Optimizing Energy Burden to Incorporate into Building Decarbonization Pathways to Retrofit Existing Buildings

Ryley McGovern[2], Dr. Bianca Howard [1], Ryan Marc Dubois [1]

Building Energy Research Laboratory, Department of Engineering, [1]Columbia University, [2]Hamilton College

Introduction

Buildings account for two thirds of New York City's greenhouse gas emissions which calls for the necessity of transforming the urban building stock to deliver on climate change goals.[1] Whilst climate change policies seek to address climate change mitigation, they also seek to address additional societal challenges such as alleviating energy burden.[2]

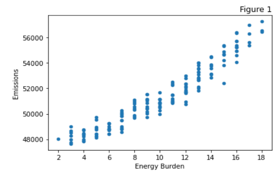
Energy burden, which is the proportion of annual household income that is spent on energy utility costs[2], remains to be a persistent issue amongst low-income households. Low-income households spend a higher percentage of their income on electricity and gas bills than any other income group[5]. To begin to address this issue, energy burden was incorporated as a metric into an optimization to determine how building decarbonization pathways changes the "optimal" way to retrofit existing buildings.

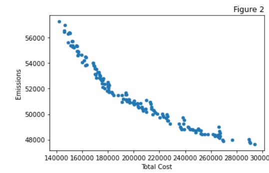
Methods

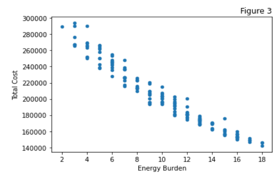
To analyze how building decarbonization pathways changed with adding energy burden as a metric, five building models were simulated in EnergyPlus with retrofits to its walls, roof, and windows using the multi-objective optimization algorithm NSGA-II. The objectives included: minimize greenhouse gas emissions, minimize capital and operational costs, and minimize disparities in energy burden between low and high income households.

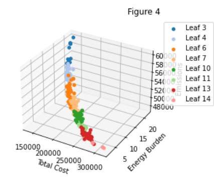
Energy burden was calculated using the operational costs simulated in each building divided by an assigned number of units and then divided by an assigned income. A unit in a building is energy burdened if the operational cost associated with that unit is more than 6% of the assigned income.

Results









Figures 1 and 2 shows the differing relationships energy burden and total cost have with emissions. It's important to note that as the amount of emissions increases, the number of energy burdened units in the buildings increases which indicates a non competitive relationship. Additionally, a fixed energy burden level contains a range of emissions and costs. With the help of a decision tree and by observing the trends in configurations, Figure 4 indicated that the roof retrofits are the dominating solutions.

Conclusion

Our findings revealed that an additional co-benefit to climate initiatives is the energy burden which disproportionately affects low-income households. Optimizing metrics such as energy burden to include in building decarbonization pathways raises awareness to the additional benefits that greatly impact marginalized communities whilst mitigating climate change.

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