

# Student Guide

## YOUR MISSION

Your team has been hired by the governor of Essowess to develop a plan to expand the electricity capacity for the country. The country is growing and has begun to experience brownouts during peak demand times. Your mission is to develop a plan that will meet the electricity demand of Essowess economically, while maintaining the quality of the country's environment.

Essowess has many energy resources that can be used to produce the electricity it will need in the future. You can use any mixture of sources, and as many of each as allowed, as long as you produce the required amount of electricity, while staying within your budget and maintaining the environmental quality of the country. You must convince the governor and the citizens of the country that your plan is the best possible plan for everyone, in terms of jobs, the environment, and the cost of electricity and changes in lifestyle. If your plan costs more than is budgeted, damages the environment more than is acceptable, or raises the cost of electricity, you must win the approval of the Citizens' Council.

## YOUR GOAL

	<b>CURRENT STATUS:</b>	<b>YOUR GOAL:</b>
<b>Capacity:</b>	<b>1,000 MW</b>	<b>1,500 MW</b>
<i>20 Modern Plants @ 40 MW</i>	800 MW	
<i>5 Old Plants @ 40 MW</i>	200 MW	
<b>Economic Cost:</b>	<b>1,000 energy bucks (\$\$)</b>	<b>1,700 energy bucks (\$\$)</b>
<i>20 Modern Plants @ 40 \$\$</i>	800 \$\$	
<i>5 Old Plants @ 40 \$\$</i>	200 \$\$	
<b>Environmental Cost:</b>	<b>1,050 enviro-units (EU)</b>	<b>1,200 enviro-units (EU)</b>
<i>20 Modern Plants @ 40 EU</i>	800 EU	
<i>5 Old Plants @ 50 EU</i>	250 EU	
<b>Cost of Electricity:</b>	<b>\$0.05 kWh</b>	<b>\$0.05 kWh</b>

## YOUR OPTIONS

### CURRENT FACILITIES

At the present time, 25 coal-fired plants provide Essowess with all of its electricity. Twenty of the plants have modern pollution control devices. Five of the plants are old and must be modernized because they have no pollution control devices. When the old plants are modernized, their total environmental impact remains the same, but their capacity is increased, resulting in lower environmental impact per megawatt.

#### TO MODERNIZE EACH OLD PLANT:

<b>Economic Cost (to modernize):</b>	<b>15 \$\$</b>
<b>Economic Cost (job gain):</b>	<b>-5 \$\$</b>
<b>Additional Capacity:</b>	<b>10 MW</b>
<b>Additional Environmental Impact:</b>	<b>0 EU</b>
<b>Cost of Electricity:</b>	<b>\$0.05 kWh</b>

## OPTIONS CONTINUED

**COAL-FIRED PLANTS:** Coal is an abundant resource in Essowess. The country has a 150-year supply of coal at the current rate of consumption. Half of the reserves, however, are located in wilderness areas.

<b>TO BUILD EACH PLANT (NO MAXIMUM):</b>	
Economic Cost (to build):	50 \$\$
Economic Cost (job gain):	-10 \$\$
Capacity:	50 MW
Environmental Impact:	_____ EU
Cost of Electricity:	\$0.05 kWh

**WIND FARMS:** There are not many places on Essowess that have consistent winds. Along the eastern coastline, however, the wind blows at a rate that would run wind machines most of the year. Some residents along the coast would like to turn the area into a tourist area with resort hotels. Wind farms cannot be counted on to produce electricity 24 hours a day, every day of the year. For every wind farm you build, you must add 1 MW to your capacity goal of 1500 MW.

<b>TO BUILD EACH WIND FARM (MAXIMUM 5—DETERMINED BY SITES WITH ACCEPTABLE WIND SPEED):</b>	
Economic Cost (to build):	10 \$\$
Economic Cost (job gain):	-2 \$\$
Economic Cost (land use loss):	1 \$\$
Capacity:	10 MW
Environmental Impact:	_____ EU
Cost of electricity:	\$0.04 kWh

**HYDROPOWER PLANTS:** The powerful Aichtuwoe River flows from the Osohi Mountains through farmland and a national park to the coast of Essowess. Two hydroelectric dams could be built on the river to produce electricity. There is no other river that can be dammed to produce hydropower.

<b>TO BUILD EACH DAM (MAXIMUM 2—DETERMINED BY ACCEPTABLE SITES ON RIVER):</b>	
Economic Cost (to build):	100 \$\$
Economic Cost (land use loss):	20 \$\$
Economic Cost (job/recreation gain):	-10 \$\$
Capacity:	50 MW
Environmental Impact:	_____ EU
Cost of electricity:	\$0.01 kWh

**NUCLEAR POWER PLANTS:** Essowess has an abundance of uranium that could be mined and processed, providing jobs for many people, if there were a demand. Many people are concerned about nuclear power plants because the country has no place at present to store the spent fuel.

<b>TO BUILD EACH PLANT (NO MAXIMUM):</b>	
Economic Cost (to build):	100 \$\$
Economic Cost (job gain):	-15 \$\$
Capacity:	100 MW
Environmental Impact:	_____ EU
Cost of electricity:	\$0.07 kWh

## OPTIONS CONTINUED

**WASTE-TO-ENERGY PLANTS:** The non-recyclable trash in Essowess is currently being landfilled. The combustible material in that trash (such as plastics, organic wastes, paper products, etc.) could be burned to produce electricity and reduce the amount of trash sent to landfills. There is enough combustible trash produced to fuel two power plants at the present time.

**TO BUILD EACH PLANT (MAXIMUM 2—DETERMINED BY AMOUNT OF ACCEPTABLE TRASH):**

Economic Cost (to build):	20 \$\$
Economic Cost (decreased disposal):	-3 \$\$
Capacity:	10 MW
Environmental Impact:	_____ EU
Cost of Electricity:	\$0.07 kWh

**NATURAL GAS PLANTS:** At present, there is no available natural gas supply on Essowess to fuel natural gas power plants. Geologists believe there are offshore deposits; however, a production and distribution system must be built. This would increase the investment cost, but also provide jobs.

**TO BUILD EACH PLANT (NO MAXIMUM):**

Economic Cost (to build):	80 \$\$
Economic Cost (job gain):	-30 \$\$
Capacity:	50 MW
Environmental Impact:	_____ EU
Cost of Electricity:	\$0.06 kWh

**GEOHERMAL POWER PLANTS:** Several high temperature geothermal reservoirs are located in a wilderness area named for the country's founder, who is buried in a shrine near one of the reservoirs.

**TO BUILD EACH PLANT (MAXIMUM 3—DETERMINED BY NUMBER OF RESERVOIRS):**

Economic Cost (to build):	30 \$\$
Economic Cost (job gain):	-5 \$\$
Capacity:	20 MW
Environmental Impact:	_____ EU
Cost of Electricity:	\$0.04 kWh

**SOLAR POWER PLANTS:** The amount of solar radiation in all seasons and in all locations in the country makes it possible to use photovoltaic power plants to produce electricity. Solar systems, however, do not produce electricity 24 hours a day or every day of the year. For every solar plant you build, you must add 1 MW to your capacity goal of 1500 MW.

**TO BUILD EACH PLANT (NO MAXIMUM):**

Economic Cost (to build):	30 \$\$
Economic Cost (job gain):	-2 \$\$
Economic Cost (land use loss):	2 \$\$
Capacity:	10 MW
Environmental Impact:	_____ EU
Cost of Electricity:	\$0.02 kWh

# FACTS ABOUT ENERGY SOURCES & POWER PLANTS

## COAL-FIRED PLANTS:

- use an abundant domestic resource—coal.
- burn coal—the mining of which can damage land and pollute water if not managed well.
- emit some pollutants into the air when burned, even if advanced anti-pollution measures are installed.
- produce carbon dioxide (CO<sub>2</sub>) when burned.
- use a nonrenewable resource as fuel.

## WIND FARMS:

- require a lot of land, but the land can also be used for other purposes.
- do not produce electricity all of the time.
- sometimes make noise and may kill birds, but do not pollute the air or water.
- use an energy source that is free to harvest.
- use a renewable resource as fuel.

## HYDROPOWER PLANTS:

- require that a lot of land be flooded for the reservoir, which can be used for recreational purposes.
- can damage ecological habitats.
- produce no air and minimal water pollution.
- use a renewable resource as fuel.

## NUCLEAR POWER PLANTS:

- use small amounts of an economical and abundant energy resource.
- produce no air or water pollution.
- produce radioactive spent fuel that can be very dangerous and must be stored carefully at secure storage facilities.

## WASTE-TO-ENERGY PLANTS:

- burn trash to produce electricity.
- reduce the need for landfill space.
- produce CO<sub>2</sub> and limited air pollutants when burned, and can smell bad.

## NATURAL GAS PLANTS:

- are excellent for peak load plants because they can be brought on-line and shut down quickly.
- use a clean burning fossil fuel, but still emit CO<sub>2</sub> and some pollutants into the air.
- use a nonrenewable resource (with undetermined reserves in Essowess).

## GEOHERMAL POWER PLANTS:

- are built on the site of the geothermal reservoir.
- produce few environmental impacts.
- use a renewable resource.

## SOLAR POWER PLANTS:

- cannot produce electricity all of the time.
- produce no pollution but require large land areas.
- use energy from the sun that is free to harvest.
- use a renewable resource.

# MISSION POSSIBLE ENERGY PLAN

FACILITIES	QUANTITY	ECONOMIC COST (\$\$)	CAPACITY MW	ENVIRO IMPACT (EU)	COST OF ELECTRICITY
Existing Modern Plants	20	800	800	800	0.05
Modernize 5 Old Coal Plants	5	200 + 50 = 250	200 + 50 = 250	250	0.05
Build New Coal Plants					
Build up to 5 Wind Farms					
Build up to 2 Hydro Dams					
Build Nuclear Plants					
Build up to 2 Waste-to-Energy Plants					
Build Natural Gas Plants					
Build up to 3 Geothermal Plants					
Build Solar Plants					
<b>TOTALS</b>					*
<b>GOAL</b>		1700	1500	1200	0.05

\* To determine the average cost of electricity per kWh, use the formula below:

Sum of all sources [(capacity of source) x (cost per kWh of source)] ÷ Total Capacity of All Sources