Testimony to the U.S. House of Representatives Committee on Appropriations
Subcommittee on Energy and Water Development

FACING THE CHALLENGES OF OIL DEPENDENCE AND CLIMATE CHANGE: WHAT WILL IT TAKE?

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by

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Good morning Mr. Chairman, distinguished committee members and guests. Thank you for the opportunity to comment on what can be done in the near term to reduce oil consumption and decrease carbon dioxide emissions from motor vehicles.

WHY ARE GAS PRICES SO HIGH, AND WHAT IS IT COSTING US?

Since January 2003, the price of gasoline in the United States has doubled: from $1.50 to $3.00 per gallon (Figure 1). The principal driving force behind the increase in gasoline prices has been the price of petroleum on world markets. In 2003, the cost of crude oil purchased by U.S. refiners averaged $28.50 per barrel (U.S. DOE/EIA, 2007, table 5.21). Today, refiners have grown accustomed to oil prices in the range of $80 to $90 per barrel. A good rule of thumb is that the cost of the petroleum in a gallon of gasoline is equal to the price of a barrel of oil divided by 42 (the number of gallons in a barrel). By this method the cost of the oil in a gallon of gasoline increased from as little as $0.60 to $0.70 per gallon in 1998 to $2.00 per gallon today (Figure 1).

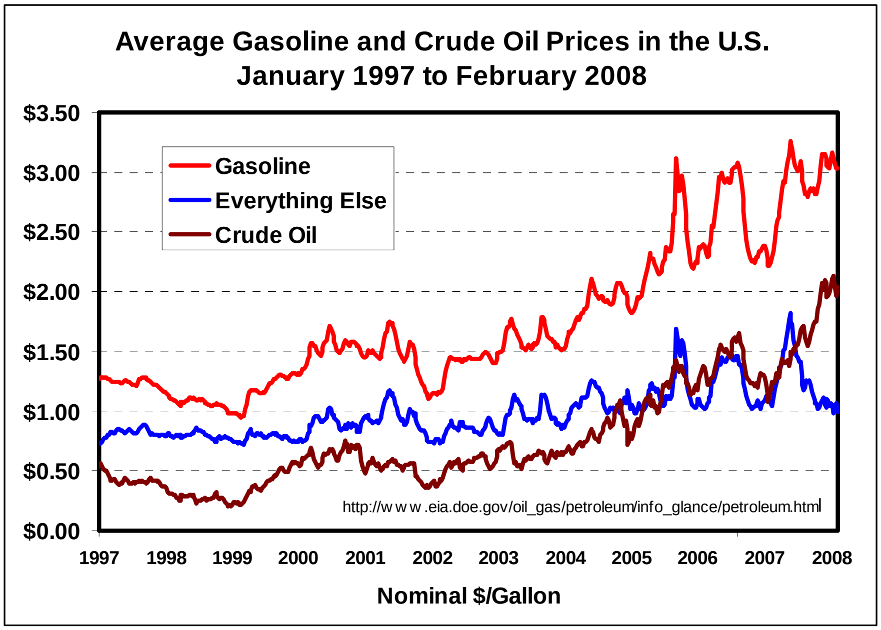

Figure 1. U.S. Gasoline and Crude Oil Prices: January, 1997 to February, 2008.

Higher prices for petroleum mean increased expenditures on motor fuel and a direct transfer of wealth from U.S. households, businesses and governments to oil exporting economies. The average U.S. household purchases approximately 1,000 gallons of gasoline each year to power its cars and light trucks for 21,000 miles (Davis and Diegel, 2007, table 8.7). Because vehicle use is relatively unresponsive to fuel prices (CBO, 2008), households are now spending $3,000 instead of $1,500 per year on fuel. Because almost 60% of the petroleum we consume is imported, roughly $900 of the increased cost of gasoline is a transfer of wealth from American consumers to oil exporting countries.

The economic cost of our dependence on oil is now at a historic high point (Figure 2). I estimate that in 2007 the economic costs of oil dependence exceeded $350 billion dollars, and that cumulative costs over the past five years have exceeded $1 trillion.[1] The economic cost of oil dependence has three components: (1) transfer of wealth equal to the quantity of oil we import times the monopoly profit per barrel; (2) dislocation losses arising from sudden and unexpected price shocks; and (3) potential GDP losses, which measure the effect of higher oil prices on our economy's ability to produce.

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[1] For an explanation of the methods by which these costs were estimated, see Greene and Leiby, 2006.

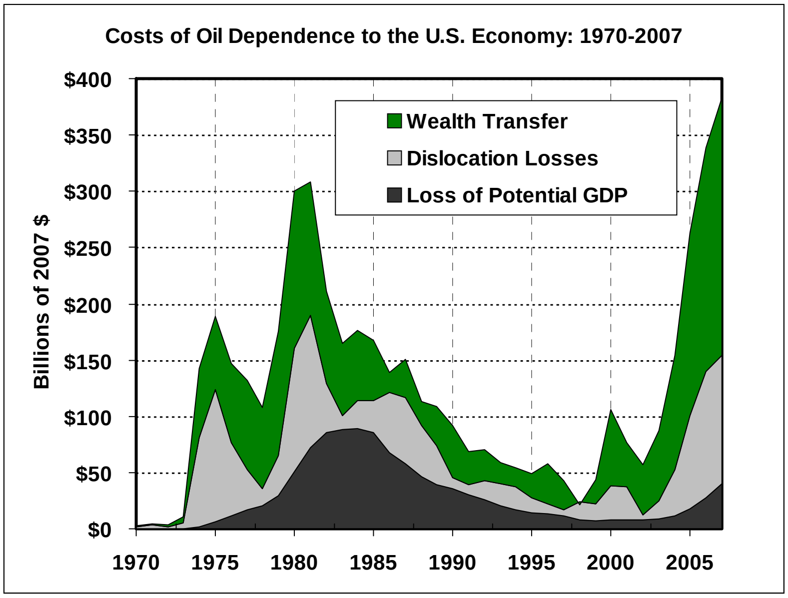
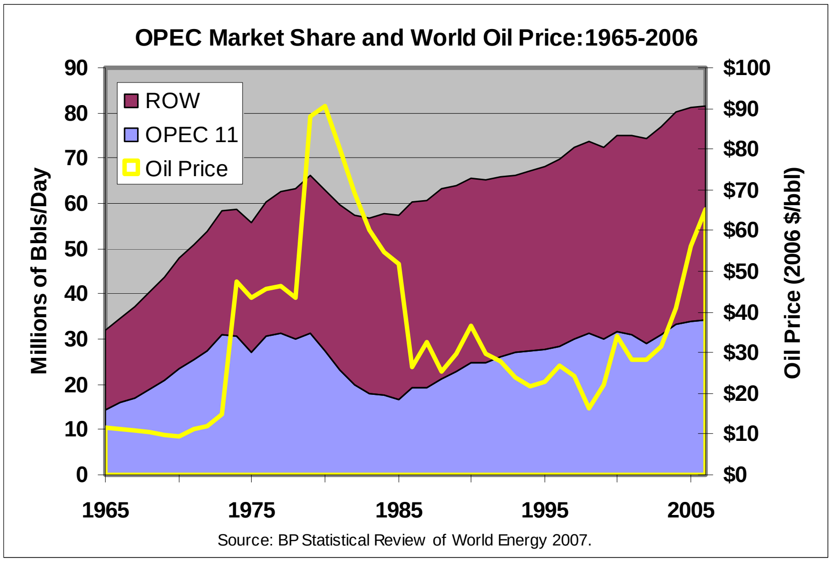


Figure 2. Estimated annual costs of oil dependence to the U.S. economy.

DÉJÀ VU?

The problem of high oil prices has been seen before, and solved, but only temporarily. Following the oil price shocks of 1973-74 and 1979-80, it took a combination of deregulated market responses to high oil prices, strong policy actions like fuel economy standards, and technological advances in energy efficiency and energy supply to bring down oil and gasoline prices. From 1977 to 1985, U.S. oil consumption decreased from 18.4 to 15.7 million barrels per day (mmbd) while U.S. supply increased from 9.9 to 10.6 mmbd. As a consequence, U.S. net imports of petroleum were cut in half, from 8.6 mmbd in 1977 to 4.3 mmbd in 1985 (U.S. DOE/EIA, 2007, tables 5.1 and 11.10). Other nations around the world took similar actions. Total world crude oil production shrank from 63 mmbd in 1979 to 54 mmbd in 1985, while oil supply outside of OPEC expanded from 29 mmbd in 1977 to 38 mmbd in 1985 (U.S. DOE/EIA, 2007, tables 11.5 and 11.10) (Figure 3).



Source: BP Statistical Review of World Energy 2007.

Figure 3. World Crude Oil Production, OPEC Share and the Price of Oil, 1965-2006.

During this period, OPEC members, led by Saudi Arabia, defended the high price of oil by cutting back on production year after year. Between 1980 and 1985, Saudi Arabia reduced its crude oil output from 9.9 million barrels per day (mmbd) to 3.4 mmbd (U.S. DOE/EIA, 2007, table 11.5). The production cutbacks eroded the cartel's market share to the point where it could no longer control the market, and in 1986 prices collapsed as OPEC members began to gradually increase the supply of oil to world markets (Figure 4).

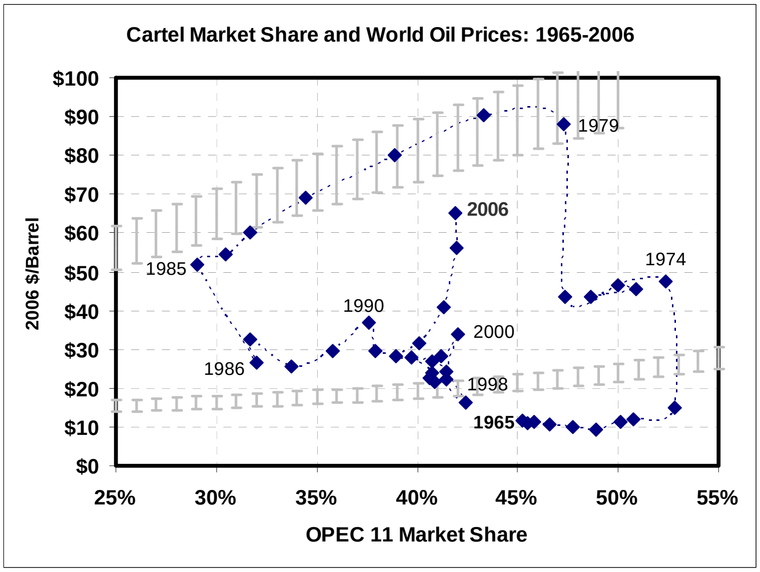


Figure 4. OPEC Market Share and World Oil Prices: 1965-2006[2].
Source: BP Statistical Review of World Energy, 2007.

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[2] The grey bars in figure 3 are estimated long-run (lower) and short-run (upper) profit maximizing oil prices for the OPEC cartel, as a function of its market share (Greene, 1991).

Unfortunately, after oil prices collapsed in 1986, we stopped trying to control our oil dependence. We left fuel economy standards virtually unchanged for two decades and lost interest in alternative energy sources for transportation. With petroleum cheap and plentiful, it was easy to convince ourselves that the problem had been solved once and for all, or even that there never really had been a problem.

WHAT'S DIFFERENT TODAY?

Several things are different today. The most important difference is the urgency of addressing climate change. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change concluded that the global climate is definitely warming and that anthropogenic emissions of greenhouse gases, predominantly carbon dioxide, are very likely the cause.

> "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (Figure SPM.1)."
>
> "Most of the observed increase in globally-averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations. It is *likely* there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica) (Figure SPM.4)."
> (IPCC, 2007, pp. 1-5)

Stabilizing atmospheric concentrations of greenhouse gases at levels that may avoid dangerous climate change will require strong measures like S.2192 (America's Climate Security Act) which requires deep, economy-wide reductions in greenhouse gas emissions by 2050. While solving the problem of oil dependence and curbing greenhouse gas emissions are mostly congruent goals, there are some areas in which they conflict.

Today, our oil dependence problem is even more about transportation than it was three decades ago. Much of the potential for sectors other than transportation to switch from petroleum to other energy sources has been accomplished. Before the first oil price shock in 1973, U.S. utilities consumed 3.1 quads of petroleum for generating electricity. In 2006, they consumed only 0.6 quads. Commercial sector petroleum use decreased from 1.6 quads in 1973 to 0.7 quads in 2006, while residential use declined from 2.8 quads to 1.4 quads over the same period. The industrial sector consumed 10.4 quads of petroleum in 1973 but used 7.9 quads in 2006. Meanwhile, transportation petroleum use increased from 17.8 quads to 27.2 quads (U.S. DOE/EIA, 2007, tables 2.1b to 2.1f). The 5 mmbd of petroleum used outside of the transportation sector is a large amount and should also be a target for energy efficiency and fuel substitution. Yet more than ever, our oil dependence problem is a consequence of transportation's dependence on oil.

Today, oil markets are less sensitive to price increases than they were in the 1970s. The doubling of fuel prices we have just experienced had only half as much impact on vehicle travel as the doubling that occurred during oil crises of the 1970s and 1980s (Small and Van Dender, 2007).

Rising incomes have made fuel costs less important relative to the value of travelers' time. At the same time the higher fuel economy of today's vehicle fleet has made gasoline a smaller factor in the overall cost per mile of travel. Motorists still change their behavior when fuel prices rise, but the changes are very small indeed (CBO, 2008).

It is very likely that oil producers outside of OPEC will be less able to increase the supply of conventional oil than they were thirty years ago. A key factor enabling the oil crises of 1973-74 and 1979-80 was the peaking of U.S. crude oil production in 1970. This important event is too often overlooked. Until 1970, the United States was the world's largest oil producer with considerable influence in the world oil market. Despite high oil prices, despite important new oil discoveries, despite impressive technological advances in oil exploration and development we have never since been able to achieve the level of production seen in 1970. Today, it appears that world oil production outside of OPEC is nearing a peak or perhaps a plateau as predicted by both the International Energy Agency (2006a, p. 95) and the ExxonMobil Corporation (2008). Increased conventional oil supply was a key contributor to bringing down oil prices in 1986 and supply from conventional and unconventional sources will also be in the future. But today it will be more difficult to increase conventional oil supply than it was thirty years ago (NPC, 2007, p. 94). If that proves to be the case, developing and implementing economically competitive, low carbon, alternative energy sources for transportation will be essential to simultaneously addressing the problems of oil dependence and climate change.

Finally, the need for more energy efficient technology is even greater today than it was thirty years ago. Today, proven, cost-efficient fuel economy technology for conventional gasoline vehicles allows only a 40-50% increase in miles per gallon by 2020, as opposed to the almost 100% increase required of new passenger cars in the Energy Policy and Conservation Act of 1975.[3] The Energy Independence and Security Act of 2007 set an appropriate, cost efficient target of 35 miles per gallon for light-duty vehicles by 2020. However, much more is needed to achieve oil independence and stabilize the global climate. To achieve the doubling or tripling of energy efficiency we need, and to transform the energy basis of our transportation system will require many new technologies.

WHAT CAN ADVANCED TECHNOLOGY DO?

Beyond 2020, advanced technologies will be needed to continue improving vehicle fuel economy without sacrificing customer satisfaction or safety. Researchers at MIT's Sloan Automotive Laboratory estimate that fuel economy increases of 80-85% for internal combustion engine vehicles may be attainable by 2030 (Figure 5). Achieving the potential improvement of 80-85% will require technological advances in several areas, including variable compression ratio engines, catalysts for reducing nitrogen oxide under lean air-fuel ratios, low rolling resistance tires and advanced materials to provide improved safety while reducing vehicle mass by 20% (Kasseris and Heywood, 2007). The MIT study concluded that future hybrid vehicles could attain almost three times the miles per gallon of today's conventional vehicles, given major

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[3] The definition of cost-efficient used here is the same as that of the National Research Council (2002) report on the Corporate Average Fuel Economy Standards.

advances in power electronics and batteries (e.g., consistent with the Department of Energy's FreedomCar and Vehicle Technologies program goals).

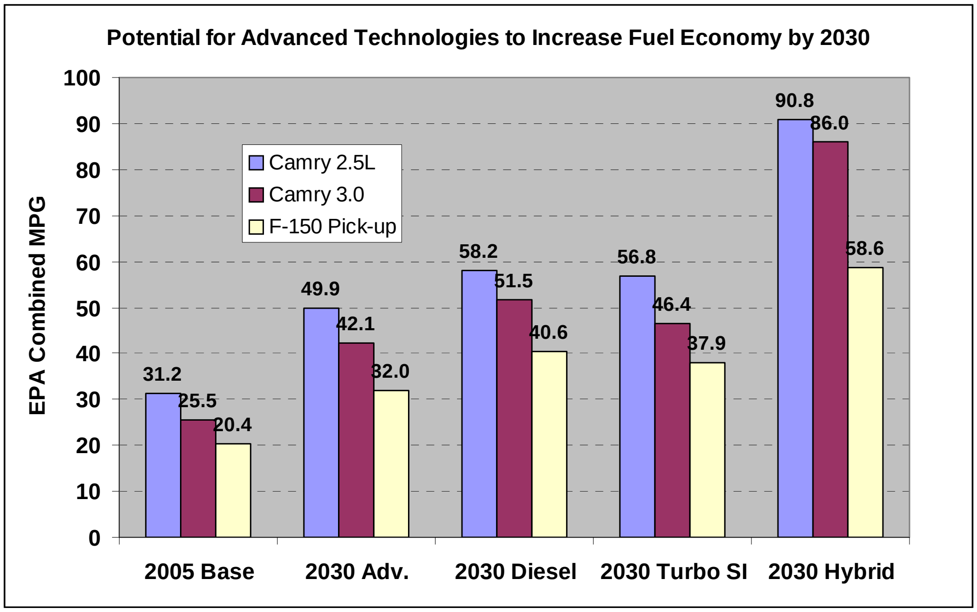


Figure 5. Potential for Advanced Conventional Vehicle Technologies to Increase Fuel Economy by 2030.

Doubling or even tripling light-duty vehicle fuel economy would save consumers tens of billions of dollars each year and make a major contribution to reducing greenhouse gas emissions. But even that will not be enough. Figures 6a-6d show my analysis of the impacts of increasingly higher fuel economy levels on fuel use and CO_2 emissions from passenger cars and light trucks by 2050 (Figure 6a). My projections are based on an extrapolation of the Energy Information Administration's 2007 Annual Energy Outlook Reference Case. In the Base Case, a doubling of vehicle travel causes about a two thirds increase in fuel use and CO_2 emissions by 2050. Complying with the EISA of 2007 restrains the growth of fuel use and emissions through 2025, but levels in 2050 are still almost 50% higher than in 2005. Doubling new vehicle fuel economy by 2030 is able to hold emissions in 2050 to current levels, offsetting all the increase in travel (Figure 6c). Tripling new vehicle fuel economy by 2050 produces about a 15% reduction over today's levels by 2050. To reduce CO_2 emissions by 60-80% by 2050 will require alternative, low carbon sources of energy for transportation vehicles.

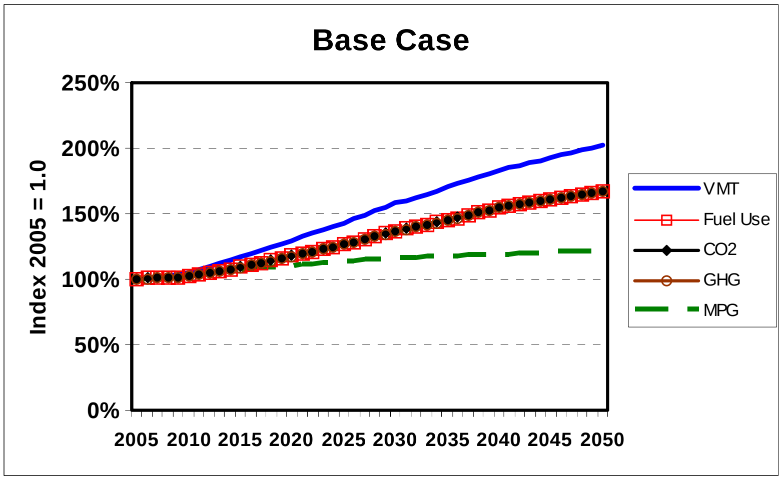


Figure 6a. Projected Fuel Use and CO_2 Emissions by Light-duty Vehicles Based on an Extrapolation of the AEO 2007 Reference Case from 2030 to 2050.

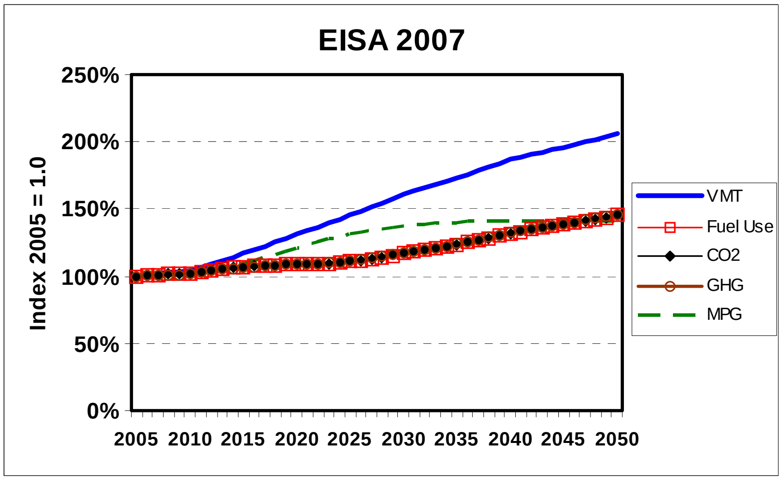


Figure 6b. Projected Fuel Use and CO_2 Emissions by Light-duty Vehicles Assuming the Energy Independence and Security Act of 2007's 35 MPG Requirement is Met.

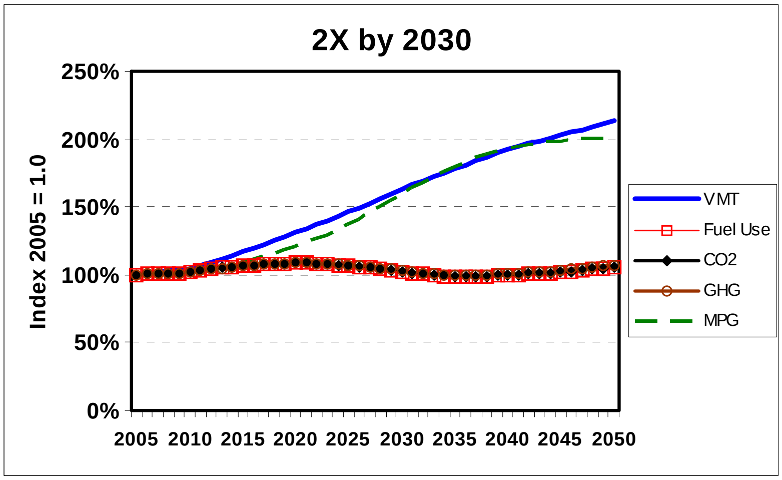


Figure 6c. Projected Fuel Use and CO_2 Emissions by Light-duty Vehicles Assuming the Average Fuel Economy of New Vehicles is Doubled by 2030.

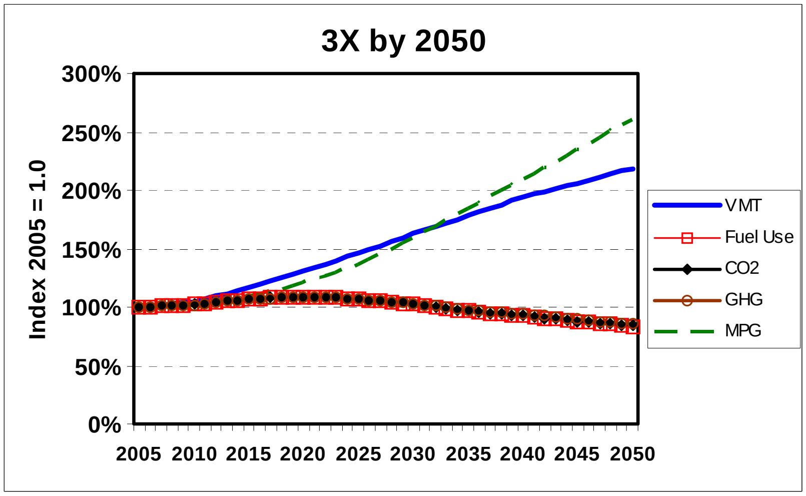


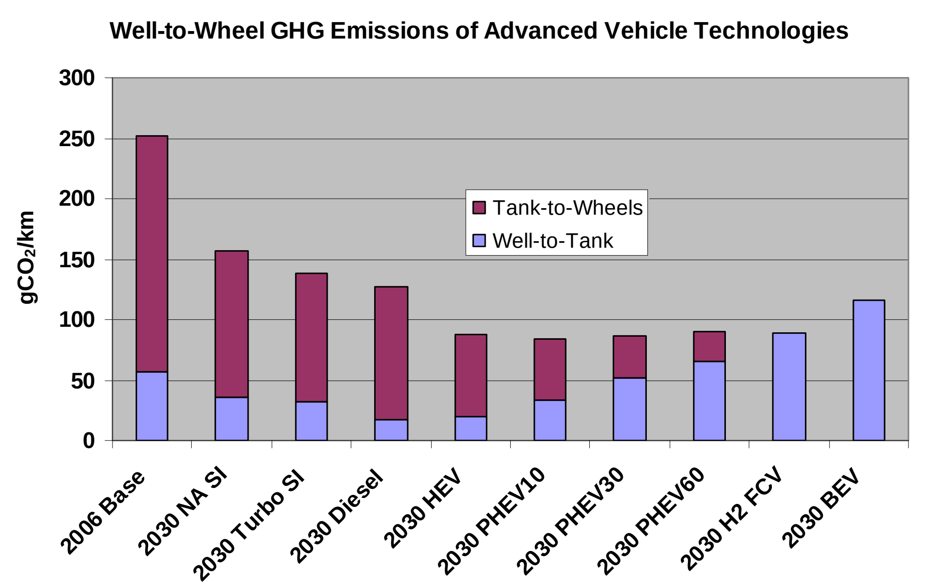
Figure 6d. Projected Fuel Use and CO_2 Emissions by Light-duty Vehicles Assuming the Average Fuel Economy of New Vehicles is Tripled by 2050.

Biofuels have the potential to make an important contribution. The United States possesses enormous agricultural resources. A joint study by the Departments of Energy and Agriculture concluded that the U.S. is capable of producing enough biomass (over 1.3 billion tons) to displace 30% of our present petroleum use (Perlack et al., 2005). The overwhelming majority of that resource potential is ligno-cellulosic biomass, not starch, sugar or oils. Significant advances in conversion technology and supply chain processes will be necessary if biofuels from ligno-cellulosic biomass are to compete with petroleum, even at prices of $50-$60 per barrel (IEA, 2006b, p. 283).

It has become clear, however, that without breakthroughs in methods of producing biofuels from ligno-cellulosic feedstocks, the levels of production envisioned by current policy will have serious impacts on food prices and may even increase net greenhouse gas emissions (Searchinger et al., 2008; Fargione et al., 2008). It is time for a comprehensive reassessment of our national biofuels policy. The choice of feedstocks, production methods, types of fuels produced and induced land use changes are critical to determining global climate change impacts of biofuels. We urgently need to incorporate such considerations in our policies. However, this is not the time to give up on our biofuels goals. Rather, this is the time to apply our best science and best policy analysis to insure that we can use our biomass resources in the ways that are most efficient and environmentally beneficial.

Achieving the magnitude of greenhouse gas reductions that appear to be necessary for climate stabilization will ultimately require the integration of electricity and or hydrogen into the transportation sector's energy mix, in addition to policies to decarbonize electricity generation and hydrogen production (Edmonds et al., 2004). This will require significant advances in battery technology, as well as continued improvements in electric motors and power electronics. The potential for hydrogen powered transportation likewise depends on significant advances in fuel cells, on-board hydrogen storage and hydrogen production from renewable sources or nuclear energy. If these technologies can be made competitive, they can not only displace petroleum and increase the responsiveness of petroleum demand to its price, they can diversify the transportation sector's energy resource base.

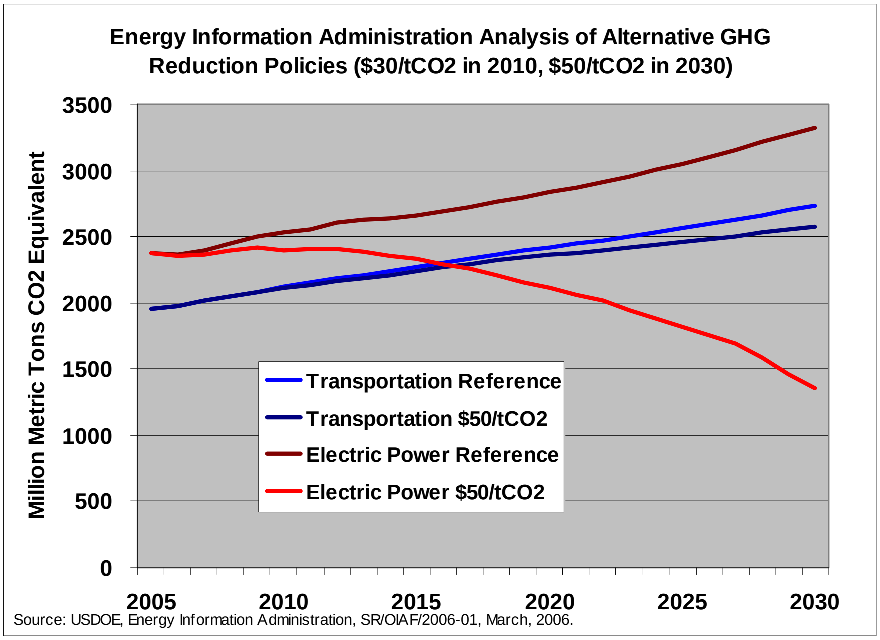
Another study by MIT's Sloan Automotive Laboratory (Kromer and Heywood, 2007) concluded that advanced hybrid electric vehicles (HEV), plug-in hybrid vehicles (PHEV), fuel cell vehicles (FCV) and battery electric vehicles (BEV) had the potential to reduce CO_2 emissions from motor vehicles by two thirds (Figure 7).



Source: Kromer & Heywood, 2007. Assumes H2 from natural gas, electricity is EIA 2030 mix.

Figure 7. Projected Well-to-Wheel Greenhouse Gas Emissions of Advanced Vehicle Technologies.

But the MIT well-to-wheel emissions calculations assume that electricity and hydrogen will be produced in the future by much the same methods used today. With appropriate carbon policies the upstream emissions from electricity generation and hydrogen production can be drastically reduced or nearly eliminated, eventually resulting in almost carbon-free vehicle travel. A carbon price of $30 per ton of CO_2 in 2010, increasing gradually to $50 per ton of CO_2 by 2030 would reduce emissions from the electric power sector in 2030 by more than 40% versus 2005 levels, according to an analysis by the Energy Information Administration (U.S. DOE/EIA, 2006). On the other hand, the same level of carbon price was estimated to have little impact on transportation emissions, in the absence of complementary policies such as tighter fuel economy standards or major breakthroughs in vehicle technologies (Figure 8).



Source: USDOE, Energy Information Administration, SR/OIAF/2006-01, March, 2006.

Figure 8. Energy Information Administration Analysis of the Impacts of the Price of Carbon on Emissions from the Electric Power and Transportation Sectors.

CONCLUDING OBSERVATIONS

The energy challenges we face today appear to be greater than those of the 1970s. Today, our solutions to the problems of oil dependence must also put us on a path to avoid dangerous climate change. In 1970 it was our own oil production that was peaking and gradually declining. Today, it appears that world production outside of OPEC is nearing a peak or plateau. Then, we achieved a temporary solution. Today, the challenge of climate protection requires a sustainable solution. The same tools are available: market forces, government policies, science and technology. But today the challenge is greater.

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