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Alternative/Renewable Energy

The following training document was created through a collaborative effort between the following people:

Kristal McCormick, Howard County Soil Conservation District
Clare Seibert, Maryland Envirothon Coordinator
Lynne Hoot, Executive Director of Maryland Association of Soil Conservation Districts
Doug Wigfield, MD Department of Natural Resources, Wildlife and Heritage Division
Elena Takaki, MD Department of Natural Resources, Watershed Services Division
Lenore Vasilas, USDA-Natural Resources Conservation Service
Frank Lopez, MD Department of Natural Resources, Forest Service

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TRADITIONAL ENERGY USES AND PRODUCTION

ELECTRICITY

Electricity is a basic part of nature and the most widely used form of energy. There are many traditional options for creating electricity. These options include hydropower, fossil fuels and nuclear power. However electricity is created the output is specified in megawatts.

Hydropower

There are two basic types of hydropower systems. The first method uses reservoirs, created by dams, to allow flowing water to accumulate. The water flows through a pipe called a penstock and applies pressure against turbine blades to drive a connected generator to produce energy. The second system uses the "run-of-river", force of the river current rather than falling water. As in the first method, water applies pressure to turbine blades to produce electricity by way of the connected generator. In both cases, the flow or fall of the moving water determines the amount of energy available.

Consumption

According to the U.S. Department of Energy, in 2002, 7 percent of the nation's electricity was generated by hydropower. In the same year, it accounted for 2 percent of Maryland's electricity.

By-products

There are no by-products from the generation of electricity by hydropower. It is considered a clean source. No pollutants are emitted into the air or water. There are no greenhouse gases adding to climate change. By the standards of discharge and emissions hydropower is considered to be the least costly environmentally.

Recreation is the most visible and publicly driven benefit of hydropower plants. Reservoirs provide recreational opportunities such as boating and fishing. Rivers beyond dams provide the opportunity for kayaking and white water rafting. Hoover Dam, completed in 1936 on the Colorado River between Arizona and Nevada created Lake Mead. Lake Mead is a 110 mile long national recreational area that offers water sports and fishing in a desert setting.

Impacts on Ecosystems

Hydropower facilities can negatively impact the environment. There is an impediment on the migration of fish and eel species. Infrastructure disturbs the nature of watercourses, altering water levels and temperature. These facilities slow down the cycling and transport of nutrients and sediments. Dams eliminate the variations in flow that occur seasonally. Due to developments of the facilities there is a loss of land. Animals can be affected on an individual level, being killed if caught in the flows through the turbines. The diversion of water, drilling, slope alterations and reservoir preparation that occur during the construction of dams can also impact the surrounding ecosystems. Though these concerns are important, fisheries is still the widest concern.

The hydropower industry has demonstrated willingness to work and plan in a manner to alleviate these problems.

Infrastructure & Distribution

Hydropower transmission facility sends the electricity to a market terminal that sends the electricity to the consumer.

Conservation Practices

Fish, and eel, passage and protection measures, including ladders and screens, lessen, but do not eliminate, the impacts that occur.

Organizations and Agencies

Some organizations and agencies work to educate the public, some work to get laws made. These organizations and agencies include U.S. Department of Energy, Foundation for Water and Energy, American Council on Renewable Energy, Hydro Research Foundation, National Hydropower Association, US Environmental Protection Agency Clean Energy, and Federal Energy Regulatory Commission - Hydropower.

Fossil Fuels

Fossil fuels are formed in the ground, after millions of years, by chemical and physical changes in plant and animal residues under high temperature and pressure. Fossil fuels include coal, natural gas and petroleum.

To create electricity the fossil fuels are burned to heat water to make steam that will push turbines connected to generators that produce electricity. Natural gas can also be burned to produce hot combustion gases that pass directly through the turbine spinning blades of the turbine attached to a generator that then produces electricity. These gas turbines are commonly used when electricity utility usage is in high demand.

Coal is a sedimentary organic rock that contains more than 50 percent carbonaceous material by weight and is composed largely of carbon, hydrogen, oxygen, nitrogen and sulfur with small amounts of other materials ranging from aluminum to zirconium. In the United States, it is the largest single primary source of energy that is used to create electricity. In 2005, the US produced 1,233.3 million short tons. In the same year 1,128.3 million short tons were consumed of which 1,039 million short tons were consumed by the electric power industry. Sometimes, electric power plants are built near the coal mines to lower transportation costs of the coal.

Consumption

According to the Energy Information Administration ...

- Coal fired plants accounted for 50 percent of all electricity generated in 2004. This share is expected to increase to 57 percent by the year 20 0.
- Natural gas fired plants accounted for 18 percent of the total supply in 2004 with a slight decline expected by the year 2030 where it will be 17 percent.
- In Maryland, electricity generated by means of natural gas used 12,045 million cubic feet of the resource in 2004. That was only 0.22 percent of the national total.

Fossil fuels account for almost 90 percent of the world's energy consumption ... petroleum 40 percent, coal 24 percent, and natural gas 22 percent.

By-products

Burning coal produces a large amount of coal ash. The primary forms of this are fly ash, bottom ash and boiler slag. This must be disposed of or recycled. There are some uses for these types of ash. Fly ash can be used as a low cost filler in golf balls, bowling balls, tennis rackets, plastics, screwdriver handles and linoleum as well as a partial replacement for cement in concrete. Bottom ash is used as a base in road construction and in concrete blocks. Boiler slag can be used as a blasting abrasive and in roofing shingles.

Natural gas burned leaves minimal ashes. It is considered clean burning compared to coal and petroleum. Natural gas, when used to generate power through gas turbines or steam turbines, produces less greenhouse gas per unit of energy released. To obtain the equivalent amount of heat burning natural gas produces about 30 percent less carbon dioxide than burning petroleum and approximately 45 percent less than burning coal.

When a barrel, a 42 US gallon barrel, of petroleum is refined there ends up being just over 44 gallons of petroleum products. It is broken down into the following:

- 19.6 gallons gasoline
- 10 gallons diesel fuel and heating oil
- 4 gallons jet fuel
- 1.7 gallons heavy fuel oil
- 1.7 gallons liquefied petroleum gas (LPG)
- 7.6 gallons other product (ink, heart valve, dishwashing liquid, crayons, tires, deodorant, bubble gum)

Petroleum by-products fall into the following categories: Fuels including gasoline, diesel fuel, jet fuel and shipping fuel; Lubricants such as mineral lube oils, grease lube oils and synthetic lube oils; Specials including solvents, paraffin, coke and asphalt.

Impacts on Ecosystems

Fossil fuel fired electricity generation is the single greatest source of air pollution. Burning fossil fuels releases compounds into the air that are harmful to humans, animals, plants and ecosystems. Carbon dioxide is released causing concern about global warming.

Methane, from natural gas, can leak into the atmosphere from wells, storage tanks and pipelines. Burning methane releases only carbon dioxide and water.

Drilling and exploring for petroleum and natural gas impacts land and marine habitats. Oil found in oceans is mostly attributed to natural oil seeping from the ocean floor. This natural seepage and leaks that occur when we use petroleum oil on land are the largest contributors. Oil from ship or barge spills only account for 2 percent of the oil found in oceans. The oil spills from ships and barges are lessened because new ships are required to have a double hull lining to protect against spills.

Infrastructure & Distribution

Coal, after being mined, is placed on conveyer belts leading to prep plants located at the mining site. The prep plant cleans and processes the coal removing dirt, rock, ash, sulfur and other undesired materials. This process increases the heating value of the coal. Once the coal is mined and processed it is shipped to market. The means of transportation can be by train, barge, ship, truck or even pipeline. Almost 60 percent of coal in the United States is transported, for at least part of its trip, by train. The cost of shipping can be greater than the cost of actually mining the coal. Due to the high price of transportation coal-fired power plants are sometimes built near the coal mines to reduce cost.

Natural gas is stored in underground caverns formed inside depleted gas reservoirs from previous gas wells, salt domes or in tanks as liquefied natural gas. Pipelines are used for distribution of natural gas.

Once electricity is created, starting with the use of fossil fuels, the components that support the electricity are very similar. The electricity travels along cables from the generator to transformer which changes the electricity from low voltage to high voltage. Electricity can be moved long distances more efficiently using high voltage. The transmission lines carry the electricity to substations where transformers change the high voltage electricity into low voltage electricity. From the substation distribution lines carry electricity to homes, offices and factories which require low voltage electricity.

Conservation Practices

Satellites, Global Positioning System (GPS) and Remote Sensing devices help find reserves for petroleum and natural gas while drilling fewer wells.

Efforts are made to reduce sulfur, nitrogen oxides and other impurities released when coal is burned. The industry has developed more effective ways in which to clean coal before it leaves the mine. There is also low sulfur coal being mined. Power plants use scrubbers to clean sulfur from the smoke before it leaves the smokestacks. Clean coal technologies remove sulfur and nitrogen oxides from the coal or convert coal to a gas or liquid form.

Land restoration after surface mining (coal less than 200 feet below surface) is an important part of the process. Efforts are made to prevent damage to ground and surface waters.

Organizations and Agencies

The main agency concerning fossil fuels is the U.S. Department of Energy, Office of Fossil Energy.

Nuclear Power

Consumption

According to the Energy Information Administration, nuclear power plants accounted for 20 percent of all electricity generated in 2004. This share is expected to decrease to 15 percent by the year 2030.

By-products

The fission reaction also creates radioactive material. This material is kept in a solid form to prevent its release and potentia' harm to people.

Impacts on Ecosystems

With nuclear power plants there are health concerns, from increased radiation levels. There is also the fear of a nuclear accident.

Infrastructure

In a nuclear power plant a reactor contains a core of nuclear fuel, primarily enriched uranium. The atoms are hit by neutrons, then split (fission), releasing heat and more neutrons. Under controlled conditions, other neutrons strike more uranium atoms splitting more atoms and the cycle continues. Continuous fission can take place forming chain reaction releasing heat. This heat is used to boil water in the core of the reactor. This water is then sent to another section of the plant to a heat exchanger. The heat exchanger heats another set of pipes filled with water, making steam. The steam spins turbines that generate electricity.

Conservation Practices

Control rods are used to keep the atom splitting regulated so it doesn't go too fast.

Most nuclear waste has low-level radioactivity. It is the tools, protective gear, ordinary trash and disposable items that are subject to special regulation. Their storage is managed so that it will not come into contact with the environment.

NATURAL GAS

A gaseous fossil fuel, natural gas is made up of methane, ethane and propane. Residential domestic uses of natural gas include cooking, clothes dryers and heating and cooling. Heating and cooling includes water heaters, boilers and furnaces. A minute amount of oderant, such as t-butyl mercaptan with a rotten egg or sulfur smell, is added to the colorless odorless gas to detect leaks.

Consumption

In 2003, the United States consumed 22.3 trillion cubic feet of natural gas. In the same year, the world consumption was 95.5 trillion cubic feet.

Of the United State's energy consumption about 23 percent is natural gas. Over half of the homes in the U.S. use it as the main heating fuel.

By-products

When natural gas is burned it leaves minimal ashes as a residue. It is considered clean burning compared to coal and petroleum. Natural gas, when used to generate power through gas turbines or steam turbines, produces less greenhouse gas per unit of energy released. To obtain the equivalent amount of heat burning natural gas produces about 30 percent less carbon dioxide than burning petroleum and approximately 45 percent less than burning coal.

Impacts on Ecosystems

The use of natural gas produces fewer emissions of sulfur, carbon and nitrogen than do coal or oil. Almost no ash particles are left after burning.

Methane, a greenhouse gas, can leak into the atmosphere from wells, storage tanks and pipelines. Burning methane releases only carbon dioxide and water. Drilling and exploring for natural gas can also impact land and marine habitats.

Infrastructure

Natural gas is stored in underground caverns formed inside depleted gas reservoirs from previous gas wells, salt domes or in tanks as liquefied natural gas. Pipelines are used for distribution of natural gas.

Liquefied Natural Gas (LNG) is transported across oceans by LNG carriers. Tank trucks carry LNG or Compressed Natural Gas (CNG) over shorter distances, transport directly to end users or to distribution points with pipelines for further transport. High costs are due to the requirement of additional facilities for liquification or compression at production point and then gasification or decompression at the end use facilities.

Conservation Practices

Satellites, Global Positioning System (GPS) and Remote Sensing Devices help find reservoirs with fewer wells being drilled.

Organizations and Agencies

American Gas Association (AGA) and Natural Gas Supply Association (NGSA) are two organizations that educate the public about natural gas and the industry.

FOSSIL FUELS - VEHICLES

Consumption

Petroleum accounts for almost 99 percent of the fuel we use in our vehicles. In 2003 the United States used 13 million barrels per day. It is estimated that in 2025 20 million barrels will be used per day.

In 2004, 259 million cubic feet of natural gas was used for vehicle fuel. This accounted for 1.26% of the national total.

By-products

When a barrel, a 42 US gallon barrel, of petroleum is refined there ends up being just over 44 gallons of petroleum products. It is broken down into the following:

19.6 gallons gasoline
10 gallons diesel fuel and heating oil
4 gallons jet fuel
1.7 gallons heavy fuel oil
1.7 gallons liquefied petroleum gas (LPG)
7.6 gallons other product (ink, heart valve, dishwashing liquid, crayons, tires, deodorant, bubble gum)

Impacts on Ecosystems

Emissions from vehicles are created from the incomplete combustion of diesel or gasoline. Engine design, emission controls and vehicle maintenance also affect vehicle emissions. Carbon monoxide, carbon dioxide, hydrocarbons, sulfur oxides, nitrogen oxides and volatile organic compounds are included in the many pollutants emitted by vehicles. These pollutants combine to form secondary pollutants including ozone and fine particulate matter. An individual vehicle's emissions may not seem like a lot when compared to a factory or other industrial source but when many vehicles are on the road at the same time, their emissions can seriously impact the air quality.

When petroleum products are burned there is a release of carbon dioxide, carbon monoxide, nitrogen oxides, particulate matter and unburned hydrocarbons.

Drilling and exploring for petroleum and natural gas impacts land and marine habitats. Oil found in oceans is mostly attributed to natural oil seeping from the ocean floor. This natural seepage and leaks that occur when we use petroleum oil on land are the largest contributors. Oil from ship or barge spills only account for 2 percent of the oil found in oceans. The oil spills from ships and barges are lessened because new ships are required to have a double hull lining to protect against spills.

Natural Gas is used for alternate fuel vehicles. It is clean burning and produces significantly fewer harmful emissions than reformulated gasoline.

Methane, from natural gas, can leak into the atmosphere from wells, storage tanks and pipelines. Burning methane releases only carbon dioxide and water.

Infrastructure

From drilling, petroleum is sent to refinery by means of pipeline, ship or barge.

The difficulty in the use of natural gas is in the transportation and storage. Pipelines are economical but impractical across the oceans.

Natural Gas can be stored on board vehicles in tanks as compressed natural gas (CNG) or cryogenically cooled to liquid state as liquefied natural gas (LNG).

Liquefied Natural Gas (LNG) is transported across oceans by LNG carriers. Tank trucks carry LNG or Compressed Natural Gas (CNG) over shorter distances, transport directly to end users or to distribution points with pipelines for further transport. High costs are due to the requirement of additional facilities for liquification or compression at production point and then gasification or decompression at the end use facilities.

Conservation Practices

Satellites, Global Positioning System (GPS) and Remote Sensing devices help find reserves, for petroleum and natural gas, with fewer wells drilled.

If a leak in a storage tank or pipeline occurs, petroleum gets into the ground then the ground must be cleaned . To prevent this all buried tanks are to be replaced by tanks with double lining.

Environmental laws are aimed at changing the make up of gasoline and diesel fuels to produce fewer emissions. Gasoline and diesel are cleaner now than in the 1990s. Over the next few years sulfurs will be reduced in gasoline and diesel.

ENVIRONMENTAL JUSTICE

The following is a brief excerpt from the USDOE Office of Environmental Policy and Assistance document entitled- "EXECUTIVE ORDER 12898, FEDERAL ACTIONS TO ADDRESS ENVIRONMENTAL JUSTICE IN MINORITY AND LOW-INCOME POPULATIONS"

BACKGROUND: On February 11, 1994, President Clinton signed Executive Order (EO) 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. The Order is designed to focus federal attention on the environmental and human health conditions in minority communities and low-income communities with the goal of achieving environmental justice. The Order is also intended to promote nondiscrimination in federal programs substantially affecting human health and the environment. In addition it places emphasis on providing minority communities and low-income communities access to public information on, and an opportunity for public participation in, matters relating to human health or the environment.

What is Environmental Justice?
The Environmental Protection Agency's (EPA's) Office of Environmental Justice offers the following definition:
The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, policies. Fair treatment means that no group of people, including racial, ethnic or socioeconomic group, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies.

What is Executive Order 12898?
Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, was signed by President Clinton on February 11, 1994. This Order broadly states that federal activities, programs, and policies should not produce disproportionately high and adverse impacts on minority and low-income populations. The Order also indicates that these populations should not be denied the benefits of or excluded from participation in these activities, programs, and policies. The Order directs federal agencies to create strategies to achieve environmental justice goals. An Interagency Working Group was established to coordinate the agencies' implementation activities. The Order also directs federal agencies to include a number of environmental justice related issues in their research and data collection activities. Agencies are directed to encourage public involvement in the implementation of the Order by ensuring that public documents are easily accessible and understood, including translations where practicable and appropriate. Further opportunities for public involvement are to be provided through public meetings sponsored by the Interagency Working Group.

ALTERNATIVE ENERGY SECTION:

The information provided pertaining to alternative energy was obtained almost exclusively from the United States Department of Energy, Energy Efficiency and Renewable Energy website: www.eere.energy.gov

Energy Policy Act of 2005

On August 8, 2005, President Bush signed the Energy Policy Act (EPAct) of 2005. Some *of* the provisions defined in EPAct 2005 are summarized below.

The Energy Policy Act of 2005

The Energy Policy Act of 2005 (EPACT), signed by President Bush on August 8, 2005, offers consumers and businesses federal tax credits beginning in January 2006 for purchasing fuel-efficient hybrid-electric vehicles and energy-efficient appliances and products. Most of these tax credits remain in effect through 2007.

Buying and driving a fuel-efficient vehicle and purchasing and installing energy-efficient appliances and products provide many benefits such as better gas mileage – meaning lower gasoline costs, fewer emissions, lower energy bills, increased indoor comfort, and reduced air pollution.

Some consumers will also be eligible for utility or state rebates, as well as state tax incentives for energy-efficient homes, vehicles and equipment. Each state's energy office web site may have more information on specific state tax information.

About Tax Credits

\ tax credit is generally more valuable than an equivalent tax deduction because a tax credit reduces tax dollar-for-dollar, while a deduction only removes a percentage of the tax that is owed. Beginning in tax year 2006, consumers will be able to itemize purchases on their federal income tax form, which will lower the total amount of tax they owe the government.

Automobile Tax Credits

Individuals and businesses who buy or lease a new hybrid gas-electric car or truck are eligible for, and can receive, an income tax credit of $250-$3,400 - depending on the fuel economy and the weight of the vehicle. Hybrid vehicles that use less gasoline than the average vehicle of similar weight and that meet an emissions standard qualify for the credit. "Lean-burn" diesel vehicles could also qualify, but currently available diesel vehicles do not meet the emissions standard. There is a similar credit for alternative-fuel vehicles and for fuel-cell vehicles.

If individuals and businesses buy more than one vehicle, they are eligible to receive a tax credit for each. If a tax-exempt organization buys such a vehicle, the retailer is also eligible to receive another credit. Companies that buy heavy-duty hybrid trucks are also eligible for a larger tax credit. Currently, there is a $2,000 tax deduction for hybrid vehicles for the remainder of 2005.

This tax credit is for vehicles "placed in service" beginning January 1, 2006, but because there is a waiting list for many hybrids, consumers can receive the tax credit if they arrange to purchase the vehicle this year as long as they do not take possession of the vehicle until January 1, 2006. This tax credit will be phased out for each manufacturer once that company has sold 60,000 eligible vehicles. At that point, the tax credit for each company's vehicles will be gradually reduced *over* the course of another year.

Home Energy Efficiency Improvement Tax Credits

Consumers who purchase and install specific products, such as energy-efficient windows, insulation, doors, roofs, and heating and cooling equipment in the home can receive a tax credit of up to $500 beginning in January 2006.

The EPACT also provides a credit equal to 30% of qualifying expenditures for purchase for qualified photovoltaic property and for solar water heating property used exclusively for purposes other than heating swimming pools and hot tubs. The credit shall not exceed $2000.

Improvements must be installed in or on the taxpayer's principal residence in the United States. Home improvement tax credits apply for improvements made between January 1, 2006 and December 31, 2007.

Business Tax Credits

Businesses are eligible for tax credits for buying hybrid vehicles, for building energy- efficient buildings, and for improving the energy efficiency of commercial buildings (as outlined in the Energy Policy Act of 2005).

Biodiesel/Alternative Fuels

Small producer biodiesel and ethanol credit. This credit will benefit small agri-biodiesel producers by giving them a 10 cent per gallon tax credit for up to 15 million gallons of agri-biodiesel produced. In addition, the limit on production capacity for small ethanol producers increased from 30 million to 60 million gallons. This is effective until the end of 2008.

Credit for installing alternative fuel refueling property. Fueling stations are eligible to claim a 30% credit for the cost of installing clean-fuel vehicle refueling equipment, (e.g. E85 ethanol pumping stations). Under the provision, a clean fuel is an_ fuel that consists of at least 85% ethanol, natural gas, compressed natural gas, liquefied natural gas, liquefied petroleum gas, or hydrogen and any mixture of diesel fuel and biodiesel containing at least 20% biodiesel. This is effective through December 31, 2010.

Buildings

Credit for business installation of qualified fuel cells, stationary microturbine power plants, and solar equipment. This provides a 30% tax credit for the purchase price for installing qualified fuel cell power plants for businesses, a 10% credit for qualifying stationary microturbine power plants and a 30% credit for qualifying solar energy equipment. This is effective January 1, 2006 through December 31, 2007. *Business credit of energy-efficient new homes.* This provides tax credits to eligible contractors for the construction of a qualified new energy-efficient home. Credit applies to manufactured homes meeting Energy Star criteria and other homes, saving 50% of the energy compared to the EPACT standard. This is effective January 1, 2006 through December 31, 2007. *Energy-efficient Commercial building deduction.* This provision allows a tax deduction for energy-efficient commercial buildings that reduce annual energy and power consumption by 50% compared to the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) 2001 standard. The deduction would equal the cost of energy-efficient property installed during construction, with a maximum deduction of $1.80 per square foot of the building. Additionally, a partial deduction of 60 cents per square foot would be provided for building subsystems. *Energy-efficient appliances* - This provides a tax credit for the manufacturer of energy-efficient dishwashers, clothes washers, and refrigerators. Credits vary depending on the efficiency of the unit. This is effective for appliances manufactured in 2006 and 2007.

SOLAR ENERGY

The sun has been burning for more than 4.5 billion years, and scientists believe it has at least as many years remaining in its lifecycle. The global population uses less energy in 27 years than the earth receives from the sun in a single day.

The potential of the solar industry has been severely underdeveloped. Currently, the global community derives three-hundredths of 1 percent of its electricity directly from the sun. Many energy experts believe that the solar energy market will continue to grow lucratively, well into the next decade as manufacturing costs continue to drop.

The nations that are reaping the economic benefits of having the largest solar manufacturing industries also have the greatest government incentives to install the technology. European nations and Japan have committed substantially more funding toward the research and development of marketable solar technologies than other regions of the world. These nations also have the advantage of citizen commitment and government subsidies for renewable technologies that are more generous than those available to U.S. firms. One of the most crucial differences is that governments in Europe and Japan tax fossil fuels heavily to pay for some of the hidden costs associated with their combustion. These taxes are partially used to offset the billions of government dollars spent on pollution-related illness, while funding programs to advance energy efficiency and renewable alternatives. This tax naturally discourages wasteful consumption of resources and consequently helps to reduce air pollution and greenhouse gas emissions. These densely populated, energy-hungry regions have the added disadvantage of expensive and limited land on which to build power plants, forcing them to seek innovative solutions.

Solar Basics

There are 3 major technology areas in solar energy: concentrating solar power (CSP); solar electricity, also known as Photovoltaics or PV; and Solar Heating and Lighting.

All these solar energy technologies put the sun's energy to work for us in our homes, schools, businesses, and government buildings. They are being developed because they are reliable, they have very few environmental impacts, and they make use of an abundant domestic energy resource: sunlight.

Concentrating Solar Power (CSP)

CSP technologies-such as dish/engine systems, parabolic troughs, and central power towers-are made of reflective materials that focus or concentrate the sun's considerable heat energy. This concentrated solar energy then drives a generator to produce electricity.

The real powerhouse in CSP plants is focused sunlight. CSP plants generate electric power by using mirrors to concentrate (focus) the sun's energy and convert it into high-temperature heat. That heat is then channeled through a conventional generator. The plants consist of two parts: one that collects solar energy and converts it to heat, and another that converts the heat energy to electricity. Within the United States, over 350MW of CSP capacity exists and these plants have been operating reliably for more than 15 years.

Today's CSP systems can convert solar energy to electricity more efficiently than ever before. Utility-scale trough plants are the lowest cost solar energy available today and further cost reductions are anticipated to make CSP competitive with conventional power plants within a decade. So, CSP is a very good renewable energy technology to use in the southwestern United States as well as in other sunny regions around the world.

Basically, CSP systems collect and concentrate (focus) the solar energy in sunlight to generate electricity. The three kinds of concentrating solar power systems - parabolic troughs, power towers, and dish/engines - are classified according to how they collect solar energy.

Environmental impacts of concentrating solar power plants
Concentrating solar power plants have few environmental impacts; land use is the primary one. Although a CSP plant's "footprint," or the amount of land it occupies, is larger than that of a fossil fuel plant, the two actually use about the same amount of land. This is true because fossil fuel plants require a significant amount of land for exploration, mining, and road-building purposes. CSP plants have the advantage in that they produce no environmental contaminants or greenhouse gases. However, the fossil fuel component of a hybrid power plant does not have the same benefits. Consider Hoover Dam, for example. Nevada's Lake Mead, which is home to the dam, covers nearly 250 square miles. In contrast, a CSP system occupying only 10 to 20 square miles could generate as much power annually as Hoover Dam did in one recent year. And if we take into consideration the amount of land required for mining, CSP plants also require less land than coal-fired power plants do.

Disadvantages to using solar energy
Solar energy heating or solar electric products often have higher "first costs" than other, similar products do. This means it will probably cost more initially to purchase and install a solar system than it will to purchase and install another kind of heating or electric system. Still, in nearly all cases, you will recover your initial costs through substantial fuel savings (as shown in lower utility bills) over the life of the product. Many solar systems last from 15 to 30 years.

Advantages of using concentrating solar power (CSP) rather than other power generation technologies
One key competitive advantage of CSP systems is that they closely resemble most of the nation's current power plants in some important ways. For example, much of the equipment *now* used for conventional, centralized power plants running on fossil fuels can also be used for CSP plants. CSP simply substitutes the use of concentrated solar power rather than combustible fossil fuels to produce electricity. This "evolutionary" - in contrast to "revolutionary" or "disruptive" - aspect means CSP can be integrated fairly easily into today's electric utility grid. It also makes CSP technologies the most cost-effective solar option for large-scale electricity generation.

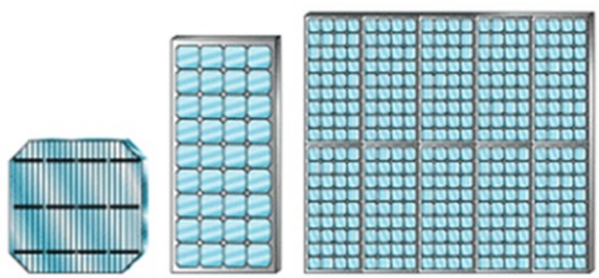
Photovoltaics (PV)

When certain semiconducting materials, such as certain kinds of silicon, are exposed to sunlight, they release small amounts of electricity. This process is known as the photoelectric effect. The photoelectric effect refers to the emission, of ejection of electrons from the surface of a metal in response to light. It is the basic physical process in which a solar electric or photovoltaic (PV) cell converts sunlight to electricity.

Sunlight is made up of photons, or particles of solar energy. Photons contain various amounts of energy, corresponding to the different wavelengths of the solar spectrum. When photons strike a PV cell, they may be reflected or absorbed, or they may pass right through the solar spectrum. Only the absorbed photons generate electricity. When this happens, the energy of the photon is transferred to an electron in an atom of the PV cell (which is actually a semiconductor). With its newfound energy, the electron escapes from its normal position in an atom of the semiconductor material and becomes part of the current in an electrical circuit. By leaving its position, the electron causes a hole to form. Special electrical properties of the PV cell-a built-in electric field-provide the voltage needed to drive the current through an external load (such as a light bulb).

PV Systems

A photovoltaic (PV) or solar cell is the basic building block of a PV (or solar electric) system. An individual PV cell is usually quite small, typically producing about 1 or 2 watts of power. To boost the power output of PV cells, we connect them together to form larger units called modules. Modules, in turn, can be connected to form even larger units called arrays, which can be interconnected to produce more power, and so on. In this way, we can build PV systems able to meet almost any electric power need, whether small or large.



Today's PV systems are used to generate electricity to pump water, light up the night, activate switches, charge batteries, supply power to the utility grid, and much more. PV has so many uses today that it probably already touches your life in some way. You might have noticed the small PV systems attached to emergency telephones along the highways. But PV provides power in many ways we can't see - for all kinds of satellites in space, including those that keep modern communication systems up and running.

PV is ideal (and often used) for water pumping, because water can be pumped into a storage tank during daylight hours and then distributed by gravity whenever it is needed. These systems commonly pump water for livestock watering tanks in remote areas. In some parts of the developing world, entire village water supplies are powered by PV. Other uses include remote monitoring, refrigeration, and energy for small commercial ventures. Virtually any power need can be met with PV.

Contrary to some popular notions, the landscape of a world relying on PV would be almost indistinguishable from the landscape we know today. The impact of PV on the landscape would be low, for three reasons. First, PV systems have siting advantages over other technologies; for example, PV can be put on roofs and can even be an integral part of a building, such as a skylight. Second, even ground-mounted PV collectors are efficient from the perspective of land use. Third, adequate sunlight is ubiquitous and often abundant, and present in predictable amounts almost everywhere. As we move away from fossil-fuel energy, PV will become important because of its land-use advantages.

Solar Heat

Solar heating technologies make use of low-temperature solar collectors that absorb the sun's heat energy, allowing that heat to be used directly for water or space heating in residential, commercial and industrial buildings.

Solar heat can be used for solar water heating, solar space heating in buildings, and solar pool heaters.

Solar water heaters and solar space heaters are constructed of solar collectors, and all systems have some kind of storage, except solar pool heaters and some industrial systems that use energy "immediately." The systems collect the sun's energy to heat air or a fluid. The air or fluid then transfers solar heat directly to a building, water, or pool.

Solar Water Heating

One of the most cost-effective ways to include renewable technologies into a building is by incorporating solar hot water.

A typical solar water-heating system reduces the need for conventional water heating by about two-thirds. It minimizes the expense of electricity or fossil fuel to heat the water and reduces the associated environmental impacts.

Most solar water-heating systems for buildings have two main parts: (1) a solar collector and (2) a storage tank. The most common collector used in solar hot water systems is the flat plate collector.

Solar water heaters use the sun to heat either water or a heat-transfer fluid in the collector. Heated water is then held in the storage tank ready for use, with a conventional system providing additional heating as necessary. The tank can be a modified standard water heater, but it is usually larger and very well insulated. Solar water heating systems can be either active or passive, but the most common are active systems.

Active solar water heaters

Active solar water heaters rely on electric pumps, valves, and controllers to circulate water, or other heat-transfer fluids through the collectors. These are the three types of active solar water-heating systems:

1. Direct-circulation systems use pumps to circulate water through the collectors. These systems are appropriate in areas that do not freeze for long periods and do not have hard or acidic water. These systems are not approved by the Solar Rating & Certification Corporation (SRCC) if they use recirculation freeze protection (circulating warm tank water during freeze conditions) because that requires electrical power for the protection to be effective.
2. Indirect-circulation systems pump heat-transfer fluids, such as a mixture of glycol and water antifreeze, through collectors. Heat exchangers transfer the heat from the fluid to the potable water

stored in the tanks. Some indirect systems have "overheat protection," which is a means to protect the collector and the glycol fluid from becoming super-heated when the load is low and the intensity of incoming solar radiation is high.

3. Drainback systems, a type of indirect system, use pumps to circulate water through the collectors. The water in the collector loop drains into a reservoir tank when the pumps stop. This makes drainback systems a good choice in colder climates. Drainback systems must be carefully installed to assure that the piping always slopes downward, so that the water will completely drain from the piping. This can be difficult to achieve in some circumstances.

Passive solar water heaters

Passive solar water heaters rely on gravity and the tendency for water to naturally circulate as it is heated. Because they contain no electrical components, passive systems are generally more reliable, easier to maintain, and possibly have a longer work life than active systems.

1. Integral-collector storage systems consist of one or more storage tanks placed in an insulated box with a glazed side facing the sun. During the winter, they must be drained or protected from freezing. These solar collectors may be best suited for areas where temperatures rarely go below freezing. They are also good in households with significant daytime and evening hot-water needs; but they do not work well in households with predominantly morning draws because they lose most of the collected energy overnight.
2. Thermosyphon systems are an economical and reliable choice, especially in new homes. These systems rely on the natural convection of warm water rising to circulate water through the collectors and to the tank (located above the collector). As water in the solar collector heats, it becomes lighter and rises naturally into the tank above. Meanwhile, the cooler water flows down the pipes to the bottom *of* the collector, enhancing the circulation. Some manufacturers place the storage tank in the house's attic, concealing it from view. Indirect thermosyphons (that use a glycol fluid in the collector loop) can be installed in freeze-prone climates if the piping in the unconditioned space is adequately protected.

Solar Space Heating

Just as solar energy can heat the water for a building, it can also heat the air.

A solar space-heating system can consist of a passive system, an active system, or a combination of both. Passive systems are typically less costly and less complex than active systems. However, when retrofitting a building, active systems might be the only option for obtaining solar energy.

Passive Solar Space Heating

Passive solar space heating takes advantage *of* warmth from the sun through design features, such as large south-facing windows, and materials in the floors or walls that absorb warmth during the day and release that warmth at night when it is needed most. A sunspace or greenhouse is a good example of a passive system for solar space heating.

Active Solar Space Heating

Active solar space-heating systems consist of collectors that collect and absorb solar radiation combined with electric fans or pumps to transfer and distribute that solar heat. Active systems also generally have an energy-storage system to provide heat when the sun is not shining. The two basic types of active solar space-heating systems use either liquid or air as the heat-transfer medium in their solar energy collectors.

Solar Collectors

Solar collectors are the key component of active solar-heating systems. Solar collectors gather the sun's energy, transform its radiation into heat, and then transfer that heat to water, solar fluid, or air. The solar thermal energy can be used in solar water-heating systems, solar pool heaters, and solar space-heating systems. There are several types of solar collectors:

- Flat-plate collectors
- Evacuated-tube collectors
- Integral collector-storage systems

Residential and commercial building applications that require temperatures below 200°F typically use flat-plate collectors, whereas those requiring temperatures higher than 200°F use evacuated-tube collectors.

Solar lighting

The most recent technology, Hybrid solar lighting, collects sunlight and routs it through optical fibers into buildings where it is combined with electric light in "hybrid" light fixtures. Sensors keep the room at a steady lighting level by adjusting the electric lights based on the sunlight available. This new generation of solar lighting combines both electric and solar power.

Solar Lighting Basics

Prototype HSL systems are made up of roof-mounted concentrators that collect and separate the visible and infrared portions of sunlight. The visible portion of the light is distributed through large-diameter optical fibers to hybrid luminaries. (Hybrid luminaries are lighting fixtures that contain both electric lamps and fiber optics to distribute sunlight directly.) Unlike conventional electric lamps, the solar component of HSL produces little heat.

The remaining "invisible" energy in the sunlight, mostly infrared radiation, is directed to a concentrating thermo-photovoltaic (solar) cell that very efficiently converts infrared radiation into electricity. The resulting electric power can be directed to other uses in a building. When sunlight is plentiful, the fiber optics in the luminaries can provide all or most of the light needed in a particular area. But when there is little or no sunlight, sensor-controlled electric lamps turn on to maintain the desired illumination level.

Independent cost and performance models suggest the overall affordability of solar energy could be doubled or tripled by using this new hybrid approach.

Road Blocks to Developing More Solar Power Plants

One reason more solar plants haven't been built in the last few years is the relatively low cost of fossil energy in most areas of the United States. The majority of today's power plants run on inexpensive coal.

And the current utility environment generally favors new natural gas power plants, which have comparatively low initial costs. With fossil fuel plants, however, customers must bear the risk of higher fuel costs in the future.

In contrast, the fuel needed to run a concentrating solar power (CSP) plant is sunlight, which is free. A CSP plant uses its field of mirrors to deliver the thermal energy that's provided by the fossil fuels burned in a conventional (e.g., gas- or coal-powered) plant. So, investing in a CSP plant is the equivalent of buying a lifetime supply of fuel. But the first costs associated with CSP plants can be high. To guarantee that they'll recover their first costs, most CSP plant operators would probably want to have some long-term power purchase agreements lined up, to minimize the financial risk. Other factors could also play a role in delayed investment in CSP. These include the perceived risks associated with new technologies and a need for tax equity with conventional technologies. Financial and regulatory incentives, advances in CSP technologies, and cost reductions resulting from economies of scale are just some of the things that could help to increase investments in CSP.

GEOTHERMAL ENERGY

Heat from the Earth, or geothermal - Geo (Earth)+ thermal (heat) - energy can be and already is accessed by drilling water or steam wells in a process similar to drilling for oil. Geothermal energy is an enormous, underused heat and power resource that is clean (emits little or no greenhouse gases), reliable (average system availability of 95%), and homegrown (making us less dependent on foreign oil).

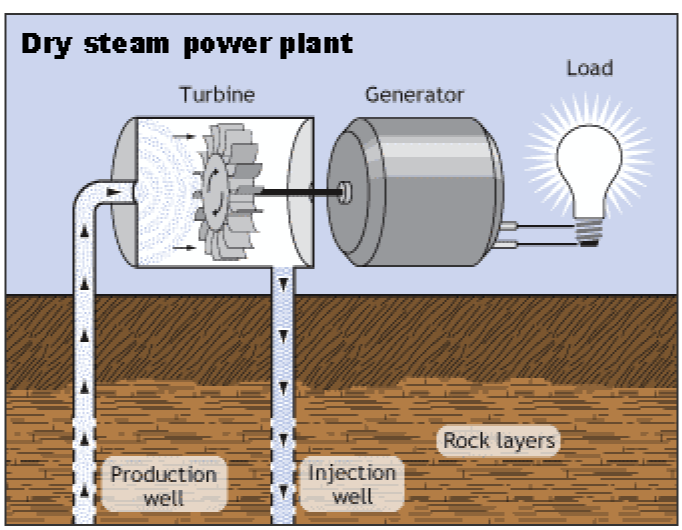
Geothermal resources range from shallow ground to hot water and rock several miles below the Earth's surface, and even farther down to the extremely hot molten rock called magma. Mile-or-more-deep wells can be drilled into underground reservoirs to tap steam and very hot water that can be brought to the surface for use in a variety of applications. In the U.S., most geothermal reservoirs are located in the western states, Alaska, and Hawaii.

Geothermal Power Plants

There are three geothermal power plant technologies being used to convert hydrothermal fluids to electricity. The conversion technologies are dry steam, flash, and binary cycle. The type of conversion used depends on the state of the fluid (whether steam or water) and its temperature. Dry steam power plants systems were the first type of geothermal power generation plants built. They use the steam from the geothermal reservoir as it comes from wells, and route it directly through turbine/generator units to produce electricity. Flash steam plants are the most common type of geothermal power generation plants in operation today. Binary cycle geothermal power generation plants differ from Dry Steam and Flash Steam systems in that the water or steam from the geothermal reservoir never comes in contact with the turbine/generator units.

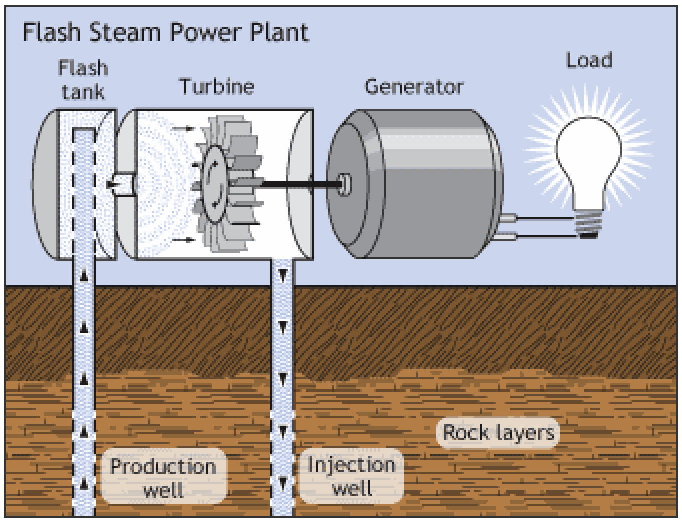
Dry Steam Power Plants

Steam plants use hydrothermal fluids that are primarily steam. The steam goes directly to a turbine, which drives a generator that produces electricity. The steam eliminates the need to burn fossil fuels to run the turbine. (Also eliminating the need to transport and store fuels!) This is the oldest type of geothermal power plant. It was first used at Lardarello in Italy in 1904, and is still very effective. Steam technology is used today at The Geysers in northern California, the world's largest single source of geothermal power. These plants emit only excess steam and very minor amounts of gases.



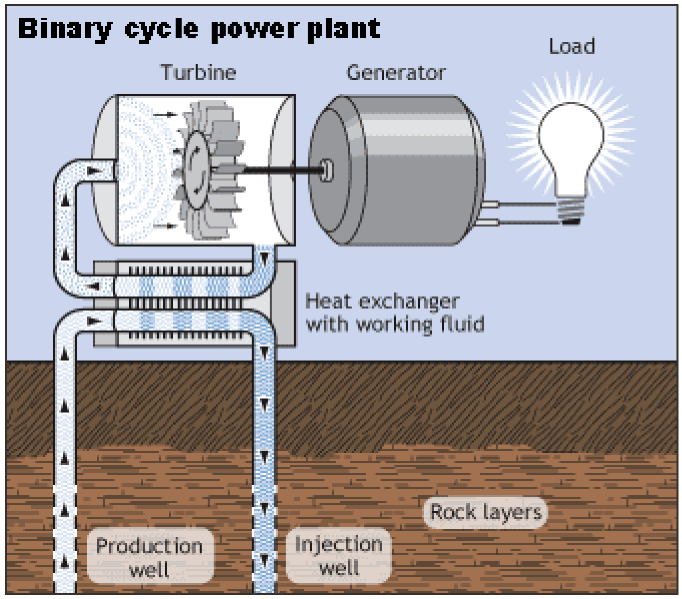
Flash Steam Power Plants

Hydrothermal fluids above 360°F (182°C) can be used in flash plants to make electricity. Fluid is sprayed into a tank held at a much lower pressure than the fluid, causing some of the fluid to rapidly vaporize, or "flash." The vapor then drives a turbine, which drives a generator. If any liquid remains in the tank, it can be flashed again in a second tank to extract even more energy.



Binary-Cycle Power Plants

Most geothermal areas contain moderate-temperature water (below 400°F). Energy is extracted from these fluids in binary-cycle power plants. Hot geothermal fluid and a secondary (hence, "binary") fluid with a much lower boiling point than water pass through a heat exchanger. Heat from the geothermal fluid causes the secondary fluid to flash to vapor, which then drives the turbines. Because this is a closed-loop system, virtually nothing is emitted to the atmosphere. Moderate-temperature water is by far the more common geothermal resource, and most geothermal power plants in the future will be binary-cycle plants.



Direct Use of Geothermal Energy

Geothermal reservoirs of low-to moderate-temperature water - 68° **F** to 302° **F** (20°C to 150° C) - provide direct heat for residential, industrial, and commercial uses. This resource is widespread in the U.S., and is used to heat homes and offices, commercial greenhouses, fish farms, food processing facilities, gold mining operations, and a variety of other applications. Spent fluids from geothermal electric plants can be subsequently used for direct use applications in so-called "cascaded" operation.

Direct use of geothermal energy in homes and commercial operations is much less expensive than using traditional fuels. Savings can be as much as 80% over fossil fuels. Direct use is also very clean, producing only a small percentage (and in many cases none) of the air pollutants emitted by burning fossil fuels.

Low-temperature geothermal resources exist throughout the western U.S., and there is tremendous potential for new direct-use applications. A recent survey of 10 western states identified more than 9000 thermal wells and springs, more than 900 low- to moderate-temperature geothermal resource areas, and hundreds of direct-use sites.

The survey also identified 271 collocated sites - cities within 5 miles (8 kilometers) of a resource hotter than 122 degrees **F** (50 degrees C) - that have excellent potential for near-term direct use. If these collocated resources were used only to heat buildings, the cities have the potential to displace 18 million barrels of oil per year!

Direct- use systems typically include three components:

- A production facility - usually a well - to bring the hot water to the surface;
- A mechanical system - piping, heat exchanger, controls - to deliver the heat to the space or process; and
- A disposal system - injection well or storage pond - to receive the cooled geothermal fluid.

The primary uses of low-temperature geothermal resources are in district and space heating, greenhouses, and aquaculture facilities. A 1996 survey found that these applications were using nearly 5.8 billion megajoules of geothermal energy each year - the energy equivalent of nearly 1.6 million barrels of oil!

Geothermal district heating systems can save consumers 30% to 50% of the cost of natural gas heating. The tremendous potential for district heating in the western U.S. was illustrated in a 1980s inventory which identified 1,277 geothermal sites within 5 miles of 373 cities in 8 states.

Greenhouses and aquaculture (fish farming) are the two primary uses of geothermal energy in the agribusiness industry. Thirty-eight greenhouses, many covering several acres, are raising vegetables, flowers, houseplants, and tree seedlings in 8 western states. Twenty-eight aquaculture operations are active in 10 states.

Most greenhouse operators estimate that using geothermal resources instead of traditional energy sources saves about 80% of fuel costs - about 5% to 8% of total operating costs. The relatively rural location of most geothermal resources also offers advantages, including clean air, few disease problems, clean water, a stable workforce, and, often, low taxes.

Industrial applications include food dehydration, laundries, gold mining, milk pasteurizing, spas, and others. Dehydration, or the drying of vegetable and fruit products, is the most common industrial use of geothermal energy. The earliest commercial use of geothermal energy was for swimming pools and spas. In 1990, 218 resorts were using geothermal hot water.

Hot water near the Earth's surface can be piped directly into facilities and used to heat buildings, grow plants in greenhouses, dehydrate onions and garlic, heat water for fish farming, and pasteurize milk. Some cities pipe the hot water under roads and sidewalks to melt snow. District heating applications use networks of piped hot water to heat buildings in whole communities.

Geothermal Heat Pumps

Almost everywhere, the upper 10 feet of Earth's surface maintains a nearly constant temperature between 50 and 60°F (10 and 16°C). A geothermal heat pump system consists of pipes buried in the shallow ground near the building, a heat exchanger, and ductwork into the building. In winter, heat from the relatively warmer ground goes through the heat exchanger into the house. In summer, hot air from the house is pulled through the heat exchanger into the relatively cooler ground. Heat removed during the summer can be used as no-cost energy to heat water.

The system includes three principal components:

1. Earth Connection

Using the Earth as a heat source/sink, a series of pipes, commonly called a "loop," is buried in the ground near the building to be conditioned. The loop can be buried either vertically or horizontally. It circulates a fluid (water, or a mixture of water and antifreeze) that absorbs heat from, or relinquishes heat to, the surrounding soil, depending on whether the ambient air is colder or warmer than the soil.

2. Heat Pump

For heating, a geothermal heat pump removes the heat from the fluid in the Earth connection, concentrates it, and then transfers it to the building. For cooling, the process is reversed.

3. Heat Distribution
Conventional ductwork is generally used to distribute heated or cooled air from the geothermal heat pump throughout the building..

Environmental Impacts and Benefits of Using Geothermal Energy

All energy development and production impacts the environment to some degree. But the use of geothermal energy can greatly minimize these impacts, resulting in environmental benefits for many states and local communities with growing energy needs.

Geothermal energy is clean, sustainable energy. Also, most geothermal energy postdates the passage of the National Environmental Policy Act in 1970. Therefore, the geothermal industry has grown up in an age of higher environmental awareness. As a result, the use of geothermal energy helps keep our air and water clean. The use of geothermal energy also greatly minimizes the amount of resulting solid waste and land required for energy production.

Most geothermal direct-use applications-such as district and space heating, aquaculture, and greenhouses-impact the environment to a lesser degree than large-scale, geothermal power plants. Direct use applications can easily meet local and federal **clean air** standards, which help protect our environment.

Geothermal Direct Use- Meeting Water Quality Standards

Geothermal fluids vary from resource to resource. The low- to mid-temperature geothermal fluids used for direct-use typically contain lower levels of gases than the higher temperature fluids used for power production. And today, most geothermal direct-use applications circulate these fluids through closed-loop, emissions-free systems.

The carbon dioxide found in geothermal fluids could prove beneficial to direct-use greenhouse applications. Carbon dioxide is a very effective growth stimulant for plants. Studies have shown that an increase in carbon dioxide from a normal level of 300 part per million (ppm) to approximately 1,000 ppm can raise crop yields up to 15 percent. Therefore, some researchers suggest that geothermal heating systems could utilize the carbon dioxide present in the fluids if they find a way to remove any hydrogen sulfide, which can damage plants. Most geothermal fluids usually contain low, non-hazardous levels of hydrogen sulfide.

To isolate geothermal fluids from the environment, including groundwater sources, production and injection wells in direct-use systems are lined with cement and steel, fiberglass, or thermoplastics. The method chosen for disposing of fluids depends on the quality of the fluids, local hydrological conditions, and environmental regulations. In some instances, these fluids, once cooled, can be safely discharged to surface water. However, if the fluids contain levels of certain chemical constituents-such as boron, fluoride, and total dissolved solids-above required environmental standards, the direct-use systems will treat them, inject them, or both.

In general, the total dissolved-solids content increases with the temperature of geothermal fluids. Therefore, the geothermal fluids used for direct-use applications typically contain less than those used for geothermal power, but more than most cold-water sources. Geothermal fluids used for direct-use applications contain between 400 to 3,000 part per million (ppm) of total dissolved solids. Most drinking water standards limit the amount of total dissolved solids at 1,000 ppm primarily for taste, not health considerations.

Geothermal Direct-Use - Minimizing Solid Waste

Aquaculture and horticulture businesses, and other industries that use geothermal direct-use systems typically don't generate any more solid waste than those that use other energy resources.

Actually, a few geothermal aquaculture operations have discovered an environmentally friendly way to dispose of byproducts from fish processing activities- alligators. Alligators thrive in geothermally heated waters in unexpected climates and areas, such as in Idaho and Colorado.

Geothermally heated livestock facilities make waste management and collection easier for farmers and ranchers. The geothermal water can be used directly for cleaning and sanitizing these facilities and drying the waste

Geothermal Direct-Use - Minimizing Land Use and Impact

With geothermal direct-use applications, land use issues usually only arise during exploration and development when geothermal reservoirs are located in or near urbanized areas, critical habitat areas, or intensive agricultural areas. Typically, these issues can be resolved through proper land use and environmental planning.

Most direct-use geothermal wells are drilled using conventional, water-well technology equipment and technology. Therefore, drilling for geothermal direct-use applications has even less of an impact than drilling for geothermal power plants.

Also, buildings designed for direct-use space or district heating systems may actually require less land. There's no need to construct space for conventional space heating equipment, such as boilers and gas vents.

Like geothermal power plants, the injection of spent geothermal fluids can be used for direct-use applications not only to maintain the geothermal reservoir, but also to prevent land subsidence. However, few, if any, direct-use applications require the removal of enough fluid that could result in subsidence.

Because direct-use applications withdraw and inject small amounts of fluid compared to geothermal power plants, induced seismicity really isn't much of an issue.

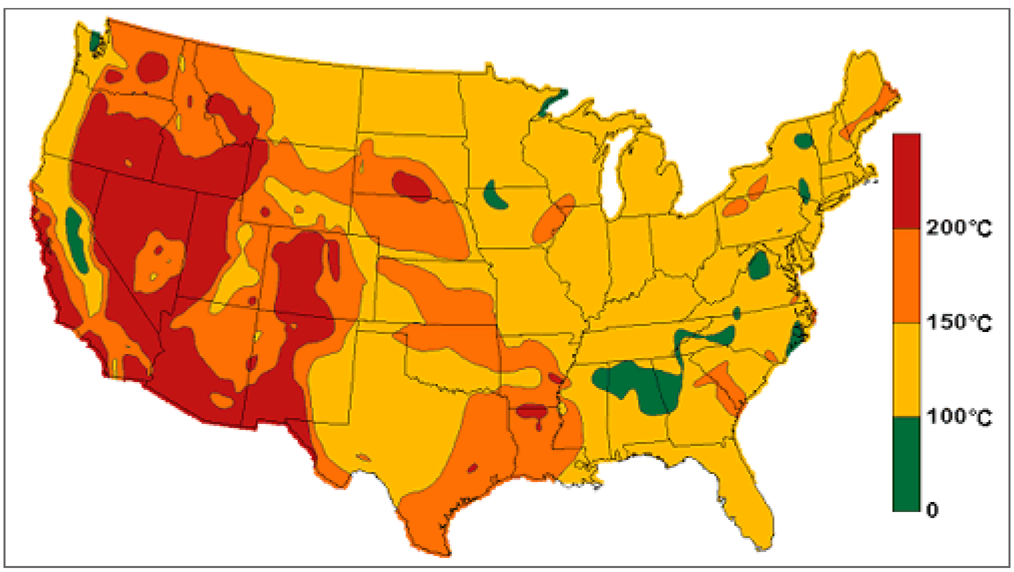
In summary: geothermal technologies offer many **environmental advantages** over conventional power generation:

- **Emissions are low.** Only excess steam is emitted by geothermal flash plants. No air emissions or liquids are discharged by binary geothermal plants, which are projected to become the dominant technology in the near future.

- Salts and dissolved minerals contained in geothermal fluids are usually reinjected with excess water back into the reservoir at a depth well below groundwater aquifers. This **recycles the geothermal water and replenishes the reservoir.** This system will prolong the life of the reservoir as it recycles the treated wastewater.
- Some geothermal plants do produce some solid materials, or sludges, that require disposal in approved sites. Some of these **solids are now being extracted for sale** (zinc, silica, and sulfur, for example), making the resource even more valuable and environmentally friendly.

U.S. Geothermal Resource Map

The geothermal resources map of the United States below shows the estimated subterranean temperatures at a depth of 6 kilometers. To determine the Earth's internal temperature at any depth below the capabilities of normal well drilling, multiple data sets are synthesized. The data used for this figure are: thermal conductivity, thickness of sedimentary rock, geothermal gradient, heat flow, and surface temperature.



HYDROGEN OVERVIEW

Hydrogen can be produced from a wide variety of domestic resources using a number of different technologies. Hydrogen can also provide a storage medium for intermittent and seasonal renewable technologies. Hydrogen can be used in combustion processes and fuel cells to provide a broad range of energy services such as lighting, mobility, heating, cooling, and cooking.

Hydrogen is the lightest and most abundant element in the universe. It is an energy carrier, not an energy source, meaning that it stores and delivers energy in a usable form. In its pure form (H2), it is a colorless and odorless gas. However, since it combines easily with other elements, hydrogen is rarely found by itself in nature and is usually found as a part of other compounds, including fossil fuels, plant material, and water.

Hydrogen Production

Hydrogen can be produced using a variety of domestic energy resources - fossil fuels, such as coal and natural gas, with carbon capture and sequestration; renewables, such as biomass, and renewable energy technologies, including solar, wind, geothermal, and hydropower; and nuclear power. Specific technologies and processes are described below.

Thermochemical Processes

- **Steam methane reforming:** In this process, high-temperature steam is used to extract hydrogen from a methane source such as natural gas. This is the most common method of producing hydrogen; about 95 percent of the hydrogen we use today in the United States is produced using this process.
- **Partial oxidation:** Scientists are exploring a process that produces hydrogen by simultaneously separating oxygen from air and partially oxidizing methane.
- **Other thermal processes:** Other processes include (1) splitting water using heat from a solar concentrator, and (2) gasifying or burning biomass (i.e., biological material, such as plants or agricultural waste) to generate a bio-oil or gas, which is then reformed to produce hydrogen.

Electrolytic Processes

- **Electrolysis:** In electrolysis, electricity is used to separate water (H2O) into hydrogen and oxygen. Current electrolysis systems are very energy intensive. The challenge is to develop low cost and more energy efficient electrolysis technologies.

Photolytic Processes

- **Photolytic methods:** In photolysis, sunlight is used to split water. Two photolytic processes are being explored: (1) photobiological methods, in which microbes, when exposed to sunlight, split water to produce hydrogen, and (2) photoelectrolysis, in which semi-conductors, when exposed to sunlight and submersed in water, generate enough electricity to produce hydrogen by splitting the water.

Hydrogen Delivery

Since it can be produced from several sources and using various methods, hydrogen can be produced at large production plants and transported to users, or it can be produced locally, using small generators, possibly at refueling stations, eliminating the need for long-distance transport. Hydrogen is currently transported by road via cylinders, tube trailers, cryogenic tankers, and in pipelines, although hydrogen pipelines currently exist in only a few regions of the United States. The delivery infrastructure for hydrogen will require high-pressure compressors for gaseous hydrogen and liquefaction for cryogenic hydrogen; both currently have significant capital and operating costs and energy inefficiencies associated with them.

Hydrogen Storage

Finding a cost-effective method of storing hydrogen on a vehicle is a challenge. While hydrogen contains more energy per weight than any other energy carrier, it contains much less energy by volume. This makes it difficult to store a large amount of hydrogen in a small space, like in a gas tank of a car.

Technologies

- **High-pressure tanks:** Hydrogen gas can be compressed and stored in storage tanks at high pressure. These tanks must be strong, durable, light-weight, and compact, as well as cost competitive.
- **Liquid hydrogen:** Hydrogen can be stored as a liquid. In this form, more hydrogen can be stored per volume, but it must be kept at cold temperatures (about -253°C).
- **Materials-based storage of hydrogen: Hydrogen can be stored within solid materials, such as powders, or liquids.**

Challenges/Disadvantages

For transportation, the overarching technical challenge for hydrogen storage is how to store the amount of hydrogen required for a conventional driving range (<300 miles), within the vehicular constraints of weight, volume, efficiency, safety, and cost. Durability over the performance lifetime of these systems must also be verified and validated and acceptable refueling times must be achieved. The key challenges include —

- **Weight and Volume:** The weight and volume of hydrogen storage systems are presently too high, resulting in inadequate vehicle range. Materials and components are needed that allow compact, lightweight, hydrogen storage systems while enabling greater than 300-mile range in all light-duty vehicle platforms.
- **Efficiency:** Energy efficiency is a challenge for all hydrogen storage approaches. The energy required to get hydrogen in and out is an issue for reversible solid-state materials. Life-cycle energy efficiency is a challenge for chemical hydride storage in which the by-product is regenerated off-board. In addition, the energy associated with compression and liquefaction must be considered for compressed and liquid hydrogen technologies.
- **Durability:** Durability of hydrogen storage systems is inadequate. Materials and components are needed that allow hydrogen storage systems with a lifetime of 1500 cycles.
- **Refueling Time:** Refueling times are too long. There is a need to develop hydrogen storage systems with refueling times of less than three minutes, over the lifetime of the system.
- **Cost:** The cost of on-board hydrogen storage systems is too high, particularly in comparison with conventional storage systems for petroleum fuels. Low-cost materials and components for hydrogen storage systems are needed, as well as low-cost, high-volume manufacturing methods.

- **Codes & Standards:** Applicable codes and standards for hydrogen storage systems and interface technologies, which will facilitate implementation/commercialization and assure safety and public acceptance, have not been established. Standardized hardware and operating procedures, and applicable codes and standards, are required.
- **Life-Cycle and Efficiency Analyses:** Analyses of the full life-cycle cost and efficiency for hydrogen storage systems are needed.

Hydrogen In Use

Today the United States uses more than 90 billion cubic meters (3.2 trillion cubic feet) of hydrogen yearly. Most of this hydrogen is used as a chemical, rather than a fuel, in a variety of commercial applications:

- Commercial fixation of nitrogen from the air to produce ammonia for fertilizer (about two-thirds of commercial hydrogen is used for this)
- Hydrogenation of fats and oils, in which vegetable oils are changed from liquids to solids; shortening is an example of a hydrogenated oil
- Methanol production, in hydrodealkylation, hydrocracking, and hydrodesulphurization
- Welding
- Hydrochloric acid production
- Metallic ore reduction
- Cryogenics and the study of superconductivity (liquid hydrogen)

Hydrogen's main use as a fuel is in the space program. Today hydrogen fuels both the main engine of the Space Shuttle and the onboard fuel cells that provide the Shuttle's electric power.

Potential Applications

Hydrogen can be used in fuel cells to power a wide variety of applications, both mobile and stationary, small- and large-scale. Fuel cells can be used to provide clean energy for transportation. And because they are modular, fuel cells can provide heat and electricity *for* single homes *or* to supply the energy to run an entire large commercial building, to provide a small amount of electricity to a community grid, or a large amount of electricity to a large grid network.

Hydrogen can be used to generate electricity for our homes and office buildings, through the use of gas turbines and microturbines (small gas turbines). Conventional gas turbines can be modified to run efficiently on hydrogen or hydrogen/natural gas blends. Microturbines can provide high-efficiency reliable power for smaller-scale applications.

Hydrogen can also be used in internal combustion engines for both stationary and mobile applications, powering industrial processes, ocean fleets, cars, and buses. As with gas turbines, conventional combustion engines can be modified to run efficiently on hydrogen or hydrogen/natural gas mixtures for these applications.

Hydrogen, in vast quantities, has been used safely in chemical and metallurgical applications, the food industry, and the space program for many years. As hydrogen and fuel cells begin to play a greater role in meeting the energy needs of our nation and the world, minimizing the safety hazards related to the use of hydrogen as a fuel is essential.

BIOMASS BASICS

Cellulose and hemicellulose, two of the three main components of the great bulk of biomass resources, are polymers of sugars and can be broken down to those component sugars for fermentation or other processing to ethanol and other valuable fuels and chemicals.

Biomass includes all plant and plant-derived material - essentially all energy originally captured by photosynthesis. This means that biomass is a fully renewable resource and that its use for biomass-derived fuels, power, chemicals, materials, or other products essentially generates no net greenhouse gas. (You must consider any fossil-fuel use to grow, collect, and convert the biomass in a full life-cycle analysis, but the carbon dioxide released when biomass is burned is balanced by the carbon dioxide captured when the biomass is grown.) Its production and use will also generally be domestic, so it has substantial environmental, economic, and security benefits.

Biomass is already making key contributions today. It has surpassed hydro-electric power as the largest domestic source of renewable energy. Biomass currently supplies over 3% of the U.S. total energy consumption - mostly through industrial heat and steam production by the pulp and paper industry and electrical generation with forest industry residues and municipal solid waste (MSW). Of growing importance are biomass-derived ethanol and biodiesel which provide the only renewable alternative liquid fuel for transportation, a sector that strongly relies on imported oil.

In addition to today's uses of biomass, and historic ones for food, shelter, and clothing, there is significant potential for new biomass feedstocks to dramatically expand the use of biomass in order to continue to reduce our reliance on fossil fuels. The first feedstocks for this "new" biomass might come from opportunities with particular industrial residues, but beyond that, large-scale expansion of biomass is expected to come from forestry and agricultural residues. The latter includes cellulosic stalks, leaves, husks, and straw in addition to the starchy grains and oily seeds currently used. In the longer term, the biomass industry could support dedicated energy crops specifically grown for energy use.
Of the many possible conversion technologies for expanded biomass use, two of the most promising are the sugar platform and the thermochemical platform. These are referred to as "platforms" because the basic technology would generate base or platform chemicals from which industry could make a wide range of fuels, chemicals, materials, and power. These platform chemicals and wide range of products are analogous to the current petrochemicals industry. The promotion of "biorefineries" as a major new domestic biomass industry is, along with reducing dependence on imported oil, the major objective of the Biomass Program.

Biomass Benefits

In 2002, fossil fuels, which are finite and nonrenewable, supplied 86% of the energy consumed in the United States. Even more alarming is that the United States imports *over* half (62%) of its petroleum and its dependence is increasing. Since the U.S economy is so closely tied with petroleum products and oil imports, small changes in oil prices or disruptions in oil supplies can have an enormous impact on our economy - from trade deficits, to industrial investment, to employment levels. As a domestic, renewable energy source, biomass offers an alternative to conventional energy sources and provides national energy security, economic growth, and environmental benefits.

Biomass Today

In 2003 - and for the fourth year in a row - biomass was the leading source of renewable energy in the United States, providing 2.9 Quadrillion Btu of energy. Biomass was the source for 47% of all renewable energy or 4% of the total energy produced in the United States. Agriculture and forestry residues, and in particular residues from paper mills, are the most common biomass resources used for generating electricity, and industrial process heat and steam and for a variety of biobased products. These are the organic byproducts of food, fiber, and forest production. In fact, 48% or 1.1 Quad Btu of biomass energy was consumed by the pulp and paper industry, solely using black liquor. Current biomass consumption in the United States is dominated by industrial use, largely derived from wood. Use of liquid transportation fuels such as ethanol and biodiesel, however, currently derived primarily from agricultural crops, is increasing dramatically. In 2003 ethanol produced from corn reached 2.81 billion gallons.

Prominent biomass uses today include ethanol and biodiesel fuel additives and process heat and power generation with paper mill and forestry residues.

Ethanol and biodiesel, made from plant matter instead of petroleum, can be blended with or directly substituted for gasoline and diesel, respectively. Use of biofuels reduces toxic air emissions, greenhouse gas buildup, and dependence on imported oil, while supporting agriculture and rural economies. Unlike gasoline and diesel, biofuels contain oxygen. Adding biofuels to petroleum products allows the fuel to combust more completely and this reduces air pollution. When fossil fuels such as petroleum are burned, they also release carbon dioxide that was captured by plants billions of years ago. This release contributes to the buildup of greenhouse gases that contributes to climate change. On the other hand, carbon dioxide released from burning biofuels is balanced by the carbon dioxide capture by the recent growth of the plant materials from which they are made. Depending on how much fossil energy is used to grow and process the biomass feedstock, this results in substantially reduced net greenhouse gas emissions.

What are energy crops?
Energy crops are crops that are grown for the specific purpose of producing energy (electricity or liquid fuels) from all or part of the resulting plant. Switchgrass, alfalfa, willow, poplar and eucalyptus are examples of plants that can be grown as energy crops.

How much biomass is used for energy today?
Worldwide, biomass is the fourth largest energy resource after coal, oil, and natural gas. It is used for heating (such as wood stoves in homes and for process heat and steam in industries such as pulp and paper), cooking (especially in many parts of the developing world), transportation (fuels such as ethanol and biodiesel) and for electric power generation. It is estimated that there are about 278 Quadrillion Btu of installed biomass capacity worldwide, with about 2.7 Quadrillion Btu of biomass generated in the United States. Most of this capacity is in the pulp and paper industry using combined heat and power systems.

What is the difference between biofuels, biopower, and bioproducts?
In practice, we tend to use these three different terms for three different end uses - transportation, electric power or heat, and products such as chemicals and materials. "Biofuel" is short for "biomass fuel." We use the term "biofuels" for liquid fuels for transportation, such as ethanol and biodiesel that can be purely from biomass such as B100 or, in part, such as E1O (the number after the letter represents the percentage of biodiesel or ethanol in the fuel). We tend to use "BioPower" for "biomass power" systems that generate

electricity or industrial process heat and steam, such as from combined heat and power (CHP) systems. The term "bioproduct" is short for biomass products, and can be used to describe a chemical, material, or other product derived from renewable biomass resources.

Ethanol (biofuels)

Ethanol, also known as ethyl alcohol or grain alcohol, can be used either as an alternative fuel or as an octane-boosting, pollution-reducing additive to gasoline. The U.S. ethanol industry produced more than 3.4 billion gallons in 2004, up from 2.8 billion gallons in 2003 and 2.1 billion gallons in 2002. (Renewable Fuels Association and Renewable Fuels Assn Ethanol Industry Outlook 2005). Although this number is small when compared with fossil fuel consumption for transportation, as individual states continue to ban the use of MTBE (Methyl Tertiary Butyl Ether) and with the possibility of a Federal ban, ethanol consumption is due for a significant boost. Because of the increased demand on ethanol as a gasoline additive, efforts to increase supplies are necessary in order to meet the increase in demand. As of the start of 2005, 81 ethanol plants in 20 states have the capacity to produce nearly 4.4 billion gallons annually and an additional 16 plants are under construction to add another 750 million gallons of capacity (RFA).

Bio Power

Power from biomass is a proven commercial electricity generation option in the United States. With about 9,733 megawatts (MW) in 2002 of installed capacity, biomass is the single largest source of non-hydro renewable electricity. This 9,733 MW of capacity includes about 5,886 MW of forest product and agricultural residues, 3,308 MW of generating capacity from municipal solid waste, and 539 MW of other capacity such as landfill gas. The majority of electricity production from biomass is used as base load power in the existing electrical distribution system. Biopower also includes industrial process heat and steam. More than 200 companies outside the wood products and food industries generate biomass power in the United States. Where power producers have access to *very* low cost biomass supplies, the choice to use biomass in the fuel mix enhances their competitiveness in the marketplace. This is particularly true in the near term for power companies choosing to co-fire biomass with coal to save fuel costs and earn emissions credits. An increasing number of power marketers are starting to offer environmentally friendly electricity, including biomass power, in response to consumer demand and regulatory requirements.

There are four primary classes of biomass power systems: direct-fired, co-fired, gasification, and modular systems. Most of today's biomass power plants are direct-fired systems that are similar to most fossil-fuel fired power plants. The biomass fuel is burned in a boiler to produce high-pressure steam. This steam is introduced into a steam turbine, where it flows over a series of aerodynamic turbine blades, causing the turbine to rotate. The turbine is connected to an electric generator, so as the steam flow causes the turbine to rotate, the electric generator turns and electricity is produced.

While steam generation technology is very dependable and proven, its efficiency is limited. Biomass power boilers are typically in the 20-50 MW range, compared to coal-fired plants in the 100-1500 MW range. The small capacity plants tend to be lower in efficiency because of economic trade-offs; efficiency-enhancing equipment cannot pay for itself in small plants. Although techniques exist to push biomass steam generation efficiency over 40%, actual plant efficiencies are in the low 20% range.

Coal-firing involves substituting biomass for a portion of coal in an existing power plant furnace. It is the most economic near-term option for introducing new biomass power generation. Because much of the existing power plant equipment can be used without major modifications, co-firing is far less expensive than building a new biomass power plant. Compared to the coal it replaces, biomass reduces sulfur dioxide

(S02), nitrogen oxides (NOx), and other air emissions. After "tuning" the boiler for peak performance, there is little or no loss in efficiency from adding biomass. This allows the energy in biomass to be converted to electricity with the high efficiency (in the 33-37% range) of a modern coal-fired power plant.

Biomass gasifiers operate by heating biomass in an environment where the solid biomass breaks down to form a flammable gas. This offers advantages over directly burning the biomass. The biogas can be cleaned and filtered to remove problem chemical compounds. The gas can be used in more efficient power generation systems called combined-cycles, which combine gas turbines and steam turbines to produce electricity. The efficiency of these systems can reach 60%.

Gasification systems will be coupled with fuel cell systems for future applications. Fuel cells convert hydrogen gas to electricity (and heat) using an electro-chemical process. There are very little air emissions and the primary exhaust is water vapor. As the costs of fuel cells and biomass gasifiers come down, these systems will proliferate.

Modular systems employ some of the same technologies mentioned above, but on a smaller scale that is more applicable to villages, farms, and small industry. These systems are now under development and could be most useful in remote areas where biomass is abundant and electricity is scarce. There are many opportunities for these systems in developing countries.

BioProducts

Renewable biobased products (bioproducts) are products created from plant- or crop-based resources such as agricultural crops and crop residues, forestry, pastures, and rangelands. Many of the products that could be made from renewable bioproducts are now made from petroleum (e.g., petrochemicals). This is because the basic molecules in petrochemicals are hydrocarbons. In plant resources, the basic molecules are carbohydrates, proteins, and plant oils. Both plant and petroleum molecules can be processed to create building blocks for industry to manufacture a wide variety of consumer goods, including plastics, solvents, paints, adhesives, and drugs. During the last century hydrocarbon feedstocks have dominated as industrial inputs. However, reserves of petroleum are finite and, while expected to last well into the next century, could be significantly depleted as the world population grows and standards of living improve in developing countries. Renewable plant resources will be one way to supplement hydrocarbon resources and meet increasing worldwide needs for consumer goods.

Plant resources, mostly for paper products and chemical feedstocks, now provide about 5 percent of manufacturing inputs. Plant-based chemical products include paints, adhesives, lubricants, inks, polymers, and resins. In many cases, using hydrocarbon resources is much less expensive. For some chemical products plant inputs are already cost-competitive, and they are a significant feedstock. Plant-based systems are the major sources for ethanol, sorbitol, cellulose, citric acid, natural rubber, most amino acids, and all proteins.

Companies from the chemical, life sciences, forestry, and agricultural communities are involved in establishing the renewable bioproducts industry. Their activities range from genetic engineering of new plant species to development of new technologies and processes for converting plants into useful industrial inputs. For example, DuPont recently developed a biobased method that uses corn instead of petroleum-based processes to produce a polymer platform for use in clothing, carpets and automobile interiors. Similarly, Cargill Dow's biorefinery in Blair, Nebraska is producing polylactide (PLA) polymers from corn sugar.

Currently, production of biobased textile fibers, polymers, adhesives, lubricants, soy-based inks, and other products is estimated at 12.4 billion pounds per year. Total production (biobased and non-biobased), however, is in the hundreds of billions of pounds. The growth opportunities for biobased products are therefore enormous.

OCEAN ENERGY

The ocean contains two types of energy: thermal energy from the sun's heat, and mechanical energy from the tides and waves.

Oceans *cover* more than 70% of Earth's surface, making them the world's largest solar collectors. The sun warms the surface water a lot more than the deep ocean water, and this temperature difference stores thermal energy. Thermal energy is used for many applications, including electricity generation. There are three types of electricity conversion systems: *closed-cycle, open-cycle,* and *hybrid.* Closed-cycle systems use the ocean's warm surface water to vaporize a *working fluid,* which has a low-boiling point, such as ammonia. The vapor expands and turns a turbine. The turbine then activates a generator to produce electricity. Open-cycle systems actually boil the seawater by operating at low pressures. This produces steam that passes through a turbine/generator. And hybrid systems combine both closed-cycle and open-cycle systems.

Ocean mechanical energy is quite different from ocean thermal energy. Even though the sun affects all ocean activity, tides are driven primarily by the gravitational pull of the moon, and waves are driven primarily by the winds. A *barrage* (dam) is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator. For *wave* energy conversion, there are three basic systems: channel systems that funnel the waves into reservoirs, float systems that drive hydraulic pumps, and oscillating water column systems that use the waves to compress air within a container. The mechanical power created from these systems either directly activates a generator or transfers to a working fluid, water, or air, which then drives a turbine/generator.

Ocean Tidal Power

Some of the oldest ocean energy technologies use tidal power. All coastal areas consistently experience two high and two low tides over a period of slightly greater than 24 hours. For those tidal differences to be harnessed into electricity, the difference between high and low tides must be at least five meters, or more than 16 feet. There are only about 40 sites on the Earth with tidal ranges of this magnitude.

Currently, there are no tidal power plants in the United States. However, conditions are good for tidal power generation in both the Pacific Northwest and the Atlantic Northeast regions of the country.

Environmental and Economic Challenges

Tidal power plants that dam estuaries can impede sea life migration, and silt build-ups behind such facilities can impact local ecosystems. Tidal fences may also disturb sea life migration.

It doesn't cost much to operate tidal power plants, but their construction costs are high and lengthen payback periods. As a result, the cost per kilowatt-hour of tidal power is not competitive with conventional fossil fuel power.

Ocean Thermal Energy Conversion

A process called Ocean Thermal Energy Conversion (OTEC) uses the heat energy stored in the Earth's oceans to generate electricity.

OTEC works best when the temperature difference between the warmer, top layer of the ocean and the colder, deep ocean water is about 20°C (36°F). These conditions exist in tropical coastal areas, roughly between the Tropic of Capricorn and the Tropic of Cancer. To bring the cold water to the surface, OTEC plants require an expensive, large diameter intake pipe, which is submerged a mile or more into the ocean's depths.

Some energy experts believe that if it could become cost-competitive with conventional power technologies, OTEC could produce billions of watts of electrical power.

Technologies

The types of OTEC systems include the following:

- **Closed-Cycle**
  These systems use fluid with a low-boiling point, such as ammonia, to rotate a turbine to generate electricity. Warm surface seawater is pumped through a heat exchanger where the low-boiling-point fluid is vaporized. The expanding vapor turns the turbo-generator. Cold deep-seawater-pumped through a second heat exchanger-condenses the vapor back into a liquid, which is then recycled through the system.

- **Open-Cycle**
  These systems use the tropical oceans' warm surface water to make electricity. When warm seawater is placed in a low-pressure container, it boils. The expanding steam drives a low-pressure turbine attached to an electrical generator. The steam, which has left its salt behind in the low-pressure container, is almost pure fresh water. It is condensed back into a liquid by exposure to cold temperatures from deep-ocean water.

- **Hybrid**
  These systems combine the features of both the closed-cycle and open-cycle systems. In a hybrid system, warm seawater enters a vacuum chamber where it is flash-evaporated into steam, similar to the open-cycle evaporation process. The steam vaporizes a low-boiling-point fluid (in a closed-cycle loop) that drives a turbine to produce electricity.

Other Technologies

OTEC has important benefits other than power production. For example, air conditioning can be a byproduct. Spent cold seawater from an OTEC plant can chill fresh water in a heat exchanger or flow directly into a cooling system.

OTEC technology also supports chilled-soil agriculture. When cold seawater flows through underground pipes, it chills the surrounding soil. The temperature difference between plant roots in the cool soil and plant leaves in the warm air allows many plants that evolved in temperate climates to be grown in the subtropics.

Aquaculture is perhaps the most well-known byproduct of OTEC. Cold-water delicacies, such as salmon and lobster, thrive in the nutrient-rich, deep seawater from the OTEC process. Microalgae such as Spirulina, a health food supplement, also can be cultivated in the deep-ocean water.

As mentioned earlier, another advantage of open or hybrid-cycle OTEC plants is the production of fresh water from seawater. Theoretically, an OTEC plant that generates 2-MW of net electricity could produce about 4,300 cubic meters (14,118.3 cubic feet) of desalinated water each day.

OTEC also may one day provide a means to mine ocean water for 57 trace elements. Most economic analyses have suggested that mining the ocean for dissolved substances would be unprofitable. Mining involves pumping large volumes of water and the expense of separating the minerals from seawater. But with OTEC plants already pumping the water, the only remaining economic challenge is to reduce the cost of the extraction process.

Environmental and Economic Challenges

In general, careful site selection is the key to keeping the environmental impacts of OTEC to a minimum. OTEC experts believe that appropriate spacing of plants throughout the tropical oceans can nearly eliminate any potential negative impacts of OTEC processes on ocean temperatures and on marine life.

OTEC power plants require substantial capital investment upfront. OTEC researchers believe private sector firms probably will be unwilling to make the enormous initial investment required to build large-scale plants until the price of fossil fuels increases dramatically or until national governments provide financial incentives. Another factor hindering the commercialization of OTEC is that there are only a few hundred land-based sites in the tropics where deep-ocean water is close enough to shore to make OTEC plants feasible.

WIND ENERGY

Wind energy is the world's fastest-growing energy technology. Today, the U.S. has more than 6,300 megawatts of wind generating capacity.

How Wind Turbines Work

Wind is a form of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetation. Humans use this wind flow, or motion energy, for many purposes: sailing, flying a kite, and even generating electricity.

The terms wind energy or wind power describe the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity.

So how do wind turbines make electricity? Simply stated, a wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Types of Wind Turbines

Modern wind turbines fall into two basic groups: the horizontal-axis variety, and the vertical-axis design.

Horizontal-axis wind turbines typically either have two or three blades. These three-bladed wind turbines are operated "upwind," with the blades facing into the wind. The other common wind turbine type is the two-bladed, downwind turbine. Horizontal axis turbines are the most common type used today.

Sizes of Wind Turbines

Utility-scale turbines range in size from 50 kilowatts to as large as several megawatts. Larger turbines are grouped together into wind farms, which provide bulk power to the electrical grid.

Single small turbines, below 50 kilowatts, are used for homes, telecommunications dishes, or water pumping. Small turbines are sometimes used in connection with diesel generators, batteries, and photovoltaic systems. These systems are called hybrid wind systems and are typically used in remote, off-grid locations, where a connection to the utility grid is not available.

Advantages and Disadvantages of Wind Energy

Wind energy offers many advantages, which explains why it's the fastest-growing energy source in the world. Research efforts are aimed at addressing the challenges to greater use of wind energy.

Advantages

Wind energy is fueled by the wind, so it's a clean fuel source. Wind energy doesn't pollute the air like power plants that rely on combustion of fossil fuels, such as coal or natural gas. Wind turbines don't produce atmospheric emissions that cause acid rain or greenhouse gasses.

Wind energy is a domestic source of energy, produced in the United States. The nation's wind supply is abundant.

Wind energy is one of the lowest-priced renewable energy technologies available today, costing between 4 and 6 cents per kilowatt-hour, depending upon the wind resource and project financing of the particular project.

Wind turbines can be built on farms or ranches, thus benefiting the economy in rural areas, where most of the best wind sites are found. Farmers and ranchers can continue to work the land because the wind turbines use only a fraction of the land. Wind power plant owners make rent payments to the farmer or rancher for the use of the land.

Disadvantages

Wind power must compete with conventional generation sources on a cost basis. Depending on how energetic a wind site is, the wind farm may or may not be cost competitive. Even though the cost of wind power has decreased dramatically in the past 10 years, the technology requires a higher initial investment than fossil-fueled generators.

The major challenge to using wind as a source of power is that the wind is intermittent and it does not always blow when electricity is needed. Wind energy cannot be stored (unless batteries are used); and not all winds can be harnessed to meet the timing of electricity demands.

Good wind sites are often located in remote locations, far from cities where the electricity is needed.

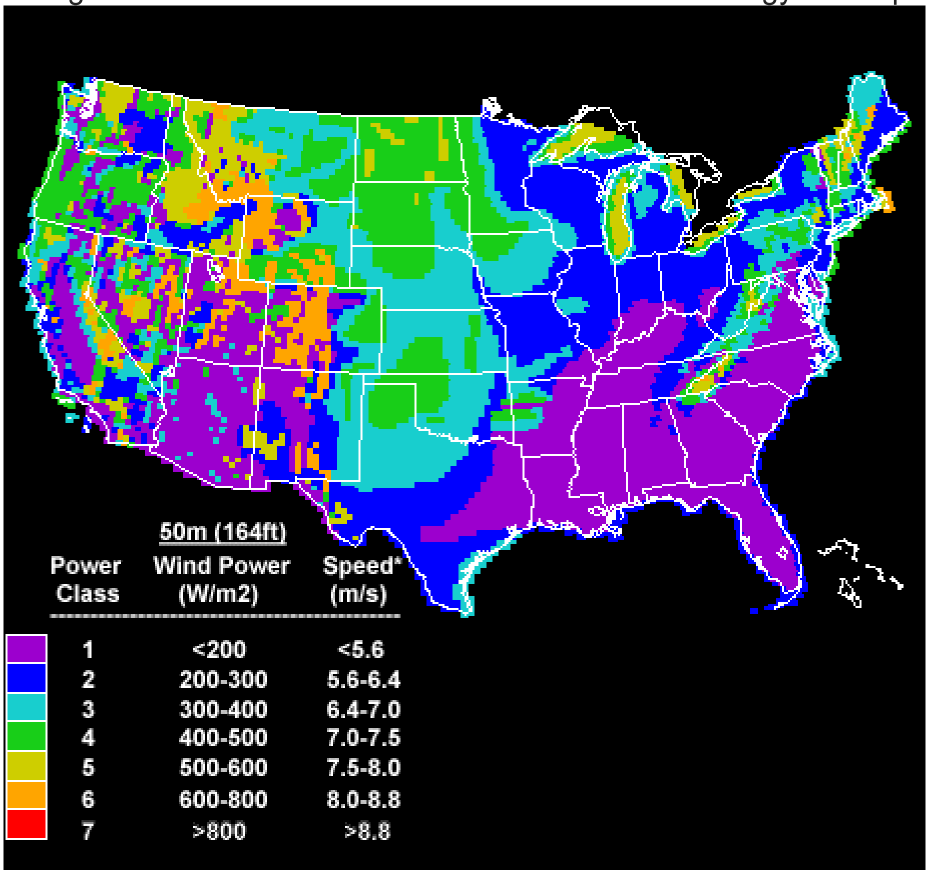
Wind resource development may compete with other uses for the land and those alternative uses may be more highly valued than electricity generation.

Although wind power plants have relatively little impact on the environment compared to other conventional power plants, there is some concern over the noise produced by the rotor blades, aesthetic (visual) impacts, and sometimes birds have been killed by flying into the rotors.

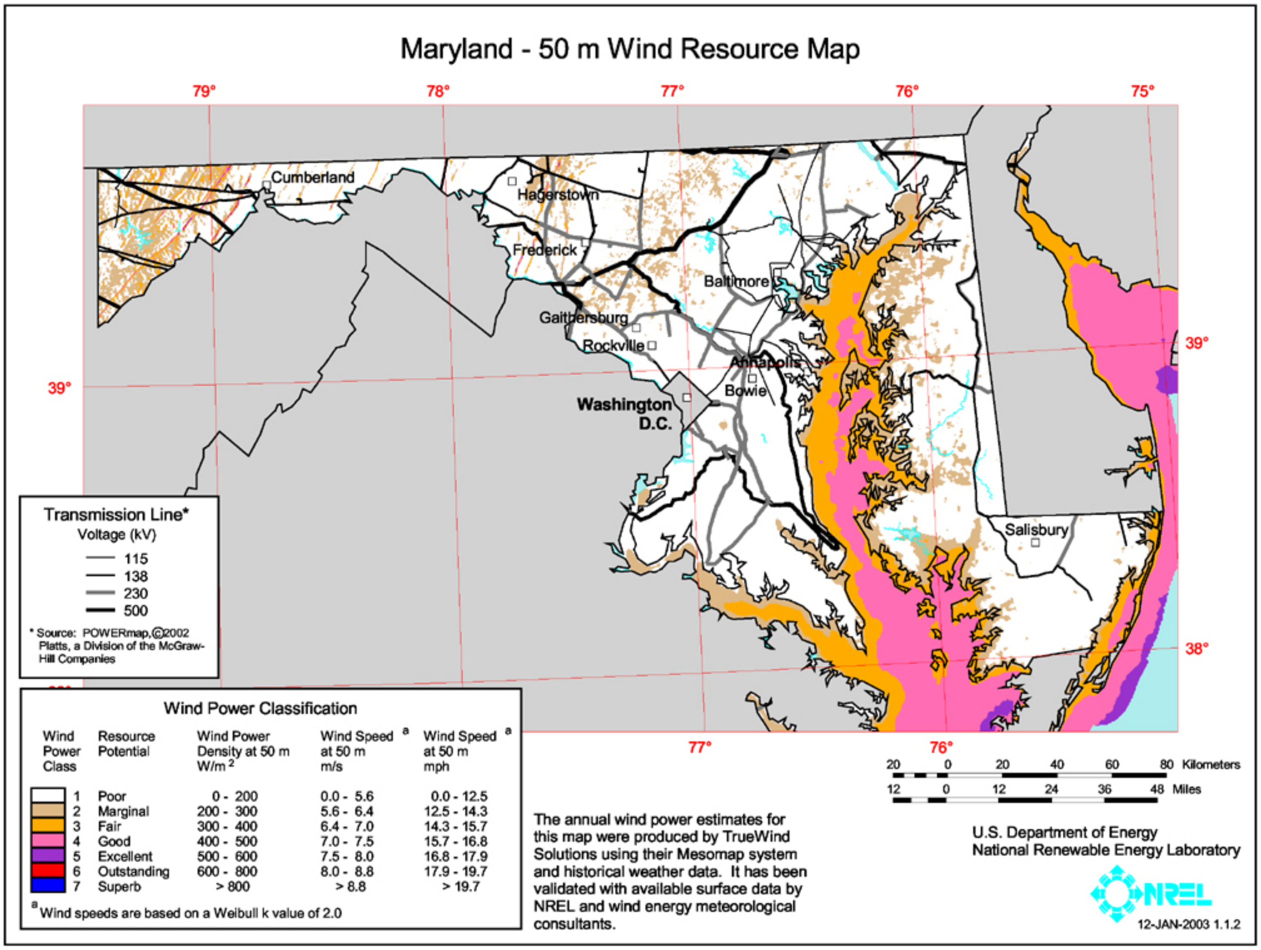
Wind Energy Resource Potential

Good wind areas, which cover 6% of the contiguous U.S. land area, have the potential to supply more than one and a half times the current electricity consumption of the United States.

Estimates of the wind resource are expressed in wind power classes ranging from class 1 to class 7, with each class representing a range of mean wind power density or equivalent mean speed at specified heights above the ground. Areas designated class 4 or greater are suitable with advanced wind turbine technology under development today. Power class 3 areas may be suitable for future technology. Class 2 areas are marginal and class 1 areas are unsuitable for wind energy development.



U.S. Annual Wind Power Resource and Wind Power Classes - Contiguous U.S. States.



The Department of Energy's Wind Program and the National Renewable Energy Laboratory (NREL) published a new wind resource map for the state of Maryland. This resource map shows wind speed estimates at 50 meters above the ground and depicts the resource that could be used for utility-scale wind development. Future plans are to provide wind speed estimates at 30 meters, which are useful for identifying small wind turbine opportunities.

This map indicates that Maryland has wind resources consistent with utility-scale production. Several areas of the state are estimated to have good to excellent wind resource. These are the barrier islands along the Atlantic Coast, the southeastern shore of the Chesapeake Bay, and ridge crests in the western parts of the state, west of Cumberland.

The sponsor of the Maryland wind map is the Maryland Energy Administration.

Wind Policy

Federal and state policies play an important role in encouraging wind energy development. More than 20 states have established renewable portfolio standards (RPS) that require electricity providers to obtain a portion of their power from renewable sources. More than 15 states have establishd renewable energy funds that provide financial incentives and other types of support for wind energy development. In addition, voluntary consumer decisions to purchase green power can provide an important revenue stream to support investment in wind energy facilities. And finally, wind may be able to play a role in helping states meet their air quality goals.

Air Quality and Wind

Incorporating Wind in Cap and Trade Programs

Wind can play a role in cap and trade programs designed to achieve compliance with air quality standards. For example, states can provide allowances to renewable energy sources in cap and trade programs to meet emission reduction goals under the Clean Air Interstate Rule (GAIR). In addition, wind may be able to play a role in regional carbon dioxide emission control programs, such as those being developed in New England and California.

State Implementation Plans

State Implementation Plans (SIPs) are a policy vehicle that allow states and municipalities to receive emission reduction credit for wind power purchases.

Supplemental Environmental Projects

Supplemental environmental projects (SEPs) are a policy vehicle that can provide funding for renewable energy projects (REPs). The U.S. Environmental Protection Agency (EPA) designed SEPs to give companies that violate environmental regulations an alternative to standard fines. When a company violates environmental regulations, it has the option to pay a fine to the state or federal government or the company can volunteer to fund environmentally friendly projects.

ETHANOL/METHANOL

Ethanol is an alcohol-based alternative fuel produced by fermenting and distilling starch crops that have been converted into simple sugars. Feedstocks for this fuel include corn, barley, and wheat. Ethanol can also be produced from "cellulosic biomass" such as trees and grasses and is called bioethanol. Ethanol is most commonly used to increase octane and improve the emissions quality of gasoline.

Ethanol can be blended with gasoline to create E85, a blend of 85% ethanol and 15% gasoline. E85 and blends with even higher concentrations of ethanol, E95, for example, qualify as alternative fuels under the Energy Policy Act of 1992 (EPAct). Vehicles that run on E85 are called flexible fuel vehicles (FFVs) and are offered by several vehicle manufacturers.

In some areas of the United States, lower concentrations of ethanol are blended with gasoline. The most common low concentration blend is E10 (10% ethanol and 90% gasoline). While it reduces emissions, E10 is not considered an alternative fuel under EPAct regulations.

How is Ethanol Made?

Ethanol can be produced from any biological feedstocks that contain appreciable amounts of sugar or materials that can be converted into sugar such as starch or cellulose. Sugar beets and sugar cane are examples of feedstocks that contain sugar. Corn contains starch that can relatively easily be converted into sugar. A significant percentage of trees and grasses are made up of cellulose, which can also be converted to sugar, although with more difficulty than required to convert starch.

The ethanol production process starts by grinding up the feedstock so it is more easily and quickly processed in the following steps. Once ground up, the sugar is either dissolved out of the material or the starch or cellulose is converted into sugar. The sugar is then fed to microbes that use it for food, producing ethanol and carbon dioxide in the process. A final step purifies the ethanol to the desired concentration.

Ethanol is also made from a wet-milling process. Many larger ethanol producers use this process, which also yields products such as high-fructose corn sweetener.

Net Energy Balance of Ethanol

Since President Bush announced the Advanced Energy Initiative, there has been an increased interest in ethanol as a fuel. Cellulosic ethanol can be produced from fast growing trees, corn stover, grain straw, switchgrass, forest products, waste, and construction waste and may yield a higher energy balance than ethanol made from corn.

Today's ethanol is produced using corn, and an increased demand for ethanol means an additional market for corn, a more stable and profitable farming industry, and an increased level of energy security for our nation.

The production of ethanol is energy efficient as it yields almost 25 percent more energy than is used in growing the corn, harvesting it, and distilling it into ethanol. The most recent findings show that corn ethanol fuel is energy efficient and yields an energy output:input ratio of 1.6.

Early ethanol plants were energy intensive, raising concerns as to whether the transportation fuel being produced was worth the energy going into making it. But the efficiency of corn ethanol production has increased over the last ten years and technical advancements have improved the net energy value of corn ethanol. Today, producing ethanol from corn using our domestic supplies of coal and natural gas achieves a net gain in the form of energy and helps displace the need for foreign oil.

Ethanol Benefits

- **E85 is easy to use and handle** - E85 fueling equipment is slightly different and of similar cost to equipment used to store and dispense petroleum fuels. In some cases, it may be possible to convert your existing petroleum equipment to handle E85.
- **Using E85 reduces petroleum consumption** - Use of E85 will reduce a fleet's overall use of petroleum and replace it with a renewable-based fuel produced ("grown") in the United States.
- **E85 is good for the environment** - Beyond operational ease, E85 offers considerable environmental benefits. 1) Ethanol is water soluble and biodegradable. If a fuel spill occurs, the effects are less severe than with gasoline. 2) Because ethanol contains oxygen, using it as a fuel additive results in lower carbon monoxide emissions.
- **Flexible Fuel Vehicles (FFVs) are available and affordable** - FFVs specifically designed to run on E85 are becoming more common each model year, and FFVs are typically available as standard equipment with little or no incremental cost.
- **FFVs have flexible fueling options** - FFVs may operate on gasoline, and, in fact, most of the 4 million FFVs on US roadways do today. Although that is not a positive from an E85-use standpoint, it does underscore the *flexibility* FFVs offer fleets. When E85 is not available, or an FFV travels outside the fueling network, a driver may simply fuel with either fuel as the situation dictates.

What is Methanol?

Methanol (CH3OH) is an alcohol fuel. Today most of the world's methanol is produced by a process using natural gas as a feedstock. However, the ability to produce methanol from non-petroleum feedstocks such as coal or biomass is of interest for reducing petroleum imports.

Chemical Properties: As engine fuels, ethanol and methanol have similar chemical and physical characteristics. Methanol is methane with one hydrogen molecule replaced by a hydroxyl radical (OH).

How is Methanol Made?

Methanol is predominantly produced by steam reforming of natural gas to create a synthesis gas, which is then fed into a reactor vessel in the presence of a catalyst to produce methanol and water vapor. Although a variety of feedstocks other than natural gas can and have been used, today's economics favor natural gas.

Synthesis gas refers to combinations of carbon monoxide (CO) and hydrogen. While a large amount of synthesis gas is used to make methanol, most synthesis gas is used to make ammonia. As a result, most methanol plants are adjacent to or are part of ammonia plants. The synthesis gas is fed into another reactor vessel under high temperatures and pressures, and CO and hydrogen are combined in the presence of a catalyst to produce methanol. Finally, the reactor product is distilled to purify and separate the methanol from the reactor effluent.

Methanol Advantages/Disadvantages

Methanol's physical and chemical characteristics result in several inherent advantages as an automotive fuel. Some methanol benefits include lower emissions, higher performance, and lower risk of flammability than gasoline. In addition, methanol can be manufactured from a variety of carbon-based feedstocks such as natural gas, coal, and biomass (e.g., wood) and the use of methanol would help reduce U.S. dependence on imported petroleum. On the down side, methanol produces a high amount of formaldehyde in emissions.

In addition, methanol can easily be made into hydrogen. Some researchers are currently working to overcome the barriers to using methanol as a hydrogen fuel source. So methanol may potentially be used to create hydrogen for hydrogen fuel cell vehicles in the future.

Using Biofuels Production to Enhance Chesapeake Bay Water Quality Through Cover Crop Planting Program

The need to increase cover crop acreage to meet nutrient reduction goals in the Chesapeake Bay watershed is well documented. The Tributary Strategies developed for the ten Maryland watersheds that feed the Chesapeake Bay call for a total of 600,000 acres of cover crop to be planted in Maryland annually. This is about one-third of the state's agricultural acreage and is a very aggressive goal, but one that is backed by research as being one of the most cost-effective practices to reduce the amount of nutrients flowing into the Bay. The advantage of a harvestable commodity cover crop program is that a farmer will be motivated by a financial reward, because of the yield improvement realized when planting the small grain early. In September, multiple tasks compete for a typical Maryland grain farmer's time: harvesting corn and soybeans and concurrently planting wheat and barley crops targeted for harvest. When these income-producing tasks are completed, a farmer typically plants cover crops. In a wet or slow year this could bump up against the latest eligible planting date to qualify for state incentives for planting cover crops. Harvestable cover crops provide an added benefit which will encourage a farmer to plant early. Since farmers have the option to harvest, the incentive payment is reduced in a cover crop program and the program uses less public dollars for the nutrient reduction benefit. By supporting the development of an ethanol industry that uses small grains, specifically hulless barley, a self-sustaining market will be established that could, in the future, reduce the level of public support required for cover crop incentives.

As ethanol production utilizes the starch component of the grain, any grain crop has the potential to provide the starch. Corn is most desirable as it contains 72% starch. Wheat and hulless barley contain 60% starch and regular hulled barley contains 52% starch. There is a desire in Maryland to establish an ethanol production facility that has the flexibility to use both small grains and corn for ethanol production. In 2005, the state legislature passed an incentive to help overcome some of the disadvantages of using small grains for ethanol rather than corn knowing that the project will meet water quality goals as well as providing a locally produced renewable energy source that provides air quality benefits.

An ethanol plant will provide a new market for small grains such as hulless barley increasing the acreage of small grains grown in the state. In many years these small grains can be planted as cover crops without fall nitrogen and this additional cover crop acreage, which will eventually be used for biofuels production, reduces nutrient and sediment movement from farm fields into local waterways and the Chesapeake Bay. The development of a local ethanol project would provide a clean burning fuel to be utilized in Maryland to improve air quality and reduce greenhouse gas emissions in the Chesapeake Bay watershed. Additionally, developing a local ethanol market will provide additional income for farmers who invest in the project, thereby improving farm viability and reducing the numbers of acres in the Chesapeake Bay watershed sold for development.

Unlike a typical cover crop where the crop must be destroyed in spring, a commodity cover crop program allows a farmer to apply spring fertilizer after a specified date, which varies by region. The farmer benefits by making money on his harvest and the state benefits as the farmer receives a reduced incentive payment from MACS (Maryland Agricultural Cost Share) and the state is able to afford more acres of cover crop using the same dollars.

The environmental implications of a commodity crop program are significant. Commodity cover crops have been shown to decrease the flow of water runoff by 55%, reduce soil loss from erosion by 50% and are estimated to reduce nitrogen by 5 pounds per acre and phosphorus by 0.2 pounds per acre. An ethanol project that uses small grains (wheat or barley) will help Maryland achieve its nutrient reduction commitments under the Chesapeake Bay Agreement.

Reference: The information above was obtained from Lynne Hoot, Executive Director of Maryland Grain producers Utilization Board.

RESOURCE SPECIFIC INFORMATION

5th Issue and Wildlfe

Information provided by Doug Wigfield, MD DNR Wildlife and Heritage Service

The demands for energy in the world and in the United States today are growing by leaps and bounds. These ever-growing demands are forcing us to take a hard look at traditional energy sources but an even harder look at emerging energy technologies and how wildlife species have been, are and may be affected.

All energy generation sources have impacts on wildlife species; some greater than others. There are some positive impacts that occur as well. For example, less wildlife habitat tends to be lost when alternative energy sources are developed rather than fossil fuel mining, and, in addition, cleaner air and water are available for wildlife.

Let's explore some of the energy issues affecting wildlife especially migratory bird and bat flyways and habitat loss and degradation as they apply to the traditional and the emerging technologies. A bibliography is provided at the end of this document for reference in expanding/explaining the bullets of this training material.

Hydropower - using water - renewable

- The hydroelectric power plant infrastructure itself causes habitat loss and direct mortality from collisions.
- However, dams usually replace one kind of habitat with another. An example would be increased surface water upstream and wetlands for waterfowl species et al. Recreation is also usually affected.

Fossil Fuels (oil, coal and natural gas) - non-renewable

- Oil and gas drilling require infrastructure (drilling and pumping facilities, refineries, roads, pipelines, temporary storage tanks, pumping facilities and pads). These all cause loss of wildlife habitat.
- Direct wildlife mortality can occur by collisions with infrastructure and associated vehicles.
- Pollutants like sulfur dioxide (SO2) and nitrogen oxide (NOx) can affect wildlife species.
- Habitat loss occurs at mining sites especially when strip mining for coal is employed. After the site's coal is exhausted many of the sites are reclaimed, creating good wildlife habitat for some species of wildlife (but probably not those that were present previously on the site).

Nuclear Energy - renewable

- Of all energy sources, nuclear energy has perhaps the lowest impact on the environment.
- Habitat loss occurs at the power plant site itself and at waste storage facilities but by-products affecting wildlife are almost negligible.
- Discharged waters used to cool reactors and equipment are typically so clean that they are usually developed as wetlands for wildlife use.

***Solar Power* - renewable**

- Photovoltaic cells *convert* sunlight directly to electricity.
- Sometimes mirrors, collectors, storage devices and generators destroy wildlife habitat.
- Usually collection of this type of power does not affect wildlife.

***Wind Energy* -renewable**

- Migrating bird and bat mortalities occur in wind farms as a result of collisions with wind turbines, meteorological towers (and their supporting guy wires) and with vehicles traveling the project roads.
- Both migrating and resident birds can collide with these wind turbines.
- Numbers of birds and bats killed depend on use of the area, surrounding vegetation and physical characteristics of the area. The causes of high bat mortality are not well understood.
- Compared with other species of birds in the Western U.S., raptors (including hawks, golden eagles, falcons and owls) appear to be at higher risk for various reasons. Migrating songbirds may be more at risk from eastern windpower facilities, but raptors are at risk at certain sites as well.
- There have been no documented large fatality events of songbirds in wind projects.
- Loss of habitat occurs where turbines exist and associated roads are established. Fragmentation of forest habitat is an additional concern.
- Lighting at turbine facilities tend to attract insects, bats and birds to these areas and may increase their vulnerability to collisions with structures.
- Poor weather events can cause migrating birds to become disoriented and fly at lower altitudes increasing the risk of collisions.

***Biofuels made from biomass crops* - energy derived from fast-growing plants and plant-derived materials - renewable**

- Some favored species are switchgrass, hybrid poplars, cottonwoods, sycamores and willows and the main row crop ... corn.
- Some row crops displace natural vegetation and cause loss of wildlife habitat.
- Carbon dioxide is recycled each growing season.
- Biopower facilities destroy wildlife habitat.

***Geothermal* - earth's heat produces electricity- renewable.**

- Geothermal plants, piping and heat exchangers destroy wildlife habitat.

Hydrogen - future renewable energy

- *Some experts think that hydrogen will form the basic energy infrastructure that will power future societies, replacing today's natural gas, oil, coal, and electricity infrastructures. They see a new "hydrogen economy" to replace our current "fossil fuel-based economy," although that vision probably won't happen until far in the future.*

***Ocean Energy* (waves, tidal, thermal)**

- There are three basic ways to tap the ocean for its energy. We can use the ocean's waves, we can use the ocean's high and low tides, or we can use temperature differences in the water.

Birds could collide with power plants and turbines.

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Aquatics and 5th issue

Information provided by Elena Takaki, MD DNR

Power Production and Fisheries Management

As the demand for electricity grows, we face tough challenges in balancing that need with managing our natural resources. This problem is especially challenging when it comes to managing anadromous fish populations such as American eel and shad. These species are especially affected by the change in flow rates and temperature.

Hydro-electric dams cause the greatest disruption to flow rates of rivers simply because the river is now dammed. They also greatly affect the reproductive cycles of anadromous fish. When there is a dam built, they can no longer spawn in the appropriate freshwater habitat. Populations of the Atlantic sturgeon, American shad, hickory shad and two species of river herring in the Susquehanna River were decimated because when the Conowingo Dam was built. Also the striped bass, white perch and American eel can no longer travel up the river into Pennsylvania to spawn.

Fossil fuel and nuclear power plants that use water as a cooling source usually have a warm water plume where they discharge back into a river or bay. In the colder months of the year this warm water plume is an attractant to fish. There is only a problem if some summer species camp out there and the plant goes off line in the middle of the winter. The cold shock will kill certain species of fish that need warm water temperatures to survive. For example, bluefish will die at a water temperature of 10-degrees Celsius.

Low flow rates from dams, whether they are in place for hydro-electric power or for a reservoir for drinking water, will cause water temperatures to rise down stream if sufficient water is not being released, such as in drought conditions. The fish, such as trout, will be the first to die and then hardier species as conditions get worse. High flows will cause flood conditions that scour out habitat and alter everything on the river from habitat to water quality.

PPRP
Power Plant Update
Volume 5, Number 4 • Summer 1999

Anadromous Fish Restoration in the Susquehanna
30 Years of Work Culminate in Construction of Final Fish Passage Facility

The Power Plant Research Program (PPRP) has been extensively involved with ongoing negotiations to restore anadromous fish presence in the upper reaches of the Susquehanna River. Historically, the Susquehanna supported large spawning runs of American shad, river herring, and striped bass, with fish migrating as far upstream as Binghamton, New York. With the construction of four major hydroelectric facilities on the lower Susquehanna River in the early 1900s – Conowingo, Holtwood, Safe Harbor, and York Haven – fish were prevented from returning upstream to their spawning grounds.

Licenses for the four Susquehanna River hydroelectric facilities came up for renewal in the early 1970s. The Federal Energy Regulat01y Commission (FERC) is the federal agency that licenses hydroelectric plants throughout the country; PPRP is the lead agency for the State of Maryland with regard to FERC licensing of Maryland's hydroelectric resources. For the Susquehanna River facilities, participants in the FERC license proceedings have included the utility applicants; PPRP, on behalf of the State of Maryland; the State of Pennsylvania; the U.S. Fish and Wildlife Service (USFWS); and several non-governmental organizations (NGOs). The ultimate goal of all parties is the restoration of anadromous fish populations to the entire Susquehanna River drainage system. Several measures are being taken to achieve this goal: installation of fish passage at the four dams, implementation of an active restoration program involving trapping and transport upstream of adult fish, and hatche1y production of young fish for stocking.

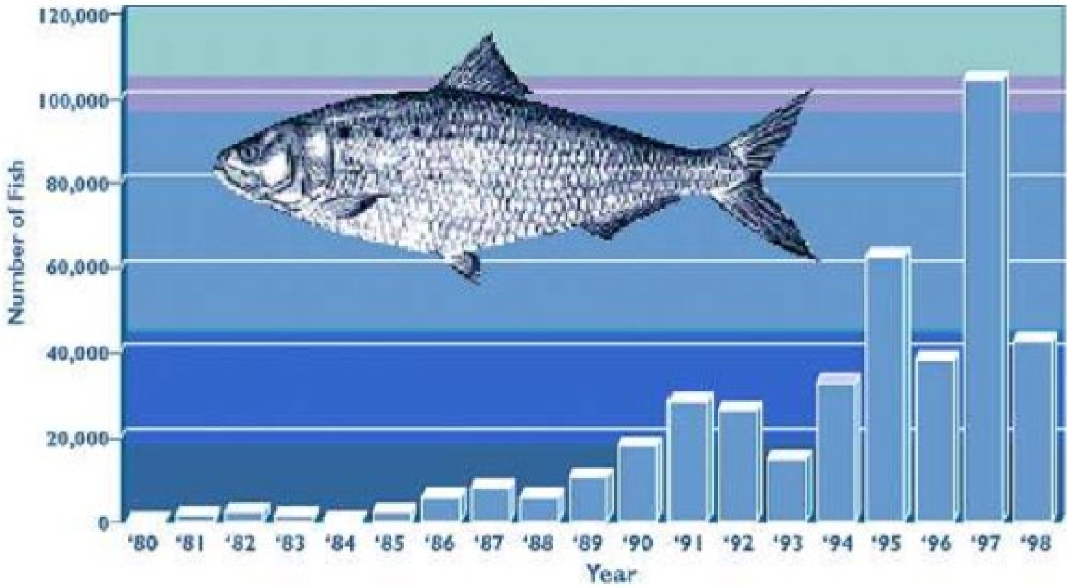


Figure 1. Shad collected at Conowingo, 1980 - 1998.

Construction of an experimental fish lift at Conowingo Dam in the early 1970s provided an oppo1tunity to evaluate the potential effectiveness of lift facilities for restoring American shad and other species and for gathering extensive info1mation on fish populations and passage behavior. Stock restoration activities began at about the same time. These activities included: 1) transporting adult fish from other East Coast rivers and releasing them into the Susquehanna River; 2) trapping adults at Conowingo, trucking, and releasing them upstream of the dams; and 3) using shad eggs from many different shad stocks to propagate larvae and juveniles, then releasing them into the Susquehanna and its tributaries. These different approaches were monitored for their effectiveness, and the findings from the monitoring were used to modify existing programs and develop new programs.

Perhaps the most significant development in the Susquehanna restoration was a 1988 settlement on fish passage at Conowingo reached by PECO Energy, which operates the hydroelectric plant at Conowingo, and the resource agencies. In accordance with this agreement, a permanent east side fish lift was completed in the spring of 1991, in time for the spring shad run. A further breakthrough in achieving the fish restoration goal was reached in October 1992, when the State of Maryland, the USFWS, the Pennsylvania Fish and Boat Commission, NGOs, Safe Harbor Water Power Corporation, and Pennsylvania Power and Light (which owns Holtwood) agreed on construction and operation of fish passage facilities at Holtwood and Safe Harbor by 1997.

Growth of the Susquehanna River shad stock in response to the restoration effo1ts and fish passage construction to date has been dramatic, culminating in 1997 in the largest number of American shad to ever be passed over Conowingo Dam, 104,000 (see Figure 1). Numbers of shad passed at Holtwood and Safe Harbor in 1997, their first year of operation, were 28,000 and 21,000 respectively, representing the first shad to swim upstream to Pennsylvania' s po1tion of the Susquehanna River since before 1900. The total number of fish passed in 1998 was somewhat smaller than in previous years, with about 46,000 American shad passing through the Conowingo lift, 8,000 through Holtwood, and 6,000 through Safe Harbor. This decrease is attributed to a compressed spawning season caused by higher than normal precipitation (and resultant river flows), coupled with unusually warm temperatures. These factors, rather than a decline in returning stock, resulted in a reduced ability to attract fish and operate lifts at Conowingo. As evidence of the compressed season, 92 percent of Conowingo's total shad passage occurred on 20 days in May. In fact, the single-day record at Conowingo was set on 21 May, when 9,151 shad passed through the lifts.

Crews erect coffer dam cells as part of the fish passage facility at York Haven, Fall 1998. The construction will be complete in time for the spring shod run in 2000.

GPU, which operates the York Haven Dam upstream of Safe Harbor, has agreed to construct a passage facility that will be operational by the year 2000. GPU is in the process of selling its non-nuclear generating assets, including the York Haven facility, to Sithe Energies as part of its overall strategy to respond to restructuring in the power industry. The completion and operation of the fish passage facility is a requirement of York Haven's license from FERC, which remains binding on any new owner of the plant.

Construction of the fish passage facility on the east side of the river at York Haven is well underway (see photos with this article). Abnormally low flows in the summer and fall of 1998 have facilitated in-stream construction. Upon completion of the facility in Spring of 2000, the entire Susquehanna River will be open to migratory fish for the first time since the dams were constructed, creating the potential for shad and other species to move as far upstream as New York State. PPRP will continue to evaluate fish passage effectiveness at all four dams to ensure restoration goals are met.

PPRP
Power Plant Update
Volume 5, Number 2• Winter 1998

Deep Creek Hydroelectric Project:

A Resource Balancing Act

Introduction and History

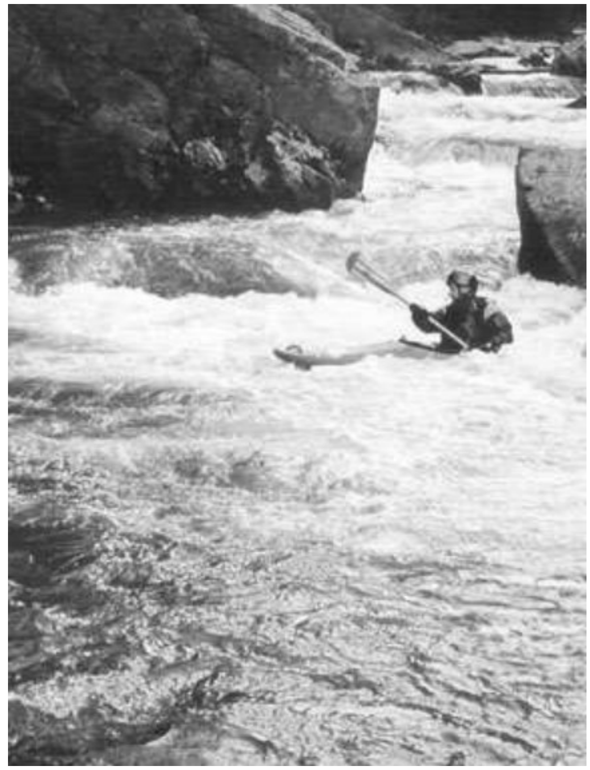
As Maryland's lead agency with respect to power plant issues, the Power Plant Research Program's (PPRP) activities are typically focused on power plants in the Chesapeake Bay area — simply because this is where most of the major plants are located. Over the past several years, however, PPRP has been extensively engaged in defining, evaluating and resolving issues related to Maryland's westernmost power plant, the Deep Creek Hydroelectric Project. Many Garrett County visitors who enjoy the recreational assets provided by Deep Creek Lake are unaware that this man-made lake was created to serve as an economical and reliable source of electricity.

The 3,900 acre Deep Creek Lake was fanned in 1925 by construction of a rockwall dam across Deep Creek, a tributary of the Youghiogheny River. The hydroelectric facility includes two turbines that have a combined generating capacity of just under 20 megawatts, the second largest hydroelectric facility in the state. When both turbines are operating, water is discharged to the Youghiogheny at a rate of 630 cubic feet per second. This water discharge has the potential to affect lake-side recreation through changes in the lake's water level, as well as the downstream environments of the Youghiogheny River. The Youghiogheny River is Maryland's only designated ' wild' river — it supports a developing trout fishery as well as one of the most challenging kayaking and rafting runs in the country.

Pennsylvania Electric Company (Penelec), the owner-operator of the Deep Creek Hydroelectric Project, received an operating license from the Federal Energy Regulatory Commission (FERC) in the 1960s. In 1988, Penelec sought license renewal — PPRP participated in the FERC relicensing process as the lead agency for the state of Maryland. Our role was to ensure that the operation of the hydroelectric plant minimized potential impacts to the state's natural and recreational resources while still allowing for the economical generation of electricity.

During this relicensing process, it was detem1ined that the Project was outside the FERC's jurisdiction. Penelec and the State negotiated conditions that had been part of the FERC relicensing effort into a Maryland water appropriations permit administered by the Maryland Department of the Environment. This permitting process afforded the State an opportunity to develop a plan that controlled the timing and quantity of water released from the hydroelectric project. The conditions attached to the state water appropriations permit, issued to Penelec in 1994, were designed to achieve two objectives: 1) provide a reliable and economical source of electricity; and 2) enhance Deep Creek Lake's and the Youghiogheny River's natural and recreational resources.

Environmental and Recreational Issues



Because the interests of various users of Deep Creek Lake's resources often result in conflicting demand on water availability, it was a difficult task to develop an operational plan to balance the following complex environmental and recreational issues with economical operation of the plant.

Issue 1: Lake Levels — Recreational lake users need minimal and consistent drawdown of the lake during summer, and a higher than historic level in the fall to extend the boating season. Historically, Penelec lowered the water level in the fall and winter to prevent ice damage to the spillway, resulting in an annual water level change of about 9 feet.

Issue 2: River Fisheries — High water temperatures in the Youghiogheny River and low dissolved oxygen (DO) levels in the hydropower project's discharge historically limited trout habitat. The discharge from the hydroelectric project is cooler than the river because it draws cold water from the bottom of the lake. The timing and volume of cool water discharges could be manipulated during periods of high temperatures in the Youghiogheny to improve trout habitat and assure that the growing trout population would not be subjected to lethal temperature extremes.

Issue 3: Whitewater Recreation - The Youghiogheny River is an exceptional whitewater recreation resource almost totally dependent upon releases from the Deep Creek Project. Whitewater boaters need certain flow volumes and timed, dependable releases from the hydroelectric facility to plan trips in advance. The "Upper Yough," which runs from Sang Run to Friendsville, is the key section of the river for whitewater boating that is affected by the Deep Creek Project. During dry periods, the Upper Yough may be the only whitewater resource in the area available to boaters.

Resolution of Issues

As part of the water appropriations permit, PPRP and Penelec developed the following measures to balance fishery and recreational interests with the need to maintain reliable and economical power generation.

Lake Levels — A computer model of historical lake inflow, storage, and generation was developed to simulate project operation and to evaluate alternative operating strategies. Using the results from the model, Penelec and PPRP developed monthly operating rules for the Deep Creek Hydroelectric Project that balanced providing reliable electricity with enhancing lake and river resources.

River Fisheries -— PPRP developed a protocol for the Deep Creek Hydroelectric Project operators to predict maximum daily river temperature. The protocol uses river flow, water temperature, and air temperature and cloud cover for the region. During low flow conditions in the late summer, plant operators follow the protocol in the morning and afternoon to calculate river temperature expected that day. The goal is to make sure the river temperature never exceeds 25°C. Based on these temperature predictions, the operators decide whether to make a release to cool the river—enhancing temperature habitat for trout. If the operators decide to make a release, they make this information available to the public on a telephone recording so that whitewater boaters can also take advantage of the release. The trout population has been increasing since Penelec implemented the protocol in 1994.

In addition to enhancing trout habitat through water temperature regulation, Penelec also installed structures to provide a continuous minimum flow in the Youghiogheny River and aerate discharge water to alleviate any low-DO problems.

Whitewater Recreation -— Penelec now schedules electrical generation to provide water releases for whitewater boating whenever possible. This includes minimum length periods of release and the establishment of fixed days and times of release, including at least one Saturday per month, and each Monday and Friday. These can be adjusted for special occasions or severe water conditions.

Epilogue: Permit Review

Thus far, PPRP's and Penelec's efforts with respect to prese1ving and enhancing the natural and socioeconomic resources associated with the Deep Creek Hydroelectric Project appear to be working well.
However, because it is difficult to satisfy all interests all the time, Penelec' s permit is subject to public review on a 3- to 5-year cycle. The first review period will cover the period from 1994 to 1999. In this review, Penelec, other agencies and the various user groups will provide input to the State for its evaluation and potential permit condition modification to ensure that the resources of the Deep Creek Hydroelectric Project are still being balanced to the benefit of the entire state.

SOILS AND 5th ISSUE

Information provided by Lenore Vasilas, USDA-NRCS Soil Scientist

Oil and Gas Drilling and Soils

- During extraction, drilling fluids or "muds" are used for lubrication. These muds contain damaging chemicals that can contaminate the soils and prevent vegetative growth around the drilling area and where they are dumped.
- Water produced from oil drilling may contain high contents of salts and other contaminants. This water is typically stored in pits or disposed of in evaporation ponds. Spills of waste water can kill vegetation and sterilize soils.
- Contaminants in the soil produced by oil drilling may *move* down through the soil into the ground water or may be released into the atmosphere.
- Additions of roads, pipelines, massive pumping facilities, well pads, and compressor station complexes denude the land of vegetation, causing soil loss and increased erosion.
- Pipe and storage tank leaks and oil spills during transportation can contaminate the soil.
- When oil and gas are removed from under the earth it leaves a large hole underground. When there is no longer anything to support the land above, the land can collapse, causing damage to the land and property above.
- Gas emissions produced through the consumption of oil and gas contribute to acid rain which affects the acidity of soils which then can affect vegetation.

Coal Mining and Soils

- When surface mining coal, topsoil and subsoil are removed and set aside to be used later to reclaim the land. Once the rock is mined the soil is them used to restore the area to its original condition or improve the land.
- Surface controls are needed to minimize erosion and reduce the amount of suspended soils in the water flowing in and around the mining site.
- Often, pyrite that is exposed during mining causes the water flowing through it to become highly acidic. This acidic water is called acid mine drainage. If not treated, the acidic water will kill off vegetation and wildlife.

Wind Energy and Soils

- Wind energy produces no air or water pollution, involves no toxic or hazardous substances, and poses no threat to public safety.
- Wind turbines occupy only a small fraction of the land. The surrounding land is typically left undisturbed and can be left in agriculture or forest.
- In forested areas the addition of wind turbines may mean clearing trees and cutting roads which causes a disturbance to the soil.

Solar Energy and Soils

- Solar energy on a large utility-scale requires a large amount of land including area for cooling ponds:

Geothermal Energy and Soils

- Geothermal energy use produces hazardous waste that may contain metals, minerals, and gases that when disposed can contaminate the soil.
- Land subsidence can occur in the area of drilling.
- Environmental impacts are confined to a centralized area around the plant; therefore, it would be difficult to site a plant in scenic or environmentally sensitive areas.
- Gas emission include some that produce acid rain that can affect the acidity of soil which then can affect vegetation.

Biofuels and Soils

- Combustion of biofuels creates emissions that contribute to acid rain which can affect soils which then can affect vegetation.
- It also creates soot and ash that can contaminate the soil.
- Facilities that burn municipal waste produce waste that often contains toxic metals, chlorinated compounds, and plastics that, when disposed, will contaminate the soil.
- Although biofuels used in automobiles can reduce emissions that cause ozone (smog), they do not reduce the acid rain generating emissions that can affect soil which than affects vegetation.
- Growing tress and other plants for the production of biofuels can benefit soil quality and create a product that can stabilize cropland or rangeland prone to erosion and flooding.
- Trees are typically grown for several years before harvesting allowing there roots and leaf litter to accumulate and stabilize the soil.
- Planting self regenerating plants minimize the need to disrupt by soil through tilling and planting. Planting perennial grasses that are harvested like hay would cause negligible soil loss compared to planting annual crops such as corn..
- Large-scale energy farms could lead to increased pesticide and fertilizer use because more land would be needed in cultivation.
- If agriculture and forestry waste and residues are used for biofuel production it could lead to a reduction of organic matter and nutrients in the soil.

Hydropower and Soils

- The initial creation of reservoirs that supply water to the dams flood soils that would typically not be flooded. Many of the areas that are flooded contain hydric soils and wetlands important to water quality. However, overtime, new fringe wetlands around the reservoir are usually established through the rise in groundwater levels created by the dams.
- The cutting of trees and land disturbance needed to build dams can cause soil erosion and landslides, causing a buildup of sediment in streams.
- Reservoirs above dams help to control flooding which prevents soil erosion.

Nuclear energy and Soils

- Uranium mining causes similar hazards to the soil as coal mining.

- Abandon mines contaminated with radioactive waste can pose radioactive risks 250,000 years after its closure.
- The uranium enrichment process depends on a great amount of electricity, most of which is provided by the burning of fossil fuels and produces radioactive waste that when disposed can contaminate the soil.
- Cooling systems require 2.5 times as much water as fossil fuel plants, creating the need for very large cooling ponds.

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FORESTRY AND 5th ISSUE

Information provided by Frank Lopez, MD DNR Forest Service

Benefits of Urban Trees

Urban and Community Forestry: Improving Our Quality of Life

Urban and community forestry can make a difference in our lives. Each one of us can make a personal contribution. As we develop and apply technologies for a better way of life, often times side effects adversely affect our natural environment. For example, in our urban areas summer temperatures and noise levels are higher than in the surrounding countryside. Air pollution problems are more concentrated, and the landscape is significantly altered, reducing personal health benefits available to us by having access to wooded areas and green open spaces. Trees help solve these problems. Now, 75 per-cent of us live in cities and towns and we can act individually to improve our natural environment through the planting and care of trees on our own streets, and by supporting community-wide forestry programs. Through technology we are learning more about trees and how they benefit mankind, and how we can do a better job of planting and caring for these trees that make up our urban forests.

TREES ADD BEAUTY AND IMPROVE PERSONAL HEALTH

Trees are major capital assets in America's cities and towns. Just as streets, sidewalks, sewers, public buildings and recreational facilities are a part of a community's infrastructure, so are publicly owned trees. Trees-and, collectively, the urban forest-are important assets that require care and maintenance the same as other public property.

Trees are on the job 24 hours every day working for all of us to improve our environment and quality of life.

Without trees, the city is a sterile landscape of concrete, brick, steel and asphalt. Picture your town without trees. Would it be a place where you would like to live? Trees make communities livable for people. Trees add beauty and create an environment beneficial to our mental health. Trees:

- Add natural character to our cities and towns.
- Provide us with colors, flowers, and beautiful shapes, forms and textures.
- Screen harsh scene ry.
- Soften the outline of masonry, metal and glass.
- Can be used architecturally to provide space definition and landscape continuity.

Trees impact deeply on our moods and emotions, providing psychological benefits impossible to measure. A healthy forest growing in places where people live and work is an essential element of the health of the people themselves. Trees:

- Create feelings of relaxation and well-being.
- Provide privacy and a sense of solitude and security.
- Shorten post-operative hospital stays when patients are placed in rooms with a view of trees and open spaces.

A well-managed urban forest contributes to a sense of community pride and ownership.

TREES REDUCE AIR POLLUTION

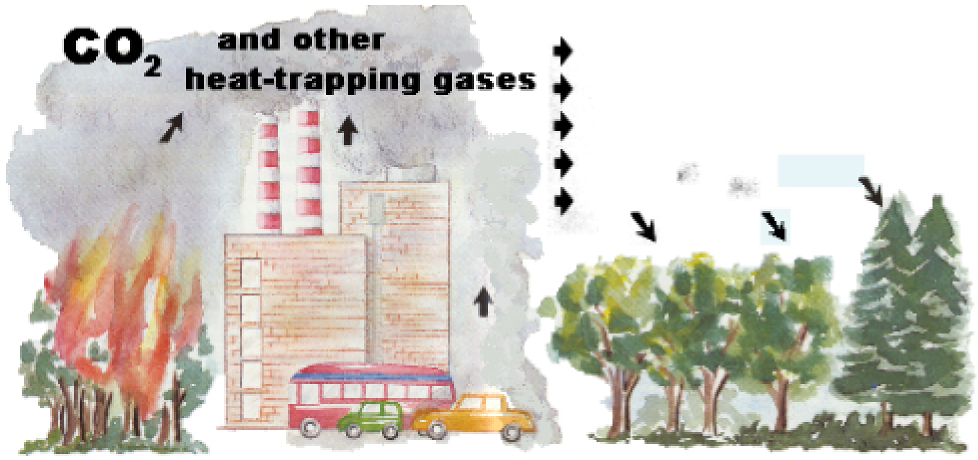
Trees and other plants make their own food from carbon dioxide (CO2) in the atmosphere, water, sunlight and a small amount of soil elements. In the process, they release oxygen (02) for us to breathe. Trees:

- Help to settle out, trap and hold particulate pollutants (dust, ash, pollen and smoke) that can damage human lungs.
- Absorb CO_2 and other dangerous gases and, in turn, replenish the atmosphere with oxygen.
- Produce enough oxygen on each acre for 18 people every day.
- Absorb enough CO, on each acre, over a years' time, to equal the amount you produce when you drive your car 26,000 miles.

Trees remove gaseous pollutants by absorbing them through the pores in the leaf surface. *Particulates* are trapped and filtered by leaves, stems and twigs, and washed to the ground by rainfall.

Air pollutants injure trees by damaging their foliage and impairing the process of photosynthesis (food making). They also weaken trees making them more susceptible to other health problems such as insects and diseases.

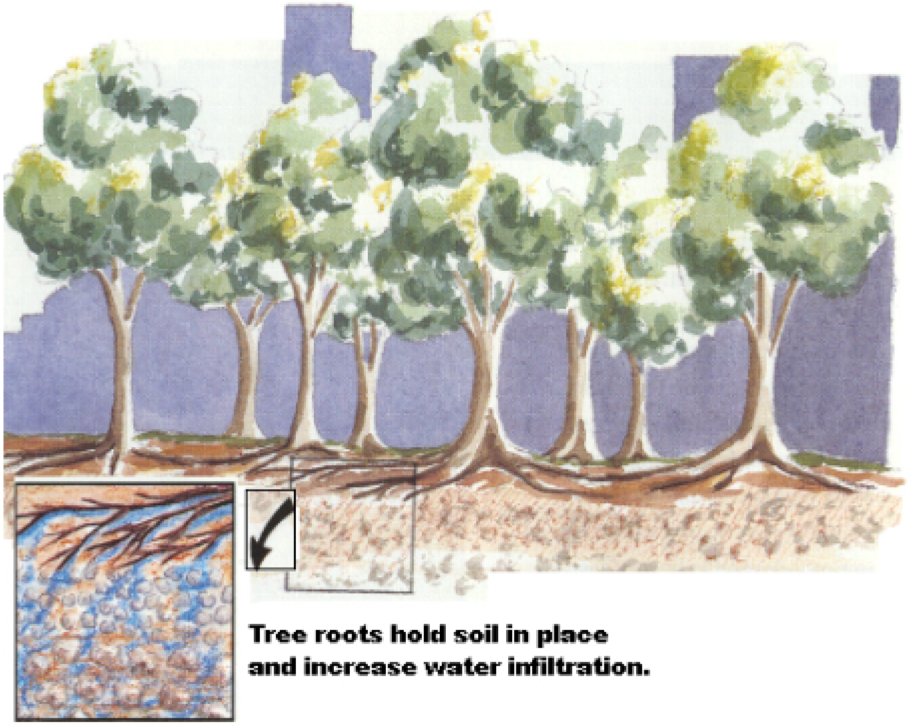
The loss of trees in our urban areas not only intensifies the urban "heat-island" effect from loss of shade and evaporation, but we lose a principal absorber of carbon dioxide and trapper of other air pollutants as well.



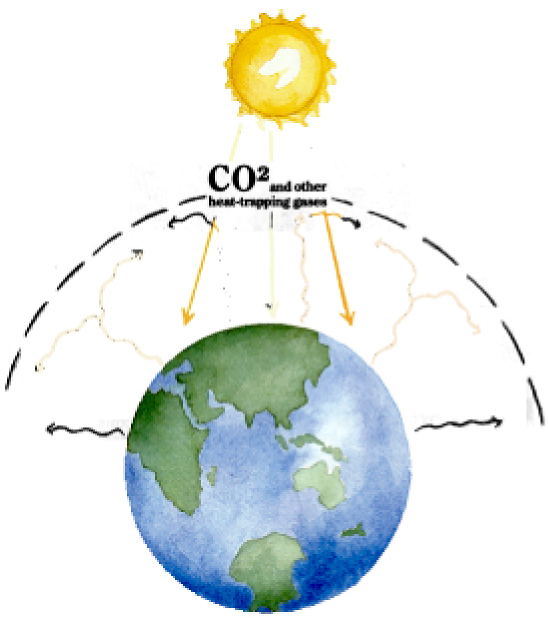
Some of the major air pollutants and their primary sources are:

POLLUTANT	MAJOR SOURCES
Carbon dioxide	Burning oil, coal, natural gas for energy. Decay and burning of tropical forests
Sulfur dioxide	Burning coal to generate electricity.
Hydrogen fluoride and silicon tetrafluoride	Aluminum and phosphate fertilizer production, oil refineries, and steel manufacturing.
Ozone	Chemical reactions of sunlight on automobile exhaust gases. Ozone is a major pollutant in smog.
Methane	Burning fossil fuels, livestock waste, landfills and rice production.
Nitrous oxides	Burning fossil fuels and automobile exhausts.
Chlorofluorocarbons	Air conditioners, refrigerators, industrial foam.

TREES FIGHT THE ATMOSPHERIC GREENHOUSE EFFECT



Tree roots hold soil in place and increase water infiltration.

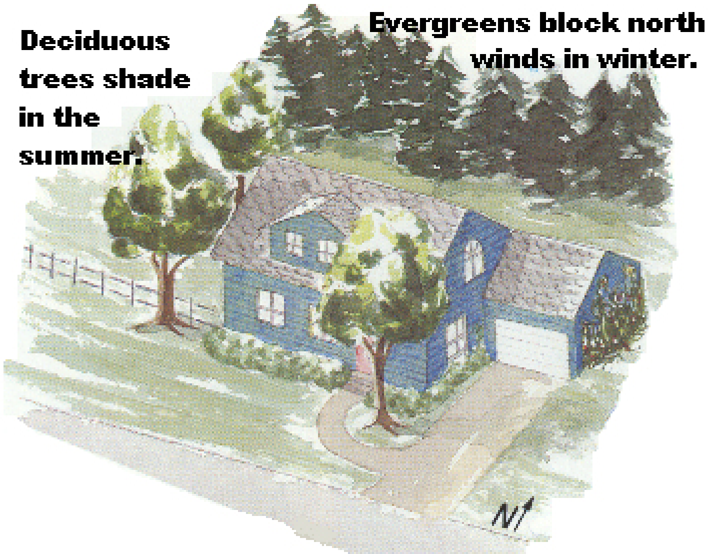


Heat from Earth is trapped in the atmosphere due to high levels of CO2 and other heat-trapping gases which prohibit it from releasing heat into space-creating a phenomenon known as the "greenhouse effect".

The greenhouse effect is created when heat from the sun enters the atmosphere and is prevented from radiating back into space by air-polluting gases. The buildup of about 40 heat-trapping gases is created mostly by human activities. Heat buildup threatens to raise global temperatures to levels unprecedented in human history. About half of the greenhouse effect is caused by CO_2.

Trees act as a carbon sink by removing the carbon from CO_2 and storing it as cellulose in the trunk while releasing the oxygen back into the air. A healthy tree stores about 13 pounds of carbon annually - or 2.6 tons per acre each year.

Trees also reduce the green-house effect by shading our homes and office buildings. This reduces air conditioning needs up to 30 percent, thereby reducing the amount of fossil fuels burned to produce electricity.



This combination of CO_2 removal from the atmosphere, carbon storage in wood, and the cooling effect makes trees a very efficient tool in fighting the greenhouse effect.

TREES CONSERVE WATER AND REDUCE SOIL EROSION
Trees create organic matter on the soil surface from their leaf litter. Their roots increase soil permeability. This results in:

- Reduced surface runoff of water from storms.
- Reduced soil erosion and sedimentation of streams.
- Increased ground water recharge that is significantly reduced by paving.
- Lesser amounts of chemicals transported to streams.
- Reduced wind erosion of soil.

Without trees, cities would need to increase sewage and storm water drainage channels and waste-treatment capacities to handle increased water runoff.

TREES SAVE ENERGY
Strategically placed trees can be as effective as other energy saving home improvements, such as insulation and the installation of weather-tight windows and doors. Trees can help reduce your heating and cooling costs.

Trees save energy through cooling in the hotter months. They provide a windbreak during winter. This results in burning less fossil fuels to generate electricity for cooling and heating.

Strategically placed shade trees-a minimum of three large trees around your home-can reduce air conditioning costs up to 30 percent. Shade trees offer their best benefits when you:

- Plant deciduous trees, which shed their leaves during winter. These trees provide shade and block heat from the sun during hotter months. By dropping their leaves in the fall they admit sun-light in the colder months.
- Place these trees on the south and west sides of buildings.
- Shade all hard surfaces such as driveways, patios and sidewalks to minimize landscape heat load.

Use evergreens, which retain their leaves/needles year-long, in a planned pattern. They will serve as *windbreaks* to save from 1Oto 50 percent in energy used for heating. Evergreens offer their best benefits when you:

- Place them to intercept and slow winter winds, usually on the north side of your home.
- Do not plant them on the south or west sides of your home, because they block warming sun-light during winter. These trees also provide some shading benefits during summer.

Get professional assistance to assure correct selection of species and their placement to maximize energy savings.

Hotter
More Glare
More Noise
More Water Runoff
More Energy Used
Harsh Landscape

Cooler
Less Glare
Absorbs Noise
Less Runoff
Less Energy
More Beautiful

TREES MODIFY LOCAL CLIMATE

Trees can help cool the "heat island"effect in our inner cities. These islands result from storage of thermal energy in concrete, steel and asphalt. Heat islands are 3 to 1O·degreeswarmer than the surrounding countryside. The collective effect of a large area of transpiring trees (evaporating water) reduces the air temperature in these areas.

Trees also:

- Lower air temperature through shade.
- Increase humidity in dry climates through evaporation of moisture.
- Reduce glare on sunny days.
- Reduce wind speed.

TREES INCREASE ECONOMIC STABILITY

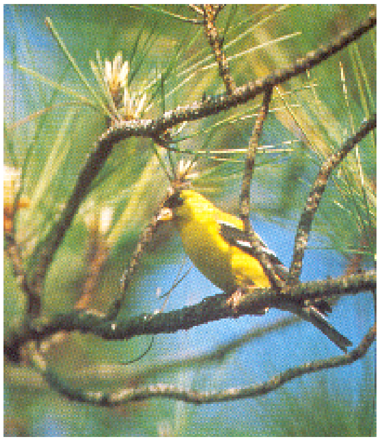
The scope and condition of a community's trees and, collectively, its urban forest, is usually the first impression a community projects to its visitors. Studies have shown that:

- Trees enhance community economic stability by attracting businesses and tourists.
- People linger and shop longer along tree-lined streets.
- Apartments and offices in wooded areas rent more quickly, have higher occupancy rates and tenants stay longer.
- Businesses leasing office space in wooded developments find their workers are more productive and absenteeism is reduced.

A community's urban forest is an extension of its pride and community spirit.

TREES REDUCE NOISE POLLUTION
Trees absorb and block noise from the urban environment

TREES CREATE WILDLIFE AND PLANT DIVERSITY
Trees and associated plants create local ecosystems that provide habitat and food for birds and animals. They offer suitable mini-climates for other plants that would otherwise be absent from urban areas. Biodiversity is an important part of urban forestry.



TREES INCREASE PROPERTY VALUES
We all know that property that is well landscaped with trees and other plants is more desirable than property sitting on a barren landscape. Studies have shown that:

- Healthy trees can add up to 15 percent to residential property value.
- Office and industrial space in a wooded setting is in more demand and is more valuable to sell or rent.

HELPING TREES AND YOUR URBAN FOREST

URBAN AND COMMUNITY FORESTRY PROGRAMS
Trees on public property belong to all of us. Proper management of this valuable resource is known as *urban and community* forestry. How is the urban forest in your community being cared for?

For more information on urban and community forestry, contact your nearest USDA Forest Service office or the SC Forestry Commission.

TREE CITY USA
One way you can get special recognition for urban forestry activities in your town is to apply for certification as a Tree City *USA.* Hundreds of cities and towns across the nation are achieving this status by meeting *Tree City USA* standards. Communities of any size can qualify, from less than one hundred to millions of people.

Write to the National Arbor Day Foundation, 100 Arbor Avenue, Nebraska City, NE 68410 or your State Forester *for* details on the Tree City USA program.

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it's the only thing that ever has."

- Margaret Mead

FOR ADDITIONAL INFORMATION

Contact the office listed below:

Sources of Assistance

USDA Forest Service
1720 Peachtree Road, NW
Atlanta, GA 30367-9102

SC Forestry Commission

Clemson Extension Service

USDA Forest Service - Southern Region
Southern Group of State Foresters
Cooperative Extension Service

Forestry Report RB-FR 17
April 1990

Cooling the greenhouse with bioenergy

D. O. Hall, H. E. Mynick and R. H. Williams

Global warming caused by burning fossil fuels could be reduced by the use of biomass for energy. This strategy could be more effective than sequestering carbon by growing more trees.

MOST proposals for reducing global warming have focused on the need to plant more trees in forest reserves, the idea being that carbon dioxide absorption would continue until the trees mature, say for 40–100 years. Although it is recognized that this is not a permanent solution, this 'carbon sequestration' strategy buys time to develop alternative energy sources. Little attention has been paid to another approach to combat global warming, that of substitution of energy derived from biomass for fossil-fuel energy[1]. If biomass is grown for energy, with the amount grown equal to that burned for a given period, there would be no net build-up of carbon dioxide in the atmosphere because the amount released in combustion would be compensated for by that absorbed by the biomass during photosynthesis. The potential for reducing carbon dioxide emissions in this way depends on the fuel displaced and on the efficiency with which energy can be produced.

Suppose that the conversion efficiencies are equal. Then a gigajoule (GJ) of biomass substituted for coal would reduce emissions by the carbon content of 1 GJ of coal, about 0.025 tonnes of carbon (tC). Because biomass, with a heating value of 20 GJ per tonne, is 50% carbon, growing 1 GJ of biomass sequesters 0.025 tC. Thus, substituting biomass for coal would be equivalent to carbon sequestration in its effect on atmospheric CO_2. Substituting biomass for petroleum or natural gas would be less effective than carbon sequestration, as these fuels contain less carbon per GJ. Although efficiencies for biomass with commercially available conversion technologies are typically less than for fossil fuels, development of energy-conversion technologies should improve this situation.

Modernization

Although little research and development has been committed to 'modernizing' biomass, there have been serious efforts to 'modernize' coal; much of this technology could be transferred to biomass strategies. The most promising near-term option involves adapting to biomass simplified integrated gasifier/combined-cycle (IGCC) technology (using gas turbines in combined cycles) being developed for power generation with coal[2]. This technology makes it possible to achieve, at the modest scales needed for biomass power generation, efficiencies higher than those for large coal steam-electric power plants. Biomass versions of this technology should involve lower unit capital cost, allowing it to compete with coal steam-electric power in many circumstances[3,4]. Biomass versions of simplified IGCC technology could be commercialized more quickly than the corresponding coal versions, because the latter require techniques for sulphur removal that are not yet commercially tested, whereas biomass contains negligible sulphur.

Although they are not competitive at today's low oil prices, synthetic fuels need to be developed to avoid overdependence on oil imports when prices rise once more. The technology for making methanol from biomass is similar to that being developed for coal, as are the conversion efficiencies. Methanol derived via thermochemical processes from biomass, as well as ethanol derived via enzymatic hydrolysis of lignocellulosic feedstocks, could be competitive with gasoline by the year 2000, if the necessary technologies are developed[5–7].

Although harvesting, transport and processing requirements make biomass for energy much more costly than growing trees to sequester carbon, energy sales revenues can be taken as a credit against cost. Because the prospects are good that biomass-derived electricity and liquid fuels can be produced competitively, the net cost of offsetting CO_2 emissions by substituting biomass energy for fossil fuels could often be near zero or even negative, and thus lower than the cost of offsetting CO_2 emissions by sequestering carbon in trees[1].

Biomass can play a larger role in reducing global warming when used to displace fossil fuel than when used for sequestration, in part because land can be used indefinitely in displacing fossil CO_2 emissions, whereas CO_2 removal ceases at forest maturity in the 'sequestration' strategy. Also, when biomass is produced for energy markets, producers will seek to maximize the harvestable annual yield rather than the total amount of carbon that can be sequestered in a mature forest. This goal shift will lead them to choose short-rotation woody or herbaceous crops, for which annual yields are 2–3 times as large as for long-rotation species[8–10]. Futhermore, herbaceous crops can often be grown at relatively high productivity on crop and pasture lands where the soil and climate conditions are not particularly favourable for growing trees.

Finally, when biomass is used as a fossil-fuel substitute, the land that can be used for biomass production is not restricted to new areas of land for planting 'energy' crops. Agricultural and forest residues that can be economically recovered and low-quality wood resources from existing forests, for example, are potential sources of biomass energy.

In many temperate-zone forests, annual removals of trees are much less than annual growth. Although much of the unharvested stock is too low in quality for traditional forest-products markets, it is well-suited for energy applications, and removal of the low-quality woodstock can simultaneously lead to enhanced yields of high-quality wood[11]. This increased productivity of high-quality wood in regrowth forests can help ease pressures to exploit original-growth forests, thereby allaying environmental concerns. In practice, the relative contributions to biomass energy — supply of residues, increased production from existing forests and plantation energy crops — will be determined by economics, availability of water and land resources, and constraints posed by environmental concerns.

Potential

The alternative global CO_2 emission projections advanced by the response strategies working group (RSWG) of the Intergovernmental Panel on Climate Change (IPCC)[12] provide a useful context in which to assess the potential for offsetting fossil CO_2 emissions with biomass energy. Global CO_2 emissions could be reduced to half the 1985 level by 2050 by supplementing the response measures of the RSWG "Scenario B" (involving a reversal of deforestation and emphasis of efficient energy use and natural gas) with biomass energy production sufficient to displace by 2050 5.4 Gt per year of carbon from fossil-fuel combustion[1]. This might plausibly be achieved by displacing coal with biomass — about one-third of which might come from various agricultural and industrial biomass residues and two-thirds from biomass plantations. Such residues are prime candidates for the first bioenergy systems. The required amount of plantation biomass might be achieved with 600 million hectares of plantations at an average productivity of 12 dry tonnes per ha per year.

This productivity is consistent with what has been achieved only at modest scales. But considering that the era of modern scientific silviculture began only around 1970[8], and that the growing of herbaceous crops for energy purposes is even more embryonic, this average productivity might plausibly be achieved on a large scale by the middle of the next century. For comparison, average productivities of wheat in the United Kingdom and maize in the United States have more than tripled since the mid-1940s; at present maize yields from 24 million hectares in the United States average 7.5 tonnes per ha per year of grain plus an equal quantity of residues[1]. The annual yield of sugar cane, averaged over 17 million hectares of cane harvested globally in 1987, was about 35 dry tonnes per ha per year of total above-ground harvestable plant matter. Moreover, the targeted productivity corresponds to a 0.4% efficiency for converting solar energy into recoverable biomass energy, which is low compared to the practical maximum photosynthetic efficiency under field conditions (5%)[13] and what has been attained under optimal field conditions (2.4% for Napier grass).

The land area targeted for biomass energy crops in 2050 is large, equivalent to 15 and 40% of the amount of land now in forests and croplands, respectively. Yet estimates of the amount of tropical land potentially available for reforestation are of the order of 800 million hectares[14]. Moreover, some of the 1,500 million hectares of tropical grasslands in the world could be used for energy crops such as perennial grasses; at present half this area is burned off each year[15]. Considerable land might also be available for energy crops in industrialized countries. In Europe, 15 million hectares of cropland or more would be taken out of production if agricultural surpluses and European Community expenditures on agricultural subsidies were bought under control[9]. In the United States, 30 million hectares of cropland are left idle to reduce production or conserve land; this area could double over the next 25 years. Such considerations suggest that the productivities and land areas associated with this biomass energy scheme are plausible, though ambitious.

The chief uncertainty about the development of biomass for large-scale energy production is whether high productivities can be achieved sustainably over wide areas without damaging the environment. One concern of environmentalists is that biomass energy will reduce biological diversity[16]. Certainly, if monoculture biomass plantations were to replace old-growth natural forests there would be substantial loss of biodiversity. But plantations could be established on deforested or degraded lands, and short-rotation tree crops and various perennial grasses would be an improvement on annual row-crop agriculture.

Experiments in Sweden have shown that in most forests trees grow at rates far below their potential and that nutrient availability is often the most important limiting factor. Under nutrient-optimized conditions all tree species investigated have achieved about the same total biomass yield per unit of light intercepted during the growing season[17]. Thus, growing trees under nutrient-optimized conditions could make it possible to achieve high yields with existing species and clones, facilitating the incorporation of pest resistance and other desirable characteristics, and the maintenance of a diverse landscape mosaic. Nutrient-induced yield increases can be achieved without nutrient leaching when good forest management is practiced. But achieving sustainable high yields this way requires matching nutrient applications to the varying need for nutrients[17,18].

At present, monocultures are favoured for energy crops, in large part because management techniques are being adapted from monocultural systems for agriculture. Achieving sustainable production and maintaining biological diversity may require polycultural strategies (for example, mixed species with various planting configurations and harvesting methods) for biomass production in many areas.

The nutrient status of afforested lands might be maintained both by recycling nutrients and by choosing suitable mixed species and clones[19]. The promise of the latter is suggested by 10-year trials in Hawaii, where yields of 25 dry tonnes per ha per year have been achieved without nitrogen fertilizer when *Eucalyptus* is interplanted with nitrogen-fixing *Albizia* trees[20].

Achieving high levels of biological diversity requires maintaining some land in a natural condition. Experience in Sweden suggests that maintaining a modest fraction of forest area in reserves is adequate for this purpose. But research is needed to find out how best to achieve desirable levels of biological diversity under the wide range of conditions where biomass might be grown for energy.

Conclusions

In conclusion, the growing of biomass for energy provided by modern energy-conversion systems would enable biomass to play much wider roles in coping with greenhouse warming than is possible with the growing of trees solely for carbon sequestration. Although carbon-sequestering strategies will be important where the biomass cannot be practically harvested for energy, or where the creation of new forest reserves is deemed desirable for environmental or economic reasons, biomass energy strategies will usually be preferred. Moreover, as biomass energy should often be cheaper than fossil-fuel energy, these strategies will be easier to implement than many other proposed strategies for reducing greenhouse warming.

Bioenergy industries have already been launched in several countries. Nevertheless the techniques and technologies for growing biomass and converting it into modern energy carriers must be more fully developed. If the research and development needed on sustainable production and conversion of biomass is given high priority, and if policies are adopted to nurture the development of bioenergy industries, these industries will be able to innovate and diversity as they grow and mature. □

D. O. Hall is in the Division of Biosphere Sciences, King's College, Campden Hill Road, London W8 7AH, UK. H. E. Mynick and R. H. Williams are at the Center for Energy and Environmental Studies, Princeton University, Princeton, New Jersey 08544, USA.

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WOODY BIOMASS USDA FOREST SERVICE OVERVIEW

University of Tennessee April 24, 2006

Marcia Patton-Mallory, PhD National Woody Biomass and Bioenergy Coordinator Office of the Chief, USDA Forest Service

Legislation and Policy Framework

• Biomass Research and Development Act of 2000- resulting in MOU between US Department of

Agriculture (USDA), US Department of the Interior (USDI) and Department of the Environment (DOE) .

www.bioproducts-bioenergy.gov

• National Fire Plan and 10-year Implementation Plan (2001)
• Healthy Forests Restoration Act of 2003
• Energy Policy Act of 2005

Context-why should we care?

• Energy costs and Energy Security
• State renewable energy portfolios (RPS)
• Greenhouse Gases
• Sustainability issues surrounding communities and forests
• Condition of forest resources
• Globalization of forest products industry

Types of Woody Biomass

• Logging residues
• Fuels and restoration treatments
• Wastes from processing and urban trees
• Conventional product extraction
• Commercial thinnings
• Short rotation woody crops
• Agroforestry

Energy from Biomass-today

Buildings

• Fuels for heating schools and community
• Wood pellets for heating homes
• Co-firing of wood with coal (w/renewable energy credits)
• Biomass power plants (w/renewable energy credits)

• Biomass waste to energy at wood products manufacturing facilities

Is economical only when part of a more integrated forest restoration or hazardous fuels portfolio of business enterprises.

Energy from Biomass-tomorrow

• Liquid fuels, pellet and chip fuels
• Distributed heat and power
• Co-firing of wood with coal at power plants (w/carbon credits)
• Biomass power plants (w/carbon credits)
• Chemicals and products from biomass substitute for fossil fuel products

Integrated biorefineries and small diversity of products from small diameter materials

Woody Biomass Potential

• Woody Biomass Potential: 368 million tons Annually (Billion Ton Repo rt).

Biomass for Energy and Biobased Products

• Reduce imports and secure energy for future, "Home Grown"
• Becoming cost competitive, especially real cost of imported oil
• Renewable and better for the environment
• Only Carbon (C)-based renewable for transport fuels

Energy, the Environment, and the Economy

• Emerging theme for natural resource and biomass management
• Need to address collectively in science and policy

Renewable Energy Goals

• DOE/USDA Biomass Advisory Committee - 30% displacement *of* current petroleum consumption by 2030
• 25x'25 - Working lands will provide 25% of Nation's energy from renewables by 2025
• 2006 State of the Union Address - 75% replacement *of* our oil imports from the Middle East by 2025

Renewables Portfolio Standards

Goal

*PA: 18%[1] by 2020

[1] PA: 8% Tier I, 10% Tier II (includes non-renewable sources)

*NJ: 6.5% by 2008
CT: 10% by 2010
MA: 4% by 2009 + 1% annual increase
WI: 2.2% by 2011
IA: 105 MW
MN: 1,125 MW wind by 2010
TX: 5,880 MW by 2015
*NM: 10% by 2011
*AZ: 1.1% by 2007
CA: 20% by 2010
*NV: 20% by 2015
ME: 30% by 2000
***MD: 7.5% by 2019**
HI: 20% by 2020
RI: 15% by 2020
*CO: 10% by 2015
*DC: 11% by 2022
NY: 25% by 2013
MT: 15% by 2015
*DE: 10% by 2019

***Minimum requirement and/or increased credit for solar**

DSIRE: www.dsireusa.org

Forests Help Mitigate Greenhouse Gas Emissions

- **Remove CO2**
  - 200 million tons/yr C
  - 10% of U.S. fossil

- **Increase fuel emissions sequestration rate**
  - Plant more trees
  - Maintain healthy forests
  - Manage productivity
  - Residue management

Biomass Management and Use

- **...and forest products**

- Biomass energy offsets
- Use more wood

Hazardous fuels and Forest Restoration Treatments that have biomass utilization as an integrated goal also contribute to:

- Jobs and sustainability for rural communities
  - Stabilizing greenhouse gas emissions- using burning only where ecologically necessary

- Reducing cost of hazardous fuels treatments
- Contributing to renewable energy and carbon sequestration

Vision and Goals for the Implementation Plan of the Woody Biomass MOU-USDA, DOI, and DOE

Preamble: The Secretaries support the utilization of woody biomass by-products from restoration and fuels treatment projects wherever ecologically and onomically appropriate and in accordance with the law.

Vision: Ecologically and economically sustainable woody biomass utilization will result in more diverse forest, woodland, and rangeland ecosystems - characterized by native flora and fauna, healthy watersheds, better air quality, improved scenic qualities, resilience to natural disturbances, and reduced wildfire threats to communities -
and provide an alternative waste management strategy contributing to rural economic vitality and national energy security.

Draft Goals of Woody Biomass Utilization – Inter-Agency Strategy

1. Reduce Forest restoration cost and increase the use of woody biomass as a renewable energy resource through environmentally sound actions, which also provide economic opportunity in rural communities

2. Risk of catastrophic fires is reduced through adoption of wide-spread woody biomass utilization practices.

3. Provide a sustainable and reliable supply of woody biomass from forests, woodlands and rangelands across a range of ownerships and regions of the nation.

4. Develop and implement consistent and complementary policies and procedures will maximize Federal efficiency and effectiveness of woody biomass utilization.

5. At-risk forest, woodland, and rangeland ecosystems are restored to healthy and resilient conditions.

6. Communities develop sustainable, living wage jobs and appropriately-scaled industries.

7. National security is enhanced through clean, renewable, diversified energy production.
8. Contribute to the stabilization of greenhouse gas concentrations.
9. Appropriate technologies are developed and applied and technology transfer is provided to stakeholders.

10. Biomass currently directed to landfills is substantially diverted to higher value use.

Roles of the Forest Service

National Forest System

-Developing management prescriptions
-Implementing stewardship contracts
-Overseeing forest restoration activities

State & Private Forestry

-Providing technical and financial assistance to businesses and communities
-Developing partnerships and community fire plans
-Managing fire prevention and suppression activities

Research & Development

-Developing new assessment, management, harvesting and conversion technologies and tools

-Creating innovative biobased products and biofuels
-Assessing ecological and economic impacts

Opportunities for R&D: Biobased Products and Bioenergy Emphasis Products and Bioenergy Emphasis Areas

• Small diameter timber utilization
• Ethanol conversion from wood
• Short rotation woody cropping systems
• Wood waste from landfills to value-added products
• Environmentally benign harvest and improved delivery systems
• Renewable energy systems
• New wood processing technology
• New silviculture management methods for feedstock production
• Sustainable products and markets

Environmental Values For Heat and Power

- Less pollutants
- Less CO2 emissions

For Transportation
Fuels Reformulated gasoline vs. ethanol (E85)
- 18% to 72% less GHG
- 32% to 81% less carbon dioxide (CO2)
- The same or 58% less methane (CH4)

Ancillary Resource Values

- **Less fire and pest damage**

  - Less smoke and emissions
  - Less erosion from catastrophic events

- **More productive forests**

  - Improved watersheds demand on resources
  - Better air quality
  - Diverse habitat

Other Values

- Less waste and reduced
- Less landfill space

"Biofuels represent an opportunity for a large share of the billions of dollars flowing to the Mideast to instead roll towards the Midwest, South and other farm belts. When farm fields replace drill fields and agricultural America becomes a net energy exporter, new revenue flows will reach farmers, and biofuels plant owners and The New Harvest" – The Energy Foundation 2005

Working With States

- Successful biomass utilization requires strong local leadership, and a mechanism for bringing the private and local communities interests together with the needs tor health forests and community wildfire protection.
- Sustainable supply of woody biomass from multiple sources (federal, private, state and tribal lands) reduced the risk of private investments.
- Long term and large scale planning are needed to attract new business investments where the forest products industry has been lost.

The Challenges

SUPPLY SIDE ISSUES

- Millions of acres needing treatment
- Treatment needs not matched to utilization facilities
- Little or no harvest/transport infrastructure
- High harvest and transport costs
- Predictability/Reliability of supply
- Sustainability and environmental concerns

DEMAND SIDE ISSUES

- Marginal economic returns
- Fluctuating markets & prices
- Few markets and little infrastructure
- Conversion technologies

INSTITUTIONAL ISSUES

- Conflicting priorities, missions, cultures, policies, etc.
- No comprehensive strategy or coordination
- Public concerns over tree removals
- Competition among products and sectors
- Community engagement

Appendix 1

Web links for further information: (This is not required reading. These sites are provided for those who wish to investigate further regarding alternative or traditional energy sources)

General:

U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy
www.eere.energy.gov

The Alternative Energy Institute
www.altenergy.org

U.S. Environmental Protection Agency, Green Communities website and links to many other websites: www.epa.gov/greenkiVq5_energ.htm

U.S. Energy Information Administration, website:
www.eia.doe.gov

National Renewable Energy Laboratory
www.nrel.gov

New York state energy Research and Development Authority
www.nypa.gov/es.htm

Business Council for Sustainable Energy
www.bcse.org

Energy Info Administration (official energy stats from Federal Gvt.)
www.eia.doe.gov/fuelrenewable.html

National Clean Cities, all alternative fuels:
http://www.nationalcleancities.org/

Solar Power:

U.S. Department *of* Energy's Office of Energy Efficiency and Renewable Energy- Solar Energy
www.eere.energy.gov/RE/solar.html

Kyocera Solar, Inc., solar systems manufacturer, www.trianglesystems.com 126 Ideaho Avenue, Plattsburge, NY 12930

International Solar Energy Society
www.ises.org

American Solar Energy Society
www.ases.org

Wind Power:

Clean Energy Partnership
cleanenergypartnership.org

New York State Energy Research and Development Authority, Community Resources for Wind Development
www.powernaturally.com/programs/Wind/toolkit.asp

U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy Wind power
www.eere.energy.gov/RE/wind.html

Green Power Network
www.eere.energy.gov/greenpower

American Wind Energy Association
www.awea.org

Canadian Wind Energy Association
www.canwea.ca

Ethanol:

This website has a wonderful ethanol curriculum guide with student activities, fact sheets, etc.
http://www.ethanolrfa.org/resoureeleducation/curriculum/

Detailed description of how ethanol is made
www.ethanol.rfa.org/resource/made/

One stop shop for industry based information:
http://ethanolfacts.com/

Ethanol Producer magazine:
http://info@ethanolproducer.com/

Grassroots organization website:
http://www.ethanol.org/index.htm

Biofuels:

National Biodiesel Board
www.biodiesel.org

United States Department of Energy Biomass Program
www.eere.energy.gov/biomass

Biodiesel fact sheets-
www.biodiesel.org

www .nbb.org

USDA research info site
http://www.ars.usda.gov/Research/Research.him?modecode=19-35-00-00

Geothermal Energy:

U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy - Geothermal Energy
www.eere.energy.gov/RE/geothermal.html

Hydropower:

U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy - Hydropower
www.eere.energy.gov/RE/hydropower.html

Hydrogen power, Fuel Cells:

U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy-Hydrogen power
www.eere.energy.gov/RE/hydrogen.html

Oceans:

U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy - ocean energy
www.eere.energy.gov/RE/ocean.html

Biomass Energy:

U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy-BioPower Program
www.eere.energy.gov/RE/biomass.html

more on Biomass and cellulostic energy:
http://www.acore.org/

http://www.harveste nergy.com/BioMass.html#

Alternative Fuel Vehicles:

Advanced Transportation Technology Institute
www.etvi.org

Alternative Fuels Data Center
www.afdc.doe.gov

Electric Auto Association
www.eaaev.org

Natural Gas Vehicle Association
www.ngvc.org

Appendix 2
Canon Current Issue Information

RATIONALE

Decisions about the production and use of energy are critical issues of environmental, economic and social policies and of individual choice. Decisions about sources and uses of energy are made not only in the halls of national and local governments, and in corporate boardrooms, but in private homes and individual minds. The environmental, economic and social outcomes of these choices will shape the future of our nation and our planet.

Efficient use of energy generated from traditional sources and the development of renewable energy resources are two aspects of energy policy currently the focus of extensive research by state and federal government agencies, academic institutions and private companies. The fund of knowledge is great, continues to grow, and offers a wealth of resources for an Envirothon competition.

The present generation of high school students will be asked to make difficult decisions about energy both in matters of public environmental and economic policy and in matters of personal choices. Providing a structure and materials for intensive investigation into energy resources and alternatives would be a service to those students and their schools.

Sustainable, renewable energy is a crucial and intrinsic element of sustainable development. Until energy needs are met by affordable, environmentally sound means, sustainable development efforts will be greatly hampered.

LEARNING OBJECTIVES: CURRENT ISSUE

GOAL

Students will comprehend long term and short term environmental, social, and economic considerations of energy production and usage.

ACTIVITIES

• Students will research, compare and contrast traditional and emerging energy production resources and applications; focusing on the environmental implications of such production.

• Students will relate energy systems to corresponding natural resources in New York State.

• Students will identify the organizations (and their roles) and the processes involved in making energy decisions in New York and globally.

• Students will describe the interactions among society, technology, and use of energy sources.

- Students will identify technologies created as a result of society's concern for dwindling non-renewable energy resources (e.g., electric cars, biodiesel).

OUTCOMES:
Students will be able to evaluate appropriate energy resource choices for a specific application.

UNDERSTANDINGS AND TOPICS OF INVESTIGATION: TASKS

I Traditional energy uses and production

1. Identify and understand the traditional sources of energy generation of:
   A. Electricity
      1. hydropower
      2. fossil fuel
      3. nuclear energy
   B. Natural gas
   C. Fossil fuels (vehicles)

2. Assess environmental impacts of the above
   A. Consumption of resources
   B. By- products (emissions/ waste)
   C. Impacts on ecosystems

3. Assess social and economic factors and implications:
   A. Infrastructure

   B. Environmental justice
   C. Conservation practices
   D. Organizations and agencies active in energy policy decision making
   E. Design of energy distribution systems

11 Emerging energy technologies
1. Identify and understand sources and applications of renewable energy
   A. Solar
   B. Wind generation
   C. Biomass
   D. Geothermal
   E. Hydrogen
   F. Ocean (Tidal) generation
   G. Ethanol/Methanol/methane
2. Assess the environmental impacts of the above.

A. Consumption of resources
B. By- products (emissions/ waste)
C. Impacts on surrounding ecosystems

3. Assess social and economic factors and implications of the above:
   A. Infrastructure
   B. Environmental justice
   C. Conservation practices
   D. Organizations and agencies active in energy policy decision making
   E. Design of energy distribution systems

III Energy Issues Related to other Canon Envirothon Study Areas:

1. Soils:
   A. Identify and understand issues of traditional and innovative energy sources related to
      1. agricultural and forested lands
      2. soil erosion control
2. Aquatics:
   A. Identify and understand issues of traditional and innovative energy sources related to:
      1. fish habitat and reproduction
      2. changes in flow rates and water levels
      3. biodiversity
      4. groundwater/aquifer resources

3. Forestry:
   A. Identify and understand issues *of* traditional and innovative energy sources related to:
      1. biofuels
      2. species diversity - plant and animal
      3. pests and pesticides
      4. forest management practices

4. Wildlife:
   A. Identify and understand issues *of* traditional and innovative energy sources to:
      1. migratory bird flyways
      2. habitat loss/degradation