Study Summary

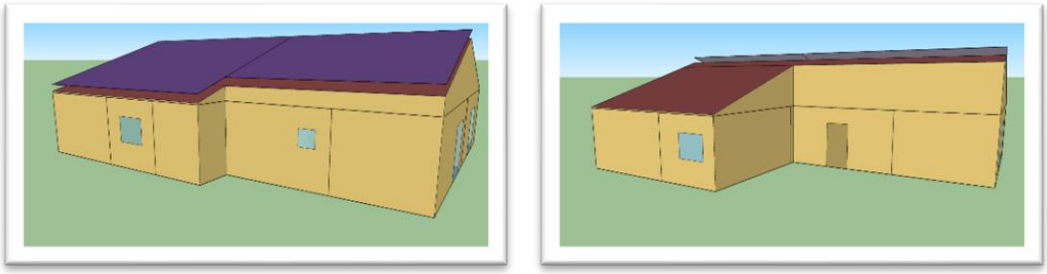
From the **simulation of 3 scenarios** for building construction, it was possible to define the ideal version of the house model. The original model exhibited **extremely high or low temperatures** throughout the simulation, ruling out its application, and incurred **significant energy costs for cooling using the HVAC system**, indicating the **need for improvement**. Consequently, various measures were adopted to alter the construction of this model to enhance its thermal and energy performance, which are detailed in this work. For instance, one measure implemented was changing the building materials of the walls. With the application of these measures, it was possible to **adjust internal temperatures within the thermal comfort range** throughout the house. However, **the energy consumption of the HVAC system increased** due to the need for building heating – **HVAC energy consumption increased from 8.92 GJ to 9.89 GJ annually, which corresponds to an increase of approximately 10.9%** –. Therefore, **additional corrective measures were necessary to achieve the ideal model**, detailed below, to ensure thermal comfort during occupancy while reducing HVAC and interior lighting energy costs. With the application of these new measures, **the ideal simulation for the building was obtained**, maintaining interior temperatures within the thermal comfort range during all room occupancies. **The HVAC system energy consumption decreased from 9.89 GJ to 7.77 GJ, a reduction of approximately 21.4%, representing savings of about €79.56 per year**, considering the electricity price of €0.1351 per kWh. Finally, to provide **alternative solutions to further improve the energy performance** of the house, it is recommended to use **conventional fans during hot seasons** to provide thermal comfort to residents despite high temperatures, due to their low electricity consumption compared to air conditioning solutions. Additionally, **adapting residents' clothing** for greater resilience to both hot and cold temperatures is advised.

Description of the building

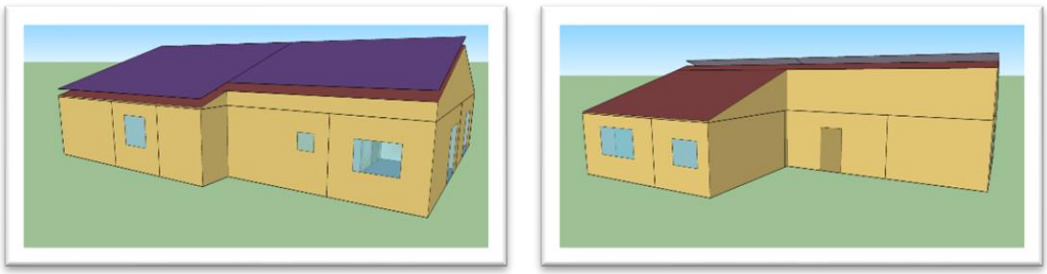
- Location: Brasília – DF, Brazil;
  - Suburbs;
  - House with 4 residents and 9 rooms.
    - 3 bedrooms, 2 bathrooms, 1 living room, 1 hall, 1 corridor, 1 kitchen e 1 attic.
- In the simulation, it is considered that the rooms do not have furniture/obstacles that "interfere" with the air circulation.

Changes made to the model

✓ ***Before***



✓ ***After***



- ***1st improvement;***
  - Two windows were added - one on the wall of thermal zone 6 (double bedroom) facing South and the other on the wall of thermal zone 7 (double bedroom) facing North - and all other windows had their respective areas increased to enhance air exchange between the exterior and interior of the building, as well as to allow for greater natural light penetration;

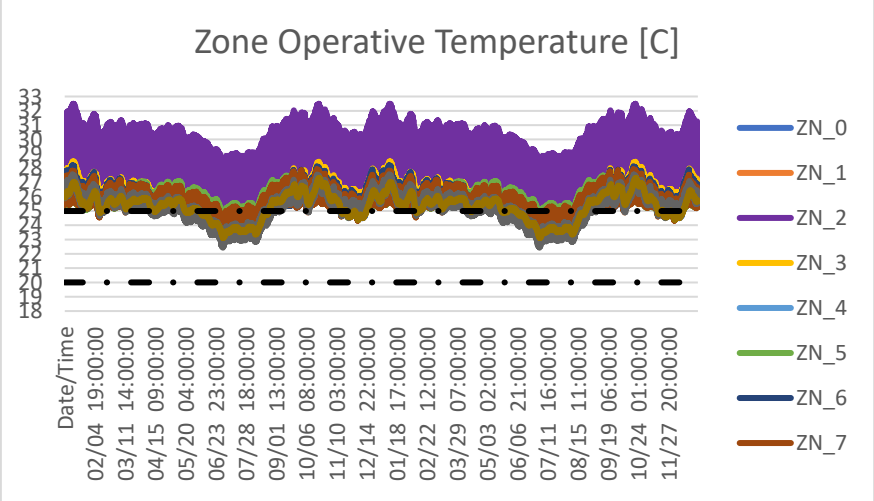
- The building materials for the walls, floors, roofs, and glass windows/doors were replaced to make the house more resilient to the noticeable thermal fluctuations of Brasília's dry climate;
  - This measure was accompanied by an increase in air infiltration into the interior.
- Wall exhaust fans were simulated in the bedrooms, kitchen, and living room to circulate indoor air to the exterior;
- The thermostats for the HVAC systems were set to the temperature range of 20 - 25°C, which represents the thermal comfort zone;
- The minimum supply air temperature for cooling was adjusted to 10°C;
- The original operating schedules of the HVAC system were modified to ensure that the operative temperatures of the rooms remain within the thermal comfort range throughout the entire day;
- A connection from the HVAC system to the attic thermal zone was added to reduce the high temperatures detected in this area, caused by constant solar radiation exposure during the day. The same applies to the thermal zone of the kitchen, where high temperatures are reported due to the operation of equipment in this environment;
- The air exchange rates for the kitchen and bathroom exhaust fans were adjusted (from 0.6 changes/hour to 1.0 change/hour);
- The openings of the windows and glass doors of the rooms were simulated to allow for natural air exchange between the interior and exterior, synchronized with the occupancy schedule of the residents in their respective rooms.

- ***2nd improvement (ideal version).***
  - The changes to the operating schedules of the HVAC system in the rooms were reverted, as the thermal discomfort that would be experienced by the occupants when these rooms are unoccupied does not occur precisely because during times of temperatures outside the thermal comfort range, the rooms are unoccupied;
  - The fractions of active internal lighting during the day for the rooms that underwent changes due to the construction of windows were adjusted, as these improvements result in increased natural light penetration.

Presentation of the results

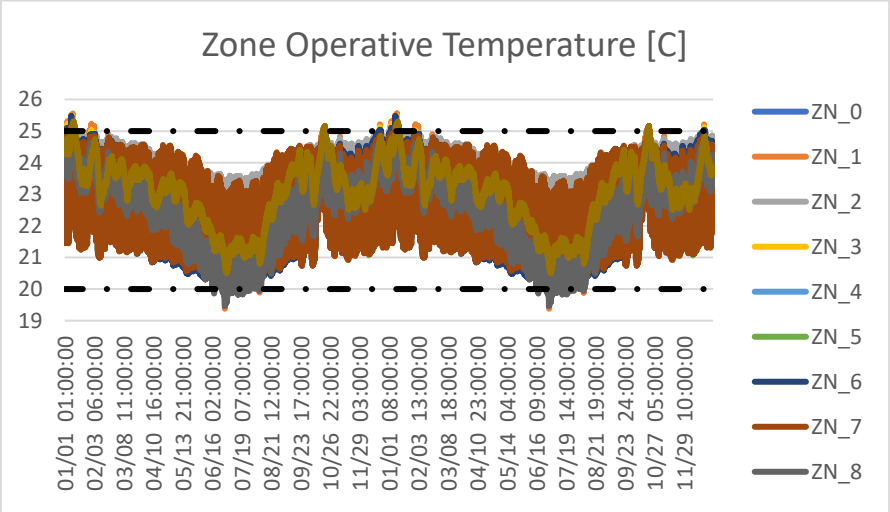
✓ ***Original;***

	Electricity [GJ]	Natural Gas [GJ]	Gasoline [GJ]	Diesel [GJ]	Coal [GJ]	Fuel Oil No 1 [GJ]	Fuel Oil No 2 [GJ]	Propane [GJ]	Other Fuel 1 [GJ]	Other Fuel 2 [GJ]	District Cooling [GJ]	District Heating [GJ]
Heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cooling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.92	0.00
Interior Lighting	5.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



✓ ***1st improvement;***

	Electricity [GJ]	Natural Gas [GJ]	Gasoline [GJ]	Diesel [GJ]	Coal [GJ]	Fuel Oil No 1 [GJ]	Fuel Oil No 2 [GJ]	Propane [GJ]	Other Fuel 1 [GJ]	Other Fuel 2 [GJ]	District Cooling [GJ]	District Heating [GJ]
Heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.19
Cooling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.00
Interior Lighting	4.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



✓ ***2nd improvement (ideal version).***

	Electricity [GJ]	Natural Gas [GJ]	Gasoline [GJ]	Diesel [GJ]	Coal [GJ]	Fuel Oil No 1 [GJ]	Fuel Oil No 2 [GJ]	Propane [GJ]	Other Fuel 1 [GJ]	Other Fuel 2 [GJ]	District Cooling [GJ]	District Heating [GJ]
Heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.21
Cooling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.56	0.00
Interior Lighting	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00