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Heat Pump Water Heaters: Standby Capacity (Part 7)

Monday Morning Minutes | by Norm Hall, September 19, 2022

Hot water availability in many commercial and institutional buildings is critical. Engineers also know that these service water systems are generously sized for the peak load and most of the time there is ample capacity, even if a single heater fails. What about standby capacity for heat pump water heaters? What choices will the engineer or designer be facing?

CO_2 Heat Pump Water Heaters and Standby Capacity

In the northern climates standby capacity takes on a different meaning when it comes to heat pumps. When it very frigid outside in the dead of winter, the heat pump may not be able to function. The heat pump is not broken, and power is available, but the limiting factor is the refrigerant used. Some refrigerants will not allow function below +30ºF, some +10ºF, and even our preferred R-744 refrigerant will cease to operate below -4ºF.

Some provision for the operation at extreme low temperatures will be necessary if the building will be used at extreme low temperatures. The R-744 commercial heat pump water heaters installed, even in the smaller size recoveries, are well over $100K each in

2022 dollars. It may be prudent, even in warmer temperatures, to use the heat pumps for the load and use another means for standby.

Standby in Retrofit Projects

One method to achieve standby in building renovations is the re-use of the older gas fired water heaters for standby. Even if the water heaters are old, they can serve a purpose. If codes or project goals allow the use of gas fired appliances, this is an inexpensive way to achieve the standby. The re-use of gas-fired equipment as backup has many advantages. Project first costs of installing and powering standby or backup capacity can be kept down. Existing equipment lifespan will increase as it will only be relied on rarely. The energy costs will still be mostly borne by the higher efficiency heat pumps, so there will only be a small impact on operating costs.

Using a gas fired water heater will also allow the owner an option if the power is out. If a generator can power the control circuit in a gas fired water heater, there will be hot water. This could be the backup required during very cold weather.

The water heaters will be piped in single pass piping as if they were the last tanks before the recirc tank. They could be used as the recirc tank but now you are introducing a carbon-based device that will operate regularly. One word of caution. We tend to use the R-744 heat pump to produce 160°F water to store. This should not be done if you are using existing glass lined tanks. Most of those tanks have a hard temperature limit at 140°F.

This would probably not be a viable or desired solution in new buildings. The cost of adding gas fired equipment including venting and gas lines would have no payback and may not even be allowed by code.

Electric Resistance Heaters Added to the Storage Tanks

One way to achieve standby capacity for the air source heat pump water heater is the addition of electric resistive heaters in the storage tank(s). These elements will heat the water in either the last tank or all tanks if the temperature drops below the lowest set point. If the backup is for 100% capacity, there will probably be heater elements in all tanks. If the backup is a fraction of the total, then there may be heater elements in a single tank. There are a variety of ways to do this depending on how the standby capacity or backup capacity is controlled.

The electric elements have a coefficient of performance (COP) of one. The kWh usage of these electric elements will be significantly higher than the heat pump. The engineer may want to think of standby in terms of less than 100% capacity. Discussions with the owner about the ability to extend peak usage time and possibly, flatten out usage to avoid the design peak load in standby mode may help satisfy needs while reducing the first cost and utility peak demands. As I mentioned, it is a discussion.

The conversion from BTUH to the kWh required load for water heaters is the same formula used for boilers. There is a convenient conversion calculator in our blog, Top 10 Things You Should Know About Commercial Electric Boilers (Part 1).

Electric Resistance Heaters for Extreme Cold Weather

The other advantage of these electric resistance elements has to do with weather. As I mentioned at the start of this blog, even R-744 heat pumps have a low outdoor air and humidity temperature limit. These electric resistance heaters can serve for those times when the heat pump cannot operate.

There may a thought brewing at this point. If I must put electric resistance heaters in for the cold weather, why am I bothering with heat pumps? Why not just put in electric water heaters to begin with? Those are viable concerns. The answer has to do with the Coefficient of performance or COP. If electricity is the major alternative to gas, the availability of

electricity will become an issue. At best we will need more sources including wind, solar, and nuclear. New utility plants take time, both political time and design/construction time. Meanwhile, there may be higher usage costs and demand charges for electricity. This already starting in some areas of the country.

The engineer and owner must look at the overall expectation of electric cost increases soon and not base the financial decisions on status quo. This will make the larger COP of air and water source heat pump water heaters a better financial opportunity. ***OK, I'll get off my soapbox now.***

Use the Standby Hydronic Boiler as the Heat Pump Water Heater Standby

Another option for the extreme cold weather is to use a standby electric boiler from the hydronic heating system and a heat exchanger package with controls. Any reset schedule would drive the boilers to full design temperature when the weather is below zero. This same idea could be used for the standby to the heat pump. There would be a requirement for a controls interface to drive the hydronic reset temperature to design in this rare standby situation. This obviously would not work with lower temperature radiant floor systems or heating and cooling heat pumps. I'll write a bit more about this next week when we talk about sizing the R-744 heat pump water heater.

Many choices and options, but that is why they call it engineering. Next week we will look at the output of R-744 refrigerant heat pump water heaters and the northern area weather using an example building.

Part 1: Heat Pump Water Heaters: The Road to Decarbonization

Part 2: Heat Pump Water Heaters: How They Work

Part 3: Heat Pump Water Heaters: Refrigerants and Weather

Part 4: Heat Pump Water Heaters: Temperatures & Storage

Part 5: Heat Pump Water Heaters: Parts & Pieces & Storage

Part 6: Heat Pump Water Heaters: Hot Water Recirculation