



## DME: From Spray Cans To Fuel Tanks

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*Jim McCandless*

Jim McCandless believes the same substance that makes aerosol spray cans work will ultimately power millions of motor vehicles in the United States.

"DME is an ultra-clean fuel that is ideal for diesel engines," said McCandless, President & CEO of Michigan-based Alternative Fuel Technologies, Inc. (AFTC) and a mechanical engineer with more than 40 years of experience in diesel engine and diesel fuel system design. Used for decades in the personal care industry as an aerosol propellant, DME is a colorless gas that can be readily liquefied. Produced primarily by removing water from methanol, DME also can be manufactured directly from synthesis gas produced by the gasification of coal or biomass or through natural gas reforming.

Like liquefied petroleum gas (LPG), DME is gaseous at normal temperature and pressure but changes to a liquid when subjected to modest pressure or cooling--making it easy to transport and store. Because it exhibits these and other properties--such as high oxygen content, no carbon-carbon bonds, and lack of sulfur or other noxious compounds--DME is increasingly being exploited as a cleaner-burning, lower-carbon fuel for domestic applications such as heating and cooking, electric power plants, and diesel engines.

### More Diesels on the Road

Foreign automakers such as Audi, Mercedes, and Volkswagen have long offered diesel-powered cars in the U.S., but domestic automakers have typically limited their diesel model offerings to pickup and heavy-duty trucks. That is set to change, however, because Chrysler, Ford, and GM plan to introduce diesel engines in passenger cars by 2011.

A key advantage of diesel engines over their gasoline counterparts lies in the area of fuel economy. For example, the U.S. Environmental Protection Agency's combined estimated miles per gallon figure for a 2009 diesel Volkswagen Jetta sedan is nearly 38% higher than that of its gasoline-powered counterpart: 33 mpg vs. 24 mpg, respectively. Assuming the number of diesel passenger cars in the U.S. does grow significantly in the next 10 years, McCandless believes that many who have made the switch to diesel will see DME as a win-win for their pocketbooks and for the environment.

"Owing to its chemical structure (CH<sub>3</sub> O CH<sub>3</sub>) it will not produce soot particulates when it is burned," McCandless said of DME. Soot particulates, or the black smoke emanating from exhaust systems on diesel-powered vehicles, are the reason why diesel trucks and passenger cars have particulate traps; these devices can add hundreds or even thousands of dollars to the cost of a vehicle. In addition, complex fuel injection systems that are designed to minimize soot particulates from heavy-duty diesel engines can constitute one-third to one-half of the engine's cost. Because particulates are not a problem with DME, simple low-cost strategies can be employed to reduce NO<sub>x</sub> (nitrogen oxide) emissions, McCandless noted. These strategies include exhaust gas recirculation (EGR) and pilot injection.

Gasoline engines in passenger cars have used EGR for decades to lower NO<sub>x</sub> emissions, but diesel engines until recently did not apply the technology. In the latter case EGR raised soot emissions and

contaminated lube oil, which in turn caused engine wear. Today's diesel engines do apply EGR because exhaust gases now contain lower soot levels and the lube oil contamination is tolerable; however, the level of EGR is limited to prevent excessive soot emissions. "DME-fueled engines do not produce soot, so it is possible to employ very high levels of EGR to lower NOx," said McCandless.

In pilot injection, one percent of the total fuel in an engine's combustion chamber is injected approximately 30 degrees before the main injection of fuel. This pilot charge releases a small amount of heat that quickly ignites the main charge, resulting in smoother combustion and lower NOx. "The smoother combustion lowers the signature -- and objectionable -- diesel knock," McCandless added.

### **Competitiveness and Adaptability**

Although DME's energy density is lower than that of diesel, McCandless pointed out the alternative fuel will cost less on an energy equivalent gallon basis. He cited one analysis suggesting that DME can be competitive with diesel when the per-barrel price of oil ranges from \$45 to \$55, assuming high-volume production of DME. "Since many believe that we will see \$100 oil, DME will be a highly desirable fuel," McCandless said. He also predicted the energy consumption rate for DME will be at least competitive with diesel on a BTU-per-mile basis.

McCandless noted that DME can be made in existing manufacturing facilities but would not be produced at oil refineries. "The process for making DME from, say, natural gas is similar to methanol," he said. "Natural gas is reformed into synthesis gas and processed through catalysts to form DME." He added that numerous proponents of using DME as a diesel alternative are exploring the co-production of methanol and DME in the same plant. "After making methanol, some quantity would then be reprocessed via dehydration to make DME." In addition, the Danish company Haldor Topsoe has developed a process that yields DME directly from synthesis gas without going through the methanol phase.

Because DME is very similar to LPG save for a lower vapor pressure (5 bar vs. 8 bar), McCandless said that DME could be shipped and stored in existing LPG pipelines and storage facilities with minor modifications. Motorists could purchase DME at fueling stations using equipment similar to what already exists in the propane retailing segment. "Many countries already have extensive infrastructure for LPG as an automotive fuel," he added, citing South Korea, Japan, Russia, and the Netherlands as examples. In addition, DME is used as a replacement for LPG and as a chemical feedstock in China.

The growing popularity of DME in China is such that annual production is expected to grow from 2 million metric tons as of last year to 20 million metric tons by 2020. Most of the new Chinese production will be used for transportation. McCandless would like to see this robust level of growth replicated in North America, where DME is largely unknown outside the oil and gas and chemicals communities. "A lot of work needs to be done to ensure that there will be a market for DME as a transportation fuel" in North America, McCandless said. The International DME Association (IDA) will soon launch a marketing campaign to promote awareness of the alternative fuel.

### **Ready for A Global Rollout**

McCandless' company has developed a fuel injection system that can be retrofitted to diesel trucks and cars so that they can run on DME. "Our fuel system is designed such that it can be retrofitted to many different engines without making modifications to the basic engine," McCandless explained. The technology is adaptable to engines ranging in size from 1.5 to 13 liters powering vehicles ranging from small passenger cars to heavy-duty trucks and buses, respectively.

Ford is testing AFTC's system on a four-cylinder diesel engine. During the alternative fuels/emissions research project, the automaker will evaluate how the technology performs when the engine fires on one cylinder. Should this phase prove successful, Ford may carry out a full-engine and car demonstration with the AFTC system.

AFTC also is building DME fuel injection pumps for the Korean Institute for Energy Research (KIER), a government organization that aims to reduce South Korea's dependence on imported oil and enhance the country's environment. KIER will run laboratory tests on a small Hyundai truck engine and then eventually test the engine in one of the automaker's e-Mighty trucks.

McCandless is hopeful the tests and possible demonstration will lead to series production of the DME fuel system for the global automotive market in the next two years. "AFTC has positioned itself to be the leader in the DME fuel system market, and winning contracts with KIER, Ford, or other automotive organizations would be a great boost for the company," he concluded.