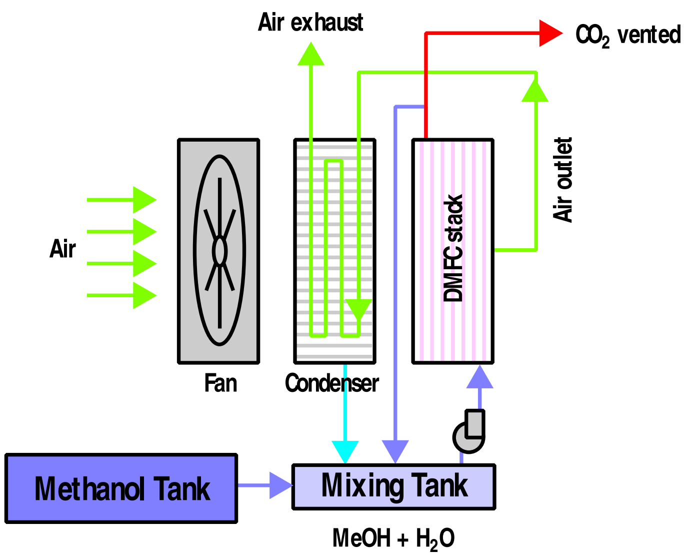
The Opel Zafira, by General Motors, reforms methanol to operate a polymer electrolyte membrane fuel cell. This vehicle has nearly zero emissions of sulfur dioxide and nitrogen oxides and the carbon dioxide output is expected to be 50% less than a comparable internal combustion engine vehicle. (Courtesy: General Motors)

Emissions from Fuel Cell Engines

The potential of fuel cells to provide zero or near zero emissions has been a significant force in the development of the technology over the past 30 years. Direct hydrogen/air systems (utilizing on-board hydrogen storage) are the only fuel cells having zero emissions from the tailpipe. On-board processing of gasoline, methanol and other carbon-based fuels into hydrogen rich gas can be done with minute amounts of tailpipe emissions and water and CO_2 as the major by-products. Over the next few years, near-zero emissions and performance will continue to improve.

Direct Methanol Fuel Cell

As its name implies, methanol fuel is directly used in this fuel cell. In the direct methanol fuel cell, as in the hydrogen/air fuel cell, oxygen from the surrounding air is the oxidant, however, there is no oxidation of hydrogen. Liquid methanol is the fuel being oxidized directly at the anode.



Schematic of direct methanol fuel cell system.
(Courtesy: Los Alamos National Laboratory)

Direct methanol fuel cell technology, unique as a low temperature fuel cell system not utilizing hydrogen, is still relatively new compared to hydrogen/air polymer electrolyte fuel cell technology, with several challenges remaining. Recent advances in direct methanol fuel cell research and development have been substantial, with the direct methanol fuel cell achieving a significant fraction of the performance of direct hydrogen/air fuel cells. However, there are critical obstacles to be overcome. To achieve high current, the necessary amount of expensive platinum catalyst is still much greater than the amount used in hydrogen/air polymer electrolyte fuel cells. Methanol fuel crosses through the membrane from the anode to the cathode; this undesired methanol "crossover" decreases the performance of the air cathode and wastes fuel.

The advantages of supplying methanol directly to the fuel cell are significant – with consumer acceptance of a liquid fuel being high on the list. While a new or modified infrastructure would be required to supply large quantities of methanol, there are some methanol pumps already available. Importantly, a direct methanol fuel cell system does not require a bulky and heavy hydrogen storage system or a reforming subsystem. This advantage, in terms of simplicity and cost, means the direct methanol fuel cell system presents an attractive alternative to hydrogen or reformate-fed systems. In addition, a direct methanol fuel cell is considered a zero emission vehicle.

Electrochemistry of a Direct Methanol Fuel Cell

The electrochemical reactions occurring in a direct methanol fuel cell are:

Anode	$CH_3OH + H_2O$	→	$CO_2 + 6H^+ + 6e^-$
Cathode	$3/2\ O_2 + 6H^+ + 6e^-$	→	$3H_2O$
Cell reaction	$CH_3OH + 3/2\ O_2$	→	$CO_2 + 2H_2O$