

Testimony presented at U.S. House of Representatives' Science Committee, Subcommittees on Energy and Research joint hearing on "Fueling the Future: On the Road to the Hydrogen Economy," Wednesday, July 20, 2005 by Professor John B. Heywood, Director Center for 21st Century Energy and the Sloan Automotive Laboratory, MIT.

It is a pleasure to testify before your committee today on meeting the future energy needs of our U.S. transportation system. I have been working in this area at MIT for the past 37 years doing technical research and broader strategic analysis on how to reduce the environmental impacts and fuel consumption of our transportation vehicles. Summaries of our groups' relevant recent studies are attached to this testimony.

Our work, and that of others, looking ahead some 10-30 years underlines how important it is that we in the U.S. aggressively pursue two parallel paths related to transportation energy and greenhouse gas emissions. By we, I mean the relevant people in the government, the auto and petroleum industries, the R&D community, and the broader car buying and car using public.

The two paths are:

1. Working effectively to improve current engine and drivetrain technologies, reduce vehicle weight and drag so we significantly reduce vehicle fuel consumption, and to provide incentives to individual light-duty vehicle owners and users to buy such improved technology vehicles and drive them less.
2. Developing the framework and knowledge base for an eventual transition to transportation energy sources, vehicle technologies, and energy consumption rates that offset the expected declining availability and rising cost of petroleum-based fuels, and which on a well-to-wheels and cradle-to-grave basis have low greenhouse gas emissions. This future transportation energy carrier could be hydrogen, it could include electricity, and in part it could be biomass derived fuels.

It is very much in our national interest to pursue both these paths aggressively, and with a real sense of urgency. The only feasible way to impact our steadily growing U.S. petroleum imports and consumption within the next twenty-five years is through reducing the fuel consumption of our U.S. transportation fleet. There are many ways to improve current vehicle technology to increase efficiency, but for most of these, the initial vehicle cost goes up by more than past experience indicates this consumer market will support. There is a strong need, therefore, for the U.S. Government to provide incentives to all the involved stakeholders (including consumers), as soon as possible, to "pull and push" this technology into the marketplace and ensure it is used. I will discuss some of my MIT groups' work on this shortly. However, even these actions will not result in much lower petroleum consumption and very low greenhouse gas emissions from the U.S. light-duty fleet. The importance of these actions is that given the size of our vehicle fleet (some 230 million light-duty vehicle), this is the only way to get off the projected growth from today's light-duty vehicle fleets consumption of 140 billion gallons of gasoline a year (an

enormous amount!) to some 1.6 times that (220 billion gallons per year) twenty-five years from now. Whether petroleum resources are available to allow this growth is unclear. While it is likely that “unconventional petroleum” such as gasoline and diesel like fuels made from tar sands, natural gas, and biomass, will increase their contribution, it will still be modest compared to this projected 25 year ahead total.

Thus the primary driver for this first path is to reduce the impact that higher petroleum prices, petroleum availability concerns and shortages, and rising negative balance of payment issues could have on our security, economy, and way of life.

In addition, however, success along this first path will have a significant enabling impact on the second path. It is anticipated by many that by mid-century we will need (in the U.S. and elsewhere) to be on a transition path to much lower vehicle fleet greenhouse gas emissions. If the transportation energy demand in the U.S. at mid-century is as large as many current projections now indicate, then that transition task due to its size, technological difficulty, and likely cost is unbelievably challenging. We are now starting to learn just how challenging that will be. If through improved efficiency and conservation we in the U.S. have cut that energy transition challenge in half, just think how large a difference that will make.

It will not be easy to “cut the challenge in half.” Over the last 20-30 years, consumers have bought larger and heavier vehicles, with higher performance, and have thus negated the roughly 30 percent improvement in vehicle fuel efficiency that improvements in engine and transmission efficiencies, reduced drag, and materials substitution have realized. A coordinated set of government actions will be needed to provide the push and pull to realize in-use fuel consumption benefits from future improvements. My group has been analyzing such a coordinated regulatory and fiscal approach. Our assessment is that an integrated multi-strategy approach has the best chance of realizing our objectives, since it shares the responsibility even handedly amongst the major stakeholders—industry and consumers, and each strategy reinforces the others. Gains only will come if we tackle all aspects of the problem simultaneously. Our proposal is to combine on improved version of CAFE regulations to push more fuel-efficient technology into new vehicles with a reinforcing feebate system imposed at time of vehicle purchase (substantial fees for purchasers who buy high fuel-consuming vehicles and rebates for those who buy low fuel consuming vehicles). Such a feebate system could be revenue neutral. To reinforce more fuel-efficient choices at vehicle purchase, taxes on transportation fuels should be steadily increased year by year for the next few decades by some 10c per gallon per year. These additional fuel taxes could be used to expand the now depleted Highway Trust Fund revenues to renovate our deteriorating highway systems and provide adequate maintenance. On the fuel side, in parallel, targets and a schedule could usefully be set for steadily increasing the amount of low greenhouse gas emitting biomass-based transportation fuels produced to augment our petroleum-based fuel supply. This would draw the petroleum and alternative fuel industries fully into our national effort. Details of our proposal area given in the attached MIT Energy and Environment article, “A Multipronged Approach to Curbing Gasoline Use” June, 2004, and its Bandivadekar and Heywood reference. Such a multi-strategy approach could also

provide a transition period so major U.S. market suppliers with different model lineups, and health care and pension legacy costs, would have time to respond appropriately.

Now let me say a few words about the second and longer-term path—working to implement a low greenhouse gas emitting energy stream for transportation. It may be that hydrogen will turn out to be the best of the low greenhouse gas emitting choices we have identified to date. There are, however, other options that warrant substantial Federal and industry R&D. The time scales for radical changes in technology to be implemented and have impact are long, much longer than we realize. My group at MIT is working hard to understand these important time scales better. There are several sequential steps that a new automotive technology must go through before that technology becomes a large enough fraction of the on-the-road vehicle fleet to make a difference. The first step is developing the new technology to the point where it is competitive in the marketplace with standard technology vehicles. While more expensive new-technology more-efficient vehicles can be subsidized, this can only be done to push their introduction up to modest levels. Once market competitive, the production volumes of the new technology components must expand to a significant fraction of total new vehicle production. For engines, for example, this takes one to two decades. For fuel cell hybrid vehicles we estimate this to be 20-30 years. Then the new technology must penetrate the in-use vehicle fleet and be driven significant mileage, which takes almost as long as the production expansion step. Thus for internal combustion engine hybrids the total time to noticeable impact is expected to be some 30-plus years. For hydrogen and fuel-cell hybrids it is likely to be more than 50 years. Hence my emphasis on the first path for nearer term improvements, and my judgment that any transition to hydrogen on a large scale is many decades away. (See MIT Energy & Environment article, “New Vehicle Technologies: How Soon Can They Make a Difference,” March, 2005, attached).

Now, some comments on a transition to hydrogen-fueled vehicles. First, the rationale for attempting such a transition is to significantly reduce greenhouse gas emissions from our transportation systems in the longer-term. Thus the source of the energy used to produce hydrogen is critical. It would have to be either coal or natural gas with effective carbon capture and sequestration, or nuclear power systems which generate both hydrogen and electricity. Electrolysis of water with “renewable electricity” from solar or wind energy does not appear a plausible way to produce hydrogen; it makes much more sense to use renewable electricity to displace coal in the electric power generating sector. Thus not only are there major hydrogen fuel cell technology issues (including cost) to be resolved, there are also major technical and cost challenges in the production, distribution and storage of hydrogen to be resolved as well. Hydrogen produced directly from fossil fuels without carbon sequestration, or from the electric power grid via electrolysis, even when used in fuel cell powered vehicles (which could be significantly more efficient than internal combustion engine powered vehicles), will not save energy nor reduce greenhouse gases.

Are there alternatives that warrant greater Federal resources? The above discussion suggests that electric vehicles with advanced high-energy-density batteries recharged with electricity from renewable or low CO₂ electric power systems is one at least partial

alternative. Such vehicles would be range limited, but if that range is more than say 200 miles these could be a substantial fraction of the market. Efficiently produced biofuels can also be low net CO₂ emitting and the extent these can contribute is not yet clear. New, much lighter weight, vehicle concepts, may be significantly smaller in size, are also likely to be a significant and necessary long-term option. All of these should be important parts of the U.S. Government's R&D transportation energy initiatives. While they are part of the Government's current portfolio, the level of funding, strategic planning, and industry and R&D community involvement should be increased.

Our longer-term list of plausible efficient vehicle technologies and the energy sources that go with them is too short, and the difficulties in realizing these options in the real world are so challenging, that a much larger Federal effort on this second path I have been discussing is warranted.

The above discussion broadly addresses the first two questions asked in the Committee's letter requesting testimony. Let me now provide a more focused summary of my response.

Question 1: How might the future regulatory environment, including possible incentives for advanced vehicles and regulations of safety and emissions, affect a transition to hydrogen-fueled motor vehicles? How could the Federal government most efficiently accelerate such a transition?

I have explained how important it is for the U.S. Federal government through regulatory and fiscal policies to reduce the energy requirements of our total transportation system. Not only would this help reduce our petroleum consumption and thus our oil imports in the nearer-term; it would also make the task of a future hydrogen transition (or more complex mix of low greenhouse gas emitting energy sources and technologies) significantly less challenging.

Question 2: Is the current balance of funding between hydrogen-related research and research on advanced vehicle technologies that might be deployed in the interim before a possible transition to hydrogen appropriate? What advanced vehicle choices should the federal government be funding between now and when the transition to a hydrogen economy occurs? How are automakers using, or how do they plan to use, the advanced vehicle technology developed for hydrogen-fueled vehicles to improve the performance of conventional vehicles? Are automakers likely to improve fuel economy and introduce advanced vehicles without government support?

The Government's FreedomCAR and Fuels program is a thoughtfully structured program of significant scale intended to advance hydrogen fuel and vehicle technologies. It is a partnership between DOE, Ford, DaimlerChrysler, GM and several petroleum companies. Its focus is on applied research with some pre-competitive advanced development. The program plan has had, and continues to have, substantial industry input. DOE cost shares major advanced development projects with the auto companies. The companies involved

have substantial programs of their own in these areas, though the details of these programs are largely proprietary. This program approach in my judgment does a reasonable job of using Federal funds to encourage the necessary development of new and better ideas, and new knowledge related to hydrogen and its use in transportation.

The FreedomCAR and Fuels Program also supports activities intended to improve the efficiency of mainstream engine and propulsion system technologies. Given the importance of the first pathway I have described, this Federal effort should be expanded. Also, efforts on advanced battery research and development, and biofuels should be expanded to better meet their potential importance in the longer-term. The Federal Government must play the role of supporting a broad portfolio of research relevant to transportation energy and transportations greenhouse gas emissions and involve all sectors of the R&D community that can contribute. Our universities, the source of the technical leadership we will need over the next several decades, must be more actively involved.

Question 3: What role should the Federal government play in the standardization of local and international codes and standards that affect hydrogen-fueled vehicles, such as building, safety, interconnection, and fire codes?

I have not addressed this question directly. Due to the long time scales involved in any transition to hydrogen or other new technologies, this is not as urgent a task as is technology development. However, as is already happening in the FreedomCAR and Fuels Program, work on these issues should be underway with the relevant Standards and Codes organizations, and with the industries involved.

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