Heat Transfer

Energy Detective

Introduction

As a wrap-up, use the model to explore heat flow in a whole house model. You can move temperature sensors around, just as you would with real temperature sensors in the standard house model. The advantage of a computer model is that you can change features and make measurements very quickly. And you can also add as many sensors as you want. On the other hand, a model is never just like the real world.

These models are more open ended than the others and students may enjoy them as a wrap-up.

6A: A well-insulated house vs. a poorly insulated house

Energy2D

Use the model to investigate the quality of construction of the two houses. Open Model 6A and follow the instructions. Then answer the following questions.

Which house required more power to keep warm, A or B? Explain how you figured this out.

To download Energy2D software, go to http://energy.concord.org/energy2d/

To run the models in this chapter, go to http://energy.concord.org/htb

Note the video tutorial.

Go back to the model and do more tests to answer these two questions. Recall that the rate of heat loss is proportional to the difference between inside and outside temperatures.

1. How much more power, roughly, does the less energy-efficient house require (for example, 1 ½ times, 2 times, 3 times, 4 times as much power)?

House A is about 3 times as insulating, because the equilibrium temperature difference is about 3 times as great (30° vs. 10°). (Please ignore the note above, which refers to the standard house.)

2. What is the ratio of high heater power to low heater power?

The ratio is 2.5:1, but any answer near to this is good. The final house temperatures are in the ratio of between 2:1 and 3:1.

Note: This is one section of the "Science of Heat Transfer" chapter of the Engineering Energy Efficiency Project. See: http://concord.org/engineering

Energy2D

6B: Where does this house lose heat the most?

Use the model to investigate the quality of construction of different parts of the model house. Open Model 6B and follow the instructions. Then answer the following questions.

Describe the method and measurements you used to find the poorly insulated places.

Move the thermometers around and look for “cold spots.”

Fill out the following table with results from Model 6B.

Results from Model 6B		
Building section	Insulating quality (great, good, fair, poor)	Evidence (measurements)
A		
B		
C		
D		
W		
R		
G		

6C: Discover a vertical temperature gradient

Energy2D

You have probably noticed that houses are often warmer near the ceiling than near the floor, and warmer upstairs than downstairs. This model shows the effect of natural convection in a house. Open Model 6C and follow the instructions. Then answer the following questions.

Results from Model 6C		
Thermometer	Temperature with ceiling	Temperature without ceiling
T1		
T2		
T3		

Describe the effect of removing the ceiling.

The temperatures become lower and more similar. The very hot air goes to the peak and stays there, affecting the upper thermometer less than when there is a ceiling.

Many modern houses have living rooms in two-story spaces, so that the ceiling is 12 or more feet high. Explain why this kind of space is difficult to heat, and what you could do about it.

The hot air will rise to the top and cold air will flood in at the bottom, making the room cold at the living level. Fix it by having lower ceilings or a paddle fan.

Summary

Think about a house you'd like to design. What directions and slopes (vertical, sloped, horizontal) would you choose for large windows? What directions and slopes would you choose for smaller windows? Why?

Vertical south-facing glass has good heat gain in winter and low heat gain in summer.
Sloped south-facing glass has slightly better heat gain in winter but much greater heat gain in summer.
Horizontal glass has modest heat gain in winter and very high heat gain in summer – generally not desirable!
East and west-facing glass has modest heat gain in winter and fairly high heat gain in summer that is hard to shade because the sun spends a lot of time at low angles in those directions in the summer.
Smaller windows to the east, west, and north are generally good to let in some natural light but not cause overheating or excessive heat loss.