LETTERS

Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 6 months or issues of general interest. They can be submitted by e-mail (science_letters@aaas.org), the Web (www.letter2science.org), or regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.

Hydrogen Cars and Water Vapor

D. W. KEITH AND A. E. FARRELL'S POLICY FORUM "Rethinking hydrogen cars" (18 July, p. 315) draws attention to the need for broad technology assessment of a popular policy alternative. In the pursuit of this new technology, the focus on the problem to be solved can lead to insufficient attention being paid to new environmental problems that might follow from its adoption. These new problems become tomorrow's unanticipated consequences, and the cycle begins again. This cycle could be dampened, however, with a thorough assessment of the new technology before it has completed development.

This cycle is currently under way with hydrogen fuel cells. As fuel cell cars are suggested as a solution to global climate change caused by rising levels of greenhouse gas emissions, they are frequently misidentified as "zero-emissions vehicles." Fuel cell vehicles emit water vapor. A global fleet could have the potential to emit amounts large enough to affect local or regional distribution of water vapor.

Variation in water vapor affects local, regional, and global climates (*1*). Data on such effects are sparse because of complexities in the water vapor life cycle. However, our preliminary calculations indicate that a complete shift to fuel cell vehicles would do little to slow water vapor emissions, which presumably have increased perceptibly in some metropolitan locations through the growth in use of internal combustion engines. In some locations, changes in relative humidity related to human activity have arguably affected local and regional climate (*2*, *3*). Depending on the fuel cell technologies actually employed, relative humidity in some locales might conceivably increase by an amount greater than with internal combustion engines. This increase could lead to shifts in local or regional precipitation or temperature patterns, with discernible effects on people and ecosystems.

> **"In the case of hydrogen cars, the cure may indeed be better than the disease, but we should make sure before taking our medicine."**
>
> –*PIELKE* ET AL.

The broad environmental effects of fuel cell vehicles are an issue worth addressing via a technology assessment before implementing a solution (*4*). Not all problems can be anticipated in this manner, but if some can, then the effort will have been well spent (*5*). In the case of hydrogen cars, the cure may indeed be better than the disease, but we should make sure before taking our medicine.

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Response

WE AGREE WITH PIELKE *ET AL.* ON THE IMPORTANCE of examining the environmental and other implications of new technology early in its development cycle. We are skeptical, however, that water vapor produced by combustion can have any important effect except when it is emitted in the stratosphere. The global emission of water due to oxidation of fossil fuels is of order 10^5 times smaller than the natural hydrological cycle, and even in cities, the humidity perturbation due to oxidation of fuels is likely to be small compared with other human impacts on near-surface water vapor, such as the land use changes described in Pielke *et al.*'s reference (*2*).

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What About the Shortcuts?

IN THEIR POLICY FORUM "RETHINKING hydrogen cars" (18 July, p. 315), D. W. Keith and A. E. Farrell overlook many shortcuts to early deployment of attractive and profitable hydrogen cars. Their over-$5000-per-car cost estimate for hydrogen fueling infrastructure is an order of magnitude above authoritative engineering-economic calculations for filling-station–scale methane reformers (*1*) now being commercialized, using off-peak distribution capacity for natural gas and not materially increasing net natural-gas demand (*2*). Their claim of needed "breakthroughs in hydrogen storage" ignores a 2000 design for a manufacturable, production-costed, cost-competitive, uncompromised, quintupled-efficiency midsize SUV (*3*, *4*) using currently commercial compressed-hydrogen tanks. The marginal cost of reducing NO_x emissions with hydrogen is zero, not ~$1 million/ton, if reducing NO_x is a free byproduct of a hydrogen transition that is profitable for other reasons (*2*). And while ultimately eliminating automotive CO_2 will require either carbon sequestration or a climate-safe source of cheap electricity, carbon-releasing gas-reformation hydrogen in an efficient hydrogen-ready car (*3*, *4*), as part of an integrated vehicles-and-buildings hydrogen transition strategy (*5*), would reduce CO_2 emissions per kilometer by ~2 to 5 times at negative cost (*3*, *4*), or officially by 2.5 times (*6*)—surely an important interim step worth pursuing with due deliberate speed.

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