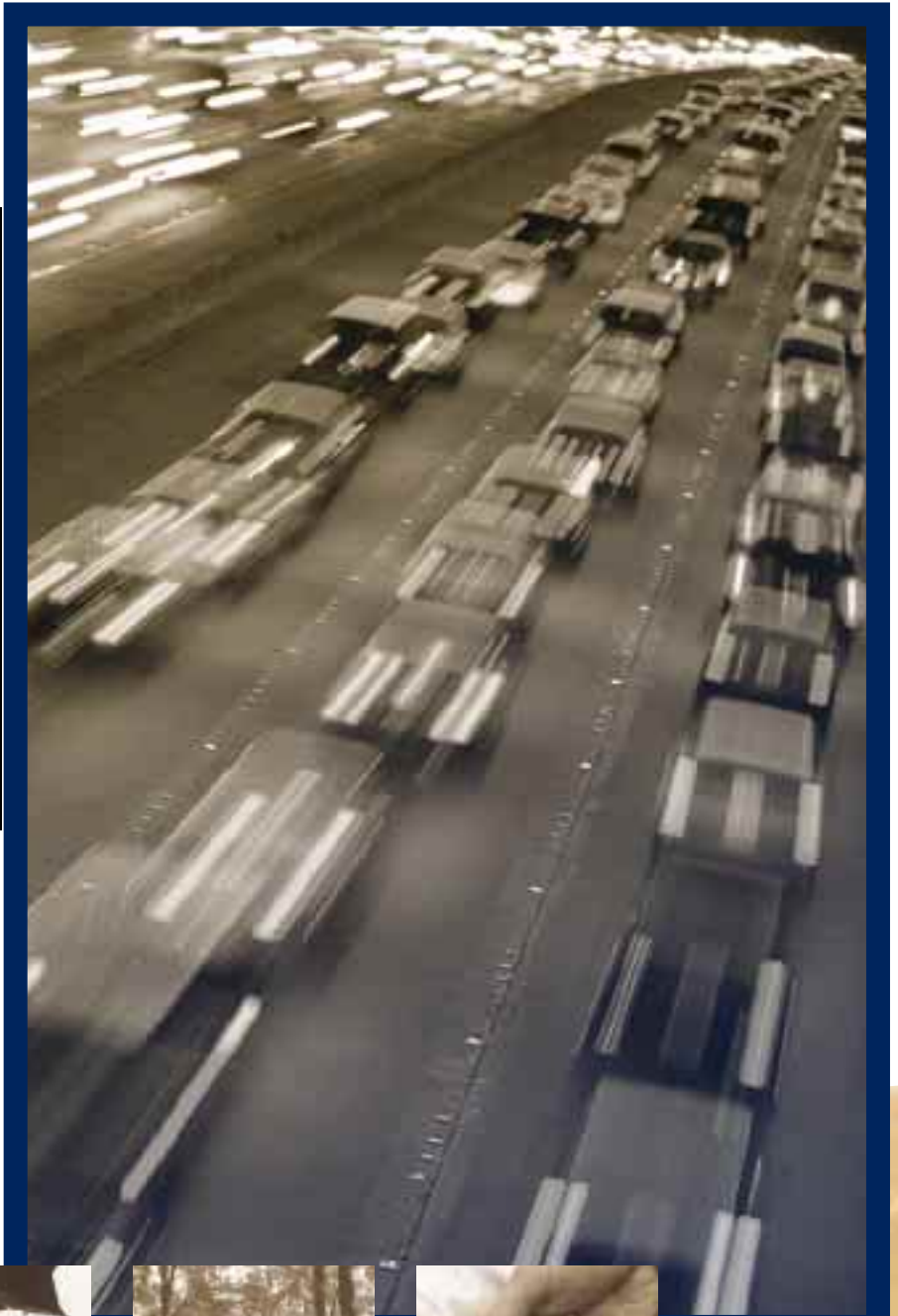
 **Biofuels**

for Sustainable Transportation

sustainable transportation fuel:

- an inexhaustible fuel supply...
- fuel that doesn't harm the environment...
- domestically produced fuel.



biomass:

- abundant, renewable, domestically grown source of energy that can be converted into transportation fuel.

Sustainable fuels made from biomass

The word *biomass* refers to all the Earth's vegetation and many products and coproducts that come from it. Biomass is the oldest known source of renewable energy—humans have been using it since we discovered fire—and it has high energy content. Domestic biomass resources include agricultural and forestry residues, municipal solid wastes, industrial wastes, and terrestrial and aquatic crops grown solely for energy purposes.

Biomass is an attractive energy source for a number of reasons. First, it is renewable as long as it is properly managed. It is also more evenly distributed over the Earth's surface than are finite energy sources, and may be exploited using more environmentally friendly technologies. Biomass provides the opportunity for increased local, regional, and national energy self-sufficiency across the globe.

The energy in biomass can be accessed by turning the raw materials, or feedstocks, into a usable form. Transportation fuels are made from biomass through biochemical or thermochemical processes. Known as biofuels, these include ethanol, methanol, biodiesel, biocrude, and methane.

biofuels:

- sustainable transportation fuel made from biomass.

Ethanol is the most widely used biofuel today. In the United States each year, more than 1.5 billion gallons are added to gasoline as an oxygenate, to improve vehicle performance and reduce air pollution. Ethanol is an alcohol, and most is made using a process similar to brewing beer, in which starch crops are fermented into ethanol, which is then distilled into its final form. Ethanol made from cellulosic biomass materials instead of traditional feedstocks (starch crops) is called bioethanol. Ethanol can be used in its pure form (neat), as a blend with gasoline, or as a fuel for fuel cells.

Methanol is also an alcohol that can be used as a transportation fuel. U.S. industry produces approximately 1.2 billion gallons of methanol annually, 38% of which is used in the transportation sector. Currently produced using natural gas, methanol can be produced from biomass through a two-step thermochemical process. First the biomass is gasified to produce hydrogen and carbon monoxide. These gases are then reacted to produce methanol. Methanol can be used in its pure form (neat), as a feedstock for the gasoline additive methyl tertiary butyl ether (MTBE), or as fuel for fuel cells.

Biodiesel is a renewable diesel fuel substitute that can be made by chemically combining any natural oil or fat with an alcohol (usually methanol). Many vegetable oils, animal fats, and recycled cooking greases can be transformed into biodiesel and there are many different ways to do it. Biodiesel can be used neat or as a diesel additive and is typically used as a fuel additive in 20% blends (B20) with petroleum diesel in compression ignition (diesel) engines. Other blend levels can be used depending on the cost of the fuel and the desired benefits.

Biocrude is a product similar to petroleum crude and can be produced from biomass using a fast pyrolysis process. Biocrude is formed when the biomass-derived oil vapors are condensed. Catalytic cracking then converts biocrude into transportation fuels.

Methane is the major component of compressed natural gas—an alternative transportation fuel, of which approximately 100 million gallons will be sold in the United States in 2000. Methane, in a blend of other gases, can be produced from biomass by a biochemical process called anaerobic digestion.



The need for biofuels

Several compelling issues drive a national effort to develop and improve technology to make biofuels. Our dependence on petroleum for fueling the transportation sector threatens our energy security, affects our environment, and weakens our economy. Developing the technology to produce and use biofuels will create transportation fuel options that can positively impact these issues and establish safe, clean, sustainable alternatives to petroleum.

■ Biofuels for U.S. Energy Security

Perhaps the most important issue surrounding the status of our transportation fuel is that no one knows how long the world's petroleum resources will last. Adding to our country's vulnerability, our limited domestic petroleum resources do not meet our energy needs. The Persian Gulf region holds nearly two-thirds of the world's known oil reserves, and the United States imports more than 53% of its petroleum—much of it from the Persian Gulf. The U.S. Department of Energy estimates that this will increase to 75% by the year 2010. In 1990, Congress voted that a dependence on foreign oil of more than 50% should be considered a peril point for the United States. Members of Congress recognize that high levels of imported oil leave our country defenseless against sudden severe energy disruptions that could capsize our economy. Producing and using fuels from renewable, domestic biomass resources can help ease our dependence on foreign oil imports and reduce our vulnerability to severe energy disruptions.

■ Biofuels for the U.S. Economy

Oil imports account for almost half the U.S. trade deficit, which has an enormous impact on our economy and the creation of new jobs. A high trade imbalance from dependence on foreign oil also leaves our economy vulnerable to price hikes from supply disruptions. Developing a stronger market for domestically produced biofuels in the United States will help alleviate the negative implications of our trade deficit and contribute to positive economic trends in the U.S. transportation sector.

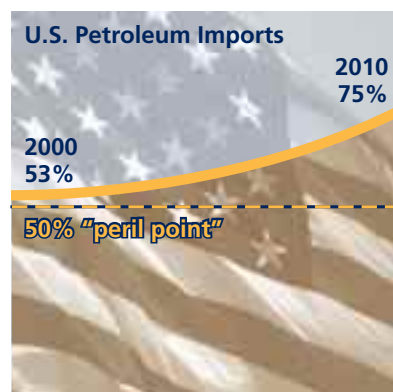
Currently, the ethanol industry is responsible for approximately 200,000 jobs. Between 1996 and 2000, the ethanol industry added approximately \$51 billion to the U.S. economy. Ethanol production creates domestic jobs in plant construction, operation, maintenance, and support in the surrounding communities. This can have a profound impact on rural America, where a decline in employment has placed increasing burdens on our cities, infrastructure, and tax base.



Transportation is a major contributor to a number of environmental problems, primarily because of our dependence on fossil fuels.



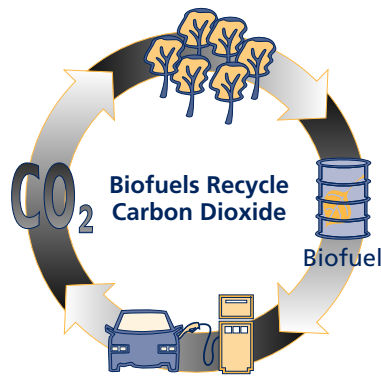
Production of biofuels will create new job opportunities for rural Americans as well as a new market for crops and agricultural by-products.



By 2010, oil imports are projected to rise to 75% of the total U.S. supply. Biofuels can help reduce our use of foreign oil.

Agricultural residues and crops grown for producing energy are major feedstock sources for biofuels.

During photosynthesis—the process used by plants to grow—carbon dioxide is absorbed from the atmosphere. The carbon that is absorbed is the major component of the biomass.



The carbon dioxide released by the combustion of biofuels is recycled, thereby reducing greenhouse gas buildup from fossil fuel emissions.

■ Biofuels for the Environment

The transportation sector of our country is a major contributor to a number of environmental problems, primarily because of our dependence on fossil fuels. From their extraction through their use in automobiles, many steps of the process either are or can be detrimental to our environment. Producing and using biofuels for transportation offers alternatives to fossil fuels that can help provide solutions to many environmental problems.

Biofuels and Global Climate Change

The U.S. transportation sector is responsible for one-third of our country's carbon dioxide (CO₂) emissions. CO₂ is considered to be a greenhouse gas, the buildup of which may lead to global climate change. These emissions result from burning nonrenewable fossil fuels, which releases their carbon content into the atmosphere as CO₂. Producing and using biofuels for transportation can help reduce CO₂ buildup significantly. By displacing the use of fossil fuels, the emissions resulting from fossil fuels use are avoided, and the CO₂ content of fossil fuels is allowed to remain in storage. Further reductions occur because the plants and trees that serve as feedstocks for biofuels require CO₂ to grow, and they absorb what they need from the atmosphere.

Biofuels and Air Quality

Over the past two decades, our nation has made great strides in improving air quality in our most polluted urban areas. Biofuels such as ethanol have been used very successfully as an oxygenate additive in gasoline to reduce emissions from older, high-polluting vehicles. In the future, as biofuels come to the forefront as replacements for gasoline, we anticipate further improvements in air quality, whether these fuels are used in conventional internal combustion engines or in new, clean vehicle technologies such as fuel cells.

Biofuels and Water Quality

Water pollution associated with gasoline includes marine oil spills, groundwater contamination from underground gasoline storage tanks, and runoff resulting from fuel spills. Biofuels can replace the most toxic parts of gasoline with fuels that quickly biodegrade in water, reducing the threat that gasoline poses to waterways and groundwater. Spills or leaks of biofuels do not constitute an environmental hazard.



Biofuels help improve the air quality of our cities, pose no threat to water resources, and will help alleviate solid waste disposal issues.



Biofuels and Waste Disposal

Almost half the landfills in the United States are close to capacity and are expected to close in the near future. To make matters worse, the rate at which we produce waste continues to increase. Disposal costs increase as available landfill space decreases. In addition, some segments of the agricultural and forest products industries produce huge amounts of waste each year. Much of the waste we produce is made of lignocellulosic material that can be converted to biofuels. This form of recycling could help relieve our growing waste problem, while at the same time replace a portion of our fossil fuel usage.



Research is focused on improving biomass conversion technology to lower costs and enable the establishment of a major biofuels industry.



Biofuels on the market

Currently, ethanol and biodiesel are commercially available. Ethanol made from starch crops is available around the country and is commonly used as a fuel oxygenate. Biodiesel is being used by some municipal fleets around the country and privately in situations where petroleum diesel is detrimental. As knowledge of the economic, energy security, and environmental benefits of biofuels spread through our country, demand for these sustainable fuels will increase. To meet the demand and provide fuels that are competitive with petroleum fuels, national research focuses on improving technology for converting biomass to fuels. This will decrease costs, and increase the kinds of biomass that can be converted to fuels, allowing for a sustainable supply of resources from which to make fuel.

The U.S. Department of Energy leads the National Biofuels Program. The Program strives to realize the large-scale use of environmentally sound, cost-competitive, biomass-based transportation fuels by adopting and commercializing the best technologies. To accomplish this, the Program works with industry to research, develop, demonstrate, and facilitate the commercialization of U.S. technologies to develop clean fuels for transportation, leading to the establishment of a major biofuels industry.

The National Biofuels Program works to develop the best technologies in order to establish a major biofuels industry.

For more information, visit the
National Biofuels Program's web site at
www.ott.doe.gov/biofuels



Produced for the U.S. Department of Energy (DOE) by the
National Renewable Energy laboratory, a DOE national laboratory.

DOE/GO-102000-0812 • June 2000



Printed with a renewable-source ink on paper containing at least
50% wastepaper, including 20% postconsumer waste.