Rooftop Gardens: Are They a Cool Idea?

sead : stem

Subjects

Engineering

Topics

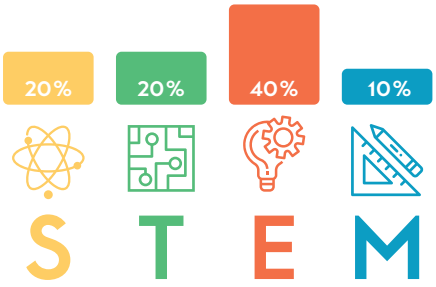
Sustainability | Climate Change | Engineering Process

Key Words

Insulation | Energy Conservation | Urban Heat Island Effect

Connection to SDG

STEM Chart



Time for Activity

4–5 lessons

Introduction

Imagine looking out over the rooftops of a city and seeing a canvas of living plants. All around the world rooftops are going green, especially in cities. These rooftop gardens are an environmentally friendly option that is gaining popularity. Living green roofs have many advantages, including providing more space for agriculture, adding beauty to the cityscape, and increasing the air quality. During photosynthesis, plants remove carbon dioxide from the air, and release oxygen. Over the course of a year, a single 1.5-meter by 1.5-meter section of a roof planted with grass produces enough oxygen to keep one human breathing for a year!

Another advantage of rooftop gardens, is the fact that they absorb heat and insulate the building better than traditional tar and gravel roofs. Because they sit in the direct sunlight for many hours, the temperature of traditional rooftops tends to rise above the actual air temperature. Then they radiate that heat back into the environment. If you live in a big city or have been to a mall with a lot of concrete buildings during warm months, you might have noticed the temperature difference between those areas and the suburbs or more rural areas. That is because when the heat is radiated back into the environment from the rooftops, an area with many buildings, like a city, can experience an increase in local air temperatures by as much as 5–7°C! This phenomenon is referred to as the urban heat island effect.

However, rooftop gardens might be able to diminish this effect. Rooftop gardens lower the maximum surface temperatures on roofs, but does this translate into changes in the internal temperature of the rooms in the building? Can a rooftop garden help conserve energy and lower your energy bill by keeping the internal temperature cooler on hot sunny days? In this project, students will find out by building two model houses—one with a rooftop garden and one without — and then they will compare how hot the inside of the houses get during the day and how they cool off when the sun goes down.

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Key Objectives

1. To determine whether or not a rooftop garden can help keep a building cool.

Materials

1. Garden clippers or strong scissors
2. Shoe boxes or photo storage boxes (2) of the same size, color, and shape. Alternatively, half-gallon size cleaned, cardboard milk cartons may be used.
3. Tar paper; available at hardware stores (enough to cover two shoebox lids)
4. Strong double-sided tape, like carpet tape or foam mounting tape (1 roll)
5. Sod; available at most nurseries or garden supply stores (enough to cover one shoebox lid)
6. Cutter
7. Thermometers (3), such as total immersion thermometers. Note: either indoor or outdoor thermometers will work. Try to avoid buying mercury thermometers, which can be dangerous if broken, and choose red alcohol thermometers instead.
1. Optional: For added convenience, you may opt to use probe digital thermometers, available from kitchen stores, for measuring the temperature inside the box houses to avoid taking the lids off. If you choose to do this, you will need 2 probe digital thermometers and 1 red alcohol thermometer.
8. Clock or timer
9. Lab notebook
10. Heat lamp; available at pet supply stores or some hardware stores

    Note: If the heat lamp does not come with a heat lamp bulb, you will also need to purchase this, which is available from hardware stores. If you buy it separately, make sure the bulb is a floodlight bulb rather than a spotlight bulb.
11. Graph paper for analyzing your data. Alternatively, you can make your graph using the 'Create a Graph' program online and print it out for your lab notebook.

Safety

1. Use caution when using the cutter.

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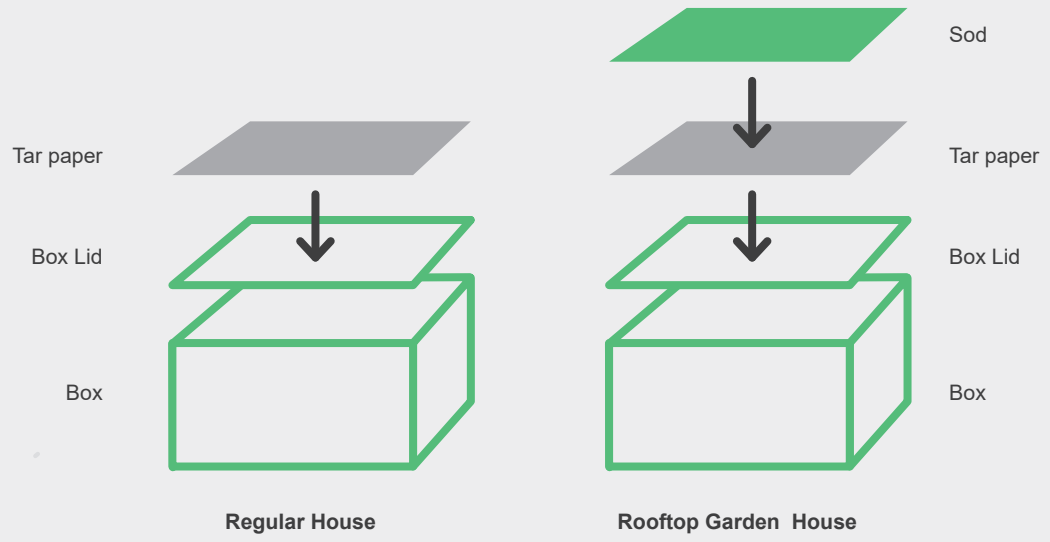
Tasks/Steps

Building the Box Houses

1. Using a pair of garden clippers or strong scissors, cut out two pieces of tar paper that are the same size as the lids of your shoe boxes.
2. With the double-sided tape, attach the tar paper to the top of the shoebox lids, as shown in Figure 2 below.
3. Place the lid of one of the boxes on the sod. Using the knife, carefully cut around the lid to get a piece of sod the same size as the lid.
4. Place the sod on top of the tar paper lid of one of the boxes, as shown below.
   - (a) The box with the tar paper and sod lid will represent your rooftop garden house.
   - (b) The box with only the tar paper lid will represent your traditional house.

Fig 1



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Measuring the Temperature in the Box Houses

5. Put your three thermometers all in one place (a tabletop or counter with the same amount of lighting and heating) for 15 minutes. Do they all read the same temperature? It is important that your thermometers do not have wide variations in their readings, as this would invalidate comparisons later. If any of the thermometers varies widely, use another thermometer. A degree or two of difference is ok.

6. Put one thermometer in each of your boxes.
   - a. The thermometers will allow you to record the indoor temperature of your box houses.
   - b. If you are using probe thermometers, the probe part will be inside the box. Close the lid as best as you can over the cord, and leave the digital reader part outside of the box.

7. Place the boxes on the same tabletop or counter, with the same amount of lighting and heating.

8. Place the third thermometer on the table between the two boxes. This is your external thermometer and represents the outside air temperature around your box houses. There is no need to use a probe thermometer for reading the external temperature.

9. Let your thermometers and boxes sit on the tabletop undisturbed for 30 minutes.

10. While you are waiting, make a data table like Table 1 below in your lab notebook. You will record your results in this data table.

File Name	Starting Temperature (C°)	Heated Temperature (C°)	1st Cooling Temperature (C°)	2nd Cooling Temperature (C°)
External				
Internal of Rooftop Garden House				
Internal of Traditional House				

11. After 30 minutes, record the temperatures in the data table in your lab notebook. These are the starting temperatures.
   - a. One at a time, open each of the boxes and quickly read the temperature on the thermometer. If you are using probe digital thermometers for inside your box houses, you will be able to read the temperature without removing the lids.
   - b. Read the temperature on the external thermometer.
   - c. Do the box houses have the same starting internal temperatures? Are the internal temperatures the same or different from the external temperature?

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12. Now place a heat lamp above the box houses. Space the boxes and external thermometer such that they are getting equal lighting from the heat lamp. The lighted heat lamp will provide warmth and simulate what happens to the houses during a hot, sunny day.

13. After 1 hour under the lighted heat lamp, record the temperatures using the same technique as in step 7. These are the heated temperatures.

    a. If you are using a red alcohol thermometer, make sure to put the lids back on the box houses as quickly as possible to maintain the internal temperature.

    b. How do the internal temperatures of the box houses compare to the external temperature? Does the rooftop garden house get as hot inside as the traditional roof house?

14. When you are done recording your temperatures, turn off the heat lamp. This is as if the sun has set for the day.

15. Then record the temperatures as the boxes cool down.

    a. After 15 minutes, record the temperatures using the same technique as in step 7. These are the first cooling temperatures.

    b. Then wait an additional 15 minutes and make a second temperature recording. These are the second cooling temperatures.

    c. How quickly do the house boxes cool? Do the rooftop garden house and the traditional roof house cool at the same rate?

16. Before drawing conclusions from their data, scientists make sure their experiments are reproducible. Repeat steps 1-11 two more times for a total of three experimental trials.

Analyzing Your Data

17. Make a line graph for each trial showing the progression of temperature from starting, to heating, to cooling for each of the shoebox houses.

    a. On the y-axis (the vertical axis), put the temperature, and on the x-axis (the horizontal axis), label the progression from starting, to heating, to cooling.

    b. You should end up with three graphs, each with three lines (one for each shoebox house and one for the external temperature) consisting of four data points (temperature readings).

    c. You can make the graphs by hand or use a website like 'Create a Graph' to make graphs on the computer and print them.

18. What do your graphs show you? Do you see a consistent pattern between repeats? Did the rooftop garden change the way the box house heated up and cooled down? If you had a rooftop garden on a building, would it help conserve energy?

Authors
Sandra Slutz, PhD
„Rooftop Gardens: Are They a Cool Idea?" Science Buddies, 12 Jan. 2020
https://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvEng_p026/environmental-engineering/rooftop-garden-cooling