



Center for Renewable Energy Advanced Technological Education

Sketchbox Lesson 3: Schedules

INSTRUCTOR'S GUIDE

Grade Level: High School, Technical College, Community College
Lesson Length: 1 hour
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Learning Goals:

- Students can explain that building set points are scheduled to be different at different times of the day
- Students can use the Sketchbox™ interface to model the energy use of a building, change schedules and set points, and discuss the results, including the relative significance of the changes on energy use and cost

Technology Required:

- Internet-accessible digital device to use Sketchbox™, Sketchbox user account (free)

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

Content Standards

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics

Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

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

The Activity:

This activity involves the use of a computer model that calculates the energy use for a specific building in a given location. Sketchbox™ is a user interface to the energy modeling software DOE2 that uses typical industry values to make quick energy estimates for energy use in buildings. Sketchbox™ and DOE2 use historical weather input data for the location selected in the model along with location specific CO₂ equivalent emissions data for electricity and cost data for electricity and natural gas.

Sketchbox™ has preloaded building schedules and set points, but these parameters can be changed. In this lesson students increase and decrease the hours of operation of a school and change the temperature set points to determine the significance of these changes on the energy use and cost for operating the building.

Discussion ideas

Post lesson discussion questions are included with the teacher slides and copied here. Slides containing these questions also have related sample data to aid in discussion.

1. Did changing the building schedule significantly affect energy use or cost?
2. Did changing the temperature set points significantly affect energy use or cost? Are there disadvantages to this change?

Extension activities and questions

These ideas are included in the teacher slides but copied here for reference. They are intended as additional learning activities, especially for students of student groups that complete other parts of the lessons before their peers.

Compare the simple thermostats baseline to the default ASHRAE schedule (ASHRAE may be more comfortable, at what cost?)

Add occupancy on weekend mornings, how significant is the change?

	Center for Renewable Energy Advanced Technological Education 	Name: _____ Date: ____ / ____ / ____ Class Hour: ____
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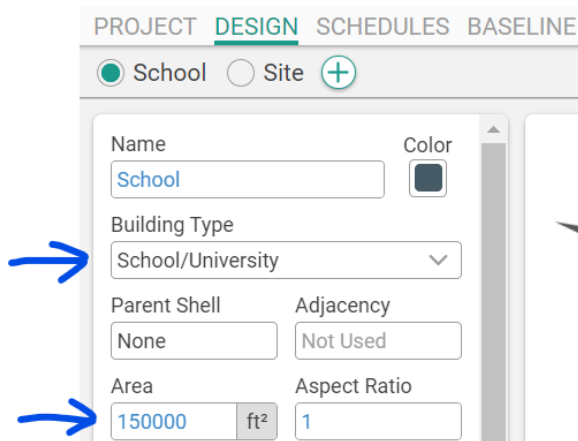
SKETCHBOX™ LESSON 3 (v1.02): Energy modeling and building schedules Student Activity and Response Guide

Introduction

A key aspect of managing energy use in buildings is determining when a building is occupied and spaces need to be heated, cooled, or provide ventilation. This means learning when most people who use the building (occupants) are there- the building schedule. If a building does not have people in it overnight (it is unoccupied), for example, the heating system can be turned down so that it will run less without affecting comfort. Similarly, ventilation systems provide outside air for each occupant, but the air coming into the building usually needs to be heated or cooled, and that takes energy. Reducing ventilation when it is not needed saves energy. In some buildings sensors can be used to find when occupants are present and the heating, ventilation, and air conditioning (HVAC) systems can adjust.

Adjusting Schedules in Sketchbox

1. First, use the project tab to set your building in Chicago, IL. Then, use the design tab to set your building to be a 150,000 square foot school / university building.



PROJECT DESIGN SCHEDULES BASELINE

☒ School ☐ Site

Name Color



Building Type

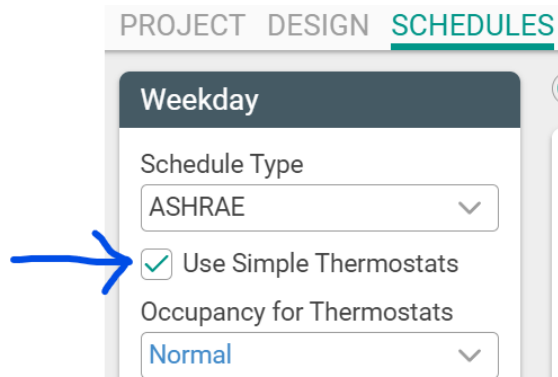
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Parent Shell Adjacency

Area Aspect Ratio

ft²

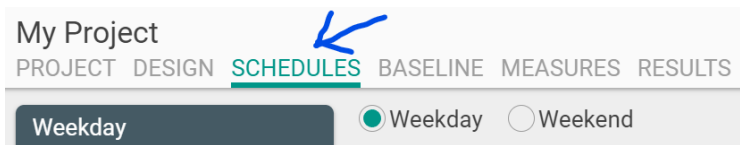
2. Switch to the “schedules” tab and change schedule type to “use simple thermostats”.



- With the weekday schedule selected, find what time the heating system changes from 60 to 70 degrees Fahrenheit in the morning and what time it switches from 70 back to 60 degrees in the evening.

Morning switch from 60 to 70°F: * 7 am

Evening switch from 70 to 60°F: * 6pm

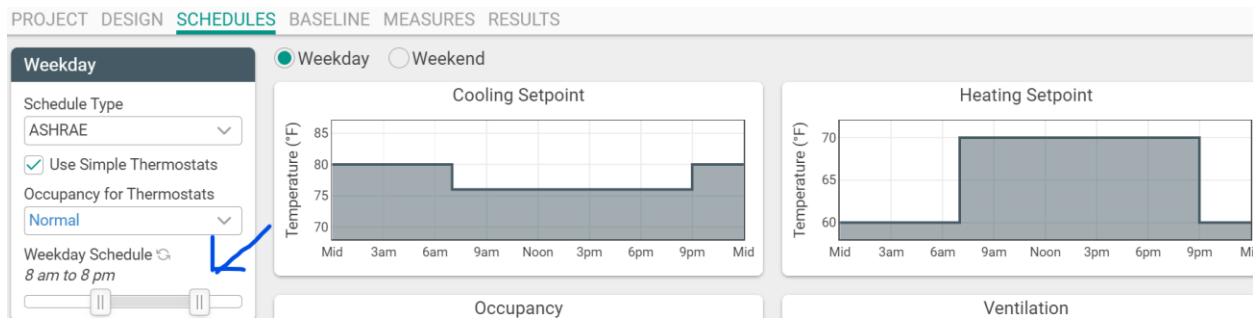


- Switch to the results tab and use the annual summary to find the annual electric and natural gas consumption and the annual energy cost. Record these values in the top row of table 1. We will compare to these values as we make changes.

Table 1

Building model	Annual electric consumption (kWh)	Annual natural gas consumption (therm)	Annual energy cost (\$)
Baseline (simple thermostats)	* 1,021,040	* 35,304	* 116,360
Simple thermostats Weekday 8am – 8 pm	* 1,023,333	* 36,149	* 117,152
Simple thermostats Weekday 8am – 4 pm	* 1,019,696	* 34,982	* 116,017
68 degree heating setpoint 77 degree cooling setpoint	* 996,779	* 33,475	* 112,908

- To explore the energy impact of changing the building schedule, switch back to the schedules tab and use the sliders to adjust the weekday schedule to extend to 8pm instead of 5pm (see image below). Switch to the results tab and include the new annual summary values in table 1.



- consider that the building being modeled might be a middle school with a school day that ends at 3:15 pm with most occupants out of the building by 4pm. Adjust the sliding weekday schedule bar again to change set the weekday occupancy schedule to continue until only 4pm. Then, return to the results tab and add the results to the next row of table 1.
- How significant is the difference between setting the building schedule to end at 4pm instead of 8pm? Is this change worthwhile, and could it have disadvantages? * **There are small energy savings and cost savings of around \$1000. This could be a disadvantage if there are people in the building for an afterschool activity- the building may be too hot or too cold.**
- Another way to reduce energy use is to change building setpoints. A setpoint is the temperature that the HVAC system will maintain in the building, and these can be changed by a building manager. For example, while occupants might prefer to have the temperature in the building to be 70 degrees Fahrenheit in the winter, most occupants might still be comfortable if the setpoint were instead 68 degrees Fahrenheit. Since the building would be cooler the heating system would run less to maintain the lower setpoint and energy use and cost would decrease. A similar change can be made for cooling setpoints.
- Open the schedules tab again. Leave the weekday schedule set from 8am to 4pm but scroll down to find the setpoint temperatures (see image below) in the "Thermostats" box.

PROJECT DESIGN **SCHEDULES**

Thermostats

Cooling Setpoint
Occupied  *Unoccupied*

76 °F 80 °F

Heating Setpoint
Occupied *Unoccupied*

70 °F 60 °F

10. Increase the occupied cooling setpoint to from 75 to 77 degrees Fahrenheit and reduce the heating occupied setpoint from 70 to 68 degrees Fahrenheit. Then, return to the results tab and add these last results to table 1.
11. Did changing the setpoints make a significant change in the energy used by this building? Should the setpoints be changed? Explain your reasoning. * **The savings are about \$3500, though the energy savings are not that large. It may be better to keep the original set points so that building remains more comfortable for classes. It may affect student performance if students are too hot or too cold.**
12. Explore the schedules tab further by making one additional change that you are interested investigating. What did you change and how did it affect building energy use? * **Answers will vary**