SBM_BR2_HeatPump

Wed, Aug 07, 2024 2:45PM 35:36

SUMMARY KEYWORDS

heat pump, pumps, heating, heat, air source heat, unit, cold climate, loads, cooling, system, temperature, building, air, ground source heat, performance, reduced, compared, capacity, manitoba, hydronic

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So hi. Good afternoon everyone, and welcome to the heat pump myth buster. Today we'll be busting the myth do heat pumps work in Manitoba? I'm Anna, a mechanical systems professional with efficiency Manitoba. I support various residential, commercial HVAC programs, including the energy efficiency Assistance Program, air source and ground source heat pump program and variable flow system rebate. I'll be providing an overview of heat pump systems, a couple sizing examples and answer the question, do heat pump, air source heat pumps work in Manitoba? Lindsay Robinson, mechanical systems engineer with em EMS high performance building team will touch on reducing systems loads, additional heat pump constraints and limitations, alternative heat pump options and alternative heat pump options. So what is a heat pump? Heat pumps typically utilized in HVAC applications. Use a vapor compression cycle. This is refrigerant circulated through four stages, expansion, evaporation, compression and heat rejection. Air conditioners, chillers and refrigerators use the vapor compression cycle for cooling, which is transferring heat from an inside space to an outdoor space. A heat pump uses the same cycle, but includes a reversing valve. The reversing valve allows the system to operate in two directions, either transferring heat from outside in or from inside out. So what is an air source heat pump? An air source heat pump uses the ambient air as a heat source, transferring heat energy from within the air air source. Heat pumps are available in a variety of arrangements, and can be further categorized based on how heat is distributed throughout the building, while many of the graphics and examples shown throughout this presentation represent residential arrangements. Heat pump equipment is available for both residential and commercial applications, air to air. Heat pumps transfer heat from an evaporator air coil through refrigerant to a condenser air coil. The conditioned air is then distributed through the occupied zone using fan energy centrally ducted air source heat pumps use ductwork to distribute conditioned air throughout the building. Think a typical newer home with a central furnace and distributed ducting throughout other types of systems that would fall under this would be air handlers, fan coils, furnaces or rooftop units, air to air systems can also be implemented without centralized ductwork. This would be considered a ductless system. Refrigerant piping is extended from the outdoor unit to individual indoor conditioning units throughout a building. Individual conditioning units could then be located at the floor level, on the wall or even sealed are also air to water heat pumps. These transfer heat energy from an evaporator air coil through the refrigerant to a condenser fluid heat exchanger, heating fluid, typically water or glycol, is then distributed throughout the building through a piping network to to the terminal heat transfer units. Terminal heat transfer units could be things like in floor heating slabs, radiant panels, wall fins and fan coils, either way, for all three of the units, there will be an outdoor unit that transfers the heat to or from the air this unit will often look like a typical air conditioner or a condensing unit. As part of the greener homes initiative Natural Resources Canada classified eligible air source heat pumps using the following performance criteria. We use the same criteria in the efficiency Manitoba heat pump repay to determine the difference between standard and cold climate air source heat pumps, you'll notice that the cold climate units have three additional criteria, heating capacity maintenance, which results in less of a capacity drop off at colder temperatures, minimum coefficient of performance at colder temperatures and variable speed. Compressors, what makes a cold climate, air source, heat pump different multi stage, cascading, multi stage or cascading compression systems, enhanced refrigerant control and variable capacity, compressors or fans to match unit operation with low demand. So what does this? How does these performance differences look when applied in real life? I've taken a home with a peak heat loss of 50 MVH or 14.6 kilowatts at a Winnipeg design day temperature. Which is minus 33 degrees Celsius, and then selected two nominal four ton heat pumps to illustrate the difference between a standard air source heat pump and a cold climate Air Source Heat Pump. Both four ton units fall within the 70 to 105% sizing recommendation by in our can specifically the standard air source heat pump rated heating capacity meets 88% of the building's heat loss, and the cold climate unit meets 96% so let's do a quick thermal balance point analysis to further compare these units. Thermal balance point refers to the outdoor air temperature, where the heat pumps heating capacity is equal to the heat loss of the building. The balance point of the standard air condition, the air source, heat pump, falls at about minus 10 degrees Celsius, and the balance point of the cold climate, air source, heat pump, falls at about minus 20 degrees Celsius. As this is a Manitoba specific session, I'll assume most of us are familiar with the winter weather that we have here. More specifically, the temperatures can sometimes go below minus 30 periodically throughout the winter, while it may be daunting that an air source heat pumps heating output is only capable of meeting a portion of the building's peak heating loss, I also want to illustrate how much of the heating season falls within the units capabilities. With that same balance point temperature determined, the air source, heat pump can meet load for almost 5000 hours of the year. That's 70% of our heating season hours in Winnipeg, the cold climate unit is almost at 6000 annual heating hours, which is about 87% of our of our annual heating requirements. Now to look at the implications of three different sizes of cold climate units, I'm comparing the same heat loss so 5050, MBH, and I've taken a nominal 210, 310, and that same four ton cold climate air source, heat pump. All of these heat pumps come from the same manufacturer and model series, the rated heating capacity of each unit at 47 degrees Fahrenheit, or eight degrees Celsius, is as follows. The two time meets 47% three ton is 70% and the four ton is 96% this results in a balance point of minus nine degrees Celsius for the two ton unit, minus 15 for the three ton unit, and minus 20 for the full time unit. So looking at the hourly profile, we see that while the two ton unit falls outside of the recommended 70 to 105% sizing recommendation, it would still meet a significant number of heating hours in Winnipeg, nearly 4500 hours, which is 66% of our heating season. The three ton unit would meet about 5200 hours, and the four ton unit is at about 6000 while well, in all six cases, an air source heat pump does not meet the buildings peak heating requirements. On a Peak Design Day, they still meet a significant proportion of the heating season hours. Does that mean they don't work in Manitoba? No air source heat pumps do work for our climate in Manitoba, just additional considerations need to be made. It's crucial to identify your goals when choosing an air source, heat pump, it is reasonable to size a heat pump for buildings cooling load, and there will still be shoulder season heating benefits by doing so, systems can also be sized to balance the heat and cooling loads. This would result in a unit which might be slightly oversized on cooling, but would provide heating down to lower temperatures, or systems can be selected to meet the majority of the building's heating while you could size a heat pump to meet all of the heating season hours. There are disadvantages in doing so this will result in a higher upfront unit cost or unit performance, from short cycling and reduced overall efficiency, reduced equipment lifespan, thermal stratification, resulting in hot and cold spots or dehumidification performance and acoustic implement implications. No matter how your heat pump is sized, an auxiliary heating source will be required for use in our cooler climate.

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Historically, air source heat pumps have only been paired with electric resistance auxiliary heating system. So. Many of the systems on the market do not require or limit you to electric electric resistance backup, air source heat pumps can be paired with fuel fired equipment such as natural gas boilers or furnaces. In all electric systems, the electric resistance heating element is located downstream of the refrigerant coil, which typically results in topping up the supplier temperature when the outdoor air temperature is beyond the units thermal balance point. Dual fuel systems report refer to air source heat pumps paired with natural gas heating equipment due to equipment arrangements, the heat pump and the gas furnace will not operate co currently. So when making a mechanical system efficiency upgrades, heat pumps can help achieve that goal. It is recommended, before looking at mechanical system upgrades, that considerations be made in reducing system loads. I'll pass it off to Lindsay to discuss this further.

11:06

Thank you very much, Anna.

11:12

Okay, so as Anna mentioned, when we're sizing heat pumps, we must be aware of the heating and cooling loads that they are intended to serve. One of the primary drivers of load is the building enclosure. While this figure is representative of a temperature rather than a cold climate like ours, it's still a good illustration of the relative proportion of heat loss in the winter and heat gain in the summer for different components of a typical house, due to lower ambient air temperatures of a cold climate, we could reasonably expect there would be a lesser proportion of heat loss or gain from the ground or below gray surfaces, and a greater proportion for the above grading. Closure in cold climates like ours, air leakage is one of the important load components shown on the previous slide, and we can see here that many of the most common areas are air leakage, in particular. Transitions and joints between the different assemblies, such as walls to floor and roof or windows and doors to their parent wall, are common areas of air leakage. Similarly mechanical, electrical and plumbing penetrations require careful design and detailing. There are many factors which influence early kitchen buildings, such as the effect of wind on the exterior enclosure, depressurization effects on the interior due to combustion or ventilation appliances, and the stack effect as warm air tends to rise. As buildings increase in height, the stack effect, thermal stratification and pressure differences can become more pronounced. This tends to cause a negative or low pressure on lower level floors, inducing cold air infiltration, while positive pressure on the upper floors causes warm air exfiltration. In the NRCan heat pump sizing guide, they suggest several methods of estimating heating and cooling loads which are shown here aligned with several different air source, heat pump applications, CSA f2 80 load analysis can be used for new construction in existing as well as for existing houses which have undergone extensive envelope upgrades to improve their energy efficiency. Perhaps is that have completed energy efficiency evaluations, particularly those which have the inner guide rating system evaluation design loads can be estimated based on the information contained in the audit report. Also, energy modeling software such as Fauci 1000 can be used to estimate design heating and cooling loads based on the construction details of the build and envelope. And lastly, I'll note that while there is no precise way of estimating loads from installed equipment capacities, and this approach should only be used as a very last resort. As an illustrative example. Here we show the hot 2000 modeling of heating and cooling loads for some prototypical dwellings, a 1500 square foot single detached bungalow in the blue egg. In each case, we vary the air tightness as well as aspects of the building enclosure to represent several different vintages and associated levels of performance. These range from relatively leaky and moderately insulated enclosure typical of an older home in the left most column to the near net zero, high performance home on the right. Consider the incremental improvement between these examples as representative of energy efficiency of representative of potential energy efficiency retrofits. For instance, consider the changes from the typical case to the NBC 2020, tier one case in which the attic insulation, air tightness and windows are all improved. Looking at the associated heating and cooling loads, we can see that the most significant improvement is between the older and typical home, but that the typical home and 2020 tier one levels still show. Show a substantial 20% reduction in heating. Also note that the building enclosure improves. As the building enclosure improves, the heating and cooling loads become increasingly balanced, which can be an important consideration in right sizing equipment now, taking those same three cold climate units from earlier and comparing them to a similar premise, but with an improved envelope, which reduces the homes heat loss from 50 MBH to 34 MBH, similar to the NBC, 2020, tier one levels, with the reduced load. The rated heating capacity of the units at 47 degrees Fahrenheit, or eight degrees Celsius is as follows, two ton meets the meets 71% of the building heat loss. The three ton means 103% of heat loss, and the four ton 141% of the heat loss. The balance point of each unit is as follows as well. The two ton comes in at minus three degrees Fahrenheit or minus 19 Celsius. The three ton at minus five degrees Fahrenheit or minus 20 Celsius, and the four ton at minus 15 Fahrenheit or minus 26 Fahrenheit Celsius. It is interesting to note that for this particular manufacturer, and in this case, the two ton unit essentially meets the same heating output demand the building that has the three ton unit. So the two ton meat unit roughly the same hourly profile as the four ton unit in the previous example, while it may be advantageous to install the larger four ton unit for this home as it will meet the vast majority of heating season hours. There are implications to oversizing the heat pump in such a way. Air source heat pumps should be sized based on the loads and in the context of the application goals. Some common approaches are to size for cooling or to size for a portion of the heating, or to size for a majority of heating, undersizing will create greater dependence on as well as a larger need for auxiliary heating to meet the peak demand, while oversizing will cause inefficient operation due to increased cycling On and off. This can cause thermal discomfort, dehumidification issues, and excessive equipment wear, leading to premature failure in retrofit applications of centrally ducted air source heat pumps. The maximum size of the air source heat pump may be limited by the maximum airflow capacity of the existing ductwork. Air source heat pumps provide lower supply air temperatures, which require more air flow to meet the same heating load when compared with the traditional furnace. Here are some citing considerations for air source heat pumps. Firstly, the outdoor unit must be carefully considered. The location of the outdoor unit must be carefully considered due to its accumulation and the runoff from the defrost cycle. Attachment to building structure is also generally not recommended due to vibration, and instead, outdoor units are ideally mounted on a stand with proper vibration isolation and a proper foundation. This stand also helps with the ice accumulation, which was mentioned above, as well as natural snow accumulation in our climate. Noise from the compressor and the fan should also be considered outdoor unit. Fans are typically in a horizontal orientation, which differs from the vertical orientation of traditional AC systems, barriers such as fences, fences, hedges and garden sheds, as well as add on features such as blankets or acoustic enclosures and offer some mitigation for noise, in addition, quality outdoor units also offer low noise operation modes. Other Air Source Heat Pump configurations include the electrical service and now capacity. Typical residential heat pumps use breakers size between 20 and 60 amps. Now electric. Electric load calculation should be performed to confirm the availability capacity of the existing service. As a note, a 200 amp service is typical for all electric air source heat pump applications. Another consideration is peak electric demand. Air Source, heat pumps do not reduce the peak electric demand posed on the electricity grid and considered in the context of constrained geared capacity in periods of drought or prolonged severe cold weather. Like time and reliability is another important consideration, one should always check the manufacturer warranty period and coverage conditions and seek out other user reviews of their make and model heat pump before making and purchasing this decision. And lastly, commissioning, system commissioning and performance verification is recommended to ensure energy and cost savings are actually. Realized. So in summary, air source heat pumps do work in Manitoba, there are many different system configurations out there, and they offer a wide flexibility to a wide variety of applications, both new and retrofits. Auxiliary heating is required in all cases to deal with peak heating loads in the most extreme temperatures of our climate. And air source heat pumps are a great solution, but have many aspects that must be carefully considered in selection sizing. Now we would be remiss not to mention ground source heat pumps, as they are a great alternative technology which address many of the shortcomings of air source heat their operation is very similar to what we've just reviewed, except the heat is exchanged with the ground rather than ambient air, due to the relatively stable temperature of the earth below the frost line. Ground source heat pumps are an extremely efficient and reliable and do not require a supplemental heat source when size for the full heating load,

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load balancing is extremely important for the long term reliability and performance in ground source heat pumps, perhaps even more so than air source heat pumps, because the ground can be considered as a thermal battery, and ideally the same amount of heat is exchanged for heating and cooling on an annual basis. But if these loads are not properly balanced and the ground heat exchanger not properly sized, it can become frozen or overheated, limiting the performance of the unit or limiting functionality entirely. Let's consider a commercial building example. In these charts, peak heating and cooling loads are represented by the solid lines, while heating and cooling energy is shown by the shaded area on the left, cooling energy is approximately 25% larger than the heating while the peak cooling demand is about 70% larger. The chart on the right is the same building with the additional load of conditioning and ventilation air added to the ground source system, along with heat recovery on that ventilation area. Well, this represents a substantial increase in both the peak load and cumulative energy. It also results in a better overall balance between heating and cooling, and as a result, the heating energy is now 40% larger, while the peak cooling load is 35% larger. Heating we can see the implications of this by looking at the ground heat exchanger itself. In fact, the size of the ground heat exchanger can actually be reduced by 8% because of this better load balance. These plots of entering and leaving water temperatures from the ground heat exchanger show that the initial case on the left would tend to warm the ground over time and lead to a decrease in system efficiency. On the right, we can see that the second scenario has a much more subtle change over time, yielding more consistent long term performance. So ground source heat pumps have numerous advantages compared with traditional systems and air source heat pumps, their operation is not limited by low or high outdoor air temperatures, and they can operate continuously and effectively in conditions outside the capability of air source heat pumps. They offer superior efficiency for the best in class energy and associated cost savings, and they also provide peak electrical demand reduction compared to electric resistance for air source heat pumps, which is an important consideration for our problems, especially as we approach the context of capacity constraints due to load growth as well as prolonged drought or severe cold weather. Since the compressor portion of a ground source heat pump is located indoors, unlike most air source heat pumps, which have their compressors outdoors, these systems also benefit from greater reliability and longevity. Finally, some other considerations. Again, with as with ground source, as with air source, the electrical service panel capacity must be considered the lifetime and reliability. Again, Manufacturer Warranty periods and coverage conditions must be checked for purchasing a unit. But we should also consider siting and landscaping. Actual space is required for the ground heat exchanger in the context of existing buildings, infrastructure and landscaping. And then lastly, commissioning installation should be performed by qualified HVAC professionals, which we would include startup reports and commissioning is an important aspect for performance verification to make sure your real world energy and cost savings are realized. Overall, Heat pumps are a more efficient heating system compared to natural gas or electric resistance heating however, there are benefits and drawbacks to each type. Air source heat pumps have the benefit of ease of implementation, generally lower costs, but have temperature operating limits which require supplement heat. Ground source heat pump have the highest seasonal efficient heating efficiency and can reduce winter peak demand. And when properly designed and sized, these systems are very reliable and have great longevity. However, ground source heat pumps typically have a higher upfront cost compared with other heating systems. So finally, we're here today in an ongoing effort to provide incentives and to support both you and your clients and continued work. I think we might have one slide out of order here, sorry. Overall, Heat pumps are more efficient heating system compared with natural gas.

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However, there, sorry, we did that one already.

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Apologies. Here, folks, air source,

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heat pumps on the back. Benefits of ease of implementation, lower upfront costs, but ground source heat pumps offer better efficiency as well as that peak demand reduction and greater reliability. So of course, we're available for any questions, comments or discussion. Feel free to reach out and contact us, yeah, and I are very passionate about heat pumps and their application, and we hope we've lasted a few minutes today. Thank you very much.

26:14

Thank you guys for that presentation. Really appreciate all of the information that you shared here. So if there is any questions, people can just drop them in the chat. What do you find is, like the top question that comes from people, when you start talking about heat pumps,

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I find it often comes back to cost. That's certainly a consideration that's on everybody's mind these days, and certainly recognizing all of the total system cost involved in implementing any system, whether it's an air source heat pump in a new or retrofit application, or a ground source heat pump, we really need to be upfront and cognizant of all of the costs, including reducting your piping controls and valves monitoring, if you're into that. But yeah, the cost associated with system implementation, I find, is, is on a topic of discussion, and one that really I think we want more data on.

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That sounds good. Yeah, that sounds great.

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One of the things that I've heard is people say that we should just be stopping to sell air conditioners period, because it's just a simple little adjustment out. Do you guys within the system to make it so that it could heat and cool, as opposed to only cool? Do you guys have any opinions on that?

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Personally, I would support that viewpoint. I would also recognize that there have to be caveats made, that there are going to be specific applications in which cooling is definitely needed and desired, and the absence of heating is also applicable. So off the top of my head, I could think of a data center highly cooling dominant. Basically, the equipment provides all the heating for its own space, as well as probably the building and much more. And you're just typically just rejecting heat in all seasons of the year. So it really doesn't matter that that system would have any heating capability whatsoever. So I truly believe that we should generally stop selling air conditioners. But cavid Being there are going to be always special cases that require air conditioning exclusively.

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Makes sense. All right, so, how does forced air heat measure up to hydronic heat when looking at G, S, H, p,

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i, pumps.

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I mean, this is my perspective as someone who came from a hydronic based heating system and moved to an air source, heat pump based forced air system. I think many people recognize the benefits of hydronic systems. They're able to move and deliver energy much more effectively with water than with air. Need a much smaller diameter pipe compared to a much larger size of ducting to remove the same equivalent energy and hydraulic systems naturally lend themselves well to radiant heating, which anyone who's experienced an informed radiant heating system knows just truly how lovely that can feel your feet on a warm, toasty floor. So yeah, there there are benefits for reduced noise, less the feeling of draftiness, so to speak, and just greater overall thermal comfort, specifically in the context of rain heating systems, it also allows us to have generally lower air temperature, but still a very comfortable mean radiant temperature in spaces, which is the actual factor which influences the feeling of thermal comfort. So all that to say is I'm generally a big proponent of hydronic systems. Um, there are a lot of specialized considerations with those systems as well. So it's not necessarily a slam dunk, but if budget allows, and if design capacity allows, I think they're great options. And if that answered the question or and if you want to, that's great way. But

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so does it affect efficiency on how ground source heat pumps transfer heat?

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Not that I'm aware of, but maybe I need to think more about that.

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I'm not entirely certain either. Yeah,

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I believe the primary driver of the efficiency of that system is really just going to be in the temperature lift that one experiences going from the ground temperature the groundwater temperature to whatever you're trying to use to convey your heat in their house. So I'm going to venture perspective, I think that the hydronic system would be slightly more efficient, because typically, again, in the context of a radiant eating scenario, you'd be able to run a lower water temperature in your radiant devices that as compared to the relative air temperature that you need to provide to convey the same amount of heat. So unless I'm mistaken in my reasoning, I think that the hydronic system will have a slight edge there.

31:33

Excellent. All right, are there any final thoughts that you folks want to share? Oh, we have another question before you. As you gather your thoughts, our last presenter mentioned issues with low income households in terms of going ongoing maintenance for solar PV panels. Are there any similar maintenance issues associated with heat pumps, either air or ground?

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I think keeping your say in the context of air source, heat pumps, keeping your outdoor unit free of obstruction, so that there's good airflow in and around the unit. So here's our seat. Pumps rely on air flow through that outdoor unit condensing unit to actually transfer the heat so they can't be blocked or obstructed if somehow leaves or ice and snow accumulation or other debris is all over. The heat pump, outdoor unit, I could see their effectiveness being reduced. So probably sort of like a bit of annual maintenance in terms of cleaning, checking for damage. No varmints have taken a vermin taking up residence in there, that kind of thing, probably similar maintenance to as compared to a traditional air conditioning outdoor unit. I just want to make sure it's clean, protected, probably serviced annually. I'm not exactly sure on the maintenance requirements for air source, heat pump outdoor unit, even though I do have one. So that's on my spring cleaning to do list. But yeah, I think that yeah. And then ground source heat pumps in terms of maintenance, maybe similar to our source heat pumps, probably the compressors need some check every now and again just to make sure that they're operating properly. I think in both cases, you might want to check for appropriate refrigerant pressures. So if your air source heat pump has a refrigerant leak, it will lose pressure and lose effectiveness and not be able to transfer heat appropriately. But you'll probably see some loud noises or heating effectiveness issues or some signs that the system isn't operating correctly, if that type of issue is present,

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trying to think anything else,

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yeah, off the top of my head, that's that's what I've got.

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Yeah, that sounds to me like it in terms of resources, it's more of a time resource than a money. Monetary resource in terms of maintenance. Is that correct? What I heard it

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probably having an HVAC contractor professional come out annually, I would say, is probably a good idea. So budget a couple of 100 bucks for their visits, and then anything that might come up as being

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necessary maintenance. But,

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yeah, great, great. Can you share anything in terms of what a typical payback period is for either ground source or air source heat pumps?

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It's funny that the question it should come up because last night I had intended to put a slide together comparing the annual energy savings, annual energy cost savings, and some net present values and ROIs based on local assume system costs. I did not get around to it, so I don't have that data. Available, but I would love to put it together, and I could, we could include it in this slide deck it's distributed.

35:07

Sure. Yeah, all right. So unless there's any more comments that questions that come up in the chat, or people raise their hand, do you guys have any final thoughts that you want to share just before we wrap up for the afternoon? I'm good

35:23

air source. Heat pumps do work in Manitoba. Don't believe anyone who says otherwise, but they need special consideration, as with any HVAC system, needs to be properly designed and sized so.