Spring 2022

# Heating Electrification Strategy Update for Decarbonizing BU's Charles River Campus:

## Analysis of Summer Reheat Electrical Loads & Capacity Requirements and Analysis of Interval Data to Identify Energy Efficiency Opportunities

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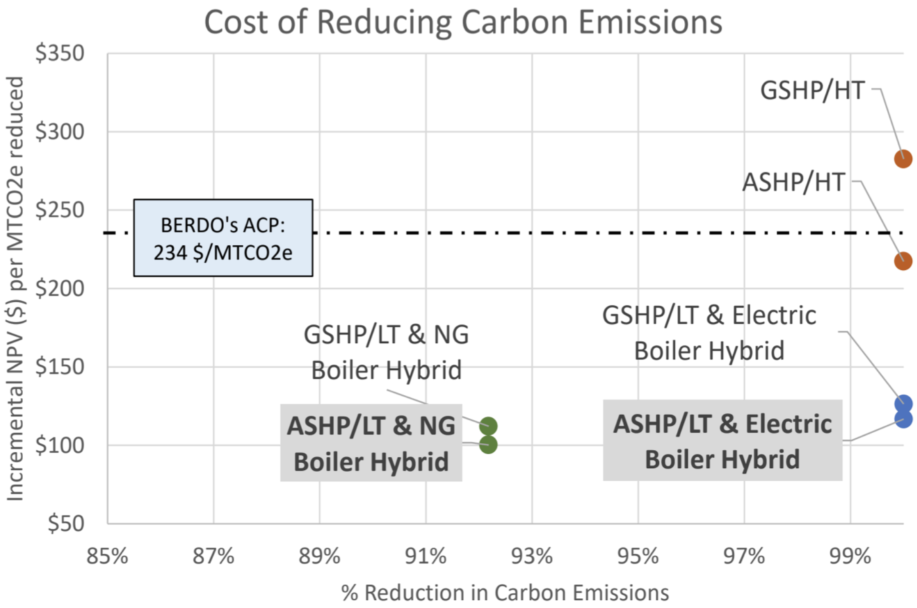
# Summary of Previous Results

- Heating represents 40% of BU CRC GHG emissions
- **Focus:** 15 Large Buildings account for **51%** of CRC Heating/Fossil GHG Emissions (26,400 MTCO2e of Emissions), **48%** of CRC Total Building Area

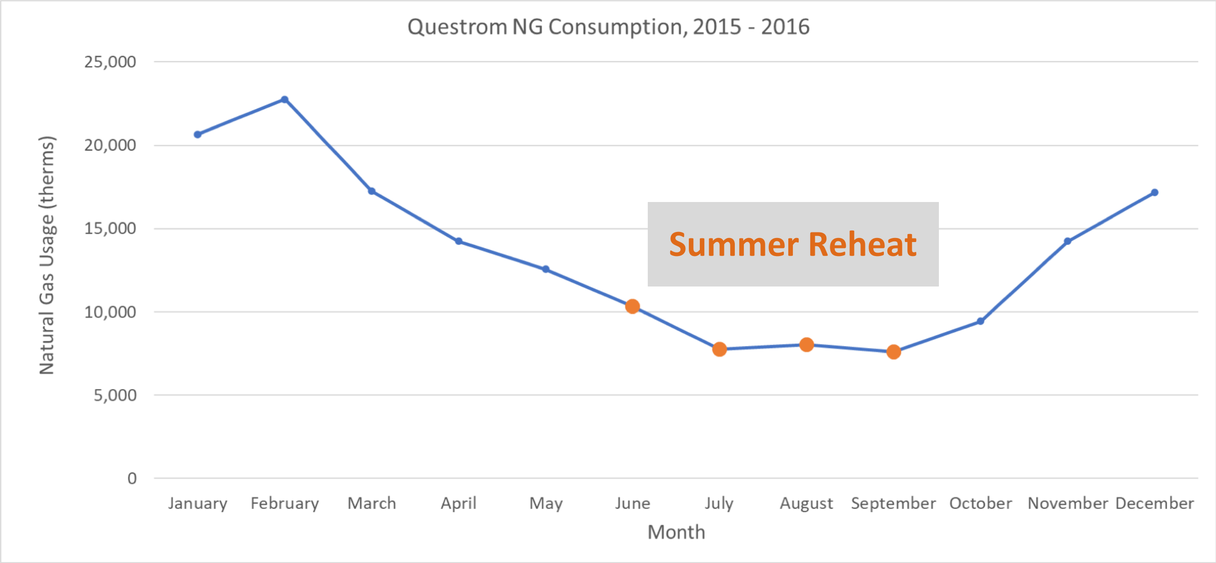
- Low-temperature ASHP hybrid strategy can achieve 90% GHG emission reduction and minimize CapEx
- Incremental cost for BU to invest in hybrid heating is ~$100/MTCO2e vs Boston BERDO's ACP of $234/MTCO2e



# Electrifying Summer Reheat

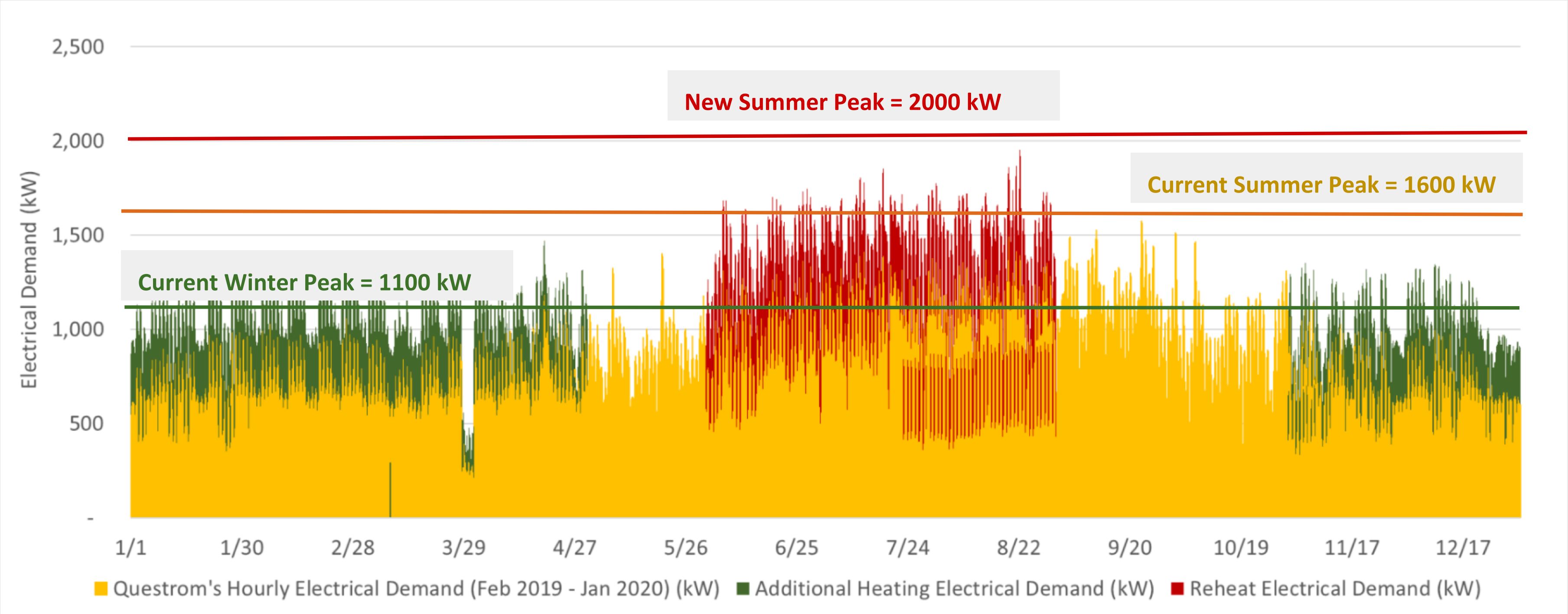
- **What is Reheat?**
  - In summer time, cool all air to 55°F to wring out humidity. Need to heat air back up to 65°F to allow the air to condense in order to control temperature and humidity
- **Why is it important?**
  - Currently **represents ~40% of natural gas use** & significant carbon emissions

- **Questions to be Answered**
  - How much additional electrical use will this entail?
  - Will the current heat pump design have enough capacity?



# Preliminary Model of Heating Electrical Demand

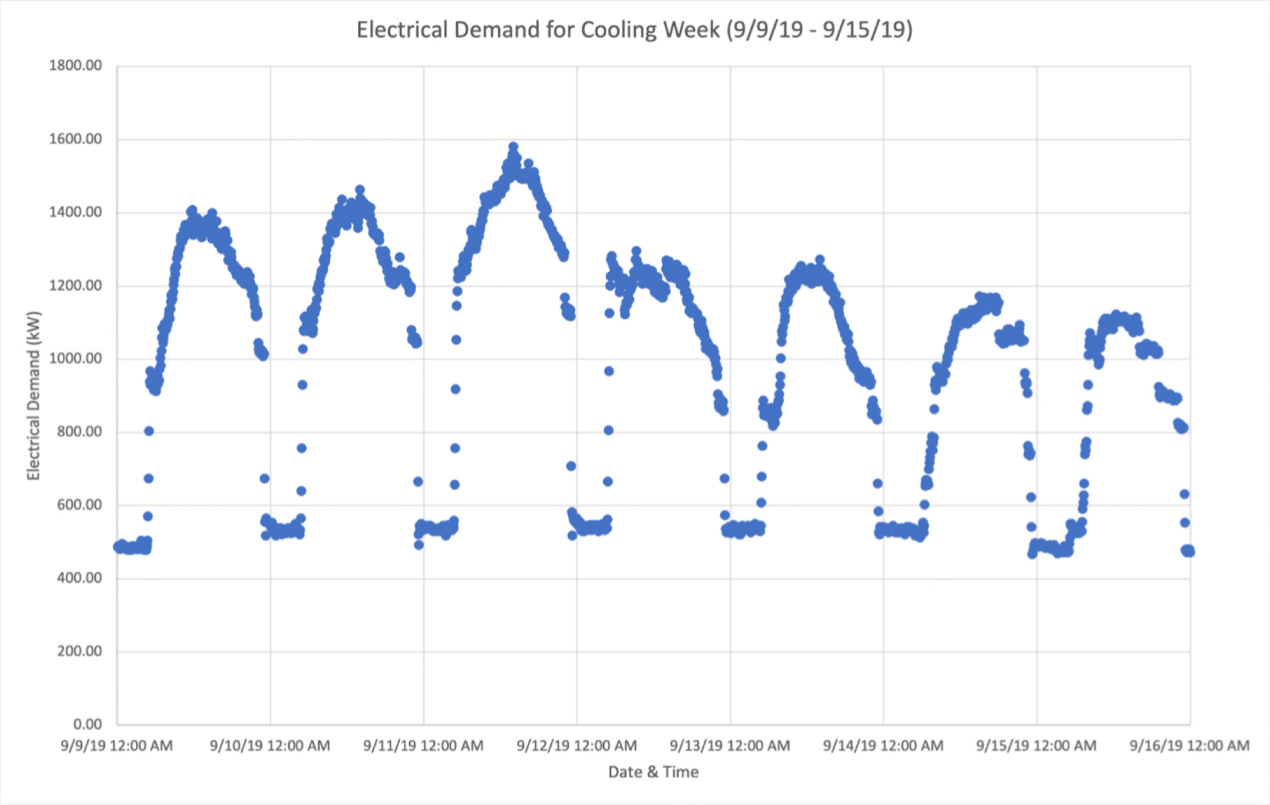
- Estimate indicates that the ASHPs in current design are sufficient to meet reheat load requirements!
- Existing transformers in building have 8,600 kW of capacity



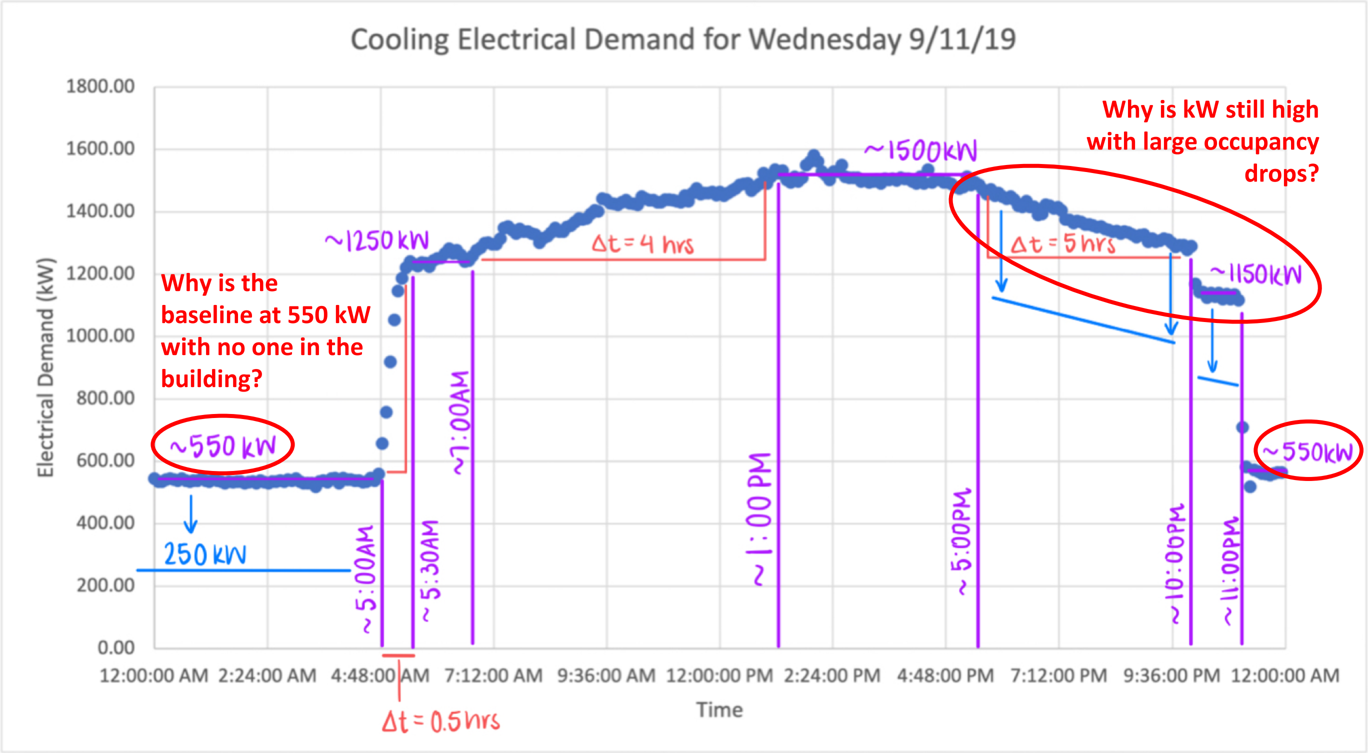
# Interval Data: Analysis to Identify Energy Efficiency Measures

**What is Interval Data?**

- Electrical demand provided for 15-minute intervals on a building-by-building basis
- Analyzing interval data can show where electrical and heating demand can be reduced with energy efficiency measures
- Preliminary research focuses on Questrom Interval Data from 2019 to 2020



# Example Interval Analysis Savings for One September Weekday




- HVAC comes on at 5am and runs until 11pm
- Large reduction of occupancy occurs at 5pm
- Could significantly reduce HVAC usage between 5am to 7am and 5pm to 11pm
- **Impact:** Could produce **15%** savings to have significant GHG emissions and cost reduction

- **Question to be Investigated**
  - What % of the building is occupied in June, July, and August & could there be savings?

# Next Steps

- Buildings on Steam Loops: Investigate cost of implementing and configuring additional heat exchangers in buildings
- Analyze Energy Efficiency Measures: Estimate potential additional energy savings from measures to reduce electrical loads
- Summer Reheat: Further investigate how we can meet this load and evaluate the use of waste heat recovery for summer reheat
- 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

# Acknowledgements

We'd like to sincerely thank the following individuals for their insight & time:

**Boston University Student Researchers**

**Author of "BU CRC Electrification" Analysis (Jan 2018)**

David Staller (ME '18)

**Authors of "Energy Efficiency Opportunities on CRC" Analysis (May 2017)**

Gabriella Henkels, Charles Bradley Miller, Ryan Peters, Carly Baracco, Anthony Graziano, Cole Ashman Paul Chiampa Jr., Jessica Gimbel, Cristian Morales

**Estimating Costs & Financing Large CapX Projects**

| | |
|---|---|
| Domenic Armano | President, Guardian Energy Management |
| Phillip Eash-Gates | Senior Associate, Synapse Energy Economics |
| Michael Gibbs | Former Assistant Executive Officer, CARB; Former Deputy Secretary of Climate Action, CalEPA; Former Senior Vice-President, ICF International; |
| Megan Howard | Director, MassCEC |
| Judith Judson | VP of Distributed Energy Systems, Ameresco |
| Robert Kaufmann | Earth & Environment Professor, Boston University Founding Partner, First Fuel Software; |
| Jeremy Koo | Associate, Cadmus Group |
| Nalin Kulatilaka | Business Professor, Boston University Founding Partner, First Fuel |
| Paul Lyons | President, Zapotec Energy Inc |

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

| | |
|---|---|
| Dennis Carlberg | Director of Sustainability, Boston University |
| Robb Dixon | Former Chair, Boston University Faculty Council |
| Shaun Finn | Assistant VP of Budget, Planning & Business Affairs, Boston University |
| Dipak Intwala | Manager of Boston University Energy Efficiency Program |
| Joseph Kajunski | Assistant Director of Boston University Engineering and Building Automation |
| Paul Rinaldi | Assistant VP for Planning, Boston University |
| Rich Ellis, Michael Downing, Craig Homen | Boston University Facilities, HVAC |

**Understanding Building HVAC Design & Heat Pumps**

| | |
|---|---|
| Bradley Campbell | President, Conservation Law Foundation |
| Nicholas Conklin | Director of Global Product Strategy, Carrier HVAC Program |
| Cris Copley | Principal of HVAC & Mechanical Design, BR+A |
| Robert Fisher | VP of Facilities, Roxbury Community College |
| Anthony Hardman | Senior BPA, The Green Engineer Inc. |
| Jacob Knowles | Director of Sustainable Design, BR+A |
| Paul Kondrat | Principal, CannonDesign |
| James McQueen | Project Manager, Boston Arts Academy |
| Carolyn Meadows | Director of Strategic Initiatives, Boston Arts Academy |
| Joshua Michaud | Associate Principal of HVAC, BR+A |
| Chris Schaffer | Founder & President, The Green Engineer Inc. |
| Neetu Siddharth | Principal, The Green Engineer Inc. |
| Timothy Simpson | AERMEC Product Specialist, Emerson Swan |
| Mike Walters | Principal & Expert in Distributed Heating Systems, Salas O'Brien |
| Jean-Philippe Drouin | Ecosystem Energy |
| Justin Thorpe | HTS New England (Aermec Distributor) |

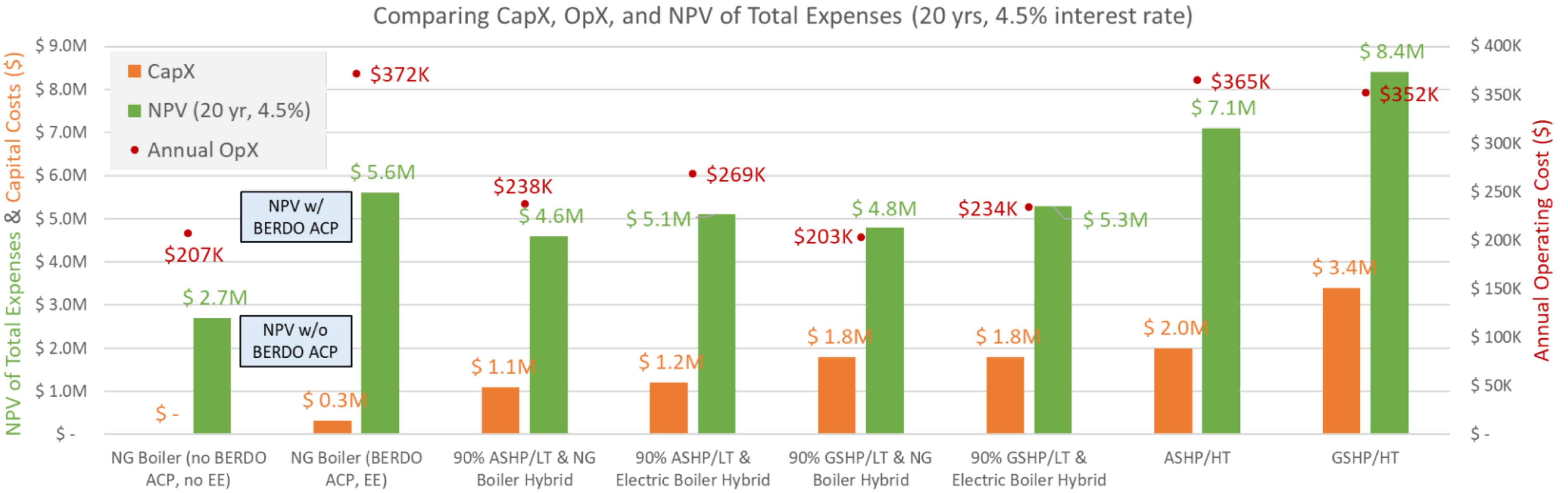
**Geothermal: Heating & District Heating**

| | |
|---|---|
| T.J. Bernier | Gap Mountain Drilling |
| Keeley Bombard | BU Earth & Environment (CAS '22) |
| Owen Brady | Manager of Future of Heat Program, National Grid |
| Jarred Mullen | Skillings and Sons |
| Tracey Ogden | Principal, TAO Consulting |
| Erik Pekkala | Growth Portfolio Lead of New Energy Products, National Grid |
| Nathan Phillips | BU Earth & Environment Professor, Boston University |

# Appendix

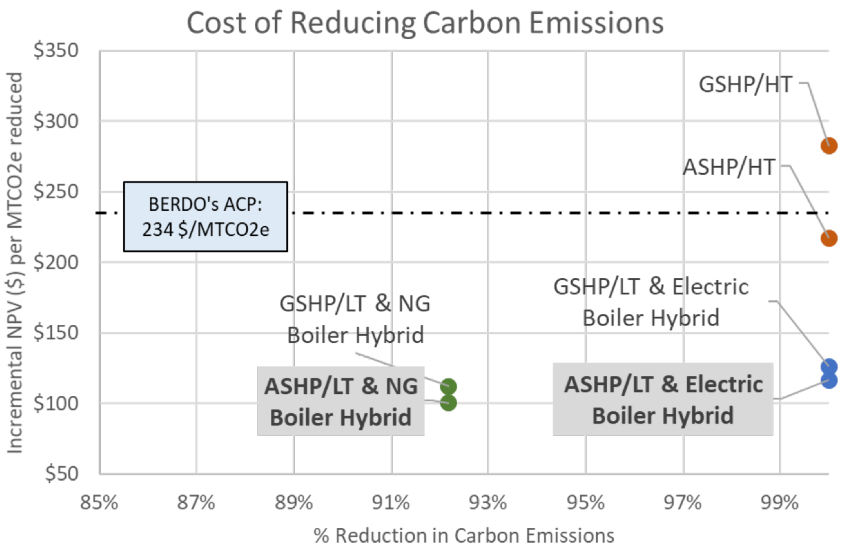
# Financial Analysis of Alternative Electrification Strategies

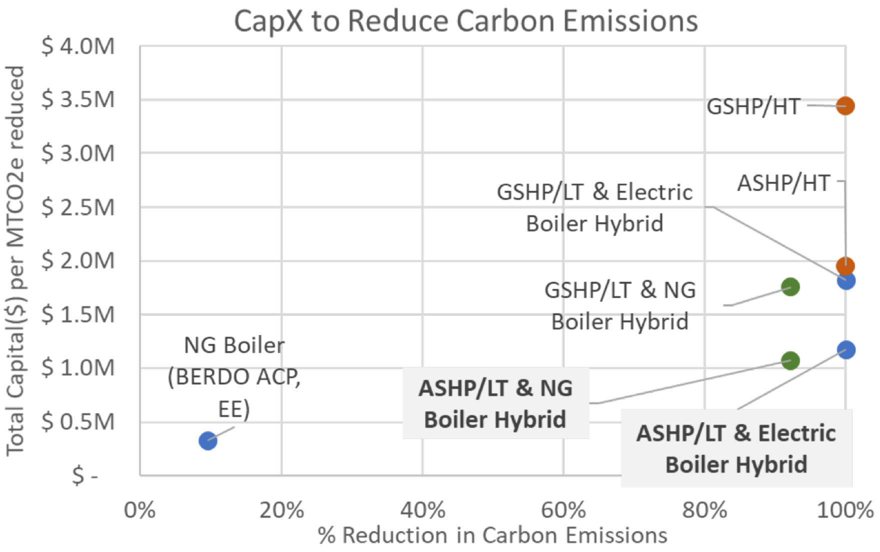
- Capital limitations  strategies that minimize CapX important
- Proposed BERDO ACP cost ($234/Mton of $CO_2e$) increases "cost" of operating existing NG Boilers
- Key Points from Plot:
  - Electric Boiler solutions require higher OpX than NG Boiler options b/c electricity is ~4x cost of NG
  - Electrification is a net cost increase compared to BAU  GSHP Hybrids require~2x the CapX of ASHP Hybrids w/ similar NPV



# Cost of Reducing Carbon Emissions

- Boston BERDO's Alternative Compliance Payment (ACP): $234/MTCO2e
  - **Corresponds to 2.2X NG price** ($1.07/therm  $2.31/therm)
- Insight: Hybrid systems provide *cost savings* vs NG system with BERDO ACP (y-axis) & minimize CapX needs for heating electrification
  - Can select & increase % decarbonization (x-axis): NG Hybrid reduces 92% of GHG emissions, while electric system reduces 100%
  - Hybrid ASHP/LT systems (NG & Electric Boiler) are both ~$100/MTCO2e.



# Key Takeaways: Financial Analysis

- Capital is limited
- **ASHP preferred over GSHPs**: ASHPs require ~40% lower CapX than GSHPs & 4% lower NPV, but a higher OpX by 17%. Necessary electrical supply available for ASHPs
- Total cost (CapX & OpX): Hybrid Systems with electric boilers have greater NPVs of total expenses than those supplemented by NG Boilers
  - Tradeoff: cost vs % decarbonization
- **Comparison to BERDO ACP**: Natural gas & electric hybrid solutions are cheaper than paying BERDO ACP on existing NG Boiler system
- Implementation: Apply learning from pilot buildings to 14 key buildings
  - Reduce scope of retrofit while maximizing GHG emissions reductions

# Implementation Strategy: Electrify Pilot & 15 Major Buildings

- **Pilot Buildings:** verify retrofit strategy, learn from performance, and evaluate suppliers & contractors
- **Major Buildings:** maximize GHG emissions reductions with the fewest number of building retrofits
- **Selection Criteria**: AHU/VAV/Perimeter heating, liquid thermal fluid in heat exchangers

**Pilot Buildings**

| Possible Retrofit Buildings | # of Buildings | Total Area (GSF) | Heating Energy Use (MMBtu) | % of CRC Fossil GHG Emissions |
|---|---|---|---|---|
| Facilities & Planning, Human Resources, Sargent, EPIC, Fraunhoffer Center for Manufacturing Innovation, School of Hospitality, Graduate Student Housing (580 Commonwealth Avenue) | 7 | 610,000 | 30,900 | 4% |

**Major Buildings**

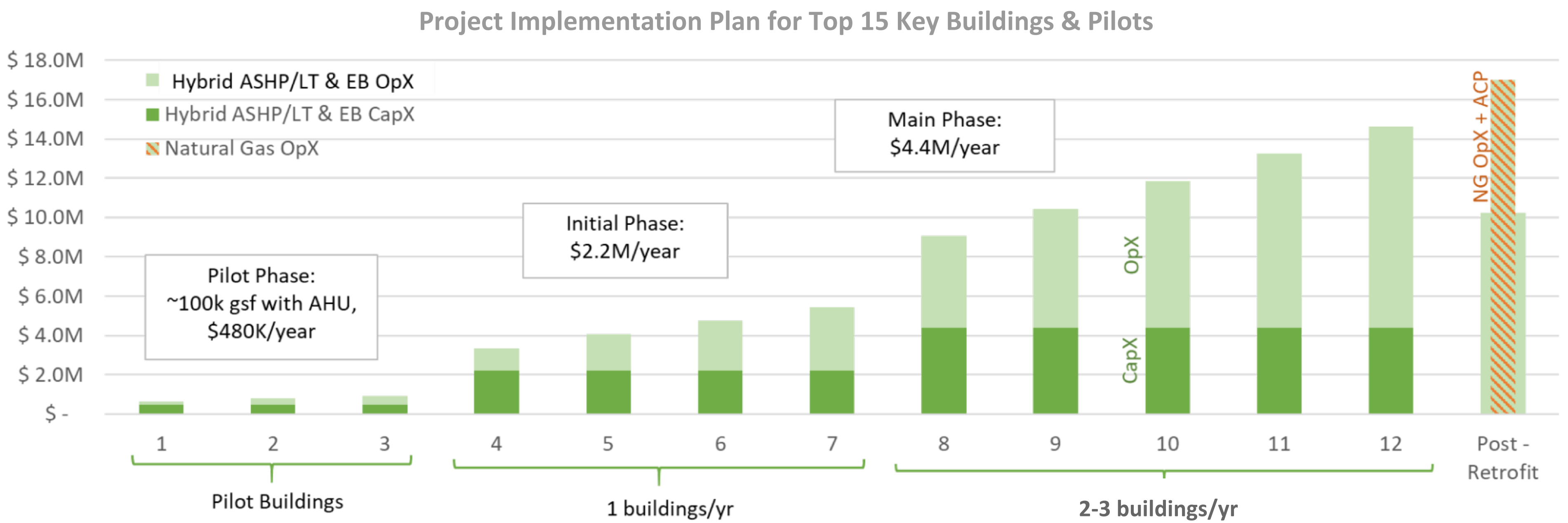
| Buildings to Retrofit | | # of Buildings | Total Area (GSF) | Heating Energy Use (MMBtu) | % of CRC Fossil GHG Emissions |
|---|---|---|---|---|---|
| Agganis Arena*<br>CILSE<br>FitRec*<br>Law School (Redstone)<br>LSE<br>Metcalf | Mugar Library**<br>Photonics<br>Physics Research Building<br>Questrom<br>Yawkey | 11 | 2,670,000 | 280,000 | 32% |
| **Buildings Under Further Evaluation** | | **# of Buildings** | **Total Area (GSF)** | **Heating Energy Use (MMBtu)** | **% of CRC Fossil GHG Emissions** |
| StuVi-1*<br>StuVi-2* | Warren Towers**<br>West Campus Dormitories* | 4 | 1,660,000 | 161,000 | 19% |

* West Campus Steam Loop

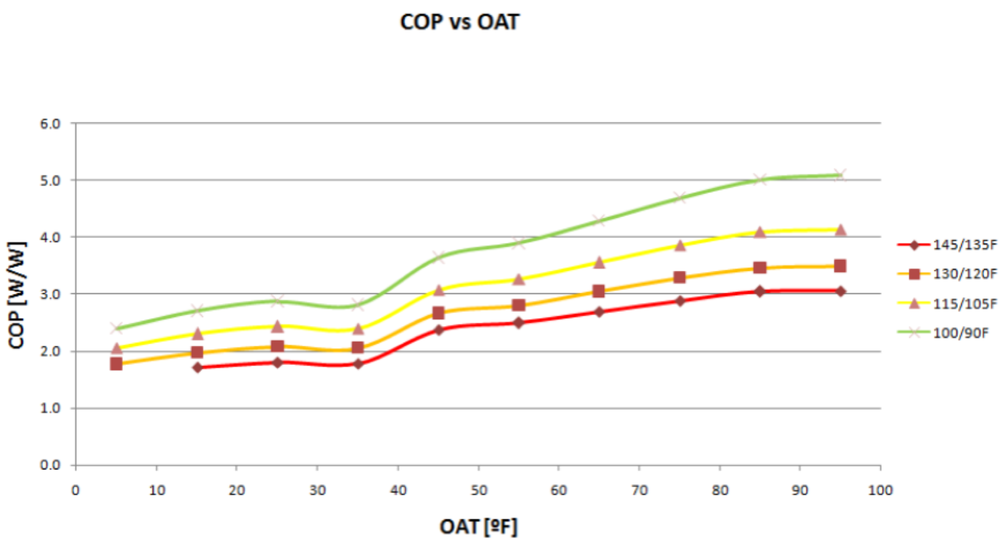
** Central Campus Steam Loop

# Preliminary Retrofit Roadmap: Electrify 15 Key Buildings

- 12 yr plan: Electrify 4.4M GSF to reduce 51% of BU CRC's heating fossil fuel use
  - Critical to have proper project & operations staffing
- CapX: $3.5M/yr **($32.2M investment)** |Annual OpX: $10.3M/yr
  - Post-Electrification OpX will be 40% less than existing NG system with BERDO ACP



# Coefficient of Performance of ASHP/LT Unit




- Updated information for COP of Aermec ASHP/LT units
- Critical for:
  - Calculating electrical demand
  - Evaluating dependence on outside air temperature