# FUELS, FUEL CELL VEHICLES, AND SUSTAINABLE FUEL SUPPLY

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## BACKGROUND

The concept of sustainable development requires changes in the current system of energy use, especially in the transportation sector which is a major contributor to the long-term effects of global climate change, depletion of nonrenewable resources, and near-term effects on human health and natural ecology. Fuel cell vehicles (FCVs) using renewable fuels are regarded as a leading technological solution to these problems. EPA review of alternative fuel options for future road transport are summarized here. The review was aimed at the potential for co-control of criteria and $CO_2$ emissions, cost reduction, and petroleum displacement with emphasis on fuels derived from biomass for use in FCVs. *The environmental impact of a new fuel/vehicle system depends not only on its tailpipe emissions and public acceptance (and cost), but also on the timing of its introduction, the proportion of the fleet that can be affected, and the rate at which it can displace the existing system*. These factors may limit the prospects of both FCVs and the alternative fuel options.

## ON THE FUEL SIDE

Ethanol produced from corn could displace no more than 1.6% of current U.S. gasoline needs which confines its role to use as a potential oxygenate. If the most optimistic estimates of dedicated energy crops and available agricultural residues are assumed for ethanol production, U.S. gasoline requirements could be reduced by only 16% (2.8 quads) and cost 48% more to produce, per quad, than reformulated gasoline. No dedicated energy crops will be available for conversion to ethanol if their probable cost of production is assumed rather than the optimistic estimates (Walsh 1998). Converted to methanol, that biomass could displace 4.5 quads of gasoline and achieve 33% more $CO_2$ emission reduction than the ethanol route. Biomass and natural gas (NG) used as methanol co-feedstocks increases the conversion efficiency of both and reduces cost to a competitive range with gasoline while decreasing net $CO_2$ emissions from the automotive fleet by half (Borgwardt 1998). However, methanol produced from domestic biomass and NG cannot compete with low-cost imported methanol. Nor can domestic methanol compete as FCV fuel with hydrogen produced from NG. Imported methanol is a lower cost fuel than hydrogen produced from domestic NG, but hydrogen greatly exceeds all other options in terms of potential for petroleum displacement and $CO_2$ emissions reduction. Nevertheless, neither biomass nor conventional domestic NG is a viable source of hydrogen on a scale necessary to support the U.S. fleet.

## ON THE VEHICLE SIDE

Availability of platinum will also restrict the degree to which FCVs alone can displace the existing fleet and will greatly extend the time frame required to accomplish a conversion. The most optimistic scenario (direct hydrogen FCVs, 0.36 g Pt/kW) would require over 60 years to convert the U.S. fleet and almost half the annual world output of platinum during that period (Borgwardt, 2001). Gasoline FCVs would require nearly twice as much platinum and are less likely candidates for that reason – irrespective of their higher cost and marginal effect on fuel economy. Direct methanol, requiring 13 times as much platinum as a direct-hydrogen PEM cell, can be dismissed on that basis alone. The prospects for realizing the efficiency goals for FCVs that were anticipated in 1993 when this project began have also declined appreciably. These developments support the conclusions of Weiss et al. (2000) – for different reasons – that favor hybrid ICE-electric vehicles either in addition to, or in place of, FCVs as the principal component of the future fleet. From the environmental and sustainability standpoints, hydrogen is the preferred fuel for both vehicle types – the advantages of hydrogen fueled SI/ICE engines are reviewed by Aceves (1996). Given the constraints on future availability of domestic NG for production of hydrogen as transportation fuel, and the associated emissions, a direct transition to a renewable source of primary energy such as solar photovoltaic (PV) electricity or wind needs serious consideration as a sustainable alternative. PV would be less costly and more effective for reduction of GHG emissions than recovery and sequestration of $CO_2$ from coal-fired power plants which is the main option for sustainable production of electric power (Hester 2000).

## NATURAL GAS: FACILITATOR OR IMPEDIMENT TO A SUSTAINABLE SYSTEM?

Use of the existing NG distribution infrastructure to produce hydrogen at local stations by steam reforming can overcome the main barrier to its use as transportation fuel (Thomas et al. 1998, 2000). Alternatively, production of PV electricity for distribution to local refueling stations to produce hydrogen by electrolysis would initially require a large credit for $CO_2$-emission avoidance in order to compete with conventional electricity. But that credit declines with the experience curve and PV power could be produced for about 4.6 mills/kWh after 50% of the fleet is converted. Electrolytic hydrogen from PV power will nevertheless remain uncompetitive with the near-term option of decentralized production of hydrogen from NG. Although conventional NG is unlikely to be available as a source of hydrogen beyond the year 2030, imported LNG and unconventional sources of domestic natural gas can extend the period of its dominance as the source of hydrogen for transport energy and will delay the introduction of a sustainable system. Achieving sustainability will thus require another complete conversion of the fuel distribution infrastructure from NG to one based, most probably, on electrolytic hydrogen from renewable energy.

## A VIEW ABOUT EPA’S ROLE

The concept of sustainable development also includes economic growth. Maintaining the benefits of growth as measured by gross domestic product (GDP) while also converting to a new source of energy to meet future demands of transportation will conflict with most any near-term option for transition to sustainability. Replacing the current infrastructure efficiently takes time and a clearly defined objective for a new system. And it should happen only once. That system, whatever it is, will have major environmental and economic impacts for decades to come. The EPA needs to *independently* assess the options in terms that include measures other than relative tailpipe emissions and short-term GDP impacts. EPA’s fuel cell program discussed at this workshop can help establish that assessment.

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