Q&A Report: Overview of Community Heat Pump Systems Currently in Operation Globally

Question Asked	Response
Have you ever had a project that you increase the temperature of ground in summer to use the heat in winter time and in opposite, reduce the temperature of ground in winter to use it during summer time? if so, is there any restriction on how much we can increase or reduce the ground temp? I believe we can change the ground temp be reducing the number of wells, length and changing the grout type.	By virtue of how geothermal systems work, that is exactly what is being done with current design practices. A typical design may cycle between 30 F in the winter & 95 F in the summer. This range could be expanded by reducing the size of the ground loop but there will be a decrease in both capacity and efficiency on the peak days when we need both. Therefore, current technology will not be appropriate with a wider swing in temperature.
Could you elaborate more on the distinctions between source- and load-side distribution?	Relative to the heat pump, the "source side" refers to the ground loop piping network that provide a heat source (in heating mode) for the heat pump. The "load-side" piping network delivers heat from the heat pump to the space demands.
John, Did you mean to say that there are 12 loop fields with between 8-12 loops per filed? You said there are 12 groups of loops each with 8-10 loops, I think but it's going pretty quickly so I'm not sure that I heard correctly.	The entire system is the loop field. For many reasons loop fields are divided into small groups, each group can have multiple loops resulting in each group is piped in parallel and each loop in a group is also in parallel with what we call a Reverse/Return manifold. Each group has a pair of pipes (Supply & Return) that are then connected to a valved manifold where all the flow is combined, thus the entire field is operational as a single loop field.
Are there any differences between design approaches for more heating dominated vs cooling dominated community systems?	Yes, and there in lies the "Art of Geothermal", there are various strategies, such as identifying offsetting loads such as domestic water heating, snow melting, solar thermal input, boilers/cooling towers, waste heat recovery and many others limited by one's imagination and ability to quantify & model.
In whisper valley, how many feet per ton do you get from the boreholes?	Each lot has 1-borehole which was 350' in depth. It was a double loop 1" PEX copper tube size. Most residential lots are running 300'/ton cooling capacity. This bore would estimate to be approximately 1.33 tons each in this geographic area.
I see you think boilers should never be needed for a campus system (John Manning - Skidmore). Do you find that adding cooling tower as insurance is a good idea? Or at least pre-plumbing for interfacing with a cooling tower.	If the application is extremely heating dominated and there is simply not enough loop field to meet the need, a boiler may be appropriate, but only on the load side of the heat pump NEVER on the source side. When incorporated on the load side it should never push temperatures above the range of the heat pump, the boiler should simply add BTUs and supplement the heat pump to maximize the use of the heat pump/loop field and minimize the use of the boiler. If temperatures exceed the capability of the heat pump the boiler will end up carrying 100% of the load undermining the ROI of the geothermal investment. When boilers are used on the source side they reduce the temperature difference between the operating fluid and the earth, and since heat transfer effectiveness is directly related to temperature difference the boiler on the source side will dramatically impact the ROI of the geothermal system. Regarding a cooling tower, a good design should be able to predict whether a cooling tower is needed or not. Too many times loop fields overheat due to poor design practices, such as excessive pressure drop or not enough "turn down" on the pump resulting in excessive pumping energy being imposed on the loop field. Based on my experience, a good design does not need insurance.
I like the Whisper Valley project. It has schools being built within the project and some commercial and retail presence - a very planned community. However, it is a very cooling dominant location. Cooling towers are built into the design. I think Whisper Valley will end up using more cooling towers than they are willing to admit after the ground loops heat up in time. Can you comment on that Howard?	You could be correct, the vertical loop boreholes are designed to handle the heating load and the tower with a maximum 95ºF and 85ºF leaving is still more efficient than air-source at 105ºF which is not uncommon in this part of the country. The bores will store the 95ºF heat energy for super high efficiency heating. Keeping the towers from operating until the bores can't handle the load shifts the demand until the wet bulb tempers are better suited to the tower efficiency.
What is done to protect the plate and frame exchangers from mineralization. Or are they throw away exchangers?	The minewater is low in total suspended solids, but high in total dissolved solids – so not too much concern for physical clogging, but more concern for chemical fouling due to precipitate deposits or corrosion. The water has relatively high salinity (brackish). Several options were considered for the heat exchanger including plate and frame options and shell and tube options. Dual plate/frame heat exchangers were selected outfitted with titanium plates each with capacity to operate in isolation of the other heat exchanger if one is under service. The heat exchangers are piped to allow isolation from the system and flushing with cleaning agents, and if necessary to tear down for more extensive cleaning in isolation from the system. Pressures are monitored upstream and downstream of the heat exchangers as an indicative parameter for identifying constriction. Measures were taken to limit exposure of the minewater to oxygen in the production, conveyance, and injection systems as a means to reduce potential for precipitate deposits.
How are homeowners charged for central heat rejection?	This will vary by developer by project type.
At Skidmore - is there any consideration to connecting the energy nodes sometime in the future? If so - was that planned with any particular interface hardware or "stub outs"?	There are no plans to connect the various nodes and there would be no benefit to doing so.
Assume buildings are not commonly owned - like all of Albany, NY. Do any of the speakers have opinions about selecting a two-pipe vs. a single-pipe network between buildings? Realize both can work but - do you have a bias in Community Heat Pump systems for buildings with separate ownership?	There are many considerations to determine when single pipe or 2 pipe is appropriate. In general, a 2 pipe system can be pushed to greater temperature extremes (avoiding the accumulative temperature impact at the end of a 1 pipe system). The greater temperature extremes can then improve the heat transfer in all the source or sink heat exchangers. However, if a single pipe system can be maintained between 40 F & 85 F (the last customer may see 30 to 95) then a single pipe system may yield the most cost-effective solution. The impact to heat transfer must be folded into the analysis.
How often do you clean the plate heat exchangers with the mineralized water for Vancouver Island? Do you do it on a schedule or wait until there is a discernable change in performance?	Currently based on need. At the part load conditions that the system currently serves cleaning has not yet been required
At Whisper Valley - what's the range of EWTs annually? How often do the fluid coolers or evaporative cooling towers operate? Do you cool the loop at night like other hybrid systems in warmer climates?	The data shows that the Maximum EWT of 95ºF and the coldest 60ºF.
At Whisper Valley - are individual homes water-source heat pumps isolated from the main loop so there is not contamination or air let into the system when someone changes out a heat pump? Does the homeowner own the heat pump or does the network own it?	Each home has Pump module with 3-Way isolation valves and can be purged independently if repairs are made.

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At the first session it was mentioned that 130 Degrees is an ideal max heating water temperature. When using the heating heater to indirectly hot potable water (via heat exchanger) which is typically provided at 140 this is not feasible. Are there economically feasible heat pumps that can be used for these applications.	There is a growing list of equipment using various refrigeration techniques and/or different refrigerants that are addressing this issue. I would suggest our industry address the 140 degree requirement, as it seems to be based on the need to kill Legionella. It is my understanding that there is not one case of contracted Legionella via potable water systems and most residential hot water tanks never reach 140 F. The requirement needs to be rigorously challenged to be safe and not arbitrarily penalize the efficiency of heating water.
What temps do you run in the ground loops? I figured you'd actually gain from piping between building because it is affectively a horizontal bore.	We typically design for 30 F minimum and 95 maximum, and then through various conservative steps and safety factors we are quite often staying between 35 & 85. You are correct in recognizing all the horizontal pipe is contributing to the overall heat exchange and has a positive effect that you may or may not want to reflect in a smaller loop field, it's a bit of a judgement call.
For Jeff, would you discuss the design considerations for waste heats on the load side? How is this affecting the network?	Waste heat can be incorporated into the system in different ways partly based on the temperature of the heat. Higher temperature heat sources can be incorporated on the load side to directly serve heating demands. Lower temperature waste heat sources can be incorporated on the source side system to help offset heat withdrawal from the source side. A full response to your question is more comprehensive than can be addressed here.
Can you review the pros and cons of central heat pump plants vs distributed hear pump plants and why you might choose one over the other?	Several setting-specific application factors warrant consideration in this evaluation - including the whether the connected buildings are new or retrofit and whether the buildings are all compatible with low temperature distribution systems or have mixed delivery temperature requirements. If all the connected buildings have similar load distribution systems that can be served by a low temp supply system, the application may lend itself well to a central heat pump system. If the connected buildings are a mix of legacy systems and new construction then distributed plants may be warrant more consideration. Central plant systems often must operate at higher temperature than optimal to satisfy certain connected buildings. Central plan systems may also be susceptible to overbuilt "stranded asset" considerations if the connected building buildout will be staged. Avoidance of need for insulated distribution pipe is a significant benefit for distributed ambient systems.
Both Skidmore and Vancouver essentially designed their heating and cooling services based on a unique supply technology. Did either consider a portfolio of sources as would be typical in a community Gen 3 or Gen 4 DE system?	A comprehensive energy options analysis is well-advised for all DES applications. In the case of Vancouver Island University, several studies were conducted over a 7-year period before the minewater system was developed. The minewater DES system was selected because of the unique source availability.
Has anyone worked on a municipality/city community heat pump system, not just houses? Potentially looking at one in the Northeast, so the winter is a factor.	The Vancouver Island University system is an example serving institutional buildings. Other systems in western Canada winter environment with more traditional types of geothermal sources serve institutional and recreational facilities. A common application includes connecting facilities with high heat of rejection (such as ice arenas) with facilities with high heat load demand (such as swimming pools). A geothermal ground loop is often incorporated into these types of DES systems to provide thermal massing heat store benefits to allow the heat reclaim and redistribution to be more effective.
At the VIU Minewater Project, has the mineral content been an issue with the heat exchangers (calcification, etc.)? Is there a regular schedule for cleaning the mine-water side of the HX?	The minewater is low in total suspended solids, but high in total dissolved solids – so not too much concern for physical clogging, but more concern for chemical fouling due to precipitate deposits or corrosion. The water has relatively high salinity (brackish). Several options were considered for the heat exchanger including plate and frame options and shell and tube options. Dual plate/frame heat exchangers were selected and outfitted with titanium plates each with capacity to operate in isolation of the other heat exchanger if one is under service. The heat exchangers are piped to allow isolation from the system and flushing with cleaning agents, and if necessary to tear down for more extensive cleaning in isolation from the system. Pressures are monitored upstream and downstream of the heat exchangers as an indicative parameter for identifying constriction. Measures were taken to limit exposure of the minewater to oxygen in the production, conveyance, and injection systems as a means to reduce potential for precipitate deposits.
For Howard: Are the Whisper Valley homes individually pumped? Are they charged for their energy to/from the loop? If so, how is that done?	Yes, by a BTU meter.
Howard - in the event of a catastrophic winter event (very cold, maybe no power), are there provisions to protect the cooling towers and outdoor piping?	At Whisper Valley there are plate/frame heat exchangers and a open cooling tower that is drained down for the winter in late October and the borefield carries it through to April 1st.
For John: Are you staging the 8 pumps based on return water temperature? Could you elaborate?	The (8) primary pumps are sequenced on based on return water temperature from each of the buildings. Both temperatures are used to determine the number of pumps to enable. Each of the enabled pumps will receive the same 0-10V control signal that correlate to a linear ramp up of flow as a function of temperature. For example, if highest water temperature equals 75 F, the desired flow is 60% of Max Flow (.6 x 1,250 = 750 gpm. Based on circulator performance characteristics, 4 pumps are enabled and a control signal of 6.3 VDC will achieve 750 gpm.
Question for Howard: Can you speak a bit more to the business model employed at Whisper Valley?	I will have to refer you to EcoSmart Solutions for more on their business model.
Was the Whisper Valley community heat pump system cost effective on its own or did it require grants or other subsidies for it to make economic sense? If not the latter, seems quite surprising given the low building density and warm climate.	The City of Austin is the utility provider for the property. I'm not aware of any grants or incentives to the Developer.
Are you raising the temperature of the ground over time since your heat rejection needs are greater than heat source?	Imbalanced designs should be modelled for a minimum of 20 years and the loop field should be designed so that temperatures stay within the design range at year 20.
	Because the system is shut down between November & April the minimum temperature has only reached 60°F with a ground temperature of 74°F. However it can vary from year-to-year.

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What happens to the system and how do you address if there is a leak in the vertical piping system? Hard to find and heard to repair/replace	This scenario has happened on a very small number of installations. Using heat fusion joints is one means to establish high reliability, designing loop fields with multiple groups will also allow for isolating a group with a leak. The specific operating temperatures after a year or two of operating without the leaky group as well as the cost to repair will dictate the appropriate strategy on any specific project. Fixing leaky loops has been performed, if discovered shortly after installation or during the pressure testing, it is the responsibility of the installing contractor. If discovered after the warranty period the repair may not be worth the cost if loop temperatures are still within an acceptable range.
	Each Individual lot can be isolated from the district loop and pressurized if a leak is suspected. A water meter is applied to district make-up system to check for excessive usage.
Question for the speaker from Canada: This project seems similar to an Aquifer Thermal Energy Storage (ATES) geothermal system that are sometimes installed in some of the Scandinavian European countries. Are you aware of any ATES type geothermal projects installed in Canada or North America where there are not abandoned coal mines?	There are examples of ATES systems in Canada. However, in the mountainous regions in British Columbia many of the available aquifers are alluvial aquifers with relatively high hydraulic gradient and relatively high groundwater flow velocities that limit opportunity for heat to be effectively stored and recaptured on a seasonal basis, and thus limiting ATES application potential in many settings. Effective ATES application requires careful characterization of site-specific aquifer.
In a Community, who is responsible for servicing the district loop?	EcoSmart Solutions acts as a utility and services Whisper Valley.
@VIU - how does the economic of GSHP look like compare to other electrification methodologies? how do you see feasibility of GSHP for other communities in BC, Canada?	As an electrification technology GSHP is particularly well-suited for BC and Canadian applications and in particular for a) northern harsh-climate applications (such as northern BC, where air-source heat pump technology has diminished performance and limited application potential), b) where site-specific conditions are particularly favourable for cost effective ground heat exchange, c) where there are opportunities to leverage benefit for ground thermal mass energy store advantage. GSHP will need to play a crucial role in electrification strategies for cold climate electrification. For example, several dozen schools have been very successfully electrified in BC using GSHP - many in climate zones that would be very difficult to electrify by other means.
At Skidmore, was the system sized for peak design load or energy model load? Could the number of bores be reduced if a boiler was used on the load side (HW) to serve the peak loads? What is the general approach to backup heating for geo systems?	Load calculations are great for sizing and selecting equipment, however the energy model will expose the actual load diversity, which should be used for loop field sizing. Although Skidmore College systems were designed to use anti-freeze however they are still running on water only. This is due to the cooling dominated load. Heat pumps that are sized to handle the peak loads will more than likely have more than enough heating capacity to handle the heating load, especially in a water only system with loop temperatures staying above 45 F. The general approach for backup heat in a geo system is none. Having said that, there are exceptions, and when needed it should be treated as "Supplemental Heat" as an active means to add additional heat if/when heat pump capacity does not meet the load. The term "Back Up Heat" implies there is fundamental poor reliability. Reliability is built into the design through proper sizing and using multiple heat pumps for a degree of redundancy
Did the Whisper Valley project have a closed loop cooling tower included to supplement cooling?	Yes, by design because of the imbalance of the Cooling/heating loads. This is a hybrid application design.
The Nanaimo mine water. Any challenges with fouling of the GS System, particularly with the plate frame HXs?	The minewater is low in total suspended solids, but high in total dissolved solids – so not too much concern for physical clogging, but more concern for chemical fouling due to precipitate deposits or corrosion. The water has high salinity (brackish). Several options were considered for the heat exchanger including plate and frame options and shell and tube options. Dual plate/frame heat exchangers were selected and outfitted with titanium plates each with capacity to operate in isolation of the other heat exchanger if one is under service. The heat exchangers are piped to allow isolation from the system and flushing with cleaning agents, and if necessary to tear down for more extensive cleaning in isolation from the system. Pressures are monitored upstream and downstream of the heat exchangers as an indicative parameter for identifying constriction. Measures were taken to limit exposure of the minewater to oxygen in the production, conveyance, and injection systems as a means to reduce potential for precipitate deposits.
How are homeowners in Whisper Valley billed for their connection to the district ground loop?	With a BTU meter which measures ΔT and GPM.
Does the sequence/order of building connections make any difference to the overall efficiency of the system?	It really doesn't matter what the sequence is to connect buildings to a Energy Node. Up until the last building is connected the loop field will be relatively oversized and loop temperatures will be more favorable than a fully loaded loop field.
What was the levelized cost of energy LCOE from The Nanaimo System?	Cost of energy is in a period of significant transition. Currently, electricity varies from 2x to more than 3x times the cost of natural gas in BC (though institutional rates for electricity are commonly lower). The heat pump coefficient of performance (CoP) leverages the geoexchange electricity use resulting in the energy cost to be similar for GSHP or natural gas for boilers - so currently there is limited opportunity to develop ROI to recover construction cost. But the gap between electricity and natural gas will rapidly narrow with recent re-affirmation of federal carbon tax that is set to escalate from $30/tonne now to $170/tonne in 2030. Furthermore, as a policy measure, BC is embarking on an aggressive heating electrification strategy. Note that BC Hydro generated electricity has a very low emission factor. Also note, when the project was first contemplated in 2009, the cost of electricity was nearly equivalent with natural gas - the COP leveraging of electricity then produced a strong ROI.
The levelized cost of energy ($/kWh) that would be required to provide a return on investment for the Geo_exchange system	The calculations were conducted under earlier prevailing conditions and will benefit from revisiting with federal carbon tax and higher contemporary natural gas commodity prices, as described in response to previous question.
what do you charge the homeowners per unit of energy Kw or MBTUH?	Honestly, I don't know that information about Whisper Valley.
How often do the plate and frame HX need to be cleaned?	At the partial load conditions that the system currently serves cleaning has not yet been required
Whisper Valley - What is the accuracy of the Btu measurement? I've found it very difficult to achieve much better than +/-5%...	Honestly, I don't know that information about Whisper Valley.

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Can you elaborate more about the Groundwater Open Loop?	Typical configuration of "groundwater open loop systems" extract groundwater from aquifers by means of pumping wells, then exchange heat from the groundwater, and then return the groundwater to the aquifer by injection wells. The Vancouver Island University project is a unique example of a groundwater open loop system (where groundwater is extracted from and returned to the mineworkings void).
What are the water temperature in Whisper Valley supply and return?	The data shows that the Maximum EWT of 95ºF and the coldest 60ºF.