SKETCHBOX LESSON 2_v1.01:
Energy Codes and Measures Sets

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, energy code

Student materials begin on the next page.

CREATE	Center for Renewable Energy Advanced Technological Education	Name: ______________________________ Date: ____ / ____ / ____ Class Hour: ____

SKETCHBOX™ LESSON 2_v1.01: Energy Codes and Measures Sets

Student Activity and Response Guide

Introduction

Most buildings, when they are built, need to meet a set of legal requirements called **building codes**. These standards help ensure that electrical systems are safe, adequate fresh air is brought into the building, people are protected from dangerous falls, and that the building is as safe as possible for fire and other hazards. Buildings also often follow an **energy code**. Energy codes give guidance for different aspects of building construction such as how much insulation must be in a building's walls or roof, how efficient various mechanical systems must be, and what types of lighting are used. It is important to know that the U.S. does not have a national energy code for buildings, energy codes can be different from state to state or sometimes even from city to city.

What energy codes are used?

In the U.S. two energy codes are commonly used. One set is produced by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) and the other by the International Code Council which creates the International Energy Conservation Code (IECC). An energy code is established as law when a city or state selects a code and then chooses to adopt it. A city or state does not need to adopt the ASHRAE or IECC standards, they can also write their own energy code. ASHRAE and IECC update codes on three-year cycles, but just because a new code exists does not mean that a state or city needs to implement it, the old code will be used until a new one is adopted.

Energy codes are built directly into Sketchbox

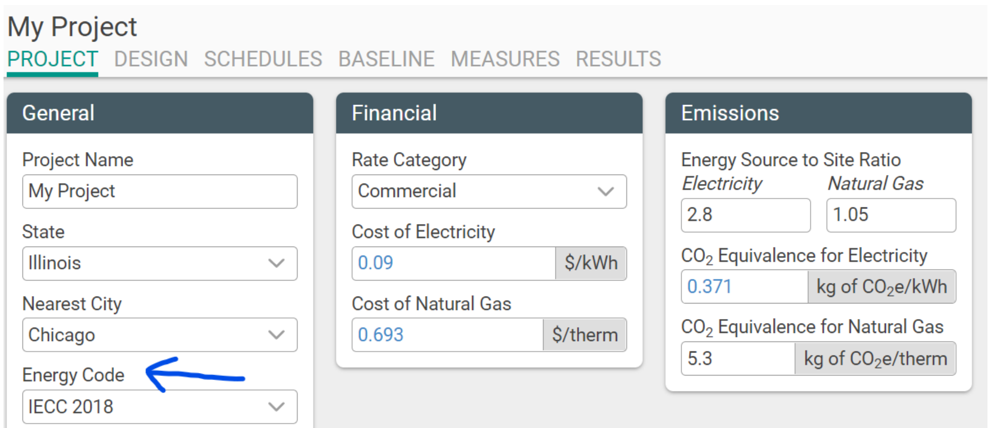
The amount of energy used by a building depends, in part, on the code it was designed to meet so energy code is important for energy modeling. Multiple energy codes are built directly into sketchbox. In this activity you will switch between several energy codes and learn how buildings can also exceed the efficiency requirements of energy codes.

Exploring energy codes

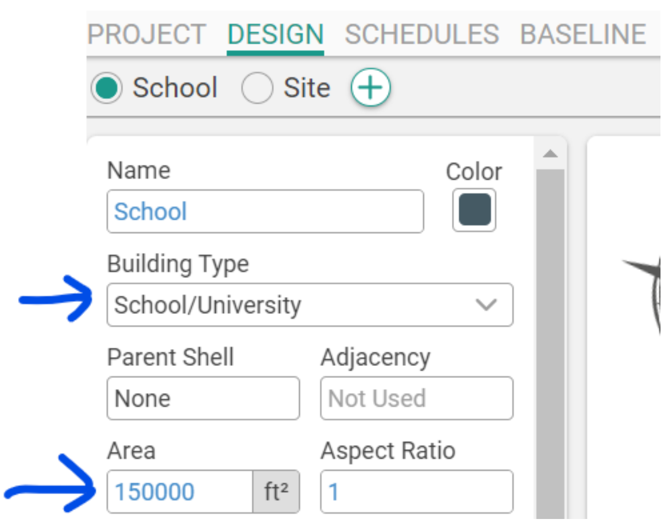
1. Access the web address: https://www.sketchbox.io/login

2. Login to sketchbox using the account you created in lesson 1

3. When sketchbox opens you should see the "project" tab selected which was used to name your project and set the project location. Directly below the state and city of the project is the energy code. This starts as IECC 2018, but it can be changed to nine different options.



Leave the energy code set to IECC 2018 and switch to the design tab. Check to make sure the building type is set to school / university and that the area is 150000 ft^2.

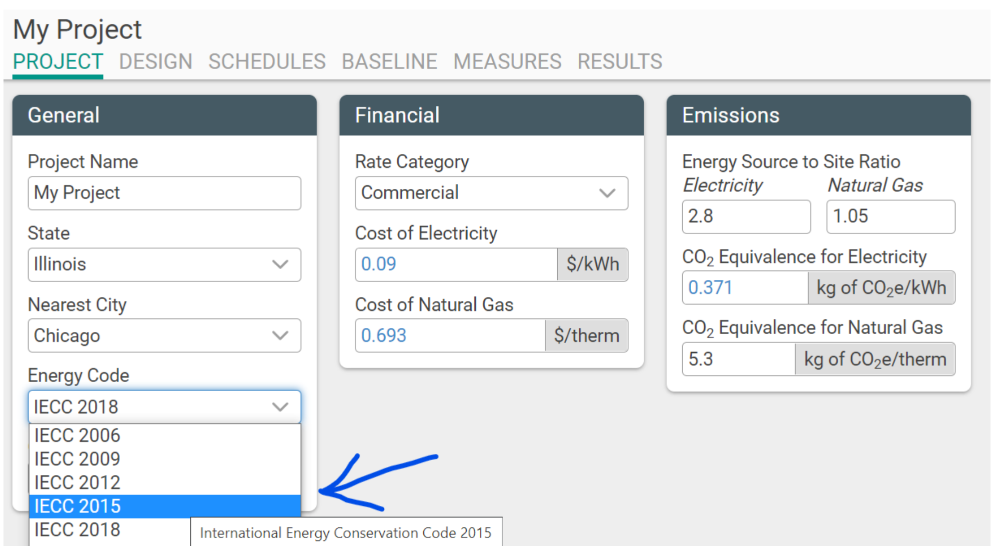


Switch to the results tab and scroll to the bottom to find summary values for the top row in table 1:

Table 1

Building model	Annual electric use (kWh)	Annual natural gas use (therm)	Annual energy cost (USD, $)
Baseline (IECC 2018)	*	*	*
IECC 2015	*	*	*
ASHRAE 2016	*	*	*

4. The building modeled by these calculations was designed to meet the 2018 IECC standards. To see how building for the 2015 IECC standard is different, switch back to the project tab, change the code to IECC 2015, then return to the results tab to see the change (enter your results in the next line of table 1, "IECC 2015").



5. Now, return to the project tab and change the code one more time, this time selecting the 2016 ASHRAE code. Return once again to the results tab and add these additional data in the last row of table 1.

6. What differences did you notice in the energy performance of buildings designed to different codes? Describe several differences and use numbers from table 1 to support your answer.

Differences between codes: *

Support: *

Part 2 Using measures sets to improve building performance

A building designed to the 2018 IECC energy code is intended to meet specific requirements for building properties and mechanical system efficiencies. Sketchbox shows values for many of these characteristics in the "baseline" and "measures" tabs, and the values can be changed to exceed code if desired.

To begin, copy the values from the first line of table 1 above into table 2, these are the baseline values that will be compared to the next results.

Table 2

Building model	Annual electric use (kWh)	Annual natural gas use (therm)	Annual energy cost (USD, $)
IECC 2018 "no change" (baseline- from table 1)	*	*	*
IECC 2018 Four selected improvements	*	*	*
IECC 2018 "best" measures set	*	*	*

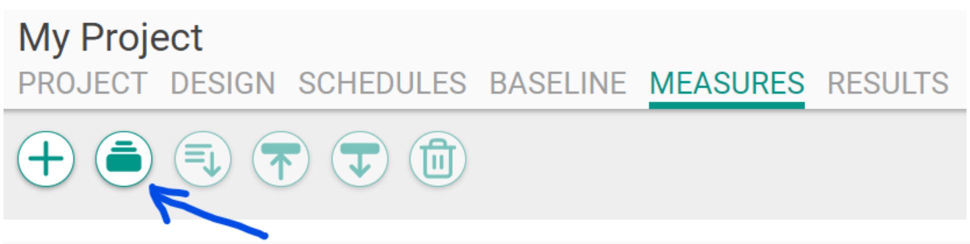
7. We will examine four variables to reduce the energy utilization of our building: Roof U-value, solar heat gain coefficient (SGHC) for windows, interior lighting efficiency, and efficiency of heating equipment. U-value describes how easily thermal energy flows through a material, a low U-value is more energy efficient. Solar heat gain efficiency measures how easily solar radiation passes through window glass to an interior space.

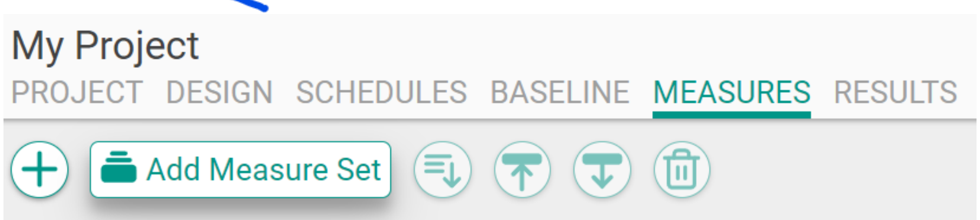
Each measure will be improved by an amount determined to be practical from a cost perspective. Predict how much energy cost these four upgrades will save. Rank them from largest to smallest energy cost savings, then explain your reasoning.

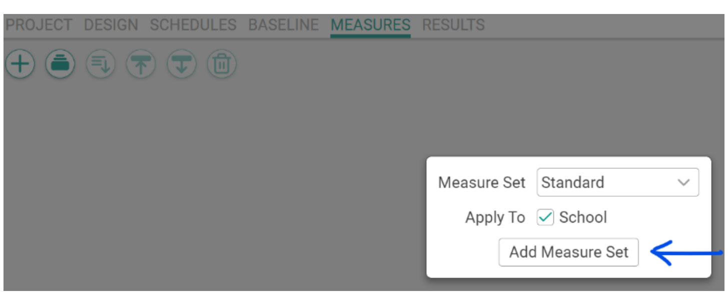
Ranking: (roof insulation, improved SHGC, efficient lights, efficient heating equipment) *

Reasoning: *

8. Return to the project tab of your sketchbox model and be sure the energy code is set to IECC 2018. Now, switch to the measures tab and select the icon to the right of the plus symbol (+) to add a measures set (see image below). Use the standard measure set by clicking the "Add Measure Set" button that pops up.



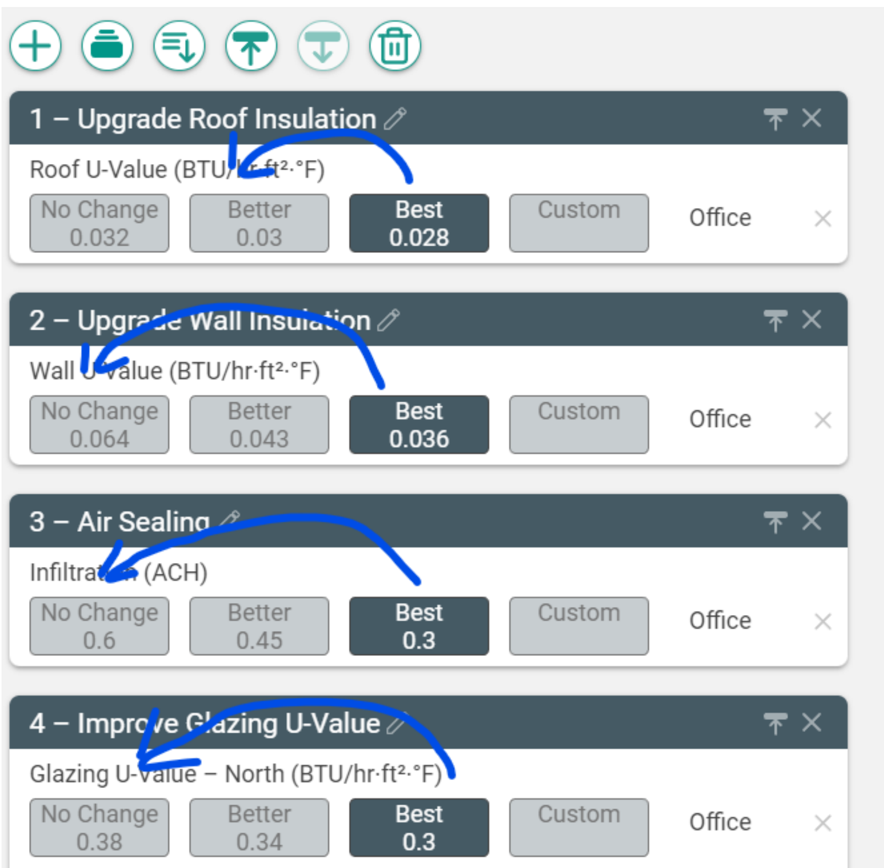




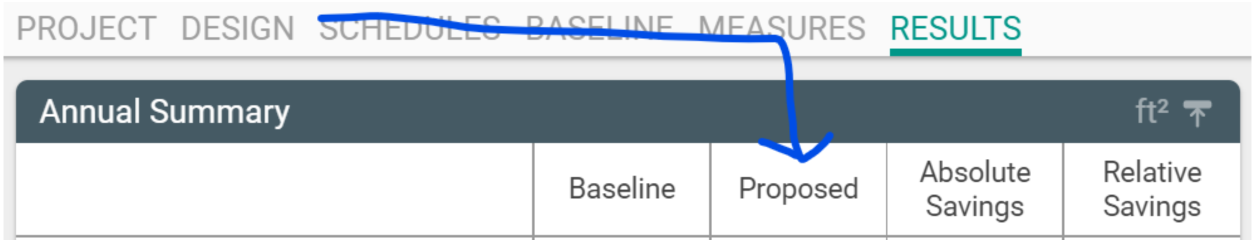
9. After adding the measures set you should see values for sixteen different building characteristics. Each of these is important to energy use in a building and most have three values listed: "no change", "better" and "best". The "no change" value was used to model a building that would meet the energy code. The "better" value is an improvement that would save energy and lower the energy cost, but it would likely cost more as the building is constructed. The "best" value is the most energy efficient value determined to be possible without making the cost too large.

To explore the selected building upgrades you ranked switch measures #1, 5, 6, and 13 to "better", being sure to change all four directions (NSWE) for measure 5 (SHGC).

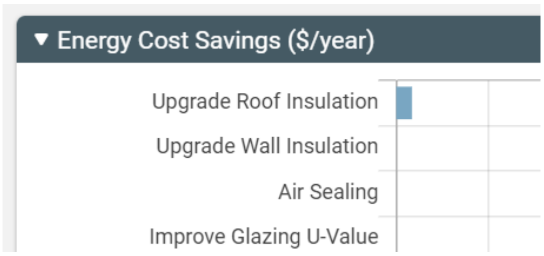
All other measures should be set to "no change" except for #14, demand control ventilation, which should be set to "no" (the following images show how to start).



10. Now, switch to the results tab and add summary values to the second line of **table 2**. You can find these values from the "proposed" column in the annual summary at the top of the results.



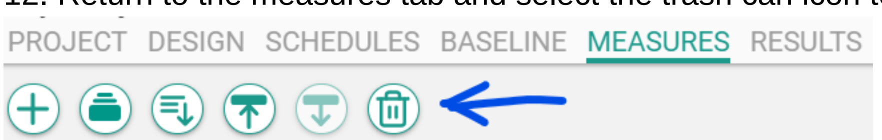
11. Continue to scroll down in the results to find the “Energy Cost Savings” graph. Note that you can hover over the bars to find a numerical value.



What is the actual ranking of the four measures that you ranked earlier? Comment on anything that surprises you in the ranking or in how different the measures are from each other.

*

12. Return to the measures tab and select the trash can icon to remove the measures.



13. Add a measure set again, this time leaving every value at the “best” setting, except demand control ventilation, which should stay at “yes” (you should not need to make any changes). Then, switch to the results tab.

14. From the “proposed” column in the annual summary on the results tab record the new values for energy cost, electric consumption, and natural gas consumption in the last row of table two.

15. What percent of electric consumption did the “best” upgrades save? To find this percent subtract the electric consumption after applying these measures (the bottom row in table two) from the baseline values (top row in table two) to find how much electricity was saved Then, divide that result by the baseline value and multiply by 100. Show your calculations below.

Relative savings calculations:
*

16. To check your work, compare your answer to the “relative savings” for electric consumption in the annual summary table on the results tab.

Annual Summary				ft²
	Baseline	Proposed	Absolute Savings	Relative Savings

Summary of energy use reductions

17. Now, calculate relative savings for natural gas comparing the “best” upgrades to the baseline. Show your calculations and check your work with the annual summary.
*

18. Finally, calculate relative savings for energy cost comparing the “best” upgrades to the baseline. Again, show calculations and check your work with the annual summary. *

19. What additional measure would you be most interested in trying next? What measures have names that are unclear to you? *