Appendix C

Electric Power Alternatives

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Electricity from Coal

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Making Electricity

You can generate electricity by waving a magnet back and forth past a coil of wire. Almost all electricity is made by spinning magnets near coils of wire. The problem is how to get magnets to spin without having people do it! The whole problem of making electricity comes down to spinning those magnets.

Using Coal to Make Electricity

Most electricity is made by having water, steam, or wind blow across big fan blades or propeller blades. The blades are connected to magnets so that when the blades turn, the magnets spin. The magnets spin past coils of wire to generate electricity. The big fan blades or propellers are called turbines when they are used for spinning magnets to make electricity.

Pulverized Coal Plants

Coal is found in the earth just like rocks and minerals are. It is dug out of the ground and crushed into a fine dust. The dust is mixed with air and blown into a big furnace where it is burned. The sides of the furnace are covered with many pipes carrying water. The hot coal fire heats the pipes and the water inside them. The water boils into steam and the steam is rises to the top of the pipes where it is collected. The furnace, together with the water pipes and collection tank on top is called a boiler.

From the collection tank, the hot steam is carried in pipes to the turbine. Hot steam pouring out of the boiler pushes hard against the turbine blades. The turbine blades are connected to a magnet. The magnet spins through coils of wire to generate electric power.

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Coal Gasification

Another way to use coal is to turn it into a cleaner burning fuel. Chemical processes heat coal to high temperatures with steam in high pressure tanks. The coal and steam react to make a fuel like natural gas. This gas can then be used in a combustion turbine to produce electricity (see "Electricity from Combustion Turbines" in this appendix). Coal plants that use this process are called coal gasification plants.

Cost of Coal Power

It costs a lot to build a coal power plant, but less than nuclear and solar power plants. Once the power plant is built, it costs extra money to buy the coal to fuel it. Including the cost of buying the coal, coal power plants costs a little less than nuclear power plants and a lot less than solar power plants.

Environmental Considerations

One problem with burning coal is that it causes air pollution. Dirt, and dangerous chemicals are released to the air when coal is burned. Some dirt and other pollutants can be washed off the coal before it is burned, and this helps reduce the problem. Some kinds of coal have less of the dangerous chemicals (like sulfur), but they often cost more to buy. Many air pollutants can be removed from the smoke by machines called scrubbers before it goes out the chimney. It costs a lot to buy and operate scrubbers. Many older coal plants do not have them, but most new ones do.

Another environmental consideration for coal is the ash that is left after the coal burns. Ash is a solid waste material that can also contain dangerous chemicals. Coal plants make a lot of ash and it needs to be put somewhere. If the power plant is near a mine, sometimes the ash can be put back into the mine where the coal came from.

Coal gasification is an important way of reducing many of these problems. Ash, smoke, and many of the air pollutants are much less of a problem with coal gasification plants. Coal plants of all kinds produce carbon dioxide that may add to warming the atmosphere (a problem called global warming).

Availability of Coal Power

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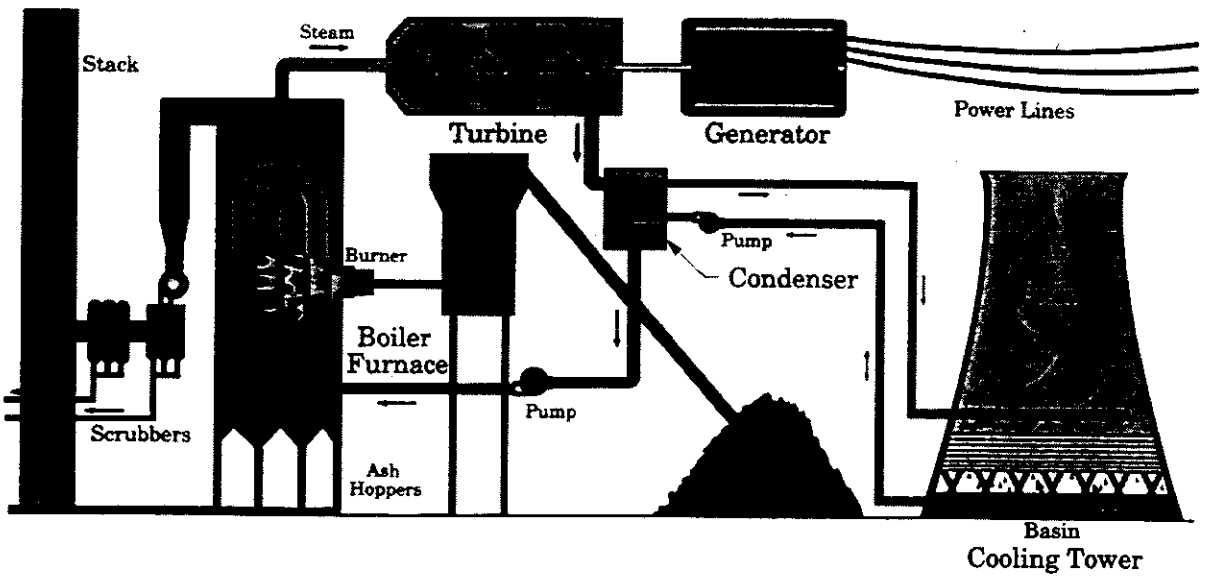
One of the great advantages to coal power is that the United States has a lot of coal underground. Although the United States has a lot of coal, most Northwest states do not have a lot. Coal for electric power in the Northwest will likely come from Wyoming, Colorado, Utah, and eastern Montana. Either the coal will come to Northwest coal power plants by train cars, or else the coal plants will be located far away and the electricity transported over power lines. Available train and power lines put some limit on how much coal can be developed here. Probably between 5 and 25 major new coal power plants could be built. This is enough to provide for most or all of our needs over the next 10 to 20 years.



Coal Fired Plant

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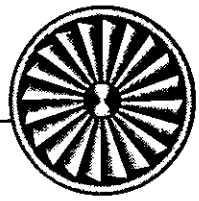

Electricity from Cogeneration

Making Electricity

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Using Cogeneration to Make Electricity

Most electricity is made by having water, steam, or wind blow across big fan blades or propeller blades. The blades are connected to magnets so that when the blades turn, the magnets spin. The magnets spin past coils of wire to generate electricity. The big fan blades or propellers are called turbines when they are used for spinning magnets to make electricity.

Cogeneration is a combination of using heat to generate electricity and for some other use, like drying foods or making paper. A common arrangement is to have a combustion turbine (see combustion turbine write up) generate the electricity. Combustion turbines are like big jet engines and the exhaust coming out of them is very hot. Instead of wasting that hot exhaust, it is used to make steam for industrial use.

Cost of Cogeneration

Cogeneration tends to be one of the less expensive resources because an industry can share some of the costs with the power company. Cogeneration is probably one of the least expensive resources available to the Northwest.

Environmental Considerations

The environmental considerations for cogeneration are usually the same as for combustion turbines (see combustion turbine write up).

Availability of Cogeneration

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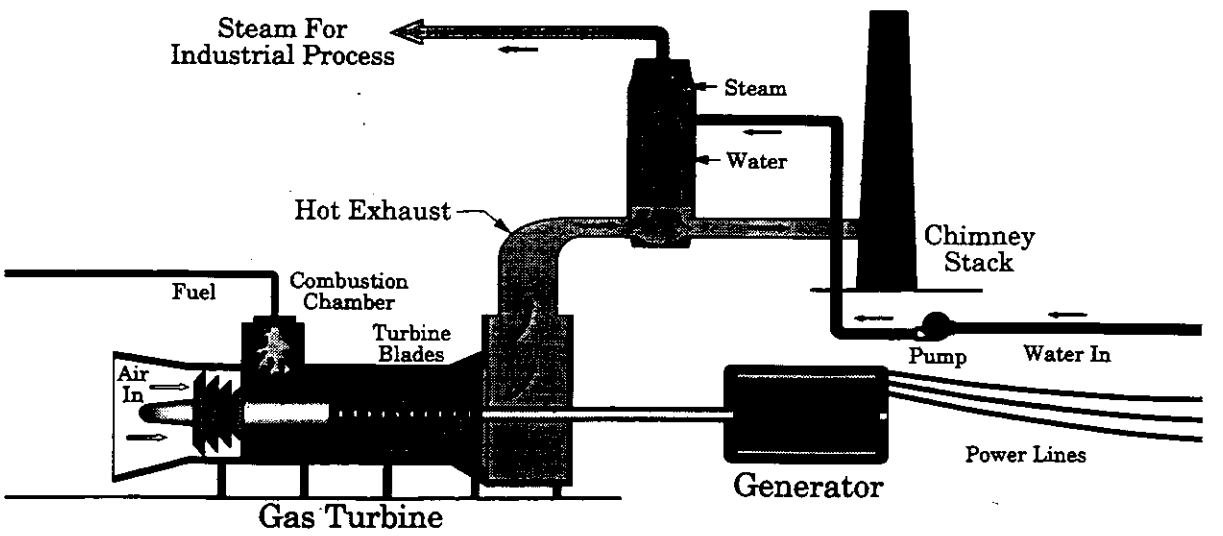
Cogeneration plants often use natural gas as a fuel because that is what combustion turbines use. There seems to be a lot of natural gas available so that is not a problem. However, cogeneration depends on having business available that can make use of the left over heat. Cogeneration power plants could probably supply 50-75% of the Northwest's power needs in the next 10 to 20 years.



Electricity From Cogeneration

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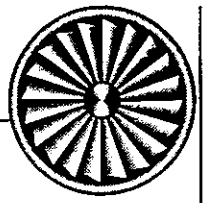

Electricity from Combustion Turbines

Making Electricity

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Using Combustion Turbines to Make Electricity

Most electricity is made by having water, steam, or wind blow across big fan blades or propeller blades. The blades are connected to magnets so that when the blades turn, the magnets spin. The magnets spin past coils of wire to generate electricity. The big fan blades or propellers are called turbines when they are used for spinning magnets to make electricity.

In combustion turbines strong fans suck air in from the outdoors and compress it under high pressure. Natural gas is mixed with the compressed air. The natural gas and air mixture is ignited in a controlled explosion. The ignited gases blow past turbine blades. The turbine blades help spin the compressor fan and also spin magnets in an electric generator to produce electric power.

Newer combustion turbine power plants use the hot exhaust coming out of the end of the turbine. The hot exhaust gases heat water to make steam. The steam then pushes against turbine blades to spin another set of magnets. When combustion turbines use the exhaust heat to run a steam turbine they are called "combined cycle plants."

Combustion turbines, without the big generator, are the same kinds of engines used on jet aircraft.

Cost of Combustion Turbine Power

Combustion turbines cost less to build than coal power plants. One of the problems with combustion turbines is that natural gas prices can change a lot and are hard to predict. Right now, natural gas costs a little more than coal, but the total cost of combustion turbines is less than for coal plants. Although it is hard to know how long fuel prices will stay low, combustion turbines are among the cheapest electric power alternatives.

Environmental Considerations

Combustion turbines contribute to some kinds of air pollution, acid rain and global warming. However, natural gas burns more cleanly than coal, and produces no toxic ash to be disposed of.

Anyone who has heard the roar of a jet will know how noisy combustion turbines can be. Noise can be a problem if the power plants are near where people live. Noise reduction devices are also helping reduce this problem.

Availability of Combustion Turbine Fuel

Combustion turbines usually burn natural gas. Natural gas is found deep in the earth, often in places where oil is found. There is almost no natural gas in the earth under the Northwest states. Large amounts of natural gas are found in British Columbia and Alberta, Canada. It is also found in California, Wyoming, and Colorado.

Gas produced in Canada is transported through large pipelines to the Northwest and California. The size of these pipelines partly limits how much power can be produced from new combustion turbines without building new pipelines or expanding the old ones. Combustion turbines can probably supply 50-75% of the electric power needed in the Northwest for the next 10 to 20 years.

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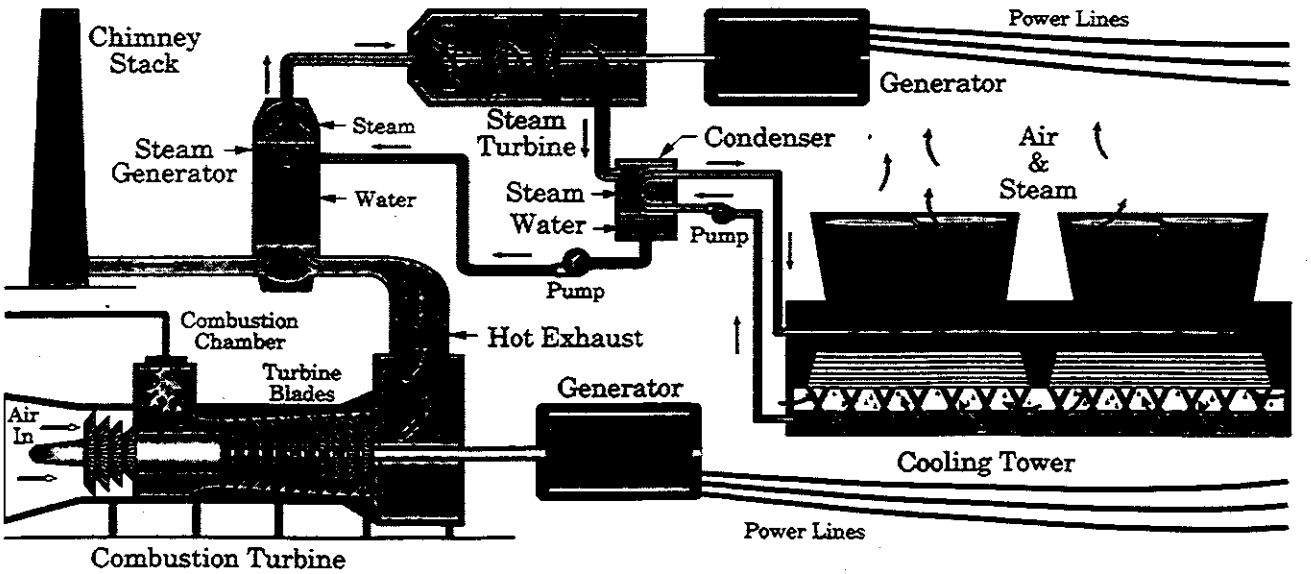

Electricity From Combustion Turbines

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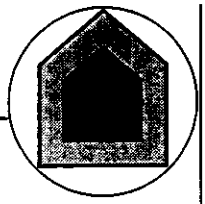

Electricity from Conservation

How Conservation Works

Conservation means using electricity smarter, so less is needed to do the same jobs. If less electricity is used in one place, it is available to be used in other ways.

There are many different ways to use electricity smarter. For electrically heated homes, plugging cracks around doors and windows, putting insulation in attics and walls, are ways to keep homes just as warm with less electricity. Using new energy efficient lights (called "compact fluorescents") in stores, offices and homes produces the same amount of light with less electricity. Electric motors are used for many purposes and can do the same work with less power if properly sized, adjusted and maintained. Power lines and electric power plants can be repaired or improved so less electricity is wasted on its way to do important work.

Another way to use electricity smarter is to use other fuels for heating jobs. For example, it takes less natural gas to heat hot water directly, than to generate electricity for electric water heaters.

Cost of Conservation

Some conservation efforts are very easy to do and don't cost very much. Improving some aspects of electric power plants can cost very little compared with the amount of electric power they free up for other purposes. Other conservation efforts cost much more. Since people will buy the cheapest conservation first, the more conservation we do, the more it costs.

Environmental Considerations

By using electricity smarter, new electric power plants may not have to be built. This can mean less air pollution, less hazardous nuclear waste, less global warming and less land used for power plants. Energy conservation is one of the best things we can do for our environment.

Availability of Conservation

Planners believe that the equivalent of 2 to 10 large power plants can be saved at reasonable costs with conservation. About the same amount of electric energy can be saved by switching from electricity to other fuels for heating. Together these programs can contribute between one fourth to all of the electric power needs expected over the next 10 to 20 years.

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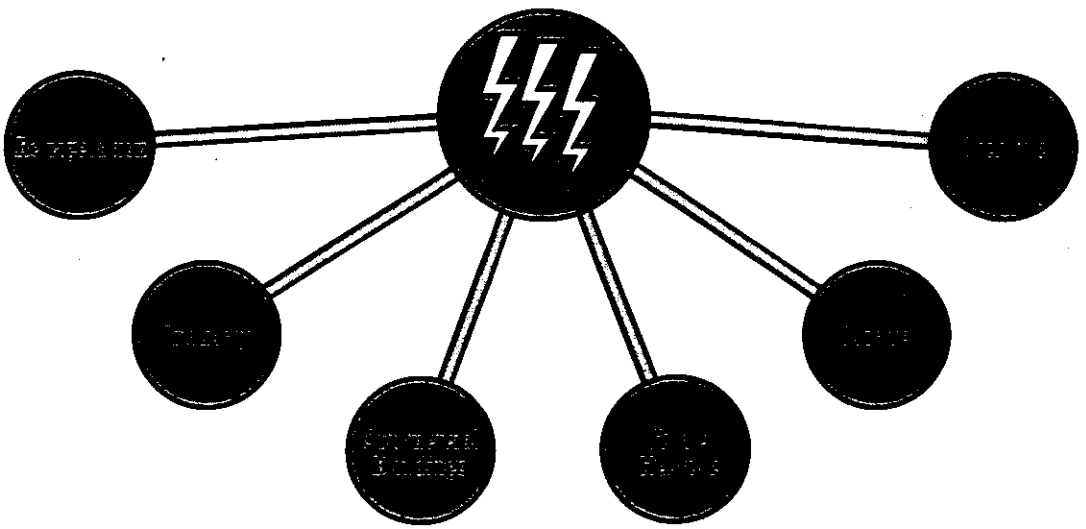

Electricity From Conservation

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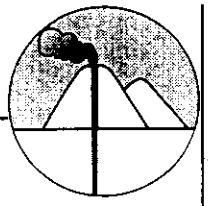

Electricity From The Earth (Geothermal)

Making Electricity

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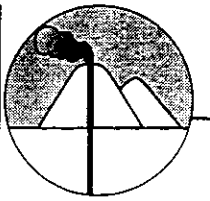
Using the Earth to Make Electricity

Most electricity is made by having water, steam, or wind blow across big fan blades or propeller blades. The blades are connected to magnets so that when the blades turn, the magnets spin. The magnets spin past coils of wire to generate electricity. The big fan blades or propellers are called turbines when they are used for spinning magnets to make electricity.

The center of the earth is thought to be made of very hot, molten rock. In some places the heat from deep in the earth finds its way up toward the surface through cracks or "vents". If these vents lead all the way to the surface of the earth they can create volcanoes.

In some places the molten rock may not come all the way to the surface, but lie underneath, heating the surrounding solid rocks. Water can sometimes find its way to these rocks and become heated. The hot water can come back to the surface as hot springs or geysers. It can also simply remain deep in the earth.

Heat in the earth can make electricity in several ways. Wells are drilled into the hot areas of the earth. Steam comes directly out of wells to push turbine blades in places where there is enough heat and water available. Water is pumped into hot dry rocks to make steam in other areas. The steam then comes to the surface (sometimes through a different well) and pushes turbine blades. The turbine spins magnets past a coil and generates electic power.



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Cost of Geothermal Power

The cost of geothermal power depends on how hot the rocks are, whether there is already hot water or steam in them, and how difficult it is to discover. The Northwest is thought to have many good places to put geothermal power plants, but finding them might be very costly. Once found, the cost of geothermal power is probably not much more expensive than other ways of making electricity (like coal plants).

Environmental Considerations

The biggest problems with geothermal plants are probably that they are located in remote areas, far from where people will use the electric power. This means that natural areas may be disturbed to build the plants, and that long power lines have to be built to bring the power to where it is needed. Power lines cut through natural areas and often require cutting a path through forest lands.

Care must be taken with the hot water coming from geothermal wells. It is not clean water and should not be allowed to return to rivers and streams. A good idea is to put the water back into the earth. If the water is not put back at the same depth, it can cause big problems with drinking water or lakes and streams. Accidents are a concern. Geothermal plants usually cause little air pollution because nothing is burned to produce the power. Some carbon dioxide (about 1/30th as much as coal plants) and some other gases are released to the atmosphere in relatively small amounts.

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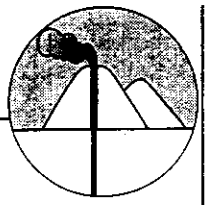
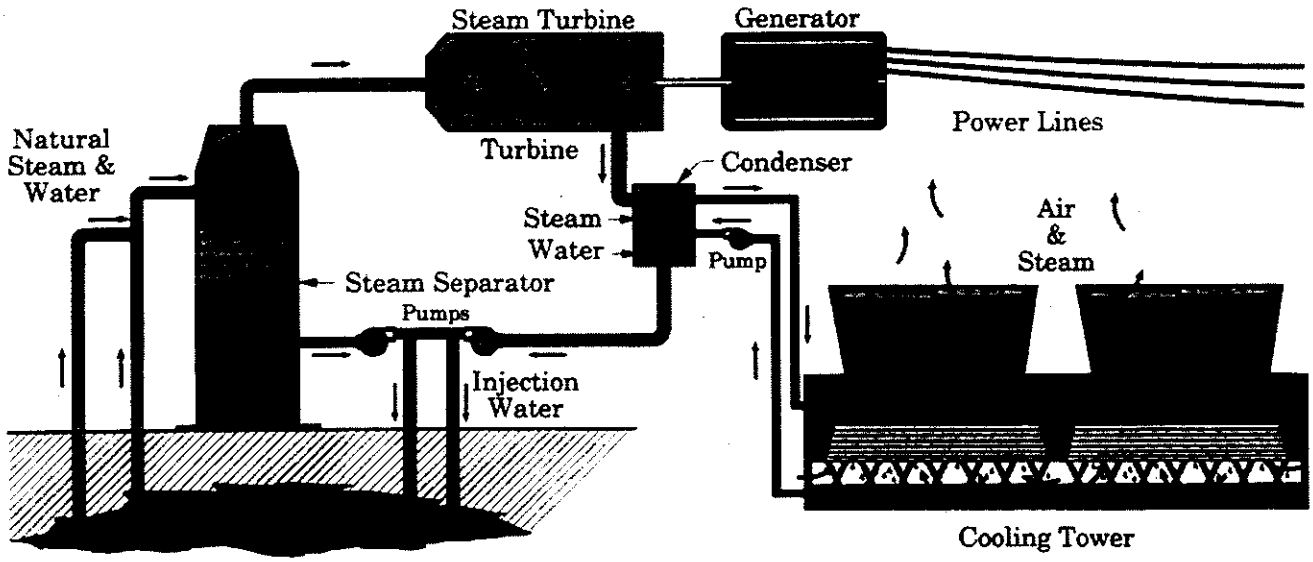


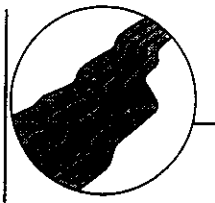
Availability of Geothermal Energy

Nobody really knows how much electric power could be generated from geothermal energy in the Northwest. There is almost certainly at least as much as can be produced by a single small coal plant. There could be quite a lot more however, perhaps as much as dozens of large power plants. Efforts are now underway to get a better idea of how much there might be. It is likely that geothermal could supply 5-10% of the Northwest's needs over the next 10-20 years, and possibly much more.



Electricity From The Earth (Geothermal)

Electricity from Water (Hydropower)



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Making Electricity

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Using Water to Make Electricity

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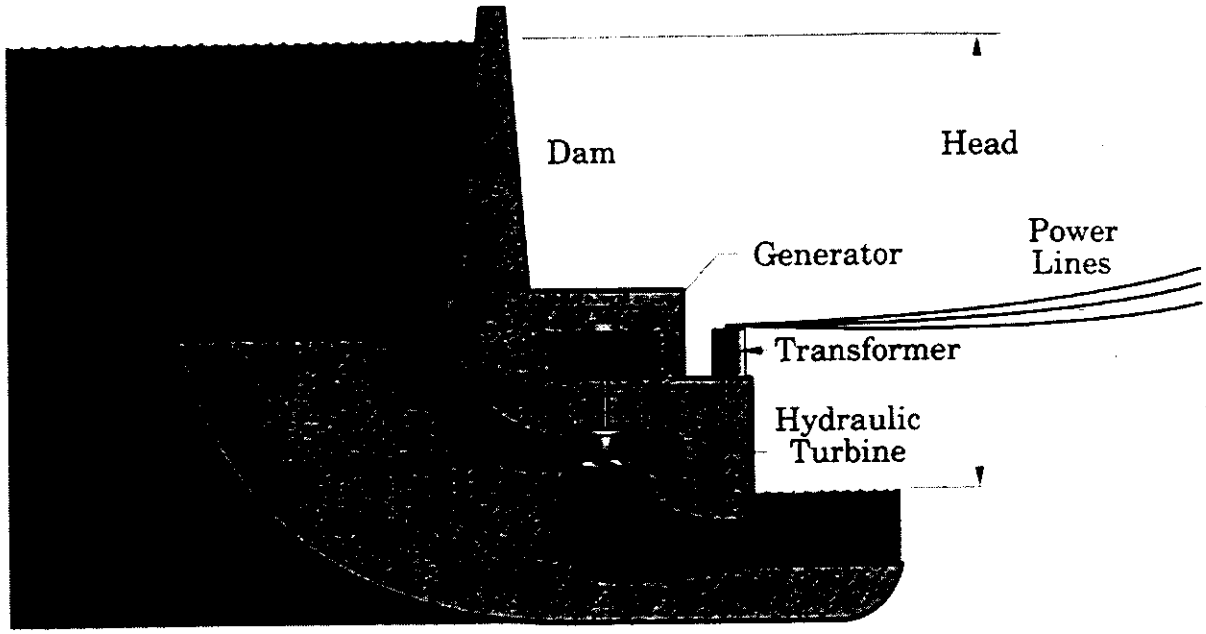
Hydropower is simply allowing water to fall onto a turbine. The turbine turns, spinning a magnet past a coil of wire to generate electric power. Water pushes harder on the turbine and produces more electric power if it falls onto the turbine from a greater height. The greater the fall, the more power the water can produce. Dams are used to back up water and make it fall farther.

Dams also create reservoirs of water behind them. Only very small amounts of electricity can be stored in batteries. Reservoirs behind dams are the only way to store large amounts of electric energy. When more power is needed, water can be taken from the reservoir. At night or on weekends when less power is needed, water can be stored in the reservoir and let out later when it is needed for power.

Cost of Hydropower

The cost of hydropower depends a lot on where it is located. In places where there is a lot of water flowing and it can be made to fall hundreds of feet, and a dam can be built easily, the cost may be fairly low. In places where there is little water that falls just a few feet, the cost can be very high.



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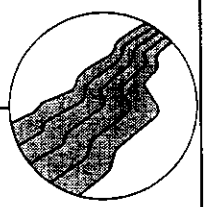


Environmental Considerations

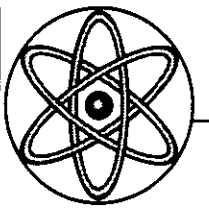
Environmental considerations of hydropower plants also depend a lot on where they are located. Dams that create large reservoirs have many severe impacts in flooding out river banks, forest, and farm lands. They also tend to increase the temperature of the water and that can be harmful to many kinds of fish. They tend to slow the flow of water, making it difficult for migrating fish to migrate. Dams themselves represent impediments to migrating fish.

Hydropower plants do produce virtually no air or other pollutants. Situated on streams with no native migratory fish, with relatively small dams, the environmental impacts may be small.

Availability of Hydropower

There are only a few good places left to put new hydropower plants in the Northwest. Places where environmental impacts are thought to be acceptable are even fewer. Although hydropower provides nearly two thirds of all the power produced in the Northwest, there is little additional available. New hydropower plants in the Northwest can provide the equivalent of about one half of the output of a large coal plant. New hydropower plants will probably provide only a small part of the Northwest's needs over the next 10 to 20 years.

Electricity From Nuclear Power



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Using Nuclear Power to Make Electricity

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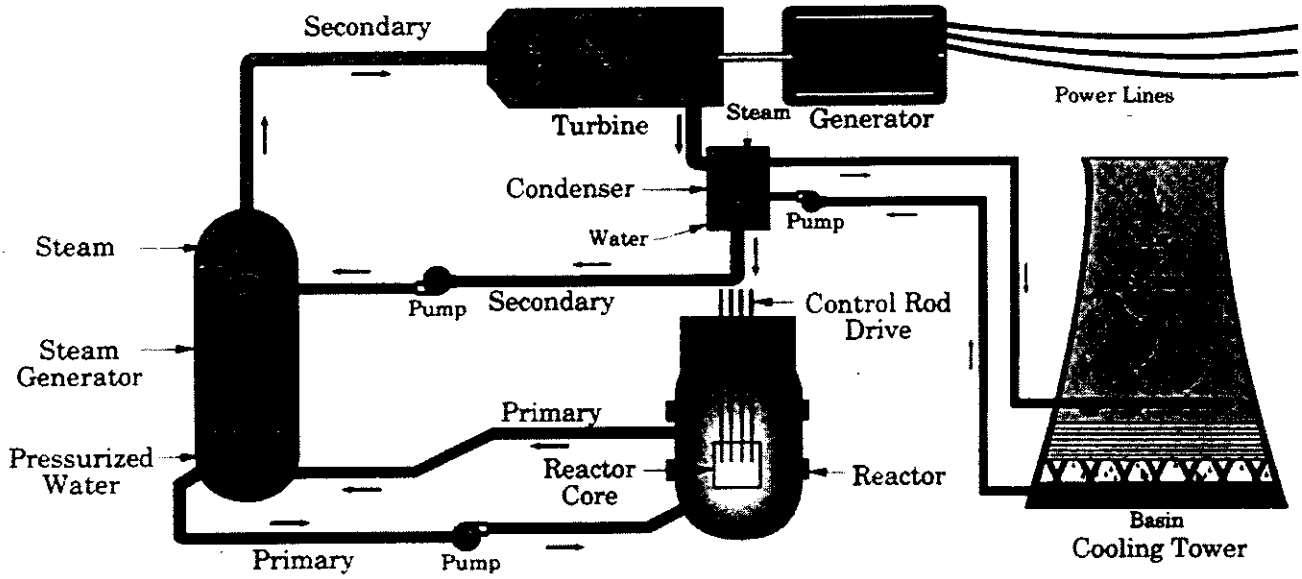
Certain types of materials are naturally radioactive. That means that very small invisible particles fly off of them. These particles heat up surrounding materials by slamming into them. Some materials send off particles that knock into other atoms and split them apart. When that happens the broken pieces are even more radioactive and send out lots more particles. These materials are called "fissionable" and can be used to make heat.

In a nuclear power plant, fissionable materials are brought together in a big tank (like a pressure cooker) filled with water. The water heats up and makes steam that pushes a turbine. The turbine is connected to an electric generator to make electric power.

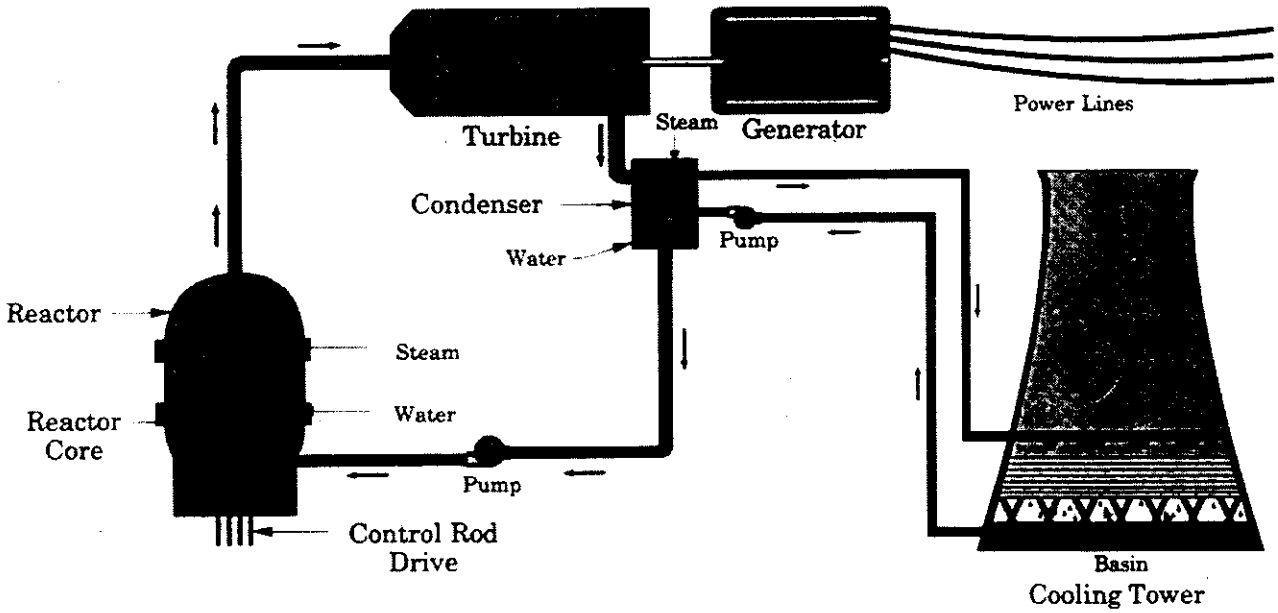
Cost of Nuclear Power

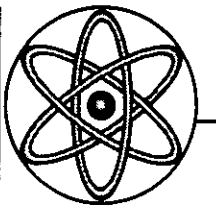
Nuclear power plants cost a little more than coal plants. This makes them more expensive than most other types of power plants.

Pressurized Water Nuclear Reactor



Boiling Water Nuclear Reactor





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Environmental Considerations

Nuclear power plants produce relatively small amounts of air and other pollutants when they are properly operating. Some environmental problems occur in mining rocks for the fuel materials. As the power plant ages, many of its parts become dangerously radioactive. At the end of the power plant's operating life, these materials must be disposed of safely. Used fuel is also a concern. Once fuel has been used up making electric power, it is very dangerous and must be kept away from people for thousands of years. There is no acceptable way of doing that at this time.

Another concern over nuclear power plants is the possibility of major accidents. Dangerous fuel and other radioactive materials can be released to the environment. It is possible that large areas around the power plant could be made too dangerous to live in for many years. The possibility of such accidents is thought to be so small by some people that this is not a significant problem.

Availability of Nuclear Energy

There is quite a lot of nuclear materials to be found in the United States. It is thought that there will be enough nuclear fuel for power plants for the next 50 to 100 years.

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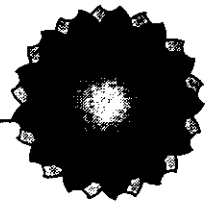

Electricity From The Sun (Solar Power)

Making Electricity

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Electric Power from the Sun

Most electricity is made by having water, steam, or wind blow across big fan blades or propeller blades. The blades are connected to magnets so that when the blades turn, the magnets spin. The magnets spin past coils of wire to generate electricity. The big fan blades or propellers are called turbines when they are used for spinning magnets to make electricity.

Solar power plants use mirrors to concentrate sunlight on a pipe or tank usually filled with oil or water. When oil is used, water is poured over the solar heated oil pipes. The water boils to create steam and the steam pushes against turbine blades. The turbine spins and is connected to magnets in a generator to produce electric power. Power plants that use sunlight to produce steam are called solar thermal plants. Nearly all of the solar power produced in the United States is produced in this way.

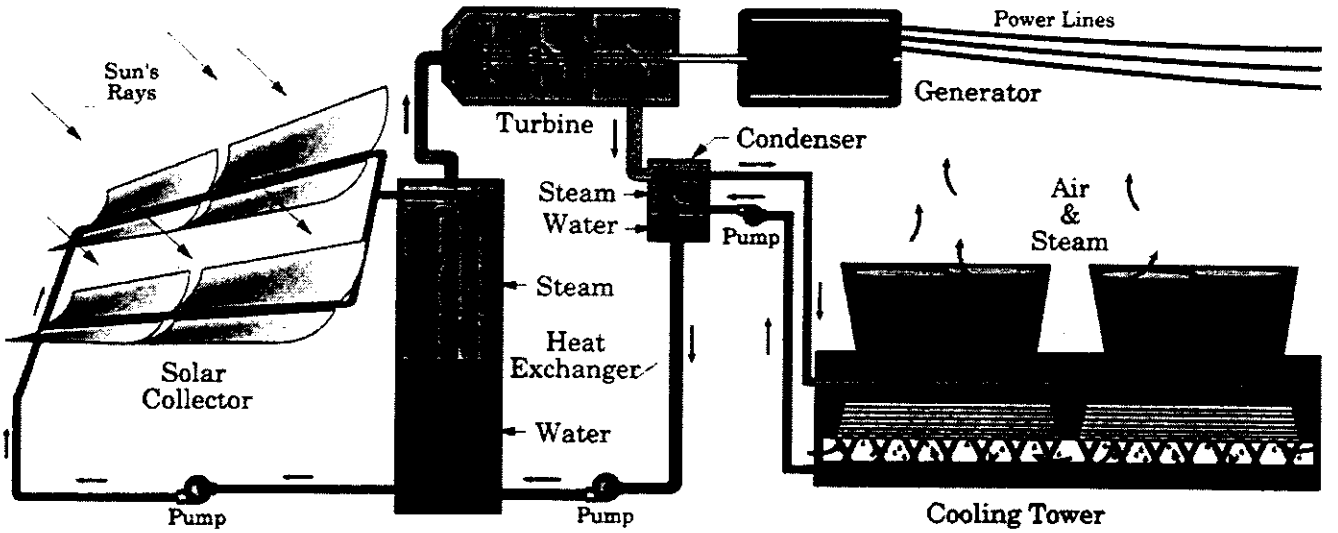
The largest solar thermal plants are in California. They burn natural gas to make steam in place of sunlight on cloudy days or at night when energy is needed but the sun isn't shining.

There is another way sunlight can be used to produce electric power. Special devices called photovoltaic cells produce electric power when they are exposed to light. There are no moving parts, no magnets, no coils of wire, no turbines, no steam. There is also no heat, noise, or air pollution produced as they operate.

Cost of Solar Power

A big advantage of solar power is that sunlight is free. Unfortunately, building solar power plants costs a lot, and is probably the biggest reason there are not very many of them. The costs of mirrors, land, and steam equipment contribute to the high cost of solar thermal power plants. Solar thermal plants are among the highest cost ways to make electric power.

The cost of photovoltaic cells is even higher than for solar thermal plants. Many scientists and engineers believe that the cost of photovoltaic cells will soon drop to affordable levels. This is because scientists and engineers continue to work on the problem of manufacturing the cells cheaper



Solar Thermal Plant

and more efficiently. The cost of photovoltaic cells has dropped a lot over the years. They are expected to cost no more than some other resources in the next 20 years or so.

Environmental Considerations

Using sunlight is one of the cleanest ways to make electric power. There are environmental problems with taking over land for solar plants. With solar thermal plants the steam must be cooled after it goes through the turbine. That process ends up warming up the air or water used to cool it. They are usually out in the desert where water is very scarce. If natural gas is used when the sun is not shining, there is some air pollution.

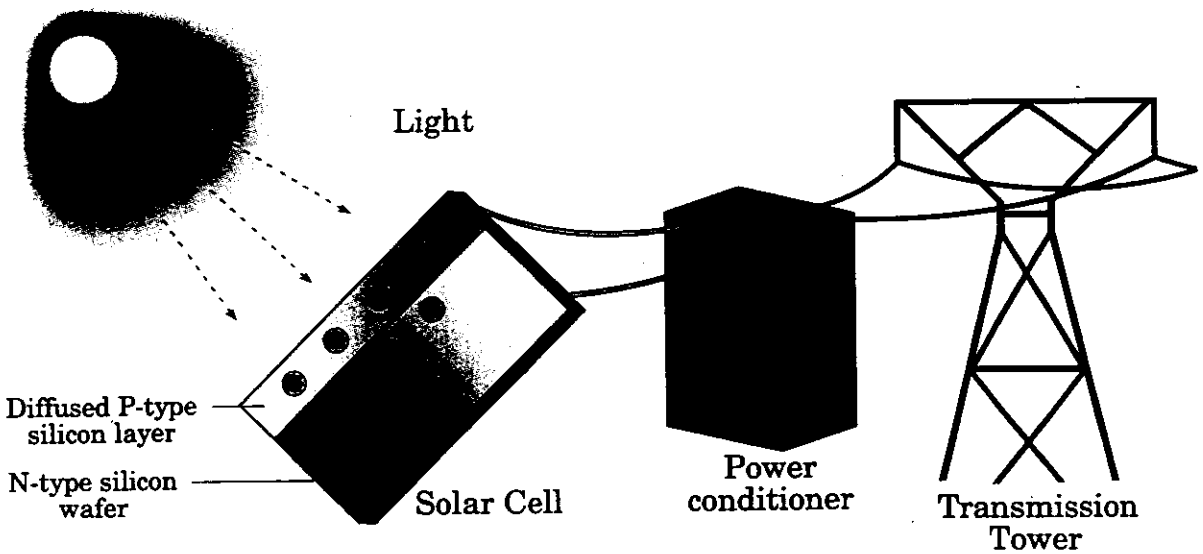
NOTES

The only environmental problems with photovoltaics have to do with land use, the power lines needed to take the electric power to cities, and some dangerous chemicals used to produce the photovoltaic cells.

Availability of Solar Power

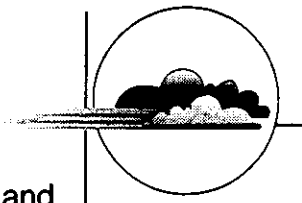
The best places to put solar power plants in the Northwest are the far southeastern part of Oregon. Even there the amount of sunlight is only about 70% of what falls on southern California. The amount of solar power plants that can efficiently be built in the Northwest is about equivalent to 1 or 2 large coal plants, no more than one fourth of the region's needs over the next 10 to 20 years.

California has a lot of sunlight and makes a very good place to put solar power plants. It is possible to build solar power plants in California and send the electricity to the Northwest over big power lines. It is possible that a big part of the Northwest's electric power needs could come from solar power in California someday.



Photovoltaic Power Plant

Electricity From the Wind



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Making Electricity

You can generate electricity by waving a magnet back and forth past a coil of wire. Almost all electricity is made by spinning magnets near coils of wire. The problem is how to get magnets to spin without having people do it! The whole problem of making electricity comes down to spinning those magnets.

Using Wind to Make Electricity

Most electricity is made by having water, steam, or wind blow across big fan blades or propeller blades. The blades are connected to magnets so that when the blades turn, the magnets spin. The magnets spin past coils of wire to generate electricity. The big fan blades or propellers are called turbines when they are used for spinning magnets to make electricity.

A wind turbine consists of propeller blades mounted at the top of a tower. When the wind blows on the propellers they turn. The spinning propeller blades are connected to magnets inside a generator. The turbine blades spin the magnets and generate electric power.

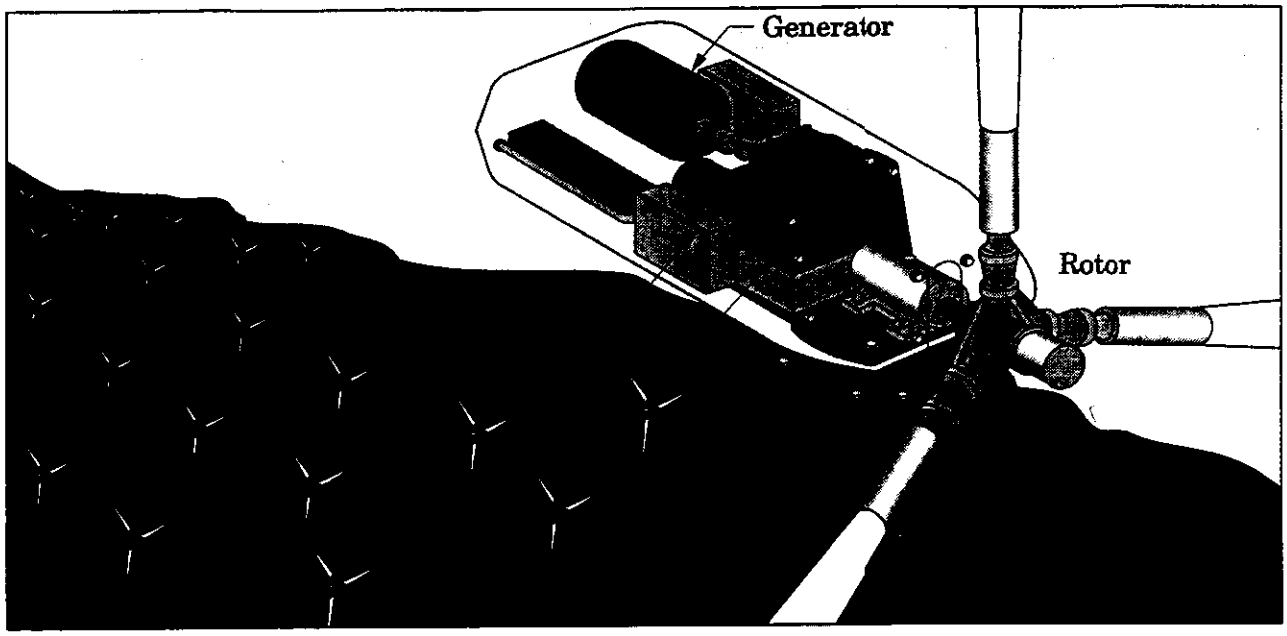
When the wind stops blowing, the propellers stop and no electricity is made. If wind turbines become a major source of energy, we will have to figure out how to store the energy when the wind is not blowing. Finding good windy places to put wind turbines is very important.

Cost of Wind Power

Wind turbines cost more than coal plants to build, but the fuel (the wind) is free. Altogether energy from the wind costs a little more than more common kinds of resources (like coal plants) and it isn't as reliable. However, wind turbine designs are improving and their costs are going down.

Environmental Considerations

Wind turbines have relatively few environmental problems. There may be problems with birds running into them. Some people think wind turbines ruin the natural beauty of the outdoors as well.



Electricity From The Wind

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The most important considerations may be the need to build long power lines and roads to take the electricity from the wind turbines to where it is needed. Good places to put wind turbines tend to be windy places away from big cities or industries. Building power lines may interfere with natural or wilderness areas. There is also some concern about whether living near power lines may cause health problems.

Availability of Wind Energy

Only one large scale wind farm exists in the Northwest. It is on the Oregon Coast at a place called Whiskey Run. The Whiskey Run site only produces less than 1% as much electricity as a large coal plant.

The availability of good places to put wind turbines limits how much wind power is likely to be available to the Northwet. Wind energy can probably supply up to 10-20% of the Northwest's needs over the next 10 to 20 years.