



Hydronic Heat Pumps with Thermal Storage Update

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Maine Goals and Background

- Goal 1: Prove the potential to retrofit standard northern Maine homes heating with boilers to air-to-water (hydronic) heat pumps
 - Determine true water temperature needs of the home
 - We are currently using the highest temperature hydronic units on the market (179F)
- Goal 2: Demonstrate that thermal storage can be used to shift load
 - Can take advantage of time-of-use rates today
 - Test transactive energy potential for the future
 - Dependent on regulatory changes and the way utilities collect and manage billing

We are currently monitoring 4 homes in Millinocket, with 1 additional installation partially completed

How Does the System Work?

- Hydronic Heat Pump with three 120-gallon water tanks and a buffer tank



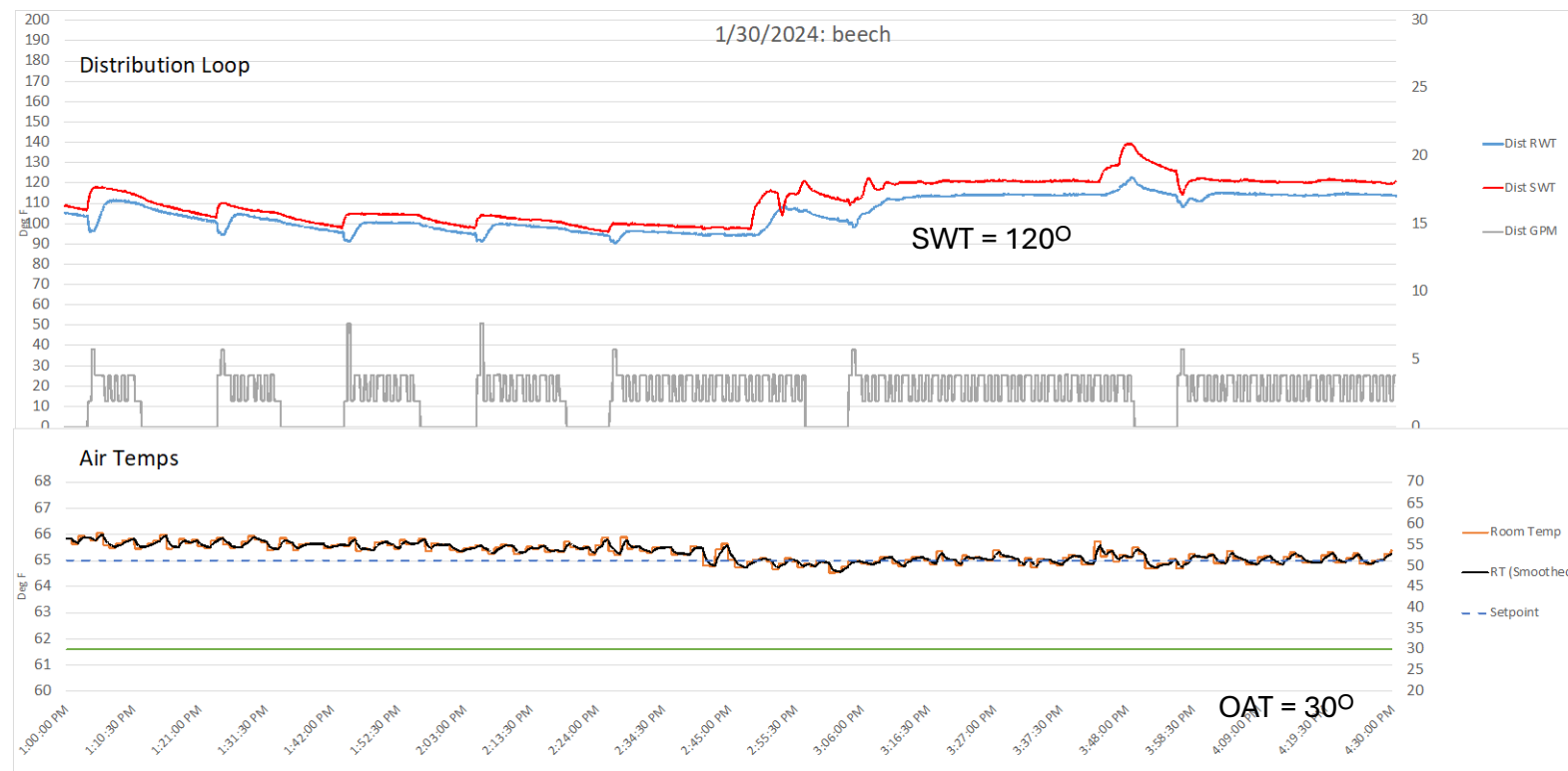
- These systems buy electricity flexibly, using forward-looking optimization techniques that can reliably operate when energy prices are lowest





Results of hydronic HPs so far:

- We have proved that we can keep an average home warm on the coldest days in northern Maine with a hydronic HP
 - Temperatures have dropped as low as negative teens this winter with no issues
- We do not need 180°F water to keep an average home warm on even the coldest days
 - Lower water temperature = higher COP

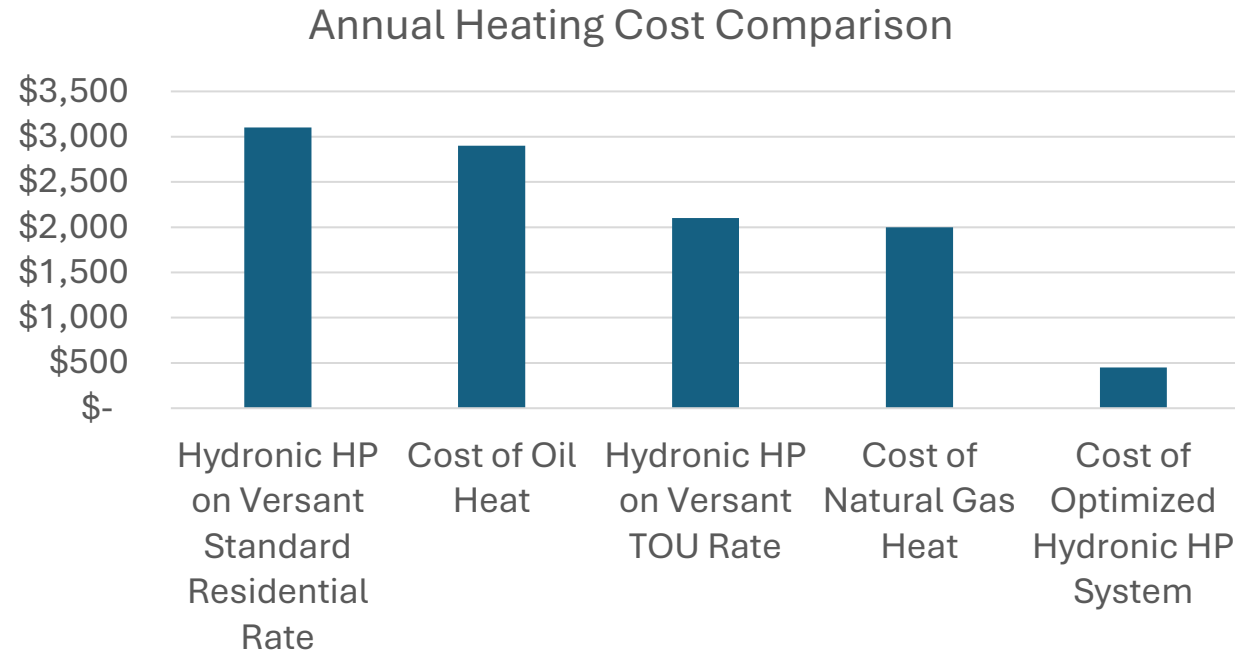


Other Programs Background

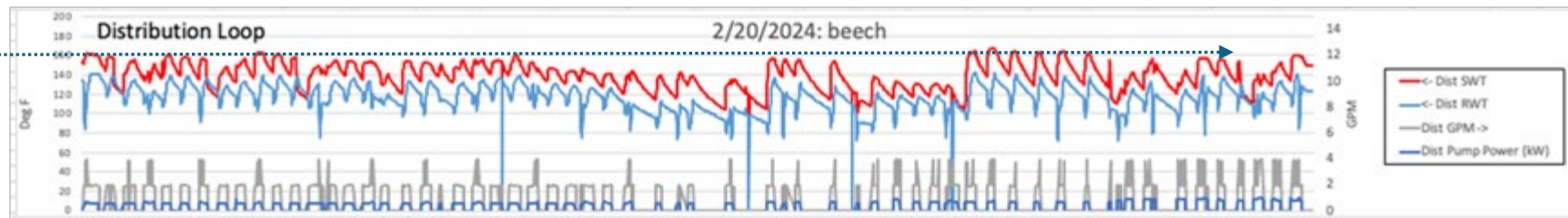
- Vermont, Massachusetts and New York currently offer rebates for air-to-water (hydronic) heat pumps
 - Installations are in radiant heated homes, mostly new construction
 - Require lower water temperatures than boilers
 - No testing standards currently exist for air-to-water heat pumps
 - Rely entirely on manufacturer reported data
 - Testing standards are reportedly being worked on by AHRI
 - Low uptake
 - Radiant heating is installed in about 2% of new constructed homes in Maine according to our New Construction Baseline study

Why Thermal Storage?

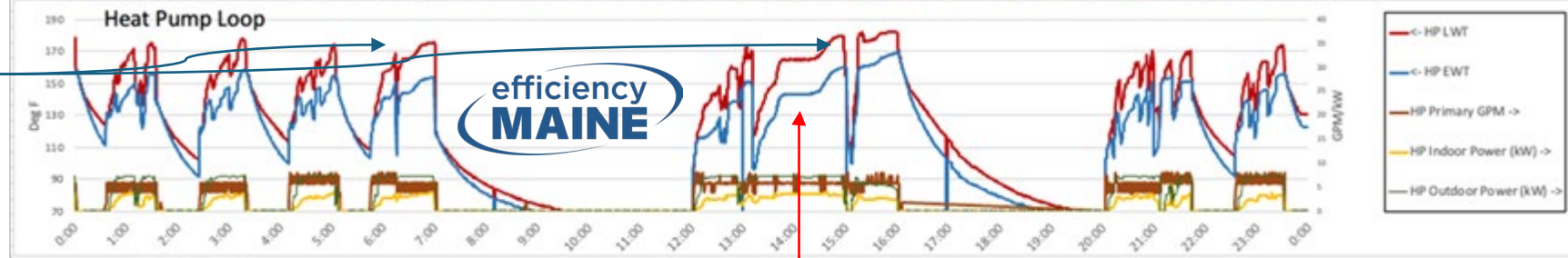
- Thermal Storage can significantly reduce the operating costs by lowering the cost of buying the electricity;
 - Accessing only Versant Power's Time-of-Use delivery rates, we are beating the cost of oil heat and demonstrating what could be possible with real-time grid response and distribution rates



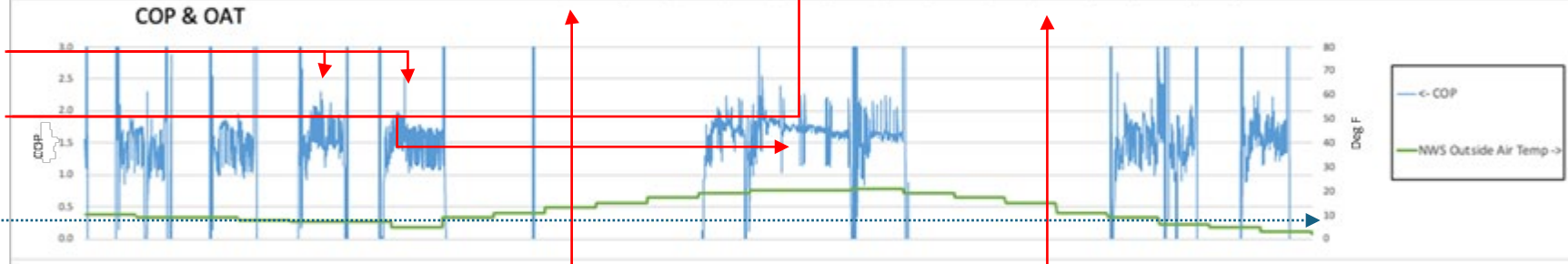
Dist SWT of 160° +



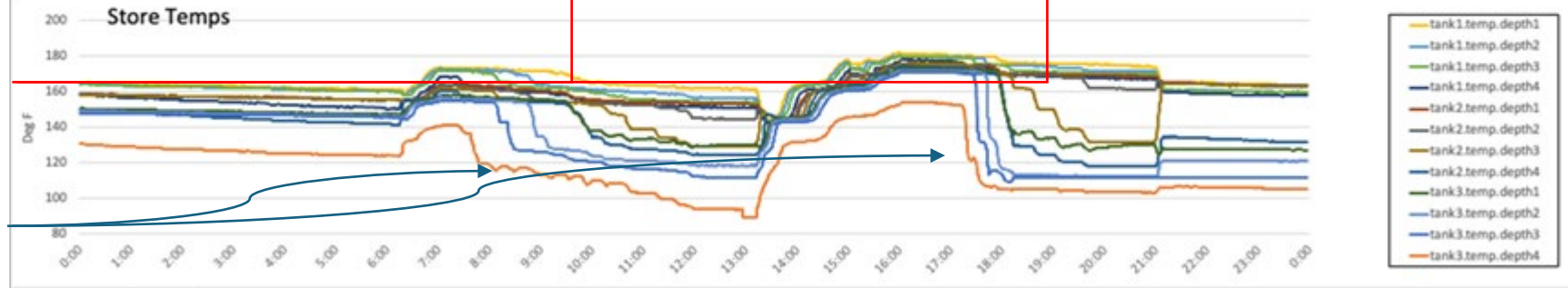
HP Leaving Water Temp (LWT) of 170° +



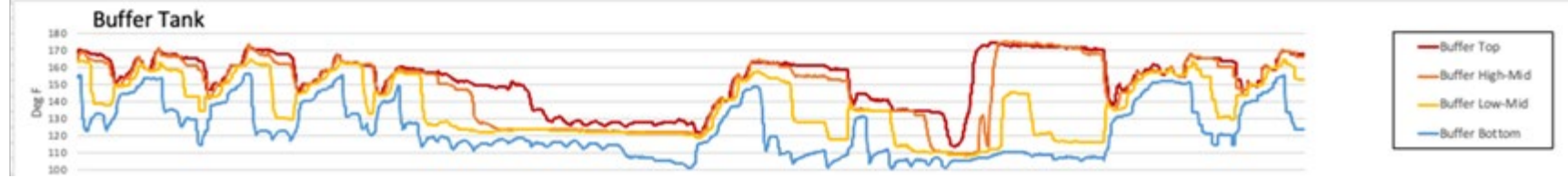
COP goes down with lower OAT and with higher LWT
Outdoor Air Temp <10°



Store heats the house thru on-peak



Storage Tank Stratification



Results of Controlled HPs so far

- We can replace boilers and keep an average home warm on the coldest days in northern Maine while not operating on peak hours
- Thermal storage works and enables us to use time-of-use tariffs
 - Operation costs are lower than oil
 - If we could access real-time prices, savings would be even larger
- The technology is still new and there are challenges with pilots
 - Still collecting more information on how to best utilize the technology

Next steps

- Continue to refine the configuration and identify new generations of air-to-water heat pumps that may be viable
- Demonstrate the load shifting potential and what shifting to real-time prices would mean for consumers and the utilities
 - Reduce energy costs by 30% - 50%
 - Use otherwise wasted energy to heat homes
 - Reduce curtailment and stranded costs for the utilities
- Explore working with Coops as next pilot phase