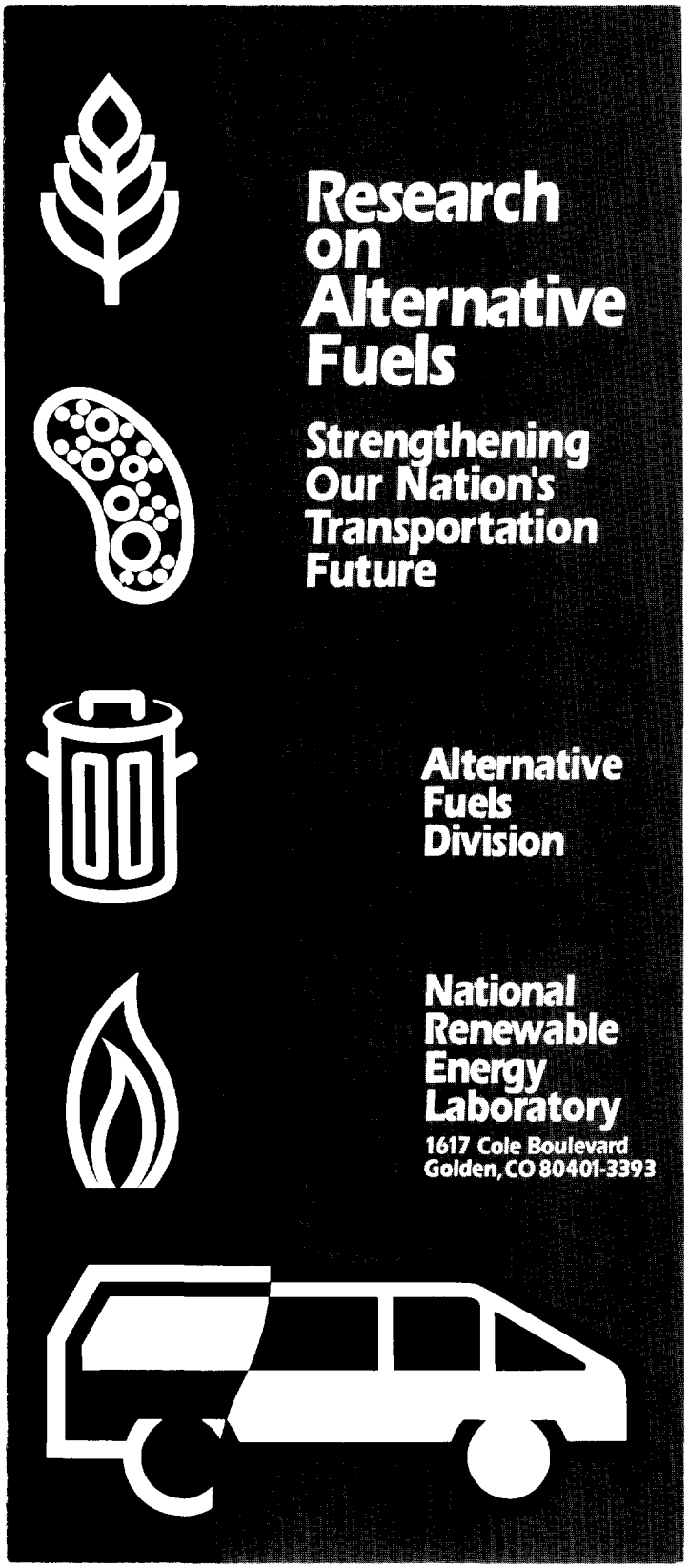
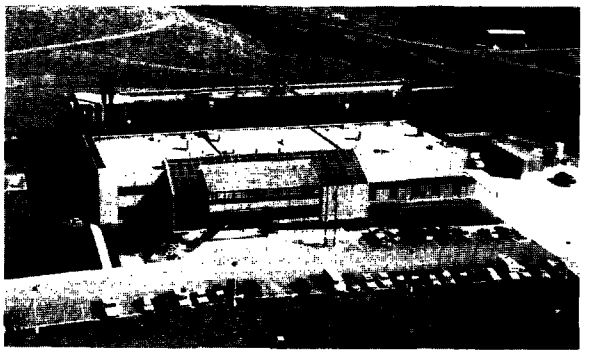

Research on Alternative Fuels
Strengthening Our Nation's Transportation Future
Alternative Fuels Division
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO 80401-3393

In the Alternative Fuels Division (AFD) of the National Renewable Energy Laboratory (NREL), we are developing ways to convert renewable resources such as trees, grasses, and wastes to alternative transportation fuels and oxygenates such as ethanol and methanol. We are also improving engine systems to increase the efficiency of utilization of a wide range of alternative fuels while minimizing air pollution. By developing these technologies that use our nation's abundant resources, we can reduce our dependence on imported petroleum, improve the quality of our air, mitigate global warming, and strengthen our farm economy.

The AFD houses a talented team of scientists and engineers trained in a wide variety of scientific, engineering, and analytical disciplines, working in state-of-the-art laboratories. And our collaborations with colleagues in industry and academia allow us to facilitate both technology development and quick transfer of new technologies to industry.



The Field Test Laboratory Building on NREL's permanent site houses fully equipped modern laboratories for alternative fuels research.

AFD researchers focus on the production of transportation fuels from biomass, or **biofuels**, and on the use of alternative fuels for transportation, or **utilization**.

Biofuels

Through biochemical and thermochemical processes, biomass such as agricultural and

forestry residues, trees, grasses, municipal solid waste (MSW), and algae can be converted to alcohol fuels and hydrocarbons, or to methane as a substitute for natural gas. The use of biofuels contributes little if any net carbon dioxide, a major greenhouse gas, to the atmosphere. Sufficient biomass could be available in the United States to produce enough biofuels to displace all gasoline now used in this country. Our research currently focuses on novel technologies for producing the liquid and gaseous fuels described below.

Ethanol. Ethanol is a high-octane, clean-burning fuel that can reduce urban air pollution. Ethanol can be used neat (or "pure"), in a direct blend with conventional gasoline, or as an ether derivative. We have focused on an enzymatic process, simultaneous saccharification and fermentation (SSF), as the most promising option for low-cost fuel ethanol production in the near future.

The biomass is first pretreated to open its structure to enzymatic attack. Then enzymes and yeast are added in the same vessel to minimize process costs. The enzymes break down the cellulose in the biomass to sugars; the yeast ferments these sugars to ethanol. With a process built around SSF technology, we have reduced the cost of ethanol significantly, from $3.60 per gallon a decade ago to $1.27 per gallon today.

Methanol. Methanol can be converted into methyl tertiary butyl ether (MTBE) to be blended with gasoline, or used in neat form as a gasoline substitute. We are studying thermochemical processes to produce methanol from biomass.

In these processes, the biomass is gasified to form a medium-Btu syngas that is then adjusted to the proper hydrogen to carbon monoxide ratio. Next, the mixture is cleaned and conditioned before being converted over commercial catalysts to methanol.

Reformulated Gasoline Components. Olefins or reformulated gasoline components (RGCs) can be produced from biomass through thermochemical processes and reacted with

alcohols to produce ethers. The use of ethers such as MTBE and ethyl tertiary butyl ether (ETBE) or other oxygenates in gasoline was mandated by the Clean Air Act Amendments of 1990 in areas with heavy pollution.

Raw biomass or processed MSW is pyrolyzed to an intermediate biocrude oil vapor in a vortex reactor. With specialized catalysts, this vapor is then cracked to produce olefins for subsequent processing to ethers.

An AFD researcher prepares liquid chromatography columns for characterizing and isolating cellulase enzymes, an important area in biomass to ethanol research.

Bio-Diesel Fuel. Fast-growing algae produce substantial amounts of lipid oils that can be converted into sulfur-free diesel fuel. Microalgae production facilities could be sited on otherwise low-value land and use high salinity water near power plants that produce carbon dioxide, playing an important role in global climate change mitigation.

We have collected and identified about 500 promising lipid-producing species that we maintain in a culture collection. We are genetically engineering these species to enhance lipid production and increase growth rates. We are also looking at resource requirements for inexpensive, large-scale, outdoor mass culture of microalgae and at technologies for economical conversion of algal lipids to diesel fuel.

Alternative Fuels Utilization

For widespread use of alternative transportation fuels, data on their performance are vital to establishing their merits and understanding future research needs. The Alternative Fuels Utilization Program supports the Alternative Motor Fuels Act (AMFA) of 1988, legislation that encourages the production of alternative-fuel vehicles.

Light-duty alternative-fuel vehicles, operating on ethanol, methanol, and compressed natural gas, are being added to federal fleets throughout the United States. Heavy-duty vehicles are part of commercial fleets or operate in short-haul service

This bus operates in the Denver regional transportation district on compressed natural gas.

within city fleets. Alternative-fuel buses operate in regional transportation district fleets at various U.S. locations. In each category, operators gather data on fuel consumption; emissions; and operating, durability, and performance characteristics.

Alternative Fuels Data Center (AFDC). The AFDC collects, analyzes, and distributes data resulting from the various fleet operations. AFDC analysts have set up a uniform data collection protocol and have designed the center to be "user friendly" to external users. The center provides unbiased, accurate information on alternative fuels and vehicles to government agencies, private industry, and other research institutions.

Alternative Fuels Research and Development Program (AFRD). In addition to monitoring the performance of fleet vehicles, the AFD supports research and development to improve engines to achieve high-efficiency operation and minimize air pollution with alternative fuels.

For More Information

The resources of the AFD are available to support technology applications in various ways: collaborative or sponsored research, cost-shared subcontracts, use of AFD facilities, the visiting researcher program, and cooperative research and development agreements (CRADAs).

Along with the activities described in this brochure, the AFD conducts research in anaerobic digestion for methane production, as well as the production of chemicals and materials from biomass. To learn more about our research, please contact:

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