Rolling Blackouts & Environmental Impact – What Are Our Electricity Options?

Making the Connection
Women in Engineering Programs & Advocates Network (WEPAN) Project Funded by Lucent Technologies Foundation

1. This unit explores options for creating electricity from available resources.
2. This activity helps students make a connection between engineering design trade-offs and the electric energy we require.
3. This activity has a resource page that provides background information.

Environment

Grades 11 & 12 (suggested)

Objective

The goal is for students to understand the environmental design considerations required when generating electricity. The electric power that we use every day at home and work is generated by a variety of power plants. Power plants are engineered to utilize the conversion of one form of energy to another. The main components of a power plant are an input source of energy that is used to turn large turbines, and a method to convert the turbine rotation into electricity. The input sources of energy include fossil fuels (coal, natural gas, and oil) wind, water, nuclear materials, and refuse. This activity focuses on how much energy can be converted to electricity from many of these input sources. It also considers the impact of the by-products associated with using these natural resources, and looks at electricity requirements. To do this the students will research and evaluate the electricity needs of their community, the available local resources for generating electricity, and impact of using those resources.

Skills & Standards

- Assessment of systems to meet needs.
- Understand the role of society in development and use of technology.
- Use design process to brainstorm, research, develop a model and communicate the results.

Activity Outline

Materials required per group:
- Poster board
- Markers
- Copies of Reference Sheet 1 and Worksheets 1 and 2

One or two weeks before you arrive:
Send the classroom teacher copies of the *Preparation Worksheet* to distribute to students as homework prior to the activity. This prep work may require 2 hours of student time.

Time frame:
Part 1: 20 minutes
Part 2: 45-60 minutes

Overview of Presentation

Briefly explain engineering.(See Presenter's Guide for more detail.)
Engineers use scientific information to design and create useful things. In designing and creating, the engineer goes through a problem solving process in which logic is an important component.

Introduce the activity to the students.
Have a general discussion about where electricity originates. Encourage the students to share any knowledge they have had with how electricity is generated or what they know about power plants. (See Activity Resource Page).

Begin the activity.
Before doing the activity, present the '*problem*' and '*who wants to know*'.

Do the activity.
Be flexible during the activity. Invariably, the group will get "hung up" somewhere in the task, needing or wanting more time on an issue. Encourage students to explore issues that interest them.

Reflect on the activity.
After the activity is completed spend time discussing what was discovered and learned. Discuss the advantages and disadvantages of the different sources of energy that can be used for generating electricity. Explain that there are no rights or wrongs, just matters of preference or availability of materials.

Career Connection
Discuss what types of engineering jobs are involved with designing, building, and running power plants.

Activity: Developing a Design to Meet Your Power Needs

The students will act as energy consultants for the planning board of a hospital. A critical part of the consultant work will focus on predicting needs, resources, and impact around the projected electrical power needs of this new hospital. The activity has been developed based on a traditional engineering design process which pose key questions – all identified in boldface type, that help the students approach the problem as engineers.

What's the problem? In certain sections of the country the amount of electricity that is available is not enough to meet the requirements of the area. This results in rolling blackouts that impact all citizens and businesses.
Who wants to know? The HMT Corporation is going to build a new hospital in your community. They want to ensure that the hospital is not impacted by any energy crisis. In order to do this, they want the hospital to have its own power plant. They want to know what the electricity requirements will be for the hospital when it is operating at full capacity.

Part 1: Establish the Baseline – Who needs electricity, and how much do they need?

1. Divide the students into groups of 2-3 and pass out Worksheet 1 to each group. Lead a discussion about who uses electricity (See Activity Resource Page). Which type of user (home, transportation, businesses and industry) do the students think are the largest consumers of electricity? Which group uses the least amount? What is the justification of the students for how these compare?
2. Have each group estimate on Worksheet 1 the percentage of electricity used by the four types of users.
3. Compare the predictions of each group. As a class, decide if you want to use the average value from the predictions for all the groups, or if each group wants to use their own predictions. These estimates will be contrasted to actual numbers gathered by the groups.
4. If you have access to the Internet, have the groups research what the actual average break down is for each of the groups. If Internet access is not available, or time doesn't permit, use the values provided on the *Leader's Resource Page*.
5. Have the groups use the personal electricity data that they have brought with them. What is the average kW//hr use for the group? Share this information to determine a kW/hr average for the entire class.
6. Discuss the resulting average and how it might vary over the course of a day, month, and year. Is there an overall group consensus on a peak demand time for electricity? Does it vary based upon the type of user? Does it vary based upon location in the country?

Part 2: What are our resources for creating electricity?

How can you help solve the problem? Your teams have been hired by HMT Corporation to estimate the power requirements of a new hospital when it operates at full capacity. The hospital is being designed to accommodate 500 patients plus all the support staff. Given that a hospital is like a small community with similar power needs for the basic four groups (home, transportation, businesses, and industry), determine what are the resources of your locality that can be used for the hospital power plant? What are the impacts of your recommendation?

7. Reinforce that the hospital is being considered for a neighboring community with resources similar to yours. Discuss where the electricity in your town comes from. What is the input source of energy? Do you have other options for energy that are readily available? You may wish to create a list as the students suggest them.
8. Present the students with the current town/hospital statistics provided on the *Leader's Resource Page* OR provide them with values that more closely represent a local community in your area.
9. Change the groups so that there are now 2 or 3 larger groups. Have each group begin working as individual consulting teams for the HMT Corporation. Pass out Worksheet 2 that outlines their objectives, and Reference Sheet 1 with energy conversion efficiencies.

Will your suggestion(s) work Have each student group present their proposal, including a discussion of why they selected the energy source they chose. Do they feel that their suggestion is worth pursuing?

10. Lead a discussion on the trade offs required for any of the choices. Every one of them has some impact on the environment.

Which types of engineers can help you solve the problem? What type of information or knowledge is needed to design and build power plants? Mechanical, structural and electrical engineers design the power plants. Input energy sources are worked on by mining, petroleum, ocean, and environmental engineers.

Engineering Summary: Finish with a discussion about how students approached the problem like engineers.

Activity Resource Page

Background Information for Activity Leader

Electricity is vital to our everyday life. We assume that there will continuously be enough for us, but this is not always true. Each power plant has an upper limit to the amount of electricity it can generate. If the demand is greater than the supply, then there are brownouts and blackouts. As our population grows, the demand for electricity increases.

New power plants can be built to help meet the demand. Each power plant requires a source of input energy that is then converted to electricity. This conversion is most often done by creating steam that is driven through large, fan like turbine blades. This causes the blades to rotate, and spin the shaft on which they are connected. The other end of the spinning shaft is then used to generate electricity using the rotation and magnetic fields.

The input energy can be a fuel, such as coal, oil, or natural gas. Burning the fuel heats the water to create the steam for the turbines. Fossil fuels are non-renewable resources that create a variety of pollution when burned. Solar energy is also used to heat water and create steam for the turbines. Since it doesn't have to be burned, there are no bad by products or pollution. However, solar energy is not very efficient for this process. The energy given off from the splitting of atoms during nuclear fission is another input source for creating the steam. Nuclear power generates radioactive by products during the fission process. Geothermal energy from within the earth can be used to as the steam that spins the turbine blades. The are very few locations around the world where geothermal temperatures are high enough to be used as the input energy.

There are also ways of generating electricity without using steam to spin turbine blades. Hydropower uses water that is falling to spin turbine blades. Usually a dam is required to maintain the water height, and this impacts the water life in the area as fish can no longer travel upstream.

Wind can also used to spin the great blades on windmills. This rotation is then used to generate electricity. Wind power is dependent on consistent winds above 12 miles per hour. Tidal or wave energy can be used to spin turbine blades. This is only effective where there are large variations in height.

Questions to Ask

As you go through this activity with the students you should encourage them to think about what they know about different types of communication methods and how fiber optics differs from other types.

Q: What things in your house or apartment do you think use electricity?
A: There are many things that require electricity for our day to day comfort. They include heating and air conditioning, hot water for showers & dish washing, lights, TV, stereo, stoves, computers, washing machines, dryers, kitchen appliances (mixers, blenders), vacuum cleaners, and clocks.

Q: How could we reduce the demand for electricity?
A: Conserving how much electricity we use and purchasing items that have been designed and built to be more energy efficient will reduce the demand.

TIPS

Involve a local expert to enhance the activity. Contact the engineering school at a local university, WEPAN at www.wepan.org or Society of Women Engineers at www.swe.org.

Potential Safety Issues

None

Vocabulary Words

Brownout – a reduction in available electricity level due to high demand.
Blackout – a power failure
Turbine – an engine driven by the pressure of steam, water, or air pushing on curved blades.

Expanding the Activity

1) Research how many power plants are in your state. What is their total electrical output? What do they use for their source of energy? How might this affect your state in the long run?

Additional References

www.energy.ca.gov/education/story/story-html/story.html
www.eia.doe.gov (Energy information admin.)
www.cleanair.net/PowerPlants/campaign.htm
www.epa.gov/acidrain/emission/
www.airhead.org
www.insc.anl.gov/pwrmaps/map/world_map.html (nuclear power)
www.howstufworks.com/nuclear-power.htm

Reference Sheet 1

Input energy source	Efficiency when converted to electricity	Advantages	Disadvantages
Solar energy	15%	Inexhaustible source	Need a large surface area. Not effective in areas with large percent cloud cover
Hydro	80%	Inexhaustible source	Impacts the ability of fish to travel up or downstream. A dam is typically required.
Wind	30%	Inexhaustible source	Need constant winds of at least 12 mph.
Natural gas	30%	Readily available	Produces air pollution and gases that add to the green house effect. Drilling impacts the land.
Coal	30%	Readily available	Produces air pollution and gases that add to green house effect. Mining impacts the land, Sulfur emissions creates acid rain.
Oil	30%	Readily available	Produces air pollution and gases that add to green house effect. Drilling impacts the land. Sulfur emissions creates acid rain.

Additional resource site about natural gas:
www.energysource.com/energyexperts/natural_gas_facts/EnergySourceGasEfficiency.html

Preparation Worksheet

1. **Do a search for articles related to the nation's energy problems. Select and read at least one article that you can share with the group.**

   Some suggested online sources are:
   http://www.pge.com/006_news/current_issues/energycrisis/index.shtml
   http://www.caiso.com/newsroom/releases/

   You can also look in newspapers or find other online sources.

2. **Make a list of all the energy resources that you can think of, and then write down the pros and cons associated with each type.**

Type of Energy	Pros	Cons

3. Bring in either a copy of your electricity bill (to show usage) or note on a separate piece of paper what your family's usage is.

An interesting resource site for California shows actual and predicted energy demands. http://www.caiso.com/SystemStatus.html

WORKSHEET 1

Names of Group Members _____

_____

_____

Your Prediction:

Type of user in your community	Prediction: % of electricity used	Actual: % of electricity used
Individual residences (homes & apartments)		
Businesses (stores, shops, etc.)		
Industry (plants that produce products)		
Transportation (ways of getting around)		
	TOTAL = 100%	TOTAL = 100%

WORKSHEET 2

Names of Group Members _____

_____

_____

Consulting Team Objectives:

- Calculate electricity needs of new hospital.
- Develop 2 <u>different</u> proposals for what type of energy should be used to generate the projected increase in demand. Each proposal should be a short paper or poster which shows:

  a) Predicted electricity demand and rationale

  b) Amount of input energy required for the suggested resource (use % efficiency values from teacher resource)

  c) Translation of what that means in volume or size
  For example, 3kW hr of solar input = ___ (how many) solar panels that are _____ (width) x ____ (length)

  d) The potential impact(s) of using the energy source

Leader's Resource Page

Type of user (national average)	% of electricity used (total to 100%)
Individual residences (homes & apartments)	22%
Businesses (stores, shops, etc.)	18%
Industry (plants that produce products)	28%
Transportation (ways of getting around)	32%

Total = 100%

Within a residence, the energy break down is:	
Space Heating	50%
Air conditioning	4%
Water heating	19%
Appliances	27%

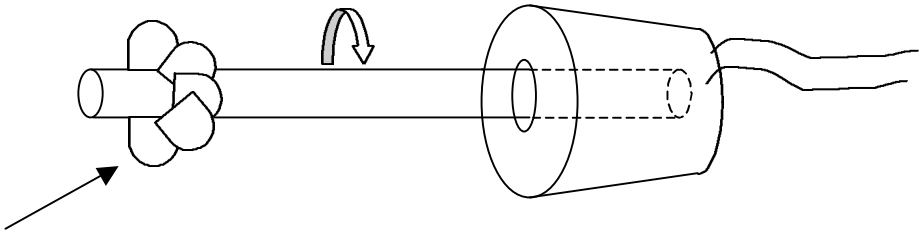
Total = 100%

This information pertaining to communities can be generalized to a hospital setting that is the focus of this activity. For example:

Community	Hospital
Individual Residences	Patients rooms and doctors' offices
Businesses	Nursing stations, medical supply area, gift shop, cafeteria
Industry	Food services operation, hospital heating air conditioning, alarm systems
Transportation	Elevators, escalators

How a Power Plant Works

Open system: fluid moves through (wind & hydro)

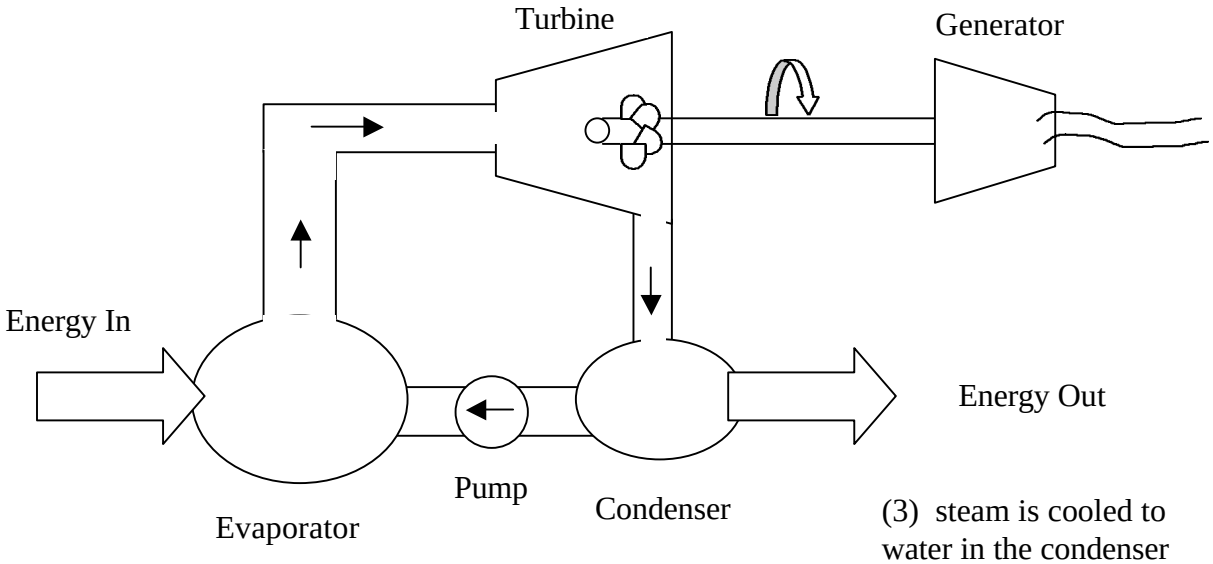


(1) moving fluid makes the turbine blades turn

(2) this spins a magnetic field in a coil, creating electricity in the generator

Closed System: fluid remains in the system, changing states from water to steam and back to water.

(2) steam turns turbine blades and generates electricity like the open system



(3) steam is cooled to water in the condenser

(1) energy from source heats water and creates steam in the evaporator

(4) water is pumped back to evaporator