Plug Loads

2017-2018

Students explore ways to save energy at school by investigating electricity consumption of common devices and determining ways to reduce that consumption.

Grade Levels:

- Int Intermediate
- Sec Secondary

Subject Areas:

- Science
- Math
- Language Arts
- Technology

NEED
National Energy Education Development Project

Teacher Advisory Board

NEED Mission Statement

The mission of The NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

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Teacher Advisory Board

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at www.eia.gov.

NEED
National Energy Education Development

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Plug Loads

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Standards Correlation Information

www.NEED.org/curriculumcorrelations

Next Generation Science Standards

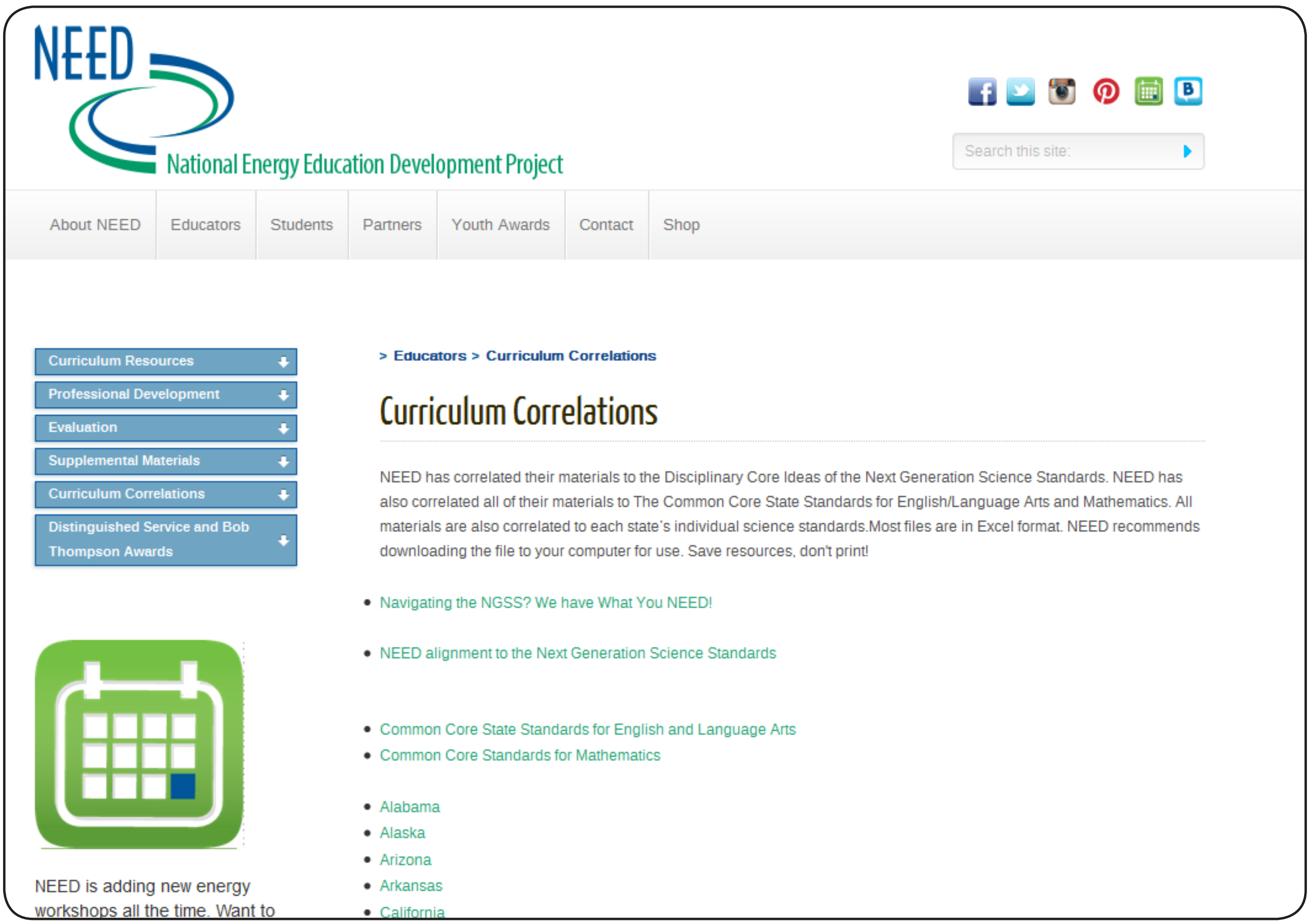
- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.

Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.



Introduction to Plug Loads

Overview

These activities teach students how to determine the annual energy consumption and operating cost of appliances found in the school building. Students will compile data and determine costs by using a spreadsheet. Students will be able to see how energy-saving actions can impact the energy consumption of their school. While using a spreadsheet, students will also be able to calculate the amount of carbon dioxide (CO_2) produced by the generation of electricity to power each appliance. In addition, the activities teach the students about the electricity consumed even when certain appliances are turned off and how these "phantom loads" affect school energy bills and CO_2 emissions.

Background

Plug Loads is designed to complement The National Energy Education Development (NEED) Project's existing Energy Management curricula, *Monitoring and Mentoring* and/or *Learning and Conserving*. These units guide students and teachers through a comprehensive study of how energy is used at school and at home. *Plug Loads* provides an additional component to the students' energy assessment of the school building, which is the culminating activity of NEED's Energy Management lessons. In *Plug Loads*, students will gather data on electrical appliances in their building and utilize a spreadsheet to calculate their energy consumption and cost over time. Through this study, students will gain a greater understanding of how plug loads affect the overall energy consumption of a building and how using plug loads efficiently can lower energy costs and improve environmental quality.

What Are Plug Loads?

Plug loads are electrical devices or appliances that draw power through an electric outlet. Schools typically have 120/240-volt electrical systems with many different loads. A load is any device that is powered by an electrical system and requires electricity to do work. Look around any classroom and see the many appliances and devices that are turned on. Anything that has an ON/OFF switch can be a load. Managing the use of these loads can help save electricity and money. A quick survey of the typical classroom and school building reveals many kinds of plug loads, such as:

- coffee makers
- computers/monitors
- laptops/tablets
- laptop/tablet charging cart
- fans
- desk and table lamps
- microwaves
- refrigerators
- televisions
- DVD/VCR players
- window air conditioners
- vending machines
- printers and scanners
- fax machines
- copiers
- fish tanks
- projectors
- ranges and stoves
- vocational equipment
- refrigerated drinking fountains
- clocks

Many of these devices are important to the learning environment. There may be other items in your building that aren't listed above. In addition, there are appliances that teachers and school staff bring from home that are not related to teaching, but are routine products found in any office or classroom. A survey of all plug loads in the school will help students, teachers, and school staff find ways to reduce electricity use and save money.

Once students, teachers, and staff are educated about the impacts of energy consumption, they are often willing to reduce their use of these devices. By simply monitoring daily use of plug loads, students and staff can lower the school's utility bills, saving the school system money. This could make additional funding available for educational materials such as textbooks, school supplies, and other equipment.

How Much Electricity Do Plug Loads Use?

It is estimated that over 30 percent of the total electricity consumed by a school is from plug loads. Managing the use of such equipment can greatly reduce a school's electricity consumption.

Using the Plug Load Spreadsheet

To estimate how much electricity is consumed by plug loads in your school, you can use the *Plug Load Spreadsheet*. This spreadsheet is a tool that helps students quantify the relationship between plug loads and energy usage. **The spreadsheet file can be downloaded from www.NEED.org.** The *Plug Load Spreadsheet* can be integrated with data gathered using NEED's *Monitoring and Mentoring*, *Learning and Conserving*, or *School Energy Survey* activities to give students a better understanding of energy consumption. Analysis of data will result in real opportunities for reducing energy use and lowering the school's utility bill.

The *Plug Load Spreadsheet* was designed to simulate real world computer programs used by professional energy analysts. The students' exposure to gathering and analyzing electrical use data demonstrates the importance of energy management and builds an essential foundation needed for entering this growing career field.

Utility companies charge their customers based on the kilowatt-hours (kWh) of electricity they use each month. The first worksheet in the spreadsheet file (Plug Load) takes data entered by students and calculates the kWh used by each appliance per month and per year. The total annual cost is calculated using the average electricity rate for commercial customers. This is the rate paid by schools. The spreadsheet comes pre-loaded with the national average electricity rate for commercial customers ($0.11) on the first active row of the worksheet. For a more accurate cost analysis, the price for electricity paid by your school should be available from your business office or utility company, and can be entered in the appropriate cells to modify the cost.

The worksheet also calculates the CO_2 emissions produced by a power plant to generate the amount of electricity required to power the device. This value is calculated using the amount of CO_2 emitted per kWh of electricity generated. The worksheet comes pre-loaded with the national average for CO_2 emissions per kWh on the first active row of the worksheet. For a more accurate emissions analysis, CO_2 emissions by state can be found at www.eia.gov/electricity/state. Click on your state name to see CO_2 emissions in pounds per megawatt-hour. Convert to pounds per kilowatt-hour before entering the data into the spreadsheet.

Plug Load Spreadsheet

Plug Load Example

Existing

Average Electricity Cost = $ 0.11 per kWh   Average CO_2 Emitted per kWh = 1.5 lbs

1	2	3	4	5	6	7	8	9	10	11
Equipment[1]	**Quantity In Use[2]**	**Typical Use, Hours/Day**	**Wattage**	**Cycle Time[3]**	**Monthly kWh[4]**	**Months/ Year[5]**	**Yearly kWh**	**Annual Cost Each**	**Total Annual Cost**	**Annual CO_2 Emissions (lbs)**
Coffee Maker	25	3	1,200	33%	594	9	5,346	$23.52	$588	8,019
Computer&Monitor	90	7	115	100%	1,449	9	13,041	$15.94	$1,435	19,562
Laptop/Tablet[6]	150	8	44	100%	1,056	9	9,504	$6.97	$1,045	14,256
Fan	10	3	115	100%	69	9	621	$6.83	$68	932
Desk Lamp	30	5	60	100%	180	9	1,620	$5.94	$178	2,430
Microwave	15	0.5	1,200	100%	180	9	1,620	$11.88	$178	2,430
Digital Projector	25	5	250	100%	625	9	5,625	$24.75	$619	8,438
Small Fridge (2.5-6.4 cu.ft.)	20	24	125	33%	602	9	5,417	$29.80	$596	8,126
Television	25	1	80	100%	40	9	360	$1.58	$40	540
DVD player	25	1	10	100%	5	9	45	$0.20	$5	68
Space Heater	15	7	1,500	20%	630	4	2,520	$18.48	$277	3,780
Window AC (8,000 Btu/hr)	3	8	900	50%	216	4	864	$31.68	$95	1,296
Window AC (12,000 Btu/hr)	3	8	1,200	50%	288	4	1,152	$42.24	$127	1,728
Cold Drink Vending Machine	6	24	800	50%	1,751	12	21,012	$385.23	$2,311	31,519
Other					-		-			
TOTAL					**7,685**		**68,748**		**$7,562**	**103,122**

Notes:

1. If necessary, change input in yellow for equipment you are analyzing.
2. Quantities shown are for a typical, 25-classroom, 100,000 sq.ft., K-12 school. You can change other numbers if needed.
3. Amount of time the appliance actually runs (e.g., a coffee maker burner is only on ~33% of the time).
4. The number of days per month an item is used has been adjusted where applicable.
For example, the digital projector may only be used on weekdays, while a refrigerator must remain on at all times, everyday.
5. Assume most items are unplugged and unused for any breaks (summer, etc.).
6. Laptop wattage denotes when tablet or notebook is on and charging. A fully charged battery will yield less wattage.

Using the Plug Load Spreadsheet

Columns 1-5 and Column 7

Data can be entered into Columns 1-5 and Column 7. Column 6 and Columns 8-11 all contain formulas and perform calculations based on the data entered in Columns 1-5 and 7. The worksheet is pre-loaded with values for Columns 1-5 and 7. The cells in Columns 1-5 and 7 are yellow, indicating cells that should be filled in or replaced with building-specific data. The best way to obtain values for Column 4 is by using a plug-in watt meter, like the Kill-A-Watt® monitor, which is included in NEED's Energy Management Kits. Below is a description of data in each column:

Column 1: Lists appliances commonly found in school buildings.

Column 2: Gives typical quantities of these appliances found in schools.

Column 3: Gives typical usage in hours per day.

Column 4: Gives typical wattages of appliances. If students meter the appliances directly or determine the wattage from appliance nameplates (see *Monitoring and Mentoring* or *Learning and Conserving* sections on nameplate data), their data should be entered in this column.

Column 5: Gives the amount of time these appliances are typically running when turned on. Some appliances, such as refrigerators, are always "on" when they are plugged in. However, they are controlled by thermostats so that the units only run when the temperature inside rises above a pre-set point. The percentage listed in this column is the percentage of time the appliance is typically running when "on".

Column 7: Gives the number of months per year the equipment is operated. Nine months is the default value for schools for most items. This value can be changed if the school or building is in use for longer periods or year-round.

Each of these columns contains typical values. The actual appliances, quantities, hours of use, run time, and cycle time can vary widely. The more data your students gather and enter into these six columns, the more accurate the assessment you will have of the actual energy use in the building. It is suggested students add items to the list and edit values based on their findings. For example, they may wish to add items like laptop or tablet charging stations, and water fountains.

When determining values for Columns 3 and 7, it may be necessary to interview school personnel. For instance, asking a school secretary may be the best way to determine the hours of operation for a copier in the main office. The interview is an important part of any energy analysis. There is always information that is hidden or difficult to measure. The interview provides necessary data and incorporates a language arts element into the student energy analysis.

Column 6 and Columns 8-11

Columns 6 and 8-11 contain exact formulas and should not be modified.

Column 6: Determines the monthly electricity usage in killwatt-hours (kWh) by multiplying the quantity of appliances by the appliance wattage and the hours of operation per day, then multiplying that figure by the percentage of time the appliance is actually running when it is turned on. Finally, this formula converts the watts to kilowatts by dividing by 1,000, then multiplies the product by the number of days per month the equipment is operated (assumed to be 20 on average for most appliances and 30.4 for refrigerators and freezers).

Column 8: Multiplies the kilowatt-hours per month by the number of months to yield the kWh per year consumed by the appliances.

Column 9: Multiplies the kWh per year by the average electricity cost and then divides by the number of pieces of equipment to show the yearly cost of operating each piece of equipment.

Column 10: Multiplies the kWh per year by the average electricity cost to yield the yearly operating cost of all pieces of equipment in this category.

Column 11: Multiplies the kWh per year by the average amount of CO_2 (in pounds) produced by generating one kWh of electricity.

Often, there is more than one kind of appliance within a category of equipment. For instance, the school's computers could include older machines with CRT (cathode ray tube) monitors and newer ones with LCD (liquid crystal display) monitors. In such cases, each of these kinds of computers should be treated as separate pieces of equipment and have their own rows on the worksheet. Similarly, there may be categories of equipment in which some pieces have longer run times or are used year-round as opposed to nine months. Each of these run times should also be considered as distinct pieces of equipment.

Finally, some pieces of equipment (such as computers and copiers) often spend much of their time in low power or sleep modes. In many cases, appliances also consume power when turned off (see *Phantom Loads* section). An advanced analysis would take this into account, as well. As with the cases mentioned above, it is necessary to use a separate row for the machine in sleep mode, with the estimated amount of hours the machine spends in that mode.

Extension: Students can build their own spreadsheets if access and time allow.

***REMINDER: Download the spreadsheets from www.NEED.org.**

Conducting the Activities

Step One

Explain to students that the electricity consumed by electrical appliances is a major component of their school's energy use. Tell students that they will be studying the electrical appliances in their building to determine their total consumption, the cost of running them, and the greenhouse gas emissions produced by generating the electricity to run them. They will then brainstorm ideas to reduce this consumption while continuing to provide a healthy, comfortable, and productive school environment. Describe the environmental effects of electricity generation and how this is related to their study of electrical appliances. Refer to the *Monitoring and Mentoring* or *Learning and Conserving* guides for background.

Explain to students that they will be utilizing a spreadsheet to enter their data and determine the consumption, cost, and CO_2 emission impacts of running appliances. They will then be able to propose changes to the conditions they find and see how these changes affect the consumption, costs, and environmental impacts.

Step Two

Define key terms for students such as load, plug load, and phantom load. Refer to the glossary or copy for students (page 19).

Step Three

OPTION 1

If you are conducting this as a stand-alone activity, first decide to what extent your students will be using the pre-loaded values in the spreadsheets. This will determine the data they will need to gather. Explain to students how to fill out the *Plug Load Data Collection Spreadsheet*, including instructions on data they do not need to gather due to the use of pre-loaded values. Two versions of the spreadsheet are provided. The first has all of the pre-loaded values included. The second version is blank for students to input the data they measure if allowable. Students may also edit the items to change or add relevant equipment. Students will need to interview school staff to establish operating hours per day. If you are utilizing one of NEED's Energy Management Kits with your students, the plug-in Kill-A-Watt® monitor can be used to determine appliance wattage. Instructions for the use of this device are found in the kit.

OPTION 2

If you are incorporating this activity into the *Electric Nameplates* investigation from *Monitoring and Mentoring* or the *Electrical Devices and Their Impacts* investigation from *Learning and Conserving,* students may use the worksheets to gather information about appliances. In addition to the information gathered during this step, students should determine how many pieces of each type of equipment there are in the building and find out how many hours per day this equipment operates. Explain that they will, in some cases, need to talk with other teachers and school staff to determine the operating hours per day of an electrical appliance. Students can then transfer their collected data to the spreadsheets for calculations.

Step Four

Once students have completed gathering data, explain the use of the digital spreadsheet, including a description of each cell. Clearly indicate to students the columns you want them to fill in based on the data they collected (it is recommended that you color code these columns). Once students have completed the first spreadsheet, discuss the results as a class. Which appliances are the largest users of electricity? Which ones are the smallest? Were there any surprises?

Step Five

Ask students if they have any recommendations for increasing efficiency or decreasing energy consumption. Discuss their ideas and add some of your own. Introduce the *Plug Load Savings Spreadsheet* (see sample, page 11). Explain that the values they see initially are automatically fed into the spreadsheet from the worksheet they just completed. They can change the values in Columns 2-4 based on actions they recommend. The recommended actions should be described in the last column on the sheet labeled, *Action Taken to Achieve Savings*. Discuss the results with the students. What actions would make the most difference? Which would be the easiest or most difficult to implement? If the recommendations are related to changing behaviors, how will they promote the change?

Step Six

Discuss phantom loads with students, explaining that the electrical consumption of appliances that are plugged in, but powered off, can be significant. Introduce the *Phantom Load Spreadsheet* and explain that it works exactly like the *Plug Load Spreadsheet* they previously completed; the main difference is that in Column 3, instead of entering *typical use*, *typical hours off* is entered. Phantom wattages are pre-loaded, or students can determine phantom loads by using the watt meter as they did in Step Three. Wattages in student spreadsheets may not all match those on the table on page 13. *Phantom Load Savings Spreadsheet* (see sample, page 15) is included in which students can determine the savings from unplugging appliances that are powered off.

Step Seven

Evaluate student performance by reviewing the completed worksheets and spreadsheets.

Step Eight

Explain to students that through implementing awareness campaigns, they can significantly decrease energy use in their schools. Guide them through an interactive process of drafting an implementation plan for changing the energy use profile of their school, or even their entire school district. The plan should be tiered and built upon easily executable steps to success.

Assist the students in translating the knowledge they've gained into school-wide or community-wide awareness campaigns. Choosing energy saving opportunities that apply to both the students' school and their homes will create rich opportunities for classroom and home discussion, and increase the level of personal involvement.

For example, during one academic quarter, students might investigate the savings available from choosing energy efficient computers and using the energy saving features on computers. A good resource for this is the EPA and DOE ENERGY STAR® program website, where students can access free software to calculate the savings potential of computer-related energy saving behaviors. Go to www.energystar.gov and type in 'power management' at the search prompt.

During another quarter, students might research the savings available by replacing older refrigerators and freezers with new, more energy efficient models. They might then present that information to key decision-makers in the school/district, as well as at home. On average, new ENERGY STAR® refrigerators typically use about 40 percent less electricity than models produced in the 1980s or earlier. Many schools—and homes, for that matter—have refrigerators and freezers that are nearly empty much of the time. Consolidating to a few newer refrigerators would add up to significant savings. Other potentially lucrative energy saving actions for the students to investigate and implement might include replacing incandescent bulbs with LED bulbs (a 75 percent savings).

Plug Load Data Collection Spreadsheet

Plug Load Model

Existing

Average Electricity Cost = $ 0.11 per kWh

Average CO_2 Emitted per kWh = 1.5 lbs

1	2	3	4	5	6	7	8	9	10	11
Equipment[1]	Quantity In Use[2]	Typical Use, Hours/Day	Wattage	Cycle Time[3]	Monthly kWh[4]	Months/Year[5]	Yearly kWh	Annual Cost Each	Total Annual Cost	Annual CO_2 Emissions (lbs)
TOTAL					-		-		-	-

Notes:

1. Enter the equipment you are analyzing.
2. Enter the quantity of each device being modeled.
3. Amount of time the appliance actually runs (e.g., a coffee maker burner is only on ~33% of the time).
4. Adjust the number of days an item is used per month.
For example, a refrigerator will remain "on" all day, every day, while a projector may only be "on" a few days per month.
5. Assume most items are unplugged and unused for any breaks (summer, etc.).

Plug Load Savings Spreadsheet

Download the spreadsheets online at **www.NEED.org/curriculum-guides.**

Plug Load Savings Model

Savings

Average Electricity Cost = $ 0.11 per kWh   Average CO_2 Emitted per kWh = 1.5 lbs

1	2	3	4	5	6	7	8	9	10	11	Savings Analysis						
Equipment[1]	Quantity In Use[2]	Typical Use, Hours/Day	Wattage	Cycle Time[3]	Monthly kWh[4]	Months/ Year[5]	Yearly kWh	Annual Cost Each	Total Annual Cost	Annual CO_2 Emissions (lbs)	Existing Yearly kWh	kWh Savings	Existing Annual Cost	$$ Savings	Existing CO_2	CO_2 Savings	Action Taken to Achieve Savings
TOTAL					-		-		$0	0	0	0	0	0	0	0	

Notes:

1. Enter the equipment you are analyzing.
2. Enter the quantity of each device being modeled.
3. Amount of time the appliance actually runs (e.g., a coffee maker burner is only on ~33% of the time).
4. Adjust the number of days an item is used per month. For example, a refrigerator will remain "on" all day, every day, while a projector may only be "on" a few days per month.
5. Assume most items are unplugged and unused for any breaks (summer, etc.).

Phantom Loads

Phantom Electrical Loads

The DVD in a classroom has been flashing the time "12:00 a.m." since it was installed four years ago. The only time it has not been flashing is when a power outage occurred last winter. This is a prime example of an electronic device in today's classroom that consumes energy when the switch indicates it is "off". The cost for this flashing for four years could add up to more than $10. With hundreds of these devices in a district, that can amount to a significant energy cost. This consumption of electrical energy is classified as a phantom load. Phantom loads are also known as standby power or leaking electricity.

Phantom loads exist in many electronic or electrical devices found in schools. Equipment with electronic clocks or timers, with remote controls, portable equipment, and office equipment with wall cubes (small box-shaped plugs that plug into AC outlets to power appliances) all have phantom loads. This equipment can consume anywhere from 3-20 watts when turned off. On the next page is a table of examples of these values. Note that as technology changes, these values are being reduced and it is estimated that with new technology as much as 75 percent of this phantom load can be reduced. Be sure to measure the phantom load of devices where possible to determine a more accurate figure.

Calculating Phantom Load

To find the phantom load for an appliance, you must know how many hours per day the appliance is turned off and what the phantom load is. Below is an example for a TV in a school building:

Appliance: TV **Phantom Load: 5.5 watts** **Hours per day turned off: 22**

The total energy used during the year would be 5.5 watts x 22 hours/day x 365 days/year = 44,165 watt-hours or 44 kWh. At the average commercial rate of $0.11/kWh, the cost would be $4.84. (Note: A home TV's phantom load cost would be different, due to a higher average residential rate of $0.127/kWh and an average turned-off time of 19 hours per day.)

Of course, the usage would vary depending on the day. To get a more accurate figure, you would have to take into account the number of days when the TV is not used at all (summer vacation, weekends, holidays, etc.) where the phantom load would be drawn for 24 hours instead of 22. Taking these factors into account, the standby usage and cost would be higher. Remember, this is just for one TV. In a large school district, there could be a hundred or more TVs. To get an accurate measure of how much TV phantom load consumption there is district-wide, you would multiply the number of TVs by the average usage.

To reduce this energy consumption, unplug the TV when not in use. Consider this suggestion for other electronic devices that may not need to be continuously plugged in for educational value. On the next page is a chart showing the following:

- Average standby power (phantom load) consumption of appliances (from research conducted by Lawrence Berkeley National Lab);
- The recomended guideline for standby power usage, provided by The Department of Energy's Federal Energy Management Program and ENERGY STAR®.

Significant savings can be achieved by reducing phantom loads. But more important than the energy reduction is the educational value for students as they gain an understanding of phantom loads and what actions can be taken to manage their impact.

You can use the *Phantom Load Spreadsheets* (pages 14-15) available from www.NEED.org to calculate phantom loads. This worksheet is set up exactly like the *Plug Load Spreadsheet*. Only enter data for the appliance for the times when it is turned off.

Standby Power (Phantom Load) of Office Electrical Devices

Electrical Device	Average* (watts)	Guidelines** (watts)
Television, CRT	3.06	does not qualify
Television, LCD	2.10	≤ 1
Set-top Box, Digital Cable	17.83	< 3
Game Console	1.01	< .5
CD Player	5.04	1
DVD Player	1.55	1
Desktop Computer	2.84	1
Laptop Computer	8.9	1
Computer Monitor (LCD)	1.13	1
Computer Speakers	1.79	< 1
Printer, Inkjet	1.26	< 1
Printer, Laser	1.58	< 1
Fax Machine, Laser, Ready	6.42	< 1
Copier	1.49	1
Coffee Maker, Off	1.14	does not qualify
USB Hub, Off	1.44	does not qualify
Microwave oven, Not Running	3.08	does not qualify
Surge Protector	1.05	does not qualify

* Lawrence Berkeley National Lab and ENERGY STAR® (2014), denotes products being "off"

** The Federal Energy Management Program and the ENERGY STAR® program set guidelines for the purchase of electrical devices by U.S. government agencies and buildings. In order to be considered an ENERGY STAR® certified device, it must meet these current guidelines. Items in your home or school may be labeled as ENERGY STAR® because they met past guidelines, however they may not meet current guidelines.

Phantom Load Spreadsheet

Phantom Load Model

Existing

$ 0.11 per kWh | Average CO_2 Emitted per kWh = 1.5 lbs

1	2	3	4	5	6	7	8	9	10
Equipment[1]	Quantity In Use[2]	Typical Hours "off" or Standby, Daily[3]	Wattage Off/Stand-by Mode	Monthly kWh[4]	Months/ Year[5]	Yearly kWh	Annual Cost Each	Total Annual Cost	Annual CO_2 Emissions (lbs)
TOTAL									

Notes:

1. Enter the equipment you are analyzing.
2. Enter the quantity of each device being modeled.
3. Amount of time the appliance is off but remains plugged in.
4. Adjust the number of days an item is used per month. For example, a refrigerator will remain "on" all day, every day, while a projector may only be "on" a few days per month.
5. Assume most items are unplugged and unused for any breaks (summer,etc).

Phantom Load Savings Spreadsheet

Download the spreadsheets online at **www.NEED.org/curriculum-guides.**

Phantom Load Savings Model

Savings

Average Electricity Cost = $ 0.11 per kWh   Average CO_2 Emitted per kWh = 1.5 lbs

1	2	3	4	5	6	7	8	9	10	Savings Analysis						
Equipment[1]	Quantity In Use[2]	Typical Hours "off" or Standby, Daily[3]	Wattage Off/Stand-by Mode	Monthly kWh[4]	Months/ Year[5]	Yearly kWh	Annual Cost Each	Total Annual Cost	Annual CO_2 Emissions (lbs)	Existing Yearly kWh	kWh Savings	Existing Annual Cost	$$ Savings	Existing CO2	CO2 Savings	Action Taken to Achieve Savings
TOTAL																

Notes:

1. Enter the equipment you are analyzing.
2. Enter the quantity of each device being modeled.
3. Amount of time the appliance is off but remains plugged in.
4. Adjust the number of days an item is used per month. For example, a refrigerator will remain "on" all day, every day, while a projector may only be "on" a few days per month.
5. Assume most items are unplugged and unused for any breaks (summer,etc).

Extension Activities

Introduce students to the concept of payback period—the amount of time it takes for an investment to pay for itself through the energy it saves. Provide students with the cost of various energy saving actions, such as replacing an incandescent light bulb with a light emitting diode bulb in a desk lamp. Then introduce the formula for determining simple payback:

Payback (PB) = Cost/Annual Savings

Tell students to determine the payback period for various energy saving actions they proposed on their *Plug Load Savings Spreadsheets*.

Activity 1: Refrigerator Replacement

Other than heating hot water with an electric heater, refrigeration is one of the largest constant contributors to plug loads in residential buildings. It is often a large factor in many school buildings, as well. The following exercises will provide students with excellent practice in energy-conscious consumer decision-making.

EXAMPLE: Students at a junior high school identified a circa-1984 refrigerator with poor seals in a teacher break room, and marked it down as a good candidate for replacement. They attached a plug-in watt meter to the old refrigerator for 24 hours and found that it used 4.2 kWh of energy per day, or 1,533 kWh per year. While metering, the students noticed that the refrigerator and freezer compartments were only about three-fourths full. They surveyed several teachers in order to determine if this was a constant situation, or an anomaly. They determined that it would be safe to downsize the replacement refrigerator by 2 cubic feet.

The students shopped online for a new refrigerator, and quickly found many ENERGY STAR® rated top-freezer-style models. They settled upon a sturdy, no-frills model that their school could purchase tax-free for $590. The product specifications showed that the model consumes approximately 407 kWh per year.

Next, they determined the annual energy savings from replacing the old refrigerator with the new one:

1,533 kWh/yr (old) – 407 kWh/yr (new) = 1,126 kWh/yr in saved electricity

To determine the cost savings, they multiplied the savings by the commercial electricity rate:

1,126 kWh/yr x $0.11/kWh (average commercial rate) = $123.86 savings per year

Finally, they divided the purchase price of the new refrigerator by the annual cost savings to determine the payback period:

$590 purchase price / $123.86 annual savings = 4.76 year payback

Since the average life of a refrigerator is 10-20 years and the payback period for replacing the refrigerator was a little under five years, the school's administration elected to request that their district purchase the model recommended by the students.

Activity 2: Light Bulb Replacement

Lighting is a significant cost to schools and homes. Reducing the cost of lighting can impact energy costs.

EXAMPLE: A fifth grade student audit team at an elementary school found that twelve of the school's teachers and staff had desk lamps either on their desks or at their computer stations. The team observed and logged run-time for the lamps for a week, and found that almost all were left on for the entire workday, or from approximately 8 a.m. to 4 p.m. They discovered that all of the bulbs in the twelve lamps were 60-watt incandescents.

The students researched the light levels (lumens) for light emitting diode bulbs (LED) and incandescent bulbs, and found that a 9-watt LED provides the same light level as a 60-watt incandescent bulb. They then looked through advertisements in the local newspaper, and discovered that a nearby home store was offering a package of six ENERGY STAR® rated light emitting diode bulbs for just $20.00. In order to replace the 12 bulbs, the students determined they would need two packages of six bulbs each. With guidance, the students set about calculating the annual plug load cost of the old incandescent bulbs. First, they determined that there were 180 school days in their district's school year, so they multiplied 180 days by 8 hours a day, and got 1,440 hours of on-time per lamp. Then they multiplied 1,440 by twelve, yielding a total of 17,280 hours of 60-watt bulb use.

1,440 hours x 12 lamps = 17,280 total hours

The fifth-graders continued their calculations by determining how many watts were used annually by the old incandescent bulbs.

17,280 hours x 60 watt = 1,036,800 watt-hours

Arriving at that large a number of watts astounded the students. They had been taught that a kilowatt equals 1,000 watts, so the students divided their grand sum of 1,036,800 watt-hours per year by 1,000 and got 1,036.8 kWh.

1,036,800 watt-hours / 1,000 watts/kW = 1,036.8 kWh

They then multiplied that number by $0.11, the national average cost for commercial electricity:

1,036.8 kWh x $.11/kWh = $114.05

For their final factor in determining payback, they figured the total cost of operating the 13-watt CFLs for a year. First, they determined how much energy the CFLs would consume during the year in kWh:

17,280 hours x 9 watt = 155,520 watt-hours /1,000 watts/kW = 155.52 kWh

Next they multiplied the consumption by the commercial electric rate:

155.5 kWh x $0.11/kWh = $17.11

The total cost for two packages of LEDs is:

2 LED Packages x $20.00 = $40.00

To determine the savings, they subtracted the cost of operating the LEDs from the cost of operating the incandescents:

$114.05 (incandescent bulb consumption) – $17.11 (LED consumption) = $96.94

Finally, they divided the cost of the LEDs by the annual savings to determine the payback period:

$40.00 / $96.94 = a payback period of 0.41, or less than half of a year

Impressed, the students went a step further to determine the life-cycle savings of making the bulb conversion. They divided the average 25,000-hour life of an LED by 1,440 hours and determined that the new bulbs could last up to 17 years (17.36). They deducted the payback period, and calculated that 17 years of savings would amount to almost $1,500. Armed with their facts and figures, the fifth grade student audit team had no problem convincing their principal to purchase $40 worth of LED bulbs for the teachers and staff to use in their personal desk lamps!

Optional

- Repeat this process using a CFL with similar lumens. The average indoor CFL bulb uses 13 watts, sells for around $3.00, and lasts 10,000 hours. Would switching to CFL bulbs be a good idea? Why or why not?
- For a simplified version of this activity, download the *Facts of Light* and *Comparing Light Bulbs* activities from NEED's *Learning and Conserving* unit.

Home Extension Activity

Step One

Have students conduct a survey with their family about the plug loads found in their homes. Students should list the appliances and electronics they have, and estimate with their parents or guardians the typical use. Students should bring these lists back to school.

NOTE: The school may want to consider loaning the Energy Management Kit items (watt meters, etc.) to families, allowing families the opportunity to collect data on their home energy use.

Step Two

Students enter the data from their home survey into the spreadsheet at school. Students may use the average residential rate for electricity of $0.127/kWh or determine what their actual rate is using a family electric bill. Have students calculate the financial and environmental impact of their home plug load.

Step Three

Students bring their calculations home to their families. Students should be encouraged to develop a plan with their families for making efficiency and conservation changes.

Step Four

Students should bring in their family plan to share with the class. Revisit the plans periodically and have students give updates on the changes their families have implemented.

Glossary

120/240-volt service	the common voltages used for wall outlets in North America
energy analyst	a professional who analyzes the energy use of a building and recommends building improvements or behavior changes that reduce energy consumption
ENERGY STAR®	a Federal Government-backed program helping businesses and individuals protect the environment through superior energy efficiency
Federal Energy Management Program (FEMP)	a program of the U.S. Department of Energy that works to reduce the cost and environmental impact of the Federal Government by advancing energy efficiency and water conservation, promoting the use of distributed and renewable energy, and improving utility management decisions at federal sites
kilowatt-hour (kWh)	a unit of energy equal to the work done by a power of 1,000 watts operating for one hour; utility companies charge their customers based on how many kilowatt-hours they consume each month
load	any device that draws power from the electrical system and requires electricity to do work
outlet	a wall-mounted receptacle that is connected to a power supply and equipped with a socket for a plug
payback period	the amount of time that it takes for the annual savings to equal the initial investment
phantom load	the electricity draw created by devices that consume electrical energy even when powered off
plug load	the electricity draw created by any electrical appliance that plugs into an electrical wall outlet
wall cube	a cube-shaped transformer that plugs into the wall outlet to power a lower voltage appliance; changes 120 V AC power to low voltage DC power to provide power to many of our electronic devices in schools
watt meter	a device that measures the power consumed by an electrical appliance

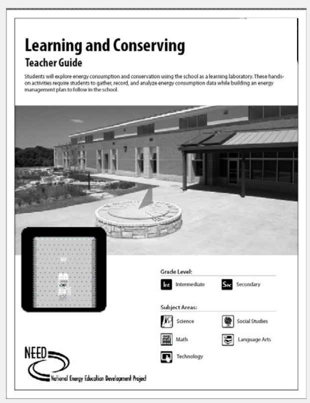
Learning and Conserving Kit

LEARNING AND CONSERVING AND KIT

Grades 7–12

In this activity, students explore energy consumption and conservation by reading utility meters and utility bills, comparing EnergyGuide labels, and exploring electric nameplates. Students conduct comprehensive surveys of the school building and school energy consumption—gathering, recording, and analyzing data, and monitoring energy usage. Students work in groups to develop comprehensive energy management plans for the school that include suggestions for retrofits, systems management, and conservation practices. The kit includes a Teacher Guide, class set of Student Guides, and the materials necessary to conduct the activities.

Levels:	Intermediate, Secondary
Teacher and Student Guides	$ 6.00
Learning and Conserving Kit	$ 275.00
Class Set of 30 Student Guides	$ 50.00


Learning and Conserving
Teacher Guide
Grade Level:
Intermediate
Secondary
Subject Areas:
Science
Social Studies
Math
Language Arts
Technology
NEED
National Energy Education Development Project

Check out the *2017-2018 Resource Catalog and Planning Guide* for more information on our efficiency and conservation kits.

www.need.org//Files/curriculum/guides/Catalog2017_18.pdf

OTHER EFFICIENCY AND CONSERVATION KITS

BUILDING SCIENCE

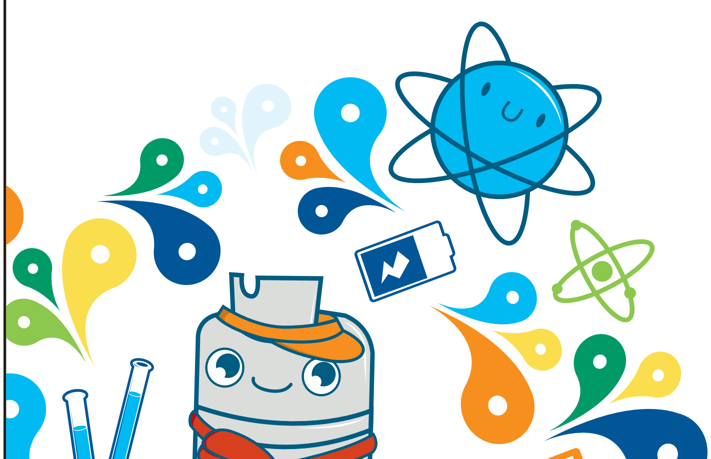
BUILDING BUDDIES

MONITORING AND MENTORING

YOUTH ENERGY CONFERENCE AND AWARDS

The NEED Youth Energy Conference and Awards gives students more opportunities to learn about energy and to explore energy in STEM (science, technology, engineering, and math). The annual June conference has students from across the country working in groups on an Energy Challenge designed to stretch their minds and energy knowledge. A limited number of spaces are available for Full STEM Ahead, a special two-day pre-conference event, which allows students access to additional information, time to discuss energy with their peers, and access to industry professionals. The conference culminates with the Youth Awards Ceremony recognizing student work throughout the year and during the conference.

For More Info: www.youthenergyconference.org



YOUTH AWARDS PROGRAM FOR ENERGY ACHIEVEMENT

All NEED schools have outstanding classroom-based programs in which students learn about energy. Does your school have student leaders who extend these activities into their communities? To recognize outstanding achievement and reward student leadership, The NEED Project conducts the National Youth Awards Program for Energy Achievement.

Share Your Energy Outreach with The NEED Network!
This program combines academic competition with recognition to acknowledge everyone involved in NEED during the year—and to recognize those who achieve excellence in energy education in their schools and communities.

What's involved?

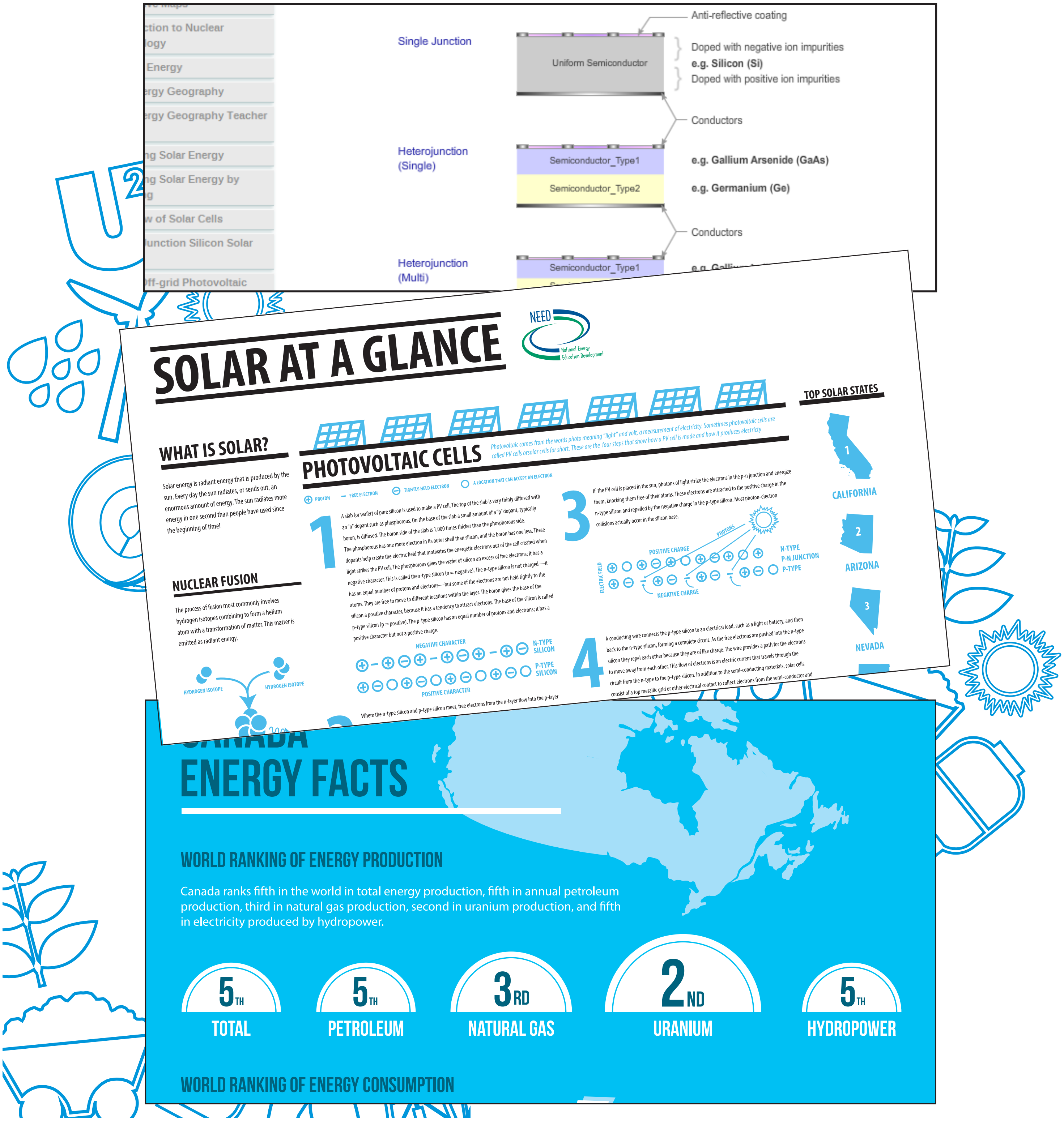
Students and teachers set goals and objectives and keep a record of their activities. Students create a digital project to submit for judging. In April, digital projects are uploaded to the online submission site.

Want more info? Check out **www.NEED.org/Youth-Awards** for more application and program information, previous winners, and photos of past events.

Awesome Extras!

Our Awesome Extras page contains PowerPoints, animations, and other great resources to compliment what you are teaching!

This page is available at www.NEED.org/educators.



Plug Loads Evaluation Form

State: ____________ **Grade Level:** ____________ **Number of Students:** ___________

1. **Did you conduct the entire activity?**	❑ Yes	❑ No
2. **Were the instructions clear and easy to follow?**	❑ Yes	❑ No
3. **Did the activity meet your academic objectives?**	❑ Yes	❑ No
4. **Was the activity age appropriate?**	❑ Yes	❑ No
5. **Was the allotted time sufficient to conduct the activity?**	❑ Yes	❑ No
6. **Was the activity easy to use?**	❑ Yes	❑ No
7. **Was the preparation required acceptable for the activity?**	❑ Yes	❑ No
8. **Were the students interested and motivated?**	❑ Yes	❑ No
9. **Was the energy knowledge content age appropriate?**	❑ Yes	❑ No
10. **Would you teach this activity again?**	❑ Yes	❑ No

Please explain any 'no' statement below.

How would you rate the activity overall?	❑ excellent	❑ good	❑ fair	❑ poor
How would your students rate the activity overall?	❑ excellent	❑ good	❑ fair	❑ poor

What would make the activity more useful to you?

Other Comments:

Please fax or mail to: **The NEED Project**
8408 Kao Circle
Manassas, VA 20110
FAX: 1-800-847-1820

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Petroleum Equipment and Services Association
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Quarto Publishing Group
Read & Stevens, Inc.
Renewable Energy Alaska Project
Rhode Island Office of Energy Resources
Robert Armstrong
Roswell Geological Society
Salt River Project
Salt River Rural Electric Cooperative
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