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Heating Electrification Strategies to Decarbonize BU's Charles River Campus:
Phase 2 Focus on Decreasing Peak Electrical Demand

1. Context & Phase 2 Focus
2. Strategies to Minimize Peak Loads & Avoid Electrical Service Upgrades
3. Financial Analysis of Alternative Electric Heating Strategies
4. Cost of Reducing Carbon Emissions

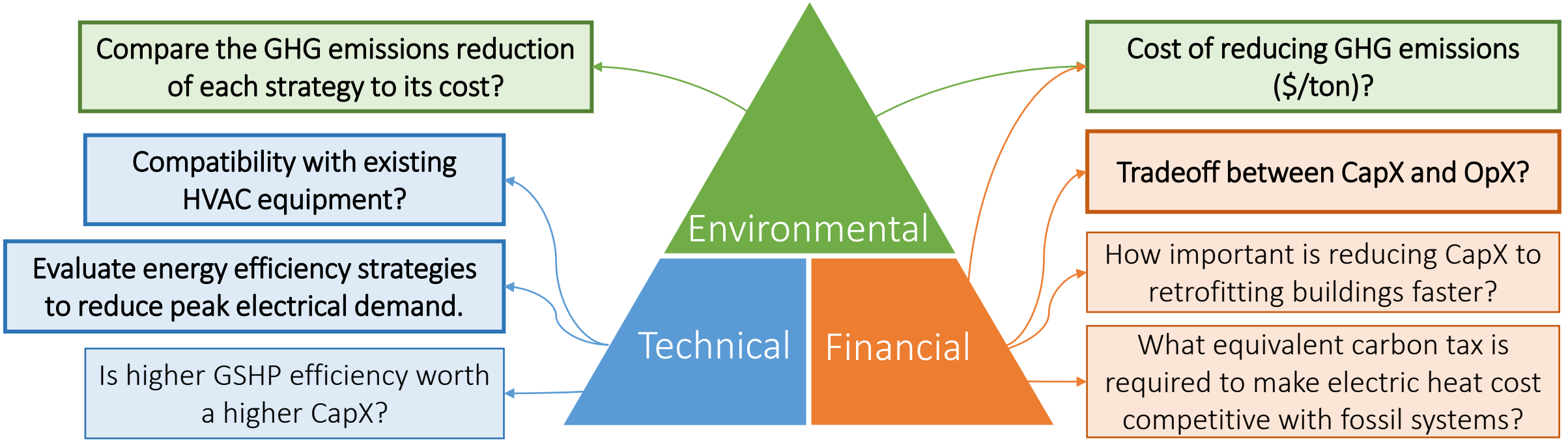
Gayatri Sundar Rajan (ENG '22)
Sabrina Dilig (ENG '23)
Cathy Cheng (ENG '23)

Professor Michael Gevelber (ENG)

Context & Phase 2 Focus

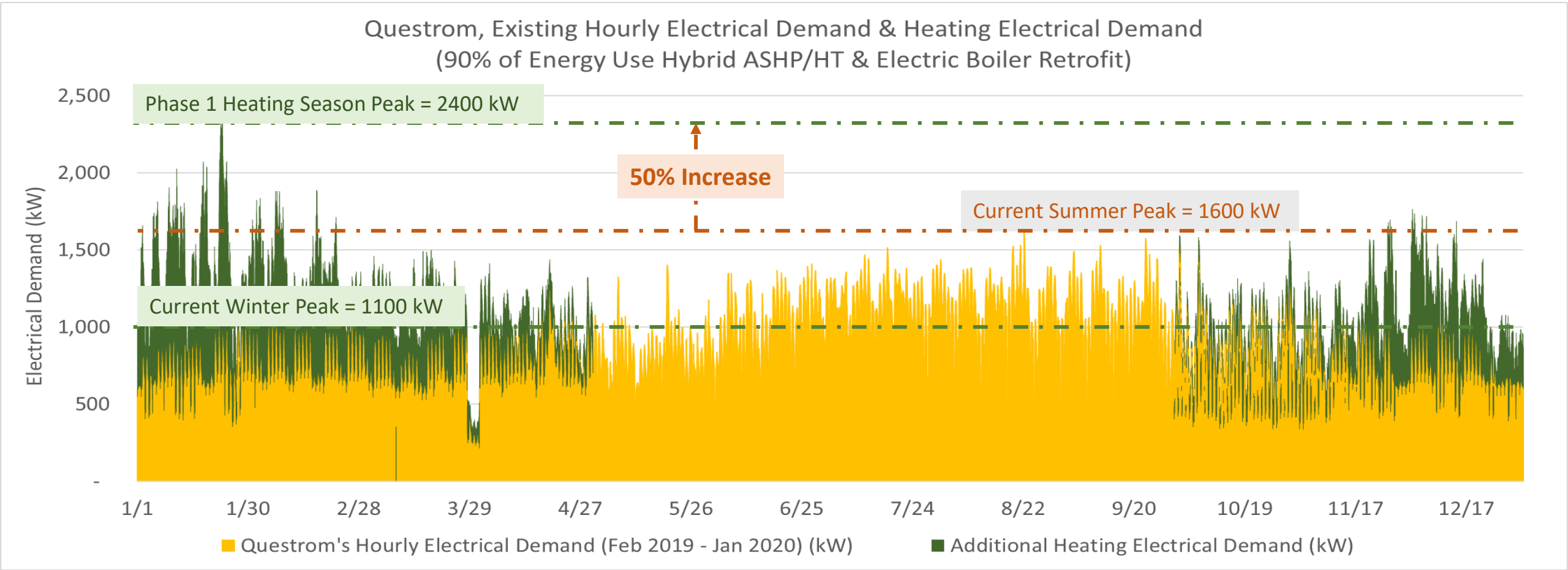
Driving Question: **How can we electrify the greatest % of BU's fossil heating systems in the shortest time given limited capital and operating budgets?**

- Phase 1 Results: Hybrid systems of heat pumps and electric boilers significantly reduce CapX and NPV
- MEP Review: Do proposed electric heating retrofits require upgrading a building's electrical service?
- **Phase 2 Focus:** How can BU electrify its heating systems without exceeding installed electrical capacity?



Problem: Phase 1 Result Exceeds Max Electrical Capacity

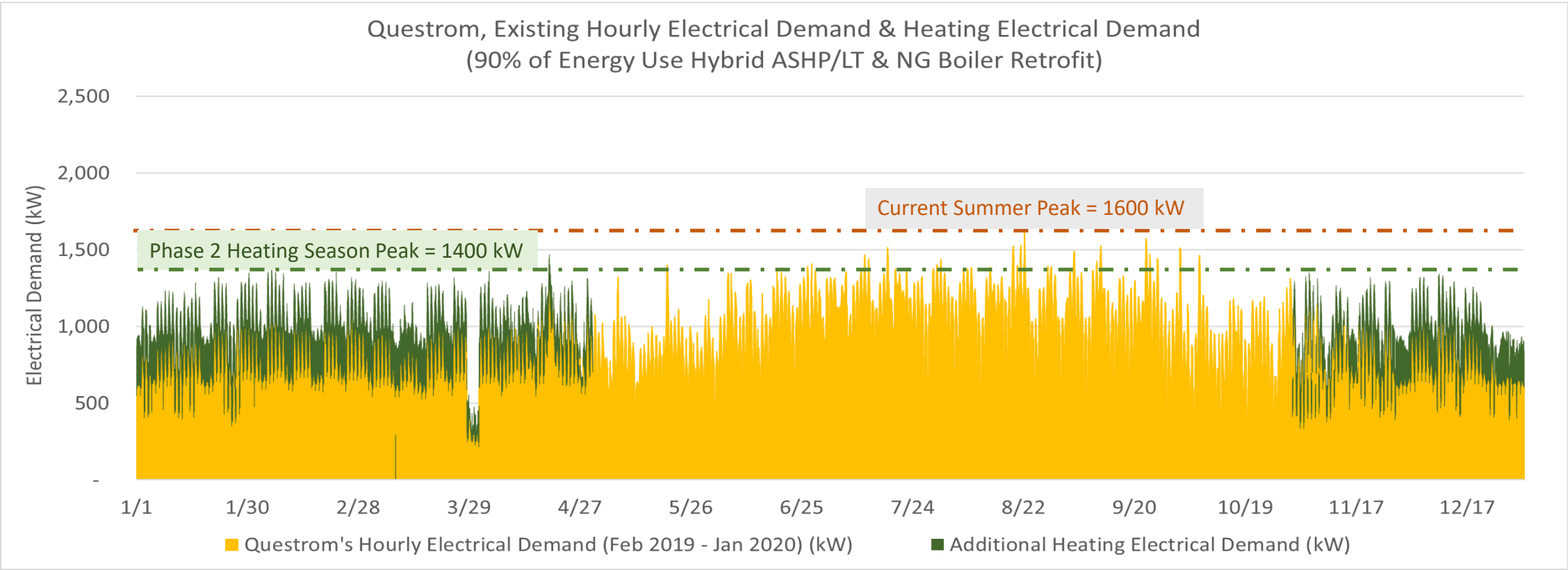
- Phase 1 Result: Use a Hybrid ASHP/HT & Electric Boiler system to minimize CapX
  - **Peak Electrical Demand exceeds existing capacity on coldest days by 50%**
  - When outside temp <40F, greater heating demand & lower ASHP's COP/heating capacity



Phase 2: Strategies to Avoid Electrical Service Upgrades

- Decrease peak heating load with EE measures (airflow optimization)
- Use existing fossil-fuel boilers (NG) for supplemental heat on coldest days (only 10% of energy use)

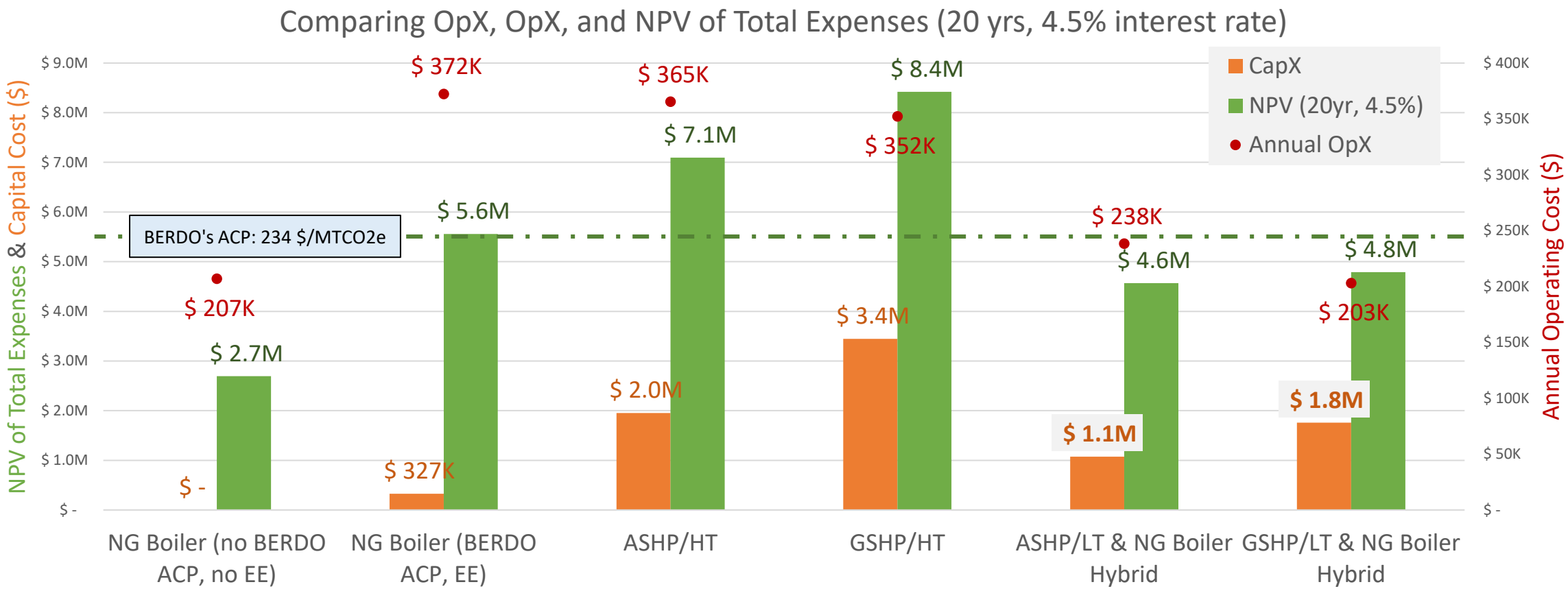
  → NG boilers also provides backup heating capacity
- Lower thermal operating temps **(130F)** enable more efficient electric heating equipment: low temp ASHPs



Financial Analysis of Alternative Electrification Strategies

- Validated financial model with Shaun Finn (BU's VP of Budget, Planning, & Business Affairs)

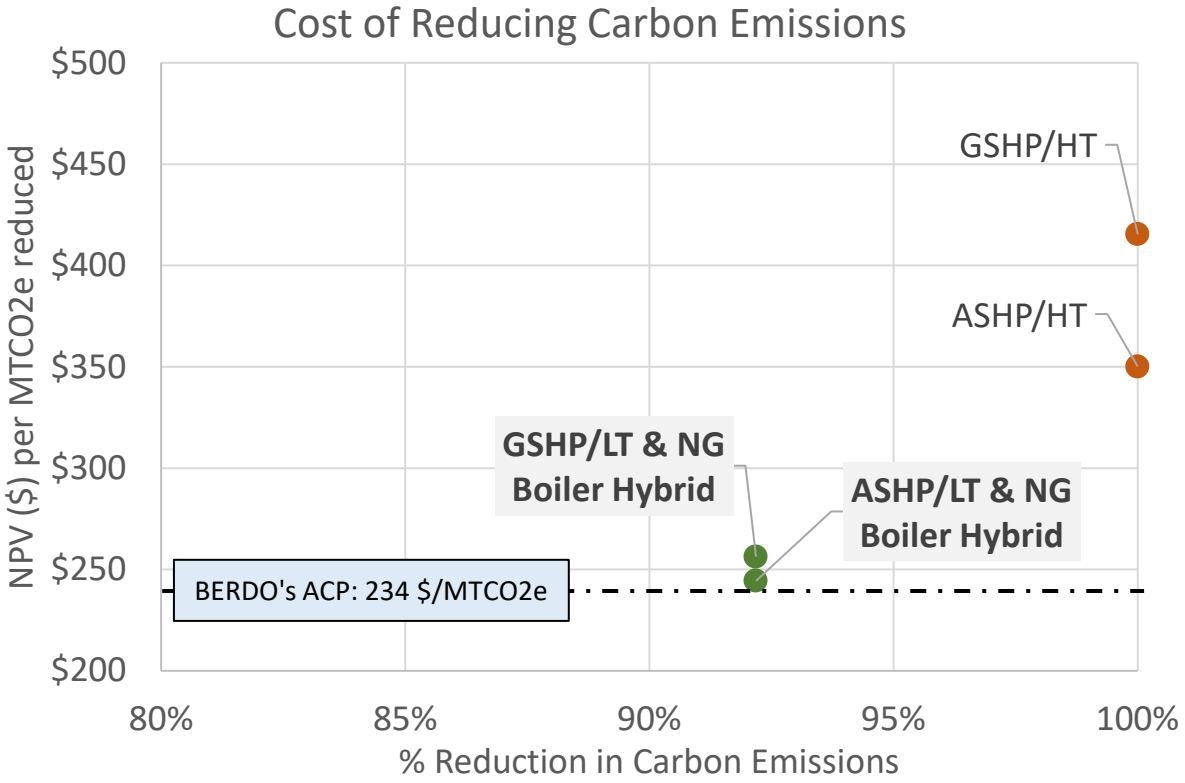
  Capital limitations → strategies that minimize CapX important
- Consider impact of proposed BERDO ACP cost on GHG emissions ($234/MTon)
- <u>Recommendation:</u> ASHP/LT & NG Boiler Hybrid requires lowest CapX and NPV

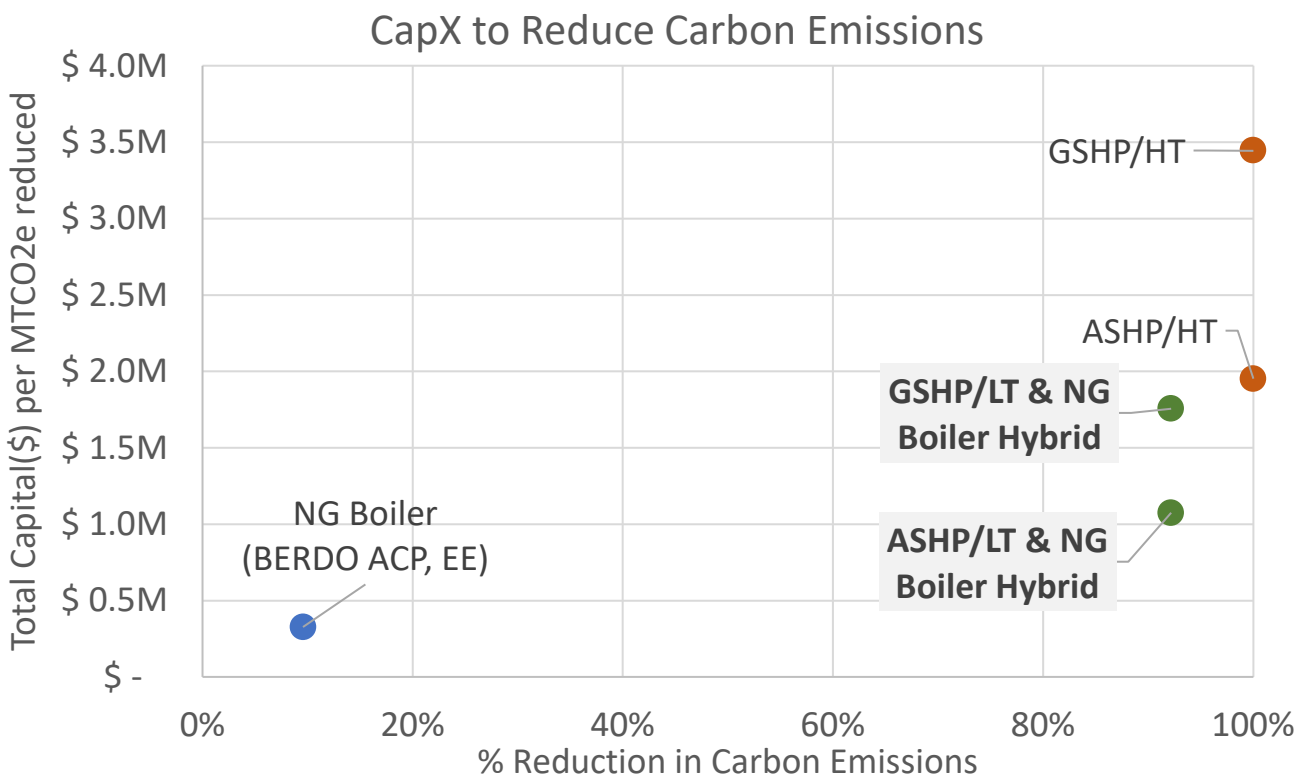


Cost of Reducing Carbon Emissions

- Boston BERDO's Alternative Compliance Payment (ACP): $234/MTCO2e
  - **Corresponds to 2.2X NG price** ($1.07/therm → $2.31/therm)
- Insight: Cost-competitive for BU to invest in hybrid electric heating systems vs pay BERDO's ACP
- Question: Is a 90% carbon emissions reduction acceptable for a lower capX retrofit?

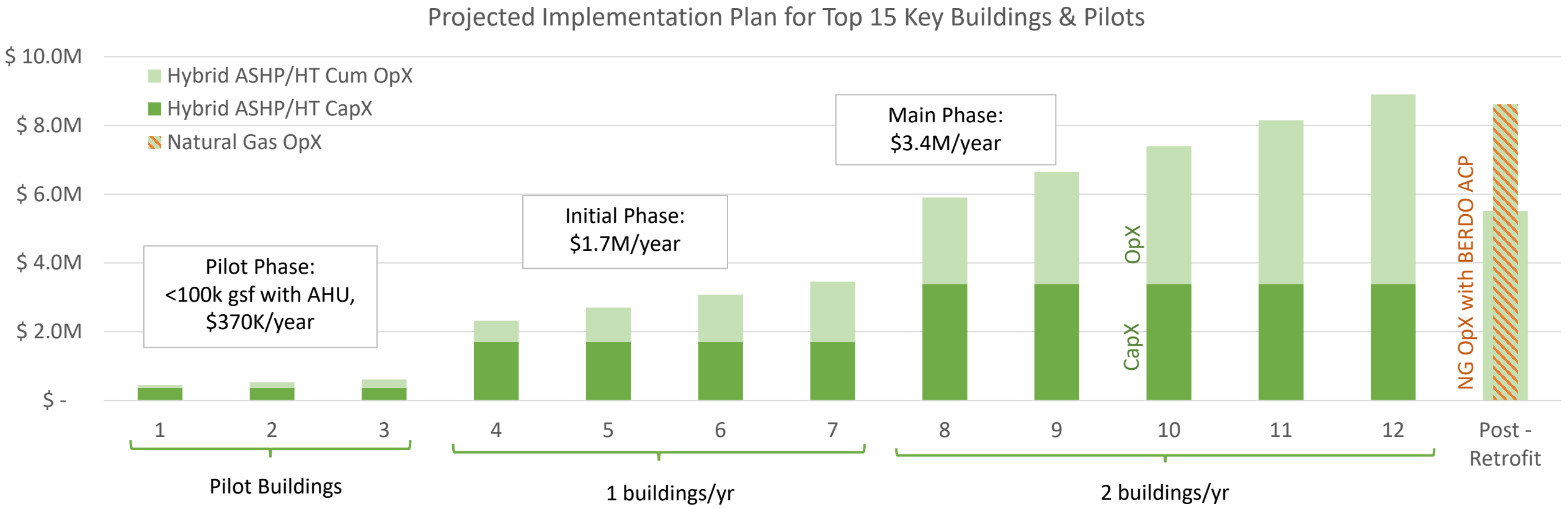
  Or: Are we willing to pay 2x the CapX for the last 10% of GHG reduction?





Retrofit Roadmap: Electrify 14 Key Buildings

- 12 yr plan: Electrify 3.8M GSF to reduce 46% of BU CRC's heating fossil fuel use
  - Designed for learning and validating performance
- CapX: $2.0M/yr **($24.9M investment)** |Annual OpX: $5.5M/yr
  - Post-Electrification OpX will be 36% less than NG system with BERDO ACP



Next Steps

1. Steam Loop: Evaluate opportunities to electrify buildings on the steam loop (37% of fossil use)
   - Building-by-building evaluation of whether steam loop buildings require high temperature fluids (>212F) [12 bldgs]
   - Good news: preliminary investigation indicates that several buildings on steam loop are compatible with lower temp fluids
2. Energy Efficiency Options that reduce peak loads, CapX, & GHG emissions
   - Identify & quantify impact of EE measures that are technically/economically feasible
3. Evaluate need for high temp fluid output for AHUs & perimeter heat
   - Importance: High-Temp Heat pumps (160F) have lower COP than Low-Temp Heat Pumps (130F) & thus result in higher peak electrical demand and heating energy costs
   - Develop experimental program for facilities to determine required fluid temp to meet thermal performance requirements
4. Continue BU Management & Industry Review: Cannon Design, Salas O'Brien, BR+A
5. Prepare for 2-Day Heating Electrification conference with ISE in Fall 2021

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Estimating Costs & Financing Large CapX Projects

Judith Judson	VP of Distributed Energy Systems, Ameresco
Paul Lyons	President, Zapotec Energy Inc
Domenic Armano	President, Guardian Energy Management
Michael Gibbs	Former Assistant Executive Officer, CARB; Former Deputy Secretary of Climate Action, CalEPA; Former Senior Vice-President, ICF International
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Shaun Finn	Assistant VP of Budget, Planning & Business Affairs, Boston University

Understanding Boston University's Project Planning & Implementation

Paul Rinaldi	Assistant VP for Planning, Boston University
Robb Dixon	Business Professor, Boston University, Former Chair, Boston University Faculty Council
Dennis Carlberg	Director of Sustainability, Boston University

Understanding Building HVAC Design & Heat Pumps

Jacob Knowles	Director of Sustainable Design, BR+A
Cris Copley	Principal of HVAC & Mechanical Design, BR+A
Joshua Michaud	Associate Principal of HVAC, BR+A
Carolyn Meadows	Director of Strategic Initiatives, Boston Arts Academy
James McQueen	Project Manager, Boston Arts Academy
Robert Fisher	VP of Facilities, Roxbury Community College
Bradley Campbell	President, Conservation Law Foundation
Timothy Simpson	AERMEC Product Specialist, Emerson Swan
Chris Schaffer	Founder & President, The Green Engineer Inc.
Neetu Siddharth	Principal, The Green Engineer Inc.
Anthony Hardman	Senior BPA, The Green Engineer Inc.
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Nicholas Conklin	Director of Global Product Strategy, Carrier HVAC
Megan Howard	Program Director, MassCEC

Geothermal: Heating & District Heating

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