Carbon Free Housing and Dining:

A UCSB Electrification Study

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The Decarbonization Problem

Climate change is considered one of the greatest challenges of our time, as increasing carbon emissions cause anthropogenic global warming. Residential and commercial buildings use significant amounts of energy for various purposes including heating, cooling, cooking, and lighting. To address necessary carbon emission reductions, decarbonization of buildings is critical. This problem is being addressed by UCSB Sustainability, a collaboration of staff, students, administrators, and faculty, who work across campus to implement substantial changes that reduce UCSB's impact on the environment. UCSB Sustainability is working towards achieving the UC system Carbon Neutrality Initiative, which requires carbon neutral Scope I and II emissions by 2025. A pathway to this ambitious goal considers looking at existing building's natural gas burning infrastructure to identify where changes can be implemented to reduce carbon emissions, and at what cost.

OBJECTIVES

I. Select campus buildings for modeled electrification. Inventory all natural gas-fueled equipment in selected buildings, and research electric replacement technologies available.

II. Develop a model to estimate future electricity demand for building services. Compile data related to building energy demand including fuel consumption, peak demand, and energy services.

III. Quantify and compare the cost of building electrification to continued baseline building operations.

San Miguel Residence Hall

UC Residence halls house hundreds of students, and are a standard feature of campus infrastructure. The space heating, water heating, and laundry machines require natural gas for operations.

This study replaced 2 hot water boilers with heat pumps, and replaced laundry services with commercially available electric machines.

De La Guerra Dining Hall

Dining halls on UC campuses feed students, staff, and campus visitors throughout the year. These industrial kitchens have appliances that require natural gas for food preparation, as well as hot water needs for dishwashing.

This study replaced 2 steam boilers with heat pumps, and 11 industrial kitchen appliances with commercially available electric models.

West Campus Apartments

Apartment style housing on UC campuses allows for accommodation for continuing students and those with families. These individual units have varied space and water heating needs.

This study replaced 21 residential water heaters with heat pumps, and 250 wall furnaces with commercially available residential mini-split heat pumps.

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APPROACH & LIMITATIONS

I. Select campus buildings for modeled electrification.

Selecting buildings on UCSB's campus that represent campus infrastructure archetypes was important to this project and ensuring its replicability. The buildings modeled in this project provide essential campus services and are important spaces to retrofit for carbon neutral operations when a full building replacement is infeasible. The electrification modeled in this study was made possible by the use of heat pumps to replace water and steam boilers, which provide space and water heating for these buildings. Heat pumps large enough for these for commercial buildings require a large capital investment, but the costs to purchase and install a heat pump will likely decrease as they become more a prevalent tool for decarbonization.

II. Develop a model to estimate future electricity demand for building services.

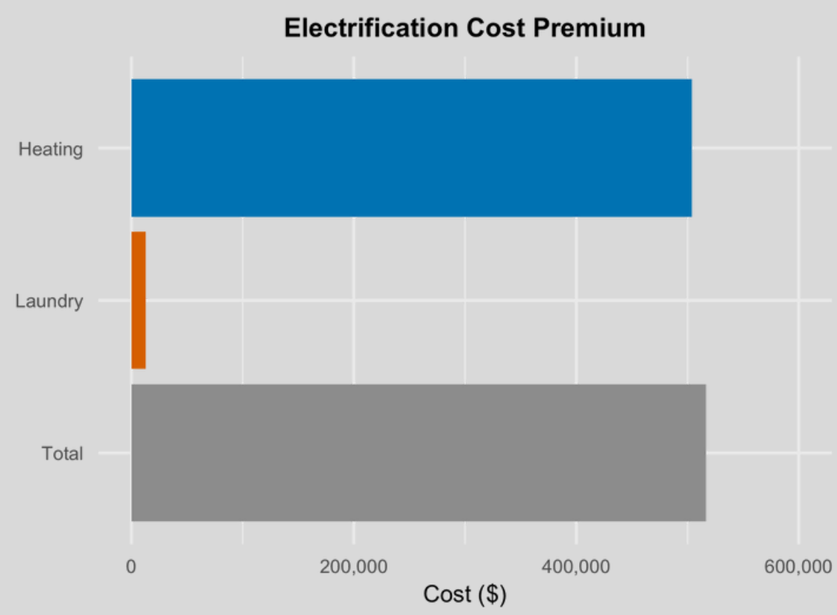
The model created for this project calculates the costs of meeting services, like space and water heating, with appliances that use natural gas, and compares it to meeting those same services with electric appliances. This study assumes a 'drop-in' replacement of these technologies, and did not incorporate the cost of upgrading campus electrical infrastructure to accommodate larger electricity demand that electrification would necessitate.

III. Quantify and compare the cost of building electrification to continued baseline building operations.

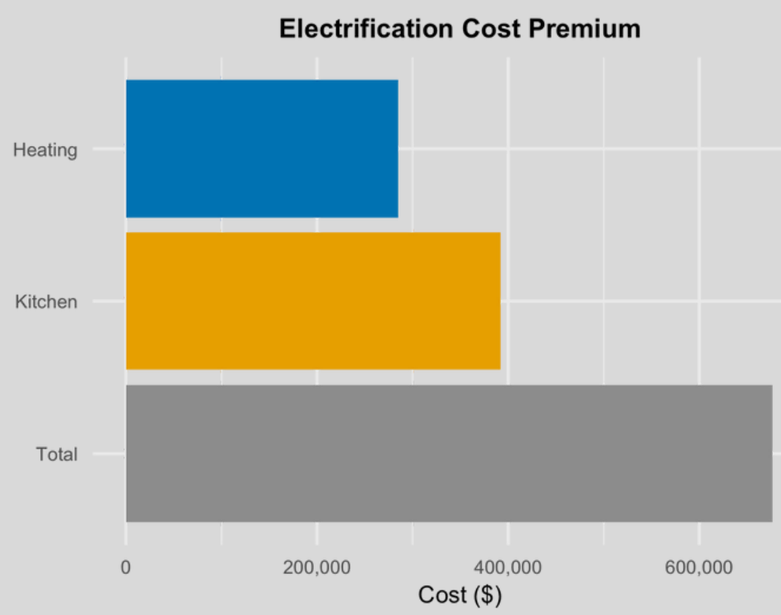
The costs of operating these buildings are calculated under a scenario using natural gas appliances, and a scenario using electric appliances. These are projected out to 2045, and include all associated costs of building operations, including capital costs and installation for the electric appliances, and replacement of natural gas appliances at their end of life.

RESULTS - How much *more* would Electrification cost?

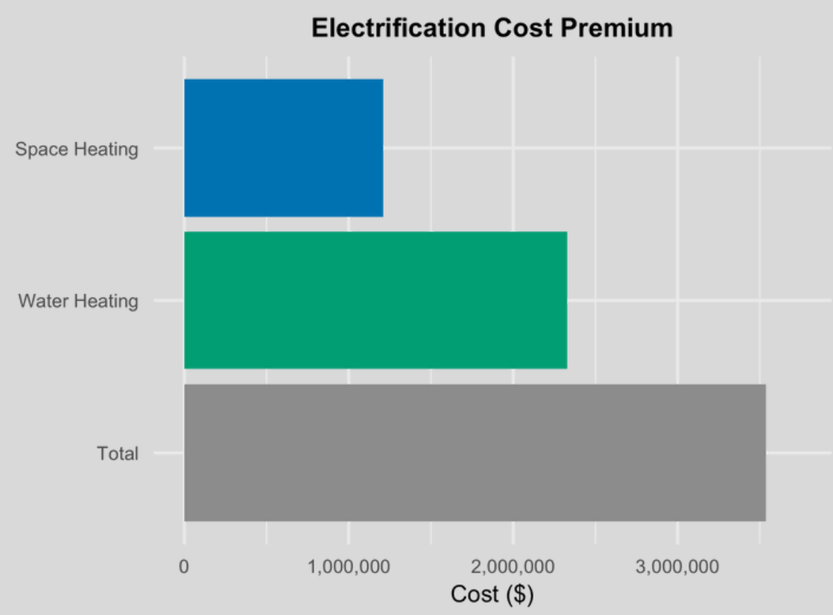
San Miguel Residence Hall



De La Guerra Dining Hall



West Campus Apartments



Findings and Recommendations

In all three buildings, the cost of electrification is substantially higher than the business-as-usual (BAU) scenario of continuing to use natural gas in campus operations. Space and water heating are the primary sources of energy demand for each building, and the differences in costs between an electrification and natural gas scenario are largely due to the capital costs of heat pumps that are used to replace standard natural gas counterparts. Looking forward, we recommend a larger campus electrification study be done, to ensure that increased electricity demands can be met when electrification does occur. A concerted effort to improve the energy efficiency of the buildings will also decrease the electrical demand placed on UCSB's infrastructure. Finally, we recommend the continued monitoring of decarbonization technology availability such as heat pumps and electrical kitchen appliances. As these technologies become more prevalent, their price per unit should decline as the production of these products increases.

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