Summer 2021

Heating Electrification Strategy Update for Decarbonizing BU's Charles River Campus: **Building-by-Building & Steam Loop Analysis**

1. Review of Previous Results: Hybrid LT ASHP & Cost of Carbon Removal
2. Issues Addressed: Steam Loop Buildings, Effectiveness of Low-Temp ASHPs, Building Electrical Capacity, Detailed Building Analysis
3. Next Steps

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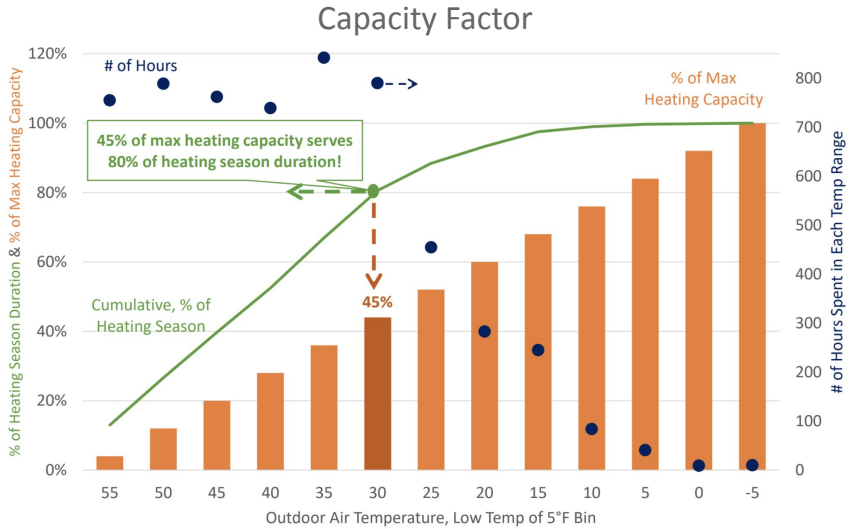
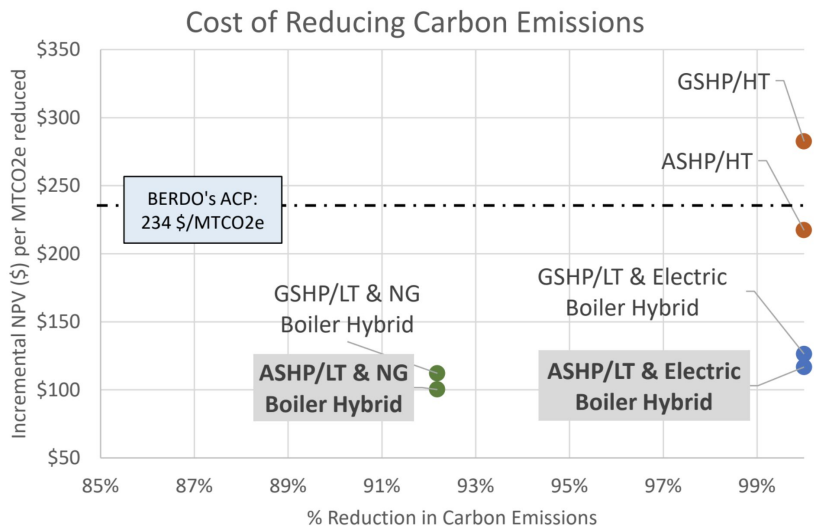
Summary of Previous Findings

- Heating represents 40% of BU CRC GHG emissions
- Low-temperature ASHP hybrid strategy can achieve 90% GHG emission reduction and minimize CapEx for expensive ASHPs
  - Use existing NG boilers and steam loops for supplemental heat for coldest days of year (<30F) & will only be 10% of fuel use/emissions & will provide backup
- Incremental cost for BU to invest in hybrid heating is ~$100/MTCO2e vs Boston BERDO's ACP of $234/MTCO2e





Scope of Summer Work

Overview

- Conducted building-by-building analysis to tailor retrofit strategy to individual buildings on campus
  - Which buildings on the campus steam loops can be electrified?
  - Are low-temperature ASHPs a viable option for buildings designed for high-temperature heating hot water?
  - Do the key buildings have sufficient electrical supply and capacity?

Outreach

- Presented preliminary technical, financial, and environmental recommendations to BU Facilities Management & Operations for discussion and feedback (June 2021)
- Outreach with Ecosystem Energy and CannonDesign

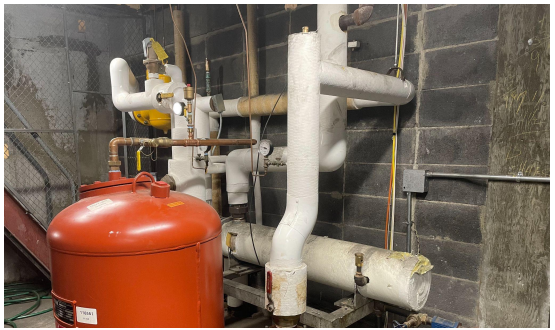
Impact

- **21** Buildings (15 Key Buildings + 6 Possible Pilot Buildings) make up **54%** of CRC Heating/Fossil GHG Emissions (26,400 MTCO2e of Emissions) and **48%** of CRC Total Building Area
  - **Residences:** Warren Towers, West Dorms, StuVi-1, StuVi-2
  - **Labs:** Photonics, CILSE, LSE, Metcalf, Physics Research Building
  - **Recreational & Activity Centers:** Yawkey, Agganis Arena, FitRec
  - **Offices & Classrooms:** Questrom, Mugar Library, School of Law (Redstone)

Which Buildings on the Steam Loops can be Electrified?

- Key buildings on the West and Central Steam Loop have steam-to-hot water (180F) converters, making them viable candidates for heating electrification
  - Older dorms: West Campus (Claflin, Sleeper & Rich Hall) and Warren Towers
  - Newer dorms: StuVi-1 and StuVi-2
  - Evaluate space, cost, and technical challenges of adding heat exchangers
- **Operation:** Similar to hybrid strategy for buildings with NG boilers, we propose using steam loops as supplemental heating on coldest days of the year
- **Will there be a problem with operating the steam distribution system on partial loads?** No — confirmed by industry experts

StuVi-1 Heat Exchanger



Claflin Hall Heat Exchanger

Are Low-Temperature ASHPs a Viable Option for Buildings Designed for High-Temperature Hot Water?

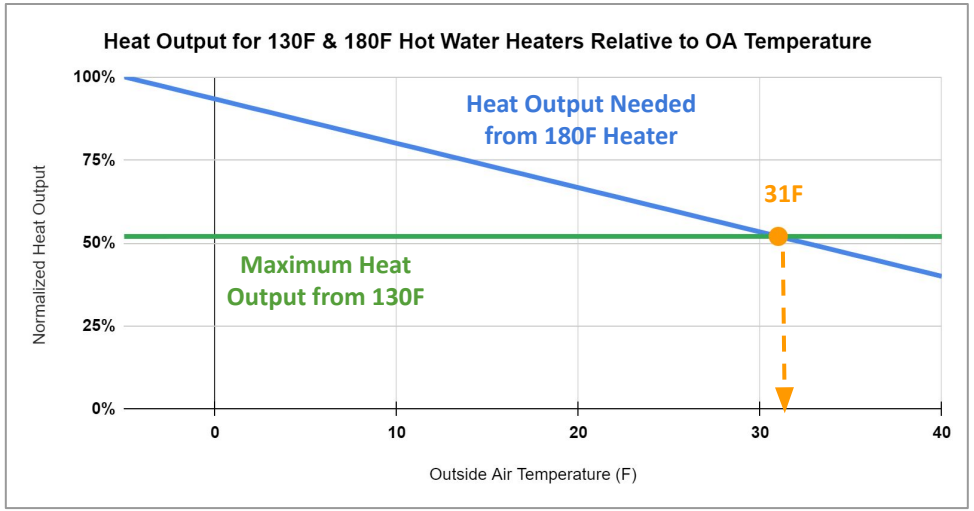
Key Question: How well will low-temperature ASHPs (130F) perform during winter in existing high-temperature (170-190F) hot water heat exchangers (perimeter heat, VAV, AHU)? (13 of 15 key buildings*)

Rationale:

- Our engineering analysis (air-water heat balance) shows that 130F hot water provides required heat when outside air temps are >= 31F. (Provides ~50% of the heating power relative to 180F hot water supply)**
- For remaining heating power (when temp <31F), use NG boilers/steam for supplemental heating and for higher temperature working fluid

Conclusion:

- Low-temp ASHP hybrid strategy will meet heating needs
- **Enables 90% carbon emissions reduction, since only ~10% of the heating energy use occurs when temp are <31F**



*CILSE and Yawkey had low-temperature water
** Verified by Sterling HS application manuals

Is There Enough Electrical Capacity in Buildings to Add Electric ASHPs?

- In previous phases, one major feedback we received is that our electrification strategy may exceed the electrical capacity of the buildings
- **Found that 13 of our 15 key buildings receive 13.6 MW (13.8 kV, 600 A, 3-phase) of electrical capacity, both from utility supply & in building hardware**
  - **Current peak is 1.6MW while expected heat pump peak will be 2MW**
- Need to conduct further analysis, but existing electrical capacity should be sufficient in at least 13 of our 15 key buildings

Next Steps

- Buildings on Steam Loops: Investigate feasibility and cost of implementing and configuring additional heat exchangers in buildings
- Summer Reheat: Investigate how we can meet this load (5% of total annual heating load) and evaluate the use of waste heat recovery for summer reheat
- Analyze Energy Efficiency Measures: Estimate potential additional energy savings from measures to reduce electrical loads
- Continue Assessment of Buildings' Electrical Capacity
  - Evaluate constraints of building electrical supply and potential additional costs to extend capacity of transformer unit substations
  - Building-by-building analysis to determine impact of electrification on existing loads
- Continued Discussion
  - Further outreach with BU Facilities Management & Operations and MEP companies
  - Prepare for Heating Electrification Seminars with ISE
  - Publish and present work to BU community and other organizations

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Estimating Costs & Financing Large CapX Projects

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Understanding Boston University's Planning, HVAC Implementation, & Budget

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Geothermal: Heating & District Heating

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