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Design of Intuitive Visualizations for Residential Heating and Cooling Demands

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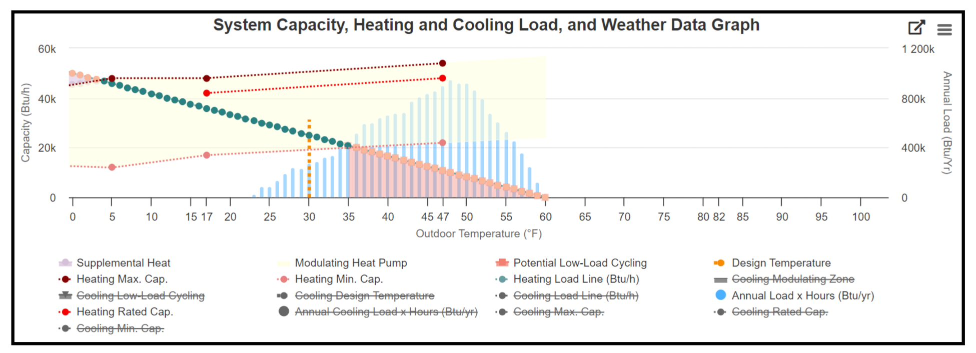
Introduction

The majority of residential Heating, Vacuum and Air Conditioning (HVAC) systems in the United States are oversized, leading to increased upfront costs and long-term home and energy sustainability implications.[1]

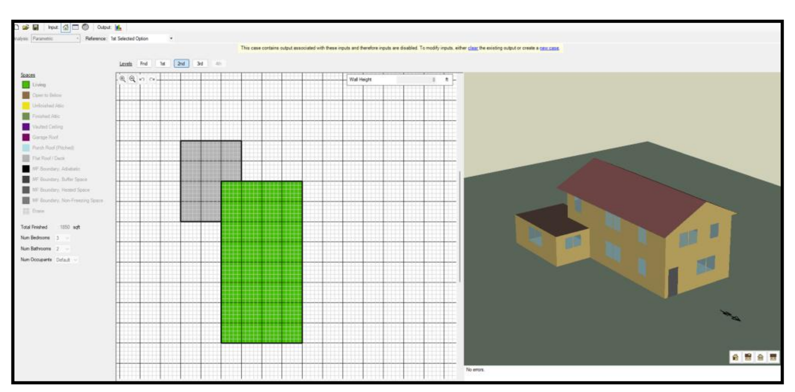
One potential factor preventing lay understanding of HVAC sizing is a lack of intuitive visualization systems: current systems are designed around contractor rather than consumer needs: [2]



As such, **our objective is to design more intuitive visualizations of the heating and cooling demands a residential home faces throughout a year** to create a better understanding of the comfort implications of choosing differently sized systems.

Methodology

Large-scale time series data on residential loads is sparse. To represent the loads a home faces throughout a year, we simulate mock homes under a variety of conditions using the National Renewable Energy Laboratory (NREL) Building Energy Optimization Tool (BEOPT): [3]

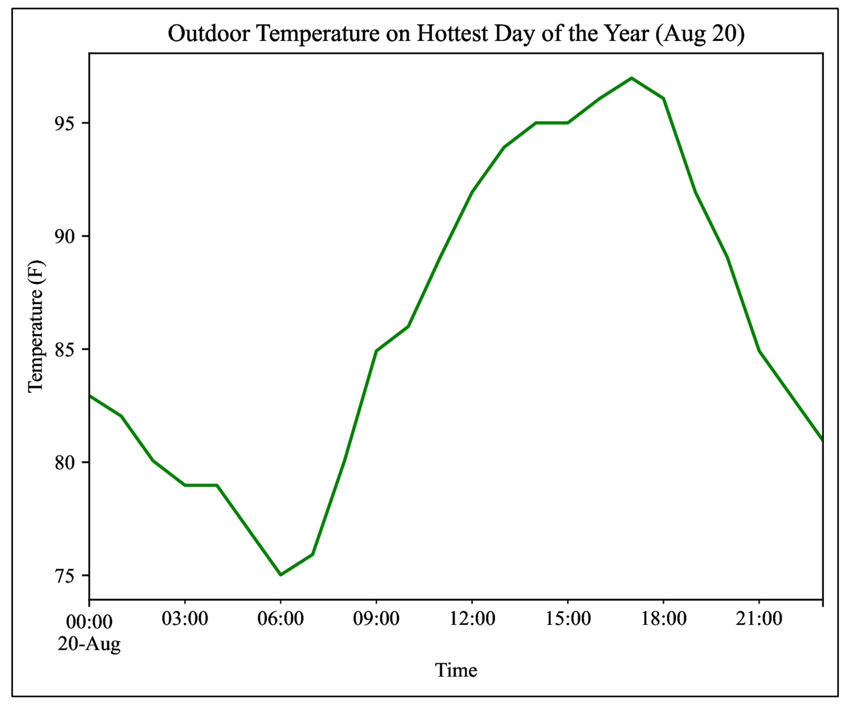


Through simulation, we collect hour-by-hour energy and load data throughout a year based on a variety of parameters including system sizing, weather, and home insulation properties. Of the various energy and HVAC related outputs, our most relevant variables are as follows:

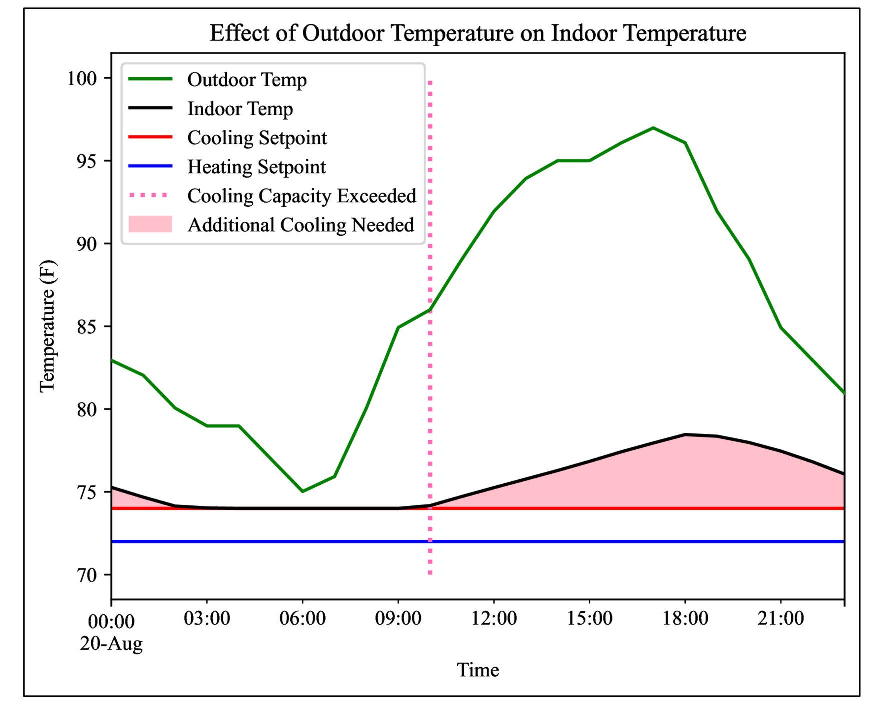
Variable	Description
Outdoor Temperature	Outdoor temperature of the house.
Indoor Temperature	Indoor temperature of the house.
Heating Setpoint	Thermostat-set indoor minimum temperature.
Cooling Setpoint	Thermostat-set indoor maximum temperature.
Excess Degrees	Degrees by which the indoor temperature exceeded either setpoint – times when the home is too hot or too cold.

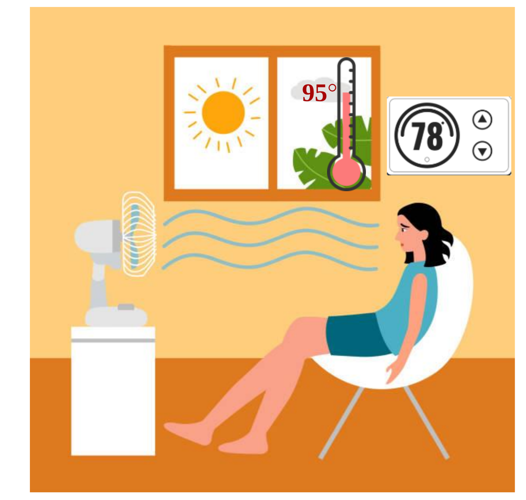
We then develop a variety of time series visualizations on both a yearly and daily scale to best communicate the comfort implications.

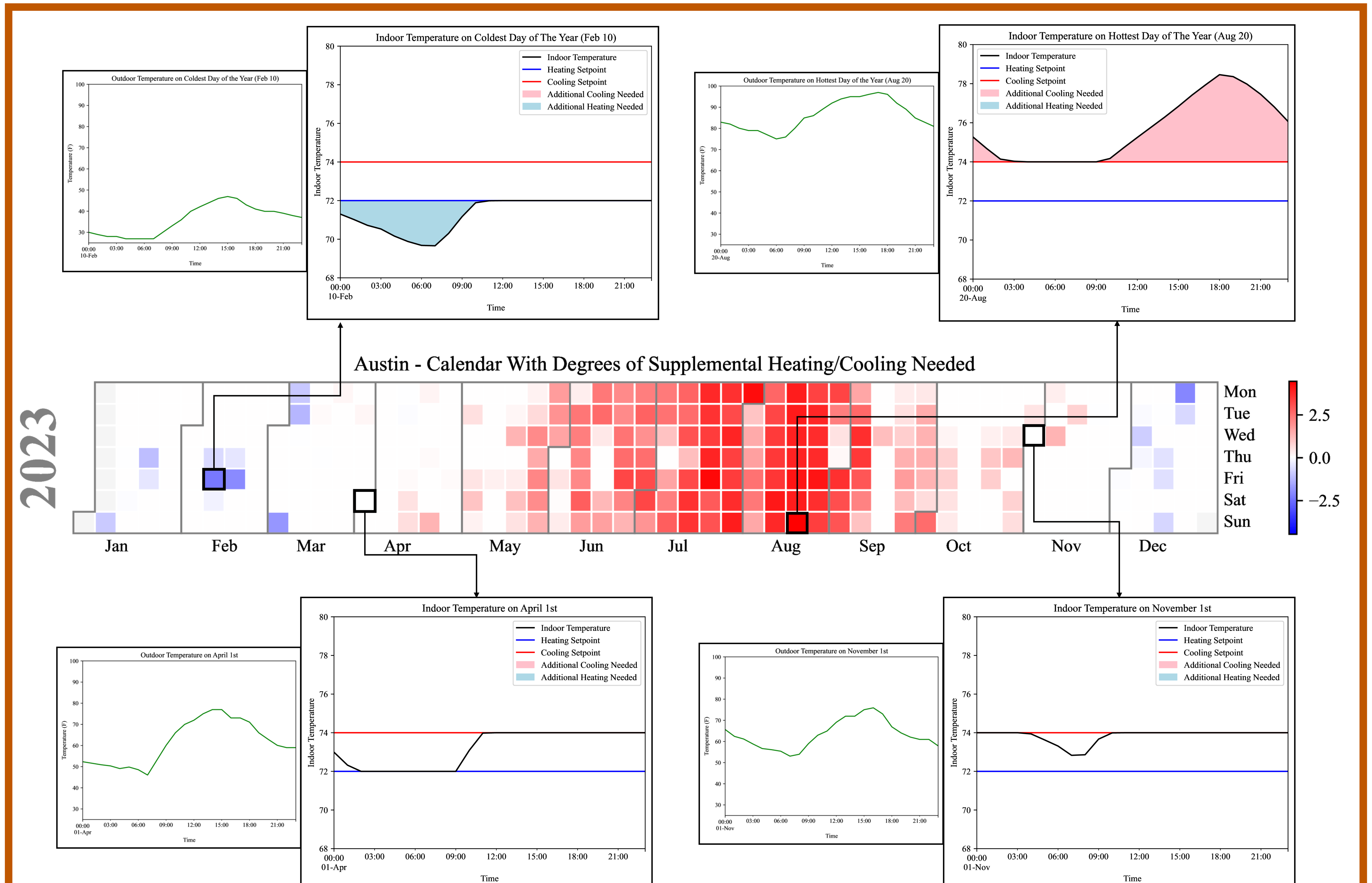
Comfort Implications: What Will a Hot Day Feel Like Indoors?



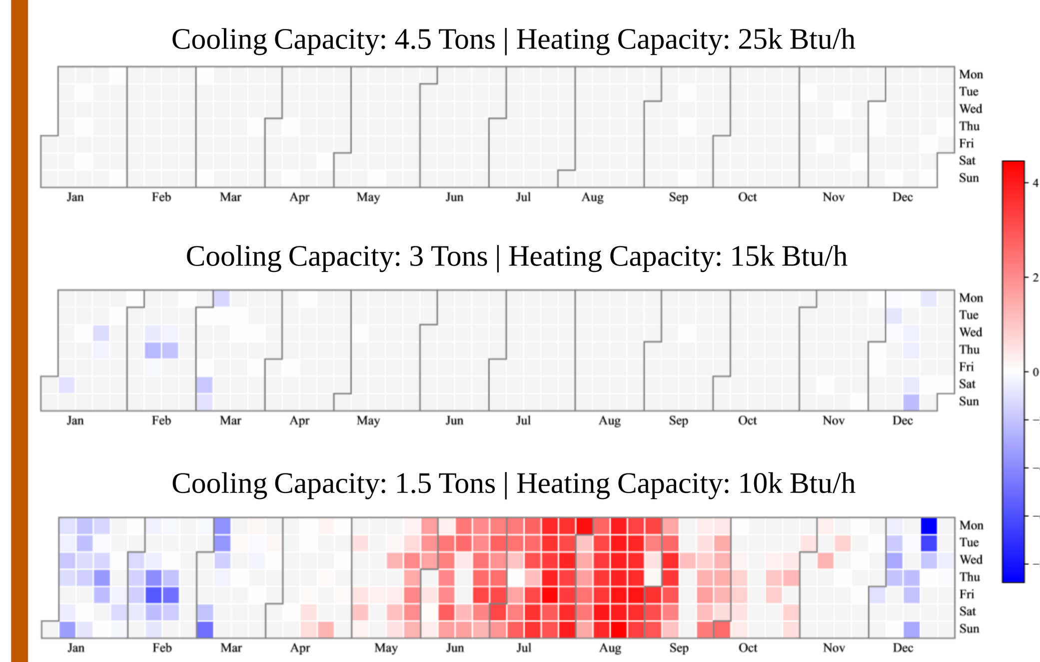
Cooling Setpoint: 74 F
Cooling Capacity: 1.5 Tons
Heating Capacity: 15k Btu/hr.







Sizing Solutions:
Progressively Smaller Systems



Conclusions & Limitations

Putting residential heating and cooling loads onto a time-series level visualization can help laypersons more intuitively understand what differently sized HVAC systems would feel like throughout the course of a year. As such, these visualization methods can prove informative to both contractors and consumers when making HVAC sizing decisions.

The complexity of representing temperature and comfort provides a limitation to this system. A core role of air conditioning is to remove humidity from a system. However, these current visualizations do not adjust for the effects of humidity and latent heat. Furthermore, simulations on historical data do not account for rare unpredictable cases, such as the 2021 Texas Winter freeze. Finally, as homeowners change their systems, such as adding insulation or utilizing different materials, past simulations will no longer be representative.

Ultimately, these visualizations serve as an introduction to more intuitive understandings of heating and cooling demands while continued nuance is required to fully capture these systems.

References

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