summertime when you want to cool your house you actually reverse the process. So I have a schematic here that says, you know, this is how the ground transfers energy to the refrigerant. You're gonna increase the pressure, which increases the temperature, and then the heat is transferred either to fluid, if you have hydronic floor heating or radiant floor heating or what – if you're replacing a natural gas system that's hot forced air – a fan actually takes that heat away and transfers it throughout your house. So why is it so – why is geothermal efficient?

And I kind of came up with this slide. It's – everyone wants the money tree in the backyard, and geothermal energy is the closest you can get to that. And this schematic actually shows you put one unit of electricity in from the grid, you harness what you can from the earth, which is three to five units, and you actually get four to six units, which is why they talk about coefficients of performance in heat pumps.  It's a little bit different than how you rate a boiler or an oil heater or something like that.

And what it is is the amount of heat that's delivered, including that which is extracted from the ground and that which is provided to the heat pump is divided by electrical power input.  So you see here you're getting one unit – you're only using one unit from the grid, but you're actually output is four to six.  So it's highly efficient over 100 percent.

So this graph is just saying why geothermal heat pumps are useful, and it's graphed to show what the average air temperature is – and this is just for a specific spot I picked; there's nowhere in general it's averaging – what the ground temperature is – 1.7 meters, and that is 3.5 feet – and then far field temperature – 75 meters; you're talking 120 feet.  So as you can see the ground temp – the air temperature is really variable, which is why sometimes you have problems with air source heat pumps, because you're bringing in that 90 temperatures during the hot days and trying to cool your house with it versus bringing in 50-degree temperatures from the ground.

You can see that the ground temperature has a little bit of a lag.  So the peak in the green line is after our peak in the air temperature. And then far field, which is optimally where you'd wanna built your geothermal heat pump, is pretty average throughout.  And when you need to heat your house, you have heat you can pull up, and when you need to cool your house you have a place to reject the heat.

So there are a couple of characteristics of heat pumps, and when you're talking to designers or installers they're gonna wanna know what – and especially for retrofits – what are the units that you're trying to replace.  And then they'll give you terminology that will help dictate what type of heat pump you're gonna use.  So if you're trying to replace a natural gas system, more than likely you're gonna go water-to-air, and that means that you have water running through loops in the ground, and you're gonna come up, and the heat pump's gonna compress it, and the heat is gonna be transferred away through a fan unit in the heat pump itself.

And that's the air portion.  Air-to-air is an air source heat pump, and it sits on the same pad that your air conditioning unit would sit and does the same thing – takes air from the outside, compresses it, delivers it.  You just have a lower coefficient of performance because of your delta that you have and variability of the outside air temperature.  And then water-to-water uses hydronic pipes within the building.  This is called—the terminology is—radiant floor heating.

This probably I'm assuming on some of the jobs that you have won't be existing in a lot of the retrofits; so more than likely you'll be water-to-air.  And then an added benefit, which I'll try and highlight in further slides, is that not only does it heat and cool, but you can produce your domestic hot water supply from a heat pump as well.  So what are the system components?  This upper left-hand picture is kind of a schematic of – you have your ground loops, and that's what we classify as your ground heat exchanger.

It is how you're getting heat from your house to the ground, and from the ground to your house.  It is the most critical part of a geothermal heat pump.  Designing that, sizing that appropriately for the space that you have for the square footage and for the kind of envelope – how tight your envelope is – is really critical.  Here and you see you have a domestic hot water loop.  So you can actually – you can provide preheating to your hot water or your full load depending on how much your – how big your water tank is, and it can always be on-demand.

And you have your refrigerant loop, which is in the – the refrigerant loop is what – sometimes it's R410, which is the newest one that's been improved that's used from a lot of heat pump manufacturers.  That's what circulated in the refrigerant loop.  It's closed-loop, so it can never contaminate the geothermal loop, which is in the field.  And then there's a picture of the air fan circulating, which that actually – you have the air heat coils heats, and then as the air sucks air through, it heats the air and transfers that through the house.

So there are two types of heat exchangers: open-loop and a closed-loop.  Open-loop is where you're using the water directly from either a river, a pond, an aquifer, and it's what some people in the industry call a "pump-n-dump."  You're literally pumping the water up, using it through your heat pump and then dumping it either in the same well or back into a river or into a pond.  There you're exchanging heat and water with the ground because the water in itself is a great ability to harness a lot of the heat.

A closed-loop is more popular just because of – not everyone has a water pond or a river surrounding their house, so closed-loop is more utilized in the industry.  It's either buried HDP, which is high-density polyethylene pipe, which is the same type of pipe that's used in the gas industry.  Manufacturers guarantee it for 50 years, but the lifetime of some of the studies is 200-plus years. And then the other is a copper pipe, and that's termed "direct exchange."

If you use the copper pipe in the ground, what you're doing is you're actually circulating your refrigerant all throughout the ground loop, and a buried HD pipe what you're circulating is water or a water and antifreeze mix. It's usually about 20 percent antifreeze, which the industry uses usually glycol. And that's just for reasons that it might be susceptible to freezing. So the closed-loop actually only exchanges heat with the ground because the fluid is closed loop, and it circulates, and you're just trying to dissipate the heat that's in the look to the surrounding rock and soil.

So the first type of closed loop is a horizontal trench loop. It's cost-effective when there's a lot of land that's plentiful because you can usually use a device like a Ditch Witch – something that's pretty inexpensive, doesn't require a lot of man hours and can get to the depths that you want to, which is usually about six feet or more below the frost line. Rule of thumb is the trench length is typically 300 feet, and that gives you about 600 feet of pipe. And you can see in this picture here, they've stacked the pipes on top of one another to try to utilize more of the trench area.

And this is a couple more layouts, and throughout the industry you can run things in series or run things in parallel, and that's kind of what this is showing here. You could have one continuous loop that goes out of the house, and the upper right-hand path says " path requires a lot of land area," and you usually need a lot – the pipe diameter is actually really large because you're trying to flow – use a lot of pumped pressure in order to get the fluid to flow without having a lot of air pockets in there versus something to the right, which is called a "slinky design," and you can have this both – a slinky can be both horizontal or vertical.

So you can have your trench four feet wide and lay the slinky down in the bottom, or you can have your trench pretty narrow and it's kind of top to bottom is how the pipe is laid. This is really useful when you have land but you're actually putting a lot more pipe area per length of trench in there, so it's usually pretty cost effective.

So the second type versus a horizontal is a vertical ground loop. It's also called "bore hole." You use this when you have land restrictions. The temperature is as we mentioned before typically more constant because you don't have the fluctuation of the seasonal effects with shallow depths. Drilling depths are usually 200 to 300 feet, which give you 400 to 600 feet of pipe, and the rule of thumb – and I'm cautioning, rule of thumb is not what you should design to, but it's a good first estimate – is for one ton of cooling for every 200 to 300 feet of bore hole.

And knowing what your program is and that you're trying to weatherize a lot of these houses, I would say that's an overestimate. If you're really gonna go into a house first and bulk up on the insulation, fix the windows and make the envelope really tight, you're gonna have one ton for maybe every – or you're gonna have two tons maybe for every 200 to 300 feet of bore hole. You're actually gonna get more out of it because you don't need so much for your house.

You're gonna reduce the length of your ground loop that you need if you have a tighter building envelope. The two types of configurations similar to the horizontal is a parallel and a series type of vertical bore holes. Definitely more economical in terms of – if you don't end up short circuiting your system or require a really large pump to power this, parallel is usually what's done in the industry. You have larger capacity heat pumps. Your pipe size usually three-quarters to one inch, the bore hole depth can be increased when you have limited planned areas.

So for instance, we're working with IKEA in Colorado, and they've basically maxed out a 4.5 acre site. They're drilling 500-feet bore holes, 130 in total, and that wasn't enough. For how big the building loads were, that still wasn't enough. So there's an economic kind of barrier that you have to analyze what are the loads you're building, how deep are you gonna go, and what is the most efficient pipe configuration that I can have that makes sense?

So how is it that you're gonna look at some of the applications on residences? And I tried to create a process for you. First it's determining what your heating and cooling loads are. There's an ACC manual J, which heating and weatherization – sorry if this is redundant – but I'm sure you guys are all aware of how to calculate the residential loads. So that's first and foremost. And if you make any adjustments in weatherization to that house that would definitely affect, and it's highly beneficial because you actually have to put in, as I mentioned before, less of a heat exchanger.

You have to put less height in the ground when you have a tighter building. So then you select the heat pump size. You select indoor air and water distribution systems. How is this being transferred throughout the house? If it's a retrofit, what are you working with in the houses? Do you already have ducts in place? If not, are they – what other upgrades have to be made in order to make this successful? And then estimate the building's energy requirements, and then you can therefore size out how big your ground heat exchanger or bore holes – vertical bore holes or horizontal trenches have to be.

So this is one of the more popular methods for residential and commercial. You don't have to look at all the internal heat gains that you have. For residential, you typically look at all the heating degree days, all the cooling degree days for where the region of this residence is. And you aggregate those based on temperature bins. And this is an example of temperature bins, and what the goal is is to maximize your heat pump so that it is efficient for the majority of the time that you need it.

It's not cost beneficial to the homeowner, nor when you're talking about operation and maintenance costs you size the heat pump for every single temperature range that's encountered. So this first one, this is actually for Stillwater, Oklahoma. You see they read 112 degrees Fahrenheit for one hour every year. It's not economical to size this heat pump to incorporate that one hour of the year that it gets to 112 degrees. And you just have to kind of balance what are the residents going to be happy with. Is it going to be okay when it's 112 degrees that it's 80 degrees in the house?

Is that something that they're gonna be able to live with? So you kind of – this is the most economic method, and it's used pretty frequently throughout the industry. And I guess I'll – a few rules of thumb that I'll bring out just so you have them in the back of your mind is kind of what I just mentioned now is that ground loops or the heat exchangers – pipe _______ in the ground is not necessarily sized for the amount of energy that can be extracted at any given point in time. The length of time or the duration is expected – sorry. The length of time it can be expected to provide the energy – so it's not a constant stream.

It's not like a natural gas pipeline. It can diminish in capacity if the design limits are cheated. And the rule of thumb is typically one ton for every 500 square foot of house. But knowing that you guys in the weatherization program, I'd say that does not account for the real heat loss and heat gain of the structure, and you'd need an accurate "BTUs per hour" heat loss for the property to size the geothermal heat pump accordingly. And for your tighter buildings, as I assume you'd be doing, the square footage for this rule of thumb is actually too small. You'll probably have one ton for every 600, 700, 800 depending on what your load calculations come out to be.

So as a designer I'm just gonna kinda give you – you might not be designing these, but when you start getting proposals and RFPs you need to know what is it you're gonna provide for your residents, and how comfortable is it gonna be for what you're paying. And this is an example of heating, cooling – building heating and cooling load. And as a designer you're saying, "Okay, I wanna be comfortable that when the temperature's between 62 Fahrenheit and 67 degrees Fahrenheit I really don't need the heat pumps to be drawing a lot of energy from the ground because I think I can re-circulate the air and just using the compressor and the heat pump itself should be able to give me the temperatures that I want.

When it goes below that – and that's kind of – it's called the balance point. Those two places are called the balance point. So you don't need any temperature – this is the temperature that no heat is required in the geothermal heat pump system. Below 62 degrees up to 13, this is when your heat pump's gonna kick on and you're gonna be circulating fluid through your ground heat exchanger extracting or absorbing heat. And then this is something I mentioned earlier, and that's the free hot water. It's called a de-super-heater. It's not a word that's used pretty often, but what you're doing is you're taking the excess heat off of the heat pumps.

So after you – as soon as you compress the evaporator refrigerant and you let it expand and it gives off the heat, you're taking some of that heat before it goes to your cooling fan because sometimes your fan isn't as efficient as going from a liquid to a liquid. So it's called a de-super-heater, and he can heat your domestic hot water. In the cooling season, depending on how big of a house you have and how big of a heat pump you sized for a unit, you can either have free hot water completely throughout the year or when it's in the heating season you actually get high COP for the heat pump unit because you're using the excess heat for heating the water and therefore not having to use an electric heater or gas heater. And water heat pumps for heat domestic water, the COP is usually – coefficient of performance is between three and five, which is 300 to 500 percent efficient if you wanna look at it in those terms.

So we're gonna look at some of the costs. Generally, geothermal heat pump systems inside the building are less than or equal to conventional systems. It's an incremental cost over a conventional system that has the greatest cost barrier, and that's the geothermal heat exchanger: a.k.a., the ground loop. And some ways to manage these costs are reducing the heating and cooling loads. First and foremost, if you have geothermal contractors out there, they wanna sell you a geothermal heat pump, and they want to be the ones giving you the ground loop.

So it's not in their interest for you to first go in and put in the high efficiency windows, insulate all the doors, weatherproof the doors, insulate the attic, because what that means to them is you buy a smaller geothermal heat pump unit for the house, which is less money, and you need a lot less labor in the field because you're putting less pipe in the ground. So first and foremost, I'd say make efficient building envelopes. And then you need a – depending on how – if you're doing multifamily houses, single-family – one thing you might wanna consider is you could optimally kind of build a district heating system where you might have single-family houses that are all close together in a residence.

Well, you could definitely build kind of a bore hole area where as each house needs heating or cooling it can call for the general ground moves off of this main bore hole system. And if that's the case, the thermal conductivity test would be required just because you're dealing with a little bit larger than – larger area, and it's a cost-benefit analysis. If you do a thermal conductivity test you have to know what the cost of it is. It's usually the cost of just drilling one bore hole, varies from region to region, could be anywhere from $9,000.00 to $15,000.00 just to drill the thermal conductivity test.

What that tells you is how much heat can be put into the bore hole, and how much does it absorb, and how much does it give back. What a TC test actually is involves drilling a bore hole, and then you – to the estimated design length, and you put a known amount of heat into the top of the pipe. They have something called GeoCubes or – every contractor has a different system that they have. But you put in a known amount of heat just like a hot water heater. They turn it on; they know what the temperature is going to be when they put it in.

And they measure the temperature going down the supply pipe, and they measure the temperature coming back up the return pipe, and the difference is what's being absorbed by the ground and the soil and the bore hole. And this gives way to what the thermal conductivity and the thermal diffusivity is, and that's basically how much heat can be transferred through the soil and how quickly it can be done. And then last is to organize and minimize your geothermal piping system. There's a website out there I'll show you at the end.  It's called GeoKISS, and the KISS is for "keep it simple stupid."

And that's what you wanna do here.  It's not a complicated process.  Geothermal heat pumps have been around since the '50s.  They've been operational – some have been operational since the '70s continuously.  It's a well known technology, so don't try and complicate things with making really intricate piping systems.  So I'm just gonna give you some costs per ton.  I know heating isn't necessarily valued on ton, but in the geothermal industry heating and cooling loads are generally sized per the ton.  So looking at just the ground loops, we've gone over what a horizontal ground loop is.

A slinky is just like you used to play with.  It's coiled over itself several times over.  And then the vertical bore holes.  So that varies anywhere from $1,100.00 to $1,500.00 a ton.  And I should emphasize that's just for installing the ground loop.  The heat pumps themselves range – depending on you want 2.5 to 4 ton – range from $2,700.00 to $3,600.00, which when you equate that to what a 90 percent efficient new gas boiler is, those costs should be pretty applicable.  And this is just a graph.  I was able to extrapolate some of Kevin ____ work in 2008.

He has the cost for a three-ton unit, and I've broken that down, and I've estimated what a mature market would give you and an immature market.  And a mature market is somewhere where heat pump – geothermal heat pump designers, installers and drillers are pretty well known and are competing for your business, so it's gonna drive the prices down.  An immature market is where you're gonna have this one lone driller, one designer in the industry, and there hasn't been a big enough demand for them to have to battle out prices, so you're probably gonna be paying a little bit more than a mature market.

So I'm giving you – this is cost per ton, and this includes the inside work – the ductwork, the heat pump unit, controls – and the outside – the ground loop, the piping, the excavation and the drilling.  So air source heat pumps are $2,000.00 a ton.  If you do gas with air conditioning, you're at $1,900.00.  Groundwater, horizontal, slinky and vertical range from $3,300.00 to $4,300.00, and that's – just looking at this graph that's the first thing that puts people off to geothermal is, "Wow!  I'm paying a lot more in the beginning for this unit.  Is it worth it?  What is my payback period, and what are my savings on an annual basis?"

So right now the industry for commercial buildings when you have – you can utilize some of the tax incentives and accelerated depreciation of capital assets you're getting paybacks in the two-year range. With residential units, usually you don't have the advantage of taking a tax break like that, so you're anywhere between three and seven years for the payback. There's some statistics out there and some studies that say it's 10 to 20 years. What it depends on is how much – what region are you in? How much is your electricity?

Is there a utility scale where you're paying more in the summertime for peak hours? All these kind of have to be taken into effect to actually see what the full payback period is. What's your gas price gonna be in five – ten years? Do you know that it won't escalate to the point where it would be not economical anymore?

So this is just to give you some average savings numbers – energy savings for a heat pump unit is between 31 and 71 percent of the energy. Cost savings – and this was a study of, I believe, 40 different geothermal heat pump installations – between 18 and 54 percent. And you're seeing efficiencies compared to other heating systems 50 to 70 percent higher and for cooling systems 20 to 40 percent higher. And then I gave you the specific breakdown on the slide before, but just to give you rough estimates – and this data is probably a little bit older – more accurate is the slide I gave you before.

But how much cost savings you have in the U.S. compared to other geothermal heat pump systems – so for electric systems, you're getting four times more the savings, propane three times, fuel oil two times, natural gas two times – and this was looking at what you're paying for your annual energy bills. The operational maintenance cost – one thing with getting a good designer or contractor is knowing that they understand you want this to be efficient, you want this to work, you don't wanna pay any extra cost and put in bigger heat pump system or ground loop than you need, and you don't want them to be using equipment such as field pumps – which is – this is what circulates the water – that are oversized and that end up being an energy hog.

So this was a study that was done by Cavanaugh Hughes, University of Alabama. He looked at different field pumps and what's been installed in there and how much energy they actually consume. And so I just wanted to put this in there to just warn you that when you start looking at proposals and what people are doing, the best pumps to get are either variable speed or decentralized loop pumps. And what this is doing is it's – the pump is on when you need the geothermal loop field to be circulating fluid, and it doesn't run constantly, and as you can see it has a significant annual energy pump savings.

So this I think would be really applicable for the audience, and this was a Habitat for Humanity project and Hope Crossings, and I got permission by Climate Master to put this in here. They had done this study on two different Habitat for Humanity projects, and they just – the first one was called Spencer. They did a standard gas house and then a geothermal house, and they did – compared what the breakdown was for what was the roof made out of. What were the windows, the walls, insulation type?

And then the next project they did was Hope Crossings, and they said, okay, well, we have our standard gas house, and we've already compared it to the standard house with geothermal heat pumps. Let's look at a low energy geothermal heat pump with PV. How does that compare with the cost and energy breakdown and emissions? And this graph just kind of gives you an estimate of how much energy you can actually save, what the cost savings are – and this is on an annualized basis to the homeowner – and how much emissions you're saving. So it's quite drastic. It's over $1,000.00 that you're saving in energy costs when they used – they actually used foam insulation I think in the low energy and geothermal heat pump.

And as you can see, they actually insulated the attic, and if you've ever been to any house in the summertime and you see their air conditioning ducts going up in the attic, and you go up there and it's sweltering, you know that that's not really an efficient system. The air conditioning ducts are actually going through the hottest part of the house before they try and cool your house. So they found that the really successful technique was foam insulation and to actually do the entire attic. It was more – foam insulation is more expensive, but it ended up having a better energy cost for the residents.

So how can you find some certified designers and installers? I'm gonna give you two really good sources. The first is IGSHPA, and that stands for the International Ground Source Heat Pump Association. They are the certifiers for all geothermal heat pump and air source designers from the drillers to the pipe welders – everyone that is certified in the industry should have gone through one of their certification programs. The second is Geo, which stands for GeoExchange, and it is the industry group.

It represents all the parts within the industry, whether it be pipe manufacturers, geothermal heat pump manufacturers, grout manufacturers, and they try to lobby Congress.  But both of these entities have websites I'm giving you links to at the last slide, and they provide lots of information, and they also provide directories. So you can go in there and pick your state, pick what it is you want and find everyone from I wanna know who the certified designers are to the certified installers, drillers, etcetera.

The second thing is go around to universities in the area and see who might be doing some research on geothermal heat pumps, even if it's a state away, call them up and find out who have they been working with, what contractors have they been working with. They'll be able to give you horror stories and, "Don't use these guys; use these guys.  These are great.  I work with them all the time."  It's really good to get another opinion and to reach out and see what the universities' opinions are.

And the last is – once you kind of do your background and you feel comfortable, make sure you understand the importance, and you can get this just from talking with them or from their RFP or solicitations about if they include certain topics and kind of stress the importance of building a system that meets the building uses and loads, and there's a good example of this.  There's a – one of the designers that I work with is based here in Colorado.  It's Terry Proffer, and he gives an example.

There's a commercial office building and a church side by side, and they both wanna do geothermal heat pumps, and they're both an eight-ton system.  Well, the difference is the church only really needs its loads two times a week, and the office building is running its load seven days a week, eight hours a day.  Well, although you'll be installing an eight-ton heat pump in each of those units, the ground loop will be significantly different.  For the church you could have a two to four times less of a geothermal ground loop than you would for the building.

So it's – getting firms to understand what they use for the building is what the loads are and that they're very, very accurate and on-the-ball with how things are designed and made and installed in the field.

So what are some of the financing options?  And unfortunately, there aren't that many, so I tried to throw out a few kind of out-of-the-box things like utility negotiations that have been done before but might not be in the scope of what you want.  The first one is ESCO, the Energy Service Company.  This was really successfully done at Fort Polk, based off an energy savings performance contract.  For the first 20 years, the contractor is getting all the savings, and then after that Fort Polk will be getting $500,000.00 a year in heating savings just for their residents.

Utility negotiations – if you're in an area that has, like just initiated this year in some of their places where they're hitting you with higher electricity rates at the peak demand times when you're pulling a lot of load – well, if you can negotiate, if you're building a lot of residents or retrofitting a lot of residents – if you can negotiate with the utility to reduce the rates because you're gonna actually be reducing their peak loads for whatever city or region you're in.  And the last is look at utility and tax incentives.  The government right now has a tax incentive for residents.

It's 30 percent of the total cost – there's no cap to it.  And then utilities above and beyond what the federal government will give you, each utility is definitely – it's in their best interest to give you a tax credit or some sort of incentive.  Sometimes it could be $300.00 a ton that they'll give you.  It ranges from utility to utility and state to state.  So I'd direct you to the Desire website.  You can pull up all the utilities and what their incentives are for geothermal heat pumps.  And then some key information for RFPs – and this was the kind of slide that I thought about for a while.

And I just wanted to bring up a few points that – if nothing else that you at least understand these are things you don't wanna forget or you wanna make sure you bring them out.  First, all contractors, installers, designers, drillers and QA/QC monitors are IGSHPA certified.  This will – this is – rigorous courses that they have, rigorous tests and a lot of man hours, similar to the requirements for a professional engineering degree.  You have to have done a certain number of projects and proved that you're capable and confident in this area.

The second is require a minimum number of previous successful GHP projects in your area and ask for references.  You don't wanna get someone that just got certified by IGSHPA and actually has no background experience whatsoever in actually designing and implementing a geothermal heat pump project.  And the references are important.  Make sure you get their references and do your due diligence.  Call them.

Find out – I put below, "Contact the bidders' previous clients." Were they good?  Were they not good?  Find out some of the pitfalls?  Ask if the client would work with them again.  And then the cost – the first is what – you might not get this from all of them, but it'd be good to include is what are the actual performance savings of their previous projects? How successful have they been? And lastly, clearly – make sure they clearly break down the geothermal heat pump cost and the components.

Don't do lump sum contacts. You're gonna get one contract that looks – one RFP that will come in or a proposal for $1.1 million, another one for $800,000.00. Well, with lump sum, you have no idea how to compare that. You don't know if someone's doing horizontal, someone's doing vertical, what their piping scheme is, if they included the cost of the heat pumps themselves. So make sure that in your RFP you request that all the costs are broken down.

And then lastly, there's a link to specifications and geothermal design specifications that were developed by Oak Ridge Laboratory, and this literally is what you'd put in your spec book. This is very comprehensive. It's a pretty long document, so I suggest if you're kind of in the beginning stages of building your project and at the stage where you'd wanna do an RFP, go through the specs and take a look at them. So how is it they can QA/QC and monitor a project? And I wasn't trying to be smart here, but literally get to know geothermal as quickly as possible.

The more that you can learn about it, the more papers you can read, the more projects you can go to – I would say call up a local contractor, see if he's installing any in the next week or two and just say, "Do you mind if I go and take a look and see what the process is?" Being out in the field, seeing things in action is really great, and you'll understand not only what it is, how complicated it can sometimes get, but you can kind of warn yourself against some of the pitfalls.

And make sure you get qualified – if you're not doing the QA/QC yourself, make sure you get qualified installers, and if they're not IGSHPA certified make sure that they've worked on several successful geothermal heat pump projects. Having people that know what they're doing and that are looking out for you is a huge blessing when you're working on a project that has multiple – multifamily houses or a lot of single-family houses that you're trying to tackle all at once. And then lastly, some tools and more information on geothermal heat pumps.

There's lots of free software out there. You'll be able to click on the links. They're all fresh and live, so they shouldn't have gone down by the time I put this together. Red Screen is a Canadian resource. Natural Resources of Canada – it's a program that they've put on. They actually have a – they're all Excel spreadsheets, pretty easy to use. As long as you have the building loads you can get some rough cost estimates, payback periods – things like that. GeoKISS is Cavanaugh at the University of Alabama – his website, and he had a lot of software there. Geothermal is one that you can purchase.

It's one of – between that and the other one is escaping my mind right now. There's a trial that you can download and try it out, but that is one of the two software that's used throughout the industry. The industry directories that I had mentioned before – IGSHPA – and people say it really funny. It sounds like "expa," but that's just how it's said. It's the International Ground Source Heat Pump Association, NGO, and you can both find out members within the organization. And just to understand more about geothermal heat pumps – trying to dive into it more – read case studies, try and pull out more information that maybe I haven't provided here.

A great resource is the Geo Heat Center. That's based at the University of Oregon – or sorry – Oregon Institute of Technology. GroundMed – that is the European project that's going on. They've outfitted a lot of residential or commercial units, and they're doing case studies on them and monitoring them for their energy consumption and cost. And the last is an actual document. It's called "Geothermal Survivor Kit." It's by Kevin Rafferty, and that's available for download, and that'll just give you a little bit more information. So we can open it up for questions.

*Liz:* Yeah, thanks, Erin. Thanks so much. And I just wanted to mention really quickly that we are gonna make these slides available, and because we're recording the webinar we're gonna get that transcribed and captioned, and that will be available also to you on the SERC website – the DOE, EERE, SERC website – as soon as we can. If you need the slides in the interim you can go ahead and email the SERC_CA@NREL.gov website and we can send them over to you in the interim.

But I think – let me just see – I'm not entirely sure that the phone is actually muted, so if you wanna give it a try to ask a question you can. But if not, we'll go straight to the questions here. The first one is from Sarah – I'm not gonna try to pronounce her last name; I apologize – and she asks, "What's the difference between energy requirement and heating and cooling load? If energy requirement simply adds the base loads why would you want to know that for a ground source heat pump?"

*Erin:* Well, the energy requirements of a house, I'm assuming, are all of the utilities of the house and all the extraneous – you know, the dryer and all that. The heating and cooling loads are what you need to know for – to heat and cool the building. So if you have an HVAC contractor coming in, and you wanna put in a new air conditioning, they're gonna look at the building load.

They're gonna look at what your windows are, how thick your walls are, what the insulation is. So maybe I'm misunderstanding the question, but energy requirements, I guess, would be the total energy requirements for the house, and the heating and cooling loads are that – those loads which need to heat and cool the house properly.

Oh, yes, and I – sorry, this was my oversight; in the beginning I should have specified there are three – the industry interchangeably uses ground source heat pumps, geothermal heat pumps, GeoExchange heat pumps and ground heat exchanger. So these are – they all mean the same thing. It's using the ground – pipes in them in order to heat and cool your house and exchange the heat.

So the different acronyms are geothermal heat pumps or GHP, ground source heat pumps or GSHP, which is in like IGSHPA, Ground Source Heat Pump Association, and GeoExchange is actually a trademark from Geo, so it's only those members who can use that terminology in print, but it still is used verbally, and then ground heat exchanger.

*Liz:* And then we had another one from Amir Bashay, and he asks, "What's the average bore size for vertical configuration loops? Have you seen situations where excessive ground freezing occurred as a result of the GHP system? Was that due to inadequate trench depth or heat loading? Are horizontal configurations more efficient than vertical?"

*Erin:* Okay – I'll try and tackle the first one. So average bore hole size diameter is usually 4.75, depth 200 to 300 feet. Have I seen situations where excess ground freezing occurs? Yes, I have, and that's usually because the system was undersized. So it's all about the design – so knowing the loads – the heating and cooling loads are really critical to design your heat exchanger properly. And can it be done – I've seen – there's vertical bore holes that can freeze, and there's horizontal bore holes that can freeze, and that – if you bury them at the correct depth, which is about six feet depending on if you're stacking your pipes or not – you might have to go a little bit deeper.

But when a geothermal heat pump or geothermal ground loop freezes it's usually because it was undersized and that you're trying to pull out more heat for our house than what the ground loop is capable of providing you. And in terms of efficiency, they'll both give you COPs that are greater than three, but if you – typically I'd say more efficient would be the vertical just because you have more of a constant temperature throughout the depths of the bore hole.

*Liz:* So I think that's all the time we actually have questions for today. But if anyone has follow-up questions please feel free to email us at the SERC_CA web box, and also if you'd like the slides between now and when we can get the recording online please also email that and we'll email them right over to you. And if you have further questions for Erin, please go ahead and send those to us as well, and we'll get those to her as we can.

So thanks so much, and just a reminder that we're not gonna have a webinar on the 30th of December. We will have our next one on January 11th at the same time, and you'll see a registration invite coming through for that maybe a week or so before. So thank you all very much. And thanks, Erin.

*Erin:* Yeah, thank you for having me.

*Liz:* Thank you for your time, and we will see you in a few weeks. I hope everyone has a safe holiday.

*Erin:* Thanks so much.

*Liz:* Thanks.

*[End of Audio]*