

How can you demonstrate the efficiency of different light bulbs?

A laboratory experiment from
the Little Shop of Physics
at Colorado State University



Overview

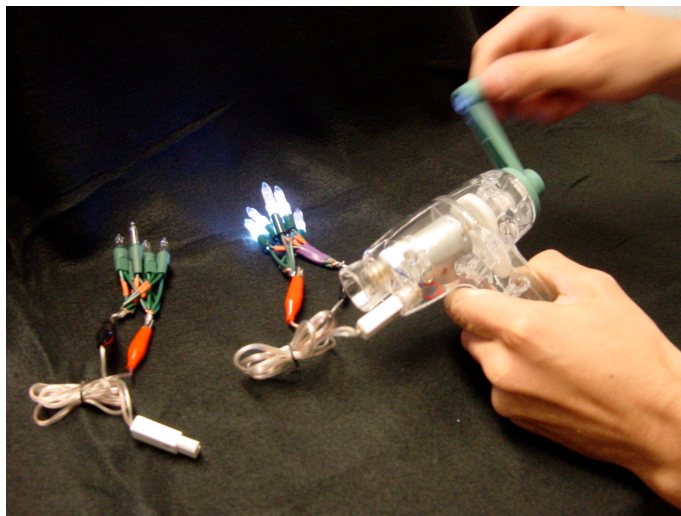
The answer to this question may be found in the following Confucian proverb:

“I hear and I forget. I see and I remember. I do and I understand.”

In this activity, students will actually feel the difference in energy required to light the two different types of light bulbs. We know that one type is more efficient... but feeling the difference helps students really understand.

Theory

There are two different types of light bulbs. The first type, the kind developed by Thomas Edison, using a simple physical principle: when you get something hot, it glows. The hot wire filament inside an incandescent



Feeling the differences in energy required to light different bulbs.

Necessary materials:

- 1 hand generator
- 2 alligator clip leads, 1 black and 1 red
- 1 cluster of 6 white LED Christmas tree lights
- 1 cluster of 6 clear incandescent Christmas tree lights
- Infrared goggles (optional)

Please don't use this activity as a demo. It's crucial that each student experiences cranking the hand generator for both types of bulbs and also gets to observe the brightness each produces. This activity would work well at a learning station or center for your students to rotate through.

light bulb gives off visible light, but it gives off a good deal of electromagnetic radiation that you can't see. A light bulb that uses 100 watts bulb of electric power only emits 4 watts of visible light. The other 96 watts are given off in the infrared spectrum. This infrared will end up as heat, so if you are using the bulb to heat something, that's OK, but, it isn't a very energy efficient way to create light. The second way to make something glow is to use electricity to excite individual atoms. This is the technique used in compact fluorescent and the newer LED bulbs. A compact fluorescent bulb can produce 4 W of visible light for an energy input of about 25 W—much

more efficient! LED bulbs are more efficient yet.

In this experiment, students will light two different types of bulbs using a generator to provide the power. Students will see that the bulbs are equally bright, but making this light with incandescent bulbs takes much more power input, and so they'll need to work quite a bit harder.

Doing the Experiment

Tell students that they have two jobs to do in this experiment. First they will watch and observe which of the two lights (the incandescent lights or the LED lights) seems brightest to them. Without telling anyone else, they should jot their observations in their notebooks. Secondly, they will each crank the hand generator for both sets of lights and decide which set of lights they think is more energy efficient and why. They should also record this information in their notebooks.

Before they begin, demonstrate how to attach the alligator clip leads to the two nails (electrodes) on the hand generator. Explain that you are attaching the black clip lead to the top nail and that this is the negative end. Now attach the red alligator clip lead to the other electrode, the positive end. Show them how to attach the red lead to one end of the incandescent cluster and the black lead to the other end. Explain that they will crank the generator and take notes on the bulb brightness and how it felt to crank it.

Explain that when they hook up the LED bulb cluster, one end of the cluster is marked positive and the other negative. They will need to hook these ends up accordingly, as in LEDs, the electricity only flows in one direction.

Before they begin, you will probably want to create a cranking rhythm, so your students are all turning the generators at a similar rate. Some teachers play music so that students crank to the beat.

After all of your students have worked with the bulbs and the hand generator, have them meet and discuss their findings. Many may be surprised at how easy it is to light the LED bulbs and how much more effort and energy it takes to light the incandescent. You may want students to slip on a pair of infrared goggles as they crank the generator and light the bulbs. They will notice that they can see which bulbs have wasted energy that we normally can't see.

Summing Up

This is a great activity for students to do as they can actually feel the energy difference it takes to achieve visible light from an incandescent bulb and an LED bulb.

For More Information

CMMAP, the Center for Multi-Scale Modeling of Atmospheric Processes: <http://cmmap.colostate.edu>

Little Shop of Physics: <http://littleshop.physics.colostate.edu>

Do things use electricity even when they are turned off?

A laboratory experiment from the
Little Shop of Physics at
Colorado State University



Overview

You may have heard it called by many different names: shadow loads, phantom load, idle current, vampire power.

These names refer to power used by appliances and other electronics that are plugged into the wall, but not powered on.

Some appliances use power even when they are turned off. Some sources estimate that up to ten percent of a household's use of electricity is used by items that are turned off but still plugged in and still drawing power.

This demonstration will give students an idea of which items are the ones that can be unplugged when not in use to save on power and which appliances do not draw power when turned off.

Theory

A power meter measures the power consumption or total energy use by appliances. If you plug a device into this meter, you can measure the power it uses, just as the electric utility measures the energy used by your household. What devices use power when they are plugged in but turned off? Look for things that have remote controls, continuous digital displays, rechargeable batteries, soft-touch keypads, things that are warm to the touch even when turned off, and devices that have power "bricks" or power packs. These are devices that have internal electronics in sleep mode, or transformers that draw power as long as they are plugged in.

Not everything left plugged in draws power. Hair dryers and toasters, for example, typically do not draw power when left plugged in and not in use.

It may be possible to eliminate five to ten percent of the energy costs of a household



This CD/radio/tape player uses energy even when it is turned off. The energy it uses depends on the function chosen.

Necessary materials:

- Power meter
- Power strip
- Small appliances such as hair dryer, microwave, battery chargers, televisions, radios

A power meter can be purchased for around \$25. We got ours from www.p3international.com. You may want to check with your local power company to see if they have a program to lend these to customers.

by unplugging or turning off a power strip when appliances are not in use. The Cornell Cooperative Extension estimates that United States households are using the “...equivalent of seven electrical generating plants just to supply the amount of electricity needed to support the standby power of our vampire appliances when they are off.”(1)

Doing the Experiment

We’ve had a good deal of fun trying out different devices. Some of the surprises we found:

- A radio/CD player/tape player used about 4 watts all the time, whether it was being used or not. When the CD player was in use and the volume was all the way up, it used about 7 watts. This is a player we only use once in a while, so we estimate that, during its lifetime, it has used 100x as much power as it would if we unplugged it when it wasn’t in use—something we now do.
- Cell phone chargers may or may not use power when they are plugged in. Some use 3 or 4 watts.
- As a test, we turned off every device in a whole house and looked at the electric meter. It was still spinning at a reasonable rate. Shadow loads at work!

As a classroom experiment, you should have your students explore:

- Have your students plug in different devices and measure the power used when they are turned on and turned off. This is a good chance for open exploration!
- The power meters can also measure cumulative energy use for a device over time. You can easily measure how much energy a device uses during a 24 hour period and then compute the true cost of a shadow load.
- Do some calculations! Estimate how much energy a household might use to support such shadow loads. How much does this come to on a national—or a global—scale?
- Have students brainstorm what things in their own houses they could unplug to make a difference in their own energy use.

Summing Up

Just because something is turned off doesn’t mean that it is not using electricity! It’s worth looking around your home to find the shadow loads lurking there....

For More Information:

(1) <http://www.news.cornell.edu/releases/Sept02/vampire.appliances.ssl.html>

CMMAP, the Center for Multi-Scale Modeling of Atmospheric Processes: <http://cmmmap.colostate.edu>

Little Shop of Physics: <http://littleshop.physics.colostate.edu>

Efficiency & Conservation

Increased efficiency of cars

GOAL

All cars in the world by must have a minimum fuel efficiency of 60 miles per gallon.

COSTS

This will require much more efficient engines and lighter weight vehicles.

Efficiency & Conservation

Reducing miles traveled by cars

GOAL

Reduce the yearly number of miles traveled of every car in the world by half.

COSTS

This will require better urban planning, increased use of telecommunication, and more use of mass transit.

Efficiency & Conservation

Increasing efficiency of buildings

GOAL

Increase (by 25%) efficiency of the space heating and cooling, water heating, lighting, and electric appliances in *all* new and existing residential and commercial buildings.

COSTS

This will require a dramatic increase in the efficiency of the buildings through insulation and other conservation measures.

Efficiency & Conservation

Increased efficiency of electricity production

GOAL

Double the efficiency of every coal plant in the world. (Coal is singled out because it is used to produce more electricity than any other fuel, and it releases more carbon per unit of energy.)

COSTS

A doubling of efficiency will require dramatic changes to the way coal is used to generate electricity.

Fossil-Fuel-Based

Fuel switching

GOAL

Retrofit 1400 coal-fired power plants to run on natural gas.

COSTS

This uses existing technology. Combined-cycle gas power plants produce much more energy per kilogram of carbon than coal plants. Nonetheless, this would be a major effort, and would increase costs.

Fossil-Fuel-Based

Carbon capture & storage (CCS)

GOAL

Capture all of the emissions of 800 coal or 1600 natural gas power plants and store the carbon dioxide underground.

COSTS

This is a technology that is still being developed. There are 3 pilot plants in the world. The technology would need to be scaled up and implemented very widely.

Fossil-Fuel-Based

Coal syngas with CCS

GOAL

Produce liquid fuels for transport from coal, and capture the carbon dioxide released in the process. 180 plants would be needed.

COSTS

This is a technology that is still being developed. New technologies will need to be developed, scaled up, and implemented.

Fossil-Fuel-Based

Fossil-based hydrogen fuel with CCS

GOAL

Produce hydrogen fuel from fossil fuels, and capture and store all carbon dioxide. Currently, hydrogen is generally produced from natural gas. The scale of this production will need to increase by a factor of 10, and all carbon will need to be captured.

COSTS

We can produce hydrogen, but we need to develop reliable ways to transport it and safely use it to fuel cars.

Nuclear Energy

Nuclear electricity

GOAL

Triple the world production of nuclear energy.

COSTS

This is a proven technology, but it has risks associated with waste storage and the possibility of the diversion of fuel or waste to weapons production.

Renewable Energy and Biostorage

Wind-generated electricity

GOAL

Increase worldwide wind power capacity by a factor of 30 and displace a corresponding amount of coal-fired power plants.

COSTS

The area required for the windmills would be approximately the size of Germany. Wind turbines are cheap to operate, but they require huge up-front costs.

Increase wind capacity by a factor of 30 and displace the corresponding amount of coal -based electricity.

Renewable Energy and Biostorage

Solar electricity

GOAL

Increase worldwide solar electric power capacity by a factor of 700 and displace a corresponding amount of coal-fired power plants.

COSTS

The area required for the solar cells would be approximately the size of New Jersey. Solar cells are cheap to operate, but they require huge up-front costs.

Renewable Energy and Biostorage

Wind-generated hydrogen fuel for cars

GOAL

Install 4 millions windmills to produce hydrogen from water and use it to power vehicles.

COSTS

The area required for the windmills would be approximately the size of France. This would require changes to cars, fueling systems, and the development of new networks for distributing hydrogen fuel.

Renewable Energy and Biostorage

Biofuels

GOAL

Increase the worldwide production of ethanol for vehicles by a factor of 30.

COSTS

The cropland required would be approximately the size of India. This would have dramatic effects on world food production.

Renewable Energy and Biostorage

Forest storage

GOAL

Halt all reduction in forest cover worldwide.

COSTS

The countries where deforestation is taking place would need to be compensated.

Renewable Energy and Biostorage

Soil storage

GOAL

All cropland in the world would be managed to reduce carbon production.

COSTS

This would be quite difficult to implement.