

LESSON PLAN

Energy/Water Use Audit

High School



SUMMARY

The students will become more familiar with and aware of the amount of energy and water they use and develop solutions on how to conserve resources. Students will calculate energy usage measured in Kilowatt hours (kWh). With the use of a Kill-A-Watt device, the students will calculate kWh usage and costs. The students will perform an energy audit of their school and then develop proposals for making their school more energy efficient.



LESSON OBJECTIVE

Upon completing this lesson the students will identify ways to help conserve energy and water usage.



ESSENTIAL QUESTION

How could you be more environmentally responsible?



DURATION

The activity requires one to two class periods.



MATERIALS

WATER FOOTPRINT ACTIVITY

Copy of the **Water Footprint Worksheet** (for each student)

ENERGY AUDIT

- Copy of the **Energy Audit Worksheet** for Each Student
- A Pencil
- A Paper Clip
- A Small Piece of Lightweight Paper (e.g., tissue paper) about 1 inch across and 3 inches long that hangs on a paper clip (See the drawing.)

KILL-A-WATT ACTIVITY

- A Kill-A-Watt Meter for Each Group (These devices can be purchased. Contact the S.C. Energy Office for details.)
- Commonly Used Small Household Appliances (e.g., hairdryer, toaster, computer, cell phone charger)
- Power Strips
- Graph Paper
- A Calculator



COLLEGE & CAREER-READY SCIENCE STANDARDS 2021

HIGH SCHOOL EARTH AND SPACE SCIENCE

STANDARD

E-ESS3-2. Evaluate competing design solutions that address the impacts of developing, managing, and using Earth's energy and mineral resources.

DISCIPLINARY CORE IDEA (DCI)

ETS1.A: Defining and Delimiting an Engineering Problem

Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

CROSS-CUTTING CONCEPTS (CCC)

Cause and Effect

Cause-and-effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.



STANDARD

E-ESS3-3. Use computational representation to illustrate the relationships among the management of Earth’s resources, the sustainability of human populations, and biodiversity.

DISCIPLINARY CORE IDEA (DCI)

ESS3.C: Human Impacts on Earth Systems

The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. When the source of an environmental problem is understood and international agreement can be reached, human activities can be regulated to mitigate global impacts (e.g., acid rain and the ozone hole near Antarctica).

CROSS-CUTTING CONCEPTS (CCC)

Stability and Change

Feedback (negative or positive) can stabilize or destabilize a system.

STANDARD

E-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

DISCIPLINARY CORE IDEA (DCI)

ESS3.C: Human Impacts on Earth Systems

Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

ETS1.B: Developing Possible Solutions

When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. Testing should lead to improvements in the design through an iterative procedure.

CROSS-CUTTING CONCEPTS (CCC)

Stability and Change

Feedback (negative or positive) can stabilize or destabilize a system.

ENGAGE

Have the students watch these short videos – **10 Ways to Save Energy** at youtu.be/nklNsdCFrqY and **Energy Saver: Low-Cost/No-Cost Energy Saving Tips** at youtu.be/Qh9jjqYvEZ4. While students are watching, have them write down two or three ways to save energy that they feel will be the most impactful. When the videos are over, have students share their justifications. Visit energysaver.sc.gov for more energy-saving tips.

EXPLORE

Have the students explore their water consumption habits and then use the **Water Footprint Calculator** – available at www.watercalculator.org – to analyze their direct and virtual water use. Students will explore the reasons why they should care about protecting water resources, making it easier for them to shift their attitudes about their water use.

Begin by dividing the class into groups of three to four students and have each group brainstorm a list of habits they have, products they buy or foods they eat that they think may require a lot of water. After 5 minutes or so, have the groups rank the items, with one indicating the habit or product they think requires the greatest amount of water. Encourage volunteers to share with the class the habits or products they think require the most water.

Alternatively, you could have them reflect on their lists in a journal entry. Then tell students that you are going to give them an opportunity to evaluate their personal water footprint using the **Water Footprint Calculator**.

Give each student a copy of the **My Water Footprint Stats Worksheet** available at www.watercalculator.org/wp-content/uploads/2019/05/WF_MS_L1-My-WF-Stats-Student-Worksheet_2020-02-25.pdf. After students have completed their Water Footprint have them reflect on the following questions:

- **Are you surprised at how much or how little water you use compared to people in other parts of the world?** SAMPLE ANSWER: I am not surprised that people in the United States consume so much water. I am surprised by how little water people in some other parts of the world consume.
- **How do the foods you eat and the products you buy affect freshwater resources in a way you never considered before?** SAMPLE ANSWER: I guess I thought I had no responsibility for the water needed to produce the food I eat and the stuff I buy. That responsibility belongs to the farmers and the manufacturers. It never occurred to me that I can actually make a difference by cutting back or rethinking what I eat and what I buy.

- **What actions can you take to help conserve freshwater resources directly?** SAMPLE ANSWER: I love our large, green yard, but it needs a lot of water and care. I think one of the biggest steps I could take would be to do research on other options for our huge yard. Maybe we can convert it into a really beautiful xeriscape.
- **What actions can you take to help conserve freshwater resources virtually?** SAMPLE ANSWER: I'm not sure yet. Maybe I could do research to find out how much water my favorite foods require. I think eating less meat would be a good way for me to conserve freshwater resources virtually.

EXPLAIN

Explain to the students that there are other ways that we could look closely to evaluate consumption and use, just like they did with their water consumption. Explain that an audit is a type of evaluation. The water footprint was an audit of their water consumption that led to ideas on how to conserve water to save resources.

Explain to the students that now the focus will be on the use of energy through an energy audit. Even though we spend a lot of our day in school, a few of us may notice details about buildings, such as windows and thermostats. We probably also pay little attention to the small actions that each of us does – such as turning lights on and off – that affect energy use. Ask the following questions.

- **Why are small actions such as turning down the thermostat or switching off lights that are not in use important?** SAMPLE ANSWER: These actions are important not only because they contribute to our comfort, but also because of the use of energy to heat, cool and provide lighting in school buildings increases the cost of operating our schools.
- **Is an energy-efficient school more comfortable than one that is not energy-efficient? Why?** SAMPLE ANSWER: An energy-efficient school is more comfortable than one that is not energy-efficient, and it needs less oil, natural gas, coal, or electricity for heating or cooling. A building that is badly designed or poorly maintained is expensive to operate because it is trying to heat or air-condition the outdoors as well as the indoors.



SOURCE

This lesson incorporates a water footprint activity from © 2017-2020 GRACE Communications Foundation. All Rights Reserved.

Explain to the students that they will be completing an energy audit of their classroom and/or school. State that the purpose of completing the audit is to evaluate the energy use of the school or classroom and look for ways to conserve energy. Share that by conducting this exercise, they can uncover ways that energy consumption could be reduced, which means saving money and making you more comfortable. Have the students work in partners to complete the **Energy Audit Worksheet** (provided).



ELABORATE

KILL-A-WATT ACTIVITY

The students will become more familiar and aware of the amount of energy they are using. With the use of a Kill-A-Watt device, students will calculate Kilowatt hours and costs. After determining the energy cost of each appliance, they will find ways to save money on the monthly bills by unplugging appliances or even considering investing in “smart appliances.”

Have students view this introductory video on using the Kill-A-Watt Meter at youtu.be/7K2uBZKLOEg.

Discuss with your students the following questions and review the definition of a Watt and Kilowatt hour.

QUESTIONS

- **Is it important to conserve energy? Why or why not?**
- **Can conserving energy put more money in your pocket? If so, estimate how much money you could save.**
- **How can we quantify how much energy we are using?** We can use an energy usage monitor like Kill-A-Watt.

REVIEW

Watt (W) – Watts are used to measure power at a particular time. This number will vary over time and may go up or down throughout the day.

Kilowatt Hour (KWH) – Kilowatt hours are used to measure total energy usage. Since $\text{Energy} = \text{Power} \times \text{Time}$, if a meter shows a constant power of 3 kilowatt hours (3,000 watts) over 2 hours, 6 kilowatts have been used.

Energy companies sell us units of energy – kilowatt hours (KWH). One KWH costs between 15 and 50 cents (depending on your total monthly usage). The more you use, the more it costs per KWH.

TASK

In groups, make a list of electronics you’d like to measure. Consider monitoring an appliance that is on, off, in power save mode and unplugged. Consider checking and cell phone or laptop charger when it isn’t charging anything. Maybe monitor large appliances that you use frequently or consume large amounts of energy. Compare old appliances to new ones, incandescent to LED bulbs or standard to Energy Star appliances. Make a table like the one below and monitor power and energy usage over time. Then estimate how much these items would use over an hour and an entire month.

DEVICE	POWER	TIME	ENERGY	HOURLY COST	MONTHLY COST

KILL-A-WATT ACTIVITY INSTRUCTIONS

Either working alone, in small groups or as a whole group, take the following steps.

1. Gather common electrical devices (at least one per group).
2. Predict which appliances use the most energy. Be sure to ask the students to justify their answers – e.g., **What makes you think the hairdryer will use the most energy? Can you explain why you think that?**
3. Plug in the different appliances to the Kill-A-Watt meter and observe the amount of energy used for several seconds. Record the findings.
4. Lead a discussion of results, asking, for instance, why some appliances used more energy than others. Generally, any appliance producing heat will require more power. The students may notice as they compare



results that there is a significant increase in power used for appliances that produce heat. Additionally, some participants may be surprised at some of the results. For instance, many chargers will draw power even when the device (e.g., cell phone, laptop, tablet) is off, and even when the electrical device is not connected to the charger. Students will be surprised to find out that when devices they use are turned off, there is still a power demand. These students also may be led to understand that almost all devices have a fairly constant power demand. For example, a toaster will change between two values – minimum and maximum.

5. When the investigation is completed, have the students write a reflection on the following questions:
 - **What are the costs associated with your personal energy consumption habits?**
 - **How could you be more environmentally responsible by reducing the use of just a couple of electric devices?**

Discuss any changes in lifestyle that the students would consider taking based on the results.



EVALUATE

Have the students design solutions to address the needs identified in the energy/water consumption audit lesson by reflecting on these questions. The students will submit these questions as their evaluation for the lesson. For each question, allow for reasonable answers.

1. **How can recycling and reducing waste be encouraged with respect to your location?**
2. **What steps might be taken to improve energy efficiency in your location?**
3. **What changes would you implement to make heating and cooling more energy efficient?**
4. **How will these changes improve the entire building's overall energy efficiency? How might they translate into cost savings?**



DID YOU KNOW?

Energy efficient light bulbs certified by ENERGY STAR use **70 to 90 percent less energy** than incandescent bulbs to do the same job – light up a room.



E-LEARNING ACTIVITY

For more tools to measure the impact energy usage has on the environment, visit the U.S. Environmental Protection Agency's website at www.epa.gov/energy/measure-impact-your-energy-use-environment.

For additional **Water Footprint** activities to use during EXPLORE, visit the following websites.

- www.watercalculator.org/resource/teaching-conservation-with-water-footprint-calculator/
- www.watercalculator.org/resource/water-footprint-lessons/
- www.watercalculator.org/wp-content/uploads/2019/05/WF_MS_L3-My-Saving-Water-Game-Plan.pdf
- www.watercalculator.org/wp-content/uploads/2019/05/WF_HS_L2-Lesson-Plan.pdf

For additional **Kill-A-Watt** activities to use during ELABORATE, visit www.teachengineering.org/activities/view/cla_activity1_household_watt_meter.

For additional **Energy Audit** activities to use during EXPLAIN, see the following websites.

- www.teachengineering.org/activities/view/cla_activity2_household_audit
- www.energy.gov/sites/prod/files/2014/07/f17/acts_durow_homeefficiency_315.pdf

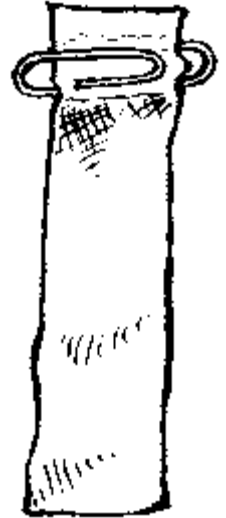
For more **School Energy Audit** activities to use during EXPLAIN, visit www.energystar.gov/sites/default/files/tools/K12EnergyEfficiencyStudentToolkit.pdf.



ENERGY AUDIT

ABOUT THIS LESSON

This audit will encourage you to examine your classroom and identify ways in which you can help conserve energy. It will require about 20 to 45 minutes to complete. You will need this **worksheet**, a **pencil**, a **paper clip** and a **small piece of lightweight paper** (such as tissue paper) about 1 inch across and 3 inches long that hangs on a paper clip. See the drawing on the right.



INTRODUCTION

We spend much of our day in school. But few of us notice details about buildings, such as windows and thermostats. We also pay little attention to the small actions that each of us does—such as turning lights on and off – that affect energy use. These actions are important not only because they contribute to our comfort, but also because the use of energy to heat, cool and provide lighting in school buildings increases the cost of operating our schools. An energy-efficient school is more comfortable than one that is not energy-efficient, and it needs less oil, natural gas, coal or electricity for heating or cooling. A building that is badly designed or poorly maintained is expensive to operate because it is trying to heat or air-condition the outdoors as well as the indoors. The following activity will teach you to conduct a simple energy audit. By conducting this exercise, you will point out areas that could be improved and save energy, which means saving money and making you more comfortable. You will learn about things that you and your classmates can do to save energy. You will conduct an audit inside your classroom.

BEGIN THE AUDIT

1. **Where is the thermostat located?** _____

- It should be located on inside walls, away from a bright light source (such as sunlight) or a heating or air conditioning vent.
- Is it? YES NO

2. **What setting is the thermostat reading?** _____

- It should be set at 68 degrees Fahrenheit in winter or 78 degrees Fahrenheit in summer.
- Is it? YES NO

3. **Do you have windows in your classroom?**

YES NO

Answer these questions, if you have windows.

- **Does your classroom have window coverings that block out intense sunlight during hot days?**
 YES NO

Take the small piece of paper and paper clip you made. This is a “draft detector.” Walk up to the window and hold the piece of paper at four different spots along the edges where the window meets the wall. Hold it still for about 30 seconds in each spot. Be sure to get really close to the window, if you can do it safely, and make sure that the heating vents aren’t blowing the paper.

- **Does the paper move?** YES NO

- **Can you feel warm or cold air coming in through the window?** YES NO

If you can feel air move, the windows are not energy-efficient.

- **Are your windows energy-efficient?**
 YES NO

4. Now take your draft detector to your classroom door. If you have a door to a hallway and a door to the outside, do this activity with both doors. Place the detector along the sides of the inside of the door, where it meets the walls, and along the floor.

- **Do you detect any air moving through the cracks between the door and the wall or the floor?**
 YES NO

If you can feel any air moving, your door is not energy-efficient.

- **Is your door energy-efficient?** YES NO

Place the detector along the sides of the outside of the door, where it meets the walls, and along the floor.

- **Do you detect any air moving through the cracks between the door and the wall or the floor?**
 YES NO

If you can feel any air moving, your door is not energy-efficient.

- **Is your door energy-efficient?** YES NO

5. **Does your classroom have a floor covering such as carpet?** YES NO
6. **How high is your ceiling?**
 - Use caution when trying to determine the height.
 - **Is it 8 feet or less?** YES NO
7. If you can safely open the air conditioning or heating unit in the classroom, look at the filters. Check to see if they are clean, a little dusty or dirty.
 - **Are they clean?** YES NO
8. **Are the light bulbs used in your classroom energy-saving bulbs?** YES NO
 - You may need to ask your facilities manager this question.
9. **Are all the desks and chairs away from heating or cooling vents?** YES NO
10. Now we will look at some of your personal activities in your classroom that affect energy use.
 - **Do you wear clothing that is appropriate for the season, such as sweaters in the winter and lightweight clothes in the summer?** YES NO
 - **Do you turn off the lights if you are the last one out of the room?** YES NO
 - **Do you avoid putting your textbooks, notebooks, etc. on top of heating or cooling vents?** YES NO

THE RESULTS

If you answered YES to most of these questions, your classroom is doing well. But if you said NO to three or more, you need to work with your teacher, facilities manager or other adult to improve these areas. Here's why your answers matter.

1. If your thermostat is located too close to a strong light or heat source, it will not properly measure the room temperature meaning that energy will be wasted because the heater or air conditioner runs more than it should. It also could mean that you are uncomfortable in your classroom. If the thermostat is near a source of heat or air-conditioning, it will turn off well before the entire room is heated or cooled.
2. If your thermostat is set too high in winter or too low in summer, you are wasting energy. Ask the person responsible for energy management in your school to check your thermostats and make sure that they are working properly.
3. If your windows do not have the ability to block out intense sun, your air-conditioning costs are too high, or your comfort level is lowered because the room cannot cool down. If you see or feel air moving through the edge of the window, this means you are losing energy from your classroom, and the windows need to be caulked, sealed, or covered by a storm window system.
4. Your draft detector has helped you to determine whether your door is energy-efficient.
5. Carpeting helps keep rooms more comfortable and conserves heat.
6. Ceilings higher than 8 feet waste energy, because warm air moves to the top of the room instead of remaining near the floor where we are.
7. Clean filters conserve energy by allowing the unit to run efficiently. Dirty filters waste energy.
8. Energy-saving bulbs are more expensive to buy but save lots of money on electricity in the long term.
9. If furniture blocks heating or cooling vents, the furnace or air conditioner will insufficiently heat or cool the room.
10. When you wear clothes that are appropriate for the weather, you require less energy to keep warm or cool. Keeping lights on when you do not need them wastes energy. Again, if objects block heating or cooling vents, the furnace or air conditioner will insufficiently heat or cool the room.