Societal Cost-Benefit Analysis of Transportation Options in a Carbon-Constrained World

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Societal Cost-Benefit Analysis of Transportation Options in a Carbon-Constrained World

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Many alternative vehicle and fuel options are under consideration to alleviate the triple threats of climate change, urban air pollution and petroleum dependence caused by operating motor vehicles. We report the results of a dynamic computer simulation model comparing the societal costs and benefits of biofuels, hybrid electric vehicles, plug-in hybrids, fuel cell electric vehicles and battery electric vehicles over the 21st century. We conclude that all-electric vehicles will be required to reduce greenhouse gas emissions by 80% below 1990 levels as shown in Figure 1, to eliminate most oil consumption from motor vehicles, and to eliminate most controllable urban air pollution. Partial electrification via hybrids and plug-in hybrids help, but we must eventually discard the venerable internal combustion engine to meet our societal goals. There are two primary choices for all-electric vehicles: batteries or fuel cells. We show that for reasonable travel range, hydrogen-powered fuel cell electric vehicles are superior to battery electric vehicles and provide greater societal benefits at lower cost. For example, Hydrogen-powered FCEVs would reduce total US societal costs by total US annual societal costs due to pollution and dependence on imported oil could be reduced by over $319 billion by the end of the century with hydrogen-powered FCEVs compared to a base case using only hybrid electric vehicles (HEVs) as shown in Figure 2, while gasoline-powered plug-in hybrid electric vehicles (PHEVs) would at best cut societal costs by $134 billion per year by 2100 as shown in Figure 2. BEVs, if they could power all US vehicles (including light-duty trucks and SUVs) would cut societal costs by $300 billion, still less than the FCEV societal cost reduction of $319 billion per year by the end of the century.

In addition to FCEVs reducing societal costs more than BEVs, GHGs and oil imports, FCEVs would cost less (according to Kromer and Heywood of MIT in their 2007 report, FCEVs would cost $6,600 less than BEVs in mass production) and the US Government infrastructure incentives needed for a distributed hydrogen fueling infrastructure would be less (US$831 million) than the government incentives required to install public charging stations for BEVs (US$1.12 billion).

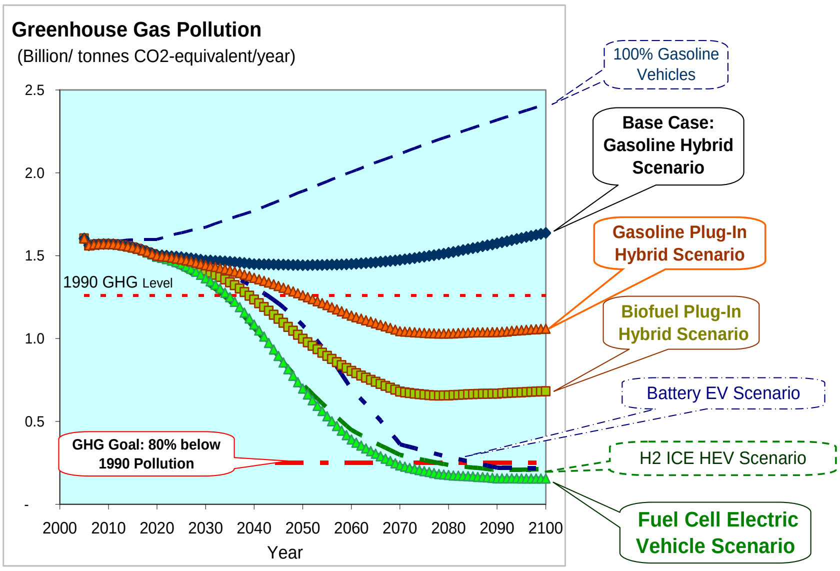

Figure 1: **Greenhouse gas pollution from light duty vehicles in the US over the 21st century with different alternative vehicle options; adding only hybrid electric vehicles (HEVs) to the fleet increasess GHGs to 30% above 1990 levels by the end of the century. Adding plug-in hybrid electric vehicles (PHEVs) to the mix would cut GHGs to 175% below 1990 levels, and fueling PHEVs with biofuels would reduced GHGs to 46% below 1990 levels levels. Hydrogen-powered ICE HEVs would cut GHGs to 75% below 1990 levels, and battery electric vehicles (BEVs) would reduce GHGs to 83% below 1990 levels, assuming that BEVs could be used in all US vehicles including light duty trucks, sports utility vans (SUVs). Adding Hydrogen-powered fuel cell electric vehicles (FCEVs) would cut GHGs to 87% below 1990 levels by the end of the century.**

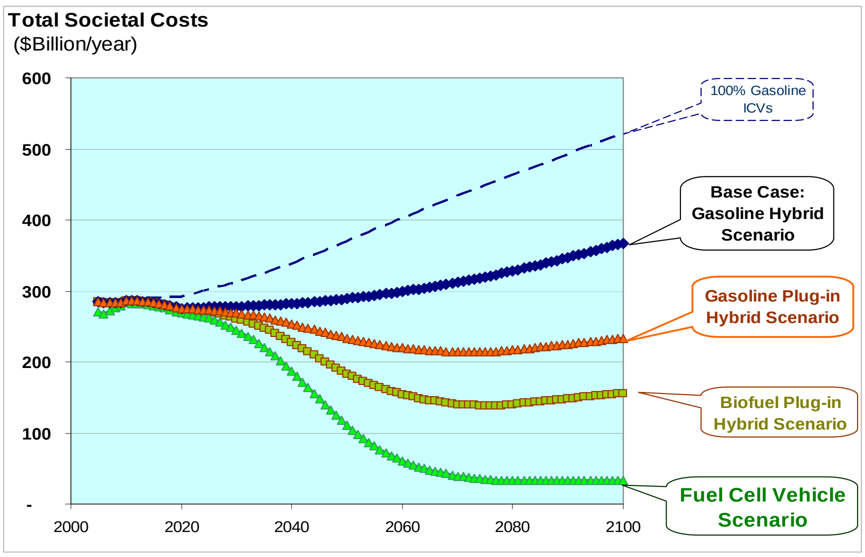

Figure 2: **Estimated total societal costs in the US due to local air pollution, greenhouse gas emissions and the economic and military costs of protecting access to imported oil**