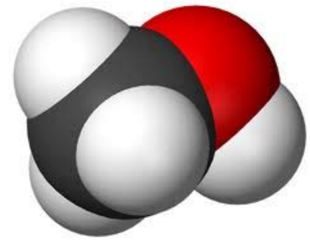
Methanol: The Clear Alternative for Transportation

Methanol Fuel and FFV Technology

What is Methanol?



The Methanol Molecule

Also known as wood alcohol, methanol is a convenient liquid fuel that is made from a number of different feedstock resources - natural gas and coal as well as renewable resources like forest thinnings or agricultural waste and even directly from CO2 captured from power plant and factory emissions. Methanol is a basic building block for hundreds of essential chemical commodities that touch our daily lives including building materials, plastic packaging, paints and coatings, even windshield washing fluid. Methanol is also a transportation fuel, a hydrogen carrier for fuel cell technologies, and an efficient fuel for electric power generation. With the chemical structure CH^3OH, methanol is the simplest alcohol, with the lowest carbon content and highest hydrogen content of any liquid fuel.

Methanol Production and Capacity

Kingsport, TN Methanol Facility.

In 2010, over 45 million metric tons of methanol was consumed around the globe, or 15 billion gallons, which is roughly equivalent to global ethanol fuel demand. By 2012, global demand is expected to reach over 50 million metric tons (17 billion gallons). This steadily increasing demand is driven in large part by the expanded use of methanol as both a liquid fuel for passenger cars and conversion to dimethyl ether which is a clean alternative to diesel fuel for trucks and buses.

In the United States, we consumed over 5.3 million tons (1.8 billion gallons) of methanol in 2010 for a wide array of uses from chemical feedstocks to plastics to building materials. A common way to make methanol from conventional energy sources is to use methane, the main component of natural gas. High natural gas prices in recent years forced a rationalization process in the global methanol industry, and older plants in the U.S. and Europe were mothballed in favor of new facilities built with less expensive off-shore natural gas. As recently as 1998, there was 9.6 million tons of annual methanol capacity in the United States, but today only four plants remain open with a total annual production capacity of less than one million tons per year. Currently, most of the methanol consumed in the US is imported from the Caribbean and South America – with methanol representing almost 40% of our trade under the Caribbean Basin Economic Recovery Act.

Currently Operating U.S. Methanol Plants

Plant	Location	Feedstock
Range Fuels	Soperton, GA	Timber Biomass
Liquid Carbonic	Geismer, LA	Natural Gas
Millennium	Deer Park, TX	Natural Gas
Eastman Chemical	Kingsport, TN	Coal Gasification

At the same time as demand continues to expand in the U.S. and around the world, global production capacity is growing at an even faster rate and is expected to reach over 85 million metric tons by 2012. Based on these forecasts, there will be 34 million tons of excess production capacity around the world, enough to produce 11 billion gallons of methanol per year. Additional billions of gallons of production capacity is also available today in mothballed plants in North America and facilities in Europe.

Diverse Feedstocks

One of the distinct advantages of employing methanol as a sustainable source of fuel is the diverse array of feedstocks from which this simple alcohol can be produced. Besides industrial production from natural gas and coal, methanol can be made from anything that is, or ever was, a plant. Timber waste, landfill gas, trash, pulp mill black liquor, agricultural waste and even CO2 pollution among a host of other viable sources – all can be converted into methanol, as an effective way to store and distribute the energy from each source.

In Soperton, GA, Range Fuels is harnessing biomass and wood waste to convert into biomethanol. In Iceland, Carbon Recycling International is building a plant utilizing CO2 flue gas and electricity from a geothermal power plant to make renewable methanol for vehicles and trucks on the island nation. In Kingsport, TN – and to a much greater scale throughout China – coal is converted into methanol fuel through gasification, a much cleaner approach than traditional coal-to-liquids technology. In Sweden, Chemrec is creating methanol and dimethyl ether from the black liquor that is a waste product of pulp mills. These innovative approaches mostly rely on a proven and reliable technology called gasification to extract the energy contained in all these feedstocks – but a number of different processes have created cost-competitive approaches to the production of methanol from a number of feedstocks.

> ” [In the US] a fully-developed pulp mill biorefinery industry could be double or more the [production] size of the current corn-ethanol industry.
> **– Eric Larson, Princeton University / DOE Study**

Polygeneration Meeting Demand

With a diverse landscape and a wide variety of resources around the country, the United States is uniquely positioned to benefit from polygeneration – producing one type of fuel from a number of different feedstocks. Polygeneration protects the transportation sector from fluctuating prices inherent in relying on one feedstock – as is seen with interruptions in oil supplies from overseas or due to production interruptions in the Gulf during hurricane season. The ability to tap into multiple resources also allows for local production based on the abundant resources of a specific geographic region, benefiting local economies and creating distributed generation that is less susceptible to pricing spikes.

In the U.S., we currently have in place the Renewable Fuel Standard, which mandates the production of 12.95 billion gallons of renewable fuel in 2010 to promote the development of renewable transportation fuels. Ethanol – which is the most commonly used renewable fuel in the market today – currently consumes almost 35% of the corn and 28% of the sorghum grown in the U.S. each year to meet demand, putting significant price pressures on both of these commodities. With over 136 billion gallons of gasoline consumed each year, these crops alone will be hard pressed to make a significant impact on the consumption of oil. By 2020, the RFS calls for 30 billion gallons of renewables to be in the transportation fuel pool, an almost three-fold increase over current consumption. **By spreading out the production of fuel over multiple feedstocks, we can more quickly realize our goal of employing domestically-produced fuels in the transportation sector.**

In order to produce 30 billion gallons of methanol fuel, we would need to only tap into less than 5% of three abundant resources in the United States which have proven technologies for conversion to methanol. According to the U.S. Energy Information Administration (EIA), 21.2 trillion cubic feet (Tcf) of dry natural gas was produced in the United States in 2008. With about 100 cubic feet of natural gas needed to produce one gallon of methanol, the production of 10 billion gallons of methanol would require 1 Tcf of natural gas, or less than 5% of current domestic natural gas production. Again, according to the EIA, the U.S. produced 1,171 million short tons of coal in 2008. It takes about 5,000 short tons of coal to produce one million gallons of methanol using proven gasification technology. The production of 10 billion gallons of methanol would require 50 million short tons of coal, or just 4.2% of current coal production. Finally, according to a joint DOE/USDA report, U.S. forestland and agricultural land - the two largest potential biomass sources - represent over 1.3 billion dry tons per year of biomass potential, which alone is enough to produce biofuels meeting more than one-third of the current demand for transportation. Using mature gasification technology, one ton of biomass can be used to produce 165 gallons of methanol, as opposed to only about 100 gallons of cellulosic ethanol. The production of 10 billion gallons of methanol would require 60 million tons of biomass, or less than 5% of the biomass production potential. With these three feedstocks alone, we could produce 30 billion gallons of methanol fuel and meet our fuel diversity goals from less than 5% of the current production capacity of each.

> ” [Methanol] is the liquid fuel that is most efficiently and inexpensively produced from natural gas…A cost competitive, room temperature liquid transportation fuel, reducing oil dependence.
> **- MIT Study, *The Future of Natural Gas***

Methanol as a Reliable Transportation Fuel

From the mid-1980s to the late-1990s, methanol flexible fuel vehicles (FFVs), capable of running on any combination of methanol (up to M-85, a blend of 85% methanol and 15% unleaded gasoline) and gasoline in the same tank were sold in the U.S. Methanol FFVs on the road peaked in 1997 at just over 21,000 with approximately 15,000 of these in California, which also had over 100 methanol refueling stations. Hundreds of transit and school buses were operated during this time period using 'neat' methanol, or M-100. **From this experience, we know the incremental cost to provide flexible fuel capability to a new car is just $50-$150, while the cost to install a methanol fueling pump is $62,000 or less.**

By the late-1990s after more than 200,000,000 miles of experience, the use of methanol as a transportation fuel in the U.S. quickly faded away for a number of reasons. In the 1980s and 1990s, when gasoline was priced below $1.00 per gallon, methanol fuel costs to the consumer were generally equivalent to premium gasoline. Methanol FFVs were fueled with gasoline most of the time, making it difficult to build volume sales to encourage the operation of retail pumps. Only four vehicle models were ever offered for commercial sale by the automakers. In stark contrast, we now see automakers building multiple models of ethanol FFVs, as well as national advertising campaigns for fuel cell cars that are years, if not decades, away from commercial introduction.

A truly flexible fuel vehicle would be "A-85" or "GEM" capable, able to run on gasoline, ethanol (E-85) or methanol (M-85) in any combination. By creating a car capable of running on M-85 – which is slightly more corrosive than ethanol – a car would then be materially compatible to run on any alcohol based fuel, including ethanol, methanol, butanol and others. A GEM or alcohol compatible FFV would offer significant benefits in fuel diversity, price competition and consumer choice. Conversion to methanol fuel capability is the common denominator that would allow for all these liquid fuels to compete in the market place.

The Open Fuel Standard

First introduced in the U.S. Congress in 2009, the Open Fuel Standard Act would ensure the widespread adoption of alcohol-fuel compatible FFVs. These bills – with slight variation in current House and Senate forms – would require that at least 50% of the vehicles produced for the U.S. market that use an internal combustion engine (which would include plug-in hybrid vehicles) must be compatible with blends up to both M-85 and E-85 fuel by the year 2012. The same rule would apply each year until 2015, at which time 80% of vehicles produced for the U.S. must be fuel-choice enabling vehicles.

With no cost to the government or taxpayers, this legislation would require automakers to produce cars that are capable of running on many different types of fuels from technology already proven through millions of miles of demonstration. The cost for these conversions would be about $50 - $150 per car, and at current prices, a driver would save more than that annually in fuel costs if they filled up with M-85 all year long. The unsubsidized cost of methanol – on an energy party basis – currently averages about 90% of the cost of regular unleaded fuel. Most importantly, when Congress was considering the 2009 bailout of the major U.S. automakers, auto executives testified that this timetable was realistic and they committed to producing these advanced vehicles – the Open Fuel Standard would simply turn that promise into law.

Methanol Fuel Costs vs. Gasoline

When compared to gasoline on an energy equivalent basis – as methanol contains less BTUs per gallon than regular gasoline – M-85 still offers the best value at today's pump prices. Methanol currently sells for about $1.08 per gallon as a commodity, meaning the current pump price for M-85 would be just $1.85 per gallon including all applicable taxes and retail mark-up. On a gasoline equivalent basis (adjusting for methanol's lower energy content that requires 1.74 gallons of M-85 to provide the same energy content or range as a gallon of gasoline), the price of methanol delivered to the consumer would be $3.23 per gallon. According to AAA, the average pump price for regular gasoline is currently $3.80 per gallon, while the energy adjusted price for E-85, including subsidies, is still $4.20 per gallon.

Methanol Fuel and the Environment

Ten or more years ago, a typical methanol manufacturing plant would emit about 0.9 - 1.0 metric tonnes of carbon dioxide for every tonne of methanol produced. In addition to the environmental concerns, large CO2 emissions represent operational inefficiencies in a methanol plant, since the carbon emitted as CO2 is not available for making methanol molecules. In fact, excess CO2 from other industrial facilities can also be captured and consumed to increase methanol production. **Through the implementation of efficiency improvements and through replacing of older facilities with newer plants that use more efficient technologies, over the last decade methanol plants have been able to significantly reduce CO2 emissions by up to 40%.**

When burned as fuel, methanol cuts emissions of nitrogen oxides and volatile organic compounds that form ground-level ozone or "smog." Methanol is much less reactive than gasoline in the atmosphere, with the only toxic component of the emissions being formaldehyde, as compared to dozens of carcinogenic components of gasoline emissions, which also contains formaldehyde. The use of heated catalytic converters has shown that methanol-fueled auto emissions meet and exceed California's stringent Ultra Low Emission Vehicle (ULEV) emission targets for formaldehyde. Methanol fuel also does not contain the toxic BTEX additives found in gasoline – benzene, toluene, ethylbenzene, and xylenes. These compounds are highly carcinogenic, do not readily biodegrade in the environment, and are capable of contaminating groundwater supplies.

Methanol and Safety

An increase in the production, transportation, storage, and use of methanol would increase the potential for accidental releases to the environment. **Relative to gasoline, methanol is a safer and more environmentally benign fuel.** Methanol is readily biodegradable and the half-life (the time required for 50% reduction in mass) in soil, surface water and groundwater is just 1-7 days. By comparison, the half-life for benzene (a toxic gasoline constituent) in groundwater is 10-730 days. Methanol is also already used extensively in the nation's wastewater treatment plants to accelerate the biodegradation of nitrogen to protect sensitive aquifers and waterways.

> ” Projections indicate that casualties [from fires] would drop dramatically if methanol were substituted for gasoline as the country's primary automotive fuel.
>
> **- EPA Report, *Methanol Fuels and Fire Safety***

The greatest danger from the use of gasoline as a vehicle fuel is from fires. Gasoline fires in vehicles result in hundreds of deaths and millions of dollars in property damage each year. Methanol does not evaporate or form vapors as readily as gasoline does, and methanol vapors must be four times more concentrated in air than gasoline to ignite. Methanol burns 75% slower than gasoline, and methanol fires release heat at only one-eight the rate of gasoline. **Methanol is inherently more difficult to ignite than gasoline, and much less likely to cause deadly or damaging car fires if it does ignite**.

Methanol, like gasoline or diesel fuels, should never be ingested and is toxic. Deaths have been reported from intake of as little as 13 ml. of gasoline (less than one ounce), which is similar to the fatal ingestion range for methanol. Our bodies contain methanol naturally, and it is found in many parts of our diet, including fresh fruit, vegetables, and fermented foods and beverages. Both methanol and gasoline can be absorbed through human skin, and the response for both is the same: remove any contaminated clothing, and wash with soap and water. Spill-free methanol nozzles have been developed that will prevent a consumer from even being able to come into contact with methanol fuel.