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SKETCHBOX LESSON 1:
Introduction to Building Models

Next Generation Science Standards (https://www.nextgenscience.org/)

Content Standards

HS-ETS1-4 Engineering Design
Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Science and Engineering Practices
2. Developing and using models
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Lesson metatags
building design, computer model, data analysis, efficiency, electricity, energy, energy conservation, energy economics, heating and cooling, HVAC, kwh, natural gas, NG, simulation, utility rates

Student materials begin on the next page.

SKETCHBOX™ LESSON 1 (v1.02):
Introduction to Building Models

Student Activity and Response Guide

**INTRODUCTION:**

Energy use in school buildings

The US department of energy reported in 2015 that buildings use 40% of all energy in the U.S. and about 75 percent of the electricity. This energy has a significant cost, and the EnergyStar program estimates U.S. schools spend roughly $162 per student each year for energy (it can be more than spending for computers and textbooks combined!). Energy use also produces significant emissions of air pollution and other environmental impacts. These effects can be reduced by making buildings, including school buildings, more efficient. The goal of this lesson is to learn ways this is done and to explore a computer model that estimates the impact of specific changes to a building.

Reducing energy use in buildings

To understand how to reduce the energy used by buildings it helps to understand what equipment uses this energy. In schools, the largest use of energy is heating, ventilation, and air conditioning, or HVAC; this is about 35% of all energy used in a school building. Major appliances like refrigerators, freezers, dryers, and hot water heaters (18%) and lights (11%) also use a lot of energy. All other devices together account for the rest (36%).

ENERGY USE IN SCHOOLS

■ HVAC ■ Appliances ■ Lighting ■ Other
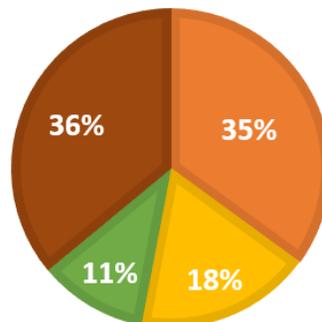
Building energy use can be reduced, for example, by installing more efficient lights, changing temperature settings when people are not in the building, upgrading outdated heating and cooling systems. Choosing which upgrade to make first can be difficult, but that is exactly where building energy modeling can help!

Using models to evaluate potential upgrades
Many different software models are used to predict how much energy a particular building upgrade will save. This lesson introduces a model interface called sketchbox, created by Slipstream, to analyze energy use in buildings. To get started, follow these steps:

1. Access the web address: https://www.sketchbox.io/login

2. Create an account and then log in

3. When Sketchbox ™ opens the "**project**" tab should be selected. This tab lets you name your project, choose its location, and enter data about energy code, energy cost, and emissions. Energy code is a legal framework that guides how buildings are designed and built and is presented in a later lesson.

Give your project a new name and keep the state set to Illinois and the city to Chicago.

4. Now, switch to the "**design"** tab.

From the design tab you can change the size, shape, and layout of your building and choose equipment for heating and cooling. For now, leave everything as a default EXCEPT to change the building type to "**School/University**". Once you have done this, make sure the building has 150,000 square feet of space (this is the size of a middle school or a small high school) and that the number of floors is 2.

5. Now you are ready to model how much energy this building will use! Select the "**Results**" tab and look for the table that looks similar to the one shown here:

	Peak Cooling (kBTU/hr)	Peak Heating (kBTU/hr)	Peak Electric Demand (kW)	Annual Electric Consumption (kWh)	Annual Natural Gas Consumption (therm)	Annual Energy Cost ($)
Baseline	878.1	751.8	127.9	326919	8539	35339

R1 Note the **annual energy cost** and record that value here: * _____

Compare the annual energy cost with the value provided by your instructor to make sure that they match.

Now, record the annual energy cost, the annual electric consumption (kWh), and the annual natural gas consumption (therm) in the **table on the next page (table 1)** in the "Baseline" row. We will compare to these values later.

Table 1

| Building model	Annual electric consumption (kWh)	Annual natural gas consumption (therm)	Annual energy cost ($)
Baseline (data from part one)	*	*	*
Half the area (75,000 square feet)	*	*	*
More windows (40% window to wall ratio)	*	*	*
New location (Los Angeles, CA)	*	*	*

Part Two

Now that you have seen inputs and results in sketchbox let's explore how changes to the building affect predicted energy use.

6. Make a prediction about how the energy use will change if the building size is cut in half (be sure to add one or two reasons to support your prediction).

R2 Prediction: *

R3 Support: *

7. To test your prediction, navigate back to the "design" tab in sketchbox then change the building area from 150000 ft² (square feet) to 75000 ft².
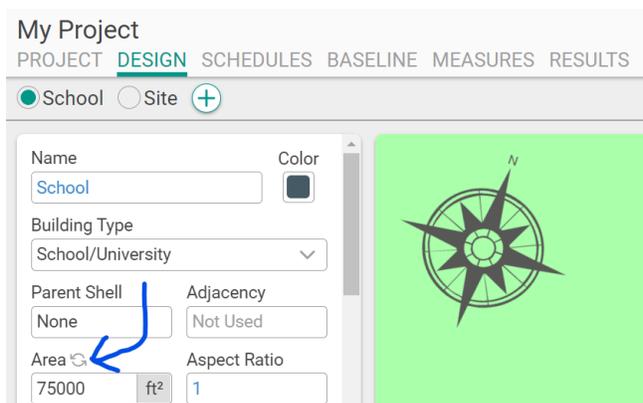
8. Return to the results tab to view the results. Enter this new data in the **second row of table 1** ("half the area").

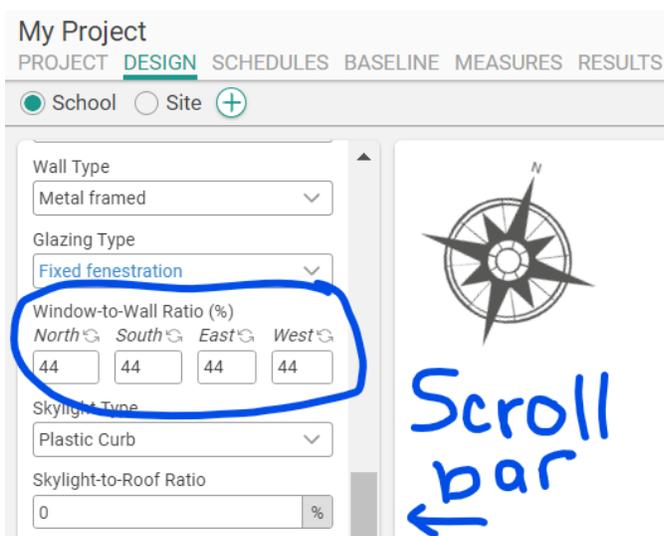R4 9. Was your prediction correct? How does the new energy use and energy cost compare to the original building?

*

10. Now let's explore how windows affect energy use in buildings. Make a prediction about how the energy use will change if more windows are added to the building (be sure to add one or two reasons to support your prediction).

R5 Prediction: *

R6 Support: *

11. To make this change select the "design" tab in sketchbox and change the building area back to 150000 ft². Then, increase the "**window-to-wall-ratio**" from 22 to 44 for the walls facing in each direction.

12. Return to the results tab, then enter your new data in the **third row of table 1** ("more windows").

R7 13. Was your prediction correct? How do the energy use and energy cost with more windows compare to the original building?
*

14. Finally, let's examine how location affects energy use in buildings. Make a prediction about how the electricity and natural gas use for this building will change if it were moved to Los Angeles, California (be sure to add one or two reasons to support your prediction).

R8 Prediction: *

R9 Support: *

15. Return to the "design" tab in sketchbox and change the "window-to-wall-ratio" from 40 back to 22 for each wall.

16. Switch to the "project" tab and record natural gas and electricity cost in Chicago (Chi).

R10 Natural gas cost Chi ($/therm): *   **R11** Electricity cost Chi ($/kWh): *

17. Make a prediction about how the energy use will change in this new location remembering that the climate will be different. Give your reasoning for the changes you predict.

R12 Prediction: *

R13 Support: *

18. Now, change the **state to California** and the **city to Los Angeles**. Record the cost of natural gas and electricity in Los Angeles (LA).

R14 Natural gas cost LA ($/therm): *   **R15** Electricity cost LA ($/kWh): *

19. Return to the results tab and enter your new data in the **bottom row of table 1** ("New location").

R16 20. Was your prediction correct? How do the new energy use and energy cost in Los Angeles compare to the same building when it was located in Chicago?

*