

Community Heat Pump Systems: Piping, Pumping and System Controls

Q&A Report:

| Question Asked | Answer |
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| Not really a question, The Wisconsin project had gas-fired radiant baseboard heat at large exterior windows that avoided loop heat removal in the winter. That caused loop overheating, not the borefield design. (It was overused, not per the design) | Thank you for the info. I suspect the same thing occurred in Indiana. Do you know of any reports or case studies on this system? |
| Are community ground loop systems being used in Europe? What experiences do they have? | Yes, the SMEs from ASHRAE are working to provide information on these systems in future Webinars, Additionally, a website with links to these projects and information that is free to the public is being developed. |
| Is there much experience with 'delta beaters' (solar thermal, heat recovery from water outflow, eg)? | I do not have information on this technology. |
| How does the design end up with more pumps than necessary? Is it due to too many independent loops, i.e. primary, secondary, tertiary, etc.? | There are several reason including the multiple loops you mention. However, the excess in pump size is typically a result of applying multiple safety factors. In some cases this is justified (i.e. a school district without resources to maintain water chemistry to minimize steel pipe tuberculation and corrosion induced strainer plugging). This is one reason HDPE pipe for GSHPs is |
| Most hydronic heating systems are designed for ~180F supply water. Can these be retrofitted with GSHP without replacing the terminal units/distribution piping in the building? | To lift water to 180°F using the ground loop as the heat source would require 2-stage compression. Thus COP would be very poor. |
| I recall that the Houston school districts started realizing increased groundwater temperature over time to the point that their cooling capacity diminished to around half after ten or so years. Has that been adequately addressed for the sites you presented? | The reported systems were in the Austin area. I am not familiar with the schools in Houston. In the mid 80s in Austin, larger low efficiency heat pumps used in the common areas were served by a ground loops with vertical bores at 240 ft. ton and 12 ft. bore spacing. Their operation overheated in almost immediately. However, classroom units arranged in a single row operated quite successfully, several of these systems are still in operation. However, ground loops in newer Austin area buildings are typically 300 ft./ton with 20 ft. bore separation. Peak heat pump EWTs are typically 90°F including those in operation for 20+ years. This |
| Can GSHP be done by commercial building owners in NYC? | A GSHP with a standing column well design was installed in St. Patrick's cathedral. These GSHPs incorporate much deeper bores that recirculate groundwater (remove and reinject into the same open loop well). Typically, some water must be bled off and disposed to maintain loop temperatures. I have not searched for any resulting performance reports. With regard to conventional closed loop vertical heat exchanger GSHPs, the lack of ground space would limit the number of units possible in high building |
| Do the charts comparing kBTU/sqft for different types of cooling consider only buildings used for similar purposes, in similar locations? For example, an office building in Florida would use more power per square foot than an identical building in Ohio, no matter how they're cooling it. When conducting those surveys, did they correct for that? | The graphs shown during the seminar include an average of all building types and climates. However, CBECS data is available that breaks this down in many ways (building type, location, number of occupants, number of computers, number of stories, amount of refrigeration, etc. etc.) |
| How do you think about DX loop type geothermal heat pumps compared with water loop geothermal heat pumps? | Installing DX systems correctly requires a high level of care. Currently I know of only one company that has installed them successfully for many years. They recently purchased the last manufacturer that provide this equipment. Like VRF systems, they also require much larger refrigerant charges that may limit their attractiveness due to environmental concerns. |
| Would you happen to know when copies of the blue book will be available again? I ordered it back at the start of the seminars and they are still on backlog. | Received this response from ASHRAE staff on Jan. 7. "Steve. Good news: the delay is simply because we sold all our copies of the book and have to reprint some more! The printer is printing them right now, so the orders should be able to ship out this month." |
| In the table showing per foot costs of borehole loops, is the cost per foot of depth? | Per ft of bore |
| I've seen a lot of issues related to low delta T in the ground loop with horizontal systems. Can you explain the importance of auxiliary heating (hot water heaters or boilers)? | It is my opinion that supplemental heat should be best provided inside the building in separate auxiliary systems. Much of the supplemental heat added to the ground loop via water heaters/boilers is lost to the ground. There is also a concern that temperature limit controls may be overridden or fail and potential damage the plastic piping loop. However, many hybrid system |
| With the big push for heat pumps providing lower temperature water, do you see fan horsepower needed to heat a building with lower temperature air overwhelming the energy saving provided by the heat pump? | The primary issue is the heating coils must be much larger. Recall also that very low water temperature may result in cold blow discomfort like air source heat pumps. Furthermore to match the heating COP of water-to-air pumps, in-floor heat is suggested than can provide comfort with lower water temperatures and no fan power (but with slightly higher pump power). |
| Where kbtu/SF-Yr figures are used, is that for the GSHP only, or the entire building energy use? | The kbtu/sf-yr values shown for the Leander ISD and Illinois one-pipe school were for the entire building. |
| I am interested in the presenter's experience with the construction quality of commercial grade water source heat pumps. From about 2010-2014 I experienced several failures (then stopped specifying them). It seems the manufacturers were incentivized to create a cost competitive/economical unit, which resulted in cutting corners which should not be cut on a system as complex as a refrigeration system. | I can not say for sure but in general the quality of all types of equipment are lower. In some cases the legacy manufacturing facilities primarily produced residential equipment and may have had limitations when moving to larger equipment. With regard to the quality issue overall, the National Comfort Institute survey 819 units (non-GSHP) the average unit cooling output was 70% of specified and average system output (include duct, etc.) was only 48% of specified. Can send reference if requested. |
| Some of this energy use data looks very questionable to me. I hope that someone has taken a hard look at the data and how/what was reported to make sure it is really representative and applies to apples. | Not sure which data you are referring to. CBECS is conducted by the DOE Energy Information Administration and the values for the kbtu/ft 2 values of three school systems was taken from the utility bills submitted to the EPA Energy Star Portfolio Manager. If you are referring to the Ball State project data, the table, photos, and graphs were lifted directly from an Oak Ridge National Laboratory report: Im, Liu, and Henderson, Final Report: Case Study for the ARRA-Funded Ground-Source Heat Pump |
| Many of the simplified examples seem to lack dedicated outdoor air systems. Are the higher efficiencies simply a result due to lack of humidity control with outdoor air? | The Leander ISD schools use several energy recovery units supplemented by water coils connected to air-cooled chillers. The Illinois schools use ventilation air fans integrated into the water-to-air heat pumps. I do not have knowledge of the outside air delivery method for the Frisco ISD schools. |
| What contributes the most to district chw system inefficiency? | While they are more reasons, failure to minimize pump and fan power can be major contributors. It also appears an overly optimistic assessments of diversity could contribute to lower efficiency. |
| Here is a link to a pdf about an interesting district GSHP system that uses the groundwater the flowed into and flooded a closed underground mine. The deep underground mine shafts helped reduced GSHP installation costs and helps the system access heat from deeper within the earth due to how deep the mine shafts go down to. https://www.renewables-networking.eu/documents/CaseStudy-Heerlen-TheNetherlands.pdf | Thank you for the link. Unlike deep lake water, mine water typically is much warmer in the winter so that it can provide significant contributions in both heating and cooling. |
| The Standard 90.1 HVAC Loopholes reminds me of the 1.75 GPM shower head efficiency requirements. There is no limit on the number of shower heads in a shower, so you can have multiple shower heads running in one shower and that is ok as long as each is water efficient. Ha! | Unfortunately good quality engineers with common sense typically don't have the time and financial resources to participate in the development of energy codes. But manufacturers' representation is quite prolific. |
| What is the COP penalty of making really hot water? How does that curve look? | The plot COP vs. the temperature difference between the heat source and sink is nearly a straight line. However, if the compressor is oversized there is likely a dip due to friction induced reduction in thermodynamic efficiency. Consult manufacturers tables but watch out for the fine print (like the flow rate at high temps may be different than the nominal values). |
| Not sure where you are getting these labor rates, but our techs are starting at \$22 to \$25 per hour and senior techs are making \$35+ per | Please do an internet search: "average annual salary for hvac technicians". While the rates in your area may be higher, values shown on the chart are in line with the search results that are for a national average. |
| What is your opinion of simplified one-pipe central geothermal systems? | The engineer that pioneered the concept passed away several years ago. If his approach is followed they are a very good alternative. Others have applied his concept but often neglect his mantra of simplicity and have added excessive controls. I do have the contact with an engineer that worked at his firm who probably stays close to the original system designs. |
| What advice do you have regarding open loop with recharging the water to the aquifer. I.e., how much bigger should the recharge pump be sized relative to the withdrawal pump. | The co-author of the blue book is the authority on open loop systems. His designs do not include recharge pumps. His emphasis is on the quality of the supply well and distribution system to limit the sand and materials of construction entering the injection well. Typically the drawdown of the supply well will be less than the water level rise of injection well even for a properly developed |
| ECM motors | They provide much better part-load efficiency than PSC motors. At full load there are quality (and much lower cost) PSC motors |
| In my experience one full time technician can take care of 72 5 ton WSHP's. They just have to keep airside coils clean. Why do they need 6? | This is 72 buildings not 72 units. Elementary schools have 125 to 175 units, high schools 300 to 400 units. The Leander techs spend much of their time servicing the outside air units, especially the ERU components. |
| Why would variable speed heat pumps be bad? | Primarily their value is overstated. They are much more complex and expensive, operate at higher speeds, must lower airflow sufficiently to dehumidify and provide comfortable air delivery temps in heating. This will compromise air supply register throw, resulting air distribution and comfort (low ADPI). This must be compensated with more elaborate ductwork/registers or additional |
| Is it just the cost? | |
| When talking about a balanced system, Can you clarify if you are referring to balancing annual kWh heating / cooling energy, or are you talking about peak demand kW in heating vs. cooling mode. | Sorry for the confusion. In this presentation balance refers to load diversity. In order to reduce the ground heat exchanger size and cost for a community system, there needs to be some balance between the heat rejected to the ground loop (cooling, refrigeration) and the heat removed from the loop (comfort heating, water heating) on both a daily and annual basis. This does not need to be perfect balance, but the closer to balance available the smaller the loop can be which improves the economic value of |

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| What was the answer in KW/ton for the homework 1.5HP/1000CFM (assume 400 CFM/ton)? | $1.5 \text{ hp}/1000 \text{ cfm} \times 400 \text{ cfm}/\text{ton} \times 0.746 \text{ kW}/\text{hp} \div 0.85 = 0.53 \text{ kW}/\text{ton}$ |
| Lake land has added 2 additional bore fields and 3 more buildings. | Thank you. Hopefully they will add more to fully utilize the central piping loop. |
| Have you looked at CO2 air to water heat pumps for generating Hot water for colder climates? | No. The operating pressures required give me pause. We have a hard time keeping R-410a machines properly charged. |
| PV systems have very low efficiency compared to thermal solar panel . I am surprised that in your analysis that heating directly with PV is much better! | This occurs only in cold weather, since PV panels do not have thermal losses and realistic measured efficiencies of themal collectors are near 20%. My comment was that in the warmer months that double the PV collector area is required. But the low cost and low maintenance of PV panels justifies this if sufficient area is available. |
| Not a question, but I appreciate the practicality of the presenter. His understanding that complexity is not always better is refreshing. Keep it simple! | Thank you! |
| Before you know it, equipment manufacturers will be selling service subscriptions like a software company.... already happened in the controls world. | To quote the Craig T. Nelson character's comment to Tommy Lee Jones in the movie Company Men. "We work for the stockholders now" |
| What are typical issues you've seen with the building HVAC system that affects the overall GSHP design? | Poor engineering design. Engineering firms are not chosen by the the success of previous designs (economic value, low maintenance, low energy use, occupant satisfaction). Architects pick the engineering firms with nifty websites and a large number of employees that have 4 or 5 initials after there names. (A friend of mine refers to them as shiny shoe engineers.) |
| Why was the loop overheated, was it underestimating cooling load? | It appears the existing fossil heating systems continue to operate, which resulting in the reversible chillers not removing sufficient heat from the loop in winter. Also the amount of diversity may have been overestimated. I believe the the Ball State vertical bores were placed at 15 ft. seperation which is less than commonly used minimum of 20 ft. when bores are placed in a grid pattern. I did |
| Is it advisable to replace existing 30 A/C split dx units and have them converted to heat pump units? What should the heat transfer fluid be for such conversions and heat transfer ? What is the typical \$ savings for such conversion and ROI? | If it is not broke don't fix it. This is not an easy question to answer. Simple paybacks are often 10 years for residential GSHPs. There are tools on the geokiss.com to assist in these types of evaluations. The biggest problem is obtaining a accurate cost. Residentially the value is quite good if the higher cost of the GSHP can be rolled into a 30-fixed rate mortgage. In some cases where simple equipment is specified, the payback is immediate. In commercial applications with <u>simple design</u> , GSHP cost is less than chilled/hot |
| As I understand it, Ball State (indiana) steam was kept in place for the Hospital only. | Would be nice to obtain the full story. Something was very wrong given those high ground loop tempertures |
| If your climate / diversity doesn't make for a balanced heating/cooling load, do you recommend a less dense borefield or pursuing a different system type? | If the goal of decarbonization is going to be met, GSHPs are currently the only electric heating option that will minimize demand during cold extremes. The question now is where do community loops provide better economic value and where do individual building GSHPs provide the better economic value. |