

Energy Efficiency in the Home

Grades: 5-8

Topic: Energy Efficiency and Conservation

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Owner: National Renewable Energy Laboratory

Title: **Energy Efficiency in the Home**

Author:

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Grade Level / Subject:

7th – 8th grade / Physical Science

Curriculum Standard (from *Benchmarks for Science Literacy* by project 2061)

- What people expect to observe often affects what they actually do observe. Strong beliefs about what should happen in particular circumstances can prevent them from detecting other results. Scientists know about this danger to objectivity and take steps to try and avoid it when designing investigations and examining data. One safeguard is to have different investigators conduct independent studies of the same questions. (1A 6-8 #3)
- Accurate record keeping, openness, and replication are essential for maintaining an investigators credibility with other scientists and society. (1C 6-8 #7)
- Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems. But they usually have to take human values and limitations into account as well. (3A 6-8 #3)
- Design usually requires taking constraints into account. Some constraints, such as gravity or the materials to be used, are unavoidable. Other constraints, including economic, political, social, ethical and aesthetic ones, limit choices. (3B 6-8 #1)
- All technologies have effects other than those intended by the design, some of which may have been predictable and some not. In either case, these side effects may turn out to be unacceptable to some of the population and therefore lead to conflict between groups. (3B 6-8 #2)
- The human ability to shape the future comes from a capacity for generating knowledge and developing new technologies—and for communicating ideas to others. (3C 6-8 #1)
- Different ways of obtaining, transforming, and distributing energy have different environmental consequences. (8C 6-8 #2)

Overview:

In this module, students will learn the economic impacts of proper energy management and the benefits of energy efficient technologies. Students will perform a simplified energy audit of the school under the supervision of their instructor, then complete an energy audit of their home individually using provided data as well as data obtained through their own investigation. Students will then be divided into small groups to compile reports of their findings.

Exercises using the watt meter on day two of the module allows students to understand that electricity consumption can vary widely from appliance to appliance, and even within one appliance itself depending on use. Accompanying this part of the module would be a discussion regarding the appliance information labels that are supplied by the manufacturer. These labels are often good for providing basic information about appliances, including maximum amperage and voltage, but generally do not tell the whole story.

One goal of this module is that students will be able to discover, on their own, ways to conserve energy in their homes.

Purpose:

The purpose of this lesson is to develop student understanding of the economic and environmental impact of energy use and energy management in a society where energy costs are rising as fossil fuels become increasingly scarce. Through personal investigation, students will learn how they can become more energy savvy.

Learning Objectives:

After completing this lesson, students will be able to:

- Understand that collectively, our daily routines can have a significant environmental and economic impact.
- Identify several ways to reduce energy consumption in the home.
- Analyze a set of data for possible energy wasting activities and use that information to design a solution that results in higher energy efficiency.
- Present their solution to a problem in an organized and efficient manner.

Vocabulary:

Energy	Kilowatt hour	Efficiency	Wattage
Energy end user	Energy provider	Voltage	Amperage

Resources and Materials:

Standard Appliance Energy Consumption Chart
Energy Efficient Appliance Consumption Chart
Energy Audit Worksheet
Calculating Energy Saving Worksheet
Individual Grade Report
Group Grade Report
Watts-Up Meter¹
Variety of Electric Household Appliances and Electrical Devices to be Used with a Watts-Up Meter

Preparatory Activities & Prerequisite Knowledge:

Basic algebra skills are required to perform some calculations, though simple addition composes the majority of the exercises.

Students should have completed a unit on energy and energy sources in which they have gained a general understanding of where electricity comes from and how electricity helps us to do work.

Student understanding of renewable energy technologies is suggested

Students should be already familiar with:

Electricity	Fossil Fuels	Renewable Energy
Electric Current	Wattage	General Algebraic functions

¹ Watts-Up meters are available from Electronic Educational Devices, Inc. 3003 Arapahoe Street, Suite 209, Denver CO 80205.
Phone: 303.297.1886

Main Activities (2 days in block schedule with 90 minute periods):

Day 1

Introduction (15 min.)

Discuss electricity consumption in the United States in comparison to other parts of the world. Give statistics if possible. Explain the environmental and economic impacts of high levels of electricity consumption.

Introduce Energy Audit Assignment (15 min.)

Discuss the capability to reduce energy consumption through energy efficient technologies and practices.

Review **Standard Appliance Energy Consumption** (Data Sheet 1) and **Energy Efficient Appliance** (data sheet 2) data sheets for use in energy audit

Explain to students that the techniques and data used in this exercise are simplified for student use. Professional energy audits are very precise and more complex.

Explain rules for calculating energy usage in the school. Discuss proper behavior while auditing the school. (Other teachers may not appreciate loud students in the hallways)

Guided Energy Audit of the School (30 min.)

Accompany students throughout the school as they record type and number of light-fixtures and appliances. Refer to the **Standard Appliance Energy Consumption** data sheet for appliances that can be used in this exercise.

Draw attention to the appliance information tags that can be found either on the back or bottom of most appliances. These tags generally contain voltage and amperage as well as additional information supplied by the manufacturer.

Use any available opportunity to point out energy efficient or wasteful practices.

Compile Energy Audit of the School (20 min.)

Instruct and lead students in calculating energy consumption and energy savings for the school using data sheet 2.

Discuss results.

Introduce Home Energy Audit Homework (10min.)

Explain that the same principles apply to the home energy audit as the school energy audit, but likely more energy efficient technologies are available for home appliances than in the school.

Give students worksheets for home energy audit and assign the audit as homework.

Review **Calculating Energy Savings** worksheet.

Remind students to take note of the appliance information tags that are easily accessible to them as they perform their energy audit.

NOTE: Be sure to remind students to be extremely careful when handling electrical appliances. Disconnect appliances from power source if possible.

Suggest that students try to discover ways to conserve electricity at home.

Familiarize students with the grading rubric.

Day 2

Review Previous Day's Work and Introduce Today's Work (5 min.)

Restate the purpose of an energy audit and review the results from the energy audit of the school that was completed as a class.

Watt Meter Activity (15 min)

Divide students into small groups for the watt meter activity.

Demonstrate how to use a watt meter to measure power consumption.

Give a watt meter to each group of students and have them measure the power consumption of a variety of appliances that have been supplied by the instructor.

Ask students to interpret the appliance information tags that they encountered during the process of performing an energy audit, as well as on the appliance that they have just metered in the class.

Discuss as a class the information obtained in this exercise. Correlate the information gathered from appliance tags and the watt meter with the information supplied on the data sheets and gathered from the energy audits.

Report Write-up Introduction (5 min)

Introduce the topics that need to be covered in a report/write-up of the activities, including: Introduction, data sheets (1 & 2 for all students in group), discussion of the energy audits and information gathered from the watt metering exercise, discussion of energy efficiency as well as energy conservation practices discovered by students, and a conclusion.

Remind students of the grading rubric that will be used in this activity.

Divide students into groups for the final report.

Student Work Time (15 min.)

Students should begin compiling data into an organized format.

Progress Check (1 - 5 min.)

Instructor stops class to check progress on final report and re-direct class if need be. Remind students that all individuals need to participate in group work.

Student Work Time (15 min.)

Students should begin writing any text that will be part of the final report.

Progress Check (1 - 5 min.)

Instructor reminds students to refer to the grading rubric to be sure to include all parts necessary for a successful report. Suggest that students begin to start finalizing the report.

Student Work Time (10 min.)

Students should be developing a final product at this time.

Wrap-up and Review (20 min.)

Discussion of results and the benefits of energy audits.

Review the process students went through to develop a report.

Students hand in final report.

Group Work Rubric:

Criteria	Non-Proficient 1 – 2 points	Proficient 3-4 points	Advanced 5 points
A. Group Contribution	All members are present for participation	Members cooperated to create finished product	Each members contribution is evident in the final product
B. Organization	Final report is poorly organized and difficult to read	Final report can be understood but organization leaves something to be desired	Final report is well organized and easily understood
C. Project Completeness	Final report lacks significant portions of discussion or information	Final report is mostly complete, but lacks a some portions of information	Final report is complete in its entirety with all important information present
D. Data	Insufficient data has been obtained to draw conclusions or data is inconsistent	Data is consistent and substantial enough to draw conclusions	Data provides overwhelming evidence to support conclusions

Individual Work Rubric:

Criteria	Non-Proficient 1 –2 Points	Proficient 3-4 Points	Advanced 5 Points
A. Knowledge	Student demonstrates little or no knowledge gain after completing this activity	Student has learned the knowledge outlined in this activity	Student has developed pertinent knowledge outside the scope of this activity
B. Individual Project Data	Students data lacks more than 4 pieces of significant data	Students data is mostly complete, may be missing small numbers of significant data	Student has gathered all significant data.
C. Individual Project Organization	Data is not organized and/or is difficult to discern	Data is clear, organized and easily understood	Data is clear, organized and accompanied by tables or graphs
Criteria	Poor 1-5 Points	Average 6-10 Points	Excellent 11-15 Points
A. General Student Performance	Student shows little desire to complete the project or contribute to the activity	Student completes the project “only to get it done”	Student shows desire to learn from the activity and completes assignments

Standard Appliance Energy Consumption				
Appliance	Average Wattage	Monthly Hours of Use	Monthly kWh	Approximate Cost per month (\$0.10/kWh)
Kitchen				
Barbecue Grill	1350	5-10	7-14	\$.70-\$1.40
Broiler	1400	4-12	5-17	\$.50-\$1.70
Coffee Maker	900	4-30	4-27	\$.40-\$2.70
Dishwasher (Electric Hot Water)	1300	8-40	20-102	\$2.00-\$10.20
Dishwasher (Non-electric Hot Water)	1300	8-40	3-16	\$.30-\$1.60
Food Blender	390	3-5	1-2	\$.10-\$.20
Food Freezer (15 Cubic Feet)	335	180-420	60-140	\$6.00-\$14.00
Hot Plate	1320	2-6	3-8	\$.30-\$.80
Kettle	1500	1-10	1-15	\$.10-\$1.50
Microwave Oven	1000	5-30	5-30	\$.50-\$3.00
Range	12500	10-50	125-625	\$12.50-\$62.50
Range (Self-Cleaning Cycle Only)	3200	.5-1.5	2-5	\$.20-\$.50
Refrigerator-Freezer (Frost Free) 17 Cu. Ft.	500	150-300	75-150	\$7.50-\$15.00

Refrigerator-Freezer (Non Frost Free) 13 FT2	300	190-300	56-90	\$5.60-\$9.00
Toaster	1150	1-3.5	1-4	\$.10-.40
Toaster Oven	1250	2-24	2.5-30	\$.25-\$3.00
Waffle Iron	1100	1-2	1-2	\$.10-\$.20
Lighting				
Heat Lamp (Infrared)	250	2-4	.5-1	\$.05-\$.10
60 Watt Incandescent	60	17-200	1-12	\$.10-\$1.20
Compact Fluorescent 60 Watt Equiv.	18	17-200	.3-3.6	\$.03-\$.36
Ceiling Fixture – 3x60 Watt Bulbs	180	6-195	2-35	\$.20-\$3.50
Chandelier – 5 lamp	300	10-183	3-55	\$.30-\$5.50
Tri-Light (Table Lamp)	100	10-200	1-20	\$.10-\$2.00
Fluorescent – 2 Tubes x 4 Feet.	100	10-200	1-20	\$.10-\$2.00
Bedroom and Bathroom				
Electric Blanket	180	30-90	5-16	\$.50-\$1.60
Hair Dryer	1000	1-10	1-10	\$.10-\$1.00
Heating Pad	65	15-30	1-2	\$.10-\$.20
Water Bed Heater	400	150-300	20-120	\$2.00-\$12.00

Laundry Room				
Dryer	5000	6-28	30-140	\$3.00-\$14.00
Washer (Electric Hot Water)	500	7-40	33-196	\$3.30-\$19.60
Washer (Non-electric Hot Water)	500	7-40	3-16	\$.30-\$1.60
Iron	1000	1-10	1-10	\$.10-\$1.00
Home Entertainment				
Computer, Monitor & Printer	200	25-160	5-32	\$.50-\$3.20
Stereo	30	1-170	.03-5.1	\$0-\$5.1
Television	80	60-440	5-35	\$.5-\$3.5
VCR	40	50-200	1-8	\$.10-\$8
Heating and Cooling				
Air Cleaner (Room & Furnace)	40	250-720	10-29	\$1.00-\$2.90
Air Conditioner (Room) 6000 BTU	750	120-720	90-540	\$9.00-\$54.00
Air Conditioner (Room) 9000 BTU	1050	120-720	126-756	\$12.60- \$75.60
Air Conditioner (Central) 2.5 Tons	3500	240-860	850-3000	\$85.00-\$300
Dehumidifier	350	120-720	42-252	\$4.20-\$25.20
Electric Heater (Portable)	1000	30-90	30-90	\$3.00-\$9.00
Fan (Portable)	115	18-52	2-6	\$.20-\$60
Furnace Fan Motor (Intermittent)	350	160-415	56-145	\$5.60-\$14.50

Furnace Fan Motor (Continuous)	350	720	252	\$25.20
Heat Exchange / HRV's	125	300-720	37-150	\$3.70-\$15.00
Humidifier (Portable)	100	80-540	8-54	\$.80-\$5.40
Oil Furnace (Burner)	260	96-288	25-75	\$2.50-\$7.50
Water Heating				
Water Heater – Typical Family of 4	3800	98-138	375-525	\$37.50-\$52.50
Outdoor – Miscellaneous				
Block Heater	500	120-480	60-240	\$6.00-\$24.00
Swimming Pool Filter Motor – ½ HP	900	720	648	\$64.80
Swimming Pool Filter Motor – ¾ HP	1200	720	864	\$86.40
Swimming Pool Filter Motor – 1 HP	1500	720	1080	\$108.00
Indoor – Miscellaneous				
Answering Machine	95	360	34	\$3.40
Aquarium w/ Heater, Light & Filter	165	30	5	\$.50
Ceiling Fan	60	15-330	1-20	\$.10-\$2.00
Clock	5	720	4	\$.40
Vacuum Cleaner (Portable)	800	2-6	2-5	\$.20-\$.50
Vacuum Cleaner (Central)	1600	2-6	4-10	\$.40-\$1.00

Making Your Home More Energy Efficient and Saving You Money

The chart below shows the energy usage of high efficiency appliances that use approximately 15% less electricity than standard models. Using this information, determine how much money could be saved by using high-efficiency appliances in your home rather than standard models.

Energy Efficient Appliance Energy Consumption			
Appliance Type	Standard Appliance Wattage	High-efficiency Appliance Wattage	Difference in Wattage
Barbecue Grill	1350	1150	200
Dishwasher	1300	1105	195
Food Freezer (15 Cubic Feet)	335	285	50
Range	12500	10625	1875
Refrigerator/Freezer (Frost Free)	500	425	75
*Compact Fluorescent Bulb	60	15	45
Water Bed Heater	400	340	60
Washer	500	425	75
Television	80	70	10
Air Conditioner (Room) 6000 BTU	750	640	110
Air Conditioner (Room) 9000 BTU	1050	890	160
Air Conditioner (Central)	3500	2975	525
Electric Heater (Portable)	115	100	15
Furnace Fan Motor (Continuous)	350	300	50
Swimming Pool Filter Motor $\frac{3}{4}$ HP	1200	1020	180
Swimming Pool Filter Motor 1 HP	1500	1275	225
Ceiling Fan	60	50	10
Water Heater	3800	3230	570
**Computer, Monitor, Printer	200	170	30

* Compact fluorescent light bulbs replace standard incandescent bulbs.

** Energy savings on Computers, monitors and printers are generally obtained through power-saving features such as automatic shut-off and standby if used properly.

Energy Audit Worksheet

Student Name:							
Energy Audit Location							
Appliance	# of Units	Wattage		Estimated use per month in hours		Wh / month Total	
1.		X		X		=	
2.		X		X		=	
3.		X		X		=	
4.		X		X		=	
5.		X		X		=	
6.		X		X		=	
7.		X		X		=	
8.		X		X		=	
9.		X		X		=	
10.		X		X		=	
11.		X		X		=	
12.		X		X		=	
13.		X		X		=	
14.		X		X		=	
15.		X		X		=	
16.		X		X		=	
17.		X		X		=	
18.		X		X		=	
19.		X		X		=	
20.		X		X		=	
21.		X		X		=	
22.		X		X		=	
23.		X		X		=	
24.		X		X		=	
25.		X		X		=	
26.		X		X		=	
27.		X		X		=	
28.		X		X		=	
29.		X		X		=	
30.		X		X		=	
Total kWh/month	X	Price per kWh		=		Total Cost/month	

In order to convert from watt-hours per month (Wh/month) to kilowatt-hours per month (kWh/month), divide Wh/month by 1000.

Calculating Energy Savings

Student Name:							
Energy Audit Location							
Appliance to be Replaced by High-efficiency Appliance	# of Units	Difference in Wattage Between Standard and High-efficiency Appliance		Estimated use per month in hours		Wh/month difference	
1. <i>Ex. Appliance</i>	2	X	75	X	20	=	3
2.		X		X		=	
3.		X		X		=	
4.		X		X		=	
5.		X		X		=	
6.		X		X		=	
7.		X		X		=	
8.		X		X		=	
9.		X		X		=	
10.		X		X		=	
11.		X		X		=	
12.		X		X		=	
13.		X		X		=	
14.		X		X		=	
15.		X		X		=	
16.		X		X		=	
17.		X		X		=	
18.		X		X		=	
19.		X		X		=	
Calculation Energy Savings							
Total kWh/Month Difference	X	Multiplied by \$ per kWh			=	Total \$ Energy Savings Per Month	

Calculating Energy Savings:

To calculate the # of kWh used per month, use the following formulas:

$$\boxed{\text{kWh/month}} = \boxed{\text{\# of units}} \times \boxed{\text{Wattage}} \times \boxed{\text{Hours used per month}} \div \boxed{1000}$$

$$\boxed{\text{Total Energy Savings Per month}} = \boxed{\text{Total kWh/Month}} \times \boxed{\text{Price per kWh}}$$

Grade Reports

Student Name:		
Grading Criteria	Comments	Score
A. Knowledge Non-Proficient : 1- 2 points Proficient : 3 - 4 points Advanced : 5 points		
Individual Project Data Non-Proficient : 1- 2 points Proficient : 3 - 4 points Advanced : 5 points		
Individual Project Organization Non-Proficient : 1- 2 points Proficient : 3 - 4 points Advanced : 5 points		
General Student Performance Poor : 1- 5 points Average 6-10 points Excellent 11-15 points		
Group Work Grade		
Total Score for Energy Audit Project		

Names of Students in Group		
Grading Criteria	Comments	Score
Group Contribution Non-Proficient : 1- 2 points Proficient : 3 - 4 points Advanced : 5 points		
Organization Non-Proficient : 1- 2 points Proficient : 3 - 4 points Advanced : 5 points		
Project Completeness Non-Proficient : 1- 2 points Proficient : 3 - 4 points Advanced : 5 points		
Data Non-Proficient : 1- 2 points Proficient : 3 - 4 points Advanced : 5 points		
Group Work Grade		

Calculating Energy Savings

Student Name:		Stuart Dent					
Energy Audit Location		Stuart Dent					
Appliance to be Replaced by High-efficiency Appliance	# of Units	Difference in Wattage Between Standard and High-efficiency Appliance		Estimated use per month in hours		kWh/month difference	
1. <i>Ex. Appliance</i>	2	X	75	X	20	=	3
2. Dishwasher	1	X	195	X	8	=	2
3. Refrigerator	2	X	75	X	300 each	=	45
4. Incandescent	22	X	45	X	180 each	=	178
5. Waterbed Heater	1	X	60	X	150	=	9
6. Washer	1	X	75	X	40	=	3
7. Computer, etc.	2	X	30	X	50	=	3
8. Television	2	X	10	X	60 each	=	1
9. Air Conditioner	1	X	525	X	240	=	126
10. Water Heater	1	X	60	X	138	=	8
11. Pool Filter	1	X	180	X	720	=	129
12.		X		X		=	
13.		X		X		=	
14.		X		X		=	
15.		X		X		=	
Calculation Energy Savings							
Total kWh/Month Difference	X	Multiplied by \$ per kWh		=	Total \$ Energy Savings Per Month		
507		\$.10			\$50.70		

Calculating Energy Savings:

To calculate the # of kWh used per month, use the following formulas:

$$\boxed{\text{kWh/month}} = \boxed{\text{\# of units}} \times \boxed{\text{Wattage}} \times \boxed{\text{Hours used per month}} \div \boxed{1000}$$

$$\boxed{\text{Total Energy Savings Per month}} = \boxed{\text{Total kWh/Month}} \times \boxed{\text{Price per kWh}}$$

Energy Audit Worksheet

Student Name:		Stuart Dent					
Energy Audit Location		My house					
Appliance	# of Units	Wattage		Estimated use per month in hours		kWh / month Total	
1. Dishwasher	1	X	1300	X	8	=	20
2. Food Blender	1	X	390	X	3	=	1
3. Microwave Oven	1	X	1000	X	10	=	10
4. Range	1	X	1250 0	X	50	=	625
5. Refrigerator (Frost Free) 17 ft3	2	X	500	X	300 each	=	300
6. Toaster	1	X	1150	X	1	=	1
7. 60 Watt Incandescent	22	X	60	X	180 each	=	216
8. Fluorescent – 2 tubes x 4ft	3	X	100	X	100each	=	30
9. Water Bed Heater	1	X	400	X	150	=	20
10. Dryer	1	X	5000	X	28	=	140
11. Washer (Non-Electric hot water)	1	X	500	X	40	=	16
12. Computer, Monitor, Printer	2	X	200	X	50 each	=	20
13. Stereo	3	X	30	X	25 each	=	2. 25
14. Television	2	X	80	X	60 each	=	10
15. VCR	1	X	40	X	25	=	1
16. Air Conditioner (Central)	1	X	3500	X	240	=	850
17. Water Heater	1	X	3800	X	138	=	525
18. Swimming Pool Filter, motor	1	X	1200	X	720	=	864
19. Answering Machine	1	X	95	X	360	=	34
20. Ceiling Fan	2	X	60	X	15 each	=	2
21. Clock	4	X	5	X	720	=	16
22. Vacuum Cleaner (Portable)	1	X	800	X	6	=	5
23.		X		X		=	
24.		X		X		=	
25.		X		X		=	
Total kWh/month	X	Price per kWh		=	Total Cost/month		
3708		\$.10			\$307.80		

Home Energy Audit Report

By Stu Dent

John Doe

Sally Student

Adam Academic

Introduction:

This activity was designed to teach the benefits of using energy efficient practices and employing energy efficient technologies. As an introduction to energy audits, Mr. Wilcox accompanied the class on an energy audit of our school.

In class we studied how appliances use energy by metering appliances with a watt meter. We also compared this information with information that was listed on the appliance on tags located on their back or bottom. This information helped to give us a better understanding of how electricity is really used in our houses.

We then perform energy audits on our own homes. Following these energy audits we compiled our information and concluded that a lot of money could be saved in our homes if we used energy efficient technologies.

Data:

The savings created by using energy efficient technologies are outlined in the table below.

Student Name	Energy costs before energy efficient technologies	Total \$ energy savings using energy efficient technology
Stu Dent	\$370.88	\$ 50.00
John Doe	\$420.32	\$ 75.00
Sally Student	\$257.45	\$ 25.00
Adam Academic	\$353.20	\$ 45.00
Total Energy Savings		\$195.00

The detailed Energy Audit Worksheet and Calculating energy savings worksheet will be attached to the end of this report.

Conclusion:

Through the energy audits and the use of a watt meter to look at how appliances use energy we learned a lot. The information labels that are listed on appliances don't necessarily represent the actual amount of electricity that the appliances are using all the time. They just provide information about the maximum power usage that the appliances use. This is something that you might want to consider when doing an energy audit or trying to conserve electricity.

Aside from this, the energy audits allowed us to see ways that we could save electricity and money. We came to the conclusion that energy efficient technologies would be a good idea for any family home. Combined, our families might be able to save up to \$2,340 per year. That is a large amount of money that could be put back into the economy.

Example