

Spencer Family heat pump - awfully boring. Photo by Justin Spencer

Decarbonization Journey Part I: Why did I buy the most boring heat pump?



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While I've been thinking, working, and writing on electrification for over a decade, I didn't actually apply this thinking to my personal household until this past winter. In a series of articles, I'm going to write more about my own personal experience with my new heat

pump, new EV, and insights I'm gleaning from the data collected on these and how these can be applied to program and policy design, as well as personal choices. But we'll start at the beginning with the heat pump choice.

Last summer, my existing central AC, a giant high efficiency Trane unit from ~2007, before I bought the house, stopped working very well. It just didn't cool very well. As somebody who does research on HVAC for a living, I had a pretty good idea of what was going on: slow refrigerant leak resulting in charge getting low enough that the TXV can't keep control very well anymore, tons of evaporator superheat leading to extra low refrigerant temps, freezing coil, dog hair popsicles that you melt by running in fan only for a while, etc.

So I considered three different choices before me, if I wanted central cooling that worked in the future:

1. **Try to get the equipment repaired.** I briefly considered this. I could have called for a repair, but it would have cost me real money and I didn't feel there was a high chance of success lasting for very long. More likely, I would have gotten a new charge of refrigerant, without leak repair, which would have promptly leaked out. This is R22 and the old system was a 4 ton system rated to have ~13 pounds of refrigerant, or 6 kG. Unfortunately, R22 has a GWP of 1810 (R410a is even higher, at about 2000). So if this refrigerant then leaked out again over the next few years, the emissions associated with this refrigerant would be equivalent to about 11 tons of CO2. That's not satisfying and really bad for the planet. R410a would have given a similar answer. So, **lesson 1: If your AC is failing and it's due to low refrigerant, and you care about the environment, don't get it charged without making sure the contractor feels good about having eliminated the leak.** And if it's old, you're likely to be developing more leaks soon. I decided not to get the system repaired.
2. **Buy a new CAC.** I briefly considered this route, but it seems silly to buy a one-way air conditioner, when I could buy a new heat pump, which does both. This was going to cost quite a bit of money. So this was really the default option, which was causing me to get off the couch and buy something.
3. **Buy a new HP.** A new HP could theoretically save a lot of carbon by displacing gas heat and potentially allow me to mitigate fuel price risk. While this would likely represent a cost premium over a new CAC, I was excited about seeing what it could do for me personally.

I ultimately decided that I wanted to get quotes for HPs, contacted several contractors, and wound up getting visits and full quotes from 3 contractors. The contractors were keen to understand the following questions as they were preparing quotes:

1. **What was the existing heating/cooling system?** I had a ~4 years old, high efficiency condensing furnace and CAC.
2. **What's the existing electrical panel situation? Can it accommodate additional equipment?** I have a 200A panel with a 100A subpanel in the basement. There was room for more equipment, but the 100A subpanel would be tapped out at some point, since there was already a 1.5 ton minisplit HP and several (unused) electric baseboards in that panel.
3. **What does the existing ductwork look like? Any existing airflow issues to report?** The contractors were eager to measure the size of existing supplies and returns. My house is a ranch with furnace in a closet in finished basement, closer to the end with with the existing CAC, with supply and return trunks and ducted returns in each large room of the house. I did have issues with getting enough airflow to the opposite end of the house, so the master bedroom was typically colder than desired in winter and definitely hotter than desired in summer.
4. **What were the homeowner objectives?** I made it clear that I was interested in a heat pump, saving carbon, but that I was open to keeping gas backup. I did not make it clear enough up front that I was also hoping for an economical solution.
5. **What were the existing bills?** One of the contractors asked me for my gas bills. They were able to use these to refine their sizing estimates without needing to do a manual J.

The contractors that I worked with and got quotes from were all professional and experienced and I was happy with their work, though

Based on the quotes, here were the four options that I considered:

1. **All-electric heat pump.** One contractor specialized in helping people on their electrification journey. This would have involved tearing out the existing gas furnace, replacing with new air handler and installing a new 240V circuit in the subpanel with some minor drywall work. Cost was pretty high and heat pump would have been borderline for covering the full load with the ducts that I had, so I also got a quote for an additional minisplit to serve the master for this situation. Sticker price for this setup was about 30k, including the minisplit. But I would have gotten ~10k in rebates for this setup.
2. **Variable speed heat pump with existing furnace.** One contractor offered this option (same as number 1). This was intriguing to me and had a pretty nice price, gross sticker price about 20k, net price of about 12k. This looked pretty great, but

the one problem they mentioned was that at temperatures in the 30s, I'd be running plenty of airflow and not much heat pump, which would mean cooler supply temps than I would get with the all-electric option.

3. **Variable speed heat pump with new furnace.** Two more traditional air conditioning contractors both offered up this choice. The better quote came in at around 22k, with a net price of 14k after rebates and incentives. They didn't have an option that could qualify for the rebate and keep the existing furnace. This option offered the best overall performance, flexibility, and comfort. High supply temperatures all the time, dedicated backup for when it drops well below zero, high heat pump capacity and efficiency down to 0 degrees.

4. **Single-stage heat pump with existing furnace.** I had to ask for this extra option, which had the lowest sticker price. There were a few variants, but the one I zeroed in on was slightly better than base (slightly quieter) and offered a more attractive financing option. This unit had lower efficiency, lower supply temperatures as it got colder, but it had the lowest sticker price, about 12k.

Ok, so given these choices, which one would you choose?

I thought long and hard about a few things:

1. **How much did I care about my personal finances and comfort?**
2. **How much did I care about helping society?**
3. **How much did I care about being able to try something different and document the experience of my path?**
4. **How much did I care about signaling my environmental values?**

I ultimately decided that while I cared about all of these, but for the heat pump purchase I cared most about #2, then 1 and 3 about the same, then 4 the least.

So, how does buying a heat pump impact my ability to help society? I'm trying to save carbon so that future humans (including my 3 kids) can live prosperous and fulfilling lives without having to deal with climate catastrophe. At the same time, I also care about current humans trying to do the same thing.

I struggled with this question: Should I ignore the impacts of my purchase decision on current ratepayers and taxpayers?

My answer to this question is no, I should not ignore these. I'm using real resources that get charged to people's real bills when I take an incentive from my utility or my government.

How should I value those cost impacts against the carbon benefits?

I fell back on the same frameworks I use to advise my clients when planning for decarbonization: What's the marginal cost of carbon saved associated with a given decision? How does that compare to other decarbonization options for our society?

I started with the baseline being the cheapest option overall, not cheapest for me, which was the single stage heat pump with the existing furnace. First, I calculated the greenhouse gas emissions associated with my current furnace, by disaggregating monthly bills into heating and non-heating. My total annual heating load was about 400-450 therms/year, while the non-heating was 250-300 therms/year. My house already had a single head minisplit serving the basement, using ~2,000 kWh/year. A fair amount of that heat also drifts upstairs, so I estimated that the existing minisplit was already meeting something like 30% of the load. With a conversion rate of 0.0053 MT CO2e/therm, my annual emissions from heating work out to about 2.5 MT CO2e/year. If I was able to get away with a 20 degree switchover temperature, I'd be able to eliminate 80% of that gas consumption, cutting gas-related emissions by 2 MT. The electric emissions in this case will go up some, about 0.5 MT. So I net saving 1.5 MT/year with this system. At an incremental cost above the central AC I would have purchased of $2,000, the annualized capital cost over 15 years works out to ~$130-200/year, depending on your discount rate assumption, plus an extra $20-50/year net in heating bill increases. The net increase in cost is about $150-$250/year, so the cost of CO2 savings works out to $100-150/ton of CO2. I value CO2 at more than than, so at a minimum, this investment made sense to me.

Then I considered each of the others. The option that looked the best was running a cold climate heat pump to cover almost the entire load at an additional incremental cost of $8000. This could save approximately 0.5 tons of CO2/year, at most. This costs an additional $550-800/year, depending on your discount rate assumption, and the additional bill cost would be ~$30/year. So a net cost of $600/year additional, with 0.5 MT of CO2 saved per year leads to a CO2 cost of $1,200/ton. I decided this was too much to ask of my fellow ratepayers, if I wasn't valuing CO2 at $1,200/ton.

Therefore, I settled on the minimum efficiency heat pump with the 20 degree switchover temperature and no rebates as the option that would be most beneficial for society and that I was willing to pay for.

The part of this that seemed risky to me at the time was whether or not we would be comfortable enough with a 20 degree switchover temperature.

The contractor was happy to install the new minimum efficiency unit. I gave the installer a tour of the systems and talked about what they were going to do. I was heartened when

they said they would use a 20 degree switchover. When I came back from work, I had a shiny new system installed, no fuss, no mess, just swapped the thing out in 1 day with minimal inconvenience for my family or me.

I'll write again soon to tell you how that 20 degree switchover worked out for me, but might need to write about the EV experience first.