

# Advanced Biomass Power

**How it Works:** Biomass comes from farm crops, paper mills, and wood chips. It is heated to make a gas. This gas is burned. Its heat is used as fuel in a type of engine, called a “turbine”. This turbine then runs a generator to make electricity. The left-over hot gas is used to make steam. The steam also fuels a turbine, which runs a second generator to make more electricity. Because it uses two turbines, the plant is more efficient.



Biomass power plant in Burlington, VT,  
Source: [www.nrel.gov/biomass/photos.html](http://www.nrel.gov/biomass/photos.html)

## MORE INFORMATION (ABOUT ADVANCED BIOMASS POWER)

<b>Cost *</b>	The cost of biomass power can vary. It depends on whether the biomass “fuel” is also needed for other reasons, such as for food (from farm crops). The first few power plants built in PA would likely be able to use leftover biomass from farms and forestry businesses. As more plants are built, new plants and trees would be grown to make biomass power. Growing biomass can be expensive. So, the cost of biomass power would go up.*
<b>CO<sub>2</sub> released *</b>	Biomass adds no new CO <sub>2</sub> to the air. Biomass fuel is made from trees and plants. Plants and trees take in CO <sub>2</sub> from the air when they are alive. So, most of the CO <sub>2</sub> released into the air when biomass is burned is not “new”. It was in the air recently. This is different than the “new” CO <sub>2</sub> from coal and gas plants, which has not been in the air for millions of years. *
<b>Other Pollution/Waste *</b>	<ul style="list-style-type: none"> <li>• The air pollution released is like that of a natural gas plant. These plants put nitrogen oxides and sulfur dioxide into the air. These pollutants can cause people to have some health problems. *</li> <li>• Biomass is sometimes grown especially to make fuel. The chemicals used to grow biomass pollute the soil and water.</li> <li>• Turning biomass into a gas makes ash, which may in some cases contain hazardous chemicals. It is disposed of in landfills.</li> <li>• Advanced biomass plants use a lot of water to cool the plant’s equipment. The amount is less than traditional coal plants. The water comes from wells, lakes, rivers or oceans. Some of it will evaporate after use. The rest is returned to its source. Since it is hot, the water may disturb plants and animals living in the water source.</li> </ul>
<b>Availability</b>	Biomass can be found everywhere in the U.S. But, many types of biomass are traditionally used for other things. This means that electricity companies will have to compete with other buyers of the biomass “fuel”.
<b>Reliability</b>	Biomass power can provide steady and dependable electricity.
<b>Limits of use</b>	If biomass plants made all (or most) of our electricity, we would need to begin to grow biomass. Growing biomass is expensive. Electricity would cost a lot. Lots of land would be used up. So, biomass plants cannot make all of the electricity that is needed for PA. Other types of plants must also be built.
<b>Noise</b>	These plants are about as loud as average street traffic.
<b>Land use and ecology</b>	Some of the biomass comes from waste products. But, at a larger scale, new trees or plants will need to be grown for biomass. This could mean that farms will grow less food, driving food prices up. Land may need to be cleared to grow biomass, causing soil erosion and disturbing the animals and plants.
<b>Safety</b>	These plants are quite safe for operators.
<b>Lifespan</b>	The lifetime of any plant is uncertain. But, a new advanced biomass plant built today would likely make electricity for at least 30 years.
<b>Current Use</b>	There are dozens of these plants working in the U.S. today. Most are small. Larger biomass plants do exist in the U.S. But, they work differently than the ones described here (more like traditional coal plants).

\* More cost and pollution information is available in “Cost Comparison” and “Pollution Comparison” sheets in Envelope #3.

# Advanced Coal Plants

## Option 1: CO<sub>2</sub> is released into air

**How it Works:** Traditional coal plants burn coal to make electricity. *Advanced coal plants* turn coal into gas. This gas is burned. Its heat is used as fuel in a type of engine, called a “turbine”. This turbine then runs a generator to make electricity. The left-over hot gas is used to make steam. The steam also fuels a turbine, which runs a second generator to make more electricity. Because *advanced coal plants* use two turbines, they are more efficient than traditional coal plants.



An Advanced Coal Plant in Indiana  
Source: www.clean-energy.us

When coal is burned, CO<sub>2</sub> is released by the plant. In **Option 1**, this CO<sub>2</sub> escapes into the air because no equipment is added to capture the CO<sub>2</sub>.

### MORE INFORMATION (ABOUT ADVANCED COAL PLANTS)

<b>Cost *</b>	Because these plants use new equipment, costs are somewhat uncertain.
<b>CO<sub>2</sub> released *</b>	Advanced coal plants release slightly less CO <sub>2</sub> to the air than traditional coal plants. *
<b>Other Pollution/Waste *</b>	<ul style="list-style-type: none"> <li>• <i>Advanced coal plants</i> release nitrogen oxides and sulfur dioxide to the air. The amount is much less than traditional coal plants. These pollutants can cause people to have many different health problems. These plants release almost no mercury or particulates. *</li> <li>• These plants produce about half as much solid waste as traditional coal plants. The waste may contain a small amount of hazardous chemicals. Some of it can be recycled, such as to make concrete. The leftover waste is usually put in a landfill near the plant.</li> <li>• <i>Advanced coal plants</i> use a lot of water to cool the plant’s equipment. The amount is less than traditional coal plants. The water comes from wells, lakes, rivers or oceans. Some of it will evaporate after use. The rest is returned to its source. Since it is hot, the water may disturb plants and animals living in the water source.</li> </ul>
<b>Availability</b>	Experts say that the U.S. has enough coal to meet its needs for at least 100 years.
<b>Reliability</b>	Coal can provide steady and dependable electricity.
<b>Limits of use</b>	Advanced coal plant release a lot of CO <sub>2</sub> . They cannot make all of the electricity that is needed in PA if we want to reduce CO <sub>2</sub> . Other types of plants must also be built.
<b>Noise</b>	These plants are about as loud as average street traffic.
<b>Land use and ecology</b>	Coal mining near the surface disturbs the land, plants and animals. It also disrupts and pollutes streams. Underground mining can cause acidic water to leak into streams. If the mine collapses, it can also cause the ground to sink or shift.
<b>Safety</b>	These plants are quite safe for operators. Coal mining is dangerous for the miners.
<b>Lifespan</b>	The lifetime of any plant is uncertain. But, a new advance coal plant built today would likely make electricity for at least 50 years.
<b>Current Use</b>	There are two advanced coal plants working in the U.S. today. Electric utility companies have plans to build more advanced coal plants in the near future.

\* More cost and pollution information is available in “Cost Comparison” and “Pollution Comparison” sheets in Envelope #3.

# Advanced Coal Plants

## Option 2: CO<sub>2</sub> is captured

**How it Works:** This is the same plant as that described in “Advanced Coal Plants, Option 1”. But in Option 2, additional equipment is added to capture the CO<sub>2</sub> before it escapes to the air. This CO<sub>2</sub> is turned into a liquid. A pipeline takes it from the plant and puts it permanently in rock formations more than half a mile (about 2,500 feet) underground. This is shown in the diagram to the right. The rock formations will be tested ahead of time to make sure the CO<sub>2</sub> will stay trapped in there. The CO<sub>2</sub> will also be monitored to make sure that it stays in place. After a few decades, the CO<sub>2</sub> will dissolve (and become trapped) in the water in the rocks. Over thousands of years, it will likely change into solid minerals.

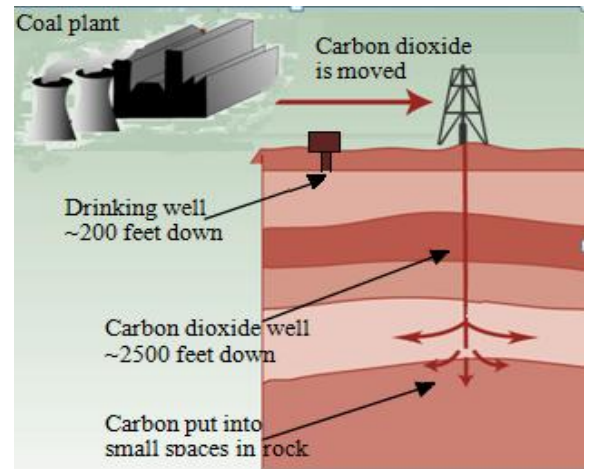


Diagram of a coal plant with carbon capture and disposal. Modified from [www.co2crrc.com.au](http://www.co2crrc.com.au)

### MORE INFORMATION (ABOUT CO<sub>2</sub> CAPTURE EQUIPMENT)

<b>Cost *</b>	It is cheaper to add CO <sub>2</sub> capture equipment to <i>advanced coal plants</i> than to traditional coal plants.*
<b>CO<sub>2</sub> released *</b>	Advanced coal plants with CO <sub>2</sub> capture equipment release very little CO <sub>2</sub> into the air. *
<b>Other Pollution/Waste *</b>	<ul style="list-style-type: none"> <li>• The equipment alone makes very little air or water pollution.*</li> <li>• If CO<sub>2</sub> gets in underground drinking water, the water can become contaminated. That risk is small because CO<sub>2</sub> wells will be built more than 10 times deeper than most wells for drinking water.</li> <li>• Adding CO<sub>2</sub> capture equipment increases the water used by advanced coal plants by a small amount.</li> </ul>
<b>Availability</b>	<ul style="list-style-type: none"> <li>• There are suitable rock formations in much of PA and the rest of the U.S. Before use, they will be tested to make sure that they can safely hold the CO<sub>2</sub>.</li> <li>• There are thousands of miles of gas pipelines in the U.S. today. CO<sub>2</sub> is moved through similar pipelines. CO<sub>2</sub> pipelines are already used in the U.S., but more need to be built.</li> </ul>
<b>Reliability</b>	Capturing CO <sub>2</sub> does not make advanced coal plants less dependable.
<b>Limits of use</b>	Advanced coal plants with CO <sub>2</sub> capture equipment could make all the electricity needed for PA.
<b>Noise</b>	There would be little change in the noise from the advanced coal plant if CO <sub>2</sub> capture equipment is added.
<b>Land use and ecology</b>	The CO <sub>2</sub> will cause very little harm to living plants or animals once it is in the deep underground rock formations. Some CO <sub>2</sub> is also naturally found in the ground.
<b>Safety</b>	<ul style="list-style-type: none"> <li>• Unlike oil or gas, CO<sub>2</sub> cannot burn or explode. As with oil and gas pipelines, the chance of pipeline leaks is low. If lots of CO<sub>2</sub> did leak from a pipeline, it would usually mix into the air. But if the leak happened in a valley or tunnel, the CO<sub>2</sub> could build up for a while. In this case, people and animals could suffocate if the leak was large enough.</li> <li>• There is a small chance that CO<sub>2</sub> could leak out of an underground space. These leaks would be very slow. In almost all cases, the CO<sub>2</sub> would mix into the air before harming anyone.</li> <li>• The CO<sub>2</sub> in the ground can be monitored with underground equipment. If the CO<sub>2</sub> starts to move to places where it should not be, there are ways that this could be fixed. For example, the leak could be plugged up or the CO<sub>2</sub> could be moved to some other location.</li> <li>• Pumping CO<sub>2</sub> into the ground builds up underground pressure. This could increase the risk of small earthquakes in some areas. However, PA is not prone to earthquakes.</li> <li>• After a few decades, the CO<sub>2</sub> dissolves in the deep underground water. This reduces many of the risks. Leaks become very unlikely. The CO<sub>2</sub> can no longer move to contaminate drinking water. It cannot move to places it should not be. It cannot cause earthquakes.</li> <li>• Once an underground space is full and closed, and shown to be secure, the government will take control and continue to monitor it for safety. Experts disagree on how long government should continue to monitor it.</li> </ul>
<b>Lifespan</b>	There is enough underground space to capture CO <sub>2</sub> for the entire life of any coal plant built.
<b>Current Use</b>	The U.S. Government is capturing CO <sub>2</sub> underground in 25 test sites across the U.S. today.

\* More cost and pollution information is available in “Cost Comparison” and “Pollution Comparison” sheets in Envelope #3.

# Advanced Nuclear Plants

**How it Works:** Nuclear plants use uranium that has been slightly processed, or “enriched”. In a nuclear plant, the uranium releases heat that is used to make steam. The steam is used as fuel in a type of engine, called a “turbine”. This turbine runs a generator to make electricity. Advanced nuclear plants have a different design than existing ones. While existing plants are very safe, the new design makes a nuclear accident virtually impossible.



Nuclear plant in McCandless, PA,  
Source: www.nrc.gov

## MORE INFORMATION (ABOUT ADVANCED NUCLEAR PLANTS)

<b>Cost *</b>	Because advanced nuclear plants are new, costs are somewhat uncertain. *
<b>CO<sub>2</sub> released *</b>	Advanced nuclear plants release no CO <sub>2</sub> to the air. *
<b>Other Pollution/ Waste *</b>	<ul style="list-style-type: none"> <li>• Normally operating nuclear plants cause almost no air or water pollution. *</li> <li>• Nuclear plants release almost no radiation into the air, ground or water. So, a person who lives near a plant gets almost no radiation.</li> <li>• The leftover fuel from a nuclear plant will produce radiation for many years. Radiation can cause cancer in people. Today, this waste is being stored in facilities next to the nuclear plants. The government has plans to permanently store the nuclear waste in a central location either under or above ground. How soon that will happen is not clear.</li> <li>• Advanced nuclear plants use a lot of water to cool the plant’s equipment. Existing nuclear plants use about the same amount as traditional coal plants. But, advanced nuclear plants will likely use much less. The water comes from wells, lakes, rivers or oceans. Some of it will evaporate after use. The rest is returned to its source. Since it is hot, the water may disturb plants and animals living in the water source.</li> </ul>
<b>Availability</b>	There is enough uranium available to power any new nuclear plants built in PA for the life of the plants.
<b>Reliability</b>	Nuclear power can provide steady and dependable electricity.
<b>Limits of use</b>	Nuclear plants could make all the electricity that is needed for PA.
<b>Noise</b>	These plants are about as loud as average street traffic.
<b>Land use and ecology</b>	Uranium fuel must be mined. This can disturb land, plants and animals. The amount of uranium that is mined is much less than that of coal.
<b>Safety</b>	<ul style="list-style-type: none"> <li>• There is a very small chance of nuclear accidents. Nuclear material might leak into the air and water if there is an accident. But, nuclear plants cannot explode like an atomic bomb.</li> <li>• Unlike plants in some parts of the world (Russia), U.S. plants are built inside strong concrete buildings. These prevent leaks if there is an accident.</li> <li>• There has been one accident at a U.S. nuclear plant. It was in 1979 at the Three Mile Island plant in Central PA. The plant’s concrete building kept the radiation from leaking. No plant workers were hurt and no one died. Plants have been fixed to be much safer since the accident.</li> <li>• Some people worry about terrorism involving a nuclear plant. The government, electric utility companies and other industries are working to make all industrial plants safer against terrorism.</li> <li>• These plants are quite safe for operators. All mining is dangerous for the miners. But mining uranium is generally much safer than mining coal.</li> </ul>
<b>Lifespan</b>	The lifetime of any plant is uncertain. But, a new advanced nuclear plant built today would likely make electricity for at least 60 years.
<b>Current Use</b>	There are a few advanced nuclear plants in the world, but none in the U.S. The U.S. does have 103 older nuclear plants in operation.

\* More cost and pollution information is available in “Cost Comparison” and “Pollution Comparison” sheets in Envelope #3.

# Energy Efficiency

**How it Works:** Energy efficiency cuts the amount of electricity we use. Fewer power plants will be built if we use less electricity. Less CO<sub>2</sub> will then be released into the air. There are many ways to cut electricity use. For example, people can use more efficient light bulbs. They can buy more efficient refrigerators, air conditioners and other appliances. Buildings can also be better insulated. Energy efficiency can help a lot. Vermont and California have programs to promote it. As a result, people in VT use about 20% less electricity than people in PA. Californians use about 40% less.



Energy efficient house in North Carolina (renovated rather than newly constructed).  
Source: www.newsweek.com

## MORE INFORMATION (ABOUT ENERGY EFFICIENCY)

<b>Cost *</b>	<ul style="list-style-type: none"> <li>• If your house uses less electricity, your bills will go down. Yet, there may be a large initial cost to buy a new efficient appliance or insulation. Over time, you would recoup this cost from the money you save each month on your electric bill. So, you may save more money in the end than you initially spent. Some states like Vermont help you with the initial cost.*</li> <li>• There is a point when you may no longer recoup the costs from buying efficient things. This happens when you try to cut your electricity use by about 13% or more.*</li> <li>• Energy efficiency means that you spend money now and get the savings later. A \$10 energy efficient light bulb costs more than a regular light bulb. But, it lasts 10 times longer and saves 50 to 80% more electricity.</li> </ul>
<b>CO<sub>2</sub> released *</b>	Energy efficiency appliances release no CO <sub>2</sub> to the air.*
<b>Other Pollution/Waste *</b>	<ul style="list-style-type: none"> <li>• There is no direct air or water pollution from energy efficiency. Because energy efficiency cuts the amount of electricity we use, it can help to reduce the pollution in the air and water because fewer power plants will need to be built.*</li> <li>• There is no direct solid waste made from energy efficient products.</li> <li>• Energy efficient products, in many cases, use less water than those they replace.</li> </ul>
<b>Availability</b>	You may be able to cut your electricity use by up to 18% at little extra cost in PA. The government may give incentives for buying efficient products. This helps to get larger savings.
<b>Reliability</b>	Most energy efficient products are as dependable as those they replace.
<b>Limits of use</b>	We can buy all efficient products. We can insulate all of our buildings. But, we will always need some electricity to live comfortably. Also, there is a point at which cutting our electricity use by any more becomes very costly. Some power plants will need to be built even if we do our best to cut electricity use.
<b>Noise</b>	Energy efficient products are no louder than those they replace.
<b>Land use and ecology</b>	Fewer power plants will be built if we use less electricity. Building power plants can disturb the surrounding land, plants and animals. Energy efficiency would stop some of this from occurring.
<b>Safety</b>	Energy efficient appliances and buildings are as safe as those they replace.
<b>Lifespan</b>	The lifetime of efficient appliances vary. Efficient light bulbs last much longer than traditional bulbs. Insulation in a building can last for as long as the building stands.
<b>Current Use</b>	Energy efficient appliances are in stores now. Most have an “energy efficiency” rating. Much more can also be done to better insulate and cool buildings. But, people must learn about these options and take action on them.

\* More cost and pollution information is available in “Cost Comparison” and “Pollution Comparison” sheets in Envelope #3

# Natural Gas

**How it works:** Most of the natural gas in western PA is used to heat homes. But, it can also be used in power plants to make electricity. In the plant, natural gas is burned. Its heat is used as fuel in a type of engine, called a “turbine”. This turbine then runs a generator to make electricity. The left-over hot gas is used to make steam. The steam also fuels a turbine, which runs a second generator to make more electricity. Because it uses two turbines, the plant is more efficient.



Natural gas plant near Albany, New York.  
Source: www.pseg.com

## MORE INFORMATION (ABOUT NATURAL GAS PLANTS)

<b>Cost *</b>	The cost of electricity from natural gas plants is very dependent on the price of natural gas. The price varies with demand and supply. Demand for natural gas is expected to increase in the future. This will likely cause the price of natural gas to rise. *
<b>CO<sub>2</sub> released *</b>	Natural gas plants release about half as much CO <sub>2</sub> to the air as traditional coal plants. *
<b>Other Pollution/Waste *</b>	<ul style="list-style-type: none"> <li>Natural gas plants release nitrogen oxides into the air. These plants are often used along with solar plants or wind power. Natural gas plants fill in power when it is not sunny or windy. In this case, the natural gas plant must be turned on quickly. This can increase the nitrogen oxides released into the air. This pollutant can cause people to have some health problems. *</li> <li>There is almost no solid waste from gas plants.</li> <li>Natural gas plants use a lot of water to cool the plant’s equipment. The amount is less than traditional coal plants. The water comes from wells, lakes, rivers or oceans. Some of it will evaporate after use. The rest is returned to its source. Since it is hot, the water may disturb plants and animals living in the water source.</li> </ul>
<b>Availability</b>	<ul style="list-style-type: none"> <li>U.S. supplies of natural gas are running low, even though new sources are still being found. There is lots of gas in other parts of the world. New plants built in PA could run for their entire lifespan on this world supply. It would be transported to the U.S. in large tanker ships.</li> <li>Gas prices have gone up and down a lot in the past 10 years. Since the U.S. has limited supplies, some of our future gas will come from places like the Middle East. A portion of U.S. government funds is used to make sure we can get gas and oil from the Middle East.</li> </ul>
<b>Reliability</b>	Natural gas, when available, can provide steady and dependable electricity.
<b>Noise</b>	These plants are about as loud as average street traffic.
<b>Limits of use</b>	The cost of natural gas may increase in the future. Since U.S. supplies are running low, we may also become more dependent on foreign (Middle East) natural gas. For these reasons, it is risky to make all the electricity needed for PA with natural gas.
<b>Land use and ecology</b>	These plants do not use much land. But, pipelines sometimes must be built under private land. The landowner and pipeline company will have to agree about how to maintain the land around the pipeline. Drilling for natural gas can disturb local land, plants and animals. This is especially true in unpopulated areas, like Alaska.
<b>Safety</b>	These plants are quite safe for operators. It is rare for natural gas to leak from a pipeline. If it does occur, unlike CO <sub>2</sub> , the gas can burn or explode. Like CO <sub>2</sub> , people can suffocate from the gas.
<b>Lifespan</b>	The lifetime of any plant is uncertain. But, a new natural gas plant built today would likely make electricity for at least 30 years.
<b>Current Use</b>	There are more than 350 of these plants working in the U.S. today.

\* More cost and pollution information is available in “Cost Comparison” and “Pollution Comparison” sheets in Envelope #3.

# Solar Cell Power



A solar plant in Fresno, CA.  
Source: [www.nrel.gov](http://www.nrel.gov)

**How it works:** There are two ways to make electricity from sunlight. In the first, sunlight is absorbed into solar cells. The energy from sunlight is then turned directly into electricity. In deserts, a second way is used. The heat from the sun is used to make steam. The steam is used as fuel in a type of engine, called a “turbine”. This turbine runs a generator to make electricity. While the second way is cheaper, it cannot be used in PA because here the sun is not hot enough.

Solar cells can be put on your home’s roof. The initial cost would be very large. So, this is not discussed further here. Instead, many solar cells can be joined together on open land. This makes a solar power plant.

## MORE INFORMATION (ABOUT SOLAR CELL POWER)

<b>Cost *</b>	Solar cell power costs more in PA than in sunnier states like Arizona and California. *
<b>CO<sub>2</sub> released*</b>	Solar plants release no CO <sub>2</sub> to the air. *
<b>Other Pollution/Waste *</b>	<ul style="list-style-type: none"> <li>• Solar plants, by themselves, release no air or water pollution. However, solar plants alone cannot make a steady amount of electricity. When it is not sunny, the solar plants need natural gas plants to fill in these gaps in electricity. These natural gas plants do release nitrogen oxides into the air. *</li> <li>• Solar cells are made of some toxic materials. There may be some pollution if they are not properly disposed of at the end of their lifetime.</li> <li>• Solar plants use a very small amount of water to clean the solar cells.</li> </ul>
<b>Availability</b>	There is no sunlight at night. There is less sunlight on cloudy days. In PA, the solar plants only make about 10% of their possible power. They cannot make 100% because the sun does not shine at maximum strength or for 24 hours per day.
<b>Reliability</b>	The dependability of solar cell power varies with the amount of sunlight. If more than about 5% of the electricity made in PA comes from solar cells, then other kinds of plants will have to be built to make up for nighttime and cloudy days. In the future, we might use very large batteries to store electricity from the sun, but that is very costly to do in PA today.
<b>Limits to use</b>	Solar power is intermittent because it is not sunny all the time. So, solar plants cannot make all of the electricity that is needed for PA. Other types of plants (usually natural gas) must also be built.
<b>Noise</b>	Solar plants are silent.
<b>Land use and ecology</b>	Many solar cells must be put together to make a solar plant. Therefore, they use a lot of land. Unlike wind, this land cannot be used for other purposes.
<b>Safety</b>	These plants are quite safe for operators.
<b>Lifespan</b>	The lifetime of any plant is uncertain. But, a new solar plant built today would likely make electricity for at least 20 years.
<b>Current Use</b>	There are five solar cell plants working in the U.S. today (in Arizona and California).

\* More cost and pollution information is available in “Cost Comparison” and “Pollution Comparison” sheets in Envelope #3.

# Traditional Coal Plants

## Option 1: CO<sub>2</sub> is released into air

**How it Works:** Traditional coal plants burn coal to make steam. The steam is used as fuel in a type of engine, called a “turbine”. This turbine runs a generator to make electricity.



The Armstrong traditional coal plant in Pennsylvania.  
Source: [www.industcards.com/st-coal-usa-pa.htm](http://www.industcards.com/st-coal-usa-pa.htm)

When coal is burned, CO<sub>2</sub> is released by the plant. In **Option 1**, this CO<sub>2</sub> escapes into the air because no equipment is added to capture the CO<sub>2</sub>.

### MORE INFORMATION (ABOUT TRADITIONAL COAL PLANTS)

<b>Cost *</b>	<i>Traditional coal plants</i> make cheaper electricity than advanced coal plants. Yet, it is more expensive to add CO <sub>2</sub> capture equipment to <i>traditional coal plants</i> . *
<b>CO<sub>2</sub> released *</b>	Traditional coal plants release CO <sub>2</sub> to the air. *
<b>Other Pollution/Waste *</b>	<ul style="list-style-type: none"> <li>• While these plants are much cleaner than in the past, they still release CO<sub>2</sub>, nitrogen oxides, sulfur dioxide, mercury and particulates to the air. These pollutants can cause people to have many different health problems. *</li> <li>• Traditional coal plants produce a lot of ash that contain hazardous chemicals. Some ash can be recycled, for example, to make concrete. The leftover solid waste is usually put in a landfill near the plant.</li> <li>• Traditional coal plants use a lot of water to cool the plant’s equipment. The water comes from wells, lakes, rivers or oceans. Some of it will evaporate after use. The rest is returned to its source. Since it is hot, the water may disturb plants and animals living in the water source.</li> </ul>
<b>Availability</b>	Experts say that the U.S. has enough coal to meet its needs for at least 100 years.
<b>Reliability</b>	Coal can provide steady and dependable electricity.
<b>Limits of use</b>	Traditional coal plants release a lot of CO <sub>2</sub> . They cannot make all of the electricity that is needed in PA if we want to reduce CO <sub>2</sub> . Other types of plants must also be built.
<b>Noise</b>	These plants are about as loud as average street traffic.
<b>Land use and ecology</b>	Coal mining near the surface disturbs the land, plants and animals. It also disrupts and pollutes streams. Underground mining can cause acidic water to leak into streams. If the mine collapses, it can also cause the ground to sink or shift.
<b>Safety</b>	These plants are quite safe for operators. Coal mining is dangerous for the miners.
<b>Lifespan</b>	The lifetime of any plant is uncertain. But, a new traditional coal plant built today would likely make electricity for at least 50 years.
<b>Current Use</b>	There are more than 1,000 of these plants working in the U.S. today.

\* More cost and pollution information is available in “Cost Comparison” and “Pollution Comparison” sheets in Envelope #3.



# Traditional Coal Plants

## Option 2: CO<sub>2</sub> is captured

**How it Works:** This is the same plant as the one described in “*Tradition Coal Plants, Option 1*”. But in Option 2, additional equipment is added to capture the CO<sub>2</sub> before it escapes to the air. This CO<sub>2</sub> is turned into a liquid. A pipeline takes it from the plant and puts it permanently in rock formations more than half a mile (about 2,500 feet) underground. This is shown in the diagram to the right. The rock formations will be tested ahead of time to make sure the CO<sub>2</sub> will stay trapped in there. The CO<sub>2</sub> will also be monitored to make sure that it does stay in place. After a few decades, the CO<sub>2</sub> will dissolve (and become trapped) in the water in the rocks. Over thousands of years, it will likely change into solid minerals.

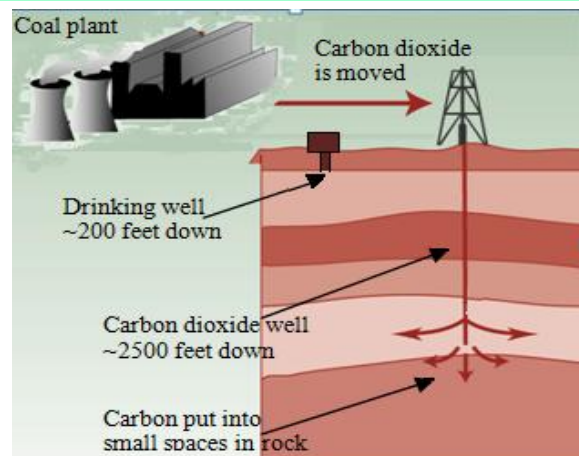


Diagram of a coal plant with carbon capture and disposal. Modified from [www.co2crc.com.au](http://www.co2crc.com.au)

### MORE INFORMATION (ABOUT CO<sub>2</sub> CAPTURE EQUIPMENT)

<b>Cost *</b>	It costs more to add CO <sub>2</sub> capture equipment to <i>traditional coal plants</i> than to advanced coal plants.*
<b>CO<sub>2</sub> released *</b>	Traditional coal plants with CO <sub>2</sub> capture equipment release very little CO <sub>2</sub> into the air. *
<b>Other Pollution/Waste *</b>	<ul style="list-style-type: none"> <li>• The equipment alone makes very little air or water pollution. *</li> <li>• If CO<sub>2</sub> gets in underground drinking water, the water can become contaminated. That risk is small because CO<sub>2</sub> wells will be built more than 10 times deeper than most wells for drinking water.</li> <li>• Adding CO<sub>2</sub> capture equipment will make traditional coal plants use about twice as much water.</li> </ul>
<b>Availability</b>	<ul style="list-style-type: none"> <li>• There are suitable rock formations in much of PA and the rest of the U.S. Before use, they will be tested to make sure that they can safely hold the CO<sub>2</sub>.</li> <li>• There are thousands of miles of gas pipelines in the U.S. today. CO<sub>2</sub> is moved through similar pipelines. CO<sub>2</sub> pipelines are already used in the U.S., but more need to be built.</li> </ul>
<b>Reliability</b>	Capturing CO <sub>2</sub> does not make advanced coal plants less dependable.
<b>Limits of Use</b>	Traditional coal plants with CO <sub>2</sub> capture equipment could make all the electricity needed for PA.
<b>Noise</b>	There would be little change in the noise from the traditional coal plant if CO <sub>2</sub> capture equipment is added.
<b>Land use and ecology</b>	The CO <sub>2</sub> will cause very little harm to living plants or animals once it is in the deep underground rock formations. Some CO <sub>2</sub> is also naturally found in the ground.
<b>Safety</b>	<ul style="list-style-type: none"> <li>• Unlike oil or gas, CO<sub>2</sub> cannot burn or explode. As with oil and gas pipelines, the chance of pipeline leaks is low. If lots of CO<sub>2</sub> did leak from a pipeline, it would usually mix into the air. But if the leak happened in a valley or tunnel, the CO<sub>2</sub> could build up for a while. In this case, people and animals could suffocate if the leak was large enough.</li> <li>• There is a small chance that CO<sub>2</sub> could leak out of an underground space. These leaks would be very slow. In almost all cases, the CO<sub>2</sub> would mix into the air before harming anyone.</li> <li>• The CO<sub>2</sub> in the ground can be monitored with underground equipment. If the CO<sub>2</sub> starts to move to places where it should not be, there are ways that this could be fixed. For example, the leak could be plugged up or the CO<sub>2</sub> could be moved to some other location.</li> <li>• Pumping CO<sub>2</sub> into the ground builds up underground pressure. This could increase the risk of small earthquakes in the some areas. However, PA is not prone to earthquakes.</li> <li>• After a few decades, the CO<sub>2</sub> dissolves in the deep underground water. This reduces many of the risks. Leaks become very unlikely. The CO<sub>2</sub> cannot get in drinking water. It cannot move to places it should not be. It cannot cause earthquakes.</li> <li>• Once an underground space is full and closed, and shown to be secure, the government will take control and continue to monitor it for safety. Experts disagree on how long government should continue to monitor it.</li> </ul>
<b>Lifespan</b>	There is enough underground space to capture CO <sub>2</sub> for the entire life of any coal plant built.
<b>Current Use</b>	The U.S. Government is capturing CO <sub>2</sub> underground in 25 test sites across the U.S. today.

\* More cost and pollution information is available in “Cost Comparison” and “Pollution Comparison” sheets in Envelope #3.

# Wind Power



Modern wind turbines in Somerset, PA  
Source: [www.solutions-site.org/](http://www.solutions-site.org/)

**How it Works:** Modern wind machines are much larger than the old windmills in Holland, or the metal wind mills that pumped water for cattle in the American West. They are often between 100 and 300 feet high. That is about as tall as a 10 to 30 story building. The machines have blades that look like an airplane propeller. The wind turns the blades, which runs a generator to make electricity.

## MORE INFORMATION (ABOUT WIND POWER)

<b>Cost *</b>	<ul style="list-style-type: none"> <li>The cost of wind power has been decreasing as larger and better machines are made. *</li> <li>The large wind machines used today make cheaper wind power than the smaller ones used in the past.</li> </ul>
<b>CO<sub>2</sub> released *</b>	Wind machines release no CO <sub>2</sub> to the air. *
<b>Other Pollution/Waste *</b>	<ul style="list-style-type: none"> <li>Wind farms, by themselves, release no air or water pollution. However, wind farms alone cannot make a steady amount of electricity. When it is not windy, the wind farms need natural gas plants to fill in these gaps in electricity. These natural gas plants do release nitrogen oxides into the air. *</li> <li>There is almost no solid waste from wind farms.</li> <li>Wind farms use a very small amount of water to clean the wind machines.</li> </ul>
<b>Availability</b>	Wind farms work well when built in windy areas. PA has lots of wind on hilltops in the center of the state. However, even the best wind farms in PA only make 30% of the power that would be possible if the wind was always blowing. They cannot make 100% because sometimes the wind is not blowing. To get the best results from a wind farm, the wind needs to blow fast, but not too fast.
<b>Reliability</b>	Wind varies in strength, which can make it less dependable for making electricity. If more than 10% of the electricity made in PA comes from wind, then gas plants will have to be built to make up for times when it is not windy. In the future, we might use very large batteries to store electricity from wind, but that is very costly to do in PA today.
<b>Limits of use</b>	Wind power is intermittent because it is not windy all the time. So, wind farms cannot make all of the electricity that is needed for PA. Other types of plants (usually natural gas) must also be built.
<b>Noise</b>	Wind farms make some low noise. It is less than the noise from most other power plants. But, since wind farms are in the country, the noise is often more noticeable.
<b>Land use and ecology</b>	Each wind machine needs between 45 and 75 acres. That is about the size of 35 to 55 football fields. Wind farms with many machines require hundreds of acres. If the machines are built on farm land, most of it can still be used for farming. In forests, trees must be cleared to build the machines. This can disturb the plants and animals. On mountain ridges, wind farms can be very visible.
<b>Safety</b>	Wind farms do not harm people. The blades of wind machines do sometimes strike and kill birds and bats.
<b>Lifespan</b>	The lifetime of any plant is uncertain. But, a new wind farm built today would likely make electricity for at least 25 years.
<b>Current Use</b>	There are more than 100 wind farms working in the U.S. today.

\* More cost and pollution information is available in "Cost Comparison" and "Pollution Comparison" sheets in Envelope #5