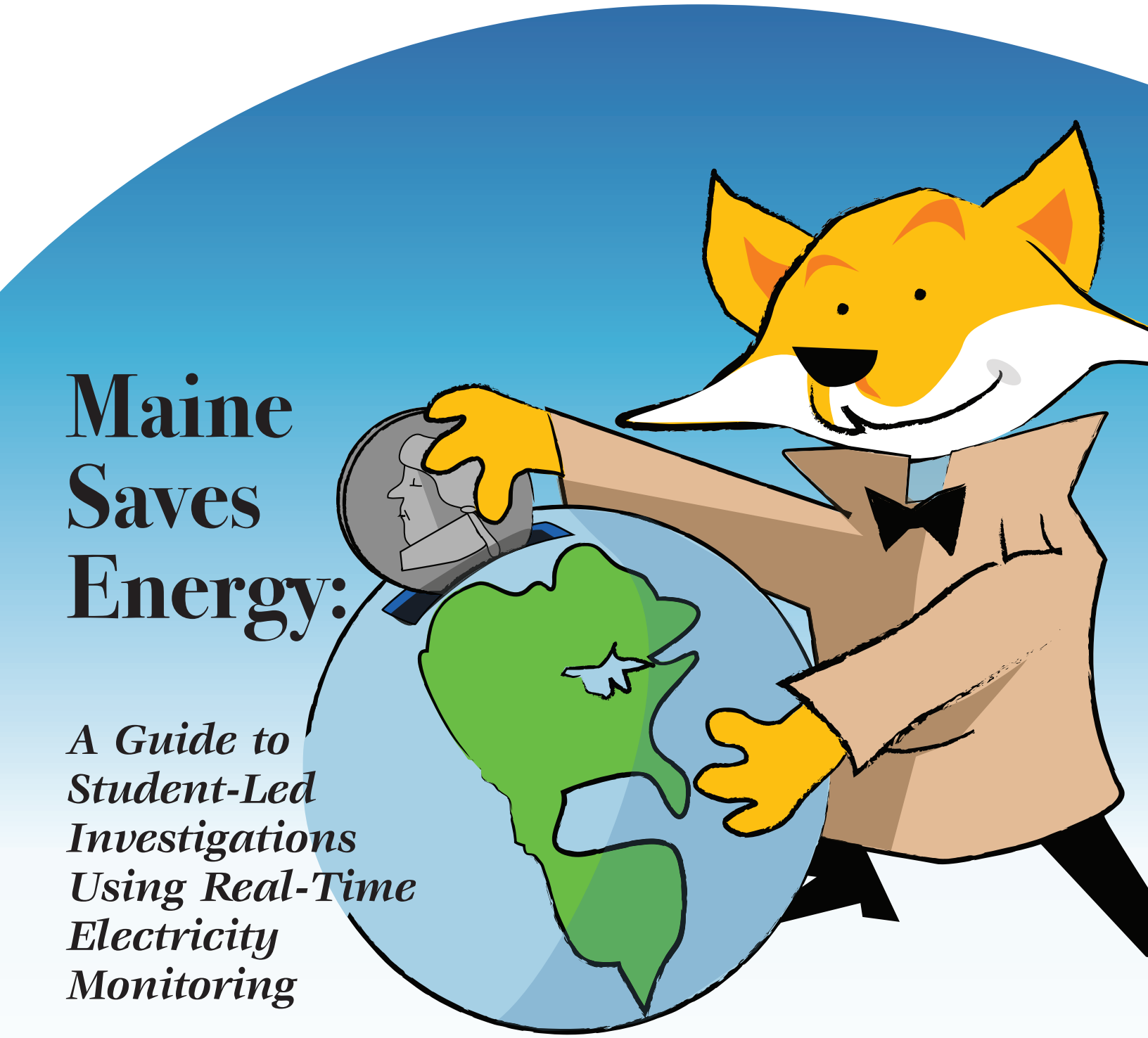
PowerSleuth

Maine Saves Energy:

A Guide to Student-Led Investigations Using Real-Time Electricity Monitoring



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Maine Saves Energy:
A Guide to Student-Led Investigations Using Real-Time Electricity Monitoring

Contents

Maine Saves Energy

About this Guide

The *Maine Saves Energy: A Guide to Student-Led Investigations Using Real-Time Electricity Monitoring* was developed to assist teachers in carrying out student-led investigations of residential electricity use utilizing existing and emerging technologies. Designed to help students learn how to use the many different types of electricity data available to homeowners, including that from new tools that provide real-time electricity information, the activities outlined in this guide will help students better understand patterns of use and pinpoint areas to conserve. Working as scientists, students collect, analyze and share data gathered from home energy monitors and/or from "smart" utility meters, instruments that provide real-time information about electricity use. Using data from these and other tools such as Kill A Watt meters, students design and carry out investigations and use their findings to make recommendations, based on evidence, for reducing consumption to homeowners and community members.

Maine Saves Energy: A Guide to Student-Led Investigations Using Real-Time Electricity Monitoring is designed to supplement and enrich the lessons in the existing *PowerSleuth* units, specifically the *Maine Saves Energy* unit. Lessons on forms of energy, transfer and transformation of energy, generation of electrical power, measurement of energy use with Kill A Watt meters and examination of the electrical energy consumption of Maine's residences are part of the *Maine Saves Energy* unit. Although it is preferable to use the activities in this guide in conjunction with the *Maine Saves Energy* unit, the structure of the guide enables teachers to carry out these investigations and its related activities independently if desired. The Teacher Background in the Investigation Guide offers suggestions for tailoring instruction to meet the needs of your students. *Maine Saves Energy: A Guide to Student-Led Investigations Using Real-Time Electricity Monitoring* is based on Maine state and national science standards and, in addition to addressing energy content standards, pays particular attention to standards that describe what students should know and be able to do with respect to scientific data. The Investigation Guide and Supplementary Activity Matrix gives an overview of each of the instructional components of this guide and lists the key ideas, student learning goals and connections to standards. The matrix also identifies activities that can be used for assessing students' understanding.

PowerSleuth and *Maine Saves Energy: A Guide to Student-Led Investigations Using Real-Time Electricity Monitoring* were developed by the Maine Mathematics and Science Alliance (www.mmsa.org) through

funding from Efficiency Maine. These materials were field tested by teachers taking part in the Citizen Science in the Classroom Project (CSIC) administered by the Maine Department of Education and funded by the American Recovery and Reinvestment Act.

All *PowerSleuth* units: *Energy Lights Maine* (Grades 4-5), *Energy Heats Maine* (Grades 6-7), *Maine Saves Energy* (Grades 7-8) and *Maine Saves Energy: A Guide to Student-Led Investigations Using Real-Time Electricity Monitoring* are available for download at no cost at the *PowerSleuth* website **www.powersleuth.org**.

Overview	Key Idea(s)	Goal(s) Students will:	Connection to Learning Goals from • *Benchmarks for Science Literacy (BSL)* • *National Science Education Standards (NSES)* • *Maine Learning Results (MLR)* • *Science for All Americans (SFAA)* • *Common Core State Standards for Mathematics (CCSS)*
Using Real-Time Electricity Data to Spark Student-Led Investigations Students examine different types of electricity data available to homeowners. They engage in a series of investigations, designed to help a "mystery" homeowner use the available data to understand and reduce electricity use and costs. *This guide serves as a framework for facilitating these investigations. Suggestions for using the supplementary activities are noted in the guide and this matrix.*	• Electricity bills, meter readings, and real-time electricity monitoring devices document actual electricity use in the home. • Electrical energy can be quantified and compared. • There are many questions that can be investigated using electricity data. Asking appropriate questions is key to driving scientific investigations. • Ongoing investigations provide evidence for solving problems, including developing strategies for conserving electricity.	• develop an understanding of and examine electricity use data. • describe and interpret patterns of household electricity use. • design and conduct an investigation to answer a question about electricity use in the home. • apply investigation findings and make recommendations for reducing the amount of electricity use in the home.	• Scientific investigations usually involve the collection of relevant data, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected data. BSL 1B/M1b* (6-8) • Organize information in simple tables and graphs and identify relationships they reveal. BSL 12D/M1 (6-8) • Understand oral, written, or visual presentations that incorporate circle charts, bar and line graphs, two-way data tables, diagrams, and symbols. BSL 12D/M4* (6-8) • Present a brief scientific explanation orally or in writing that includes a claim and the evidence and reasoning that supports the claim. BSL 12D/M6** (6-8) • Use appropriate tools and techniques to gather, analyze, and interpret data. NSES A (5-8) • Describe rates of change and cyclical patterns using appropriate grade-level mathematics. MLR A3 (6-8) c • Students plan, conduct, analyze data from, and communicate results of investigations, including simple experiments. MLR B1 (6-8) a-f • Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number. CCSS 6.SP.3 • Students plan, conduct, analyze data from, and communicate results of investigations, including simple experiments. MLR B1 (6-8) a-f

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			• Summarize numerical data sets in relation to their context, such as by…relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered. CCSS 6.SP.5 • Recognize and represent proportional relationships between quantities. CCSS 7.RP.2 • Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error. CCSS 7.RP.3

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***Energy for Maine,* Lesson 1 Modification: Electricity Discovery Box** This activity uses an "Electricity Discovery Box" to engage students and elicit their ideas about electricity. Students randomly select items from the box and discuss how they think each relates to electricity. *Use this activity prior to beginning the investigation as a way to stimulate interest and pre-assess students' ideas.*	• Energy is in some way connected to all physical objects and processes in the universe • People use and depend on electricity in a variety of ways, many of which are not readily apparent.	• explore their current ideas about electricity. • examine people's first and second-hand interactions with electricity.	• Energy is required for technological processes such as taking apart, putting together, moving around, and communicating. BSL 8C/M7** (6-8) • Electrical energy can be generated from a variety of energy resources and can be transformed into almost any other form of energy. Electric circuits are used to distribute energy quickly and conveniently to distant locations. BSL 8C/M4* (6-8)

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***Energy for Maine,* Lesson 6 Modification: Maine's Energy Picture** Students analyze the way they personally use energy and investigate energy use on a much larger scale (in Maine and nationally) through examination of data. Students discuss and make predictions about the amount of energy used by each sector. They create a visual representation of their predictions that they compare to the actual percentage of energy used by each sector. Students begin to discover how reliant all sectors are on electricity and fossil fuels as energy sources. *This activity can be used to help build students' background knowledge of electricity use as it provides the "big picture" view of how people have used and currently use electricity.*	• Data about energy use is divided into different categories known as sectors and include transportation, residential, industrial, and commercial. • Different sectors use energy and electricity in different ways. • The amount of energy people in the United States and in Maine use continues to increase. • Data is collected to answer a question and can be used to make informed decisions.	• become familiar with the various ways energy, including electricity, is used by different sectors. • analyze and determine energy use trends for themselves, for Maine, and the nation. • begin to consider the cumulative effects of energy decisions they make daily.	• Organize information into simple tables and graphs and identify relationships they reveal. BSL 12D/M1 (6-8) • Read simple tables and graphs produced by others and describe in words what they show. BSL 12D/M2 (6-8) • Locate information in reference books, back issues of newspapers and magazines, compact disks, and computer data bases. BSL 12D/M4* (6-8) • Trends based on what has happened in the past can be used to make predictions about what things will be like in the future. However, these predictions may not always match what actually happens. BSL 11C/M10** (6-8)

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***Energy for Maine,* Lesson 7: Watt's in a Name(plate)?** In this lesson, students determine how much electricity a particular device uses by reading electric nameplates and using Kill A Watt meters that monitor electrical energy consumption. They discuss the cumulative effects of parasitic or phantom loads and strategies to minimize and/or eliminate them. *This activity can be used either before students are introduced to real-time electricity monitoring displays to help them develop a sense of the number of Watts different appliances use or after students have familiarity with the graphs to help determine the types of appliances that might cause the patterns observed. This activity is one that can also be used in conjunction with the Appliance Card Sort.* Download lesson at: http://www.powersleuth.org/teacher/energy-powers/lesson7-overview	• Many devices have parasitic or phantom loads even when switched "off." • Parasitic or phantom loads cumulatively have a significant impact on overall energy consumption. • Connecting devices that have parasitic/phantom loads to power strips and turning the strip completely off when a device is not in use and purchasing Energy Star certified appliances are two strategies that can be used to reduce energy use.	• determine the number of Watts an electrical device uses by reading the device's electric nameplate. • give an example of a parasitic or phantom load. • describe the cumulative effects of parasitic or phantoms loads. • suggest strategies to eliminate or minimize parasitic or phantom loads.	• All technologies have effects other than those intended by the design, some of which may have been predictable and some not. BSL 3B/M2a (6-8) • Use statistics to summarize, describe, analyze, and interpret results. MLR B1 (6-8) c • Use a variety of tools and technologies to improve investigations and communications. MLR B1 (6-8) e

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Next Month's Electricity Use Students are given monthly kilowatt hour data from Addison Fox's home and asked to settle an argument between two friends about the best way to use the data to make a prediction about next month's electricity use. *This activity might be used with Step 1 of the investigation guide as a supplement or later in the investigation as an assessment.*	• Measures of central tendency (mean, median, mode) locate only the center of a data set. Other methods are often more useful in making sense of or describing the data.	• use strategies for analyzing data and interpreting the analysis in order to answer the question posed. • recognize when to use the mean and median to describe a distribution. • make effective use of a variety of representations to display distributions, including tables, bar and line graphs, dot or line plots, and pie charts.	• Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number. CCSS 6.SP.3 • Summarize numerical data sets in relation to their context, such as by…relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered. CCSS 6.SP.5 • Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations. CCSS 7.SP.4 • The mean, median and mode tell different things about the middle of a data set. BSL 9D/M3 (6-8) • Comparison of data from two groups should involve comparing both their middles and the spreads around them. BSL 9D/M4 (6-8)
Appliance Card Sort A versatile set of appliance cards can be used to preassess students' knowledge about "energy hogs" and to engage students in research on the number of watts various appliances use. *There are many ways this activity can be used. One suggestion is to use this activity after students have some familiarity with real-time electricity use displays as the activity helps students develop a sense of how many Watts particular appliances use. Another is to use this activity in conjunction with Energy for Maine, Lesson 7: Watt's in a Name(plate)?*	• Household appliances vary in the number of watts they use. • The number of watts something uses is dependent on the make, model, and year of the appliance and how (long) it is used. • Generally devices involved in cooling or heating use larger amounts of electricity. • Appliances have nameplates that list the number of Watts it uses.	• recognize that household appliances use different amounts of electricity. • identify household appliances that typically use large amounts of electricity. • determine the number of Watts an appliance uses by reading the device's electrical nameplate.	• Recognize and represent proportional relationships between quantities. CCSS 7.RP.2

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How Many Ways to a Kilowatt Hour? Scavenger Hunt This exercise helps students conceptualize how much electricity use is equivalent to 1 kilowatt hour (kWh). *This activity can be used in a number of places in the investigation sequence but is perhaps best used after students are familiar with real-time electricity use displays and have some experiences working with kWh. This activity can also be used in conjunction with the Appliance Card Sort and Energy for Maine, Lesson 7: Watt's in a Name(plate). This activity can be one that students complete with their parents or other community members. Some teachers have divided up the scavenger items, assigning one or two at a time, to make the activity more manageable.*	• A kilowatt hour (kWh) is 1 kilowatt (or 1000 Watts) of electricity used over the period of 1 hour.	• give examples of appliance use that would equate to 1 kilowatt hour of electricity use.	• Compute unit rates associated with ratios and fractions, including ratios of lengths, areas and other quantities measured in like or different units. CCSS 7.RP.1

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Going Graphic! Students determine how to best represent raw data collected from a home electricity use monitor. They compare and contrast their graph to those generated by others including the way the data is displayed by Google PowerMeter. *Part of step 5, option B in the investigation guide, this exercise can be done as a separate independent follow up activity. With modification it can also be used as a performance assessment task.*	• Data is gathered and organized in order to answer a question. • Different types of graphs and specific features of graphs provide different information about the data. • Choice of graphical representation impacts how well the data is understood. • How data is organized should be directly related to the question that caused collection of the data in the first place.	• represent data graphically to answer a question. • compare and contrast different graphical representations of the same data. • critique features of graphical representations by identifying the information they strongly convey and information that is not readily apparent. • recognize that graphs and statistics summarize data and provide a collective picture of the data.	• The graphic display of numbers may help to show patterns such as trends, varying rates of change, gaps, or clusters. Such patterns sometimes can be used to make predictions about the phenomena being graphed. BSL 9C/M4 (6-8) • Develop and use tables, graphs and rules to describe situations. NSES A (5-8)
Graph Match Students are given visual representations (graphs) of real-time electricity use and are asked to match each to its description. *Consider using this to help students become familiar with the types of patterns produced by electricity use. This activity can also be used to sharpen students' skills in matching real-time electricity use patterns to their displays or as an assessment.*	• Graphical representations can be described in words. • Graphs are representations of real (actual) events.	• describe in words the story the data tells and/or be able to describe in words the pattern of electricity use.	• Read simple tables and graphs produced by others and describe in words what they show. BSL 12D/M2 (6-8)

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Developing a Narrative from a Graph Students create a narrative description to match a real-time electricity use graph. *This exercise and the one that follows are aimed at helping students become familiar with matching electricity use with its real-time display. Each offers a slightly different approach and can be used in a number of places during the investigation sequence once students have had some experiences with examining real-time data.*	• Graphical representations can be described in words. • Graphs are representations of real (actual) events.	• describe in words the story the data tells and/or be able to describe in words the pattern of electricity use.	• Read simple tables and graphs produced by others and describe in words what they show. BSL 12D/M2 (6-8)
Developing a Graph from a Narrative Students make a graph of real-time electricity use based on the activities described in a narrative. *See suggestions above.*	• Graphical representations can be described in words. • Graphs are representations of real (actual) events.	• be able to sketch a graph which reasonably represents the events described in a narrative.	• Read simple tables and graphs produced by others and describe in words what they show. BSL 12D/M2 (6-8)

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Making a Statement Students are given real-time electricity use graphs and a series of statements about the graphs. Students discuss each statement to determine which are accurate. *Use this activity toward the later part of the investigation sequence to help prepare students or sharpen students' abilities in making accurate claims based on evidence. It can be used as a post investigation assessment.*	• A key part of any scientific investigation is interpreting and making sense of the data gathered. • Claims must be supported by evidence (data) from the investigation.	• determine which statements made about a data set are accurate using evidence from the data. • recognize the difference between evidence that comes from data and inferences based on assumptions.	• Present a brief scientific explanation orally or in writing that includes a claim and the evidence and reasoning that supports the claim. BSL 12D/M6** (6-8) • Sometimes people invent a generalization to summarize a set of observations. But sometimes people overgeneralize, imagining generalizations on the basis of too few observations. BSL 9E/M3* (6-8)
The Wishings This set of activities provides students with the opportunity to examine electricity use through mathematics and includes analysis of electricity costs and rate of change using graphs. *This activity set can be used after students have been introduced to electricity rates in conjunction with Step 1 of the Investigation Guide or after students have been introduced to real-time electricity data displays.*	• A key part of any scientific investigation is interpreting and making sense of the data gathered. • Linear equations can be used to illustrate a variety of relationships. • The slope of a line tells how something changes over time.	• make predictions and identify patterns using graphs. • identify relationships between two variables as shown in a table, graph, or equation and describe how the relationship can be seen in each of the other forms of representation. • solve problems and make decisions about linear equations and patterns in tables and graphs of those relations – rate of change, slope, y-intercept.	• Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. CCSS 6.EE.9 • Recognize and represent proportional relationships between quantities. CCSS 7.RP.2 • Graphs can show a variety of possible relationships between two variables. As one variable increases uniformly, the other may do one of the following: increase or decrease steadily, increase or decrease faster and faster, get closer and closer to some limiting value, reach some intermediate maximum or minimum, alternately increase and decrease, increase or decrease in steps, or do something different from any of these. BSL 9B/M3*(6-8)

Resource Pages

Resource Pages are versatile handouts containing additional information aimed at supporting specific aspects of students' investigations and the supplementary activities.

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Annotated Real-time Electricity Use Display for Addison Fox Household This handout shows real-time electricity use graphs and describes the activities for the household during a typical morning. Two displays are included – the graph at the top left is an enlarged view of the morning hours and at the bottom is a graph showing the entire day's electricity use (the scale for the y axis is in kW). *Use this handout to help students connect patterns of use to displays. This resource is best used after students have become somewhat familiar with the basics of what real-time data displays show. This resource can also be used in conjunction with the activities Developing a Graph from a Narrative and Developing a Narrative from a Graph.*	• Graphical representations can be described in words. • Graphs are representations of real (actual) events.	• associate patterns of real-time electricity use with household activities.	• Read simple tables and graphs produced by others and describe in words what they show. BSL 12D/M2 (6-8)

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Home Specification Sheet for Addison Fox Household This handout provides additional information about the Addison Fox household including home size, heating and cooling systems, past energy use, and a room-by-room list of appliances and lighting. *This is useful for students who want to take into account additional information about the mystery household. Students, working with their parents can also find out more about their own homes using this spec sheet as a model.*	• The amount of electricity a household uses depends on a number of factors including number of occupants, size of home, heating and cooling systems, appliances, and location.	• associate patterns of real-time electricity use with household activities. • Identify additional factors that contribute to household electricity use.	• People have invented ingenious ways of deliberately bringing about energy transformations that are useful to them. SFAA 8C/M8** (6-8)

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Two Views, Same Data This handout shows the same data collected by different instruments but viewed through Google PowerMeter. One display reports data in 1-hour intervals from a Bangor Hydroelectrtic Smart Meter and the second shows data reported every 10 minutes from The Energy Detective or TED, a home energy monitoring device. Both instruments' data set are sent to Google and graphed by Google PowerMeter. *This handout can be used to discuss similarities and differences that students notice in the details of the two displays and engage them in a conversation about the advantages and limitations of each view. This handout can stimulate a discussion about the kinds of details that help the consumer make informed decisions about electricity use. Students can also be asked, after giving these displays some further thought, to write a letter to their local utility company explaining their display preferences and providing specific examples of the sorts of details they think would be useful for helping consumers make informed decisions about electricity use.*	• Different types of graphs and specific features of graphs provide different information about the data. • Choice of graphical representation (can) impact(s) how well the data is understood and used to make decisions.	• represent data graphically to answer a question. • compare and contrast different graphical representations of the same data. • critique features of graphical representations by identifying the information they convey clearly (strongly) and information that is not readily apparent. • recognize that graphs and statistics provide a sense of trends and patterns and are more than a collection of numbers.	• The graphic display of numbers may help to show patterns such as trends, varying rates of change, gaps, or clusters. Such patterns sometimes can be used to make predictions about the phenomena being graphed. BSL 9C/M4 (6-8) • Develop and use tables, graphs and rules to describe situations. NSES A (5-8)