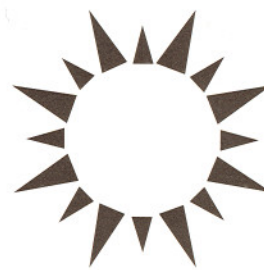


# Alternative Transportation Fuels: Contemporary Case Studies



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## Glossary

**biodiesel** An ester that can be made from substances such as vegetable oils and animal fats. Biodiesel can either be used in its pure state or blended with conventional diesel fuel derived from petroleum.

**ethanol** Ethyl alcohol ( $\text{CH}_3\text{CH}_2\text{OH}$ ); one of a group of chemical compounds (alcohols) composed of molecules that contain a hydroxyl group (OH) bonded to a carbon atom. Ethanol is produced through the fermentation of agricultural products such as sugarcane, corn, and manioc. Most of the ethanol produced in the world is from sugarcane, mainly in Brazil. In the United States, ethanol is made from corn.

**gasohol** A mixture of 20–26% anhydrous ethanol (99.6° Gay-Lussac and 0.4% water) and gasoline; used in most vehicles in Brazil.

**methyl *tert*-butyl ether (MTBE)** A chemical compound that is manufactured by the chemical reaction of methanol and isobutylene. MTBE is produced in very large quantities (over  $3.18 \times 10^6$  liters/day in the United States in 1999) and is almost exclusively used as a fuel additive in motor gasoline. It is one of a group of chemicals commonly known as “oxygenates” because they raise the oxygen content of gasoline. At room temperature, MTBE is a volatile, flammable, and colorless liquid that dissolves rather easily in water.

**Organization for Economic Cooperation and Development (OECD)** An international body composed of 30 member nations. Its objective is to coordinate economic and development policies of the member nations.

**transesterification** The reaction of a fat or oil with an alcohol in the presence of a catalyst to produce glycerin and esters or biodiesel. The alcohol, which carries a

positive charge to assist in quick conversion, is recovered for reuse. The catalyst is usually sodium hydroxide or potassium hydroxide.

Alternative transportation fuels are those fuels not derived from petroleum. They include not only those derived from renewable sources but also natural gas and its derived fuels. A general overview of the existing status of development of alternative fuels for transportation throughout the world is presented in this article. Long-term experiences, such as the Brazilian Alcohol Program and several programs in the United States, as well as those in other countries, are also discussed.

## 1. INTRODUCTION

The perspective that envisions exhaustion of the world's oil reserves is not the main reason for researching and developing alternative fuels; rather, it is for environmental and strategic reasons that alternative fuel technology is of importance. For example, big cities such as São Paulo, Mexico City, and Delhi (among others) currently face serious environmental problems due to the pollutant emissions from vehicles. Some countries have proposed and enacted solutions for these problems. Ambient concentrations of lead in the São Paulo metropolitan region dropped more than 10 times from 1978 to 1991, far below the air quality standard maximum, due to the mandatory use of either an ethanol/gasoline blend or straight ethanol in all cars, legislated through the Brazilian Alcohol Program (further details are discussed in Section 3.1). Strategic aspects of alternative fuel development are also significant due to the fact that most oil reserves are



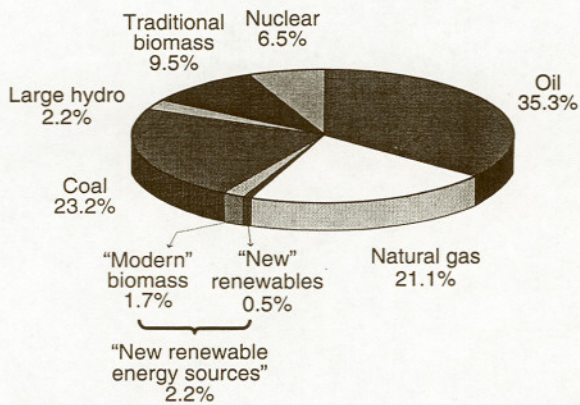


FIGURE 1 World consumption of primary energy and renewables, by energy type, 1998.

in the Middle East, a region facing complex political conflicts. The current trends show that the world will continue to depend on fossil fuels for decades; however, because the largest share of the world's oil resources is concentrated in regions with potential or active political or economic instabilities, alternative fuels ease the complexity of worldwide distribution of necessary energy resources. Nuclear energy plants, although an alternative to fossil fuels, are also concentrated only in a few countries and nuclear technology raises numerous concerns on physical security grounds.

Organization for Economic Cooperation and Development (OECD) countries, which account for 80% of the world economic activity, are quite dependent on oil imports, with a 63% share of global oil consumption (expected to rise to 76% in 2020). Asian Pacific countries are expected to increase the external dependence of their energy requirements to 72% by 2005. Compared to fossil and nuclear fuels, renewable energy resources are more evenly distributed, although only 2.2% of the world energy supply in 1998 was from new renewable sources. New renewable sources include modern biomass, small hydropower, geothermal energy, wind energy, solar (including photovoltaic) energy, and marine energy. Natural gas accounts for 21.1% of this supply (Fig. 1).

## 2. GENERAL OVERVIEW

The alternative fuels being used in the world today include biodiesel, electricity, ethanol, hydrogen, methanol, natural gas, propane, and solar energy. In 1999, the U.S. Department of Energy finalized an amendment to the Energy Policy Act of 1992 that

added certain blends of methyltetrahydrofuran (MeTHF), ethanol, and light hydrocarbons to the list of approved "alternative fuels." These liquid products for spark-ignited engines have come to be known under the registered trademark, "P-series." The discussion here is limited to the fuels already being commercialized.