Examining Future Climate Readiness of Typical Residential Buildings

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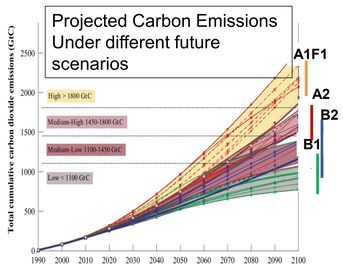
General Problem:

Climate is becoming warmer, requiring more cooling in buildings, resulting in larger energy use by buildings. We do not know exactly what the future climate will be and therefore are uncertain of the extent of the warming. Yet engineers need to design and build for the future.



IPCC Special Report on Emission Scenarios - Summary for

Specific Problem:

How can buildings be built or remodeled affordably to be comfortable and energy efficient so as to reduce electricity cost and emissions from energy supplier in possible future climates?

Future Climate Scenarios:

International Panel on Climate Change (IPCC) has developed 4 different future climate families of models depend on changes in future economics, innovations and demographics. These scenarios result in different greenhouse gas emissions

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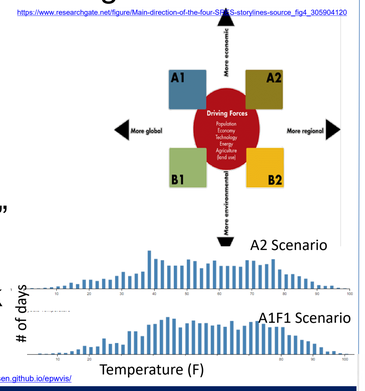
To be useful in building energy models, local weather data are "morphed" to reflect these different scenarios into a benchmark annual weather profile.



https://mdahlhausen.github.io/epwviz/

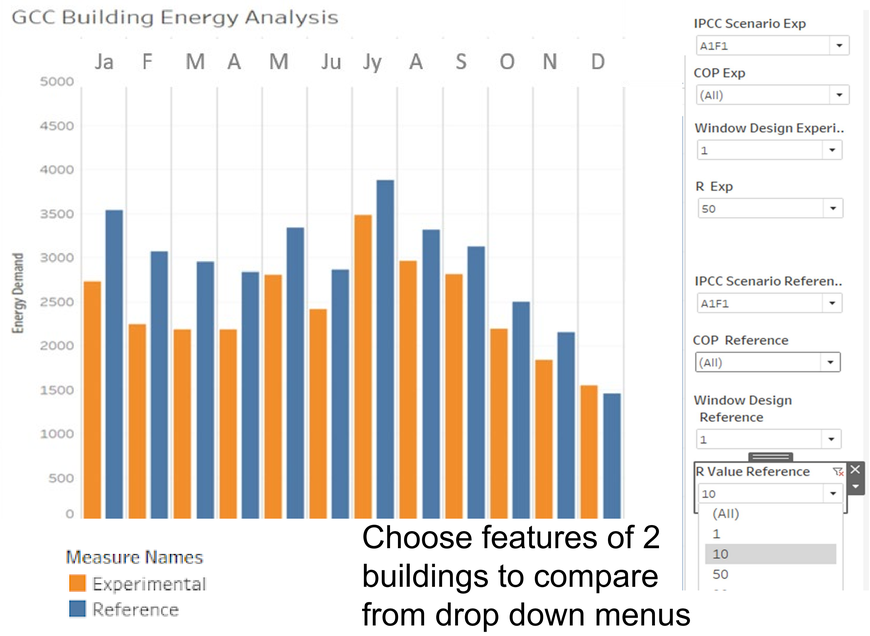
Research Methodology

A single family house in State College PA was modeled with varying values for insulation R values, window constructions and COP for a total of 3078 building models. The models were generated using Python code.

These building models and the four climate scenarios were input into a building energy modeler, EnergyPlus, which gave the hourly energy use for an entire year for a total of 12,312 runs on the PSU ICDS ACI high performance research environment (supercomputer)

The energy demands for each model were then inputted into a data visualization tool, Tableaux, to allow for comparisons

Result: Interactive Visualization

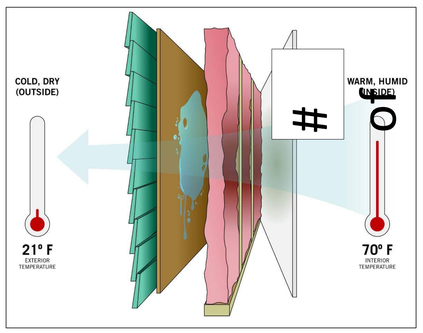


Choose features of 2 buildings to compare from drop down menus

Factors in Building Energy Use:

Use materials that reduce heat transfer between inside and outside of building and use HVAC systems that use energy more efficiently but do so in a way that is cost effective and matches the future climate.
Make a library of energy needed by building as a result of changes in the building and climate to direct choice

Wall Construction

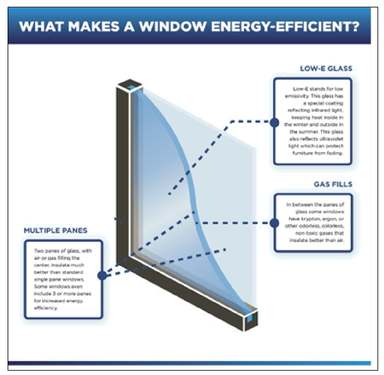


https://www.huberwood.com/blog/designing-with-continuous-insulation-for-thermal-and-moisture-management

Insulation in walls prevent heat transfer via conduction between inside of the building and the outside environment
Study modelled 1<R < 90

# of days

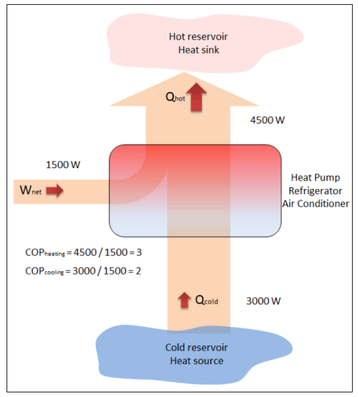
Window Construction



https://www.buildingenergyvt.com/construction/energy-efficient-windows/

Multiple panes, gas filling and glass coating prevent heat transfer via conduction, conduction, convection and radiation between the building and the outside environment
Study modelled 18 window designs

HVAC COP



https://www.nuclear-power.net/nuclear-engineering/thermodynamics/thermodynamic-cycles/heating-and-air-conditioning/coefficient-of-performance-cop-refrigerator-air-conditioner/

COP is a ratio of electrical energy required to heat energy moved into or out of the building

Study modelled 1<COP < 5

Future Work

Add cost of materials to attain building changes
Add new window design of thermionic windows
Different location around the US
Map CO2 emitted based on time of use of energy

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