MATERIALS

- *Northwest Power System Game Maps*
- *Resource cards (showing costs, energy production, and environmental impacts)*
- *Siting cards*
- *Current Events cards*
- *Load Growth Scenarios Chart*
- *Resource Card Facsimile Sheets*

In this game, students make choices among various types of electric power facilities to meet future energy needs, striking a balance between costs and environmental impacts. This section outlines various ways the game can be played.

The objective of the Power Game is to give students the experience of choosing resource alternatives to meet a growing but uncertain demand for electricity. Students must purchase resources, site them somewhere in the Pacific Northwest, and examine the economic and environmental consequences of their actions. There are not necessarily winners or losers in this game, although some strategies will be more successful than others in keeping economic costs down and maintaining a healthy environment. Emphasize to the students that these are the real decisions facing the Northwest's energy future— their future.

Students have acquainted themselves with the various types of resource choices and understand the basics of resource choices and environmental impacts. They may refer to their notebooks with the information they learned from Sections 1 and 2.

Resource Cards: Each card shows typical amounts of energy such a plant can produce in megawatts (It takes about 1,000 megawatts to power a city the size of Seattle). Resource cards show three costs associated with the resource. Focus first on the annual cost, this is a weighted combination of the purchase and operating costs shown on the cards. The purchase price is how much it costs to build the power plants. The yearly cost of operating the plants is shown as the "operating cost." Related environmental considerations are summarized on the backs of the cards.

Stack resource cards by resource type (for example, all solar cards go together) facing up. Some resource types have as many as three different colors. Those cards must be sorted so that the red cards are on top, followed by yellow cards, and finally the white cards. The different colors represent different costs for that resource as more are purchased. Prototypes of new technologies are more expensive, and then typically the price goes down. Conservation prices go up as the least expensive measures are taken first.

Hydropower resource cards are blue. They do not list purchase prices because no more hydropower is available to be bought. The region's major hydropower facilities have been installed. Some small hydro may be developed, but not in any significant amounts.

Resource Card Facsimile Sheets: These handouts replicate the resource cards in miniature. They are handed out to students to remind them of the costs and other features of the resources they will be purchasing.

Siting Tokens: Siting tokens represent each of the resource types in symbolic form. They are issued with resource cards for students to place on the map board. Students need to consider the availability of power lines or load centers, wind or sun for those resources, and the potential damage to air and watersheds in the vicinity.

Current Events Cards: Sometimes the Load Growth Scenarios Chart will indicate that the teacher should pick a lavender-colored Current Events card. These cards change the course of the game in several ways. They may change the loads, the availability or price of resource cards, or resource performance. For example, a card may say "there has been a breakthrough in solar cell technology and that the price of solar resources will be reduced by 50 percent for the remainder of the game."

Load Growth Scenarios Chart: The Load Growth Scenarios Chart should be kept by the teacher in confidence from the students. The chart incudes several growth scenarios to choose from. The teacher may select one set of numbers to use. Each set of numbers represents a future Northwest growth scenario. The chart shows the loads for each round of play. It also shows the amount of available hydropower— hydropower availability varies from year to year depending on precipitation. Operating costs (high, medium, or low) are also shown.

PRACTICE SESSION

Have student teams practice purchasing resource cards to get used to the numbers involved. Resources cost different amounts, but they also produce different amounts of energy. Advanced students may separately calculate a dollars per megawatt cost for each type. For each resource, students compare the annual costs, list the environmental advantages and disadvantages, and indicate the amount of power produced by their cards. Teams site resources by placing siting cards on map boards.

THREE APPROACHES TO THE POWER GAME

Three ways to play the Power Game are described below. These include two simpler versions of the game that expand on the practice session. The third is a full simulation which requires more time and the ability to keep track of more variables than the simpler versions.

Version 1: Meeting Set Energy Goals

By some estimates, the Northwest is likely to need some 3,000 megawatts of new resources over the next 10 years. This exercise has students select 3,000 megawatts of resources they would like to add to the region.

Students break into teams representing power companies. Have students select names for their companies. Each team will come up with an energy plan for the Northwest. Hand out Resource Card Facsimile Sheets to each group. They must choose enough resource cards to meet 3,000 megawatts of increased demand.

The resource cards are color coded. For a given resource type, all of the red cards (if any) must be chosen first, yellow cards second, and white cards last. This represents limited availability of some resources, and maturing technology of others. Teams should be given plenty of time to select resources (perhaps 10-15 minutes or longer with older students who may want to calculate relative costs). Allow students to select resource cards at any time throughout this period (there is some strategy involved with selecting the red cards, or waiting for the availability of other colors).

Have the power companies add up the annual cost of all their resource cards. The following table lists the annual costs of the resources (in millions of dollars):

	Red	Yellow	White
Conservation	$20	$40	$80
Cogeneration			$30
Combustion Turbines		$90	
Coal			$200
Wind		$50	$30
Nuclear			$450
Geothermal	$120	$60	$60
Solar	$200	$160	$100
Hydro	Not available (major rivers already dammed)		

Note that the annual costs of resources does not reflect the **relative** cost of the resources because some produce more power than others. The following table can be used to roughly assess the relative costs of these resources.

Relative annual costs of resources per 100 megawatts (in millions):

	Red	Yellow	White
Conservation	$10	$20	$40
Cogeneration			$30
Combustion Turbines			$30
Coal			$40
Wind		$50	$30
Nuclear			$55
Geothermal	$60	$30	$15
Solar	$100	$80	$50
Hydro	Not available (major rivers already dammed)		

The students discuss: Which team had the most expensive plan and which the least expensive? What were the teams' strategies for meeting loads; how did they differ? How did the teams decide on the resource plans—did they vote; were there "experts"; did one or two students end up dominating the group? How were dissenting views dealt with—did everyone on the team agree? How were environmental and economic concerns resolved? How are differing opinions dealt with when utilities make these kinds of choices?

One recent regional plan suggested the following combination of resources:

Conservation	1,500 megawatts
Cogeneration	300
Combustion Turbines	700
Wind, Solar, Geothermal	400

Are any of the students' plans similar to this one (none can be identical because of the way the resource cards were made—for example, combustion turbines can only be bought in multiples of 300 megawatts). What does this plan reveal about the strategy of Northwest power planners? Can the student teams compare their plans and come up with a single plan?

The regional plan outlined above represents an annual cost of about $800 million. How did the students' plans compare with it in cost? Every $100 million over $800 million means that students or their parents will pay an extra $25 per year for their electricity. Ask the students what their family would have to do without to be able to pay the extra money their plans require. Would they change their resource plans in light of that?

Version 2: Changing Goals and Introducing Different Variables

Follow the directions under version 1 until about half way through the students' resource selections. At that point select one or more current events cards. The teacher selects these cards to force students to consider some of the real world variables that complicate planning for the future. Ask similar questions as in version 1. Ask the students how the current event changed their ideas about what resources to buy. Would students change their strategies next time given other possible current events? You may want to read several or all of the current events cards so students understand what can happen.

Full Simulation of the Power Game

To Start:

Players divide into groups of three or more. Each group represents an electric utility and invents a name for itself. Utilities will meet the demand for electricity (or "load") with resources represented on resource cards. There are nine different kinds of resource cards —nuclear, coal, solar, conservation, wind, cogeneration, combustion turbines, geothermal, and hydro. The resource cards are replicated for the students' use on Resource Card Facsimile Sheets which are handed out at this time.

Each utility is issued a set of resource cards at the beginning of the game. The initial set includes one nuclear, two coal, and one hydro resource card. The cards indicate the amount of electricity that can be produced by that resource (except hydro which will be explained below).

Separate the remaining resource cards by resource type (coal, nuclear, solar, etc.) in piles. Most of the resource cards are white; others are red or yellow. Stack all resource cards of a given type (e.g., solar) together, with the white cards on the bottom, followed by the yellow cards, and finally the red cards on top, all facing up.

The teacher has a Load Growth Scenarios Chart which provides information to be given to the students as the game progresses. To begin the game, the teacher writes on a chalk board, or other prominent place "3,800 megawatts." This is the amount of power needed by each utility to serve its customers at the start of the game. The utilities must possess enough megawatts in their resource cards to equal the amount written on the board (their is a cost penalty for failing to do so).

On the top line of each resource card is shown the amount of electricity the resource can produce (except for hydro). The hydro resource card produces 2,000, 3,000, or 6,000 megawatts depending on the play of the game, as described below. The initial set of resources will give the utilities enough power to meet 3,800 megawatts even at the lowest level of hydro production.

The play begins with each utility buying additional resource(s) to add to the ones already issued. Tell the students that there is a good chance the loads (the 3,800 megawatts) will increase on the next round by 100 megawatts, and maybe by as much as 200. It is possible that the loads will go down as well. Utilities may choose not to buy any resources if they desire. Utilities buy resources from the teacher.

The purchase price of each resource is listed on the resource cards under "Purchase Cost." Utilities may not purchase additional blue hydro resource cards because there is almost no more hydropower available in the Northwest to buy. The utilities may spend as much money as they wish during the game. The teacher will keep track of how much money each utility spends on buying and operating resources through the course of the game. A worksheet is provided for the teacher (or designated student) to keep track of how much the utilities spend. The total for each utility will be calculated and discussed at the end of the game.

The Play:

Each round of the game corresponds to the passage of one year. Rounds begin with the teacher reading new loads off the Load Growth Scenarios Chart. Utilities then make their resource choices for that round in order to ensure themselves enough resources to meet the load. The teacher records resource purchases in the Power Game Record Sheet for each utility. Students use siting tokens to place selected resources on the map board. The teacher picks and reads a Current Events card if indicated for that round in the Load Growth Scenarios Chart.

After resources have been selected, the teacher reads operating costs and hydropower availability from the Load Growth Scenarios Chart. The high, medium, or low operating costs correspond to figures on the resource cards. Hydro availability shows how much hydropower is available for that round.

Each utility sends a representative up to the teacher with enough load resource cards to meet the new load. The teacher verifies that each utility has brought enough resources and writes down all the operating costs for that utility in this round. Utilities pay high, medium, or low operating costs depending on the information provided from the Load Growth Chart.

If a utility brings more megawatts to the teacher than the amount of the load for that round, the teacher credits their account $10 million for every 100 megawatts they exceed the load. This represents a sale of surplus power to other utilities. If a utility does not have enough resource cards to meet the load, the teacher will add a charge of $100 million for every 100 megawatts they fall short of the load. This represents emergency purchases of power from other utilities.

Cooperating Utilities:

Utilities often find it to their advantage to share the cost of buying some resources. This is especially helpful in buying large resources such as coal and nuclear. It is also a useful strategy in buying new or experimental technology resources such as solar and geothermal. You may also allow utilities to buy and sell power to avoid the credits and charges described above. Although allowing these transactions complicates the game for the teacher, it may be desirable to show this feature of the power system.

Concluding the Game:

At the end of the game, the teacher adds up the amount of money in each utility's account. Before revealing this information to the players, each utility adds up the amount of megawatts it possesses and writes the total where all can see. Hydro is assumed to be 2,000 megawatts.

The teacher can then ask each utility about its experience. What went well, what didn't? What was their strategy for meeting loads? How did they take into account the environmental impacts of their resource choices? Where did they site the resources (e.g., are resources sited in scenic areas, near existing transmission lines, alongside other resources, near the source of the energy, near load centers, etc.)?

The teacher may then reveal to everyone what the utilities spent over the course of the game. Generally, spending less is better since it means lower electric bills. Everyone can discuss whether there were tradeoffs between environmental impacts and economic costs. The teacher may ask students what they might do differently if they were to play the game again. Finally, the students can choose which utility seemed to have the best strategy for meeting loads.

If time permits, students will gain more insight by playing the game a number of times. Each time students play the game, they can examine the benefits of different resources and resource strategies.

Summary of the Flow of the Game:

1) Initial set-up: distribute resource cards; teacher writes 3,800 Megawatts for students to see.

2) Pick current events card, if indicated.

3) Utilities buy resources; teacher records costs.

4) Adjust loads, report hydro generation and operating costs from Load Growth Scenarios Chart.

5) Utilities present resource cards; teacher records operating costs.

6) Repeat steps 2 through 5, up to 20 times.

7) Reveal total money spent and conduct end-of-game review.

Game Notes:

Students find it easier to calculate what resources they need to show the teacher if the teacher calls out how many megawatts they need in addition to the hydro card. For example, it is easier for students to find 1,800 megawatts of non-hydro resources than 3,800 megawatts of total resources.

The costs of solar, geothermal, and wind resources go down as more of them are purchased. Each different color represents a different resource cost. Conservation costs increase as more is purchased. There is a fairly significant limit to the number of conservation and cogeneration cards.

The siting tokens may be placed on a map of the Northwest to indicate where utilities have sited their resources at the time of purchase, or at the end of the game. The teacher may elect not to make use of this part of the game.

For more information on the Power Game, please call Ken Dragoon, Section Chief of the Hydro Resource Analysis Section, Bonneville Power Administration, at (503) 230-3000.