NCEP Technical Appendix

Chapter 1: Enhancing Oil Security

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The Costs of US Oil Dependency

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Resources for the Future

November 17, 2004

Paper prepared for the National Commission on Energy Policy.

1. Introduction

Energy security may broadly be described as a state of affairs characterized by conditions and policies that safeguard the health of the US economy against circumstances threatening significant short- or long-term increases in energy costs. It is a concept with many dimensions, only one of which—the problem of dependence on a world oil market characterized by substantial price volatility and exercise of market power—will be addressed in this paper.[1] Even the energy security aspects of oil dependence are numerous: some are geopolitical (e.g., efforts to promote the stability of oil-exporting regimes), while others revolve around geological or technological issues (e.g., the payoff from R&D investments to expand domestic liquid fuel reserves). However, the topic addressed here—the economic costs of US oil consumption and import dependence—occupies a central place in energy security policy analysis and debate. The exposition proceeds as follows.

Section 2 sets the scene with a brief statistical background, including trends in US petroleum consumption, imports and where they come from, oil prices, the energy-intensity of GDP, and the world distribution of known oil reserves. We also discuss the potential power of OPEC to manipulate world oil prices, projected trends in US oil dependency, the effect of oil prices on aggregate economic activity, and the potential role of the Strategic Petroleum Reserve in mitigating against price shocks.

Section 3 discusses the components of the oil premium and recent quantitative assessments of them. The premium reflects the extent to which the costs to the US from an extra barrel of petroleum consumption exceeds the private costs paid by oil users; it tells us how much policy intervention to reduce oil dependency is warranted on economic grounds through, for

[1] Other dimensions include dangers to the country's energy infrastructure (transmission lines, refineries, electric power stations, pipelines, terminal facilities, etc.), safety concerns over civilian nuclear power, and disruptions in liquefied natural gas shipping, a growing factor augmenting the nation's natural gas supplies.

example, energy conservation measures. The premium has two main components, one reflecting US monopsony power in the world oil market and ability to lower oil prices by reducing imports. The other reflects disruption costs from potential future oil price shocks including temporarily higher oil payments to overseas suppliers and a range of adjustment costs throughout the economy as industries respond to higher energy prices. Both monopsony and disruption components are difficult to pin down accurately, as a number of factors are uncertain, such as how OPEC would respond to a cut in US oil imports, the likelihood of future price shocks, and the extent to which the private sector takes into account the risk of price shocks.

Estimates of the oil premium have fallen over time as the oil-intensity of GDP has declined, price volatility and oil market disruptions are less pronounced than twenty years ago, and the private sector can now respond more flexibly to shocks. Recent estimates put the total premium at between around \$0 and \$14/barrel, equivalent to between 0 and 30 cents/gallon of gasoline; our best assessment is that the premium is around \$5/barrel. Whether the premium will increase or decrease in the future is unclear: the share of oil in US GDP will continue to decline while the imported share of US oil petroleum will continues to rise. One caveat is that studies of the oil premium could be biased downwards as they do not account for certain geopolitical factors that are not easily quantified, such as the risk of oil supply sabotage by terrorists or the takeover of Saudi Arabia and other oil rich nations by extremist governments willing to sacrifice oil revenues to inflict economic damage on the US.

A final section briefly comments on some policy implications.

2. Background

A. Basic Oil Statistics

The United States consumes almost 20 million barrels of petroleum per day (MBD), or 7.2 billion barrels annually. Easily the most important use is the production of gasoline for motor vehicles, which accounts for 45% of petroleum products; distillate fuel oil (e.g. diesel fuel) accounts for 19%, liquefied petroleum gases 10%, aviation fuel 8%, and a variety of other uses combined 18% (see Figure 1).

US demand for petroleum fell from an initial peak of 18.8 MBD in 1978 to 15.2 MBD in 1983 following the second major oil price shock; since then it has grown steadily with the general expansion of the economy, increased demand for travel, etc., and is now around 20 MBD (Figure 2). However the petroleum intensity of GDP has almost halved in the last 30 years, down from 1.5 barrels per thousand dollars of (real) GDP to 0.8 barrels in 2000 (Figure 2), with improved energy efficiency and a shift away from oil in the electricity sector.[2] Declining oil intensity means that the effect of oil price changes on the economy is significantly less—in relative terms—than in the 1970s.

[2] For example, average fuel economy of all on-road vehicles has increased by 40% over the last three decades, though the growth has stalled in recent years with the increasing market share of sport-utility vehicles, pickup trucks and minivans (see www.fhwa.dot.gov/ohim/onh00/line9.htm).

The United States currently imports 11.6 million barrels of petroleum per day, or 59% of its consumption, compared with 23% in 1970 (Figure 3). There was a sharp fall in the oil-import fraction from the late 1970s to the mid 1980s as high prices encouraged an expansion of high-cost domestic production; however domestic production has been steadily losing ground to low-cost foreign suppliers since then as oil prices have fallen. 47% of US oil imports currently come from OPEC countries, and about half of OPEC imports come from the Persian Gulf, with Saudi Arabia being the dominant exporter. Canada and Mexico combined supply about half of non-OPEC imports to the United States. The United States is easily the world's largest oil consumer, accounting for 25.4% of world consumption (Table 1).

OPEC countries produce around 42% of world oil, and of these supplies 68% come from the Persian Gulf (Table 2). Saudi Arabia produced 8.0 MBD in 2001, while Iran, Iraq, Kuwait and United Arab Emirates each produced between 2.0 and 3.7 MBD. Venezuela and Nigeria are the two largest non-Gulf OPEC producers. The major non-OPEC producers include Russia (7.1 MBD in 2001), United States (5.9), China (3.3), Norway (3.2), and Mexico (3.1). It is estimated that the Persian Gulf region has around two-thirds of the world's known oil reserves (that would be profitable at current prices), while the United States has only 2% of reserves (Table 2).[3]

B. Previous Oil Price Shocks and Trends

The two most dramatic oil price shocks both doubled prices—from around $12 per barrel to $25 during the Arab-Israeli war in late 1973, and up to $50 per barrel in 1980, following reduced production during the Iran-Iraq war (figures in 1996 dollars). Prices fell rapidly after that, and since the mid-1980s prices have fluctuated between $12 and $25 per barrel (Figure 4).[4]

The main cause of the two big price shocks was supply disruptions by Persian Gulf countries.[5] Middle-East production was cut back by 4–5 MBD in each case, which then represented a world oil supply reduction of nearly 10%. In the short run (up to a year), the demand for oil is very insensitive to price: a typical estimate for the short-run price elasticity is –0.1 (e.g., Huntington 1991, 1993). This implies that a 10% oil supply reduction would initially double the world oil price.

After the oil price shocks, OPEC members restrained production through negotiated country quotas in succeeding years in an attempt to keep prices at the new higher levels: for example, OPEC production fell from 30.6 MBD in 1979 to 16.2 MBD in 1985 (Figure 5). Nonetheless, prices still fell steadily; over time higher prices encouraged a reduction in demand

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[3] Known economic reserves grow over time with exploration and improved technology for extracting it. Nonetheless the US geological survey's world petroleum assessment puts ultimate world resources at about double currently known reserves, with 55% located in the Persian Gulf region and 5% in the United States.

[4] All these figures refer to oil prices averaged over a year. The variation in spot prices is obviously more dramatic; for example prices reached $40 per barrel in September 1990, prior to the first Gulf war.

[5] Another contributory factor may have been excessive oil inventory buildup in 1979-80.

through energy conservation, fuel switching, etc. and oil production increased in non-OPEC countries as previously uneconomic wells became profitable and increased exploratory activity brought previously unknown reserves on-line.

At the beginning and the end of the 1990s there were two further oil price rises, though they were less pronounced than in the earlier period. In 1990 during the first Gulf war, oil output from Kuwait and Iraq fell by almost 5 MBD; however expanded production from Saudi Arabia made up much of the lost supply. And from 1998 to 2000 oil prices jumped from $12.1 to $26.4 per barrel. This resulted from OPEC expanding production just as East Asia was going into an unexpectedly sharp downturn; to correct the oil glut OPEC cut production in 1999, just as East Asian economies rebounded faster than anticipated.

Finally, a causal inspection of Figure 5 does not reveal any obvious long-run upward trend in oil prices, counter to some predictions during the 1970s that the world was running out of oil. So far at least, exploration and improvements in extraction technology have neutralized any pressure for rising prices from the depletion of oil reserves.

C. Market Power of OPEC

Worldwide, there are several exporting countries that are willing to produce well below their capacity in order to retain influence over prices; they include the big five Persian Gulf exporters listed in Table 2, Venezuela, and two non-OPEC countries (Mexico and Norway).[6] OPEC is a far cry from a well-coordinated group of countries agreeing on a single strategy to maximize their joint profits from oil exports. Nonetheless, at least in theory, a number of factors facilitate their ability to manipulate prices. One is that significant supply reductions can have a dramatic immediate effect on raising oil prices and profits for oil exports, as world demand, and supply in non-OPEC countries, are highly price insensitive in the very short run. Another is that seven countries in OPEC are responsible for over 80% of its production, limiting the number of governments that must reach agreement for an effective strategy. And oil is a homogeneous product, which makes it easier to check whether member countries are sticking to agreed limitations, at least as production data becomes available on a quarterly basis.

However OPEC is hardly a unified bloc; under the Baathist regime Iraq went to war with Kuwait and Iran, and Iran has frequently differed with Saudi Arabia. And among OPEC's 11 member countries there is no enduring consensus about pricing policy. In general the countries with large populations and urgent requirements for development financing tend to favor the highest possible oil prices now. But the countries with large reserves and smaller populations, particularly Saudi Arabia and Kuwait, take a longer perspective and seek to manage prices to maximize returns over a period of decades. That means holding prices down to discourage large new investments in high-cost sources by non-OPEC suppliers, and major innovation on the demand side to further reduce oil dependency. The current target range in the Saudi-Kuwaiti

[6] Other oil-producing countries, including the United States, run at or close to full capacity, making them price takers.

strategy seems to be around $20–28 per barrel. In the absence of unusual emotional circumstances, such as the 1973 Arab-Israeli war, the Saudi-Kuwaiti strategy usually prevails.

On balance the evidence appears to suggest that OPEC, or at least a core group within OPEC, has acted as a monopolistic cartel in the past. Empirical studies suggest that OPEC supply behavior conforms more closely to an (imperfect) output-sharing cartel than a competitive model (e.g., Griffin 1985, Dahl and Yücel 1991, Jones 1990).[7] Furthermore, most estimates of marginal production costs for OPEC producers, or prices that would prevail in a competitive market, are well below observed prices.[8]

D. Projections of Future US Oil Dependence

Table 3, which is based on the Energy Information Administration (EIA)'s "Reference Case", shows projections for various oil statistics over the next 25 years. These projections reflect several widely accepted trends.

The first is steadily increasing US petroleum consumption from around 20 MBD in 2000 to just under 30MBD by 2025. This is due to the anticipated expansion of the economy in general, and continued growth in the demand for travel (despite increasing congestion on roads).

Second, OPEC's steadily growing share of world oil output from around 40% today to around 50% by 2025, which reflects the large concentration of low cost reserves among its Persian Gulf members. This is in spite of expanded supply in certain non-OPEC countries, particularly Russia.[9]

Third, a steep increase in the share of imports in US oil consumption, up from 42% in 1990 to 68% (or 20 MBD) by 2025. This reflects the growing gap between rising domestic demand and stagnant domestic supply.

Fourth, however, the EIA projects a further decline in petroleum intensity of GDP, down from 4.2 Btus per $1 of GDP in 2000 to 2.8 in 2025, suggesting that the costs from a given price spike will be a smaller proportion of GDP.[10]

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[7] And the casual observation that OPEC routinely sets production quotas implies that its members believe they can manipulate market prices.

[8] Estimates of the costs of developing reserves, adjusting for depletion or scarcity rents, suggest marginal costs for Persian Gulf producers of below $2/barrel (e.g., Adelman and Shahi 1989, Dahl and Yücel 1991). And predictions of oil prices in simulated competitive markets by Energy Modeling Forum (1992) and Greene and Leiby (1993) are around $5 to $10/barrel (in year-1990$).

[9] In non-OPEC countries producing up to where price equals marginal cost, in the absence of major technological change, there is little incentive to expand future production without a significant increase in the world oil price: US oil output remains essentially flat over the projection period. In contrast OPEC countries, currently producing at well below capacity, can easily and profitably respond to future increases in demand without a significant price jump.

[10] One reason for the continued decline is that vehicle miles traveled tend to grow by less than in proportion to GDP over time.

A final, important projection is that the long-term world oil price is expected to remain more or less constant, at somewhat below $30/barrel (in 2001 dollars). The assumption here is that OPEC will continue to keep a lid on prices, as it seems, with at least limited success, to have been able to do since the 1980's; this will enable the organization to protect and increase its market share over time.

These projections, though perhaps best-guess view of future developments, are not the only plausible scenarios. Table 4 summarizes the implications of six alternative cases constructed by the EIA. A couple of noteworthy points emerge from the table.

First, projections of rising oil import dependence are not very sensitive to the rather wide range of alternative economic and technological scenarios postulated by EIA. Oil imports vary between 64.5% and 70.0% of domestic consumption across all EIA's scenarios, all of which are considerably in excess of the 53% figure for the year 2000. Second however, the significant reduction in the nation's oil intensity characterizes all cases shown; even the least dramatic change (the case reflecting a pessimistic technological outlook) still shows a roughly 25% decline in oil intensity between 2000 and 2025.[11]

E. Effects of Oil Price on Aggregate Economic Activity

There are a number of ways that an oil price increase could lead to a reduction in aggregate economic activity. On the supply side, higher input prices raise the cost to firms of producing output, which induces them to cut back the level of production. On the demand side, the transfer of purchasing power from domestic consumers to overseas suppliers reduces aggregate domestic demand for goods and services.[12]

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[11] These projections are sometimes held to be of limited usefulness because of EIA's mandated bar to injecting policy change assumptions (e.g., an increase in the federal gasoline tax) in its analysis, which therefore produces what some see as "safe," "conservative," or "uninteresting" results. However, there is latitude in EIA's consideration of other policy-driven trends; for example, alternative scenarios of OPEC behavior that give rise to a range of world oil prices are considered. Moreover, EIA's alternative technology cases (such as in transportation or electric generation) have value even if uncoupled from any assumptions about changed or new policies. Imaginative users of the projections can, after all, speculate on, and debate, policies (say, tax breaks or R&D subsidies) needed to satisfy the technological cases and outcomes postulated by EIA. Of course, quite apart from the "hands-off" rule on policy, there is the matter of EIA's methodology and analytical framework. But we do not in this report take up those technical aspects. Readers interested in doing so will find descriptive details in Appendix G—"Major Assumptions for the Forecasts"—in *Annual Energy Outlook* 2003. Assumptions underlying the "International Energy Module" component of the U.S. projections can be accessed at www.eia.doe.gov/oiaf/aeo/assumption/international.html. The approach to international energy demand and supply projections are briefly described in EIA, *International Energy Outlook* 2003, p. 249.

[12] If the government responds to oil price spikes by contracting the (growth of the) money supply, this may compound the reduction on GDP. However, analysts disagree on both the extent to which monetary policy has been used in this way, and on the extent to which it can affect GDP in the short term.

Many studies have documented an inverse empirical relation between oil prices and aggregate economic activity.[13] In an extensive survey of the early literature, Jones and Leiby (1996) find that a 1% increase in oil prices reduces GNP by around 0.02 to 0.08%, with most estimates clustered around 0.05%. At the time, these estimates were roughly equal to the share of oil expenditure in GNP; from the mid 1970s to the mid 1980s this share was around 4–6%. However this share has now fallen to below 2%, suggesting that the relation between oil prices and economic activity has weakened significantly.

That volatility in oil prices—especially precipitous and significant increases in price—should exact an economic penalty makes intuitive sense. An oil-intensive firm faces increasing costs, whether it chose to maintain its oil input at its existing mix of productive factors or it opted prematurely to write off investments in order to adapt to new oil-market conditions. If there were many firms in this situation, or if there were major spillover effects to other firms and broad industry groups, it is easy to see why nationwide productivity and economic growth would suffer. However, the fact that the economy has become progressively less oil-intensive the case for significant macroeconomic impacts of oil price increases becomes harder to make.

From an exhaustive literature survey and analysis of the long-term oil price-GDP relationship extending to the late nineties, Brown and Yücel (2002) though circumspect in drawing firm conclusions, note that the "sensitivity of the U.S. economy to oil price shocks seems to have decreased over the past two decades". Indeed, looking at the behavior of GDP and oil prices during the most recent decade, one finds little evidence of a closely linked relationship. Of the thirteen years 1990-2002, more than half exhibited an anomalous relationship between the two—small declines in GDP accompanying large declines in oil prices; trend-line growth in GDP in spite of large increases in oil prices (see Figure 6). Most striking is the year 2000—oil prices rising by two-thirds, yet GDP growth is 3.7%.

Of course, to claim from any of the foregoing insensitivity of GDP to oil price changes could be a gross misreading of the relationship. For one thing, without, for example, the 68% rise in oil prices in 2000, GDP might have grown much more than it did. Also, the period dating from around the mid-nineties has been described by some as one characterized by some unique phenomena—notably, developments related to information technology. The effects of these developments might have dominated the effects of turmoil in energy markets. Under more normal circumstances, such effects might have been deduced from the data.

Aside from the economic impact of short-term fluctuations, concern is also expressed about the economic consequences of sustained, long-term increase in oil prices. Since, over the long run, producers have greater flexibility to alter their production function so as to accommodate to an observed trend in oil prices, one would expect a more muted impact on the GDP trend line. Whether for that reason or other explanations (including methodological quirks), it is interesting to note that EIA's most recent "oil price" cases for the period 2001-2025 discloses little measurable effect on GDP whether or not there is a large departure in the oil price from that projected in the "reference" case; projected average annual growth in GDP varies

[13] See for example Mork and Hall (1980), Darby (1982), Gisser and Goodwin (1986), Hamilton (1983).

across a very narrow range of 3.20–3.23% as the trend in oil prices to 2025 is increased and decreased by 30%.

F. Use of the Strategic Petroleum Reserve to Counteract Short Term Price Volatility

The US Strategic Petroleum Reserve (SPR) provides one means to calm and stabilize oil markets through timely, Presidentially-directed releases of emergency crude oil stocks.[14] The volume of oil in the SPR in mid-year 2003 amounts to around 600 million barrels, or around 52 day's worth of imports. Although the level of oil in the SPR has not changed much in recent years, its effective import "coverage" has fallen as the level of imports has grown over time. Coverage is now less than half of the 115 days achieved in the peak year 1985 Figure 7. Currently, the US has the capacity to store up to 700 million barrels, although the House-passed energy bill of early 2003 (H.R. 6) proposes raising that limit to one billion barrels.

Past episodes of significant oil market disruptions that might have tested SPR's effectiveness in meeting the security objectives for which it was created have largely been squandered or mishandled. Decisions to release SPR oil have been strongly influenced by federal deficit reduction needs, while the opportunity to purchase oil under conditions of depressed prices was only haltingly pursued. It is certainly the case that successful deployment of SPR involves a host of uncertainties, numerous working assumptions, and consideration of how SPR strategy relates to other energy policies.

In the end, however, government policymakers confront a major benefit-cost decision: Given the potential economic cost of a major disruption in world oil supplies (and therefore of U.S. imports), how do the benefits of mitigating such economic damage compare with the cost of maintaining a strategic stockpile necessary to achieve that mitigation? Posing the question in this way makes it clear that there is no axiomatic basis for a position holding "the larger the reserve, the better."

Here, we rely on analysis reported by Leiby and Bowman (2000).[15] The authors employ a "numerical simulation model" whose estimate of gross benefits is based on SPR's ability to lessen GDP losses and oil import costs during a disruption (these costs are explained below), with net benefits subtracting the cost of developing and operating the SPR. The "base case" exercise, on which the authors put major stress yields a net benefit of between $1.5 and $1.8 billion. They say: "Moderate expansion of the U.S. reserve (on the order of at least 120 million barrels) is justified on the basis of [such] benefits to the U.S. economy alone." (p. 2) The model assumes a 1% probability of a 15% loss of world oil supplies lasting 4-1/2 months. The authors are not dogmatic about the incremental fill of 120 million barrels, pointing out that, with SPR

[14] The extent to which mere existence of the reserve could deter purposeful disruptions appears not to figure in most analyses of SPR strategy and is not considered here.

[15] One virtue of that study is that its point of departure is a SPR volume of 580 million barrels—not far off from prevailing levels—and oil market conditions close enough to the current one to lend an air of realism to the calculations.

spare capacity remaining adequate, a significant decline in oil prices would favor additional buildup of the reserve.

3. Assessment of the Oil Premium

In general the United States benefits greatly from free trade and from the use of oil. However, in cases where the market for a commodity is not fully competitive, or is subject to price shocks that reverberate throughout the economy, consumption of it may involve social costs that not borne by the users of the commodity.[16] This section discusses the marginal external costs of petroleum consumption, that is, the difference between the costs to the US economy as a whole and that to individuals or firms from additional oil consumption. Marginal external costs, expressed in $/BBL, are referred to as the oil premium; they reflect how much, in principle, oil use should be taxed. We assume that additional demand would be met through extra imports rather than expanded domestic production, which is a reasonable approximation.

Prior literature has identified two main sources of external costs. One has to do with how additional demand by individual importers raises the price for all US importers, and the other with economic disruptions throughout the economy caused by unanticipated price shocks. The first component depends on long run factors rather than short-term price volatility, particularly the extent of US imports and US monopsony power in the world oil market, accounting for responses by OPEC and other countries. The second component depends on short-term price variability (about a given long run trend), total petroleum consumption (relative to GDP) as well as imports, and the flexibility of firms and households outside the energy sector to respond to, and insure against, changing energy costs. We discuss these cost components in more detail, and then briefly comment on why US military expenditures in the Middle East are usually excluded from calculations of the oil premium. Much of the following discussion is based on an excellent review by Leiby et al. (1997).

A. Monopsony Power

If the United States were a price taker in world oil markets, the fact that behavior by OPEC kept the world oil price above its competitive level over the long run would have no implications for the marginal external costs of US oil imports (leaving aside costs from short term price volatility). This is because the price paid by importers for extra oil would equal the cost of the extra oil to the US economy as a whole; consequently individuals or firms in the United States would not consume “too much” oil from the nation’s perspective. Thus, *even though OPEC might be extracting large income transfers from domestic oil users by price manipulation, the oil premium is still zero, because changes in US imports would have no effect on the world price*.

However, the United States has market power, or more precisely, monopsony power, in the world oil market, because its consumption is a substantial fraction of total world petroleum

[16] Oil consumption may also have environmental implications, but these are beyond the scope of our discussion.

consumption. This means that when US customers as a group increase their demand for imports there is a significant effect on world demand, and the world oil price is likely to increase slightly. Higher prices raise the total amount that must be paid for all (marginal and infra-marginal) US petroleum consumption. Some of the extra expenditure goes to domestic suppliers; however about 60% of it goes to foreign suppliers, and is effectively a transfer of dollars out of the US economy to other countries. This transfer is an additional cost borne by the United States as a whole that is not taken into account by individual US consumers—they consider the market price they must pay for additional barrels, and not the collective effect of importers as a group on raising world prices and hence the total bill for US oil imports.

The difference between the cost to the nation as a whole, and the market price, for extra oil imports depends on two key factors:

(i) *The level of US oil imports*. If the United States were self-sufficient in oil there would be no monopsony power externality; higher prices paid for oil would simply transfer income from domestic consumers to domestic firms with no overall loss for the economy.[17] However, the greater the gap between domestic consumption and domestic supply, the greater the transfer of purchasing power from US consumers to foreign firms, following a US-induced increase in the world price. Note that the portion of US imports from the Middle East is irrelevant—for a given total amount of imports the transfer out of the economy is the same, regardless of whether 0% or 100% of US imports come from the Middle East.

(ii) *The effect of US demand on the world oil price*. If the world oil market was competitive and supply perfectly elastic, then extra US demand would be met barrel for barrel by extra world supply with no effect on the world price, regardless of the share of US demand in world oil demand. Again, in this case the oil premium would be zero, as changes in US imports would have no effect on the world price. In practice, supply is not perfectly elastic because of OPEC behavior, which is difficult to predict. At one extreme, OPEC production may not respond at all, in which case extra US demand can have a noticeable effect on price; at the other OPEC could completely neutralize the effect of changes in US demand with offsetting changes in its supply. In addition to OPEC behavior, the change in the equilibrium world price will also depend on supply and demand responses in other non-OPEC countries.

The marginal external cost per barrel of US oil imports from monopsony power (denoted E^M) can be expressed in a couple of ways (e.g. Leiby et al 1997, pp.10):

$$E^M = M\frac{dp^w}{dM} = \frac{p^w}{\varepsilon}; \qquad \varepsilon = \frac{dM}{dp^w}\frac{p^w}{M}$$

The first way is to view it as the quantity of US imports, M, times the increase in world price resulting from an extra barrel of US imports, dp^w / dM. Alternatively, the marginal external cost is simply the world price divided by the elasticity of supply of US imports with respect to the

[17] Obviously if the US were a net oil exporter rather than an oil importer it would benefit, rather than lose, overall from higher world oil prices.

world price, ε.[18] A country with a small share of imports in the world market is effectively a price taker, meaning that it faces a perfectly elastic import supply curve, $\varepsilon = \infty$ and $E^M = 0$. And even with potential monopsony power, E^M could still be zero. This would be the case if OPEC had both the ability and the desire to keep world prices at some target level by tightening their production quotas; in principle, this appears to be the Saudi strategy, however in practice it is difficult for OPEC to allocate production cuts among member countries.

Figure 8 plots p^w / ε for world oil prices of $15, $25 and $35/BBL, and import supply elasticities between 0 and 20. The premium can be substantial if the import supply elasticity is small; for example, the premium is greater than $12/BBL if $\varepsilon < 3$ and the world price is $25/BBL. But if the supply elasticity is 20, the premium falls to $1.3/BBL (for p^w = $25/BBL). Recent computations by Leiby et al. (1997) put the US import supply elasticity at between around 5 and 20;[19] this implies a premium of $1.3/BBL to $5.0/BBL for an oil price of $25/BBL.[20]

B. Disruption costs

Even without de-stabilizing behavior by OPEC, we might still expect volatility in world oil prices due to fluctuating economic conditions; for example, unexpectedly cold winters or unexpectedly rapid world economic growth can lead to transitory price spikes. Economic disruption costs from oil price volatility have two main components, increased import costs and macroeconomic adjustment costs. We discuss each of these in turn.

Increased Import Costs. This is the wealth transfer from domestic consumers to foreign suppliers from a temporary price increase, approximately equal to the level of US imports times the price increase. Whether there is actually any externality here is somewhat questionable. If businesses and households correctly anticipate the risk of price shocks this would be factored into their decisions and there would be no externality. Unfortunately it is very difficult to judge to what extent actual price volatility might be anticipated beforehand. Analysts therefore take a wide range of scenarios; for example, Leiby et al. (1997) assume that the portion of any given price shock that is anticipated is between 25 and 100%.

There are two ways to estimate the associated component of the oil premium. The first is to infer the likelihood of future price shocks from previous experience. For example, there were five price shocks from 1973-1997, and the average price increase was 110% of the pre-disruption

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[18] This is the inverse elasticity rule for an optimum tariff that is familiar in international trade theory. Note that p^w and ε are evaluated at the optimum (reduced) level of imports, rather than at the currently observed market equilibrium.

[19] The lower elasticity scenario assumes OPEC would respond to a 1% fall in the world price by reducing their production by 1%; the higher scenario assumes OPEC would cut their supply by 5%.

[20] Estimates of the monopsony component of the premium may be biased upwards somewhat as they do not account for possible costs to the US economy from the possibility of retaliation imposed on non-oil products by overseas suppliers (Canada, Mexico, Russia, OPEC, etc.) should the United States deliberately reduce its oil imports.

price, or $10/BBL (Leiby et al. 1997). The expected shock size per year over this period (counting no-shock years as zero) was therefore $2/BBL. Using scenarios when the portion of the price shock that is anticipated is 25% and 100% gives a premium component of $1.5/BBL or $0 respectively (in the latter case there is no premium because the risk of price shocks has already been taken into account by the private sector). Most analysts expect the future frequency and size of disruptions to be lower than in the past, though there is little agreement on how much lower.

The other approach is to attach probabilities to given supply disruptions due to OPEC and other factors in any given year, and infer the resulting price effects based on assumptions about oil demand and supply elasticities, use of the SPR, etc. For example, in their high disruptions scenario, Leiby et al. (1997) assume 13% probability of a 1MMBD disruption each year, 3.5% probability of a 3 MMBD disruption, and 0.5% for a 6MMBD disruption. Leiby et al. (1997) compute the import cost component of the oil premium as high as $4/BBL, but typically below $1/BBL, under different scenarios for disruption probabilities, and how a reduction in US imports might dampen the price effect of a given supply disruption (see their Table 3).

Adjustment Costs. At a first glance, variability of oil prices about a given trend might appear to have approximately no effect on the expected costs of petroleum consumption. Additional energy costs in times of high prices will be roughly offset by energy savings in times of lower prices. Indeed price volatility is pervasive across many primary commodity markets, including those for agricultural products and other natural resources. What is different about oil?

There are three main linkages at issue here. First, oil is an intermediate good that is widely used by firms and households throughout the economy, outside of upstream suppliers engaged in the production, importation and refining of petroleum. Price volatility may impose costs on others in the economy that are not taken into account by upstream oil suppliers when they are deciding how much to produce.

Second, price volatility matters for downstream, or ultimate users of oil products, because of adjustment costs. A basic result from production theory is that the short run costs of varying output in response to changes in input prices are greater when firms have fixed factors, such as sunk investments in plant and machinery. This means that average production costs when firms have to keep changing production levels exceed average production costs when there is no need to vary output because input prices are constant over time. Other examples of adjustment costs include workers or capital temporarily unemployed as energy-intensive industries expand and contract over time with volatile oil prices (e.g., because it is costly and takes time for workers to re-train or re-locate, or for plants to be re-furbished), or households stuck with previously purchased automobiles or investments in residential heating/cooling systems that would not have been optimal at current fuel prices. In all these examples, the presence of adjustment costs means that firms and households are worse off under variable prices than constant prices, for a given mean price.[21]

[21] For more discussion of adjustment costs see Hamilton (1988), Huntingdon (2001), Atkeson and Kehoe (1999).

Third, adjustment costs would not matter if firms and households could perfectly anticipate and insure against volatile oil prices; that is, if they could effectively guarantee themselves a fixed price by letting other parties cover additional energy costs when prices are high and making payments to other parties when prices are low. Futures markets provide one way to hedge against price volatility; oil stockpiling and investments in flexible energy use technologies are other options. But to the extent that private markets cannot completely handle all risks associated with price volatility there is a potential market failure and a positive oil premium.

The extent to which markets insure against oil price volatility is largely an empirical issue that has not been fully resolved. A number of studies using aggregate time series data find that greater oil price volatility reduces GDP (see the review by Brown and Yücel 2002); indeed all but one of the post-World-War-II recessions have followed a sharp rise in oil prices, yet an acceleration of US economic activity did not follow the oil price declines over the past two decades. This suggests that the costs of oil price increases exceed the benefits of oil price reductions, and a logical explanation is that in both cases adjustment costs are incurred that have not been fully insured against.[22]

Note that it is total petroleum consumption that matters for macroeconomic adjustment costs and not the level of imports. Even if the share of imports in domestic consumption were drastically reduced through expanded domestic supply, the price of oil in the US would still be determined by the world price, and the United States would be just as vulnerable to oil price volatility.[23] The only way to reduce adjustment costs from oil price volatility is to reduce the petroleum intensity of GDP.

The adjustment cost component of the oil premium is calculated using assumptions about the GNP oil-price elasticity, which is assigned values between –0.025 and –0.06 in Leiby et al. (1997); that is, an oil price doubling will causes adjustment losses between 2.5 and 6% of GNP. Combining with scenarios for disruption probabilities mentioned in Section B above, yields a premium component of between $0 and $6.5/BBL (Leiby et al. 1997, Table 4).[24]

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[22] There is some controversy over whether oil price shocks do in fact have significant effects on macroeconomic activity. Using disaggregate data on 3-digit industries Bohi and Toman did not find larger than average output losses in energy-intensive industries relative to other industries following the 1973-74 and 1979-80 price shocks (see Bohi 1989, Bohi 1991, Bohi and Toman 1993). In other words Bohi and Toman looked for underlying factors that might explain a link between oil prices and aggregate economic activity, but could not find them. They suggested that the apparent correlation could be due instead to de-stabilizing monetary policy (i.e. contractionary policy to avoid cost-push inflation in response to price increases). While the view that oil price shocks do not have significant effects on economic activity is a minority one among oil analysts, there remain unresolved issues concerning the disaggregated data.

[23] Indeed a subsidy to domestic oil producers could increase US consumption to the extent that world oil prices might fall, and increase disruption costs.

[24] One caveat to the above is that the aggregate economic costs mask some important distributional considerations. In particular, sudden rises in oil prices in winter can create serious social distress among low-income families who depend on oil to heat their homes. This concern is partly mitigated by the federal Low-Income Home Energy Assistance Program, and most of the New England states, which are subject to distribution difficulties, also have assistance programs of their own.

C. Summary, Comparison with Other Studies, and Future Projections

Leiby et al. (1997) Table 5, presents a summary combining the three components of the oil import premium under narrower ranges of assumptions, based on their judgment of the likely range of conditions. The total premium in their preferred range lies between $0 and $4.60/BBL, equivalent to between 0 and 11 cents/gallon of gasoline; under broader assumptions their range is $0 to $10/barrel.

An earlier study by Broadman and Hogan (1986, 1988) put the oil premium at $4.3 (monopsony component) + $10 (disruptions component) = $14.5/BBL (34 cents/gallon of gasoline). Leiby et al. (1997) provide a detailed reconciliation of these differing results, and we briefly mention some of the main points here.

Updating the Broadman and Hogan analysis to simply reflect more recent oil market conditions compared with 1985 slices $4.5/BBL from their premium. This is adjusting for the (a) lower US share in the world oil market (b) the lower market price of oil (c) the smaller share of petroleum in US GDP and (d) the increased level of imports. (a)-(c) all serve to reduce the premium while (d) increases it. Two other adjustments of note were made by Leiby et al: allowing for a positive portion of the price shocks to be anticipated and insured against by private agents (Broadman and Hogan assumed all price shocks were unanticipated) and using lower disruption probabilities than those based solely on experience prior to 1985.

Another recent assessment by a panel of experts put the best estimate for the oil premium at $5/BBL, with an upper bound of $10/BBL (NRC 2002). This somewhat higher range mainly reflects updating over Leiby et al. (1997) for higher baseline oil prices. Other recent studies (which are less detailed than Leiby et al. 1997) are summarized in Table 5: estimates vary between $0 and $14/barrel. Differences of opinion over the magnitude of the disruptions component of the oil premium boil down to different views about how efficiently markets take into account the risk of, and respond to, oil price shocks. Most analysts believe that the full extent of oil-market upheaval is not fully captured in firm behavior, and consequently the disruptions component of the premium is positive; it is zero under the assumption that markets fully internalize and hedge against the risk of price shocks. And most analysts allow for a positive monopsony power component; this component is zero only under scenarios when OPEC matches any reduced US import demand with barrel for barrel cuts in production.

In light of these considerations we put our best assessment of the quantifiable component of the oil premium at $5/BBL, with a wide range of $0 to $14 to account for the diversity of opinion among oil analysts.

It is not clear how future adjustments to baseline market data may affect the oil import premium over the next 25 years. World oil production will become increasingly concentrated in the Persian Gulf; in theory this gives OPEC more market power. However this is taken into account in projections of future world oil prices: Energy Information Administration (EIA) projects world oil prices in 2025 at about the same as current levels, with approximate range of plus or minus 30% (similar projections are offered by the International Energy Agency). Declining petroleum intensity of GDP will continue to reduce the disruptions component of the premium in the future; EIA projects oil intensity to fall by 24–34% by 2025. On the other hand the growth of the oil import share will increase components of the premium; EIA projects growth in this share of 22–33% by 2025. Our best assessment is that, in real terms, the oil premium will remain unchanged over the next twenty years, at $5/BBL in real terms, with a margin of error of plus or minus 50%.

D. Persian Gulf Military Expenditures

US military expenditures in the Middle East are in part the result of US interests in securing its flow of imported oil from that region, and therefore count as a total cost of oil import dependency. However, many analysts do not include them when assessing the external costs of *marginal* changes in US oil imports.

One reason is that it is difficult to assess what portion of costs—which include recurrent costs of troops and ships in the region, as well as large one-off costs for wars involving the United States—should be assigned to imports as opposed to other political objectives, such protecting the security of Israel, reducing the threat of terrorism, and humanitarian objectives.[25] But most important reason for not counting military spending as a component of *marginal* external costs is that it does not really vary with (modest) changes in oil imports; military spending is more of a fixed cost than a variable cost. A policy to moderately reduce imports over time, and that did not entirely eliminate import dependency, would probably have little benefit in terms of cutting the costs of US military involvement in the region.

4. Concluding Remarks

There remains substantial dispute over the magnitude of the oil premium; recent estimates vary between $0 and $14 per barrel, is equivalent to between 0 and 33 cents per gallon of gasoline. Our preferred value, $5 per barrel, is towards the lower end of this range. In principle, the social costs of oil dependency call for a modest tax, though the tax should be on all oil uses, not just those related to transportation.

The gasoline tax (combining federal and an average of state taxes) is currently around 40 cents per gallon, much larger than the oil premium. However the tax also addresses, albeit very imperfectly, a number of other social costs associated with automobiles including local and global air pollution, traffic congestion and accidents. A recent assessment by Parry and Small (2003) put the economically optimal fuel tax to address these other social problems, leaving aside the oil premium, at around $1 per gallon; this suggests that the extent to which fuel is

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[25] It is difficult to know where to draw the line on what spending should be included; for example, whether to include military aid to Israel and Egypt. There have been a few attempts to quantify the military costs of oil dependency. Delucchi (1998), Table 7-23, put them at $0.6-6.8 billion for 1991, or $0.25 to $2.9 per barrel of imports, after updating to 2002 dollars.

currently under-taxed from other perspectives is significantly greater than what is implied by even the highest end of the oil premium range.

Higher fuel taxes have proved to be politically difficult, however.[26] Other measures to encourage greater oil conservation include higher fuel economy standards for new passenger vehicles; current standards are 27.5 miles per gallon for cars and 20.7 miles per gallon for light-duty trucks (minivans, sport utility vehicles, pick-ups). Tighter standards could encourage manufacturers to modify vehicle design in a variety of ways to improve fuel economy, however they are less efficient than higher gasoline taxes. By lowering fuel costs per mile they encourage people to drive vehicles more, increasing traffic congestion and accidents; in contrast higher fuel taxes raise the cost of driving. And, unlike fuel taxes, they do not encourage households to conserve fuel through better vehicle maintenance, driving behavior, and making more use of existing fuel efficient vehicles (e.g. using the car rather than the sport utility vehicle for errands).

Other policies that could encourage reduced oil dependence over time include subsidies for the development of alterative fuel technologies (e.g., hydrogen and electric vehicles, hybrid gasoline-electric vehicles), either through government provided R&D or subsidies for private R&D. In the absence of government policy, such R&D efforts by the private sector alone may be inadequate due to the inability of innovators to capture spillover benefits of new technologies to other firms. The case for encouraging domestic oil production to displace oil imports is less convincing; much of the macroeconomic disruptions component of the oil premium depends on total oil consumption and not the share of it that comes from oil imports. Whether restrictions on drilling in, for example, the Arctic National Wildlife Refuge should be relaxed or not should be evaluated on a case-by-case assessment of economic, environmental and oil dependency effects, rather than simply on the amount of foreign oil displaced.

Finally, an argument could be made for more active use of the Strategic Petroleum Reserve in times of severe oil market disruptions, particularly if actions could be coordinated with other large oil-importing regions. To be sure private firms can be expected to include disruption risks in their inventory and other strategies. Still, there is a wide body of professional writing suggesting that the full extent of oil-market upheavals is far from captured in firms' behavior. SPR is a defensible instrument for compensating for that gap.

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[26] The Clinton Administration managed to increase the federal gasoline tax by only 4 cents per gallon in 1993, despite a major effort. The tax has declined in real terms since then.

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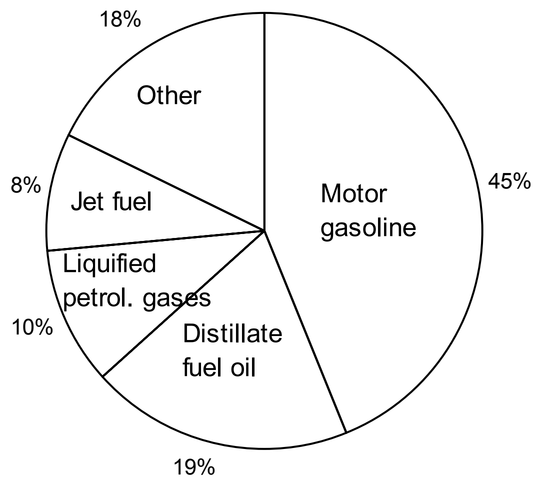
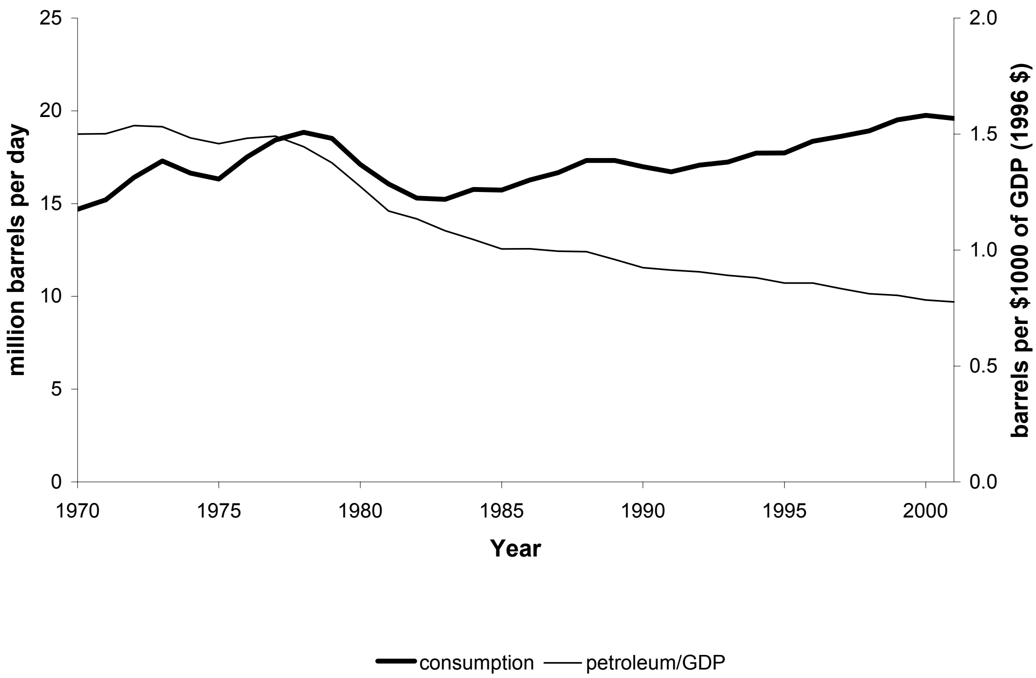
Figure 1. Uses of Petroleum by Product 2001



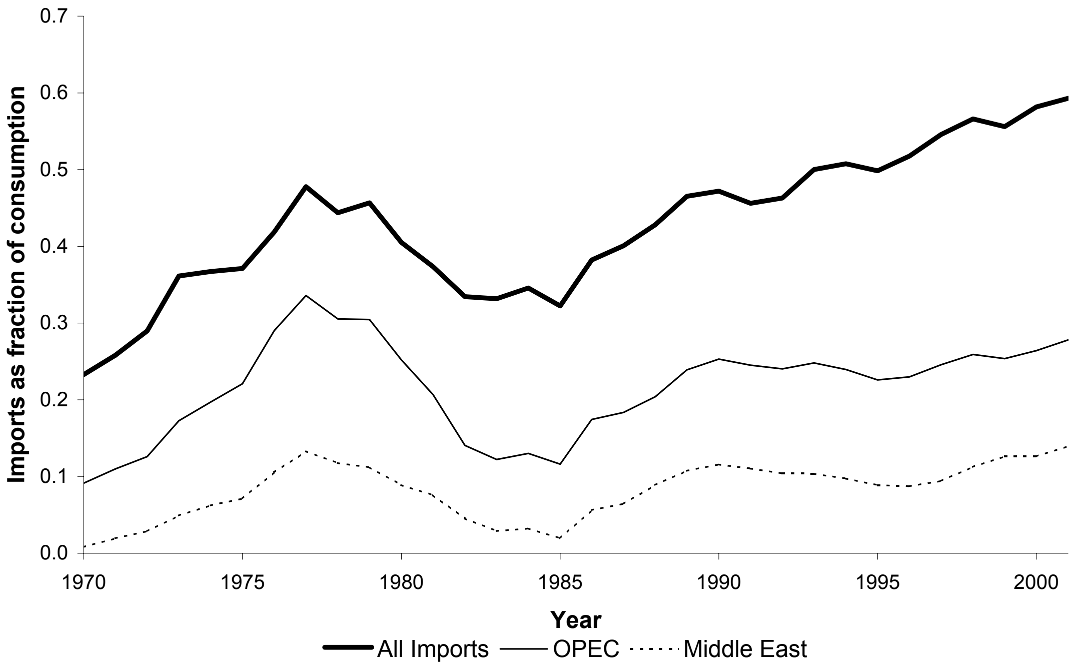
Source: Energy Information Administration (2002), Table 5.11.

Figure 2. Trends in Petroleum Consumption



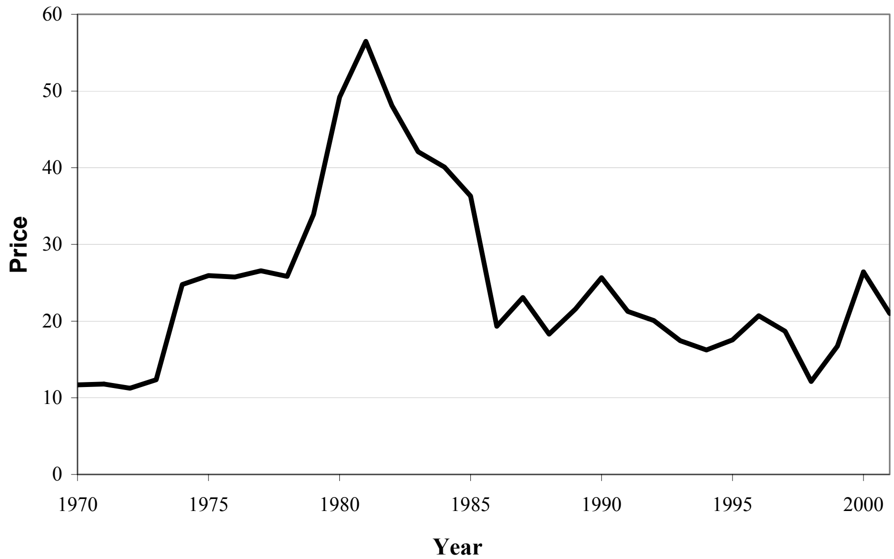
Source: Energy Information Administration (2002).

Figure 3. Fraction of US Petroleum Consumption from Imports



Source: Energy Information Administration (2002), Table 5.4.

Figure 4. Oil Prices, 1970-2001
(refinery acquisition price in $1996 per barrel)



Source: Energy Information Administration (2002).

Figure 5. Crude Oil Prodution by Country/Region

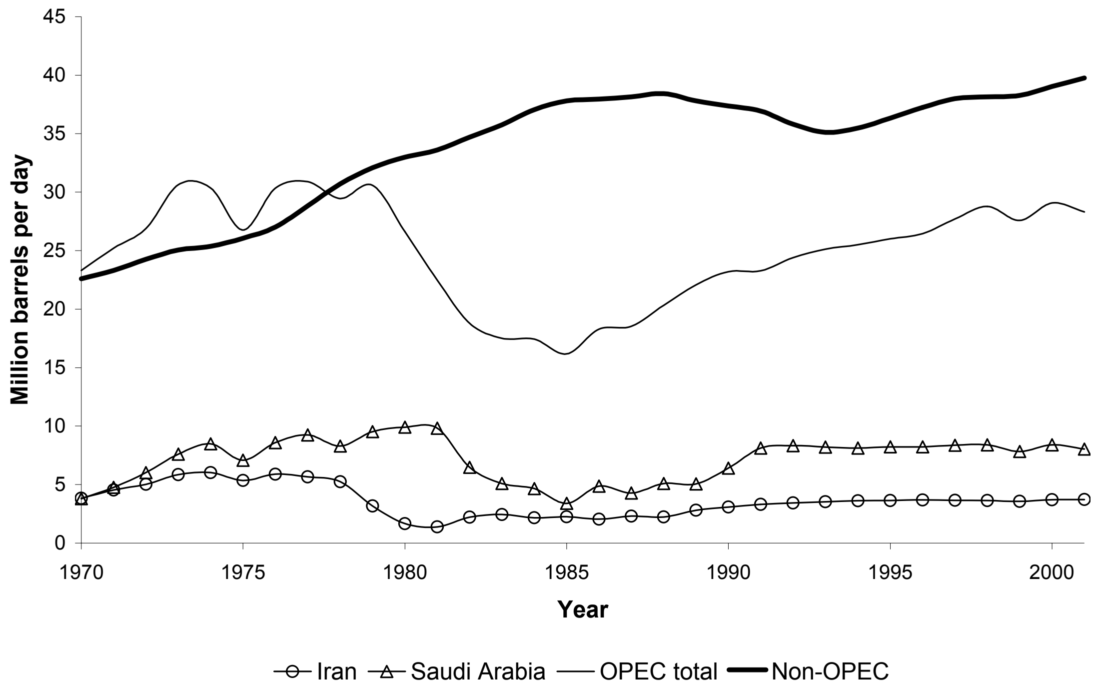


Figure 6. Percent Change in Oil Price and GDP

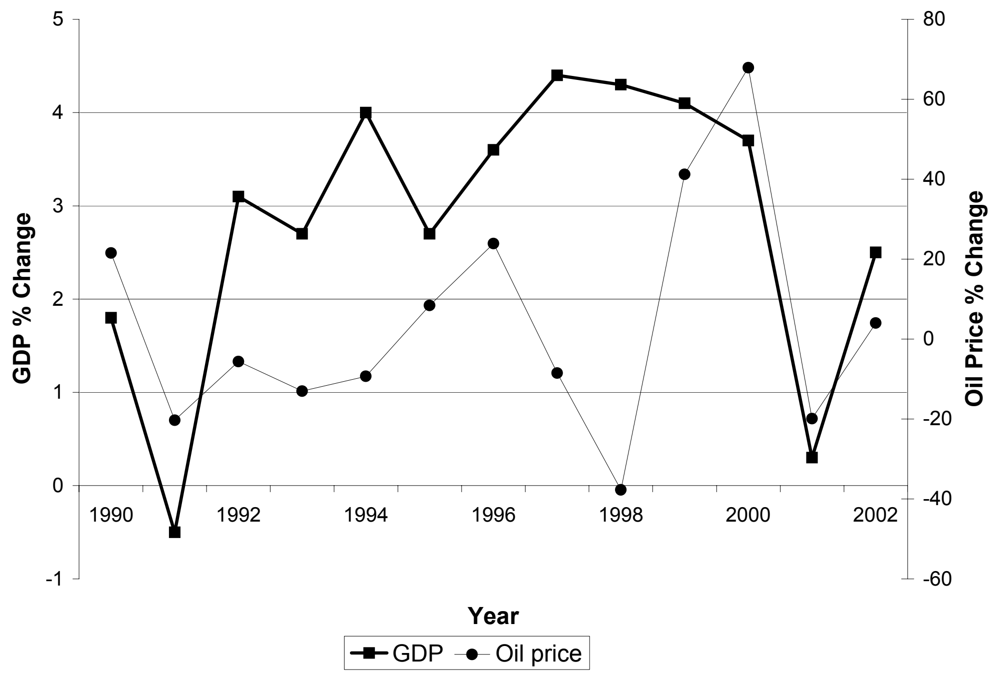
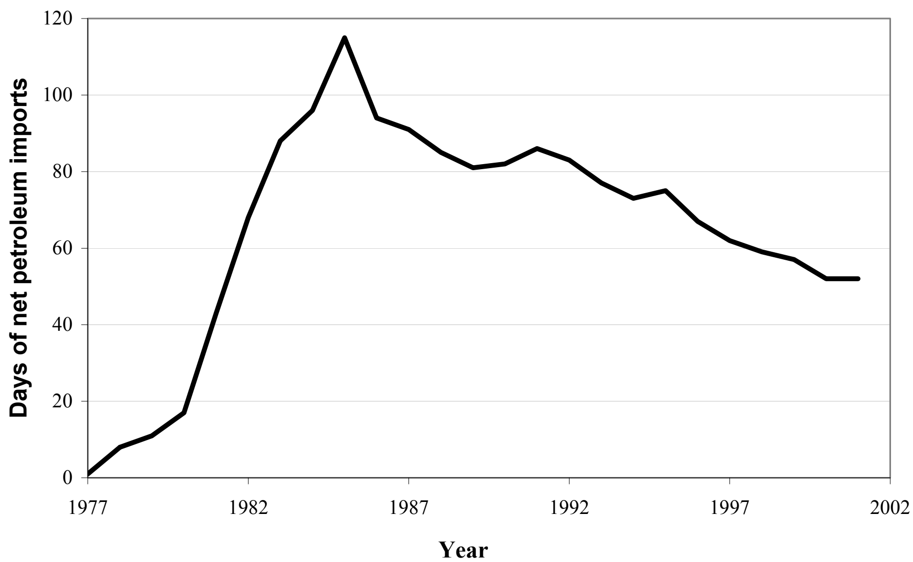


Figure 7. Import Coverage from the SPR



Source: www.eia.doe.gov/emeu/aer/pdf/pages/sec5-193.pdf.

Figure 8. Calculations of Monopsony Premium

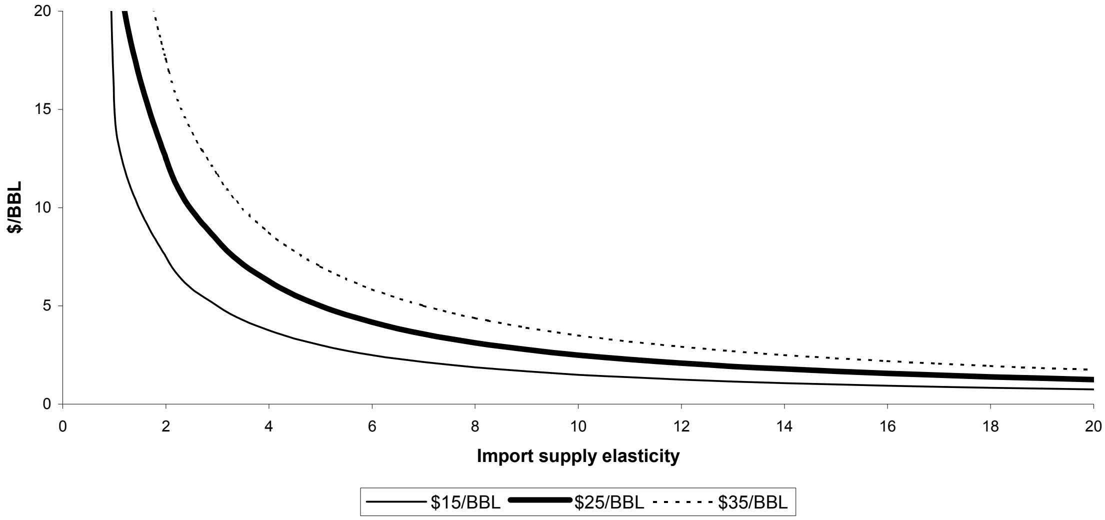


Table 1. World Oil Consumption by Region, 2002

Country/Region	% of world total	
Total OECD		61.3
United States	25.4	
Japan	6.9	
OECD in Europe	19.5	
Other OECD	9.6	
Non-OECD		38.7
Former USSR	5.1	
China	6.8	
Other Asia	10.0	
Other non-OECD	15.9	
World total		100.0

Source: www.eia.doe.gov/emeu/ipsr/t24.xls.

Table 2. Oil Supply and Reserves by Region, 2001

Region/Country	Current Production: Million barrels per day	Current Production: % of world total	Known economic reserves: Billion barrels	Known economic reserves: % of world total
Selected OPEC Producers				
Iran	3.7	5.5	99.1	9.7
Iraq	2.4	3.6	115	11.3
Kuwait	2.0	3.0	98.8	9.7
Saudi Arabia	8.0	11.8	261.7	25.7
United Arab Emirates	2.3	3.3	62.8	6.2
Persian Gulf total	**19.2**	**28.2**	**652.0**	**64.0**
Venezuela	2.9	4.2	50.2	4.9
Nigeria	2.3	3.3	30	2.9
Non-Persian Gulf OPEC total	**9.1**	**13.4**	**107.0**	**10.5**
OPEC Total	**28.3**	**41.6**	**759.0**	**74.4**
Selected Non-OPEC Producers				
Canada	2.0	3.0	5.4	0.5
China	3.3	4.8	29.5	2.9
Mexico	3.1	4.6	23.1	2.3
Norway	3.2	4.7	10.3	1.0
Former USSR	0.0	0.0	13.2	1.3
Russia	7.1	10.4	53.9	5.3
United Kingdom	2.3	3.3	4.6	0.5
United States	5.9	8.6	22.4	2.2
Non-OPEC Total	**39.8**	**58.4**	**260.8**	**25.6**
World total	**68.1**	**100.0**	**1018.7**	**100.0**

Source: *World Oil*, 223 (8), 2002 (August). The reserve estimates are crude oil resources that have been discovered and would be economic to produce at prices similar to those in recent years.

Table 3. Projected US Oil Import Dependence: Some Relevant Numbers

	1990	2000	2025
Net oil imports as percent of total U.S. supply	42.1	52.8	67.9
World oil price (2001 $'s/barrel)	27.5	28.3	26.5
World crude oil production (mill. barrels/day)	60.6	76.7	122.9
Of which: OPEC share (percent)	38.3	40.2	49.8
US Petroleum Consumption (MBD)	17.1	19.6	28.7
Oil Intensity [a]	5.0	4.2	2.8

Sources: U.S. DOE, EIA, *Monthly Energy Review*, May 2003; and *Annual Energy Outlook 2003*. The 1990 real oil price was calculated by deflating (using the GDP deflator, from *Economic Report of the President*, Feb. 2002) the current price percentage change between 1990 and 2000.

[a] Oil-intensity refers to 1,000 Btu's of nationwide oil consumption per $1 of GDP expressed in 1996 prices.

Table 4. Oil Import Dependence and Oil-Import Intensity, 2025

	Oil-import dependence[a]	Oil intensity[a]
High world oil price	64.5	2.9
Low economic growth	66.4	3.1
Advanced technology	66.7	2.8
REFERENCE CASE	**67.9**	**2.8**
Base-year technology	69.3	3.2
High economic growth	69.7	2.9
Low world oil price	70.0	3.1
(Memo: data for the year 2000	52.8	4.2)

[a]Oil-import dependence is defined, as in Table 3, as net oil imports as percent of total U.S. supply; oil-intensity refers to 1,000 Btu's of nationwide oil consumption per $1 of GDP expressed in 1996 prices.

Note: Because of data unavailability, the technological cases in the oil-import column refer to technologies particular to the oil and gas industries; the technological cases in the oil-intensity column refer to an "integrated" technological scenario across various sectors.

Table 5. Oil Premium Estimates from Other Studies

Study	Estimate, $ per Barrel
Energy Comission (1994)	13.0
Behrens et al. (1992)	4-13
Delucchi (1997)	0-5
NRC (2002)	5
Ketchen and Komanoff (1992)	14
Mackenzie et al. (1992)	11
Leiby et al. (1997)	0-10

Source: CEC (2003).

Source: Adapted from U.S. DOE, EIA, *Annual Energy Outlook 2003*.

United States and the Middle East: Policies and Dilemmas
By Amy Myers Jaffe[1]

Introduction

The purpose of this paper is to explore the topic of the externality costs associated with rising U.S. oil consumption that are not easily quantifiable by strictly economic or monetary calculations. These hard to measure externalities include the strategic and diplomatic costs that, particularly since the attacks on the US on September 11, 2001, have heightened relevance in American foreign policy debate. They also include the rising cost of US military intervention of the protection of the flow of oil to the international community, both in terms of dollar expense and human lives.

While it is hard to put an absolute number on what Americans pay for our overwhelming dependence on oil as a transportation fuel, clearly the gasoline price at US gasoline stations does not reflect the real cost to the American taxpayer. This paper is aimed to heighten awareness that oil is not as "cheap" as it seems to the average American motorist. Rather the seemingly higher costs of alternative fuels may not be so out of line with the cost of gasoline when juxtaposed against the real cost for depending on foreign oil that includes the taxpayers' bills for US expanded military operations abroad as well as the diplomatic and security challenges associated with this dependence.

For the past two decades or so, United States international oil policy has relied on maintenance of free access to Middle East Gulf oil and free access for Gulf exports to world markets. American policy in the Persian Gulf is not designed, as conspiracy theorists might argue, simply to keep the price of US gasoline cheap or to make sure that

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American companies get handsome oil exploration contracts. Neither of these goals would likely merit the intense level of US intervention in the region.

Rather, America ensures that oil flows from the Persian Gulf are available to fuel international trade and economy as part of its global superpower responsibilities. More simply put, the physical oil needs of the US economy can certainly be met fully by protecting oil flows closer to home, from Canada, Mexico, South America, the North Sea and Africa. But the United States must consider the health of the overall global economic system since a massive shortfall of oil elsewhere would not only effect the price of oil everywhere but almost certainly collapse the global economic system.

The Persian Gulf today represents 25-30% of world oil supply. Saudi Arabia is the world's largest oil producer and controls the majority of the world's excess production capacity, which it uses to stabilize and control the price of oil by increasing or decreasing production as needed during times of market crisis or instability. The sudden loss of the Saudi oil network would paralyze the global economy. Thus, the United States has a concrete interest in preventing any hostile state or internal groups from gaining control over the Persian Gulf region and using this control to amass power or blackmail the world community.

But this strategic and economic reality is costing the United States dearly in terms of military operations, diplomatic freedom and national security. At $20 billion a year in military expenditure to protect the flow of oil, the US taxpayer is spending roughly an extra hidden $4 to $5 a barrel for the crude oil beyond its market price.

Continued dependence on Middle East oil can potentially place costly constraints on the US freedom of maneuver in international relations. Such constraints are evident already in such areas as terrorist financing, human rights, political reform in the Middle East and the status of women. In important areas of national security, such as the US campaign in Afghanistan, Middle East sensitivities were relegated to a lesser plain, but it is not out of the question that the United States could face, one day, a tough choice between the global economic hardship of a destabilized oil market and a foreign policy or national security imperative. Similarly, in a tight oil market, an important oil producer could try to use access to its exports as a lever to attain access to sophisticated military hardware or technology from a major oil-consuming nation.

Finally, high dependence on Middle East oil has been cited as a troublesome factor in shutting down dangerous state-sponsored terrorism, terrorist financing and proliferation of weapons of mass destruction. Many important US analysts argue that oil sales proceeds can be directed by authoritarian governments to fund terrorist organizations or to aid regional governments that harbor them. Some foreign policy analysts are now arguing that low oil prices – in addition to providing substantial economic benefits for the US and global economies – will reduce the revenue available to oil states, which sponsor terrorism or pursue the acquisition of weapons of mass destruction. This argument has powerful logic, but raises the question as to whether the link between oil rents and terrorism is really bonafide. While the link between terrorism and oil is neither necessary nor sufficient, as this paper will discuss, several oil states remain on the US Department of State terrorism list, and there are also private donors to terrorist groups who benefit from the trickle down of oil budgets into several key Middle East, Asian and North African societies.

<u>US Dependence on the Middle East: Status Quo policies</u>

For the past two decades or so, United States international oil policy has relied on maintenance of free access to Middle East Gulf oil and free access for Gulf exports to world markets. This policy was accelerated in the 1980s as the US strengthened its special relationships with key Middle East exporters, notably Saudi Arabia and Kuwait. These exporters expressed and exhibited a common interest in stable oil prices and adjusted their oil output to keep prices at levels that would neither discourage global economic growth nor fuel inflation. Then Saudi Oil Minister Hisham Nazer announced in the late 1980s that Saudi Arabia intended to make available an "ocean of oil" in exchange for "security of demand,"[i] and Saudi Arabia made the bold step of purchasing a

50% stake in US refiner Texaco to ensure a permanent, guaranteed outlet for its oil in the United States.[ii]

Taking this dependence a step further, the US also counted on these countries to make the sizable investments needed to maintain enough surplus capacity to form a cushion against disruptions elsewhere in the world. This spare capacity has served as a vital protection to US energy security. In August 1990, when Iraq attacked Kuwait, so much spare capacity existed in the international oil market that the 5 million barrels a day (b/d) of lost production from Iraq and Kuwait was easily replaced by production increases from Saudi Arabia, Venezuela, Abu Dhabi and other OPEC (Organization of Petroleum Exporting Countries) members.[iii]

The quid pro quo of this special relationship with the Arab Gulf was that the United States would guarantee the security of Saudi Arabia and its small Gulf neighbors in return for the Gulf Arabs' cooperation in keeping a reliable flow of moderately priced oil to international petroleum markets.[iv] The United States communicated its willingness to intervene militarily should Saudi Arabia or another Gulf Arab ally be threatened by implementing a strategy through the 1970s and 1980s referred to in US military circles as "offshore balancing," that is, keeping American troops, pre-positioned equipment and navy positioned in and around the Persian Gulf and Indian Ocean.[v] Washington demonstrated its willingness to intervene more concretely in the mid-1980s when its navy escorted Gulf Arab oil shipping through the Persian Gulf to protect it from Iranian warplanes and mines during the Iran-Iraq war, and, most notably, in 1990-1 when it rushed troops to Saudi Arabia after Iraq invaded Kuwait.[vi]

Protecting the Oil: US Military Costs in the Persian Gulf

The policy, while producing relatively moderate oil prices over the 1980s and into the 1990s, was still an expensive one. The US General Accounting Office (GAO) estimates that from 1980-1990 about $33 billion a year of the US military budget was spent on defending oil supplies from the Middle East. Other studies that tried to refine the GAO's approach to eliminate more general Mideast initiatives not directly related to the protection of oil flows attribute lower numbers of $6.4 billion to $14.3 billion.[vii] A more recent 1996 study projected that annual costs of US military operations in the Persian Gulf would range between $20 to $40 billion in peacetime.[viii] Exports from the six Gulf Cooperation Council countries –Saudi Arabia, Kuwait, UAE, Qatar, Yemen, Oman—total about 12 to 13 million barrels a day or 4.4 to 4.7 billion barrels of oil a year. At $20 billion a year in military expenditure to protect the flow of oil, the US taxpayer is spending roughly an extra hidden $4 to $5 a barrel for the crude oil beyond its market price.

Prior to 1980, the United States maintained only three naval ships in the region and limited pre-positioned equipment in Oman and Bahrain.[ix] After 1990, the US forged new agreements with most of the states of the Gulf Cooperation Council (GCC), fostering multilateral exercises, command and control coordination (now in Qatar), a defense initiative against chemical and biological weapons, and a multilateral missile launch early warning system.[x] The GCC is a regional security grouping founded in May 1981 in Abu Dhabi in reaction to the Islamic revolution in Iran, the Iran-Iraq war and the Soviet invasion of Afghanistan. The GCC membership includes Saudi Arabia, Kuwait, Bahrain, Qatar, Oman and the United Arab Emirates. US readiness in 2000 entailed rapid access to two combat divisions, three carrier battle groups, and 14 tactical fighter squadrons, with 25,000 soldiers and one to two aircraft carriers permanently assigned to the Persian Gulf.[xi]

Beyond these routine costs, there has been the cost of occasional military actions to defend the region and its oil supply. During the latter years of the Iraq-Iran war, which began in 1980 and lasted eight years, the US Navy engaged in an active escort campaign for Kuwaiti oil tankers in the Persian Gulf. This activity is estimated to have cost $200,000, according to the GAO.

Operations Desert Shield and Desert Storm (the 1991 Gulf War), which removed the Iraqi army from Kuwait, is estimated to have cost $61 billion, according to press reports and the GAO.[xii] The majority of this expense was paid for by Saudi Arabia and Kuwait, with the total cost to the US taxpayer pegged at around $7 billion.

Iraq's invasion of Kuwait was considered a major infraction to the international system, and the Bush Administration began its efforts to utilize coercive diplomacy to pressure Iraq to withdraw.[xiii] As diplomacy and economic blockage failed to motivate Iraqi strongman Saddam Hussein, the US led a coalition to eject Iraq from Kuwait by military means. Although the Gulf War was not just fought about oil, senior Administration officials acknowledged that the need to go to war also had a large energy security component.

In testimony to the Senate Armed Services Committee in 1990, then Secretary of Defense Richard Cheney said, "Iraq controlled 10% of the world's reserves prior to the invasion of Kuwait. Once Saddam Hussein took Kuwait, he doubled that to approximately 20% of the world's known oil reserves…Once he acquired Kuwait… he was clearly in a position to dictate the future of worldwide energy policy, and that gave him a stranglehold on our economy and on that of most of the other nations of the world as well."[xiv]

That sentiment was echoed in "A World Transformed," a 1999 book published by President George Bush Sr. and his National Security Advisor Brent Scowcroft. "… no hostile regional power could hold hostage much of the world's oil supply." President Bush Sr. explained the need to go to war in an address before a joint session of the Congress on the Persian Gulf crisis and the Federal Budget Deficit on September 11, 1990, "Vital issues of principle are at stake. Saddam Hussein is literally trying to wipe a country off the face of the Earth. We do not exaggerate. Nor do we exaggerate when we say Saddam Hussein will fail. Vital economic interests are at risk as well. Iraq itself controls some 10% of the world's proven oil reserves. Iraq plus Kuwait controls twice that. An Iraq permitted to swallow Kuwait would have the economic and military power, as well as the arrogance, to intimidate and coerce its neighbors –neighbors who control the lion's share of the world's remaining oil reserves. We cannot permit a resource so vital to be dominated by one so ruthless. And we won't…"

General Scowcroft in an interview in Frontline's series the Decision Makers, first broadcast on January 9, 1996, noted that reversing Iraq's invasion of Kuwait mattered because…" at the heart was naked aggression against an unoffending country, that was the firm and legal position, but what gave enormous urgency to it was the issue of oil…Principally because there was a struggle and had been a struggle going on within OPEC over, if you will, control of OPEC and it was a struggle basically between Saudi Arabia and the radicals, over keeping production flowing and keeping prices reasonable or trying to squeeze, if you will, the industrialized world. And the notion of Iraq, which was an oil powerhouse in itself, acquiring the Kuwaiti resources and thus perhaps of being able to dominate, OPEC was a tremendous danger to the United States and to the industrialized world."

Surprisingly, the debate surrounding the Gulf War and its aftermath did not lead to a strident political debate in the US about the risks of heavy reliance on Middle East oil. The subject entered the American political debate from time to time, especially around 1999 to 2000 when oil prices rose significantly following a concrete agreement within the Organization of Petroleum Exporting Countries to reduce production to defend a $25 oil price. But, it was not until the terrorist attacks on the United States on September 11, 2001 that the question of import dependence on Middle East supply became a more central concern among U.S. foreign policy elites.

Tightening Oil Markets and the Role of Saudi Arabia

The renewed focus on energy security post-September 11 comes in the context of increasing US vulnerability to a disruption of oil supply from the Middle East. This exposure is more pronounced because there has been an extraordinarily rapid erosion of spare capacities at critical segments of the energy supply chain over the past decade. Sustained growth in oil use world-wide, combined with under investment in OPEC oil fields, has eaten away at the amount of spare capacity carried by key OPEC countries. The constraints to OPEC investment in expanding oil productive capacity has been driven by social/economic pressures in many oil producing countries whose government spending has had to be shifted away from capital investment to social programs in an effort to relieve the pressures of rapidly growing populations and an accompanying growth in unemployment. OPEC capacity has also been constrained by international and American economic sanctions policy, which has discouraged investment in key producing countries such as Iraq, Iran and Libya.[xv] In the late 1980s, OPEC had planned capacity expansions to a total of 32.95 million barrels a day targeted for 1995, but by early 1997, OPEC capacity had reached only 29 million barrels a day. Iran, Libya and Iraq all failed to achieve production targets due to international sanctions policy.[xvi] The decline in spare capacity means that the rapid and sizable replacement of disrupted supplies implemented by OPEC in 1990 would be difficult to repeat.

During the 1985 oil price collapse, OPEC was estimated to be carrying some 15 million b/d of shut in production capacity, equal to 25% of world oil demand. Saudi Arabia's shut-in capacity represented 60% of total spare capacity. When oil prices came under pressure in the early 1980s, Saudi Arabia agreed to play the role of swing producer, pulling back its oil production single-handedly to help OPEC stabilize fixed oil prices set by the producer group. By 1984, a glut of oil supplies from non-OPEC countries and flagging demand meant that Saudi Arabia had been forced to cut its production to 2.3 million b/d, down substantially from its production capacity of 10 million b/d.

By 1990, when Iraq invaded Kuwait, OPEC had about 5.5 million b/d of spare capacity, enough to replace the oil from those two countries and representing about 8% of global demand. Again, Saudi spare capacity represented about 60%. But by 2000, OPEC's spare capacity was a negligible 2% of world oil demand and resided almost exclusively in Saudi Arabia, roughly about 90% of current world spare capacity. That situation carries forward to today, leaving the oil markets extremely vulnerable to short term disruptions. These persistently tight crude oil markets highlight the concentration of spare capacity in Saudi Arabia and the vulnerability of the global economy to domestic conditions there.

In late 2002, Venezuela's deepening social and financial problems and increased political polarization eventually prompted extra-constitutional attempts to remove Chavez from power. Violence became more prevalent until December 2002, when Venezuelan opposition groups organized a nation-wide strike that crippled the oil sector, bringing oil production to a virtual halt. The strike was designed to force an early referendum on the President's rule. President Chavez declared the strikers' demands as unconstitutional and called in loyal factions of the military to put down the protests.

The strike quickly curtailed close to 3 million barrels a day of Venezuelan oil production, prompting oil prices to rise but not dramatically so because the strike was not expected to last for a long time and other OPEC members had producing more than their production quotas mandated by the group. When OPEC met on December 12 and agreed to restrain output, prices began to rise more precipitously, reaching $31 by year end.[xvii] As prices climbed to a two-year high, OPEC producers met on January 12 and agreed to increase output to cool markets but failed to replace fully the lost Venezuelan volumes. This, combined with fears of an impending US attack on Iraq, kept oil prices high throughout most of the spring of 2003.

Saudi Arabia's place in the oil world is unrivaled despite the existence of other countries, notably Russia and the United States, whose total hydrocarbons liquids production is of similar magnitude. The kingdom is the only oil producer in the world that can replace single-handedly, within months, the total loss of *exports* of any other oil producer on the globe. The kingdom currently carries about 1 to 2 million barrels a day of sustainable spare production capacity, that is, production that can be maintained for more than 30 to 60 days. But Riyadh has the ability to surge its production temporarily by 3 to 4 million b/d in an emergency for 30 days or so. With massive investment, the kingdom could also increase its capacity by significant volumes more quickly than other oil producers because of its prolific geology and giant oil export facilities. No other nation currently has enough spare capacity and investment revenue to claim this role.

Saudi Arabia's cushion of spare capacity has provided security and stability to world oil markets for two decades. The kingdom has intervened to calm markets on numerous occasions in recent years by quickly raising its production and exports, most notably during the 1990 Gulf crisis; immediately following the September 11, 2001 attacks; and most recently during the U.S. campaign in Iraq, preventing oil prices from soaring above $40 for any length of time during major supply interruptions from the Gulf. Saudi Arabia raised production to 9.5 million barrels a day in March and April 2003 (up from its OPEC quota allocation of 8.256 million b/d) to limit the rise in oil prices caused by the US campaign in Iraq.[xviii] Despite coaxing the International Energy Agency (IEA) to forego a major consumer strategic stock release, the kingdom did not use surge capacity to replace fully all Iraqi exports lost to the market, but chose rather to push out just enough oil to keep prices close to the OPEC price target range of $22 to $28 a barrel.[xix]

The kingdom derives its international clout from this custodial role and is unlikely under the current regime to relinquish it. The oil market regulator role played by Saudi Arabia is also an important element to its strategic relationship and alliance with the United States.

Yet, despite the kingdom's general reliability in oil emergencies as the supplier of last resort, key voices in the United States policy community have increasingly voiced their discomfort with continuation of a high level on dependence on Saudi largesse. Senior U.S. officials have publicly expressed the need to reduce dependence on Middle East crude. These concerns stem not only from worries that a deterioration of the U.S.-Saudi relationship might adversely affect the kingdom's willingness to continue to act as the world's oil superpower but also about the anxiety about the future stability of the desert country.

Saudi Arabia's Internal Stability under Pressure

Western Middle East studies analysts are increasingly writing specialized articles and books showing that the kingdom of Saudi Arabia is becoming a less stable place.[xx] Population growth rates in Saudi Arabia are among the highest in the world at over 3% per annum. The kingdom's population is expected to double over the next twenty years or so. Moreover, in the year 2000, 42% of the total Saudi population was 15 years or younger.[xxi] This demographic boom is placing the Saudi regime under increasing pressure, with the state being called upon to create more jobs and provide more services with lower per capita resources than in the past. The kingdom has, in recent years, been lowering subsidies for basic services, and has called upon the private sector to enhance its ability to provide jobs, but many Saudis lack basic job training and the Saudi education system faces fundamental challenges. Many Saudis are graduating from the Islamic university system with degrees in Islamic law, sciences or religious studies.[xxii] The Saudi economy to date remains highly dependent on foreign labor, which represents about 75% of those employed in the kingdom.[xxiii]

Saudi Arabia has a long history of forging closer ties with outside powers to promote its national security. As far back as 1957, it supported the "Eisenhower doctrine" that aimed to check communism in the Middle East. The move towards the United States was driven in part by a then revolutionary movement in Iraq whose foreign policy included support for national liberation movements that sought to overthrow conservative monarchies such as the regime in Saudi Arabia.[xxiv] By 1979, Saudi anxiety about its northern neighbors worsened with the establishment of the Islamic Republic of Iran. Prior to the revolution, the Shah of Iran was seen as a key guardian of the status quo in the Gulf.[xxv] Saudi-Iranian relations became greatly strained following the Islamic revolution, especially in light of the 1979 Mecca Grand Mosque takeover and the 1981 disturbance in Medina where a number of Iranian pilgrims were arrested and deported for distributing leaflets calling for the overthrow of the Saudi government.[xxvi]

With the toppling of the regime of Saddam Hussein of Iraq and an improvement in Saudi-Iranian relations following the election of President Mohammed Khatami, the threat to Saudi stability is shifting and may become more internal than external. This has prompted the United States to announce the withdrawal of its decades long military presence inside the kingdom. Both U.S. Secretary Donald Rumsfeld and Saudi Defense Minister Prince Sultan Bin Abdul Aziz attributed the imminent end to the American air force presence in the country to the success in the war on Iraq, stressing that there is no longer a need for American flights to use the Prince Sultan airbase outside Riyadh to patrol the southern no fly zone over Iraq. The withdrawal of U.S. troops was meant to mollify the kingdom's fundamentalists and even moderates who opposed ongoing American military presence in the Gulf country for both political and religious reasons.[xxvii]

The announcement by the Bush Administration on April 29 that it was effectively ending its military presence in Saudi Arabia, with most of the 5,000 American troops (save a 500-member training crew) leaving the Kingdom by the end of the summer, surprised most observers, who were prepared for an eventual announcement but were caught off guard by the timing and immediacy of the move. The U.S. has already moved the U.S. Combined Air Operations Center from the Prince Sultan air base to Qatar's Al Udeid air base, which the tiny emirate built in 1996 at a cost of $1 billion to encourage the U.S. military to base its regional aircraft there.

Ironically, the announcement of the U.S. withdrawal was followed almost immediately by an attack on Westerners in the Kingdom. The simultaneous suicide bombing attacks carried out by 15 Saudis on three compounds housing foreigners in Riyadh on May 12 that wounded 200 people and killed at least 34, including eight Americans and seven Saudis, highlights the threat that internal groups now pose inside the kingdom.[xxviii]

Seven of the Americans killed had worked for the subsidiary of the U.S. defense contractor Northrop Grumman, Vinnell Corp., a Virginia firm that has a contract to train the Saudi National Guard and Saudi and civilian officials. The fact that employees of a U.S. defense contractor providing training and support for the protection of the Saudi regime were specifically targeted is highly significant. The action was interpreted within the Saudi leadership as an indication that not just American targets were at risk but attacks might be directed at the Saudi regime itself. The incident, now linked to the Al-Qaeda terrorist network, is not the first internal attack but one in a series of incidents in recent months.[xxix]

Worries about Saudi Arabia's stability started creeping into US foreign policy literature prior to September 11. And, it was observed that a less stable Saudi Arabia mightn't have as much flexibility to carry and use spare oil capacity to help the industrialized West. "Things have changed," observed a 52-person task force sponsored by the James A. Baker III Institute for Public Policy and the Council on Foreign Relations on Strategic Energy Policy Challenges for the 21st Century in April 2001. "These Gulf allies are finding their domestic and foreign policy interests increasingly at odds with U.S. strategic considerations, especially as the Arab-Israeli tensions flare."

Neo-Conservative Critique of the Special Relationship between the US and Saudi Arabia

But post-September 11, the neo-conservative critique of the special relationship between the US and Saudi Arabia became sharper in the aftermath of the attacks on New York and Washington DC. It entered the mainstream US foreign policy debate as never before.

Department of Defense advisor and prominent neo-conservative Richard Perle sponsored a 2002 briefing at the Pentagon in which Saudi Arabia was described as the "kernel of evil."[xxx] Victor Davis Hanson went as far as to title a summer of 2002 article in Commentary Magazine "Our Enemies, The Saudis."[xxxi]

Summing up the dangers of heavy reliance on Middle East oil, former CIA director R. James Woolsey wrote in "Defeating the Oil Weapon" in Commentary in September 2002, "We had a working partnership with the Saudis for much of the cold war, offering them protection against the Soviets (and Soviet clients states) in exchange for a reliable supply of cheap oil. But in light of the direction taken by the Saudis for nearly a quarter-century now (accommodating extremist Wahhabi views) it is also imperative that we take steps to reduce their hold over us."

"The wealth produced by oil is what underlies, almost exclusively, the strength of three major groups in the Middle East –Islamists, both Shiite and Sunni, and Baathists— that have chosen to be at war with us. Our own dependence on that oil, and the effect this has had on our conduct over the past quarter-century, have helped encourage each of these groups to believe that we are vulnerable," Woolsey argued.

Ariel Cohen, key analyst at the conservative Heritage Foundation, explicitly argued that access to oil revenues was a critical aspect of the export of radical Islam. "The oil bonanza funded the worldwide export of radical Wahhabi Islam, the ideological breeding ground of al Qaeda and the Taliban, over the last three decades. Government sponsored foundations, supervised by members of the Saudi royal family, fueled jihad from New York to Kabul, and from Miami to Manila, by funding brainwashing for violence in Wahhabi academies (madrassas), and terrorism training under the guise of charity. Hamas and Yasser Arafat's al Aqsa Martrys Brigades, which undermined the Oslo process and now are busily blowing the roadmap to bits with their weapon of choice brainwashed Palestinian suicide bombers are partially funded through Saudi telethons and hailed by preachers in Saudi government-supported mosques worldwide."[xxxii]

"Bin Laden understands both economics and the politics of terrorism. He has proclaimed that if he takes over his native land, he will drive oil to $125 a barrel…and Bin Laden's engineering and managerial skills can conceivably suffice to stage a super attack on the kingdom's oil infrastructure, one that could neutralize Saudi Arabia's 2 million barrels a day surplus oil producing capacity, vital for price stability," he warned.

Such concerns among analysts transcend the direct economic impact of high oil prices and volatility on the US economy. They center on a belief that oil revenues permit Middle East countries to sustain authoritarian regimes and promote anti-American policies such as support for international terrorism or pursuit of weapons of mass destruction. Under this analysis, state-owned oil companies in major Middle East producers serve as a government agent for the collection of economic rents that would, under a privatized system, flow to the people of the countries themselves. Collusion on production levels through OPEC, in turn, sustains those rents at a high level.

Saudi Arabia, though an ally of the United States, plays a particularly pernicious role in neo-conservative analysis, using its immense oil revenues and leadership in OPEC to promote the Kingdom's own brand of fundamentalist Islam – Wahabism – in the Middle East and Central Asia. "Saudi Arabia is a special case, being the home of Osama bin Laden himself and fifteen of the nineteen suicide hijakers, the seedbed of the ideas that stand at the heart of the Taliban, and the source of much of the funding of Islamist networks around the world. Although Saudi authorities have managed a working relationship with the West for decades, they have also permitted the kingdom's public discourse to be taken over by militant Islam, " wrote Daniel Pipes, "Who is the Enemy" Commentary January 2002. Pipes criticizes the close relationship between Saudi officials and the Bush Administration, which approved the evacuation of dozens of influential Saudis, including relatives of Osama bin Laden, from the United States in the days after September 11 despite the fact that most air travel was grounded.[xxxiii]

Growing Bi-Partisan Consensus

However, concerns about Saudi Arabia, its stability and its foreign policy are not limited to the neo-conservative vein. Mainstream policy leaders are voicing similar concerns in mainstream journals. "The flow of funds to certain oil producing states has financed widespread corruption, perpetuated repressive regimes, funded radical anti-American fundamentalism, and fed hatreds that derive from rigid rule and stark contrasts between rich and poor. Terrorism and aggression are byproducts of these realities. Iraq tried to use its oil wealth to buy weapons of mass destruction. In the future, some oil-producing states may seek to swap assured access to oil for the weapons themselves. It is also increasingly clear that the riches from oil trickle down to those who would do harm to America and its friends. If this situation remains unchanged, the United States will find itself sending soldiers into battle again and again, adding the lives of American men and women in uniform to the already high cost of oil" wrote Timothy E. Wirth, C. Boyden Gray, and John D. Podesta, in "The Future of Energy Policy" Foreign Affairs, July/August 2003.

Harvard University's John F. Kennedy School of Government hosted an executive seminar on "Oil and Security" in May 2003, noting that "developments in the Middle East have highlighted the need to reassess the economic and political implications of the United States' growing dependence on imported petroleum, and to evaluate the changing relations between the United States and the Middle East oil producing countries." The seminar, which brought together many of America's top experts on oil and security, concluded, "Terrorism has emerged as a key concern in two regards. One is the risk to the oil industry's infrastructure and its "soft targets" in both consuming and producing countries. The other is the use of the proceeds from oil sales to fund terrorist organizations and the governments who harbor them."

The discussion at the Harvard seminar regarding Saudi Arabia focused on the Saudis critical role in oil markets and elaborated the obstacles to reducing or diluting their importance. The Rapporteur's report, published by the Environment and Natural Resources Program at the Belfer Center for Science and International Affairs, concluded that the global oil market benefits from having a "swing producer" who can raise production to regulate oil prices and noted that there are few, if any, other countries besides Saudi Arabia who might play this role in the coming decades. "The criteria for candidates are essentially economic," noted the seminar report. "The swing producer would need to be the low cost producer, and someone with sufficiently centralized and enforceable policies. It is unlikely to be Russia given the multitude of private producers with different interests, and the limited discretionary power of the central government.

While Iraq may have the prerequisite volume of reserves, its economic needs will make it virtually impossible for it to forego 20-25 percent of its production capacity. In the short- to medium-term, this leaves only Saudi Arabia."

The Harvard report posited the possibility that Saudi Arabia could experience a change in government, and that this could negatively impact its international oil market regulator role but suggested, "Economic necessity would constrain the government to adopting export-friendly policies in the medium- and long-term." Still, the report qualified this optimism by noting that "a change of regime in itself might be problematic." It added that the exodus of skilled personnel and foreign expertise might result in a loss of adequate personnel required to operate the system, resulting in a drop in production, or at the very least a curtailment of the investment needed to maintain and expand production. "History has not been kind on the impacts of regime change on oil production," explained the report. "It took approximately 10 years for Russia to start reviving its former production levels, and Iran has yet to return to the levels it was producing in 1980. It is thus conceivable that world oil supplies could be disrupted considerably longer than the "few months" that analysts have hinted at so far."

<u>The Links between Terrorism and Oil: Real or Imagined?</u>

As discussed above, some analysts are arguing that low oil prices – in addition to providing substantial economic benefits for the US and global economies – will reduce the revenue available to oil states, which sponsor terrorism or pursue the acquisition of weapons of mass destruction. This argument has powerful logic, but raises the question as to whether the link between oil rents and terrorism is really bonafide.

The proposition that oil producing countries have the resources to sponsor international terrorism seems, at first glance, to have merit upon glancing at the State Department list for such "states of concern." In the 1990s, several among the top violators, Iran, Iraq, Syria, Sudan, and Libya, all have state budgets supplemented by oil export revenues. Sudan is no longer on the list, and U.S. military sits in Iraq. On the US government's current watch, Iran registered annual oil revenues of $18 billion in 2002, with $22 to $24 billion in foreign assets; Syria, oil revenues of $5.4 billion; and Libya, oil revenues of $11 billion, with $25 billion in foreign assets.[xxxiv] However, it should be noted that oil revenue is not a necessary and sufficient requirement to host terrorist networks or to develop nuclear weapons since many states lacking oil resources (or in fact, wealth of any kind), hold this dubious distinction including Afghanistan, Pakistan, and North Korea.

Iran's economy is highly dependent on oil export revenues, which constitute roughly 80% of total export earnings and 40-50% of the government budget and 10-20% of GDP. The US Department of State concluded in its 2002 Patterns of Global Terrorism Report that Iran remained "the most active state sponsor of terrorism in 2002." Oil revenue represents a significant portion of Iran's disposable income. The State Department report concluded that Iran provided Lebanese Hizbollah and Palestinian rejectionist groups such as HAMAS, the Palestine Islamic Jihad, and the Popular Front for the Liberation of Palestine-General Command, with funding, safehaven, training and weapons. Iranian funding for Hizbollah was reportedly about $60 million to $80 million a year in the 1980s. The State Department report also asserted that Iran provided support to extremist groups in Central Asia, Afghanistan, and Iraq with ties to Al-Qaeda.

The US first placed Iran on the State Department terrorism list in 1984, in response to allegations of Iranian involvement in the 1983 suicide attack by Hizbullah on US marine barracks in Lebanon.[xxxv] Iran was also linked to the bombing of Khobar Towers in Saudi Arabia, where 19 American servicemen were killed. On June 21, the Justice Department announced that it had indicted thirteen Saudis and one Lebanese who were members of Saudi Hizbollah. The indictment said that these individuals belonged to groups that were "inspired, supported and supervised" by elements of the Iranian government.[xxxvi] In April 2001, Iran sponsored an international conference supporting Palestinian groups, including groups promoting violence in Israel. In January 2002, a shipment of fifty tons of arms from Iran to the Palestinian Authority was uncovered.[xxxvii] The US maintains economic sanctions against Iran because of its terrorist links, and American firms are not allowed to purchase oil from Iran, nor invest in its oil fields.[xxxviii]

Oil-rich Iraq was also reported to fund terrorist training and operations prior to the US invasion. Iraq defector interviews published on the internet include stories of terrorist training camps and US troops encountered such camps during the recent campaign against the regime of Saddam Hussein as reported on CNN. Press reports also covered Iraq's generous support of Palestinian suicide bombers. Saddam Hussein reportedly pledged $25,000 each for the families of suicide bombers. The Arab Liberation Front, a Palestinian group, said that it had distributed between $30 million to $35 million in Iraqi money.[xxxix]

But by far the most controversial in the debate of terrorist financing is the direct and indirect role of Saudi oil revenues to assist terrorist groups. Oil and oil derived products account for roughly 90-95% of total Saudi export earnings, 75% of budget revenues, and approximately 30-35% of GDP. A 34 page private study compiled at the end of 2002 at the request of the President of the United Nation's Security Council concluded that Saudi-funded charities and businesses are still supporting Al-Qaeda terrorist networks. "Al-Qaeda was able to receive between $300 million and $500 million over the last 10 years from wealthy businessmen and bankers, whose fortunes represent about 20% of Saudi GNP, through a web of charities and companies acting as fronts" Jean-Charles Brisard, the report's author and former analyst for French intelligence told the London Times.[xl]

The government of Saudi Arabia has declared its support for the US War on Terror but has been fairly open in support of Palestinian terrorist groups. Saudi Crown Prince Abdullah, the de facto ruler of Saudi Arabia, met with a delegation from Lebanon's Hizbollah, praising resistance to Israel's attacks against southern Lebanon.[xli] Newsweek Magazine also reported in July 2003 that while the Saudi government has cracked down on Islamic extremists since September 11, it has increased its support of HAMAS.[xlii] Newsweek quoted a US Senate staff memo citing an Israeli national assessment that Saudi Arabia is funding more than 50% of HAMAS's needs. Newsweek reported that US assessments of the Saudi contribution to HAMAS are higher than those cited by Israel.[xliii] The Newsweek article says documents seized by Israel during a raid showed that Khaled Mishai, a top HAMAS leader, was the guest of a Saudi-government backed charity, the World Assembly of Muslim Youth, at a convention in Riyadh. The convention was sponsored by Crown Prince Abdullah. A Saudi Government spokesman acknowledged at a Washington press conference in June 2003 that the Saudi government provides some funding for the "political wing" of HAMAS.

The Newsweek article also asserted that R. Richard Newcomb, director of the Treasury Department's Office of Foreign Assets Control, "has apparently told (Senate) staffers that virtually every attempt by the Treasury Department to impose sanctions on wealthy Saudi businessmen or entities that have been linked to terror financing has been "blocked" on foreign-policy and national-security grounds—usually invoked by the State Department but on some occasions by the FBI and CIA. In other words, other agencies of the government were worried sanctions would upset Saudi-American relations or disrupt ongoing investigations in other areas."

A Council on Foreign Relations Task Force on Terrorist Financing concluded similar findings, saying "For years, individuals and charities based in Saudi Arabia have been the most important sources of funds for Al-Qaeda; and for years, Saudi officials have turned a blind eye to this problem."[xliv]

Middle East analysts say that Saudi Arabia has increased its support for the War on Terror since the bombing attacks on three compounds housing foreigners in Riyadh. Reports of Saudi police raids on Al-Qaeda hideouts have become more common place, and US officials have been quoted in the press as saying the Kingdom is providing more cooperation in shutting down Al-Qaeda. But recent Saudi cooperation comes against a backdrop of emerging reports of past Saudi aid for the Taliban and possible indirect connections to funding for Al-Qaeda. Starting in 1999 and extending into mid-2000, Saudi Arabia gave 150,000 barrels a day of free oil exports to Pakistan and the Taliban government in Afghanistan, according to Petroleum Intelligence Weekly.[xlv] Oil trading community sources say that these shipments exceeded Afghanistan's oil use and may have been resold to arm the Taliban.[xlvi] Saudi Arabia also extended an oil grant (the Saudi Oil Facility (SOF)) to Pakistan, following nuclear tests conducted by Islamabad in May 1998, to help Pakistan avoid defaulting on its international loan commitments. Pakistan was, at the time, building debt arrears in the wake of nuclear proliferation-related sanctions imposed by the West.[xlvii]

More concerning are reports in the Boston Herald that assert that two Saudi billionaire families are being scrutinized by US authorities for possible financial ties to Osama Bin Laden's terrorist network.[xlviii] Evidence for the allegations revolve around a 1999 audit conducted by the Saudi government that reportedly discovered that the Bin Mahfouz family's National Commercial Bank, had transferred at least $3 million to charitable organizations believed to be fronts for Bin Laden's terrorist networks, including Islamic charity Blessed Relief, whose board members include Abdul Rahman bin Mahfouz, son of Khalid Bin Mahfouz. In October 2003, the US Department of Treasury named Blessed Relief as a front organization providing funds to Bin Laden.

US and British authorities also reportedly looked at Al-Amoudi's Capitol Trust Bank in London and New York for similar activities. Mohammed Hussein Al-Amoudi is based in Ethiopia and oversees a vast network of companies in construction, mining, banking and oil, many of which have cross ownership with businesses owned by Saudi defense Minister Prince Sultan. Al-Amoudi has categorically denied any links to Bin Laden and declared himself "unalterably" opposed to terrorism, according to the Herald article. Both the bin Mahfouz families and Al-Amoudi families have close business links to the Saudi government.

The Bush administration has tried to press Saudi Arabia to crack down on Saudi charities, businesses and individuals who have links to terrorist groups. But the US is limited in how much of a conflict it can generate with Riyadh over the issue –despite its importance-- given the importance of Saudi largesse in keeping oil markets stable. The US must also concern itself not to press the kingdom for cooperation too stridently, thereby prompting such a negative reaction that Saudi Arabia opts to cut its oil production in retaliation or refuses to assist the international community should a new oil supply disruption emerge. Similarly, the US has to worry that too much US diplomatic pressure for sweeping changes might precipitate Saudi policies that could lead to the fall of the current Saudi government in favor of a more radical one. Finally, the US is closed off --by the inexorable dependence on Saudi swing capacity in times of unexpected crisis—from using the kind of tools that might be utilized to pressure regimes with similar "issues" such as denying the country access to international lending, instituting oil sanctions or other economic sanctions or banning its businesses from the US market.

The reality of US policy constraints toward Saudi Arabia is demonstrated dramatically by a comparison of US-Iranian relations versus US-Saudi relations. The US maintains no diplomatic ties with Iran, has branded it a member of the "Axis of Evil," continues comprehensive economic sanctions against Iran and actively supports opposition groups and internal unrest inside Iran in hopes that the government will fall from power. The rationale for this policy is, of course, Iranian support for terrorism and its pursuit of weapons of mass destruction.

Ironically, however, Iran's support of terrorist groups includes two organizations that are the same groups reportedly receiving support from Saudi Arabia. As to Iran's weapons programs, Saudi defector Mohammed Khilewi, who was first secretary to the Saudi mission to the United Nations until 1994, alleges that Saudi Arabia sought to buy nuclear reactors from China, supported Pakistan's nuclear program[xlix] and contributed $5 billion to Iraq's nuclear weapons program between 1985 and 1990.[l]

In contrast to US-Iranian relations, the US, rather than sanction Saudi Arabia for these actions, has a historically close alliance with the kingdom. Indeed, the US has few means at its disposal to influence Riyadh if it chooses to block US efforts to close down terrorist funding or operations, except to withdraw US support for the country's security which, given the importance of its oil resources, would be counterproductive.

Chances are only the most extreme revelation, such as direct evidence that Saudi Arabia is officially attacking US citizens, is likely to tip the balance for open hostility towards the kingdom. That is because a US-led attack on Saudi Arabia that would lead to a change of government would almost certainly spur a crisis in international oil markets, damaging the US and international economy. Markets would have to be well-assured that chaos, sabotage or looting wouldn't disrupt oil exports as it has in Iraq, were the US to engage in a war in the kingdom. An economic blockage on Saudi Arabia, though actually proposed in the US Congress, would have a similarly deleterious impact on the world economy.

The constraints that dependence on Saudi oil creates on US foreign policy are not, however, necessarily limited to issues related to terrorism or policies related directly to Saudi Arabia itself. The Saudi "relationship" could also be called into force to influence other US foreign policy choices -should a potential American policy choice be considered of vital national interest to Saudi Arabia.

"To a certain extent, we let US foreign policy be dictated to us by the house of Saud," private oil consultant and former senior advisor in the Carter Administration Philip Verleger told the New York Times.[li]

Robert Baer, author of "Sleeping with the Devil" and Atlantic Monthly article "The Fall of the House of Saud"[lii] warns of the dangers in Saudi Arabia's position as the "market regulator for the global petroleum industry" when Saudi oil is controlled by "an increasingly bankrupt, criminal, dysfunctional, and out-of-touch royal family that is hated by the people it rules and by the nations that surround its kingdom."

While it might seem hard to imagine, beyond terrorism or banking, what other areas of undue pressure could realistically be drawn, it needs to be remembered that Saudi Arabia cooperated with the US in the mid-1980s to lower the price of oil to weaken the Soviet Union as well as Iran and Iraq. Those choices to pressure Moscow, Tehran and Baghdad suited US interests. In fact, to the extent that low oil prices helped foster a change in government in the USSR, the US was ecstatic. But what of a case where an aggressive Saudi oil pricing policy threatens an important US allied leader?

Such was the case in 1998 when extremely low oil prices put the last nail in the coffin of a friendly Venezuelan government and ushered into power the unfriendly regime of Hugo Chavez. Prior to the change of leadership in Caracas, Venezuela had been actively expanding its oil production capacity through an opening up to foreign direct investment by American oil companies initiated in 1992. The program was expected to take Venezuela's oil production as high as 7 million barrels a day by 2010, a level almost rivaling Saudi Arabia. For a period of many months, Saudi Arabia warned Venezuela to stop overproducing and to abandon its plans to expand its oil market share. It threatened to initiate an oil price war to knock out the incentives for continued investment in Venezuela and to "punish" the Venezuelan government. Venezuela failed to heed Saudi warnings and Saudi Arabia sat back as oil prices moved into a free fall. When oil prices reached a low of $8 a barrel in 1999, Venezuela was forced to cry "uncle" and the new Venezuelan government immediately trimmed back plans to expand oil production capacity. In fact, continued political unrest in Venezuela, in the aftermath of the entire financial debacle stimulated by the 1998 crash, led to an oil workers strike that has set Venezuela's state oil industry back tremendously. Venezuela's production capacity has fallen from 3.7 million barrels a day prior to the election of Hugo Chavez to roughly 2 million b/d today, contributing dramatically to the tightening of oil markets in recent years and related high prices.[liii] Concluded the Harvard seminar report about this Saudi strategy, it "has been costly for countries attempting to challenge the position of Saudi Arabia. The Saudis have responded aggressively and ruthlessly to protect their leading role in the world market."

Riyadh could easily use the same trick down the road to weaken the base of support for Russia's President Vladimir Putin or to dislodge a new Iraqi or Mexican government not to its liking. One motivation could be one of these countries stepping up to the plate with investments (or an opening to massive foreign direct investments) designed to overtake Saudi Arabia as the pivotal oil superpower.[liv]

There has been speculation that Russia could replace Saudi Arabia as the key US energy ally, and this has prompted some speculation (and Saudi public warnings) that Riyadh might start a price war to hinder rising Russian production. In reality, however, Russia possesses next to no unutilized capacity, nor is Russia likely to develop such capacity in the future. This stands in stark contrast to Saudi Arabia, who, as discussed above, has spare capacity that can be offered in times of market emergencies.

The unique ability of Saudi Arabia to serve as market guarantor makes the costs of an unexpected change of government a major concern to the West. The establishment of a radical or openly hostile government in Saudi Arabia would be a major problem for international oil markets. History has shown that sudden changes of government – whether by military take-over or by a shift to democracy—is often followed by a sharp drop in oil production levels for a sustained period of time, frequently ten to twenty years. This is because a major government change is often accompanied by bureaucratic confusion and/or internal chaos for a period of time. In the case of Iran, the country's oil production levels have still not recovered to pre-revolutionary levels despite the passing of over 30 years. Russia too is just now recovering after a 10-year slump in oil production following the collapse of the Soviet Union. A bin Laden style government would not need to reduce production purposely to grab higher oil rents but may simply do so by accident through disorganization or the politically motivated replacement of knowledgeable technocrats.

Conclusion

October 17, 2003 marks the 30th anniversary of the 1973 Arab oil embargo. Thirty years later, oil remains, incomprehensibly, a continuing worry for the international community. Ironically, despite three decades of liberalization and the development of global markets and free trade, the world has not been able to shake off the "threat" of political interdiction of oil supplies. And now, new worries have emerged that oil revenues are being diverted to support international terrorism and development of weapons of mass destruction.

Diplomatic creativity by the United States and the other industrial democracies in the 1970s helped counter and limit the economic and political damage wreaked upon the West by OPEC's oil weapon. Renewed focus on similar efforts is imperative for U.S. and its allies. Serious efforts need to be made to lower dependence on oil and to marginalize oil supplies from the Middle East and elsewhere that are not available to our citizens on terms suitable to our interests. This can be done by simultaneously nurturing sources of "new" oil such as Russia, the Caspian and Canadian tar sands while at the same time allocating more substantial resources towards developing alternatives.

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[i] "Search for New World Order Confronts Oil World" Petroleum Intelligence Weekly, Monday, February 11, 1991 and February 4, 1991, page 1.

[ii] "Texaco, Saudis Finalize Joint Oil Venture" Associated Press, November 11, 1988, as printed in the Wall Street Journal p. 16

[iii] "The Political, Economic, Social, Cultural, and Religious Trends in the Middle East and the Gulf and Their Impact on Energy Supply, Security and Pricing, available at www.bakerinstitute.org; also Petroleum Intelligence Weekly covered these production increases in great detail in various issues from August 1990 to January 1991

[iv] Strategic Energy Policy: Challenges for the 21st Century, Report of an Independent Task Force Co-sponsored by the James A. Baker III Institute for Public Policy of Rice University and the Council On Foreign Relations, 2001, available at www.bakerinstitute.org. While no formal written treaty to this affect exists, the quid pro quo of oil pricing policy was a common feature of private discourse between US officials and Saudi officials during the mid to late 1980s. For discussion of the Gulf Arab pricing policies to keep pricing artificially low, see F. Gregory Gause, "Iraq's Decision to Go to War" Middle East Journal, Winter 2002 (Volume 56, No. 1) and Lawrence Freedman and Efraim Karsh, The Gulf Conflict 1990-1991 Princeton University Press, Princeton, 1993) as well as The Washington Post, January 15 1991 which described Iraq's dissatisfaction with the Gulf Arab policy of keeping oil prices low. Also, William Quandt, Saudi Arabia in the 1980s: Foreign Policy, Security and Oil, The Brookings Institution, Washington DC, 1981

[v] Kenneth M. Pollack, "Securing the Gulf" Foreign Affairs, July/August 2003, Vol. 82, No. 4. For other readings on this subject of the security of the Persian Gulf, see "Toward a New Regional Security Architecture," Joseph McMillan, Richard Sokolsky and Andrew Winner, The Washington Quarterly, Summer 2003, Vol. 26, No. 3 or "Towards a Regional Security Regime for the Middle East: Issues and Options at http://projects.sipri.se/mideast/MEreport.pdf.

[vi]For discussion and analysis of the formation of the GCC, Simon Henderson, "Policy Watch: The Gulf Cooperation Council Defense Pact: An Exercise in Ambiguity" at http://washingtoninstitute.org/watch/policywatch/ and the U.S. Library of Congress, entry under Persian Gulf. Henderson's piece lays out the Clinton Administration's efforts to integrate GCC defenses within the GCC with the US in the areas of communications systems and early warning missile systems. The US has formal defense agreements with some of the GCC states and has pre-positioned military equipment in Kuwait, Qatar, the UAE and Oman. A formal defense alliance between the US and the entire GCC has proved elusive over the years for a variety of local political reasons. For more deeper analysis of the politics and security deliberations of the GCC, see Iran, Iraq and the Arab Gulf States, Edited by Joseph A. Kechichian, Palgrave, New York, 2001 and for discussion of the Gulf war and security in 1990-1991, see F. Gregory Gause, "Iraq's Decision to Go to War" Middle East Journal, Winter 2002 (Volume 56, No. 1); Also, Shibley Telhami, "Between Theory and Fact: Explaining American Behavior in the Gulf War" Security Studies, Vol. 2, No. 1, 1992. Also, James A. Baker III, The Politics of Diplomacy, New York: Putnam) 1995

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[ix] Presentation by James Bodner, principal deputy undersecretary for defense for policy, in "Running on Empty: Prospects for Future World Oil Supplies" Baker Institute Study No. 14, available at www.bakerinstitute.org

[x] Ibid

[xi] Ibid

[xii] Hu, Patricia Op cit; Congressional Research Service, Document on Persian Gulf War: US Costs and Allied Financial Contributions, Washington DC CRS, IB 91019, September 21, 1992. Also, Patrick Tyler and Richard W. Stevenson, "Profound Effect on US Economy Seen in a War with Iraq" The New York Times, July 30, 2002.

[xiii] Jon B. Alterman, In Robert J. Art and Patrick M. Cronin, "Coercive Diplomacy Against Iraq, 1990-1998" The United States and Coercive Diplomacy, P 275-303, Washington, D.C., The United States Institute for Peace, 2003; Also, this strategy is confirmed in the autobiography of James A. Baker III in which Sec. Baker recounts that the US planned to "begin with diplomatic pressure, then add economic pressure…and finally move toward military pressure by gradually increasing American troop strength in the Gulf." The Politics of Diplomacy, p. 277

[xiv] Michael Klare, "The Coming War with Iraq: Deciphering The Bush Administration's Motives" Foreign Policy in Focus, January 16, 2003 at www.fpif.org/commentary/2003/0301warreasons_body.html

[xv] For a detailed discussion on sanctions impact on investment, see Meghan L. O'Sullivan, "Shrewd Sanctions: Statecraft and State Sponsors of Terrorism" Brookings Institution Press, Washington DC, 2003

[xvi] Iran had aimed to reach 4 million b/d, Libya 1.6 million b/d and Iraq 4.5 million barrels a day, but were constrained at 3.8 million b/d, 1.4 million b/d and 1.2 million b/d respectively. See Political, Economic, Social, Cultural, and Religious Trends in the Middle East and the Gulf and Their Impact on Energy Supply, Security and Pricing, op cit

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[xxiv] David Holden and Richard Johns, The House of Saud: The Rise and Rule of the Most powerful Dynasty in the Arab World, Holt, Rinehart, and Winston, 1981, New York, p. 198-225

[xxv] R.K. Ramazani, "Iran's Islamic Revolution and the Persian Gulf" Current History, 84, No. 498, January 1985.

[xxvi] Joseph A. Kechichian, "Trends in Saudi National Security" Middle East Journal, Vol. 53, No. 2 Spring 1999, p. 232-253. Also, for an overview of political instability in Saudi Arabia, see Milton Viorst, "The Storm and the Citadel, Foreign Affairs, Jan/Feb 1996

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[xxxii] Ariel Cohen, Energy Security at Risk, May 23, 2003, available in the press room at www.heritage.org/press/commentary/ed052703a.cfm

[xxxiii] Eric Lichtblau, White House Approves Departure of Saudis After September 11, ex-aide says, The New York Times, September 4, 2003, p. 19

[xxxiv] Country analysis briefs available at www.eia.gov. Also, Energy Intelligence Group's Oil Market Intelligence, July , 2003, Vol. VIII No. 7

[xxxv] Meghan L. O'Sullivan, "Shrewd Sanctions: Statecraft and State Sponsors of Terrorism" Brookings Institute Press, Washington DC, 2003, Chapter 3

[xxxvi] http://news.findlaw.com/cnn

[xxxvii] Overview on Iranian terrorism links also outlined by George Tenet, Testimony given on Current and Future Threats to National Security, Senate Armed Services Committee, February 2, 1999

[xxxviii] For a detailed account of the US oil sanctions policy against Iran, see Meghan L. O'Sullivan, "Shrewd Sanctions: Statecraft and State Sponsors of Terrorism" Brookings Institute Press, Washington DC, 2003

[xxxix] "Saddam paying suicide bombers" The Associated Press, October 10, 2002

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[xlii] Newsweek Magazine Website, July 30, 2003 "Financing Terror: Are the Saudis increasing support for Hamas? By Michael Isikoff

[xliii] Newsweek Magazine Website, July 30, 2003 "Financing Terror: Are the Saudis increasing support for Hamas? By Michael Isikoff

[xliv] Terrorist Financing, Report of an Independent Task Force sponsored by the Council On Foreign Relations, Maurice Greenberg, Chair; William F. Wechsler and Lee S. Wolosky, project co-directors, 2002, available at www.cfr.org

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[xlvii] Nadeem Malik, Saudi Oil Facility and Strong Fiscal Management Help Pakistan Narrow Its Balance of Payments and Budget Deficits, August 29, 2001, http://atimes.com
[xlviii] Jack Meyers, Jonathan Wells and Maggie Mulvihill, “Saudi Clans Working with US Oil Firms May be Tied to Bin Laden
[xlix] For more on this, See the book the Islamic Bomb by Steve Weissman, Times Books 1981
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Federal Oil Subsidies:
How Can They Best Be Targeted?

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Prepared for the National Commission on Energy Policy

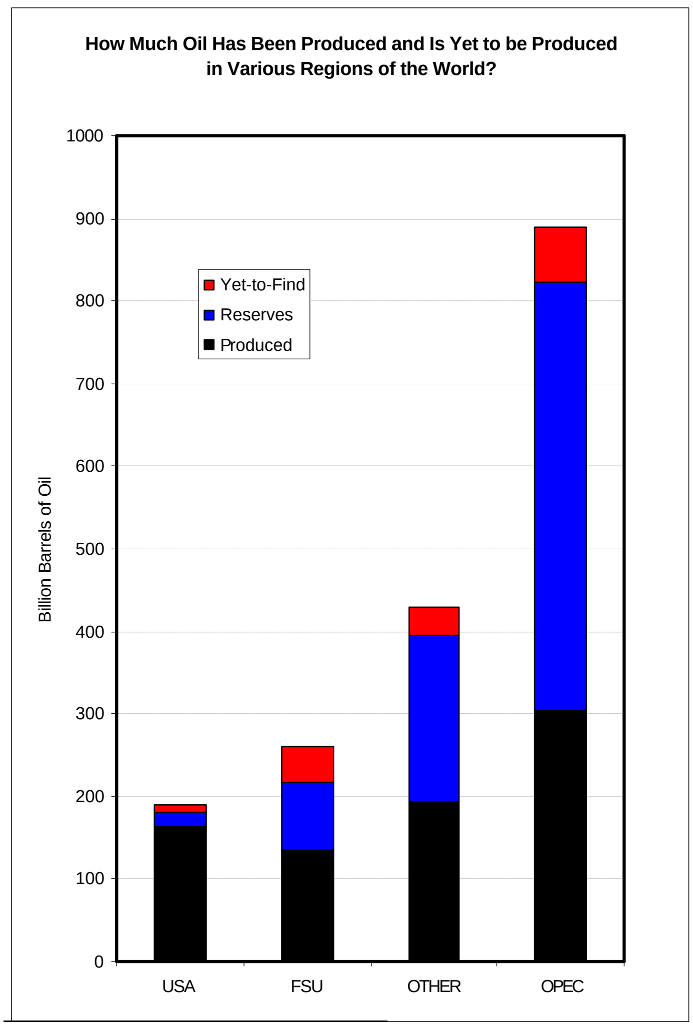
May 20, 2004

Introduction

Much of federal petroleum policy is propelled by the stated desire to reduce dependence on oil imports and increase domestic supplies. The notion is that substantial domestic oil resources remain untapped, and, once developed, could displace imports barrel-for-barrel. In reality, this is not always the case, since the world's largest oil producers can profitably extract and transport oil to the U.S. at prices far below those needed to make many marginal or remote oil fields in the U.S. profitable to drill.

The U.S. also faces the stark reality (see Figure 1) that about 80% of all the oil that will ever be found within its borders has already been extracted and burned, while many OPEC countries are only just beginning to tap their substantial reserves.

Figure 1
Less than 3% of the World's Remaining Oil Resources are within U.S. Borders



On the other hand, U.S. opportunities to cost effectively reduce oil consumption are among the largest and most lucrative in the world. The U.S. is the world's largest single oil consumer, and burns most of its oil in a fleet of vehicles that has grown steadily less efficient over the last two decades. Average number of vehicles per person and number of miles driven per vehicle also continue to rise steadily.

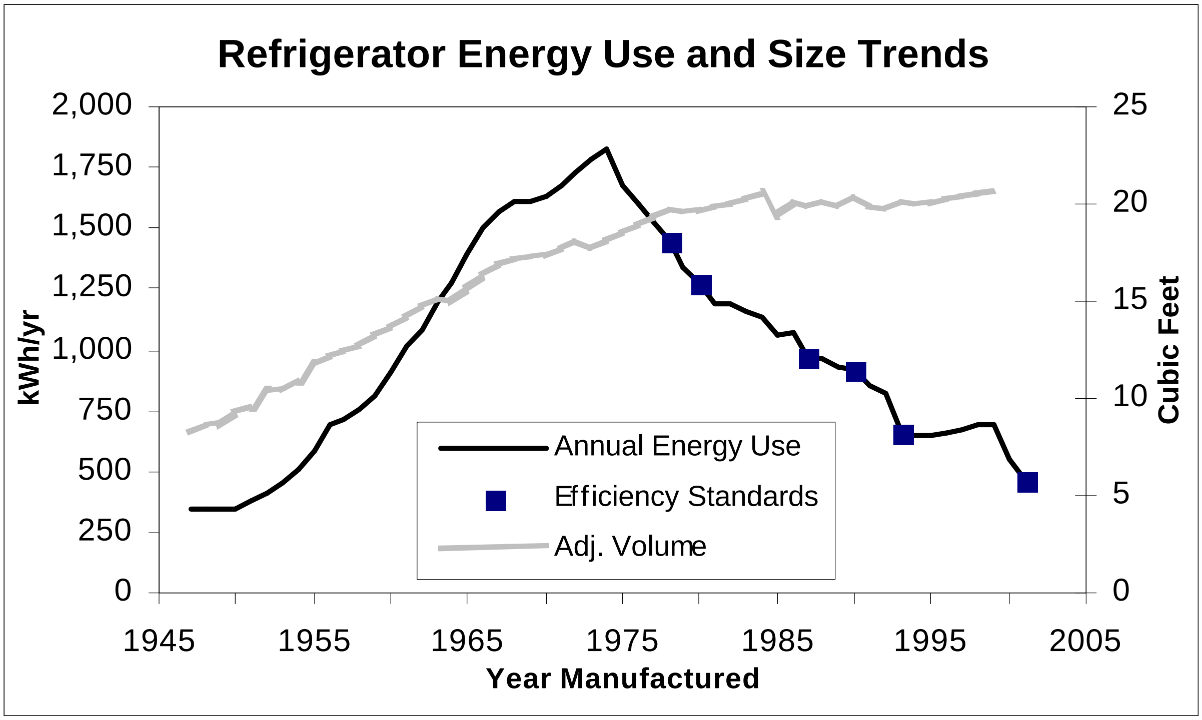
In response, many in the environmental community have called for mandatory improvements in the fuel economy of new vehicles. Indeed, there appear to be a number of technological means of improving new vehicle fuel efficiency whose incremental costs are cheaper per gallon of gasoline saved than the cost of domestically finding, refining, and selling a gallon of gasoline at the pump.[1]

However, it is unusual to expect mandatory fuel economy standards to *lead* the market to new fuel economy

[1] John DeCicco, Feng An, and Marc Ross, ACEEE, *Technical Options for Improving the Fuel Economy of U.S. Cars and Light Trucks by 2010-2015*, June 2001.

technologies instead of *following* the market to lock in savings already achieved by market leaders. This historical sequence is perhaps easiest to see by analogy in the refrigerator market (Figure 2).

Figure 2
Average Refrigerator Size Continued to Grow from 1975 to 2000, While Average Refrigerator Energy Use Fell by 70%.



Market Based Approaches

In this oft-cited example, it is evident that mandatory efficiency standards have helped push average refrigerator energy usage downward. What is not shown here but is equally true, however, is that tens of millions of dollars of utility energy efficiency programs lured manufacturers to develop the new technologies needed to achieve higher efficiency. At the same time, labeling efforts like EnergyGuide mandatory labels and ENERGY STAR voluntary labels made it easy for consumers to determine which choices would save the most money on energy bills. Together, these market tools were instrumental in enabling and encouraging successive technological leaps by leading manufacturers. Standards came along afterward to mop up, compelling lagging manufacturers to achieve what the leaders had already shown was possible. More importantly, ever-tighter standards were politically *possible* because voluntary programs had already proven that more efficient refrigerators could be made and sold profitably, reducing manufacturer opposition to tighter standards.

Financial incentives have been employed in very limited ways in the vehicles market to discourage the sale of the most gas guzzling cars and encourage the sale of hybrid vehicles. But perhaps 90 to 95% of the vehicles sold in a given year are subject to no differential government financial incentive, positive or negative, tied to their fuel economy. Moreover, no federal or state sources of funding are routinely deployed to help consumers reduce their fuel consumption through measures to make their existing vehicles more efficient, even though such savings opportunities are even larger than near term savings from improving new vehicles.

This paper explores three scaleable, market-based program options for reducing gasoline use in motor vehicles, estimating costs per saved gallon of gasoline for each. It also examines a handful of past and present federal subsidies to the oil industry, assessing annual expenditures, resulting increases in domestic oil supply (where they can be estimated), and average cost per additional gallon of gasoline contributed to U.S. supply. Lastly, it compares the cost per saved gallon of various demand side program options to the cost per produced gallon of various federal oil subsidies, suggesting the idea of a fair and open competition between the two for future federal dollars. We argue that federal money spent to reduce dependence on imported oil should flow to those options that can deliver the largest number of gallons per dollar through supply additions or demand reductions.

Federal Oil Subsidies

In general, U.S. oil subsidies are not tied to incremental increases in oil supplies or assessed by Congress for cost effectiveness on a dollars per gallon basis. According to the Energy Information Administration, "programs that offer small subsidies for products for which there are huge existing markets tend to function mostly as transfer programs; that is, their market impacts are negligible, and for the most part they simply redistribute funds from one part of the economy to another, with the Government acting as the intermediary."[2, 3]

Although oil subsidies do not result in substantial increases in oil production, they are significant public spending programs. Four examples of these spending programs are discussed in this report. They include: (1) excess of percentage of cost depletion; (2) expensing of exploration and development costs; (3) oil and gas exception from passive loss limitation; and (4) credit for enhanced oil recovery costs. Estimates of federal revenue losses for each of these petroleum industry incentives are detailed in Table 1 below.

[2] Energy Information Administration, "Federal Financial Interventions and Subsidies in Energy Markets 1999: Primary Energy," SR/OIAF/99-03, September 1999.
[3] Note: Taxpayers for Common Sense, the non-profit organization that analyzes tax subsidies and runs the "Green Scissors Campaign", supports EIA's claim in its own publications and analyses.

Table 1
Estimates of Costs of Petroleum Industry Tax Incentive Programs

TAX INCENTIVE	DATE INITIATED	CUMULATIVE TOTAL THROUGH 2000 (adjusted to $2000)	PROJECTED 2004 ANNUAL COST (million $ in 2004)
Excess of percentage over cost depletion	1968	$82 billion	$400 to $620
Expensing of exploration and development costs[a]	1968	$43 to $55 billion	$270 to $500
Oil and gas exception from passive loss limitation	1988	$8 to $11 billion	$20 to $25
Credit for enhanced oil recovery costs	1994	$0.5 to $1 billion	$200 to $400
TOTAL		**$134 to $149 billion**	**$890 to $1,540 million**

Sources: "Tax Incentives for Petroleum and Ethanol Fuel," GAO/RCED-00-301R, September 25, 2000; Energy Information Administration, "Federal Financial Interventions and Subsidies in Energy Markets 1999: Primary Energy," SR/OIAF/99-03, September 1999; Joint Committee on Taxation, "Estimates of Federal Tax Expenditures for Fiscal Years 2004 – 2008," December 22, 2003, http://www.house.gov/jct/s-8-03.pdf; Office of Management and Budget, "Budget of the United States Government," Fiscal Year 2005, http://www.whitehouse.gov/omb/budget/fy2005/pdf/spec.pdf

a. This estimate of the cash flow into the government for this tax provision does not necessarily reflect the true economic cost of this provision. A feature of tax deferrals is that they can cause the cash-basis tax expenditure to be negatively valued in some years. However, in present-value terms, current deferrals do have a real, positive cost to the government.

Excess of Percentage Over Cost Depletion, for Oil and Gas

Depletion, like depreciation, is a form of cost recovery for capital investments. Normally, capital assets are deducted from taxable income over a period of years, until the entire investment is written off. Percentage depletion allowances for oil allow the industry to write off a percentage of the gross income from oil production each year, as opposed to a percentage of the gross investment. As a result, deductions can actually exceed the original investment. While this tax provision was supposed to have primarily benefited smaller, independent oil companies, since 1990, percentage depletion has been allowed on transferred properties (even if the new owner is a large oil company) and exempted from the Alternative Minimum Tax.[4, 5]

Expensing of Exploration and Development Costs for Oil

This tax provision allows oil companies to immediately deduct many types of expenses from their taxable income that other industries must deduct over multiple years. Tax benefits apply whether the wells are productive or not. This scheme allows oil producers to deduct their expenses from gross income in the period incurred rather than over the productive life of the oil property. Larger oil producers can expense 70% of such costs and must deduct the remaining 30 percent over 5 years for wells that are successful, but can expense 100% of such costs for wells that are unsuccessful. Curiously enough, this encourages oil companies to look for oil, but not necessarily to find it.

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[4] Congressional Research Service, *Tax Expenditures: Compendium of Background Materials on Individual Provisions*, Senate Committee on the Budget, December 1996 and www.greenpeace.org/~climate/oil/fdsuboil.pdf

[5] For a more detail discussion see: "Tax Incentives for Petroleum and Ethanol Fuel," GAO/RCED-00-301R, September 25, 2000.

Oil and Gas Exception from Passive Loss Limitation
Owners of working interests in oil and gas properties are exempt from the passive income limitations.[6] These allow partnership and individual owners of oil and gas wells to offset financial losses from passive activities against active income. Exceptions to the passive loss rules have the effect of restoring the magnitude of the tax incentives to which they apply.

Credit for Enhanced Oil Recovery Costs
A tax credit of 15% is provided for qualified tertiary oil recovery costs incurred in the production of oil on U.S. projects. Qualifying costs include tertiary injectant expenses, intangible drilling and development costs on a qualified EOR project, and amounts incurred for tangible depreciable property.[7]

While oil subsidies have had a long history as U.S. energy and tax policy, these expenditures have not been justified on the grounds that they increase marginal oil production. The U.S. Energy Information Administration and the U.S. General Accounting Office, the two agencies that have undertaken most of the analysis in this field, do not cite any increased oil production as a result of the aforementioned tax subsidies.[8] The Congressional and Senate Committees who are responsible for writing the laws affecting oil subsidies – House Ways and Means, Join Committee on Taxation, and Senate Energy Committee – have not been provided with oil production estimates in the testimony delivered to them. The oil industry has testified repeatedly before Congress about continued oil subsidization, but has not estimated the volume of increased oil production as a result of tax subsidies.[9] As such, oil industry testimony on these subsidies is qualitative in nature, stating that "tax rules…encourage the tremendous capital investment that will be needed to meet U.S. and global energy demand growth."[10]

Research on these programs has consistently failed to find evidence that the subsidies increase domestic oil supply, reduce imports, or cut oil prices. However, given the goal of this paper – to identify the most cost-effective means of meeting the nation's oil needs – we turned to the American Petroleum Institute (API). Although API did not have these figures available, they were willing to make assumptions and calculate estimates of marginal oil production resulting from these subsidies. Their assumptions and calculations follow in italics below.

[6] Information on exceptions to the passive activity rules for working interests in oil or gas properties can be found in IRC section 469.
[7] Information on the tax credit for enhanced oil recovery costs can be found in IRC section 43.
[8] Ecos' conversations with EIA staff confirm that the Agency does not have any estimates for oil production resulting from oil subsidies, nor do they necessarily believe that significant oil production results from these tax provisions.
[9] See www.api.org : "Statement of the American Petroleum Institute, The Domestic Petroleum Council, and the US Oil & Gas Association, on the Role of Tax Incentives in Energy Policy," Submitted for the Printed Record of the July 11, 2001 Hearing, Committee on Finance, US Senate and "Statement of the American Petroleum Institute, The Domestic Petroleum Council, and the US Oil & Gas Association To Accompany the Testimony of Charles N. MacFarlane, Assistant General Tax Counsel, Chevron Corporation Regarding the June 13, 2001 Hearing on the Effect of Federal Tax Laws on the Production, Supply and Conservation of Energy, Subcommittee on Select Revenue Measures, Committee on Ways and Means, U.S. House of Representatives.
[10] Ibid.

According to API, a very rough analysis of the four oil tax policies discussed in this paper indicates that such provisions would stimulate domestic oil and gas production as follows:

- *Using revenue estimates prepared by the Joint Committee on Taxation and Treasury, the provisions are assumed to result in a revenue cost of roughly $1.7 billion per year.*

- *In 2002, the most recent year for which cost data is available, an estimated $54 billion was spent by industry in adding an incremental 6.8 billion barrels of oil equivalent (BOE), implying an average cost of $7.89 per BOE for these incremental reserves.*

- *Imposed on this cost structure, an annual tax benefit of $1.7 billion would be equivalent to a 3.4% increase in the marginal value of those incremental resources to producers.*

- *Based on an assumed price elasticity of supply associated with gross reserve additions of between 0.1 (short-run) and 0.3 (long run), and an assumed constant reserve to production ratio of 10, we estimate the supply effect of the provisions to rise to about 100 thousand barrels a day BOE after 10 years, an increase of about 1.1%.*[11]

The volume of oil produced as a result of oil subsidies is heavily determined by the price elasticity asserted by API. However, oil supply tends by highly inelastic in the short term.[12] That is, production will not increase no matter how high oil subsidies are, given that oil exploration, production, and refining require significant long-term investments. Moreover, as a percentage of industry profits, oil subsidies are not significant. Reports of oil industry profits of over $30 billion in the first half of 2003[13] and increasing 17 percent in the first half of 2004[14], place annual oil subsidies at roughly below 3 percent of industry profits and a much smaller share of industry expenditures. Thus, EIA's claim that a small subsidy attached to a huge market will not result in meaningful production volumes, just a transfer of wealth, is likely justifiable.

Likewise, the world oil price has fluctuated between $17 and $42 per barrel just since January 2002, a variation of +/- 42% around the midpoint of $29.50. This suggests that a federal subsidy equivalent in value to the oil industry of a 3.4% price increase is not likely to have a tremendous impact on the long term price forecasting that they do to determine future oil exploration, production, and infrastructure investments. Natural market variations and uncertainties swamp the impact of the subsidies.

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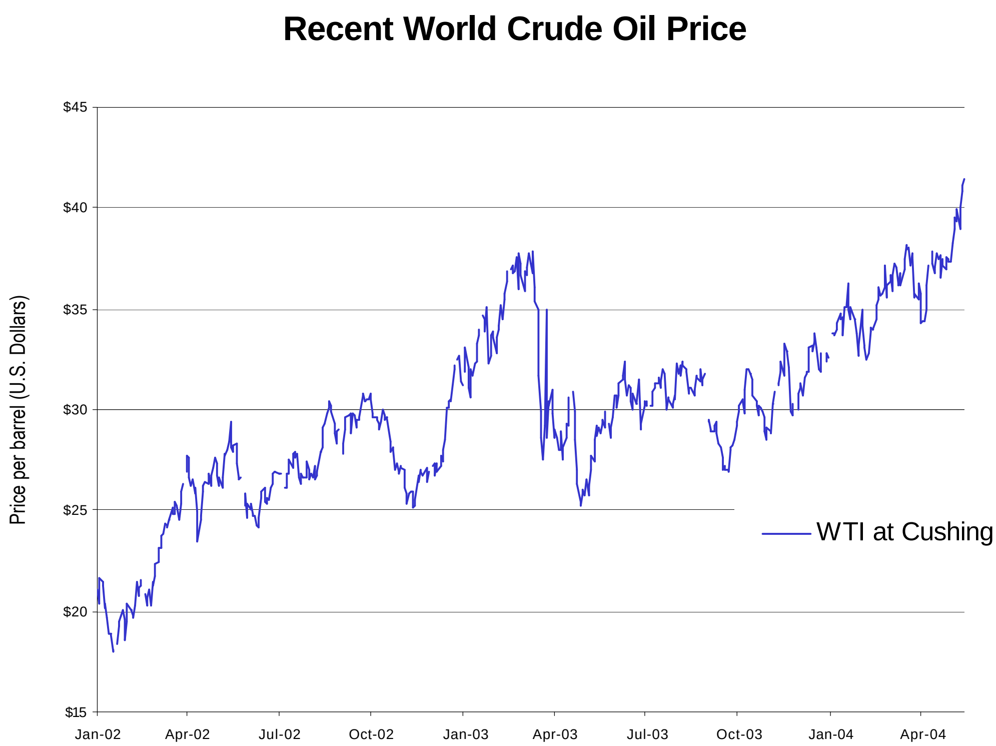
[11] Ed Porter and Mark Kibbe, American Petroleum Institute, email communications to Debbie Gordon, April 2, 2004.
[12] Dr. Mark N. Cooper, "Fueling Profits: Industry Consolidation, Excess Profits & Federal Neglect Domestic Causes of Recent Gasoline and Natural Gas Price Shocks," Consumers Federation of America and Consumers Union, May 2004. See: http://www.consumersunion.org/pub/oilprofits.pdf
[13] James R. Healey, "Record Gas Prices Pump up Profits for Oil Companies," USA Today, August 28, 2003.
[14] Cooper, Op. Sit.

Figure 3 – Oil Price Variations Since January 2002[15]



Nevertheless, if a dollar per gallon price tag is to be put on oil subsidies, API's calculations are illustrative. The API analysis proposes that any short-term impact of the provisions is modest, but that the long-term impact of sustained subsidies of $1.7 billion per year could be 36.5 million barrels of oil equivalent per year. If the overall cumulative effect of a given $1.7 billion per year subsidy were to increase the domestic oil supply by 1.1%, this translates into a cost (before discounting) per incremental gallon of gasoline of about $1.24.[16] Even this cost per gallon is likely smaller than the actual value, since the API analysis valiantly assumes that every federal subsidy dollar received by the industry is plowed into exploration for new domestic oil supplies. This argument strains credibility in a number of ways, perhaps most significantly with regard to the absence of a connection between the amount of incremental oil found and the payments received. It is as if the oil industry agreed to work for the federal government on a commission basis instead of salary, but would like to be paid in proportion to the amount of money it spends instead of the amount of oil it finds. Is the purpose of the subsidies to encourage the finding of oil or the spending of money?

[15] Personal communication, Grant Brummels, Ecos Consulting, May 14, 2004.

[16] 1.1% of 6.8 billion barrels is 74.8 million barrels. ORNL's *Transportation Data Book* indicates that a barrel of oil typically yields 19.2 gallons of gasoline (45.7% * 42 gallons). 19.2 gallons per barrel * 74.8 million barrels = 1.44 billion gallons of gasoline. $1.7 billion / 1.44 billion gallons of gasoline = $1.18 per gallon.

The Utility Industry Analogue

A related and comparably massive energy industry – electric utilities – also operated for many decades under a model where public funds were commonly paid in proportion to money expended building new power plants instead of results (kilowatt-hours) delivered. The surest way for utilities in that era to increase revenues for shareholders was to spend money building things like power plants and power lines, and then put those items in the rate base for cost recovery from regulators. This became very costly during a downturn in demand in the 1980s. All the nuclear power plants ordered by utilities between 1974 and 1989 were canceled, leading to costs of more than $20 billion for 115 abandoned nuclear plants. During the same time period, about two-thirds of coal-fired power plant orders were canceled at various stages of completion, adding further to the disconnection between expenditures and results on the supply side.[17]

In the aftermath arose the notion of least cost planning, which required electric utilities to rigorously compare various options for generating electricity with each other and with demand-side options for reducing energy usage on an equal basis – cost per kWh delivered. Regulators began to allocate public funding to the mixture of new electricity generation and programs to save electricity that could deliver kilowatt-hours for the lowest cost, treating a saved kWh as indistinguishable from one generated in a power plant.

The cumulative impact of utility-funded efficiency programs between the late 1980s and 2003 has been quite significant, though reliable, consistently accounted estimates of costs and savings over that period are still difficult to assemble. EIA-reported utility efficiency program expenditures varied from $0.92 to $1.76 billion/year between 1993 and 2000, averaging $1.15 billion/year. Savings over the same period varied from 43,023 to 61,552 gWh/year, averaging 55,447 gWh/year.[18] Expenditures in one year tend to yield a stream of savings over the subsequent 3 to 10 years, so detailed time series analysis is required at a disaggregated level to accurately estimate the cost effectiveness of past efficiency programs. However, comparing average yearly expenditures to average yearly savings over the 1993 to 2000 period suggests typical costs of about 2.0 to 2.5 cents/kWh saved.

Whether such funding is entirely under the control of utilities as portfolio managers, controlled significantly by public utilities commissions, or collected and dispensed centrally through systems benefit charges (SBCs) is less important than its overall magnitude and impact. Between 1983 and 2003, we estimate that about $15 to $20 billion was invested by U.S. electric utilities in efficiency programs that reduced utility bills by roughly $35 to $45 billion.[19] These investments also spawned a competitive national industry of efficiency entrepreneurs that employ new technologies, training tools, and marketing strategies to save electricity cheaply. Rigorous measurement, evaluation, and verification efforts follow the implementation

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[17] See Ralph Cavanagh, Chris Calwell, David Goldstein, and Robert Watson, "Toward a National Energy Policy," *World Policy Journal*, Spring 1989, p. 248.
[18] Dan York and Marty Kushler, ACEEE, *State Scorecard on Utility and Public Benefits Energy Efficiency Programs: An Update*, December 2002.
[19] Assumes average annual funding of $0.75 to $1 billion, obtaining savings for an average of 2 to 2.5 cents/kwh, with average retail electric rates of 7 to 8 cents/kwh

cycles of most programs, ensuring that claimed energy savings were achieved and often withholding final payments until such savings can be documented.

The Rationale for Public Sector Investment in Transportation Efficiency

Yet for all of the success of efficiency funding in the utility arena, no comparable mechanism has ever been established in the transportation arena, where environmental impacts of fossil fuel use are even greater and opportunities abound to save gasoline more cheaply than its source, petroleum, can be found. Oil companies already possess ample private sector incentives to prospect for oil domestically whenever and wherever they believe the amount they find will fetch a higher price than what they must spend to find it.

Yet the federal government is now willing to pay at least $1.24 in subsidies for each incremental gallon of new gasoline added to supply if API's analysis is correct. If, instead, the subsidies act primarily to increase oil industry profits from the amount of exploration they are already planning to pursue, the federal government is paying vastly more per incremental gallon – perhaps $5 to $10. Any price between $1.24 and $10 per gallon is more than the long term, wholesale, pre-tax price of gasoline and would not be judged cost effective by the metrics employed by public utilities commissions when evaluating proposed new power plants or efficiency programs.

Alternately, and more interestingly, the government could hold a competition between the supply and demand side for its scarce funding. Taking a page from the utility sector, the government would in effect offer to purchase the best bargains first from options put forward for consideration on both the supply and demand sides. In practice, federal energy subsidies that offer relatively large payments to specific energy technologies that would otherwise be uneconomical or confronted with market barriers can have significant impacts on the use of particular technologies.[20] Following is an overview of some of the most promising demand side options and their estimated costs per saved gallon.

Low Rolling Resistance Tires

Tire manufacturers already provide low rolling resistance versions of their most popular tire models to manufacturers of new vehicles, who have a strong incentive to utilize these technologies to help them meet federal fuel economy standards. However, many of these same tire models are not currently offered to the replacement tire market, in part due to a concern that consumers would be unwilling to pay the additional few dollars of cost. Yet the value of the resulting fuel savings (1.5 to 4.5% improvements in overall vehicle fuel economy, depending on driving cycle) is significantly higher than the $1 to $2.50 per tire incremental cost required to achieve them.[21] Consumers are largely unaware of the opportunity to purchase more fuel-efficient tires because of the absence of manufacturer and retailer labeling of tires for efficiency. A program to market more fuel efficient tires to consumers and overcome the

[20] Energy Information Administration, "Federal Financial Interventions and Subsidies in Energy Markets 1999: Primary Energy," SR/OIAF/99-03, September 1999.
[21] Chris Calwell, My Ton, Deborah Gordon, Travis Reeder, Marissa Olson, and Suzanne Foster, Ecos Consulting, *California State Fuel Efficient Tires Report: Volume II,* prepared for the California Energy Commission, January 2003, pp. 13-15.

incremental cost of the tires by paying financial incentives to manufacturers could achieve gasoline savings at a cost of about $0.20 to $0.23 per gallon.[22] This is about 85% less than the current retail price of gasoline and at least 60% less than the long-term, wholesale, pre-tax price of gasoline.

Low Viscosity Synthetic (LVS) Motor Oil

This technology, like low rolling resistance tires, reduces friction and improves fuel economy. Recent testing in Germany documented an average improvement in vehicle fuel efficiency of 5.5% across more than 2,100 vehicles of widely different models and sizes driven an average of 2,000 km or more.[23] LVS oil is significantly more expensive than conventional oil per quart, but more than makes up for its higher cost by significantly lengthening recommended oil change intervals, and therefore reducing annual expenditures for the labor, the filter, and the disposal/recycling costs associated with each oil change.[24] As with LRR tires, a program could be fielded to pay manufacturers for most or all of the incremental cost of the better oil, allowing them to sell it for a comparable price to retailers with no loss of profit. Even including costs associated with marketing the program to consumers and processing incentives, this program could save gasoline for approximately $0.27 to $0.43 per gallon – about 70 to 80% less than the current retail gasoline price and at least 45 to 55% less than the long term, wholesale, pre-tax price of gasoline.

Dealer Incentives for Fuel Efficient Vehicles

Automotive dealer profits typically correlate inversely with the fuel economy of the vehicles and options packages they sell. This gives dealers a natural incentive to promote vehicles that are less fuel efficient than average and to encourage consumers to select options packages like four wheel drive, larger engines, and automatic transmissions that tend to further reduce fuel economy. Ecos Consulting has analyzed for the National Commission on Energy Policy a proposal to offer financial incentives to auto dealers in proportion to their success at increasing the average fuel efficiency of the vehicles they sell.[25] Because relatively modest gains in miles-per-gallon are needed in trucks to achieve significant lifetime fuel savings, we found that the incentives needed for trucks -- $0.12 to $0.22 per gallon -- were significantly lower than the incentives needed for cars – about $0.30 to $0.44 per gallon. Including a mixture of car and truck incentives along with associated marketing and administration costs, we estimate that a mandatory, internally funded, national dealer incentive program for fuel efficiency could save

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[22] Calculation assumes fuel economy improvements of 1.5 to 4.5% in a 20 mpg vehicle over a 45,000 mile replacement tire lifetime with incremental costs of $1 to $2.50 per tire. This would require manufacturer incentives of $0.12 to $0.11 per gallon and program administration and marketing costs of $0.08 to $0.12 per gallon.

[23] Castrol, *Cars and Climate – A Transatlantic Coalition*, presentation in Washington DC, June 15, 2001.

[24] Assuming a 5.5% improvement in fuel economy in a 20 mpg vehicle, an average price of gasoline of $1.50/gallon, an increase in oil change interval from 4,000 miles to 10,000 miles, a retail oil price difference of $4/quart, and a combined filter/labor/disposal cost of $20/oil change, the average customer would already save $113.20 every 20,000 miles of driving by switching from conventional motor oil to LVS motor oil.

[25] Catherine Hardy, Debbie Gordon, Chris Calwell, and My Ton, *Dealer Incentives for Fuel Efficiency: Are They a Cost Effective Way to Save Gasoline?*, prepared by Ecos Consulting for NCEP, March 4, 2004.

gasoline for $0.24 to $0.41 per gallon.[26] These costs are nearly identical to those of an LVS motor oil program – about 70 to 80% less than the current retail gasoline price and at least 45 to 55% less than the long term, wholesale, pre-tax price of gasoline.

Conclusions

We have considered three ideas among the many innovative options available to save gasoline, concluding in each case that savings are achievable in the marketplace at prices ranging from $0.20 to $0.43 per saved gallon. By contrast, we have noted that the federal government currently subsidizes the domestic oil industry through four tax incentives to the tune of $900 million to $1.5 billion per year. If these savings lead to the amount of long term production increase asserted by API, the government is paying at least $1.24 per incremental gallon of gasoline produced – about 3 to 6 times the cost of the demand side measures noted above. Cumulative federal subsidies to the domestic oil industry between 1968 and 2000 total at least $134 billion. This is enough money to have saved more than 430 billion gallons of gasoline through demand-side measures like the ones noted above, *or about 10% of all U.S. gasoline consumption over the same time period.*

The purpose of this analysis is not to suggest that the federal government guarantee funding to a particular set of demand side programs to save gasoline. Nor is it to propose a massive new federal gasoline tax to fund efficiency programs. On the contrary, it is to argue for the introduction of rigorous criteria to determine how *existing* federal spending on oil incentives should be allocated. We argue for a fair competition between demand and supply-side options for federal funds. Let the money flow where it can do the most good. In an era of steadily rising gasoline prices and import dependence, we owe the taxpayers at least that much.

[26] Assumes typical incentives of $0.19 to $0.31 per gallon with a 60% truck, 40% car split and program administrative and marketing costs of $0.05 to $0.10 per gallon. Also assumes that fees assessed on dealers with below-average fuel economy improvements fund incentives to dealers with above average fuel economy improvements, yielding overall fuel economy averages beyond what CAFÉ standards require.

NCEP Staff Background Paper - Unconventional Oil

Introduction

This paper explores the potential contribution of unconventional oil to future world oil supplies, discusses current production of unconventional oil in Venezuela and Canada, and reviews some of the cost, energy, and environmental challenges currently associated with the extraction and refining of unconventional oil resources.

Unconventional Oil Resources

Unconventional oil is an umbrella term for oil resources that are typically more challenging to extract than conventional oil. While many unconventional oil resources cannot be economically produced at the present time, two exceptions are extra-heavy oil from Venezuela's Orinoco oil belt region and bitumen — a tar-like hydrocarbon that is abundant in Canada's tar sands.[1] These resources are already being economically produced and are likely, in coming years, to become increasingly important to global oil supplies generally, and to U.S. oil security in particular, given their close proximity to U.S. markets. Canada's tar sands are especially valuable from an energy security perspective since they are not controlled by governments that are politically unstable or aligned with the Organization of Petroleum Exporting Countries (OPEC).

Both of these Canadian and Venezuelan unconventional oils are characterized by the fact that they are nearly as dense as, or denser than, water.[2] Venezuelan extra-heavy crude is significantly more viscous than conventional crude,[3] while Canadian bitumen is even more so.[4] The high densities and viscosities of these hydrocarbons pose significant challenges for extraction and transport (e.g., standard pipelines generally cannot ship raw, extra-heavy oil or bitumen[5]), while their high levels of sulfur and other characteristics can make them challenging and energy-intensive to refine.

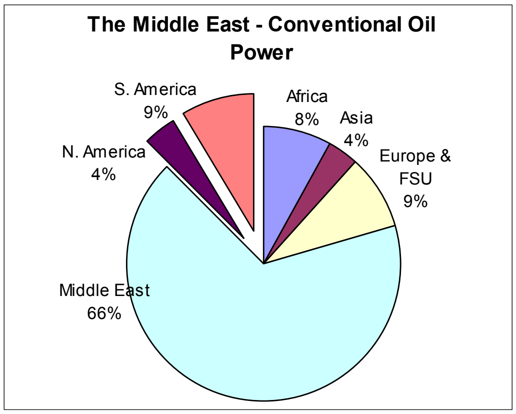
Today, Canada and Venezuela both produce approximately 3 million barrels per day (MBD) of oil.[6] As of 2000, they produced approximately 0.6 MBD and 0.3 MBD,[7] respectively, of this total from unconventional oil in raw form (typically mixed with a diluent to allow pipeline transport) or as a syncrude (generally a light, sweet petroleum created through one or several basic refining procedures). By 2015, government forecasts project that Canada and Venezuela combined will produce nearly 3.5 MBD of extra-heavy oil or diluted bitumen and syncrude[8].

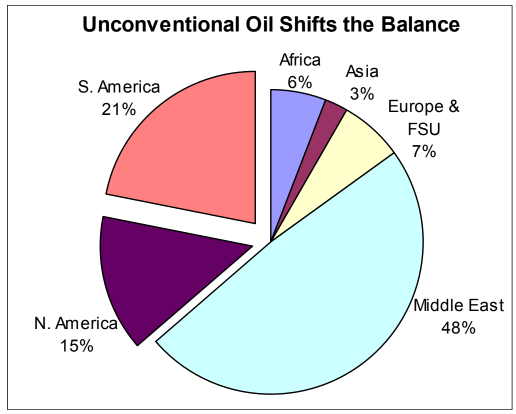
Are Unconventional Oil Resources Economically Recoverable?

As has already been noted, most unconventional oil resources, like oil shales, are not currently economically recoverable. The exceptions, as indicated above and described in more detail below, are Canadian tar sands and Venezuelan extra-heavy oil.

If these unconventional oil resources are recognized as established reserves at some point in the future, overall estimates of globally recoverable oil would increase substantially. In 2002, the *Oil & Gas Journal* accepted Canada's classification of 174 billion barrels of oil sands as established reserves and Canada became the second largest oil reserve-holding nation in the world after Saudi Arabia.[9] If the 235 billion barrels of extra-heavy oil that Venezuela considers recoverable, but that are not currently acknowledged as established or proven, are re-classified in the same way as Canada's oil sands, Venezuela would be credited with the largest oil reserves in the world. This change in classification would help to tilt the balance of global oil reserves away from the Middle East, though neither of these unconventional oil-producing regions is likely to displace the Middle East as the lowest-cost or highest volume supplier of oil to world markets anytime soon.

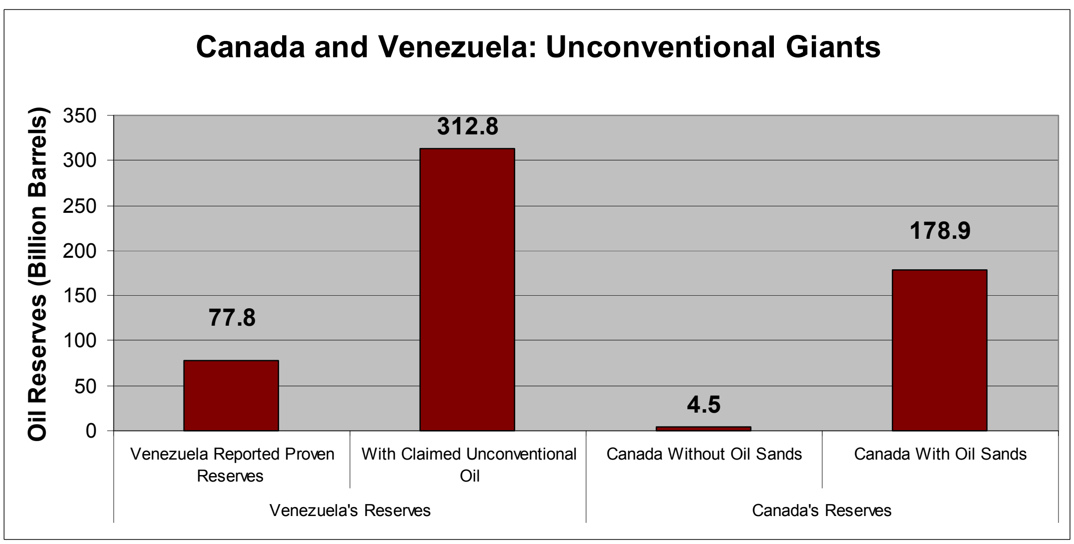
Figure 1: Effect of Canadian and Venezuelan Unconventional Oil on World Oil Reserve Balance





Data Source: EIA International Energy Outlook 2004[10], Oil and Gas Journal[11]

Figure 2: Unconventional Potential



Data Source: Oil and Gas Journal[12]

Canadian Potential

It has been estimated that Canada will likely supply as much as 1.2 MBD of diluted bitumen and syncrude by 2010.[13] Unlike Venezuela's extra-heavy oil deposits, which tend to contain oil in liquid form, Canada's oil is locked in sticky sedimentary layers called tar sands. These deposits tend to be approximately 10–12 percent bitumen by volume and pose some unique challenges in terms of resource extraction. Presently, most tar sands are harvested either by strip mining, or by heating or solvating underground deposits and pumping out the resulting oil (in-situ production). Though strip mining is still the most common means of commercially extracting tar sands, in-situ production will likely overtake strip mining operations as technology advances — simply because the majority of bitumen resources are not surface accessible[14].

Canada's tar sands deposits, though, are vast. Up to 2.5 trillion barrels exist in Alberta alone.[15] Of this amount, Canada's National Energy Board estimates that up to 315 billion barrels may ultimately be recoverable.[16] As has already been noted, the prospects for tar sands have improved sufficiently to warrant classification of 174 billion barrels as proven reserves in the *Oil and Gas Journal.*[17]

While labor-intensive, a comfortable profit margin exists for these projects with oil prices at $24 a barrel or more.[18] Given current oil prices, tar sands are attractive investments. As always, however, uncertainty about future prices and price volatility poses challenges for unconventional oil producers. An additional challenge facing Canadian producers is the potential lack of available U.S. refining capacity that can handle diluted or upgraded bitumen.[19]

Venezuelan Potential

Venezuela has traditionally been recognized as a country with substantial reserves of conventional oil and is the only country in the Western Hemisphere to belong to OPEC. Its currently proven oil reserves total 77.8 billion barrels, approximately 35 billion barrels of which are extra-heavy oil.[20] Though this is a considerable amount of oil, it is dwarfed by the potential of extra-heavy oil reserves that are not yet considered proven. Up to 1.2 (and perhaps even 1.7) trillion barrels may exist in Venezuela's Orinoco Belt[21] (a band of oil deposited roughly beneath the Orinoco River). The Venezuelan government considers nearly 235 billion barrels of this total as established reserves;[22] since the country's OPEC production quotas are partially based on its reserves, recognition of these resources by other OPEC members would likely allow Venezuela's production quota to increase.[23]

It has been estimated that Venezuela could provide as much as 1.4 MBD of extra-heavy oil to the marketplace by 2010, whether as syncrude or in a non-upgraded form[24].

In Venezuela, the difficulty of extracting heavy, viscous oil from deep underground (Venezuela's deposits are much deeper than Canada's oil sands) makes the recovery of unconventional oil more difficult and capital-intensive than in Canada.[25]

Energy and Environmental Considerations

The energy required and the environmental impacts incurred in extracting and utilizing unconventional, extra-heavy and bitumen-based oils are generally greater than in the case of conventional oil. Tar sands require substantial amounts of energy for mining and separating (in the case of strip mining operations) or for heating underground reservoirs (in the case of in-situ production). Similarly, extra-heavy oil requires significant effort to bring to the surface and transport for processing. Upgrading extra-heavy oil or bitumen to syncrude also requires significant quantities of energy. In many cases, natural gas is used to generate electricity to power equipment and physical plants, as well as to produce hydrogen or power cokers for the upgrading process. In Canada, rising rates of natural gas consumption are already creating stresses in natural gas markets and may prove unsustainable in the long run. Substitute fuels for powering unconventional oil production are under consideration, including coke combustion or gasification (consuming a process byproduct), or even nuclear power.[26]

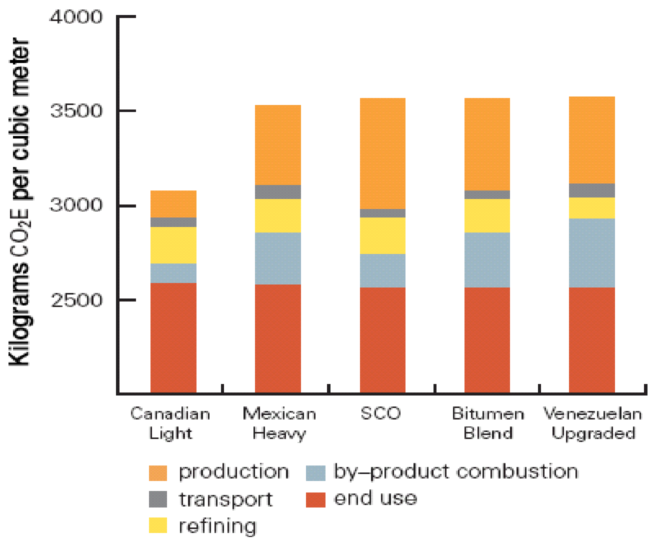
Besides their greater upstream energy requirements, producing extra-heavy oil and bitumen entails greater environmental impacts than conventional oil production. In the case of Canadian tar sands production, large amounts of water are necessary to separate bitumen from the sand and other solids, or to produce steam, depending on which oil-recovery method is being used. As many as four barrels of water may be used to produce a barrel of bitumen, though most can be reclaimed. For in-situ production, however, which commonly uses steam to heat deposits, as much as one barrel of this water may be unrecoverably trapped underground for each barrel of extra-heavy oil produced. [27] Used process water that is not recycled is released into tailings ponds, some of which have remained in use for a decade or more, and which can pose leaching threats to surface and groundwater. In surface mining, large areas of overlying forest and muskeg (a wet, swampy vegetation) must be removed before mining can begin. Like in-situ production, surface mining relies on large amounts of water, with resultant tailing ponds, though the water is mostly necessary to separate bitumen from other solids.[28]

The release of by-products, including air pollutants, is also more significant in producing bitumen than is the case for conventional oil production. Pollutants like sulfur dioxide, nitrogen oxides, hydrogen sulfide, volatile organic compounds, ozone, polycyclic aromatic hydrocarbons, particulate matter, and reduced sulfur compounds are commonly released during bitumen production.[29]

Additionally, at least two times (and as much as six times) more carbon dioxide is emitted in producing and upgrading extra heavy oil and bitumen as compared to conventional oil. Canada's ratification of the Kyoto Protocol may expose tar sands production to additional costs, though the Canadian government has worked to address uncertainty about this issue and Suncor, a major tar sands producer, expects the Kyoto requirements to add only 20 to 27 cents (Canadian) per barrel of oil produced.[30] Other environmental concerns associated with unconventional oil production include the disposition of byproducts as larger amounts of materials like coke and sulfur are produced in upgrading and refining bitumen and extra-heavy oil than in conventional oil production.

The production of extra-heavy oil in Venezuela, where there is less environmental regulation than in Canada, also appears to be more environmentally damaging than conventional oil production, though definitive data on this question are difficult to locate. The extra-heavy oil produced in Venezuela is typically high in sulfur, as well as in metals like nickel and vanadium.[31] The production of extra-heavy oil clearly requires greater energy inputs, so it is likely that associated environmental impacts are also more significant than in the case of conventional oil production.

Figure 3: Lifecycle CO_2 Equivalent Emissions



Source: Alberta Chamber of Resources; Data source: T.J. McCann and Associates[32]

Conclusion

Given these challenges there is significant commercial pressure to develop more efficient and lower-cost means of producing unconventional oils. Considerable progress has already occurred. Costs for Canadian syncrude production have declined by more than 50 percent since the early 1990s,[33] while carbon dioxide emissions for a given volume of oil sands production have decreased approximately 35 percent in the same timeframe.[34] The efficiency of extra-heavy oil production in Venezuela has also improved significantly as a result of better pumping technologies and with the integration of production and upgrading operations so as to supply a higher-value export product.[35]

Globally, significant unconventional oil resources are not limited to Canada and Venezuela. Russia, for example, is estimated to have similarly large reserves of extra-heavy oil (though they are unlikely to be tapped in the near future), while numerous other countries also have relatively large unconventional resources (the potential U.S. resource base, for instance, is estimated at 40 billion barrels).[36] With further technology development and depending on the price of conventional oil in the future, some of these additional unconventional resources may eventually become economical.

[1] Bob Williams, "Heavy Hydrocarbons Playing Key Role in Peak-Oil Debate, Future Energy Supply," *Oil & Gas Journal* 101, no. 29 (2003). In some cases, bitumen and extra-heavy oil are used interchangeably; for the purposes of this memo, and in light of the substantially higher viscosities of oil from Canada's tar sands, Venezuela's resources will be referred to as extra-heavy oil and Canada's resources will be referred to as bitumen.
[2] Ibid., also National Energy Board (Canada), *Canada's Oil Sands: Opportunities and Challenges to 2015* (Calgary, AB: National Energy Board, 2004).
[3] Guntis Moritis, "New Techniques Improve Heavy Oil Production Feasibility," *Oil & Gas Journal* 96, No. 42 (1998). Viscosities in several Orinoco Belt extra-heavy projects range from 2,000 to 5,000 centipoise at reservoir temperatures.
[4] National Energy Board, *Opportunities and Challenges*. Viscosity at room temperature (often warmer than reservoir temperatures) is typically greater than 50,000 centipoise.
[5] Alberta Chamber of Resources, *Oil Sands Technology Roadmap: Unlocking the Potential* (Edmonton, AB: Alberta Chamber of Resources, 2004).
[6] BP, *Energy in Focus: BP Statistical Review of World Energy* (London: BP, 2004)
[7] Williams, "Heavy Hydrocarbons."
[8] United States Department of Energy, Energy Information Administration, *International Energy Outlook 2004 With Projection to 2025* (Washington, DC: Energy Information Administration, 2004): 44; and Canada National Energy Board, *Opportunities and Challenges,* 61-73.
[9] Radler, "Worldwide Reserves." Not all groups accept Canada's classification of tar sands as proven reserves. BP, for example, only credits those fields currently being developed, in keeping with its classification of other nations' reserves.
[10] Energy Information Administration. *International Energy Outlook 2004.* Washington: April 2004.
[11] Radler, "Worldwide Reserves."
[12] *Ibid.*
[13] Williams, "Heavy Hydrocarbons."
[14] National Energy Board, *Opportunities and Challenges*.
[15] Williams, "Heavy Hydrocarbons."
[16] National Energy Board (Canada), *Canada's Oil Sands: A Supply and Market Outlook to 2015* (Calgary, AB: October 2000).
[17] Radler, "Worldwide Reserves."
[18] Tar sands producers, for example, maintain a comfortable profit margin when oil prices exceed $24 per barrel. National Energy Board, *Opportunities and Challenges*. The last time prices dipped below that level was a several-day span in 2003. WTRG Economics. "Crude Oil Spot and Natural Gas Spot Prices". *Energy Economics Newsletter*, http://www.wtrg.com/daily/oilandgasspot.html, June 9, 2004.
[19] National Energy Board, *Opportunities and Challenges*; Martin Meyers and Robert Esser, *Western Canada's Oil Sands: An Investment Boom Increases the Marketing Challenge* (Cambridge, MA: Cambridge Energy Research Associates, 2002).
[20] Marilyn Radler, "Worldwide Reserves."
[21] See *Petroleum Economist*, "Analysis: Nonconventional Hydrocarbons – Scratching the Surface," March 31, 2002; United States Department of Energy, Energy Information Administration, "Country Analysis Briefs: Venezuela," June 2004, http://www.eia.doe.gov/emeu/cabs/venez.html; Williams, "Heavy Hydrocarbons;" Radler, "Worldwide Reserves"
[22] Several sources offering different analyses of Venezuela's current accounting of conventional and unconventional resources. Marilyn Radner, in *Oil & Gas Journal* notes that PDVSA (Petroleos de Venezuela S.A. – the state oil company) report 312 billion barrels as total reserves, and 235 billion as the technically recoverable total from the Orinoco Belt. Of the 77.8 billion barrels listed as proven reserves, 35 billion is attributed to unconventional heavy and extra heavy crude in the Orinoco region ("Worldwide Reserves"). The United States Department of Energy, Energy Information Administration notes "Venezuela is home to the Western Hemisphere's largest proven oil reserves at 77.8 billion barrels, as of January 2003. Substantial extra-heavy oil and bitumen deposits are not included in this total," and goes on to comment that estimates of "extra-heavy oil and bitumen deposits" range from 100 – 270 billion barrels of recoverable reserves, while also noting that several projects are already tapping into Venezuela's unconventional crude in "Country Analysis Briefs: Venezuela," June 2004, http://www.eia.doe.gov/emeu/cabs/venez.html. Typically, reserves currently being developed are considered

proven, lending credence to *Oil & Gas Journal*'s assertion that part of the claimed 270 billion barrel Orinoco belt is already included in Venezuela's proven reserves total.
[23] Steve Ixer and Margaret McQuaile, "Venezuela Wants OPEC to Make Room for its Extra Heavy Oil," *Platt's Oilgram News* 81, no. 194 (2003).
[24] Williams, "Heavy Hydrocarbons."
[25] *Petroleum Economist*, "Analysis: Nonconventional Hydrocarbons."
[26] National Energy Board, *Opportunities and Challenges*; Alberta Chamber of Resources, *Oil Sands Technology Roadmap*.
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[31] *Petroleum Economist*, "Analysis: Nonconventional Hydrocarbons," Williams, "Heavy Hydrocarbons;" Guntis Moritis, "New Techniques Improve Heavy Oil Production Feasibility," *Oil & Gas Journal* 96, No. 42 (1998).
[32] Alberta Chamber of Resources, *Oil Sands Technology Roadmap*.
[33] Williams, "Heavy Hydrocarbons."
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NCEP Staff Background Paper –
Basic Facts about the Strategic Petroleum Reserve

Overview:

The Strategic Petroleum Reserve (SPR) is an emergency supply of federally-owned crude oil stored in deep underground salt caverns along the Gulf Coast. The SPR is widely viewed as a useful asset for improving the nation's energy and economic security because it provides a potentially valuable buffer against short-term oil supply disruptions. Indeed, permanent authority to continue operation of the Reserve was among the uncontroversial provisions included in proposed national energy legislation in 2003. Within that context of broad support, debate has instead focused on: (a) how much oil should be stored in the SPR (b) what specific rules should govern future withdrawals and (c) what should the international community be doing in terms of establishing similar emergency reserves. In particular, there is disagreement about whether and when releases from the SPR should be used to dampen the macroeconomic impacts of high oil prices, even in the absence of an actual supply emergency. Questions have also been raised about recent government purchases to fill the SPR at a time when oil prices are high. The purpose of this paper is to provide a brief background of the SPR in an effort to clarify and provide perspective on the important economic and security issues that surround its establishment and use.

Details of the Strategic Petroleum Reserve:

Provisions for the SPR were included in the Energy Policy and Conservation Act (EPCA) of 1975 with the intent of protecting the nation against supply disruptions of the kind created by the 1973 oil embargo. Today, the SPR holds roughly 660 million barrels of oil (with the capacity to hold 700 million barrels) and is the largest emergency stockpile of oil in the world. The capacity of the SPR is adequate to meet total U.S. oil demand for about 35 days and to offset nearly 53 days of oil imports from foreign suppliers. It takes 13 days for oil from the SPR to enter the market once a presidential order for a withdrawal is given. Oil can be withdrawn from the reserve at a rate of 4.3 million barrels per day.

The SPR is located at four sites along the Gulf Coast in Texas and Louisiana (Bryan Mound, Big Hill, West Hackberry, and Bayou Choctaw) where massive salt

Figure 1 – Four Storage Sites of the Strategic Petroleum Reserve[1]

caverns provide an environmentally secure and cost-effective means of storing large quantities of oil. Storing oil in these salt caverns — which on average hold about 10 million barrels of oil (one cavern in particular is large enough to hold the Sears Tower with room to spare) — costs ten times less than storing it in above-ground storage tanks and 20 times less than storing it in hard rock mines.[2] In addition, these sites are well-placed because of their proximity to Gulf ports where a large fraction of U.S. oil imports are received and because it is relatively easy to connect to the nation's commercial oil transport network at these locations.

Filling the Reserve:

The U.S. government can fill the SPR by either purchasing oil on the open market, or by collecting royalties from oil producers in the form of "in kind" payments (i.e., oil). Most of the oil added to the Reserve in the late 1970s and early 1980s was purchased on the open market when prices were relatively high. This is the main reason why the average price of oil in the SPR is greater than $27 per barrel.[3] Recently, the SPR has been filled by collecting royalty oil from companies who operate leases on the federally-owned Outer Continental Shelf. By law, these companies must pay royalties on these leases in the range of 12.5 to 16.7 percent of the oil produced. This percentage can be paid in oil dollars equivalent or by actually delivering the oil "in kind".

Conditions for Withdrawing Oil from the Reserve:

The President is authorized to decide when to withdraw crude oil from the Reserve under the Energy Policy and Conservation Act (EPCA) of 1975. Withdrawals from the reserve are then distributed to oil companies via competitive sale. Current law provides for three types of withdrawals from the SPR:

- Full drawdown to counter "severe energy supply disruptions"

[1] DOE (Website)
[2] DOE (Website)
[3] DOE (Website)

- Limited drawdown to prevent or reduce the adverse impacts of a "supply shortage of significant scope or duration" (such drawdowns are limited to 30 million barrels, 60 days, and in no case are allowed to lower the SPR below 500 million barrels)[4]
- Test sales of very small quantities of oil

According to the EPCA, the Department of Energy (DOE) is also allowed to exchange oil with private companies for the purpose of "acquiring additional oil for the stockpile."[5] In other words, these exchanges are allowed only where the SPR receives more oil in return than the amount that is released.

What conditions justify withdrawals from the Reserve has been a contentious issue since the SPR was established. Debate usually centers on whether or not the SPR should be used to dampen or moderate minor price spikes. Some argue that early intervention during a minor supply shortage will help calm markets and therefore prevent a major disruption. Others argue that the Reserve should only be used during emergency situations and suggest that early intervention will only discourage "private sector initiatives for preparedness or investment in contingency inventories."[6] Inevitably, politics sometimes enters the debate, particularly during an election year.

History:

During the course of its existence, there have been twelve major releases of oil from the SPR. These included:

- 1 emergency drawdown by Presidential order
- 2 test sales to ensure "readiness"
- 6 exchange arrangements with private companies
- 3 non-emergency sales authorized by Congress to raise revenues

There one presidentially-ordered emergency drawdown from the SPR occurred on January 16, 1991, when the United States began Operation Desert Storm to liberate Kuwait from Iraq and its intent was to stabilize world oil prices. Less than 12 hours after the order was given by the President, DOE released sales notices and on January 28 (11 days later) 26 companies submitted bids. In all, DOE accepted bids from 13 companies for 17.3 million barrels on January 30, and the first oil was delivered to the market on February 5.

There have also been two test sales from the SPR to ensure the "readiness" and operational effectiveness of the SPR. In 1985, the competitive bidding process was tested for the first time when DOE conducted a 1.1 million barrel test sale. On November 18, 1985, DOE announced that it would begin to accept bids and one week later (11/26/85) 17 companies submitted offers. On December 4, the first contract had been awarded, and by January 8, 1985 all of the 1.1 million barrels had been successfully

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[4] NCEP Workgroup
[5] DOE (Website)
[6] NCEP Workgroup

distributed. The second test sale was also successful and took place in the months prior to Operation Desert Storm.

Under the EPCA, DOE also has authority to exchange oil from the reserve with private companies so that more oil can ultimately be acquired. There have been six of these types of exchanges. In general, they have taken place to alleviate the effects of a temporary supply disruption such as a pipeline malfunction, a dock collapse, a hurricane, etc. One of the more notable exchanges occurred on July 10, 2000 when President Clinton ordered the creation of the Northeast Heating Oil Reserve. This is an emergency reserve which today contains 2 million barrels of fuel stored in above-ground tanks in New Jersey, Rhode Island, and Connecticut. According to the DOE, the reserve was established with the intent to create a "buffer large enough to allow commercial companies to compensate for interruptions in supply or severe winter weather, but not so large as to dissuade suppliers from responding to increasing prices as a sign that more supply is needed."[7] Ultimately, this transaction resulted in 2.7 million barrels of crude oil being released from the SPR, in exchange for 2 million barrels of heating oil being added to the Northeast Heating Oil Reserve.

Congress has also authorized three non-emergency sales from the SPR to help raise revenues. In the first of these, 7 million barrels were sold to help cover costs for the decommissioning of the Weeks Island SPR site. This site was decommissioned due to its geologic faults as part of the Balanced Budget Downpayment Act. On a second occasion, 13 million barrels of oil were sold as part of the Omnibus Consolidated Rescissions and Appropriations Act to help reduce the federal deficit. Finally, the third non-emergency sale was for 10 million barrels of oil to help offset FY 1997 appropriations as part of the Omnibus Consolidated Appropriations Act.

How much does the SPR cost taxpayers?

According to DOE, the nation's total investment in the SPR is more than $21 billion to date.[8] Federal accounting for the Reserve is done on a cash basis: each year, funds appropriated by Congress are placed into one of three accounts: storage facility development, storage facility management, and oil acquisition.[9] The storage facility account covers both capital and operating costs and has absorbed roughly $4 billion to date. Oil acquisition accounts for the rest of the investment at $17 billion.

According to Doug Koplow and Aaron Martin, the costs of storage facility development, management, and oil acquisition — while certainly important — "present only a small part of the real cost of SPR to taxpayers."[10] Specifically, in their report "Fueling Global Warming: Federal Subsidies to Oil in the United States", Koplow and Martin estimate that the total cost associated with maintaining the SPR was between $1.6 and $5.4 billion for 1995. Because the federal budget had been in deficit every year through 1995, most of the money invested in the SPR was actually debt issued in the

[7] DOE (Website)
[8] DOE (Website)
[9] Koplow / Martin, Pg. 4-19
[10] Koplow / Martin, Pg. 4-17

form of Treasury bonds. In other words, the money for the SPR had to be borrowed and interest had to be paid on those funds. These are real costs that are directly attributable to the SPR that the government generally omits from its cost reports for the program.

The range of costs estimated by Koplow and Martin (i.e., $1.6–$5.4 billion) is based on two different approaches for calculating the cost of debt associated with SPR outlays. The lower figure assumes that the SPR can write off the unpaid debt interest each year without accumulating greater debt. The higher figure assumes compounding interest on the debt. To the extent that the government has been running a deficit for much of the time since the SPR came into existence, the U.S. Treasury has had to issue new debt to cover interest payments on its old debt, effectively compounding interest on its debts.

The Koplow and Martin analysis is useful for examining the actual costs of the SPR to U.S. taxpayers but it does not attempt to answer the question of whether the program has been a good or bad investment.[11] Accordingly, the authors do not quantify in any way the benefits associated with any protection the SPR might provide against oil security and supply disruptions.

International Action:

The United States is not the only country with emergency oil stockpiles. The 26 industrialized nations (including the United States) that participate in the International Energy Agency's (IEA's) emergency reserve system are required to "hold oil stocks equivalent to 90 days of net imports in the previous year."[12] This equates to an emergency global supply stock of about 1.4 billion barrels. In addition, two important non-member oil consuming nations, India and China, have also begun to contemplate establishing strategic petroleum reserves.[13] One important difference between the United States and other IEA member countries is that the cost of maintaining a strategic reserve is entirely born by taxpayers. Most other countries that maintain a stockpile shift some of the cost burden on to private oil companies by requiring them to maintain excess inventories.

Current Debate / Recommendations:

As has already been noted, the current debate surrounding the SPR seems to be almost entirely focused on whether oil in the Reserve should be used at times when there is no supply emergency to mitigate the impacts of high oil prices on the economy. A closely related debate concerns the question of whether government should be adding to the Reserve at a time of high oil prices, thereby contributing to higher domestic demand and upward price pressures. The general consensus is that diverting oil from the SPR would likely lower oil prices in the short term. The longer-term effects of such a policy, however, are less certain.

[11] Koplow / Martin, Pg. 4-25
[12] IEA (Website)
[13] MSNBC

Those who favor filling the Reserve to capacity argue that the amount of oil diverted for this purpose in the context of overall U.S. demand is so miniscule that it would not affect oil prices at all. John Felmy, the chief economist for the American Petroleum Institute (API), has said that while the Reserve is "absolutely an important insurance policy," "you have to be realistic, if we had some negative scenarios, about what kind of role it could play."[14] An analysis by the Petroleum Industry Research Foundation (PIRINC) has concluded that diverting oil from the SPR would impact the oil prices seen by consumers by no more than about 1 cent per gallon.[15] There is even concern that oil diverted from the U.S. Reserve could instead find its way to other markets, such as China. Finally, proponents of filling the Reserve to capacity argue that current oil prices, if adjusted for inflation, are actually not at record highs and do not signal a supply emergency (which is what the Reserve is intended for). Those who argue for using the Reserve to respond to current market stresses, by contrast, generally argue that at a time of tight supply and high demand, even a small change in demand resulting from a suspension of purchases for filling the Reserve can have a substantial impact on prices.

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[14] WSJ (5/17/04)
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NCEP Staff Background Paper[1] - The Potential Role of Diesel Technology in Improving the Fuel Economy of the U.S. Passenger Vehicle Fleet

Background

The potential performance advantages of light-duty diesel vehicles include better fuel economy (30–40% improvement), more torque, greater durability (engines generally last over 200,000 miles), and lower CO_2 emissions (15–20% reduction) compared to conventional gasoline vehicles. Modern diesel engines have improved significantly over the relatively smoky and noisy engines of 15 years ago and could provide substantial fuel economy benefits if they gain a larger share of the U.S. passenger vehicle market. Along with hybrid-electric gasoline vehicles, in fact, diesels may offer the most significant near-term opportunity for substantial improvements in passenger vehicle fuel economy. As with most efficiency-improving technologies, however, an emphasis on increased horsepower rather than fuel-economy and increased driving as a result of better gas mileage (the so-called "rebound" effect) could erode some of these benefits.

Diesels are very popular in Europe where they account for 30% of new passenger vehicle sales. Within Europe, the market share of diesel vehicles varies widely from a maximum of about 70% in Austria to a much lower level in Sweden, where the market share of diesels is similar to that in the United States at less than 1%. Many European governments encourage the use of diesel technology through lower taxes on diesel fuel and on diesel vehicle sales. By comparison, diesel passenger vehicles are virtually nonexistent in the U.S. market, where experts have projected that it could take as long as five years for this technology to achieve even a 1% share of the overall passenger vehicle market.

Automobile emissions regulations are an important factor in terms of the future prospects for diesel passenger vehicle technology as it is generally more difficult to reduce emissions of nitrogen oxides (NOx) and particulate matter (PM) from diesel engines relative to their conventional gasoline counterparts.[2] Future European emission standards are not as stringent as the U.S. Tier 2 standards that are being phased-in starting with model year 2004 (for example, the U.S. Tier 2 fleet-average NOx standard is 0.07 grams per mile (g/m) compared to the European Euro IV NOx standard of 0.4 g/m while U.S. Tier 2 PM standards range from 0.01 to 0.02 g/m compared to the Euro IV PM standard of 0.04 g/m). There have been some early, successful demonstrations of light-

[1] This briefing paper includes key points from a Commission-sponsored meeting on diesel technology which took place in February of 2003 and which was attended by about 35 people, including technical/engineering experts, environmentalists, auto manufacturers and association representatives, Commission staff, Commissioners, and others. A complete list of attendees at the Commission's diesel workshop is appended at the end of this briefing paper.

[2] For example, the 2002 National Academy of Sciences study on fuel economy did not consider diesel technology in large part because the panel believed that new federal emissions standards would effectively preclude diesels from entering the U.S. light-duty vehicle market.

duty vehicle diesel exhaust after-treatment technologies (by Toyota, for example[3]) that may be able to achieve Tier 2 emission standards with some further improvement, but these after-treatment technologies have not been demonstrated commercially and their durability remains an open question.

The U.S. Environmental Protection Agency (EPA) is highly supportive of diesel vehicles entering the U.S. passenger vehicle market as long as they meet Tier 2 emission standards. California, which has officially categorized diesel exhaust as a toxic air contaminant, is also supportive of diesel passenger vehicles provided they meet current California emission standards.

Finally, environmental organizations have long advocated for cleaner diesel technologies for heavy-duty trucks and buses, particularly in urban areas. These groups have generally opposed the increased use of diesel technology in the light-duty passenger vehicle fleet because of public health concerns associated with diesel exhaust. These groups also, however, recognize the importance of improving vehicle fuel-economy as a means of addressing climate change risks. Thus, their support for future diesel vehicles depends in significant part on whether it will be possible for those vehicles to achieve stringent criteria pollutant emissions requirements.

Key Findings

1. **Passenger diesel vehicles are expected to achieve stringent PM emission standards; NOx standards pose a greater challenge.**

- PM: Most experts agree that PM filters are a known technology that is likely to work well on light-duty diesel passenger vehicles to reduce fine particle emissions to levels that not only achieve Tier 2 emission standards, but also rival, or surpass, fine particle emissions from passenger vehicles. This finding is significant because fine particles are largely responsible for diesel-related environmental and public health concerns (see below).

- NOx: Conflicting evidence has been presented to the Commission about the feasibility of diesel passenger vehicles achieving Tier 2 NOx emission standards. There is broad agreement that NOx standards represent a high hurdle for diesel engines to enter the U.S. passenger vehicle market. On the one hand, some believe that manufacturers of after-treatment emission controls such as PM traps and NOx adsorbers are on track to achieve new standards by 2007, particularly for heavy-duty vehicles. However, light-duty vehicle manufacturers have indicated that — although progress is being made and there have been

[3] *Simultaneous PM and NOx Reduction System for Diesel Engines*, Toyota Motor Co., SAE 2002 World Congress, March 4 – 7, 2002. Toyota has developed a combined after-treatment device called the "Diesel Particulate-NOx Reduction System" that achieves an 80% reduction in PM and NOx emissions. This performance is close to what is needed to allow diesels to meet federal Tier 2 motor vehicle emission standards.

successful emission tests of prototype diesel vehicles — ultimate success in achieving the Tier 2 NOx standard in a production diesel vehicle for its full useful life is not yet assured. Meanwhile, individual manufacturers as well as the Alliance of Automobile Manufacturers have told the Commission that they are not seeking a revision of Tier 2 emission standards.

2. Environmental organizations and government regulators are prepared to support diesel passenger vehicles that comply with Tier 2 emission standards.

- Health Effects. Historically, diesel engines have emitted more hydrocarbons, nitrogen oxides, and fine particles than gasoline engines. Moreover, in 2001 EPA found diesel exhaust from older diesel vehicles to be a likely human carcinogen. However, a new study suggests that Tier 2-compliant diesel vehicles are likely to have cancer effects similar to those associated with gasoline vehicles. Meanwhile, high-emitting gasoline engines may make a larger contribution to ambient PM than previously thought. In short, Tier 2-compliant diesel passenger vehicles are likely to close the emissions/public health gap between gasoline and diesel vehicles, provided that (as noted above) remaining questions about the durability of diesel exhaust after-treatment technologies can be addressed.

- Diesel Soot and Climate Change. Uncertainty remains about the extent to which diesel emissions of black carbon, or soot, offset the global warming benefits associated with reduced fuel use and CO_2 emissions. Experts agree that diesel emissions of black carbon have a net warming effect in the atmosphere, but expert opinion varies by almost an order of magnitude as to the size of this effect.[4] Meanwhile, Tier 2-compliant diesel vehicles with PM filters are expected to produce dramatically lower amounts of fine particle (including black carbon) emissions.

3. The potential fuel economy benefits of diesel technology have to be considered in the context of other technologies and strategies that could provide similar benefits.

- Diesel vehicles cost more than their gasoline counterparts. At present, outfitting a conventional vehicle with a diesel engine increases the retail price by approximately $2,000. This cost premium can be expected to increase once the cost of the after-treatment technologies needed to achieve compliance with stringent criteria pollutant emissions requirements are incorporated into the price.

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[4] In a paper recently published in the Journal of Geophysical Research (2002), for example, Stanford Professor Mark Jacobson concludes that diesel passenger vehicles increase rather than decrease global warming for two reasons: (1) a modern direct injection diesel engines gets 25–35% better mileage than an equivalent gasoline engine, but some of this gain is offset because diesel fuel releases more CO_2 per unit volume than gasoline and (2) black carbon particles released by diesel engines tend on balance to contribute to global warming, offsetting the remainder of the fuel efficiency / CO_2 reduction benefits of diesel engines. Jacobson concludes that the above finding holds even for vehicles meeting the more stringent Tier 2 particle standards..

It is difficult to estimate costs for these after-treatment technologies since they are still being developed. But it may be that if the same resources were put towards improving the fuel economy of conventional gasoline passenger vehicles, equally significant or more significant fuel economy improvements could be achieved.[5]

- Conventional gasoline and hybrid-electric technologies can also provide substantial fuel economy benefits. One analysis by the Union of Concerned Scientists suggests that technology improvements and weight reduction applied to conventional gasoline vehicles could provide the largest new vehicle fuel economy improvement (an increase of 9–16 mpg from the current combined car and light-truck average of 24 mpg) and associated GHG reduction for the lowest cost (a $700–$1,800 retail price increase). The same study concludes that diesel passenger vehicles would provide slightly lower greenhouse gas reduction benefits for a higher cost, while hybrid gasoline vehicles would provide greater greenhouse gas reductions, but at a significantly higher cost.[6]

Questions for Policymakers:

1. Lessons from the European Experience. Over the last decade, consumer preference for diesel vehicles in Europe has grown substantially, so that today one in three cars sold in Europe is powered by a diesel engine. This increase in market penetration was accomplished through a combination of pricing incentives and other policies. U.S. policymakers may be able to draw some broad lessons from the European experience about successful strategies for shifting consumer demand towards more efficient vehicles.

2. Performance Standards. Most experts agreed that government should set performance standards rather than attempt to encourage a particular technology. For example, the federal government currently encourages consumers to purchase hybrid electric vehicles — regardless of their fuel economy performance — with a tax deduction An incentive tied to the policy objective being pursued, in this case improved fuel economy, would likely achieve desired benefits more effectively and at lower cost to the public.

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[5] For example, the cost premium for hybrid-electric gasoline vehicles is predicted to be approximately $3,000 to $5,000 at production volumes over 100,000 units per year. By comparison, it has been estimated that for a similar cost of $2,000 to $3,500 per vehicle a package of about 20 existing and emerging conventional gasoline vehicle technologies could produce a 40–60% improvement in fuel economy depending on vehicle class. *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards*, National Research Council, 2002

[6] Mark, J., *Light-duty Diesel in Context: What are the alternatives?,* Union of Concerned Scientists, Presentation to the National Commission on Energy Policy, Diesel Technology Forum, February, 2003. These estimates by UCS are consistent with cost curves for conventional fuel economy improvement technologies from selected studies compiled by the National Academy of Sciences in its 2002 report on fuel economy. For passenger cars, a $2,000 retail price increase could achieve between 10 and 20 mpg increase in fuel economy. For light trucks, a $2,000 retail price increase could achieve a 10 to 15 mpg fuel economy improvement. However, it is important to note that Ford and GM have disputed these findings concerning potential gains in fuel economy and believe that they are significantly overstated.

3. Balancing Environmental Goals. Current U.S. vehicle emission standards are designed to address public health and environmental concerns associated with local air pollution. They are not designed to incorporate trade-offs between criteria pollutant emissions and the fuel-saving and greenhouse gas reduction benefits offered by diesel technologies. Depending on the progress of diesel exhaust after-treatment technologies and the prospects for further fuel-economy improvement through conventional gasoline and hybrid-electric technologies, it may be appropriate to re-visit these trade-offs in the context of future standards design. As one participant in the Commission's 2003 diesel workshop pointed out, the fact that there are so few diesel vehicles in the current U.S. passenger fleet may allow more time for after-treatment technology to improve sufficiently to enable diesels to comply with Tier 2 standards. Other participants argued that policymakers should be willing to balance environmental goals.

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Diesel Workshop Attendees

Name	Affiliation
Martin Zimmerman	NCEP Commissioner / Ford Group V.P. of Corp. Affairs
Hank Habicht	NCEP Commissioner / GETF Executive Director
Ken Katz	NHTSA, Chief Engineer Fuel Economy Standards
Neil Schilke	GM, General Director of Engineering
Allen Schaeffer	Diesel Technology Forum, Executive Director
Marc Ross	U. of Michigan, Professor
Gerhardt Schmidt	Ford, VP of Research
Jason Mark	Union of Concerned Scientists
Charles Gray	EPA, Division Director, OTAQ
Dan Greenbaum	Health Effects Institute, Executive Director
Dale McKinnon	Mfgs. of Emission Controls Ass'n, Executive Director
Jim Hansen	Goddard Institute for Space Studies, Director
Michael Walsh	Consultant
Rich Kassel	Natural Resources Defense Council, Senior Attorney
Ellen Shapiro	Alliance of Automobile Mfgs., staff
William Craven	Daimler Chrysler, Regulatory Affairs
Hal Harvey	Hewlett Foundation
K.G. Duleep	EEA / Clean Air Task Force
Jose G. Mantilla	Volpe Center
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Tom Stricker	Toyota
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Transportation Policy Options
Policy Definitions and Discussion

Overview. The transportation sector policy options analysis is intended to provide a side-by-side comparison of potential energy strategy options. It is *not* intended to represent a final exposition on policy benefits since many of the policies can be adjusted to provide either lesser or greater benefits through applicable policy levers. For example, the gas tax option is based on a tax of 28 cents per gallon (2000$) - alternative tax levels will produce differing impacts, but the evaluated option provides a sense of the value of the policy approach relative to other available options. Similarly, the CAFE option is based on a modest increase in the stringency of existing standards, an increase tailored specifically to produce benefits similar to those of the gas tax option. More aggressive standards can produce greater benefits, albeit at decreasing marginal cost effectiveness. Each policy should be subjected to more detailed analysis before recommendation as a preferred policy.

A series of numeric metrics for each policy option are intended to allow a quantitative assessment of relative policy impact. Overall energy demand impacts are expressed as millions of petroleum barrels displaced per day. Policy costs are also presented, but it is important to recognize that these costs are developed from a consumer expenditure standpoint. Costs do not represent a rigorous macroeconomic analysis, but instead focus on the incremental cost of vehicles and fuel as borne by the consumer.[1] It is believed that this approach reflects a more

[1] The only minor exception to this is the increased oil production option, where the Energy Information Administration (EIA) analysis that forms the basis of the presented impacts includes the effects of the shift in domestic/import supply shares on world oil price. This price shift was considered for that option, even though equilibrium price shifts for the other oil demand options were not considered. This differential treatment is due to the fact that the equilibrium price shift is the only consumer cost associated with the increased supply option, whereas it is a minor component of the other demand option costs. For example, the price shift for the increased oil demand option is less than one cent per gallon and since it produces overall import demand reductions similar to the other policy options, the equilibrium price impacts for those options can be expected to be similar.

accurate representation of how policies might be accepted, as opposed to alternative approaches that treat costs on a more formal "societal" basis. For example, a recent Congressional Budget Office (CBO) evaluation of gas taxes versus CAFE concludes that gas taxes are a more cost effective option, but that study treats gas taxes as a transfer payment so that no costs are incurred due to the tax itself, but rather through its macroeconomic impacts.[2]

It is likely that consumers make no distinction between public and private monetary transfers and consider gas taxes to be costs no different than additional expenditures for more efficient vehicles. This is entirely consistent with consumer surveys that find gas taxes among the least favorable fuel efficiency options.[3] Even in instances of transfer payments where revenue neutrality is mandated, consumers tend to greatly discount their return on "investment." Thus, it is believed that consumer expenditures represent the most reliable metric for evaluating overall policy cost and acceptability. Nevertheless, in the interest of consistency with other analyses, such as that of the CBO, the policy options comparison also includes an otherwise identical gas tax policy evaluation that treats the tax itself as a transfer payment rather than a cost. Therefore, the specific impact of the tax treatment (i.e., as a cost or a transfer payment) can be evaluated through the direct comparison of the two alternative tax policy treatments.

Using estimated petroleum reduction and consumer expenditure impacts, two cost effectiveness metrics are developed. The first evaluates cost in the context of oil security, measuring dollars expended per barrel of oil reduced. The second evaluates cost in the context of climate change, measuring dollars expended per ton of carbon reduced. In most cases, the two metrics provide for similar relative comparisons across policies, but in some cases differences are observed. For example, increasing domestic oil production does provide some oil security benefit, but carbon emissions are largely unchanged.

The following sections provide a brief issue discussion for each evaluated policy option.

Gas Tax Option:

- The gas tax option reflects the imposition of an incremental 28 cent (2000$) gas tax. The tax is assumed to begin in 2008 and remain unchanged through 2025, so that its magnitude declines in real terms over time (as is the case with current gas taxes). All impacts are measured using the NEMS transportation model.

Gas taxes represent an attractive lever to generate fuel efficiency improvement. Unlike CAFE-type policies, gas taxes promote an immediate reduction in travel demand by raising the cost of driving for *both new and existing vehicles*. Over the longer term, gas taxes approach a CAFE-type program as consumers demand more fuel efficient vehicles to offset the increased cost of driving. Long term equilibrium between increased vehicle and fuel costs results in a level

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[2] *The Economic Costs of Fuel Economy Standards Versus a Gasoline Tax*, Congressional Budget Office, December 2003.

[3] See, for example, a 2001 NREL study (#710148), which found that only 6 percent of respondents rated gas taxes as a favorable energy efficiency option, while 44 percent found gas taxes to be the policy they would least support. Conversely, 48 percent would most support a CAFE-type option. *Consumer Views on Transportation and Energy*, NREL/TP-620-34468, National Renewable Energy Laboratory, August 2003 (page 25).

of travel demand that continues to be reduced relative to a CAFE-type policy, but this is combined with a new vehicle fuel efficiency that is less than that induced by a CAFE-type policy. Table 1 presents comparative metrics for programs that produce nearly equivalent (±1 percent) overall petroleum demand reductions.

Table 1. Comparison of Gas Tax and Equivalent CAFE Energy Parameters in 2025 (all costs are in 2000$)

Parameter	Base	Tax	CAFE	Delta from Base		Delta from Base		Tax to CAFE
				Tax	CAFE	Tax	CAFE	
VMT (billions of miles)	4133.8	3977.4	4144.3	-156.4	+10.5	-3.8%	+0.3%	-4.0%
New LDV Fuel Economy (mpg)	26.07	27.26	28.15	+1.19	+2.08	+4.6%	+8.0%	-3.2%
New LDV Fuel Consumption (gal/mi)	0.0384	0.0367	0.0355	-0.0017	-0.0028	-4.4%	-7.4%	+3.3%
LDV Fuel Use (MMBbls/day)	13.374	12.392	12.378	-0.982	-0.996	-7.3%	-7.4%	+0.1%
Fuel Cost ($/gal)	1.47	1.75	1.47	+0.28	+0.00	+19.0%	+0.0%	+19.0%
LDV Fuel Cost (billions)	302.0	333.0	279.5	+31.0	-22.5	+10.3%	-7.4%	+19.1%
New LDV Cost	25,233	25,335	25,479	+103	+246	+0.4%	+1.0%	-0.6%
Total Cost of New LDV (billions)	472.6	474.6	477.3	+1.9	+4.6	+0.4%	+1.0%	-0.6%
Net Cost of Vehicles and Fuel (billions)	774.6	807.6	756.8	+32.9	-17.9	+4.3%	-2.3%	+6.7%

While the gas tax option produces an attractive consumer response, it does so by imposing high consumer expenditures. Unlike CAFE-type programs, where consumers absorb the cost of improved vehicle efficiency through offsets in fuel savings, the gas tax policy results in both increased vehicle and fuel costs for consumers. Unless the price elasticity of fuel demand is unitary, the overall cost of driving <u>will</u> increase under a gas tax policy. This results in an unfavorable expenditure balance for consumers, *but provides a lasting incentive to control travel*. If the increased tax is viewed not as a cost, but as a transfer payment, then the gas tax option can look <u>very</u> favorable relative to other policy options since the induced travel demand reductions essentially accrue for free. However, it is not clear that such treatment provides either an accurate assessment of overall policy costs or an accurate picture of how such a policy would be received by consumers.

Because a gas tax serves to reduce travel demand, it also produces a number of related benefits, including reduced congestion, reduced criteria pollutants, and reduced toxic emissions. Significant gas tax increases, especially for environmental (as opposed to revenue generation) purposes, are likely to face stiff political opposition due to perceived consumer unpopularity. Moreover, gas tax policies are considered to be regressive by some economists since they consume a disproportionate share of low income expenditures. From an implementation standpoint, a gas tax policy could be easily implemented within the structure of the existing federal fuel tax program.

Light Duty Vehicle (LDV) CAFE Option:

- For this analysis, the CAFE option is designed to provide oil reduction benefits equal to those of the gas tax option. To produce the desired reduction of 1 million barrels per day, the combined (car plus light truck) CAFE standard was raised by approximately 15 percent.

  The specific standards imposed to generate the required reductions are 31.0 mpg for cars (up from 27.5 mpg) and 24.3 mpg for light trucks (up from 20.7/22.2 mpg). The standards are phased in between 2008 and 2015 and held constant thereafter. As with the gas tax option, all impacts are measured using the NEMS transportation model.

Table 1 above presents the key metrics associated with the equivalent CAFE option. As indicated in that table, the option leads to a large increase in new vehicle fuel economy, which reduces the cost of driving and generates a modest increase in VMT. It is perhaps important to note that *the NEMS model does capture this so-called "rebound effect,"* so that estimated oil demand impacts include the increased driving inducement associated with CAFE.

Under CAFE, overall fuel demand declines similarly to that of the equivalent gas tax option, but does so at a *lower* level of consumer expenditures. Under the CAFE option, consumers absorb vehicle cost increases over twice as large as those of the gas tax option, but this cost is offset by reduced operating costs.

Take for example, the average vehicle statistics from Table 1. Assuming a useful vehicle life of 150,000 miles, a 28.2 mpg vehicle will use 428 less gallons of gasoline than a 26.1 mpg vehicle over its lifetime (5,319 gallons versus 5,747 gallons). At a per-gallon cost of about $1.50 per gallon, this equates to a savings of about $642 over the vehicle's lifespan, or a savings of about $340 discounted to present value. Thus, for a $250 incremental vehicle cost, consumers receive a net present savings of $340. So, unless vehicle usage increases by over 25 percent, the net cost to consumers will be negative.

Although the U.S. currently administers a light duty CAFE program, enhancing the stringency of the existing program has proven to be very difficult politically. Attempts to alter the program have generally failed for more than a decade and only modest changes to the program standards have been implemented (at the regulatory, as opposed to legislative, level). Passenger car CAFE standards have remained unchanged for two decades, while light trucks standards have changed by only a modest amount. Nevertheless, given existing program structure, modifications to the program standards are easily implemented from an administrative standpoint. Because CAFE standards provide no incentive to reduce travel, they produce no (or negative) congestion, criteria pollutant, and toxic emission benefits.

Heavy Duty Vehicle (HDV) CAFE Option:

- The HDV CAFE option is designed to promote the availability and sales of higher efficiency heavy duty trucks. The policy is based on analyses by researchers at

Argonne National Laboratory[4] that estimated the fraction of trucks for which specific efficiency improvements were feasible and the associated costs of those improvements. These analyses indicate that:

- Long haul truck mpg can increase from 6.2 to 9.8 mpg,
- 50 percent of Class 3-5 trucks can increase mpg from 9.2 to 17.8,
- 50 percent of Class 6 trucks can increase mpg from 7.2 to 12.3, and
- 50 percent of short haul Class 7 and 8 trucks can increase mpg from 6.2 to 10.6.

Standards equal to these potential improvements are implemented between 2008 and 2015. Argonne-estimated costs for these improvements decline over time, but generally range from $3,000 to $15,000 (2000$). As is the case with the LDV CAFE policy, all impacts are measured using the NEMS transportation model.

Even though the incremental cost of vehicles is much higher in the heavy duty vehicle sector, average fuel use is also considerably greater than that of the light duty vehicle sector, so that there is a net cost savings to consumers. In 2025, heavy duty vehicle consumers absorb average new vehicle cost increases of about $6,500. However, this increased cost is offset by over $14,000 (non-discounted) or $7,500 (discounted) in fuel cost savings, so that consumers obtain a net present cost savings of about $1,000.

Politically and administratively, the implementation of heavy duty fuel economy standards could pose a considerable challenge. Heavy truck owners hold considerable lobbying power and are likely to oppose the implementation of standards, despite the fact that there may be a net economic benefit due to fuel savings. Additionally, heavy truck engines are certified prior to their installation into vehicles, so both the setting of standards and a demonstration of compliance could be difficult. As is the case with light duty vehicle CAFE, heavy duty standards are unlikely to produce peripheral benefits related to congestion, criteria pollutant, or toxic emission reduction.

Increased Oil Production Option:

- The increased oil production option assumes that approximately one-half of the known oil reserves in the U.S. are opened for production. Primarily, this means reserves in the Alaskan National Wildlife Refuge (ANWR), but also includes a modest level of reserves along the Atlantic and Pacific coasts and in the Gulf of Mexico.

  Production capacity is taken from analyses conducted by the Energy Information Administration (EIA), that indicates a best estimate production capacity of about 2 million barrels per day by 2025 (beginning at about 0.09 million barrels per day in 2010) - of which half was assumed to be initiated for this analysis.[5] Consumer

[4] *The Potential Effect of Future Energy-Efficiency and Emissions-Improving Technologies on Fuel Consumption of Heavy Trucks*, Argonne National Laboratory, August 2002. *Scenario Analysis of Hybrid Class 3-7 Heavy Vehicles*, Presented at the Society of Automotive Engineers International Congress and Exposition, March 2000.

[5] *The Effects of the Alaska Oil and Natural Gas Provisions of H.R. 4 and S. 1766 on U.S. Energy Markets*, Energy Information Administration, February 2002, plus supported NEMS runs.

cost impacts are estimated using the NEMS transportation model, as implemented for an ANWR analysis scenario by EIA. Under the EIA analysis, world oil price is estimated to decline by about 38 cents per barrel (2000$) by 2025 under the increased domestic production scenario. This equates to a net consumer savings of about 5 billion (2000$) per year.

Determining cost effectiveness of the oil production scenario is somewhat more complicated than for other policy options since overall oil demand does not change, although import demand is reduced by about 1 million barrels per day. Based on analysis conducted by Leiby et al. at Oak Ridge National Laboratory in 1997, the import portion of the security externality of oil is estimated at between $1.01 and $2.94 (2000$) per barrel, while the total security externality is estimated to range from $1.48 to $5.23 (2000$) per barrel.[6] Using a mean estimate of $1.98 per barrel for the import externality and $3.35 for the total externality, the fractional value of reduced imports can be estimated at about 59 percent of the total displaced volume. This discounted benefit was used in lieu of the total displaced import volume to produce the tabulated oil security cost effectiveness estimate in the policy options table. From a CO_2 reduction standpoint, there are no net CO_2 reductions since oil production is simply shifted from one location to another. Thus, CO_2 cost effectiveness is undefined for the increased oil production option.

Politically, the opening of additional oil fields in the U.S. for production is likely to face substantial challenge. Certainly, debate over the last few years related to the opening of ANWR fields provides an illustrative lesson. Environmental advocacy groups are likely to oppose increased production on the basic of local environmental issues such as waste generation and disposal, potential water pollution, and increased criteria pollutant and toxic emissions.

Corn Ethanol - Current Policy - Option:

- The current policy corn ethanol option assumes that the mandated use of ethanol is increased in accordance with the 2003 Energy Bill requirements currently under consideration by Congress, and that the existing ethanol subsidy is retained through 2025. In 2005, the ethanol subsidy decreases to 51 cents per gallon (current $) and is assumed to stay at that level in all later years, so that in real terms, the subsidy declines to about 28 cents per gallon in 2000$ by 2025. Since the House and Senate versions of the Energy Bill contain somewhat different ethanol sales mandates, this analysis assumes a mandate equal to the arithmetic average of the two bills. Mandated sales begin at 2.9 billion gallons per year in 2005 and reach 5.9 billion gallons per year by 2025.

It is important to recognize that ethanol sales do not start from zero, so that mandated sales volumes are not equal to incremental sales. Using baseline NEMS data on ethanol volumes, incremental ethanol sales begin at 0.9 billion gallons per year in 2005 and reach 3.2 billion gallons per year by 2025. In calculating the volume of petroleum displaced by these incremental ethanol sales, a correction between the energy content of ethanol relative to that of gasoline is also required, so that one gallon of gasoline is displaced for every 1.7 gallons of ethanol.

[6] *Oil Imports: An Assessment of Benefits and Costs*, ORNL-6851, Oak Ridge National Laboratory, November 1997.

Therefore, the total volume of gasoline displaced is equal to about 0.04 million barrels per day in 2005, increasing to about 0.12 million barrels per day in 2025.

The production plant gate cost of corn ethanol ranges from \$0.80-\$1.40 per gallon (2000\$).[7] Assuming an average cost (\$1.10 per gallon) through the mandated production period results in an estimated net expenditure (including the subsidy) of 1.1 billion (2000\$) by 2025. It is important to recognize that this expenditure includes both increased consumer costs due to the higher sales price of gasoline and the direct costs of the ethanol subsidy (no administrative costs are assumed for the subsidy program). This is somewhat different from all other policies, which are analyzed from a strict consumer viewpoint. However, since the subsidy is used to avoid even higher consumer costs, its inclusion in overall policy costs is appropriate. Energy security cost effectiveness is simply calculated as the ratio of incremental cost to displaced gasoline volume. However, climate change cost effectiveness also considers the reduced life cycle GHG performance of ethanol relative to gasoline, so that an additional credit of 25-33 percent is applied above the direct volume of gasoline displaced in determining climate change cost effectiveness.

As demonstrated by the current proposed Energy Bill, legislative support for increased ethanol production remains strong. Existing administrative mechanisms are in place to handle subsidy reconciliation, so that there is likely to be little or no additional impact in this area. Depending on production practices, increased ethanol use could also produce decreases in criteria pollutant and toxic emissions.

Bioethanol Option:

- The bioethanol policy option assumes that mandated ethanol sales volumes rise to encompass all currently available unused agricultural waste, estimated to be 16.9 billions gallons per year by researchers at Oak Ridge National Laboratory.[8] All oil reduction and cost calculations are performed in a manner identical to the corn ethanol option previously described. As was also the case with that option, it is assumed that the current ethanol subsidy remains in effect through 2025. The per gallon cost of bioethanol at the production plant gate is assumed to decline from about \$1.35 per gallon (2000\$) in 2000 to about \$0.98 per gallon (2000\$) in 2025.[9] Like the corn ethanol policy, climate change cost effectiveness considers the reduced life cycle GHG performance of ethanol relative to gasoline. However, for bioethanol, the GHG performance improvement is substantially greater, resulting in an additional credit of 67-567 percent above the direct volume of gasoline displaced. Based on these assumptions, the net cost of the policy is about 3.5 billion (2000\$) in 2025, as compared to 1.1 billion (2000\$) for the current corn ethanol policy option, but the resulting oil reduction benefits are six times as large.

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7 *Outlook for Biomass Ethanol Production and Demand*, DiPardo, Energy Information Administration, July 2000.

8 *Agricultural Waste to Energy*, Graham (Oak Ridge National Laboratory) presentation at NCEP Forum: The Future of Biomass and Transportation Fuels, June 13, 2003.

9 *Outlook for Biomass Ethanol Production and Demand*, DiPardo, Energy Information Administration, July 2000.

As with the corn ethanol policy, political support for a bioethanol policy is likely to be strong. The need for administrative mechanisms continues as long as the tax subsidy support is required. As is also the case for the corn ethanol policy, decreases in criteria pollutant and toxic emissions could accrue if environmentally conscious production practices are employed.

<u>Component Efficiency Standards</u>:

- The component efficiency standards policy option assumes that in-use vehicle efficiency can be improved through the regulation of aftermarket tire and lubricating oil performance. Using data from a variety of sources, a *crude* estimate of the fuel consumption impacts and prevalence of current behavior were constructed. These estimates imply at, on a fleetwide basis, a fuel consumption reduction of about 1.9 percent would be possible if *all* consumers were affected. However, an assumption of 100 percent consumer coverage is unrealistic since a large proportion of vehicles in any given year are operating on factory-installed tires and a substantial portion of vehicles currently utilize low viscosity lubricating oil.

  For this analysis, it is assumed that 60 percent of vehicles are affected by the tire standard and that these vehicles undergo tire replacement every five years, so that in any given year about 12 percent of vehicles are affected. For lubricating oil, this analysis assumes that about 30 percent of vehicles in any given year could benefit from the use of lower viscosity oil. Using NEMS estimates for light duty vehicle fuel consumption and the assumed impact estimates, it is estimated that the policy might reduce overall fuel consumption by about 0.2 million barrels per day in 2025.

It is estimated that the program will result in incremental maintenance costs of about $7.50 per vehicle, averaged over the entire fleet. This results in a total incremental vehicle cost of about 2.2 billion (2000$) per year in 2025. However, these costs are offset by an overall decrease in fleet fuel costs of about 5.0 billion (2000$) in 2025, so that there is a net savings to consumers of about 2.8 billion (2000$) per year in 2025.

It is possible that in addition to the assumed component efficiency standards, a coordinated public education program could influence both the vehicle purchase behavior and general maintenance habits of the public. However, it is difficult to estimate to what extent, if any, purchasers might be willing to alter behavior and at what cost that behavioral change will occur. Since there are higher fuel efficiency vehicles available for no incremental cost (or a cost savings) relative to more fuel inefficient vehicles, the only cost would be that associated with the education campaign itself and the net cost to consumers would likely be negative. In the current absence of resources necessary to investigate vehicle purchasing elasticity in more detail, this potential benefit has been excluded from consideration in this analysis.

Both politically and administratively, a component efficiency policy should be straightforward and noncontroversial. However, determining effectiveness and certifying benefits could pose a substantial challenge. Of course, any benefits accrue whether they are certified or not, so the administrative challenge is more properly viewed in the context of monitoring to ensure maximum effectiveness and provide feedback for program refinement. If a successful program can be implemented, peripheral benefits related to criteria pollutants and toxic emissions are also likely to accrue through the same maintenance and behavioral changes that lead to climate change emission reductions.

VMT Reduction Option:

- The VMT reduction policy option attempts to influence vehicle usage by imposing fees upon vehicles operating in certain areas of the most congested U.S. metropolitan areas. As an initial policy, restrictions in the following ten metropolitan areas are assumed:[10]

  - New York City,
  - Los Angeles,
  - San Francisco,
  - Houston,
  - Atlanta,
  - Washington, D.C.,
  - Chicago,
  - Dallas,
  - Detroit, and
  - Boston.

Together these areas comprise about 18 percent of total U.S. VMT.[11] Based on a similar program operating in London, it appears that a daily VMT reduction of just under one percent is possible if restricted operational areas are well defined, at a cost of about \$0.70 (2000\$) per mile reduced. Based on current U.S. VMT and the fraction controllable through restrictions in the 10 metropolitan areas, overall U.S. light duty vehicle VMT might be reduced by about 6 billion miles per year in 2025, or by about 0.1 percent. This equates to a petroleum demand reduction of about 0.02 million barrels per day.

At \$0.70 (2000\$) per mile, the cost of the petroleum demand reduction is about \$4.4 billion (2000\$) in 2025. This cost is offset by some fuel savings, but the estimated net value of that savings is \$0.5 billion (2000\$), so that net costs are just under \$4 billion (2000\$). Unless U.S. consumers are substantially more responsive than their British counterparts, this policy is by far the most expensive mechanism evaluated in terms of cost effectiveness. Moreover, the program carries significant administrative burdens since a mechanism must be implemented to determine and collect fees. In London, the program is enforced via a series of remote cameras that monitor the restricted travel zone and cite offenders using license plate recognition software. Obviously this represents a significant additional cost burden and further diminishes the value of the program. However, through travel demand reduction, peripheral benefits related to congestion, criteria pollutant, and toxic emission reduction also accrue.

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[10] *Congestion Charging: Solutions for the Escalating Problem of Vehicle Miles Traveled*, Walsh, National Commission on Energy Policy, December 2003 (with accompanying spreadsheet).

[11] *Highway Statistics 2001*, Federal Highway Administration, 2002.

Transportation Policy Options

Brief Policy Definitions

Policy	Definition
Gas Tax	28 cents per gallon (2000$), beginning in 2008 and increasing through 2025.
LDV CAFE	Light duty vehicle CAFE program designed to provide reductions equivalent to the Gas Tax policy option. The program raises passenger car CAFE to 31.0 mpg and light truck CAFE to 24.3 mpg between 2008 and 2015.
HDV CAFE	CAFE-type program to increase the fuel economy (mpg) of heavy duty trucks. Standards would increase mpg of: (1) long haul Class 7 and 8 trucks from 6.2 to 9.8 mpg, (2) short haul Class 7 and 8 trucks from 6.2 to 7.9 mpg, (3) Class 6 trucks from 7.2 to 9.1 mpg, and (4) Class 3-5 trucks from 9.2 to 12.1 mpg.
Increase Oil Production	Program designed to reduce import dependency through increased recovery and production of domestic oil. Additional resources in the Atlantic, Gulf of Mexico, Pacific, and Alaskan regions are considered.
Corn Ethanol Current Policy	Supply-based program designed to promote the economic efficiency and demand for renewable fuels. The current policy is based on a subsidized corn-derived ethanol response to mandated production levels based on 2003 Energy Policy Act quotas.
Bioethanol	Supply-based program designed to promote the economic efficiency and demand for renewable fuels. The cellulosic ethanol policy is based on a biomass-derived ethanol response to mandated production levels based on current unused agricultural waste streams.
Component Efficiency Standards	This policy involves the regulation of replacement tire and lubricating oil performance.
VMT Reduction	This policy is based on the imposition of fees for vehicles entering congestion centers in ten of the most congested U.S. metropolitan areas.

Transportation Policy Options
Large Reduction (1+ MMBbl/day) Options

Evaluation Parameter		Gas Tax (Tax is Cost)	Gas Tax (Tax Not a Cost)	LDV CAFE	HDV CAFE	Bioethanol	Increase Oil Production (No Discount)
Barrels Reduced (MMBbl/day)	In 2025	1.0	1.0	1.0	1.0	0.6	1.0 imports 0.0 net
	Cumulative	11.3	11.3	12.4	10.3	8.7	12.1 imports 0.0 net
Consumer Cost (Billions of 2000$)	In 2025	33	-20	-18	-17	3.5	-5
	Cumulative	635	-217	-152	-131	80	-51
Oil Security Cost Effectiveness (2000$/Bbl Reduced)	In 2025	89	-55	-47	-45	15	-14
	Cumulative	154	-53	-34	-35	25	-12
Climate Change Cost Effectiveness (2000$/Ton C Reduced)	In 2025	823	-506	-440	-351	20	--- (no CO_2 change)
	Cumulative	1,423	-486	-317	-273	39	--- (no CO_2 change)
Who Pays?		Consumers	Consumers	Consumers, Automakers	Consumers, Automakers	Government Consumers	Oil Producers, Consumers
Other Benefits? Congestion Reductions Criteria Pollutant Reductions Toxic Emission Reductions		 Yes Yes Yes	 Yes Yes Yes	 No No No	 No No No	 No Possibly Possibly	 No Increase Increase
Equity Issues?		Regressive	Regressive	Automobile Industry	Automobile Industry	Oil Industry	None
Political Viability?		Poor	Poor	Poor	Poor	Good	Moderate
Implementation		Easy, Structure in Place	Easy, Structure in Place	Easy, Structure in Place	Difficult, No Existing Structure	Moderate, Assumes Price Support	Easy, but Oversight Required
Incremental Vehicle Cost in 2025 (2000$)		$103 (LDV)	$103 (LDV)	$246 (LDV)	$1,538 (C3-6) $9,905 (C7-8) (HDV)	$0	$0

Transportation Policy Options
Small Reduction (0.1-0.2 MMBbl/day) Options

Evaluation Parameter		Increase Oil Production (Discounted)	Corn Ethanol Current Policy	Component Efficiency Standards	VMT Reduction
Barrels Reduced (MMBbl/day)	In 2025	0.6 imports 0.0 net	0.1	0.2	0.02
	Cumulative	7.1 imports 0.0 net	2.0	3.9	0.3
Consumer Cost (Billions of 2000$)	In 2025	-5	1.1	-2.8	4.0
	Cumulative	-51	23	-44	65
Oil Security Cost Effectiveness (2000$/Bbl Reduced)	In 2025	-24	23	-34	530
	Cumulative	-20	32	-31	515
Climate Change Cost Effectiveness (2000$/Ton C Reduced)	In 2025	--- (no CO_2 change)	156	-307	4,749
	Cumulative	--- (no CO_2 change)	214	-278	4,611
Who Pays?		Oil Producers, Consumers	Government Consumers	Consumers	Consumers
Other Benefits?					
Congestion Reductions		No	No	No	Yes
Criteria Pollutant Reductions		Increase	Possibly	Possibly	Yes
Toxic Emission Reductions		Increase	Possibly	Possibly	Yes
Equity Issues?		None	Oil Industry	None	Possibly Regressive
Political Viability?		Moderate	In Place, Under Debate	Good	Moderate
Implementation		Easy, but Oversight Required	Easy, Structure in Place	Easy, but Administration Required	Difficult, Administration Required
Incremental Vehicle Cost in 2025 (2000$)		$0	$0	$0	$0

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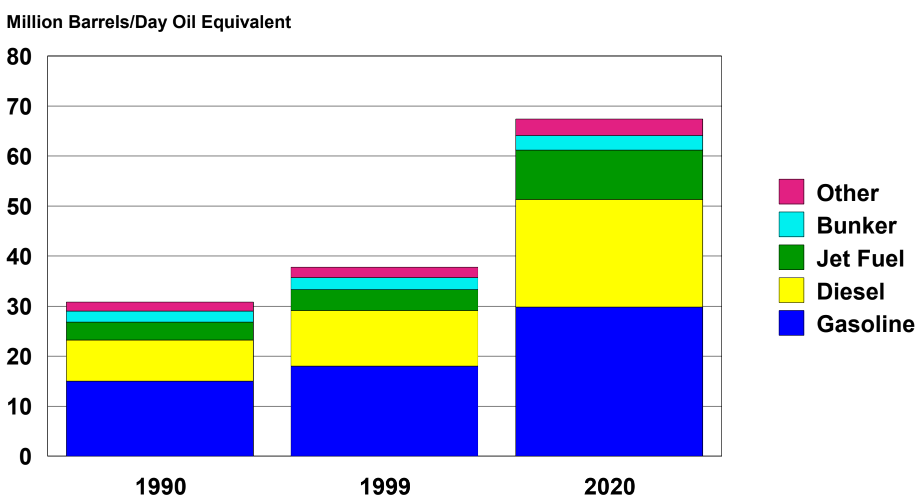
Auto-Ramblings

Recent and Projected World Transportation Fuel Demand



Source: EIA/DOE (2001)

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Table of Contents

1. Introduction – The Important Role of Transportation

Review of recent progress shows that developed countries continue to make impressive progress in reducing conventional pollutants and cleaning up fuels. Newly adopted emissions standards, especially those reducing diesel particulate, should also substantially reduce the contribution of vehicles to the toxics problem. However, a significant discrepancy between European and Japanese standards for NOx and PM emissions from diesel vehicles compared with those in the U.S. is arguably the biggest short term issue for future control of vehicle emissions and technology development directions in the industrialized world.

Many developing countries are also moving toward world-class standards, but have found further progress hampered by poor quality fuels. For example, China will move to Euro 2 emissions standards in 2004, but will not be able to gain the full advantage of the more stringent Euro 3 and Euro 4 standards without requiring cleaner gasoline and diesel.

In contrast to global progress on conventional pollutants, policies to reduce GHGs from vehicles or to improve fuel efficiency continue to be weak or nonexistent in most areas, with only Europe and Japan showing some leadership. On a bright note, the EU/Japan leadership appears to have influenced the recent voluntary agreement in Australia to reduce fuel consumption of new passenger cars by about 18 percent by 2010 to help cut emissions of carbon dioxide. One promising development for an integrated approach is new legislation in California, the Pavley Bill, directing the California Air Resources Board to add GHGs to it existing, aggressive control programs for conventional pollutants and toxics.

While no country has yet successfully combined strong control efforts to aggressively control conventional pollutants, toxics and greenhouse gases, cutting-edge hybrid-electric vehicles like the Toyota Prius and Honda Civic and advanced diesel models like Peugeot's models equipped with a particle filter[1] offer potentially dramatic improvements in conventional and greenhouse pollution at competitive costs. Policies to encourage wider commercialization and sales of these advanced vehicles vary but are generally weak and sometimes poorly structured with the result that sales are lower than they otherwise could be or that less effective alternatives are equally incentivized. Also, there is very little coordination between major vehicles markets which reduces the size of the overall market for the best vehicles.

Further, very few countries have successfully used the full variety if policy instruments which are available to them to clean up vehicles and fuels. Even Germany, which has had a strong tax incentive program to complement the mandatory performance standards adopted by the EU, has been constrained by EU law from overcoming the currently weak diesel PM and NOx standards.

This paper will review the motor vehicle pollution control and energy conservation efforts around the world, with the principle focus being on developed countries.

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1. Peugeot has produced more than 500,000 light -duty diesels using an actively regenerated PM filter.

2. The European Approach

A. "Conventional" Vehicle Emission Standards

New light duty emission limits 2000 and 2005 were published in December 1998 as EU Directive 98/69/EC. The Directive also included a revised light duty cycle (eliminating the initial 40 second idle period with no emissions measurements) and a cold start (-7°C) emissions test. New heavy duty emissions limits and test cycles were introduced in EU Directive 1999/96/EC and this was further refined for gas powered engines in 2001/27/EC. Work on the "Clean Air for Europe" (CAFE) program is underway.

Emission Limits For Passenger Cars

Emission Limits for Petrol Cars (g/km)[a]

PETROL	As from [b]:	CO	HC	NO_x
EURO I*	1/7/1992	4.05	0.66	0.49
EURO II*	1/1/1996	3.28	0.34	0.25
EURO III	1/1/2000	2.30	0.20	0.15
EURO IV	1/1/2005	1.00	0.10	0.08

* As measured on new test cycle for application in year 2000.

Emission Limits for Diesel Cars (g/km) [a]

DIESEL	As from [b]:	CO	HC	NO_x	PM
EURO I*	1/7/1992	2.88	0.20	0.78	0.14
EURO II*	1/1/1996	1.06	0.19	0.73	0.10
EURO III	1/1/2000	0.64	0.06	0.50	0.05
EURO IV	1/1/2005	0.50	0.05	0.25	0.025

* As measured on new test cycle for application in year 2000.

Notes:

a) "Euro 3 and 4" (Directive 98/69/EC): Standards also apply to light commercial vehicles (<1305 kg).
b) The above dates refer to new vehicle types; dates for new vehicles are 1 year later.

Light Commercial Vehicles N1 Class (<1350 kg) Emission Limits (g/km).

N1	As from:	Fuel Type:	CO	HC	NO_x	HC + NO_x	PM
EURO I*	1/10/1994	All	2.72	-	-	0.97	0.14
EURO II*	1/1/1998	Petrol	2.2	-	-	0.5	-
		Diesel	1.0	-	-	0.60	0.1
EURO III	1/1/2001	Petrol	2.3	0.2	0.15	-	-
		Diesel	0.64	-	0.5	0.56	0.05
EURO IV	1/1/2006	Petrol	1	0.1	0.08	-	-
		Diesel	0.5	-	0.25	0.3	0.025

* For Euro I and II the weight classes were N1 (<1250 kg), N2 (1250-1700 kg) and N3 (>1700 kg)

Light Commercial Vehicles N2 Class (1305-1760 kg) Emission Limits (g/km).

N2	As from:	Fuel Type:	CO	HC	NO_x	HC + NO_x	PM
EURO I*	1/10/1994	All	5.17	-	-	1.4	0.19
EURO II*	1/1/1998	Petrol	4	-	-	0.65	-
		Diesel	1.2	-	-	1.1	0.15
EURO III	1/1/2002	Petrol	4.17	0.25	0.18	-	-
		Diesel	0.8	-	0.65	0.72	0.07
EURO IV	1/1/2006	Petrol	1.81	0.13	0.1	-	-
		Diesel	0.63	-	0.33	0.39	0.04

* For Euro I and II the weight classes were N1 (<1250 kg), N2 (1250-1700 kg) and N3 (>1700 kg)

Light Commercial Vehicles N3 Class (>1760 kg) Emission Limits (g/km).

N3	As from:	Fuel Type:	CO	HC	NO_x	HC + NO_x	PM
EURO I*	1/10/1994	All	6.9	-	-	1.7	0.25

EURO II*	1/1/1998	Petrol	5	-	-	0.8	-
		Diesel	1.35	-	-	1.3	0.2
EURO III	1/1/2002	Petrol	5.22	0.29	0.21	-	-
		Diesel	0.95	-	0.78	0.86	0.1
EURO IV	1/1/2006	Petrol	2.27	0.16	0.11	-	-
		Diesel	0.74	-	0.39	0.46	0.06

* For Euro I and II the weight classes were N1 (<1250 kg), N2 (1250-1700 kg) and N3 (>1700 kg)

"Euro I and II": Directive 91/542/EEC; "Euro III, IV and V": Council position December 1998 and agreed with the European Parliament.

Relevant Petrol and Diesel Fuel Specification Limits.

PETROL	2000	**2005**
RVP summer	60	-
Aromatics	42	35
Benzene	1	-
Olefins	18	-
Oxygen	2,7	-
Sulphur	150	50

DIESEL	**2000**	**2005**
Cetane # (min)	51	-
Density 15°C	845	-
Distillation 95°C	360	-
Polyaromatics	11	-
Sulphur	350	50

B. Efforts To Improve Vehicle Fuel Efficiency

Carbon Dioxide (CO_2) from passenger cars accounts for about half of CO_2 emissions from transport, and about 12 percent of total CO_2 emissions in the European Union.[2] Under a "business as usual" scenario, CO_2 emissions from cars were expected to increase by about 20 percent by 2000 and by about 36 percent by the year 2010 from 1990 levels. The road transport sector has stood out in recent years as one of the few sectors in the Union experiencing CO_2 emissions growth.

In the face of these concerns, the European Automobile Manufacturers Association, ACEA, entered into a Voluntary Agreement with the European Commission to reduce the CO_2 emissions from new light-duty passenger vehicles[3], with firm fleet-wide targets[4]

2. Derived from "A Community strategy to reduce CO2 emissions from passenger cars and improve fuel economy", COM (95) 689, Communication from the Commission to the Council and the European Parliament, Adopted by the Commission on December 20, 1995.
3. The Agreement applies to light passenger vehicles classified as M1 in European Council Directive 93/116/EEC, which includes vehicles with no more than 8 seats in addition to the driver.
4. Note that the 140 g CO_2/km goal is a collective target, not a target for each individual company. The participants in the agreement – BMW, Fiat, Ford of Europe, GM Europe, DaimlerChrysler, Porsche, PSA Peugeot Citroen, Renault, Rolls Royce, Volkswagen, and Volvo – have not publicly

of 140 g CO_2/km (about 41 mpg for gasoline) by 2008, measured under the new European test cycle[5]. This represents about a 25 percent reduction from the 1995 average of 187 g/km (about 30 mpg). Accounting for the differences in driving cycles, the "U.S. equivalent" mpg ratings[6] of the year 2008 European fleet will likely be higher than 41 mpg if the targets are met. The EU Council approved the ACEA self-commitment in October 1998, with an agreement between ACEA and the Commission finalized in early 1999.

The Agreement includes a promise to introduce some models emitting 120g/km (about 48 mpg) or less by 2000, and a non-binding 2003 target range of 165-170g/km (about 34-35 mpg). In addition, the commitment is to be reviewed in 2003, with the aim of moving towards a fleet goal of 120g/km by 2012. Finally, ACEA agreed to monitor compliance with the Agreement jointly with the Commission.

The Commission estimates that the agreement with ACEA will contribute more than 15% of the total GHG emission savings required from the EU under the Kyoto Protocol. ACEA's collective commitments are ambitious, both technically and economically.

Subsequent to the ACEA voluntary agreement, the European Commission negotiated similar agreements with the Japanese and Korean vehicle manufacturer's associations.[7]

So far, the Agreement is a success. Average CO_2 emissions for new ACEA cars registered in the EU fell steadily in all EU countries from 1995 to 2001, for an overall 11 percent reduction in CO_2 emission levels (Table 1). By achieving a 2001 average of 164 gm CO_2 per km, ACEA has already met the 2003 non-binding goal. Trends in specific fuel consumption and CO_2 emissions of new passenger cars in Europe are summarized in Figure 2, which shows a post-Agreement strengthening of the CO_2 reduction trend that began around 1993 following a seven-year plateau in fuel economy. In 2000 ACEA met its commitment to ensure that "*some members of ACEA will introduce in the EU market models emitting 120g CO_2 /km or less."* Its manufacturers brought to market more than 20 models that achieved 120g/km or less, and sales of such cars totaled almost 160,000 units in 2000, rising in 2001 to over 306,000 units.

Table 1: Specific Emissions of new Passenger Cars - Average for EU15[8]

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defined individual objectives, but before signing the Agreement they discussed among themselves the likely tradeoffs that would have to be made to achieve the goal.

5. Directive 93/116/EEC defines the new test cycle.
6. Without discounting. The mpg values that appear on new car stickers reflect a 10 percent discount off the city test results and a 22 percent discount off the highway test results, or 15 percent off the combined 55-city/45-highway rating.
7. It should be noted that for EU countries almost identical data is reported in the *Communication on Implementing the Community Strategy to Reduce CO_2 Emissions from Cars: Third Annual Report on the Effectiveness of the Strategy*, December 2002 [COM(2002)693 final see http://europa.er.int/comm/environment/co2/co2_home.htm] and the *Joint Report of the European Automobile Manufacturers Association and the Commission Services*, Final Report of 25 June 2002. The Commission compares figures from the two monitoring systems in its Communication, reporting a difference of just over 1% for 2001.
8. Excluding Finland and Greece to 2000 and excluding Greece in 2001 (with little impact on the average due to the relatively small sizes of the car markets in these countries). Emissions recorded under the mandatory type-approval testing required for all new cars. ACEA/OICA/ECMT 2002, drawn from AAA database.

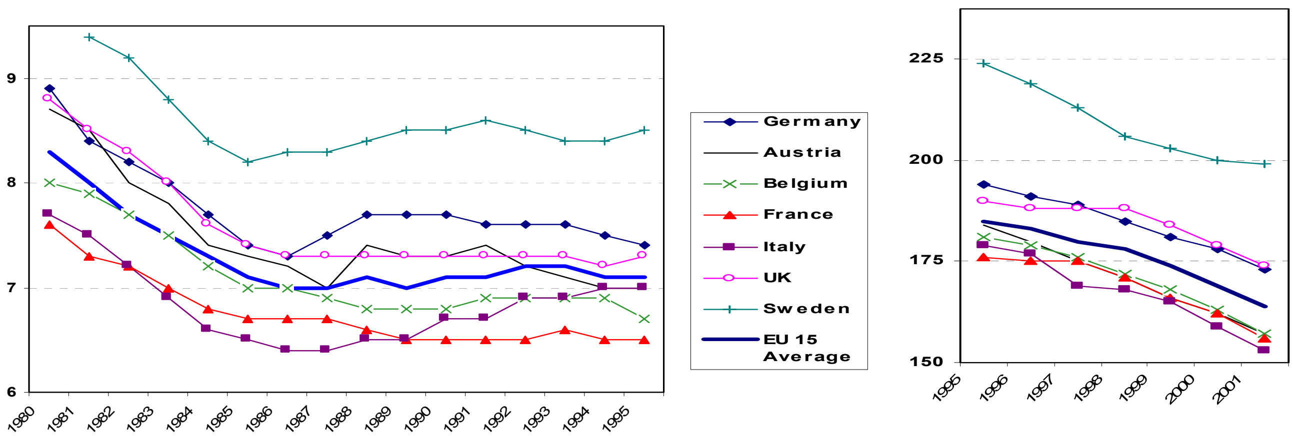
	1995	1996	1997	1998	1999	2000	2001
All cars	186	184	182	179	176	172	167
ACEA cars	185	183	180	178	174	169	164

(CO_2 g/km measured by the test cycle specified in Directive 93/116/EC)

These figures show that not only has ACEA met its commitment to reduce test

Figure 1: Weighted Averages for New Cars (Fuel Economy and CO2)

1980 to 1995—Fuel Consumption (liters/100 km) **CO_2 Emissions** (gm CO_2/km)



emissions to between 165 and 170 g/km by 2003, but it is also on course to meeting the target of 140g of CO_2 per km in 2008 (a 25% reduction compared to 1995)[9]. ACEA calculates that improvements in its cars since 1995 have already contributed almost 35 million tons CO_2 emission reductions. According to official Auto-Oil II simulations, ACEA's Commitment **will cut the increase** in EU road CO_2 emissions, leading to stabilization in road transport's share of CO_2 emissions by 2004-2005 in spite of expected traffic growth. This continues to represent much the largest contribution **in the transport sector** towards meeting CO_2 reduction commitments made under the 1997 UN Kyoto protocol.

The following figure and tables show the trend in weighted average CO_2 emissions from new cars manufactured by ACEA members for each of 16 countries since 1995.

Average Specific CO_2 Emissions of New Cars Weighted By Registrations
(Grams CO_2 /km measured by the test cycle specified in Directive 93/116/EC)

	1995	1996	1997	1998	1999	2000	2001
Italy	179	177	169	168	165	159	153

9. The target date is 2009 under the voluntary agreements concluded between the European Commission and JAMA and KAMA.

Portugal	171	168	164	162	159	156	154
France	176	175	175	171	166	162	156
Spain	175	174	170	169	165	162	157
Belgium	181	179	176	172	168	163	157
Austria	184	180	175	171	166	162	157
Ireland	180	179	173	175	168	165	165
Poland	-	-	-	177	174	168	165
Luxembourg	196	192	190	185	181	173	167
Finland	185	-	-	-	-	178	177
The Netherlands	189	188	186	182	177	174	171
Denmark	190	188	189	186	182	178	173
Germany	194	191	189	185	181	178	173
United Kingdom	190	188	188	188	184	179	174
Sweden	224	219	213	206	203	200	199
Norway	196	191	192	-	-	-	-
Switzerland	216	212	211	-	-	-	-
EU Average	185	183	180	178	174	169	164

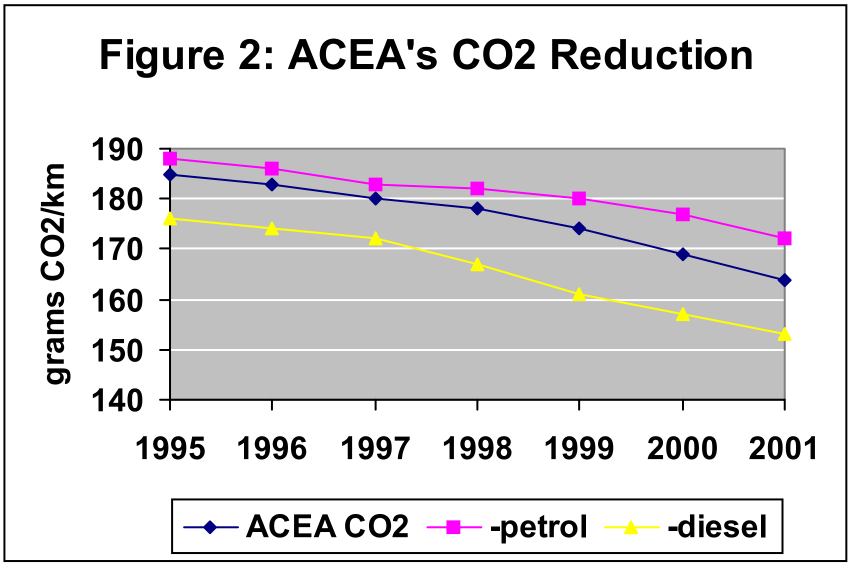
Note: EU average excludes Finland and Greece.
Source: ACEA/OICA/ECMT 2002, from AAA database for ACEA cars; except for Finland and Poland.

Average Fuel Consumption of New Cars Weighted by Registrations
(Litres/100km test cycle measured by the test cycle specified in Directive 93/116/EC)

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
EU average	7.6	7.5	7.4	7.2	7	6.8	6.7
Austria	7.4	7.1	6.9	6.7	6.5	6.3	6.1
Belgium	7.2	7.1	7	6.8	6.6	6.4	6.2
Denmark	8	7.9	7.9	7.8	7.5	7.3	7.2
France	7	7	7	6.8	6.6	6.4	6.2
Germany	8	7.9	7.8	7.6	7.4	7.2	7
Ireland	7.4	7.4	7.2	7.2	6.9	6.8	6.9
Italy	7.4	7.3	7	6.8	6.7	6.4	6.2
Luxembourg	8	7.8	7.7	7.5	7.2	6.9	6.6
The Netherlands	7.8	7.8	7.6	7.4	7.2	7.1	7
Poland	-	-	-	7.4	7.1	6.9	6.8
Portugal	7.1	7	6.8	6.6	6.5	6.3	6.3
Spain	7.1	7	6.8	6.7	6.5	6.4	6.3
Sweden	9.4	9.2	8.9	8.6	8.4	8.3	8.4
United Kingdom	7.8	7.7	7.7	7.7	7.5	7.4	7.2

Note: EU average excludes Finland and Greece.
Source: ACEA/OICA/ECMT 2002, from AAA database for ACEA cars; except for Poland.

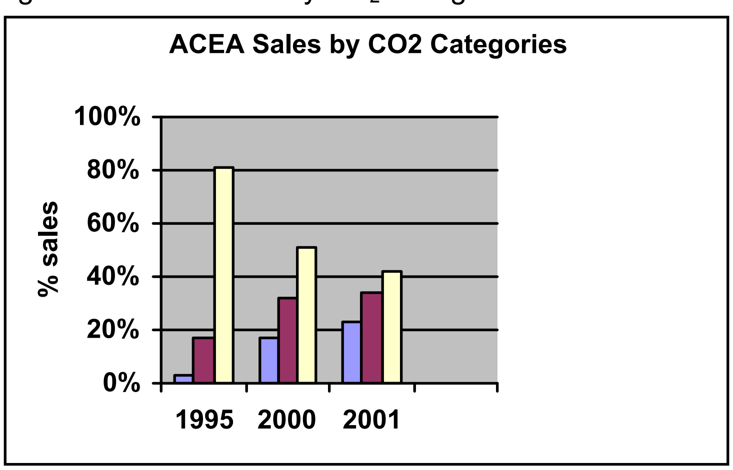
Technical and product developments, dieselisation and the weight and power of vehicles are amongst a number of factors that determine average test CO_2 emissions for new cars. The trends in test emissions from new petrol and diesel cars are shown in Figure 2 below.



C. EU Fuel Economy Related Technology Improvements

The Commitment is also expected to have a positive impact on technological advance, ensuring that across the European automotive sector CO_2 reduction remains a high priority in R&D expenditures, as well as in product and process planning and development. Achievement of further technological advances is seen as key to further significant CO_2 abatement. Although each ACEA manufacturer undertakes the vast majority of this R&D effort independently, the Commitment presented the opportunity to launch in 1998 a collaborative, pre-competitive research program (CO2perate). CO2perate seeks to develop and demonstrate longer-term CO_2 reducing breakthrough technologies and systems through collaborative projects between manufacturers, suppliers, research institutes and universities across Europe.

Figure 3: ACEA Sales by CO_2 Categories



Since making their commitments, manufacturers have introduced a wide range of technical and product developments to reduce CO_2 emissions. Technologies have been commercialised on a very large scale, and enhanced fuel efficiency has been combined with other attractive product attributes. This was particularly the case for the new generation of technically-advanced, highly fuel-efficient and competitive direct-injection diesels. Technology highlights are detailed in the box below.

Technical advances by manufacturers have resulted in a strong upward trend in fuel-efficient car sales. Over 2.8 million ACEA cars were sold in 2001 with CO_2 levels of 140g/km or less, a growth of almost 40% on 2000. These cars accounted for 23% of sales in 2001 -- up from 17% in 2000, and 2.6% in 1995. (See Figure 3).

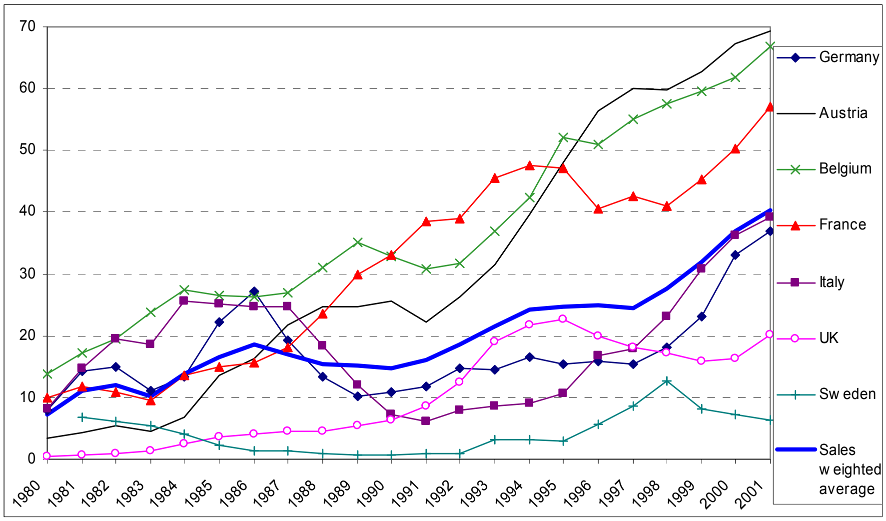
ACEA's new CO_2-reducing technical and product developments

- Direct injection diesel engines were successfully introduced in 1998, followed by the launch of a new generation of technically advanced diesels, notably incorporating highly efficient unit injector and common rail technology. Some gasoline direct injection models were also launched.
- 2001 saw the introduction of: 2-step variable valve lift, fully variable valve lift, fully variable intake manifolds, 2nd generation common rail injection (high pressure), application of advanced diesel technology to small cars, 6-speed automatic gearboxes, and other improvements.
- Automakers are now also making greater use of continuously variable transmission (CVT), robotized gearboxes, 6-gear manual boxes, electric power steering, route guidance systems, etc.
- Introductions of technically advanced new models (including "120g/km or less" models).
- On-going development of alternative-fuelled vehicles. Manufacturers have offered: LPG bi-fuel, CNG/biogas bi-fuel, and alcohol flex-fuel vehicles, as well as series production of dedicated LPG and CNG/biogas vehicles. In 2001 automakers launched a new generation of bio-fuelled vehicles. Certain ACEA manufacturers have also introduced electric or innovative-concept vehicles onto the EU market.

D. Importance of Diesels in Europe

Diesel penetration in Europe has risen dramatically in recent years to reach 40% of registrations in the 14 EU countries (excluding Greece) in 2001. In the past few years the market share for diesel has expanded with the introduction of technically advanced direct injection (DI) diesels. Dieselisation varies considerably across Europe with certain countries at diesel shares approaching 70% (Austria, Belgium), and other countries with very low diesel penetration (e.g., Denmark, Norway, Sweden). Inspired in part by this rise in diesel vehicle use, the EU moved recently to reduce diesel sulfur levels. Further, some EU member countries are urging the region to tighten NOx and particulate standards for diesel vehicles.

Figure 4: Penetration of Diesel Cars (% of new sales)



Source: ACEA/OICA/ECMT, 2002, drawn from AAA database for all manufacturers to 1997, figures extrapolated linearly to 2000, figures for ACEA cars only in 2001.

i. Near Zero Sulfur Fuels

Following years of debate, the European Parliament set a deadline of Jan. 1, 2009, for an EU-wide changeover to "zero sulfur" (10 parts per million) gasoline and diesel fuels for road transport. The Council of Ministers approved the measure on February 7, 2002.

Limiting sulfur content to 10 parts per million (ppm) will allow industry to develop new generations of "lean burn" (fuel-efficient) engines and improve the efficiency of catalytic exhaust gas converters, according to EU Environment Commissioner Margot Wallström. Zero-sulfur road fuel also will help the EU reach its goal of reducing carbon dioxide emissions from new cars to 120 grams per kilogram of fuel on average.

Urging the Parliament to approve the draft, Wallström described the draft as "an important part of our strategy for reducing air pollution and greenhouse emissions." The 2009 deadline for completing the EU-wide changeover to zero-sulfur road fuels represents a two-year advance on Wallström's original proposal, which had recommended a 2011 deadline.

The final text also provides for review by 2006 of the standards of fuel used by "non-road mobile machinery," such as tractors used in farming and forestry, and construction equipment such as earthmovers and bulldozers.

Meanwhile, the new legislation will require the oil industry to ensure that by 2005 zero-sulfur fuels are available across Europe on a "sufficiently balanced geographical basis" to allow drivers to refuel without having to drive long distances.

A further amendment secured by the Parliament will require Wallström to review technical issues regarding fuel quality in light of EU moves to encourage use of biofuels. As part of the 2005 review of fuel quality standards, the European Commission has been instructed to look at the case for changing EU rules on fuel volatility to facilitate sales of environmentally friendlier blends of gasoline and bioethanol. Currently, straight blends of the two fuels risk contravening EU rules on volatility, particularly in high temperatures.

ii. Tighter Diesel Standards

Many if not most manufacturers are expected to be able to meet the Euro IV car and truck standards without diesel particulate filters (DPFs). At the same time pressure is building within the EU to require or at a minimum allow member states to incentivize these PM control systems. Approximately a year ago, Sweden requested authority to move in this direction, or to have amended the Directive provision that prohibits incentives for standards beyond those adopted by the EU. The request was denied. However, just recently, France and Germany sent a letter to the Commission raising several additional points:

- In spite of the significant improvement in diesel vehicle emissions, a substantial problem remains with both PM and NOx. France and Germany note that the World Health Organization, the EU Commission, the US National Research Council, and the US Environmental Protection Agency have all identified fine particulate as a high priority problem because of its roles in causing respiratory problems, heart disease and premature mortality.

- Air quality measurements show that the number of particles in the size range of 0.01 to 2.5 μm are high and have not declined in the past six years. In Germany, it is estimated that in areas near road traffic vehicle emissions contribute 45% to 65% of the particle load of the air in the breathing zone.

- The portion of new diesel car registrations has more than doubled in recent years and is now at approximately 40%, and while this technology has clear CO_2 advantages it will result in PM emissions 60% higher than previously estimated for the year 2020.

- NOx reductions are also urgently needed to reduce the ozone burden. A modern diesel passenger car discharges about eight to ten times as much NOx as a petrol-fueled car.

- It now appears that Euro IV for cars can largely be met without PM filters; a further tightening of the limit values is needed to require this highly efficient technology and its associated health benefits.

- Particle filters are demonstrated to be available and effective under practical conditions as over 270,000 cars and more than 50,000 commercial vehicles are currently so equipped.

- US Tier 2 limit values for NOx and PM are approximately 80% lower than Euro IV car limits. Japanese PM limits approach zero.

In this context, France and Germany called upon the Commission to submit by mid-2004 suggestions for updating 98/69/EG and 99/96/EG with the goal of further NOx and PM reductions, using the possibilities of particle filter technology.

In summary, it appears that a serious push is about to begin in Europe to tighten NOx and PM limits for all categories of vehicles sufficiently to require the introduction of PM filters on all diesel vehicles. In parallel with this EU-wide effort, there is also a strong campaign in Germany to modify their tax incentive scheme for early introduction of Euro IV limits, to make it apply only to vehicles that are equipped with PM filters. In response to this campaign, a variety of manufacturers including Mercedes, VW, Opel, Renault, Peugeot and BMW have indicated that they will offer traps on at least some models.

In light of these developments and in view of further work being carried out at the GRPE regarding test procedures and equipment to measure ultrafine particles, which is due to be completed soon, the Commission has been considering several alternative approaches. These include:

- Adopting enhanced environmentally friendly vehicle limits which could be used by member states with tax incentives to encourage the early introduction of vehicles with PM filters, or

- Adopting Euro V limits for light duty vehicles which would include lower NOx levels and possibly a PM number limit, or

- All of the above.

For a variety of reasons – the expected addition of 10 new member states to the EU in 2004, Parliamentary elections in 2004, the appointment of a new Commission in November 2004, the work still underway and not yet completed under the EU CAFÉ[10] program, and the soon to be completed PMP program – the Commission has decided not to propose new emissions limits at this time. The likely schedule for new proposals is as follows:

First meeting of MVEG sub-group at JRC Ispra:	4 September 2003
GRPE receives final PMP report:	15 September 2003
Second meeting of MVEG sub-group:	15 October 2003
Third meeting of MVEG sub-group:	15 November 2003
Fourth meeting of MVEG sub-group:	9/10 December 2003
MVEG signs-off deliverables of sub-group to CAFE:	15 December 2003
First draft position paper on Euro 5 and Euro 6 internally in Commission services and data to CAFE:	15 December 2003
CAFE position paper on particulates:	end 2003
Stakeholder consultation through MVEG and Internet:	February-April 2004
Final advice from WHO on health effects of pollutants:	February 2004
CAFE baseline available. Commence development of Euro 5 and Euro 6 scenarios in CAFE:	1 April 2004
Start integrated assessment modeling in CAFE:	1 April 2004
Final output of technical/economic analysis on Euro 5 and Euro 6 in MVEG sub-group:	September 2004
Output of CAFE integrated assessment modeling and cost-benefit studies:	November 2004
Adoption of Commission proposal for Euro 5:	April 2005
Adoption of Commission proposal for Euro 6:	November 2005

10. Clean Air For Europe

iii. UBA Issues Proposal On Diesel Standards

In an effort to focus attention on specific targets, the German Umweltbundesamt recently proposed new standards for light and heavy duty diesels.[11] The Euro 5 particulate limit value for passenger cars of 0.0025 g/km (for the time being only mass-based) should correspond to an emission reduction of 90% compared with the Euro 4 limit value. At 0.08 g/km, the NOx limit value for diesel passenger cars should correspond to the value for petrol cars in Euro 4. The proposal is summarized in the Table below.

Passenger Cars (g/km)	PM	NOx
Current Euro 4 (2005)	0.025	0.25
Proposed Euro 5 (2008)	0.0025	0.08

In addition, the total number of particulates emitted by both passenger cars and heavy-duty engines limits should be limited in the size range that is relevant for health.[12] The PMP group will propose annexes to Directives for precise definition of the improved gravimetric procedure and the CPC procedure by the end of 2003.[13]

The additional costs for Euro 5 designs in diesel passenger cars and the appropriate combinations of measures to fulfill the aforementioned limit values are estimated by UBA to be €200 to €400 per vehicle compared with Euro 4 technology.

iv. Conditions On The CO_2 Agreement May Conflict With Tighter Standards

One complication for the commission in pursuing tighter standards with regard to cars is the voluntary CO_2 reduction agreement between ACEA, the auto industry trade association, and the Commission. In exchange for their commitment to meeting the 2008 CO_2 emissions goal, the industry asked that a number of conditions be met:

- **Clean fuels availability.** Because the industry believes that direct injected engines will play a key role in achieving the targets, the Agreement asks for the "full market availability" of clean fuels needed for this technology by 2005 – gasoline with 30 ppm sulfur content and less than 30% aromatics, diesel fuel at 30 ppm sulfur and cetane number greater than or equal to 58.[14]
- **Protection against unfair competition.** Non-ACEA members must commit to similar goals, and the European Community will agree to try to persuade other car manufacturing countries to embrace equivalent efforts. The Korean and Japanese industries have agreed with a one year delay.
- **Regulatory cease-fire.** No new regulatory measures to limit fuel consumption or CO_2 emissions.
- **Unhampered diffusion of technologies.** The companies assume that the

11. While as noted earlier the Commission has indicated that it will not propose new standards until 2005, Germany hopes to force the issue politically by putting new standards on the table and perhaps trying to use them as a basis of their tax incentive scheme.
12. Recent work by Ricardo and others has demonstrated that PM filters are capable of reducing not only the mass but the number of particles by over 90%.
13. "**GENEVA: GRPE Particulate Measurement Programme (PMP)",** Mike Dunne, UK Department of Transport, MVEG Ispra, 3 September 2003.
14. Of course the industry got even more than this with the recent decision to provide fuels with a maximum sulfur content of 10 PPM or less.

Commission **will take no action that would hamper the diffusion of efficiency technologies**, particularly direct injected gasoline and diesel engines. Presumably, the auto industry could argue that this means no tightening of emissions standards on NOx and particulates.

Negotiations between the car industry and the Commission are expected to begin soon regarding the next stage of CO_2 improvements in the car fleet. Presumptively the aim will be to reduce average levels to about 120 g/km by 2012. In these discussions, it is also expected that the car industry will raise concerns regarding efforts to tighten NOx and PM limits for vehicles as an impediment to further reductions in CO_2 emissions.

E. Taxation Policies

One of the most effective policies in Europe to stimulate the introduction of clean or efficient vehicle technologies or fuels has been the use of tax incentives. Perhaps the most advanced such program with regard to fuel efficient vehicles is the Danish scheme which will be summarized below.

i. Denmark's Tax System For Vehicles and Fuels

a) Vehicle tax

(1) Cars

From 1 July 1997 the <u>*yearly tax*</u> has been based on energy consumption, measured according to Directive 93/116. Before that date it was based on weight. Twenty-four classes are defined for both gasoline and diesel cars. Examples of selected classes (basis 2000) are given below (the figures will be increased with inflation plus 1.5% every year):

Examples of Danish Tax Incentive System (year 2000)

Vehicle Class		Fuel Consumption (km/l)	Annual Tax (DKK)
Gasoline	1	> 20.0	460
	11	10.0 – 10.5	5,040
	24	< 4.5	16,920
Diesel	1	25> 22.5	1,860
	12	10.2 – 11.3	9,000
	24	< 5.1	23,340

As the table shows, diesel vehicles are taxed at a much higher rate than gasoline vehicles. This is based on an effort to encourage fuel efficient vehicles but without increasing the urban air pollution that would be associated with increased diesel penetration.

From 1st January 2000 three new classes for diesel passenger cars were defined. The annual tax (DKK) is:

	2000	2001	2002
> 32.1 km/l	140	200	280
28.1-32.1 km/l	700	780	860
25-28.1 km/l	1280	1380	1460

From 1st of January 2000 a supplementary reduction in *purchase tax* for energy efficient passenger cars was introduced:

Diesel	gasoline	2000-2005	2006-2010
> 45 km/l	> 40 km/	4/6	3/5
37.5-45 km/l	33.3-40 km/l	3/6	2/5
32.1-37.5 km/l	28.6-33.3 km/l	2/6	1/5
28.1-32.1 km/l	25-28.6 km/l	1/6	-

This means that a diesel car running more than 45 km/l in the period 2000-2005 will have to pay a purchase tax which is 2/6 of the normal tax - and so on.

(2) Light commercial vehicles

In the new system incentives were also given to light commercial vehicles for which it can be demonstrated that they meet the EURO 3 (2000) or EURO 4 (2005) standards, before they became mandatory.

The Danish system operates with 4 classes based on gross vehicle weight. Examples on the reduction in the yearly taxes for class 1 and 4 are given below:

Class		EURO 3 (Dkr)	EURO 4 (Dkr)
1 (below 1,000 kg)	1998-2000	350	450
	2001	0	100
	2002-2005	0	100
4 (2,500-3,500 kg)	1998-2000	1,150	1,600
	2001	1,150	1,600
	2002-2005	0	450

The system entered into force 1st of January 1998.

b) Fuels

(3) Gasoline

Since 1995 incentives (Dkr 0.03 pr liter) have been given to gasoline delivered from stations equipped with vapor recovery systems (even if it has become mandatory for stations with a yearly capacity 500 m3 or more from 2000).

A benzene limit of 1% was introduced from 2000 (directive 98/70)

(4) Diesel fuel

From 1st of June 1999 a tax incentive was introduced in order to promote auto diesel with low sulphur content (defined as sulphur below 50 ppm). The incentive is 0.18 DKK pr liter. As a result all auto diesel sold on the Danish market from that date has met the low sulphur spec.

ii. Recent Developments in Denmark

During the last year two inter governmental groups have worked with different problems.

1. Change in registration fee for passenger cars from a value-based system (app. 200%) to a system based on energy consumption (CO_2). A report was published in April 2003 following which the government decided not to make any changes to the current system. The concern was that an increase in the number of more environmental friendly cars would reduce the revenue of fuel taxes.

2. Promotion of vehicles with reduced particulate emission. The group has looked at the following options:

a) Requirement (legal) of filters on existing trucks and busses,
b) Subsidies to owners of trucks and busses if filters are installed,
c) Tax incentives for Euro 4-trucks and busses,
d) Tax incentives for sulphur free fuels,
e) Introduction of environmental zones in the biggest cities, and
f) Tax incentives for passenger cars with filters

The report gives an update of the health aspects in relation to emission of particles. It is estimated, that installation of filters on all heavy-duty trucks in Denmark will result in a reduction of premature death of 450 per year.

iii. Denmark Decides To Push Diesel PM Filters

In general, the current government is opposed to increasing taxes and therefore increased government spending but at the same time the government created Institute for Environmental Assessment (IMV) some months ago published a report which concluded that fitting particle filters to diesel engines would yield a "maximum possible gain" of DKr83bn (€11.2bn) over the next 15 years. Unlike previous cost-benefit analyses that tended to focus only on heavy vehicles (over 3.5 tons), vans and taxis were included in this study because of their prevalence in urban areas. The study takes into account the public health impact of filtering out ultrafine as well as fine particles, with calculations being made "partly on the basis of pure cost and partly on... willingness to pay". It concluded that fitting particle filters to all diesel engines would save up to 1,250 lives per year and DKr83bn over 15 years through avoided health impacts.

Another report was published on the 6th of June with its main conclusions being:

- PM is a serious problem
- Denmark will support work in the EU for more stringent PM-standards
- More research is necessary
- Local initiatives with definition of environmental zones in big cities are important

After some discussion in the media and the government an agreement was reached (24th June) between the government and two supporting parties in Parliament. In the years 2004 and 2005, Denmark is to spend DKr30m (€4m) subsidizing up to 30% of the cost of fitting diesel particle filters to trucks.

The city of Copenhagen has also decided to create environmental zones, where PM filters will be required - from 1. October 2004. The 30m DKr will support this initiative.

F. Fuel Pricing Policies

Throughout Europe, fuels are highly taxed, not only as a means of raising revenue but also to encourage energy conservation. As illustrated below in Figure 5, because of taxes, the retail prices of fuels are generally much higher in Europe (and Japan) than in the US. In addition, in some European countries, diesel fuel is taxed lower than gasoline, providing an additional stimulus to diesel car sales. Conversely, in other countries, diesel fuels are taxed equally as gasoline, so as not to encourage increased diesel penetration.[15]

The UK has had an especially innovative approach to fuel taxes, announcing and then implementing a program of gradually increasing fuel prices year by year. In addition, so as not to encourage diesel car sales which have been seen to be harmful to urban air pollution, the UK has taxed diesel fuel the same as gasoline (petrol).

This year, however, U.K. Chancellor of the Exchequer Gordon Brown announced on April 9 a freeze in tax rates for air passengers, climate change, and **fuel consumption** as part of the nation's 2003-2004 budget. Brown cited the current global economic downturn as the reason behind "some important tax freezes to help maintain business competitiveness. However, the government is committed to tackling environmental problems, by ensuring the polluter pays and introducing new incentives for more environmentally friendly behavior."

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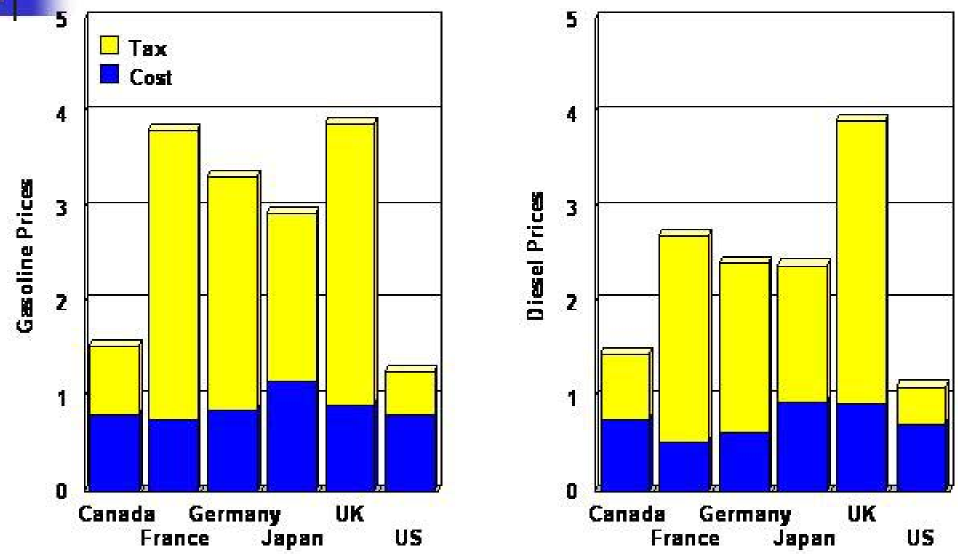
15. Tax policies, whether on vehicles as in the case of Denmark or on fuels as in the case of the UK, are one of the important reasons why diesel penetration rates are so markedly different in different EU member states.

Figure 5: Fuel Prices in Selected Countries (1998$/Gal)



The climate change tax was introduced two years ago to help meet Britain's targets for cutting emissions of greenhouse gases. The revenue raised by the tax is recycled back to business, primarily through the 0.3 percentage point reduction--worth around £1.7 billion ($2.66 billion) in 2003-2004--in employers' National Insurance Contributions tax. Exemption from the climate change tax for energy used in certain environmentally friendly industrial recycling processes was introduced last July.

Other measures in the UK include a new tax differential for **sulfur-free fuels** from Sept. 1, of 0.5 pence (0.78 cents) per liter relative to the rates for ultra-low sulfur fuels, to encourage the use of these fuels; an increase in the taxes for rebated gas oil and fuel oil--which have higher levels of sulfur than road fuels--by 1 pence (1.56 cents) per liter; and a new tax incentive for bioethanol used as a road fuel, set at 20 pence (31 cents) per liter below the prevailing rate for sulfur-free fuel, from Jan. 1, 2005.

3. The Japanese Approach

A. Emission Standards

On December 14th, 1998, the Air Quality Committee, Central Council for Environmental Pollution Control issued new Short Term Targets for diesel vehicle pollution control. These short-term targets reduce NOx emissions by 25 to 30 percent and particulate matter by 28 to 35 percent over the period from 2002 to 2004. Moreover, with a view to maintaining adequate performance of exhaust emissions controls in use, durability requirements were extended and installation of on-board diagnostic (OBD) systems became mandatory.

Serious and growing concerns regarding diesel vehicle emissions have, however, led to additional controls. In mid-1999, the Governor of Tokyo launched a campaign to ban diesels entirely from the city of Tokyo because of persistently high levels of NO_2 and growing concerns over the health effects of diesel PM. Then on January 31, 2000, the Kobe District Court ordered the government and Hanshin Expressway Public Corporation to pay for the health damages to plaintiffs who were residents in the roadside area of National Highway No. 43 and Hanshin Expressway.[16] In the finding, the Court acknowledged the relationship between asthma of the plaintiffs and suspended particulate matter (SPM), especially diesel exhaust particulate (DEP). The Court also ruled that the government and Hanshin Expressway should keep the SPM concentration level lower than 0.15mg/m3 within 50 meters from the roadside of both roads.

Subsequently, the Tokyo Metropolitan Government announced draft regulations for the mandatory installation of Diesel Particulate Filters (DPF) for all diesel vehicles that run in the Tokyo area. (Approximately 190,000 diesel passenger cars and 460,000 commercial vehicles are registered in Tokyo. In addition, about 240,000 diesel vehicles come into Tokyo from other areas each day.) The government proposed to amend its anti-pollution law by the end of 2000 to require particulate retrofitting of all existing diesel engines. The new regulation became effective on April 1, 2001. The rule allowed for a 2-year preparation time for retrofit, so the first group under the regulation will be equipped with diesel particulate filters (DPFs) after April 2003. The requirements phase in on a step-by-step basis, with 100% of the vehicles to be equipped with DPF by April of 2006.

Japan's Central Environmental Council on March 7, 2002 released for public comment new, more stringent requirements on tailpipe emissions for new motor vehicles to be sold in 2005 and later, including foreign-manufactured vehicles. The interim final regulation applies both to gasoline- and diesel-powered passenger cars, trucks, and buses and sets different requirements for different classes of vehicles.

The new regulation calls for reducing PM emissions from trucks and buses by up to 85 percent and NOx emissions by 50 percent from the levels set in the short-term diesel auto emission regulation. Domestic products and imported vehicles that fail to meet the regulation cannot be registered for use in Japan. The test mode will be also changed; transient mode will replace the steady state mode.

The new emissions level would be cut to 0.027 gram per kilowatt-hour for PM from 0.18 gram per kWh under the 2002-2004 regulation, or an 85 percent reduction. The standards for NOx emissions for the same category of trucks must be cut to 2 grams per kWh from 3.38 grams under the 2002-2004.

The Japanese New-Long-Term Regulations, decided on March 5,
which will start from October 2005.

Vehicle Type	Inertia Weight	Units	NOx	NMHC	CO	PM
	EIW<1,250kg and 1,250kg	G/km	0.14	0.024	0.63	0.013

16. "Gov't to cough up over air pollution", Mainichi Shimbun, February 1, 2000

Diesel Passenger Vehicle	EIW<1,250kg and 1,250kg	G/km	0.14	0.024	0.63	0.013
	EIW>1,250kg	G/km	0.15	0.024	0.63	0.014
Diesel Trucks and Buses	GVW<1,750kg and 1,750kg	G/km	0.14	0.024	0.63	0.013
	1,750kg<GVW<3,500kg and 3,500kg	G/km	0.25	0.024	0.63	0.015
	3,500kg<GVW	G/kWh	2.0	0.17	2.22	0.027
Gasoline Passenger Vehicle	All	G/km	0.05	0.05	1.15	NA
Gasoline Light Duty Vehicles	All	G/km	0.05	0.05	4.02	NA
Gasoline Trucks and Buses	GVW<1,750kg and 1,750kg	G/km	0.05	0.05	1.15	NA
	1,750kg<GVW<3,500kg and 3,500kg	G/km	0.07	0.05	2.55	NA
	3,500kg<GVW	G/kWh	0.7	0.23	16.0	NA

EIW = Equivalent Inertia Weight and GVW is Gross Vehicle Weight; NA=Not Applicable

B. Fuels Pricing

As shown above in Figure Japan has followed a similar pattern as in Europe in terms of taxing road fuels quite heavily, compared to the US and Canada. Also note that the tax on diesel fuel is lower than the tax on gasoline.

C. Fuel Economy Standards

The Japanese government has established a set of fuel economy standards for gasoline and diesel-powered light duty passenger and freight vehicles, with fuel economy targets based on vehicle weight classes. Table 2 shows the vehicle targets for gasoline and diesel-powered passenger vehicles, as measured on the Japanese 10.15 driving cycle. The targets for gasoline-powered vehicles are to be met in 2010; 2005 is the target year for diesel-powered vehicles. Figure 4 illustrates the percentage improvements required for each weight class of gasoline-powered vehicles as well as the current market shares for each class. The targets are to be met by each automaker for each weight class—that is, automakers cannot average across weight classes by balancing a less-than-target vehicle in one class with a better-than-target vehicle in another.

Table 2. Japanese Weight Class Fuel Economy Standards for Passenger Vehicles

Gasoline-fueled Passenger Vehicles for 2010

(Metric System)

Vehicle Wt (Kg)	<703	703-827	828-1015	1016-1265	1266-1515	1516-1765	1766-2015	2016-2265	2266+
F.E. Target (Km/l)	21.2	18.8	17.9	16.0	13.0	10.5	8.9	7.8	6.4

(English System)

Vehicle Wt (Lbs)	<1550	1550-1824	1826-2238	2240-2789	2791-3341	3343-3892	3894-4443	4445-4994	4997+
F.E. Target (Mpg)	49.9	44.2	42.1	37.6	30.6	24.7	20.9	18.3	15.0

Diesel-fueled Passenger Vehicles for 2005

(Metric System)

Vehicle Wt (Kg)	<1016	1016-1265	1266-1515	1516-1765	1766-2015	2016-2265	2266+
F.E. Target (Km/l)	18.9	16.2	13.2	11.9	10.8	9.8	8.7

(English System)

Vehicle Wt (Lbs)	<2240	2240-2789	2792-3341	3343-3892	3894-4443	4445-4994	4997+
F.E. Target (Mpg)	44.5	38.1	31.0	28.0	25.4	23.0	20.5

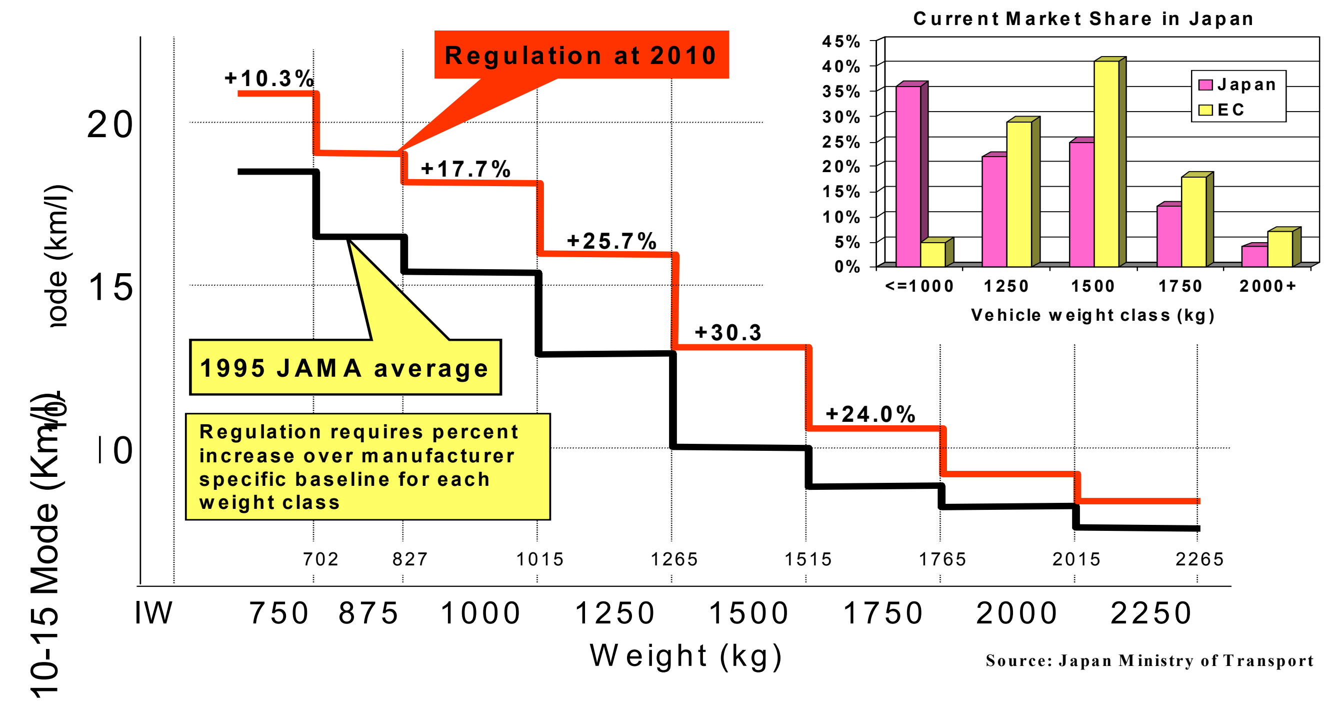
Assuming no change in vehicle mix, these targets imply a 22.8 percent improvement in gasoline passenger vehicle fuel economy (15.1 km/l in 2010 vs. 1995 level of 12.3 km/l[17]), and a 14.0 percent improvement in diesel passenger vehicle fuel economy (11.6 km/l vs. 10 km/l) compared to the 1995 fleet. In other words, compliance with these standards will produce by 2010 and 2005, respectively, a Japanese gasoline-fueled light-duty passenger vehicle fleet of 35.5 mpg and a diesel fleet of 27.3 mpg[18] as measured using the Japanese 10.15 driving cycle.

17. Assuming no change in market shares. From "Interim Report on Target Standards for Vehicle Fuel Consumption," from Ministry of Transport website.
18. In the Japanese fleet, diesel vehicles are larger, on average, than gasoline vehicles.

The regulations call for civil penalties if the targets are not met, but these penalties are very small. Realistically, enforcement will come from pressure from the government and the auto companies' desire to avoid public embarrassment, not from the financial penalties.

The fuel economy targets were selected by identifying "best-in-class" fuel economies in

Figure 6: New Japanese Fuel Economy Regulations



each weight class and demanding that the *average* new vehicle meet that level in the target year. The Japanese call this the "top runner" method of selecting fuel economy targets. Theoretically, this method is not "technology forcing" in that the technology has already been identified. Practically speaking, however, the standards may prove to be technology forcing unless the "top runners" in each weight class already fully matched their competitors in other areas of performance and amenities.

The fuel economy regulations have additional requirements over-and-above the actual fuel economy targets. These are:

- For new vehicles, fuel economy and major efficiency technologies onboard must be recorded in catalogs and displayed at exhibits.

- The government is charged with: providing education and other incentives for vehicle users and manufacturers, making sure that fuel economy regulation proceeds in harmony with other regulations (especially new emission standards), reviewing manufacturers' efforts to improve fuel economy, and trying to harmonize this regulation with similar efforts in Europe and the United States.

- Manufacturers are expected to develop new efficiency technologies, design vehicles of outstanding efficiency, and help educate the public.

- The public is charged with selecting efficient vehicles and using them in an efficient manner.

Beyond fuel economy requirements, Japan has continued to lead in the development and introduction of advanced technology vehicles such as hybrids. This will be discussed below.

D. Advanced Technology Incentives

Whereas Europe is clearly the dominant market for diesel vehicles and therefore the driver for advances in diesel technology, Japan seems to be the clear leader in terms of both hybrid and fuel cell cars. This reflects in part a conclusion on the part of Japanese manufacturers that the long term market for these potentially very clean and fuel efficient technologies could be significant and in part a clear effort on the part of the Japanese government to support and encourage these initiatives. Highlighted below are a series of announcement and events that support these conclusions.

- Shortly after taking office, Prime Minister Junichiro Koizumi was taken for a ride in a fuel-cell car. After a brief spin around the drive in front of Japan's parliament building, a beaming Koizumi pronounced the car "the ultimate" and said he would do all he could to promote the use of fuel-cell vehicles. "The ride is great, it's much quieter than the cars used now and very comfortable," he said. Koizumi singled out the environment as a key policy area and has urged government officials to switch to cars friendly to the environment.

- After investing hundreds of millions of yen and years of research into the development of environmentally friendly cars, the auto industry recently received a big boost from the Japanese government. Three government ministries have crafted a plan to significantly increase the number of low-emission vehicles on the road by 2010. Currently, only 630,000 models are in use, but officials want to push that number beyond 10 million within 10 years. Achieving this goal means that one out of every eight cars in the nation would be eco-friendly, compared with about one out of every 115 vehicles today. To make this transition, the government has announced that it would expand tax incentives and subsidies and promote the development of fuel-cell vehicles. Under the plan, five types of vehicles would be considered eco-friendly: Those running on compressed natural gas, electric cars with rechargeable batteries, hybrid vehicles that combine gasoline engines with electric motors, vehicles running on methanol and those with gasoline engines that emit low levels of carbon dioxide and other pollutants.

- Prime Minister Koizumi has asked government agencies to purchase only environmentally friendly vehicles with the aim of eventually replacing the government’s fleet of 7,000 gasoline-powered models over the next three years. He also is encouraging private corporations and local governments to do the same.

- During 2002, Japan's government pledged to buy eco-friendly fuel cell vehicles from next year in an effort to promote the fledgling technology. "We decided at today's cabinet meeting that the government would start buying fuel cell vehicles from next year if car companies are able to market them," Prime Minister Junichiro Koizumi told a news conference to mark his first year in power. "This is going to have a huge impact on the world because they are useful in terms of our environmental and energy measures as well as improving our industrial competitiveness," Koizumi said.

- In the first quarter of 2002 Toyota passed the 100,000 mark in cumulative sales of hybrid vehicles, which combine conventional engines and electric power. The achievement means the Japanese manufacturer, which is the clear industry leader in hybrid sales, is well on the way to its target of annual production of 300,000 hybrid vehicles around 2005. In city driving conditions Toyota's Prius travels twice as far per liter of fuel as conventional cars of comparable size and performance, meaning it produces half the carbon dioxide emissions. As a SULEV (Super Ultra Low Emission Vehicle), it exceeds both California's stringent emission requirements and the Euro4 environmental standard. The Prius went on the market in Japan in late 1997, when it was the world's first mass-production hybrid. The model debuted in North America and Europe during 2000 and is now sold in more than 20 countries. Last year sales reached almost 30,000.

- Hybrid technology can be adapted to fuel cell vehicles, and Toyota started limited marketing of fuel cell hybrid (FCHV) sport utility vehicle (SUV) in Japan and the U.S. around the end 2002, much earlier than originally planned. Lowering cost and other issues remain, but the company believes that technology has been a solution, and will continue to be. Toyota has negotiated to lease about 20 vehicles in Japan and in California. Toyota President Fujio Cho said at a July 2, 2002 news conference that the company decided to advance the fuel cell vehicle launch by almost one year with the hope of "capturing the global standard position with our technology." Toyota wants to help fuel cell technology replace fossil fuel-burning engines as the power train standard for motor vehicles, he said. The auto giant stressed, however, that high costs meant its marketing efforts would be limited and it said only 20 vehicles would only be leased in the first 12 months to government bodies, research institutions and energy-related companies. Toyota said it had brought forward a plan to begin marketing a fuel cell vehicle from 2003 after successfully road testing its FCHV-4 prototype for a year in Japan and the United States. Toyota said the vehicles available from the end of the year would be offered only in Japan and the United States, in limited areas where the company had confirmed the availability of hydrogen supply and after-sales service.

- Japan's government has announced that it will work with automakers and energy firms in three-year projects to encourage the development of fuel cell technology for vehicles and households. "The aim of the projects is to see what problems arise when using fuel cells and developing an infrastructure, to ascertain whether in total - including such things as maintenance - they are actually good for the environment," a government official said.

  - In one project, automakers including Toyota Motor Corp, Honda Motor Co and Nissan Motor Co, as well as General Motors Corp and DaimlerChrysler AG, will participate in road tests. Each automaker will provide one fuel cell vehicle for the tests. Five hydrogen supply stations in different parts of Japan will be set up to test different ways of refilling the hydrogen and examine safety issues. The Japanese government is keen to encourage the development of fuel cell vehicles, having set a (probably unrealistic!) goal of 50,000 fuel cell cars on the road in Japan by 2010.

  - In another project, energy and fuel cell development firms such as Nippon Oil Corp and Sanyo Electric Co Ltd will work on assessing fuel cells designed to power homes and businesses.

  - The Ministry of Economy, Trade and Industry has set aside 2.5 billion yen ($21.50 million) in this fiscal year's budget for the projects.

- Among Japan's seven passenger car manufacturers, Honda Motor Co., Mitsubishi Motors Corp. (a unit of DaimlerChrysler Corp.), and Mazda Motor Corp. (a subsidiary of Ford Motor Co.) also are competing to introduce fuel cell vehicles. All manufacturers expect fuel cell vehicle sales to be years away, probably not until 2008-2010.[19] When sales reach a few thousand vehicles per month for each company, they can be sold at more competitive prices, automakers say.

- Honda Motor Co. is testing a fuel cell car in Japan and the United States. It has built a hydrogen fueling station that produces hydrogen from solar power in California. Honda, Japan's second-largest automaker, put its first fuel-cell vehicle on the market at the end of 2002, matching rival Toyota Motor Corp.

- Matsushita Electric Industrial Co. is testing a compact household-type fuel cell power generator with the hope of commercial launch in 2004. Other electrical/electronic makers, including Toshiba Corp. and Hitachi Ltd., also are developing fuel cell generators. Mitsubishi Heavy Industries Ltd. plans to commercially sell a household-type fuel cell unit in 2005 that uses natural gas as fuel; the price is expected to be about $5,000-$6,000. The maximum output of the unit is one kilowatt. The company estimates annual heating bill savings of about $500 on average Japanese household use of heating units.

- The Japanese government is supporting fuel cell vehicle development projects offering tax relief on research and development, equipment amortization, and the building of hydrogen supply stations in Tokyo, Osaka, and other large cities.

- The government also is preparing to begin Japan's first comprehensive fuel-cell testing on the island of Hokkaido. After initial preparations, METI, the Ministry of Land, Infrastructure and Transport, and the Ministry of Environment will commence operating experimental fuel cell air-conditioning units, called the FC HVAC systems, as well as road tests of fuel cell vehicles (which are expected to be leased from Toyota) in the Hokkaido capital of Sapporo. The three ministries

19. More recent statements indicate that significant sales of fuel cell vehicles are probably quite a bit further off than this, more like 2020 or even later.

are building a hydrogen filling station for the fuel cell cars. The three ministries chose Hokkaido, which is the coldest region in Japan, as their testing site because fuel cells generate far more heat than conventional fuels at time of use, and because of the easy availability of methane gas, the source for generating hydrogen. The three ministries plan to continue the experiment until 2005.

- Toyota Motor Corp plans to double the number of its eco-friendly hybrid models to six by the end of 2003 to cement its lead in the growing field of low emission vehicles, the Nihon Keizai Shimbun's said. Toyota, Japan's largest automaker, will release in the fall a hybrid gas-electric version of its 2-liter Crown sedan and will later add hybrid models of the Harrier sport-utility vehicle, along with its recently debuted Alphard minivan, the paper said. The hybrid version of the Harrier, a popular model known as Lexus RX300 in the United States, will be exported to U.S. dealers, the report said. Toyota, which last August debuted a 3-liter hybrid Crown, or Camry in the United States, will market the 2-liter hybrid Crown mainly to government and municipal offices that are increasingly replacing their cars with low-emission vehicles, the paper said. It also noted that Toyota would likely keep the price of the new hybrid Crown only 150,000 yen higher than the gasoline-powered model.

- Nissan Motor Co Ltd, Japan's third largest automaker, has announced that it plans to sell its first fuel cell car in 2003, speeding up its original plans for a launch in 2005. "We are advancing it by two years," Nissan Chief Executive Carlos Ghosn told a news conference. Nissan is working with partner Renault SA of France in fuel cells. Customers are likely to be government bodies, research institutions and energy companies.

- Japan's top automaker, Toyota, and third-largest Nissan have announced an agreement to cooperate on hybrid systems including the sharing of technology. The agreement to cooperate over at least 10 years calls for Toyota to supply state-of-the-art hybrid system components to Nissan, the two automakers said in a joint statement. As an initial project, Nissan will install a hybrid system being developed by Toyota in its vehicles to be sold in the United States in 2006.

- Japan's Ministry of Land, Infrastructure, and Transport has issued type certification for the fuel cell cars produced by Toyota and Honda. Toyota said four units of its FCHV model soon will be leased to the Cabinet Secretariat; the Ministry of Economy, Trade, and Industry; the Ministry of Land, Infrastructure, and Transport; and the Ministry of Environment. The lease cost is 1.2 million yen (about $8,215) per month, the company said. Honda said it would lease one unit of its FCX fuel cell car to the Cabinet Secretariat, with a lease cost of 800,000 yen (about $6,571) per month. The Toyota FCHV, which is powered by pure hydrogen, seats five passengers and features a cruising distance of 300 kilometers (187.5 miles) and top speed of 155 km/h. The Honda FCX, which seats four passengers and is powered by compressed hydrogen gas, has a driving range of 355 kilometers (about 222 miles) and a top speed of 150 km/h. Both automakers are preparing to sell the FC vehicles to more Japanese government offices and municipalities, as well as in California, officials of the two companies said.

HEVs are now at the forefront of transportation technology development and the Japanese have been at the forefront in bringing them to the market. Hybrids have the potential to allow continued growth in the automotive sector, while also reducing critical resource consumption, dependence on foreign oil and air pollution.

Hybrids' widespread penetration into the automotive market hinges mainly on the economics of producing a complex hybrid power system, rather than the inherent capabilities of the technology itself.[1] The hybrid's complexity, and the fact that some of the best storage and conversion systems have yet to be fully developed, are responsible for varied opinions on hybrids' ultimate impact in the marketplace. As with any new technology, there may be obstacles to its ready acceptance by consumers. To help with market acceptance, government incentives are in place to offset some of the HEV purchase costs.

Japanese automakers have taken early ownership of the hybrid-electric car market. Barring any major push by U.S. or European automakers over the next few years, projections show the Japanese holding that lead through 2010 by continually adding new products. But any significant growth will be contingent on the industry's ability to spread the technology into mainstream volume vehicles as quickly as possible. At the same time, the technology's costs must come down to enable automakers to eliminate a price penalty on the vehicles.

Hybrid sales to date have been relatively small, reflecting both a lack of product and the narrowness of the early buyer base - technical- and environment-motivated early adopters. Until this year, when Honda introduced the Civic Hybrid, would-be hybrid buyers could choose only between the spacey-looking, two-seat Honda Insight or the more mainstream Toyota Prius. Even so, the segment has grown dramatically.

In 1999, the first year for hybrid sales in North America, 17 were sold. All were Honda Insights, then the only hybrid available. Last year, Americans bought just over 20,000. This year, Toyota and Honda - still the only two makers with hybrid cars on the market - will sell more than 40,000. But by 2006, according to projections by J.D. Power, Americans will be buying upward of 500,000 a year from half a dozen companies. And by 2010 to 2012, the research firm says, annual U.S. sales will be at least twice that number.[2]

Barring any surprise announcements during the next couple of years, most of the vehicles and sales in the segment will be Japanese, Power says. He estimates that by the time the first domestic-brand hybrid debuts in mid-2004 - either a Ford Escape or General Motors full-sized pickup - Honda and Toyota will have as many as five on the market and the two companies will have sold a combined total of more than 150,000 hybrids here.

4. The US Approach

A. Emission Standards

20. [1] In a survey of 5,200 new-car buyers, the research firm J.D. Power and Associates found that 60 percent would "definitely" or "strongly" consider buying a hybrid. And eight out of 10 respondents said they were aware of gasoline-electric hybrids, double the awareness in 1999.
21. [2] "Japanese rule the hybrid world", By Joe Kohn, **Automotive News** / December 23, 2002

i. National

On December 16, 1997, EPA finalized the regulations for the National Low Emission Vehicle (National LEV) program. Starting in the northeastern states in model year 1999 and nationally in model year 2001, new cars and light light-duty trucks met tailpipe standards that are more stringent than EPA could have mandated prior to model year 2004.

NLEV Exhaust Emission Standards (g/mi) For LDV's and LLDTs (50,000 miles)				
Vehicle Type	Model Year	Fleet Average NMOG	NOX	CO
LDV and LDT (0-3750 LVW)	1999*	0.148	0.2	3.4
	2000*	0.095	0.2	3.4
	2001 and later**	0.075	0.2	3.4
LDT (3751-5750 LVW)	1999*	0.190	0.4	4.4
	2000*	0.124	0.4	4.4
	2001 and later**	0.100	0.4	4.4

* 9 Northeastern States and DC, except New York and Massachusetts
** All states except California, New York, Massachusetts, Vermont and Maine, which have the California standards.

On December 21, 1999, the US EPA issued the final Tier 2/low sulfur gasoline regulation that will substantially tighten standards for new light duty vehicles and reduce the sulfur content of gasoline.

a) Tier 2 Vehicle Requirements

The Tier 2 standards will reduce new vehicle NOx levels to an average of 0.07 grams per mile (g/mi). For new passenger cars and light LDTs, these standards will phase in beginning in 2004, with the standards to be fully phased in by 2007.[20] For heavy LDTs

[20/] By comparison, the NOx standards for the National Low Emission Vehicle (NLEV) program, which will be in place nationally in 2001, range from 0.30 g/mi for passenger cars to 0.50 g/mi for medium-sized light trucks (larger light trucks are not covered). For further comparison, the standards met by today's Tier 1 vehicles range from 0.60 g/mi to 1.53 g/mi.

and MDPVs, the Tier 2 standards will be phased in beginning in 2008, with full compliance in 2009.

During the phase-in period from 2004-2007, all passenger cars and light LDTs not certified to the primary Tier 2 standards will have to meet an interim average standard of 0.30 g/mi NOx, equivalent to the current NLEV standards for LDVs and more stringent than NLEV for LDT2s (e.g., minivans).[21] During the period 2004-2008, heavy LDTs and MDPVs not certified to the final Tier 2 standards will phase in to an interim program with an average standard of 0.20 g/mi NOx, with those not covered by the phase-in meeting a per-vehicle standard (i.e., an emissions "cap") of 0.60 g/mi NOx (for HLDTs) and 0.09 g/mi NOx (for MDPVs).

The program will ultimately require each manufacturer's average full life NOx emissions over all of its Tier 2 vehicles to meet a NOx standard of 0.07 g/mi each model year. Manufacturers will have the flexibility to certify Tier 2 vehicles to different sets of exhaust standards that are referred to as "bins," but will have to choose the bins so that their corporate sales weighted average full life NOx level for their Tier 2 vehicles is no more than the 0.07 g/mi. The manufacturer will be in compliance with the standard if its corporate average NOx emissions for its Tier 2 vehicles meets or falls below 0.07 g/mi. In years when a manufacturer's corporate average is below 0.07 g/mi, it can generate credits. It can trade (sell) those credits to other manufacturers or use them in years when its average exceeds the standard (i.e. when the manufacturer runs a deficit).

The final Tier 2 bin structure has eight emission standards bins (bins 1-8), each one a set of standards to which manufacturers can certify their vehicles. Table 3 shows the full useful life standards that will apply for each bin in the final Tier 2 program, i.e. after full phase-in occurs for all LDVs and LDTs. Two additional bins, bins 9 and 10, will be available only during the interim program and will be deleted before final phase-in of the Tier 2 program. An eleventh bin is available but only for MDPVs (see below). Many bins have the same values as bins in the California LEV II program as a means to increase the economic efficiency of the transition to as well as model availability. The two highest of the ten bins shown in Table 3 are designed to provide flexibility only during the phase-in years and will terminate after the standards are fully phased in, leaving eight bins in place for the duration of the Tier 2 program.

Tier 3 Light-Duty Full Useful Life Exhaust Emission Standards
(Grams per mile)

Bin#	NOx	NMOG	CO	HCHO	PM	Comments
10	0.6	0.156/0.230	4.2/6.4	0.018/0.027	0.08	a,b,c,d
9	0.3	0.090/0.180	4.2	0.018	0.06	a,b,e
The above temporary bins expire in 2006 (for LDVs and LLDTs) and 2008 (for HLDTs)						

21/ There are also NMOG standards associated with both the interim and Tier 2 standards. The NMOG standards vary depending on which of various individual sets of emission standards manufacturers choose to use in complying with the average NOx standard. This "bin" approach is described more fully in section IV.B. of this preamble.

8	0.20	0.125/0.156	4.2	0.018	0.02	b,f
7	0.15	0.090	4.2	0.018	0.02	
6	0.10	0.090	4.2	0.018	0.01	
5	0.07	0.090	4.2	0.018	0.01	
4	0.04	0.070	2.1	0.011	0.01	
3	0.03	0.055	2.1	0.011	0.01	
2	0.02	0.010	2.1	0.004	0.01	
1	0.00	0.000	0.0	0.000	0.00	

NOTES
a. Bin deleted at end of 2006 model year (2008 for HLDTs).
b. The higher of the two temporary NMOG, CO and HCHO values apply only to HLDTs.
c. An additional higher temporary bin restricted to MDPVs is discussed below.
d. Optional temporary NMOG standard of 0.280 g/mi applies for qualifying LDT4s and MDPVs only.
e. Optional temporary NMOG standard of 0.130 g/mi applies for qualifying LDT2s only.
f. Higher temporary NMOG value of 0.156g/mi deleted at end of 2008 model year.

Light-Duty Intermediate Useful Life (50,000 mile) Exhaust Emission Standards (grams per mile)

Bin Number	NOx	NMOG	CO	HCHO	PM	Comments
10	0.4	0.125/0.160	3.4/4.4	0.015/0.018	--	a,b,c,d,f,h
9	0.2	0.075/0.140	3.4	0.015	--	a,b,e,h
The above temporary bins expire in 2006 (for LDVs and LLDTs) and 2008 (for HLDTs)						
8	0.14	0.100/0.125	3.4	0.015	--	b,g,h
7	0.11	0.075	3.4	0.015	--	h
6	0.08	0.075	3.4	0.015	--	h
5	0.05	0.075	3.4	0.015	--	h

NOTES
a. Bin deleted at end of 2006 model year (2008 for HLDTs).
b. The higher temporary NMOG, CO and HCHO values apply only to HLDTs and expire in 2008.
c. An additional higher temporary bin restricted to MDPVs is available.
d. Optional temporary NMOG standard of 0.195 g/mi applies for qualifying LDT4s and MDPVs only.
e. Optional temporary NMOG standard of 0.100 g/mi applies for qualifying LDT2s only.
f. Intermediate life standards are optional for diesels certified to bin 10.
g. Higher temporary NMOG value deleted at end of 2008 model year.
h. Intermediate life standards are optional for any test group certified to a 150,000 mile useful life (if credits are not claimed).

Any combination of vehicles meeting the 0.07 g/mi average NOx standard will have average NMOG levels below 0.09 g/mi. The actual value will vary by manufacturer depending on the sales mix of the vehicles used to meet the 0.07 g/mi average NOx standard. In addition, there will be overall improvements in NMOG since Tier 2 incorporates HLDTs, which are not covered by the NLEV program. Tier 2 also imposes tighter standards on LDT2s than the NLEV program by making them average with the LDVs and LDT1s. NLEV has separate, higher standards for LDT2s.

Table 4 provides a graphical representation of how the phase-in of the Tier 2 program will work for all vehicles.

Table 4
TIER 2 AND INTERIM NON-TIER 2 PHASE-IN AND EXHAUST AVERAGING SETS
(Bold lines around shaded areas indicate averaging sets)

	2001	2002	2003	2004 %	2005 %	2006 %	2007 %	2008 %	2009+ later %	NOx STD. (g/mi)
LDV/LLDT (INTERIM)	NLEV	NLEV	NLEV	75 max	50 max	25 max				0.30 avg
LDV/LLDT (TIER 2 +evap)	early banking [b]	[b]	[b]	25	50	75	100	100	100	0.07 avg
HLDT (TIER 2 +evap)	early banking [b] [b]	[b]	[b]	[b]	[b]	[b]		50	100	0.07[d] avg
HLDT (INTERIM)	TIER 1 [b]	TIER 1 [b]	TIER 1 [b]	25 c,e	50 e	75 e	100 e	50 max		0.20[a], [d] avg
MDPVs (INTERIM)	HDE	HDE	HDE							
MDPVs (TIER 2 + evap)	early banking [b] [b]	[b]	[b]	[b]	[b]	[b]		50	100	0.07[d] avg

NOTES

a. 0.60 NOx cap applies to balance of LDT3s/LDT4s, respectively, during the 2004-2006 phase-in years

b. Alternative phase-in provisions permit manufacturers to deviate from the 25/50/75% 2004-2006 and 50% 2008 phase-in requirements and provide credit for phasing in some vehicles during one or more of these model years..

c. Required only for manufacturers electing to use optional NMOG values for LDT2s or LDT4s and MDPV flexibilities during the applicable interim program and for vehicles whose model year commences on or after the fourth anniversary date of the signature of this rule.

d. MDPVs HLDTs and MDPVs must be averaged together.

e. Diesels may be engine-certified through the 2007 model year.

b) Sulfur Provisions

The program requires that most refiners and importers meet a corporate average gasoline sulfur standard of 120 ppm and a cap of 300 ppm beginning in 2004. By 2006, the cap will be reduced to 80 ppm and most refineries must produce gasoline averaging no more than 30 ppm sulfur. The program includes provisions for trading of sulfur credits.

Table 5 summarizes the standards for gasoline refiners and importers. There are three standards which refiners and importers must meet. In 2004 and beyond, every gallon of gasoline produced is limited by a per-gallon maximum or "cap." The cap standard becomes effective January 1, 2004 (and January 1 of subsequent years as the cap standard changes). Also, in 2004 and 2005, each refiner must meet an annual-average standard for its entire corporate gasoline pool. Finally, each individual refinery is subject to a refinery average standard, beginning in 2005. Refineries that do not take advantage of the sulfur ABT program will have actual sulfur levels averaging 30 ppm beginning in 2005.

Table 5
Gasoline Sulfur Standards for Refiners, Importers, and Individual Refineries
(Excluding Small Refiners and GPA Gasoline)

Compliance as of:	2004[a]	2005	2006+
Refinery Average, ppm[b]	--	30	30
Corporate Pool Average, ppm[c]	120	90	--
Per-Gallon Cap[d], ppm	300	300	80

NOTES
[a.] EPA projects that the pool averages will actually be below 120 ppm in 2004. For a discussion of how the program gets early sulfur reductions before 2004.
[b.] The refinery average standard can be met through the use of sulfur credits or allotments from the sulfur ABT program, as long as the applicable corporate pool average and per-gallon caps are not exceeded.
[c.] The corporate pool average standard can be met through the use of corporate allotments obtained from other refiners, if necessary.
[d.] In 2004, exceedences up to 50 ppm beyond the 300 ppm cap are allowed. However, in 2005, the cap for all batches will be reduced by the magnitude of the exceedence.

ii. California "LEV2" Standards

On November 5th, 1998 CARB adopted a plan to require passenger cars and certain sport utility vehicles (SUVs), minivans and large pickup trucks to meet tighter emission standards beginning in 2004.

These amendments include the following primary elements:

< Restructuring vehicle weight classifications so that all current light-duty trucks, and all current medium-duty vehicles having a gross vehicle weight (GVW) of less than 8,500 lbs., would generally be subject to the same LEV and ULEV standards as passenger cars; only the very heaviest SUVs and pick-up trucks would remain subject to separate medium-duty vehicle standards;

< New more stringent "LEV II" exhaust emission standards for the current LEV, ULEV and SULEV categories, which would be phased in from the 2004 to 2007 model years; the changes include reducing the NOx standard for passenger cars and light-duty trucks certified to the LEV and ULEV standards to 0.05 g/mi from the current 0.2 g/mi level, equivalent NOx reductions for medium-duty vehicles, more stringent particulate emission standards for diesel vehicles, increasing the useful life for passenger cars and light-duty trucks from the current 100,000 miles to 120,000 miles, a new light-duty SULEV category would be created with an NMOG standard less than one-fourth of the level for ULEVs, and a manufacturer option of certifying any LEV, ULEV or SULEV to a

150,000 mile certification standard, resulting in greater NMOG credits as long as the manufacturer provides an 8-year/100,000-mile warranty for high-cost parts rather than for the normal 7-years/70,000 miles;

< Continuing yearly reductions in the fleet average NMOG requirements from model years 2004 through 2010, when the fleet average NMOG requirement for passenger cars would be 0.035 g/mi; there would be a separate phase-in schedule for the heavier light-duty trucks in the new LDT2 class, and for medium-duty vehicles the requirement of a 60/40 mix of LEVs and ULEVs in 2004 and subsequent model years would be changed to 40/60;

< A new "partial ZEV allowance" mechanism under which advanced technology vehicles could provide partial credits towards satisfying a manufacturer's ZEV requirement; in order to receive any ZEV allowance, a vehicle would have to qualify for the "baseline ZEV allowance" of 0.2 by meeting the SULEV standard at 150,000 miles, satisfying applicable second generation on-board diagnostics requirements (OBD II), having "zero" evaporative emissions, and carrying an emission warranty covering all malfunctions identified by the OBD II system for 15 years or 150,000 miles; an additional allowance would be provided based on the potential for realizing zero-emission VMT (e.g., capable of some all-electric operation traceable to energy from off-vehicle charging), up to a maximum of 0.6; and a vehicle that uses fuel with very low fuel-cycle emissions could receive a ZEV allowance of up to 0.2; a large volume manufacturer would have to meet at least 40% of its ZEV requirement with true ZEVs or vehicles with a 1.0 ZEV allowance;

< More stringent evaporative emission standards for the 3-day diurnal-plus-hot-soak test and the 2-day diurnal-plus-hot-soak test, applicable to both fuel and non-fuel vehicle emissions and for a useful-life of 15 years or 150,000 miles, whichever first occurs; certification to the new standards would be required for 40% of a manufacturer's vehicles in the 2004 model year, 80% in the 2005 model year, and 100% in the 2006 model year, with an optional alternative phase-in mechanism; and

< "CAP 2000" amendments which would significantly reduce the emission testing and reporting requirements for new vehicle certification, and substitute new requirements that manufacturers conduct more extensive compliance tests of in-use vehicles that have accumulated substantial mileage;

An element of the approved amendments allows a manufacturer to certify up to 4% of its truck sales in the LDT2 category to a marginally higher NOx emission standard (0.07 for 50,000 miles and 0.10 for 120,000 and 150,000 miles); this will satisfy a manufacturer's need to engineer some of its heavier trucks for more rigorous duty.

The projected costs to comply with the amendments are expected to range from about $100 to $200 per vehicle, with an-average of about $107; the estimated cost-effectiveness ranges from $0.50 to $1.39 per pound of ROG + NOx reduced (about $1 per pound overall), which compares very favorably to the typical cost-effectiveness values for current air pollution control measures.

Effective with the 2004 model year, the following standards apply.

Vehicle Type	Mileage for Compliance	Vehicle Emission Category	NMOG (g/mi)	Carbon Monoxide (g/mi)	Oxides of Nitrogen (g/mi)	Formaldehyde (mg/mi)	Diesel Particulate (g/mi)
All PCs; LDTs<8,500 lbs. GVW	50000	LEV	0.075	3.4	0.05	15	n/a
		LEV[1]	0.075	3.4	0.07	15	n/a
		ULEV	0.04	1.7	0.05	8	n/a
	120000	LEV	0.09	4.2	0.07	18	0.01
		LEV[1]	0.09	4.2	0.1	18	0.01
		ULEV	0.055	2.1	0.07	11	0.01
		SULEV	0.01	1	0.02	4	0.01
	150000	LEV	0.09	4.2	0.07	18	0.01
		LEV[1]	0.09	4.2	0.1	18	0.01
		ULEV	0.055	2.1	0.07	11	0.01
		SULEV	0.01	1	0.02	4	0.01
MDVs 8,500-10,000 lbs. GVWR	120000	LEV	0.195	6.4	0.2	32	0.12
		ULEV	0.143	6.4	0.2	16	0.06
		SULEV	0.1	3.2	0.1	8	0.06
MDVs 10,001-14,000 lbs. GVWR	120000	LEV	0.23	7.3	0.4	40	0.12
		ULEV	0.167	7.3	0.4	21	0.06
		SULEV	0.117	3.7	0.2	10	0.06

(1) This optional LEV standard applies to up to 4% of a manufacturers LDT2 fleet with a maximum base payload in excess of 2500 lbs.

After the 2003 model year, Tier 1 standards (0.25 grams per mile NMHC) and TLEV standards would be eliminated as available emissions categories. The 50^{o}F multiplier for SULEVs would be 2.0 and the cold temperature carbon monoxide standard would be 10.0.

With regard to fuel economy, perhaps the most significant aspect of the California program is the more limited number of bins and the maximum allowable level of emissions versus those of the national program. At 120,000 miles, PM levels can be no higher than 0.01 grams/mile and NOx at 0.07, compared to national bin 8 levels which could be as high as 0.02 and 0.20, respectively.

B. Fuels Pricing

As noted earlier, fuel taxes in the US are much lower than in Europe and Japan and this is not likely to change significantly any time soon.

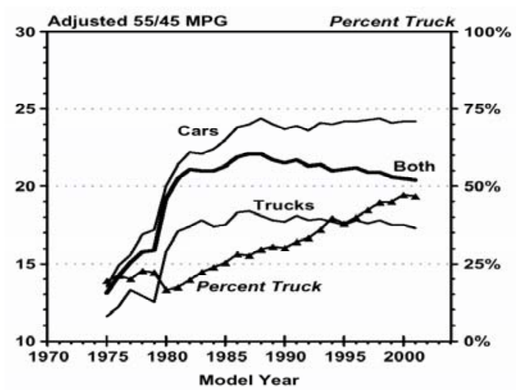
C. Fuel Efficiency and Greenhouse Gas Reduction Programs

i. National

The U.S. has no GHG reduction policy for vehicles and is the only industrialized country opposed to ratification of the Kyoto protocol[22]. Although it was once a world leader in fuel economy policy, establishing ambitious fuel economy standards in the wake of the 1973-‘74 world oil crisis, the U.S. has failed to take meaningful action on fuel economy for nearly two decades.

U.S. fuel economy policy is embodied in the Corporate Average Fuel Economy (CAFE) standards, which were enacted in the Energy Policy and Conservation Act of 1975. These standards currently require new model year cars to meet an average fuel economy standard of 27.5 miles per U.S. gallon (mpg) and new light trucks (including SUVs and minivans) to meet a 20.7 mpg average standard (8.6 liters/100 km and 11.4 litres/100 km, respectively) as measured by U.S. EPA test procedures. CAFE was tremendously effective, nearly doubling new passenger car fuel economy between 1975 and 1988, and increasing the fuel economy of new light trucks by 50 percent (Figure 5).

Figure 7: CAFE and Fuel Economy



But the CAFE standards are out-of-date. They have not kept up with technology development or with the rapid rise in sales of SUVs, minivans, and pick ups—vehicles that meet the less stringent 20.7 mpg CAFE standard that was established when light trucks constituted fewer than 20 percent of new sales and were used primarily as work vehicles. According to the U.S. EPA, technology improvements could have increased fuel economy by 20 percent between 1988 and 2001; instead, fuel economy declined while average horsepower increased 53 percent. Average fuel economy for new U.S. vehicles is now about 8 percent below the peak fuel economies achieved in model years 1987 and 1988, according to the U.S. Environmental Protection Agency (U.S. EPA), lower than it has been at any time since 1980.

The U.S. Congress debated CAFE standards as part of omnibus energy legislation in 2002; attempts to raise the standards failed in the face of heavy opposition from automakers and the autoworkers union. In April 2003, the Bush Administration raised the future CAFE standard for light trucks slightly, requiring only a 1.5 mpg increase over three years, to bring the fleet-average standard for light trucks to 22.2 mpg by 2007. Standards for cars were left unchanged.

a) The PNGV Program

Starting in the late 1980's, the US Congress restricted the ability of the National Highway Traffic Safety Administration to adopt tighter CAFE requirements and the program was effectively frozen in place. As a substitute, the Big Three automakers and the US government had been sharing high-tech information and manufacturing know-how since 1993 in an effort to develop low fuel consumption technologies. The program was called

22. Two other industrialized countries have not yet ratified the protocol—Russia is expected to ratify soon, and Australia has made their ratification contingent on U.S. ratification.

the Partnership for a New Generation of Vehicles (PNGV) and matches engineers from the auto industry with government researchers from national laboratories.

The goal was to create technology that would lead to a working model of a clean and efficient car by the year 2004 -- a car capable of getting 80 miles to the gallon while meeting Tier 2 emissions levels or better.

When this partnership was announced by President Clinton and the CEOs of Chrysler, Ford, and General Motors in September 1993, the participants recognized that the development of a new generation of vehicles with up to three times the fuel efficiency of conventional cars was a challenge requiring a national initiative. To improve the probability of achieving needed technology breakthroughs, a large number of promising technologies were initially identified for simultaneous research and development. A major milestone was to narrow the technology development efforts by the end of 1997 and to focus resources on the most promising approaches.

In January 1998, the PNGV completed its selection of technologies considered to be the most promising for achieving the goals of the Partnership, and was to focus its research and technology development efforts in four key system areas:

- hybrid-electric vehicle drive,
- direct-injection engines,
- fuel cells, and
- lightweight materials.

PNGV's long-term goal was the development of technologies for new- generation, mid-size family sedans that get up to 80 mpg; carry up to six passengers and 200 pounds of luggage; meet or exceed safety and emissions requirements; provide ample acceleration; are at least 80 percent recyclable; and provide range, comfort, and utility similar to today's models.

The Partnership expected American consumers will buy these vehicles only if they cost no more to own and operate than today's models. Because US gasoline prices are among the lowest in the world, few consumers are willing to pay more for advanced technologies even if they provide greatly increased fuel economy.

b) Freedom Car

In January 2002, the Bush Administration announced that it was abandoning the PNGV program and replacing it with a push for fuel cell technology. No performance targets have been announced.

ii. California

In view of this leadership failure at the national level, eyes turned to the states in the hopes of initiating greenhouse gas controls at this level. On July 22, 2002, California Governor Davis signed AB 1493—landmark legislation to combat climate change. This bill requires the California Air Resources Board (ARB) to develop and adopt regulations that reduce greenhouse gases emitted by passenger vehicles and light duty trucks.

Transportation is California's largest source of carbon dioxide, with passenger vehicles and light duty trucks creating more than 30 percent of total climate change emissions.

Under the new law, the California Air Resources Board is required to adopt regulations that achieve the maximum feasible and cost-effective reduction of greenhouse gas emissions from motor vehicles. The regulations must be adopted by January 1, 2005, and may not take effect prior to January 1, 2006. They will apply to 2009 and later model year vehicles.

In developing regulations, the ARB will carefully consider technical feasibility and the impact of the proposal on the economy of the state. The Board will provide flexibility to the maximum extent feasible as to how auto manufacturers may comply with the regulations.

Californians will continue to be able to purchase and drive their vehicle of choice. The bill clearly prohibits:

- New fees or taxes on vehicles, fuel or miles traveled.
- A ban on the sale of any vehicle category.
- A required reduction in vehicle weight.
- A limitation or reduction in the speed limit.
- A limitation or reduction in vehicle miles traveled.

The regulation will follow the ARB's standard regulatory development process. Several other states have indicated their intention to adopt California greenhouse gas standards, once they are in place.

5. Other Fuel Economy Efforts

A. Taiwan

The Regulation on Fuel Economy Standard and Inspection and Administration of Vehicles for Taiwan was published on: Dec. 28 2001. It was formulated in accordance with Article 15 of the Energy Management Law.

Any passenger car (including sedans and station wagons) that consumes gasoline (or diesel),[23] manufactured or imported by the entity shall comply with the following standards governing fuel economy of vehicles:

Engine Displacement (cubic centimeters)	Fuel Economy Standard (Kilometer/liter)
Below 1200	15.4
Over 1200 to 1800	11.6
Over 1800 to 2400	10.5
Over 2400 to 3000	9.4
Over 3000 to 3600	8.5
Over 3600 to 4200	7.8

23. Taiwan has traditionally banned the sale of diesel cars. However, as part of the negotiations for joining the WTO, the EU pressured Taiwan to agree to sell diesel cars as a condition of receiving EU support.

Over 4200	7.2

Any vehicle, which has met the Fuel Economy Standard specified in the following Article of this regulation and been issued a certificate of conformity by the Administration Authority **before** June 30, 2004 shall be sold until June 30, 2005 and not restricted by the foregoing Article. For example, a vehicle weighing 1100 kgs which has already received a C of C before June 2004 and goes less than 12 km/L, doesn't have to meet the more restrictive standard of 15.4 km/L until those that are are produced after June 30, 2005.

Reference Weight (kilogram)	Fuel Economy Standard (Kilometer/liter)
Below 1046	14.7
Over 1046 to 1276	12.0
Over 1276 to 1496	10.1
Over 1496 to 1726	8.7
Over 1726 to 1956	7.7
Over 1956 to 2176	6.9
Over 2176	5.3

Any motorcycles manufactured or imported by the entity shall comply with the following Fuel Economy Standard:

Engine Displacement (cubic centimeters)	Fuel Economy Standard (Kilometer/liter)
Below 50	50.0
Over 50 to 100	42.0
Over 100 to 150	39.0
Over 150 to 400	29.2
Over 400 to 650	19.7
Over 650 to 1000	17.0
Over 1000	15.8

Any vehicle, which has met the Fuel Economy Standard specified in the following Article of this regulation and been issued a certificate of conformity by the Administration Authority before December 31, 2003 shall be sold until December 31, 2004 and not restricted by the foregoing Article.

Engine Displacement (cubic centimeters)	Fuel Economy Standard (Kilometer/liter)
Below 50	43.0
Over 50 to 100	37.0
Over 100 to 150	36.0
Over 150 to 400	25.3
Over 400 to 650	18.2
Over 650 to 1000	15.9
Over 1000	14.4

After July 1, 2004, any light truck (having a total weight of less than 2,500 kilograms), commercial vehicle, and passenger car (not sedans or station wagons) with gasoline (or diesel) engine, manufactured or imported by the entity shall comply with the following standards governing fuel economy of vehicles:

Engine Displacement (cubic centimeters)	Fuel Economy Standard (Kilometer/liter)
Below 1200	10.6
Over 1200 to 1800	8.7
Over 1800 to 2400	8.1
Over 2400 to 3000	7.1
Over 3000 to 3600	6.4
Over 3600 to 4200	5.9
Over 4200	5.4

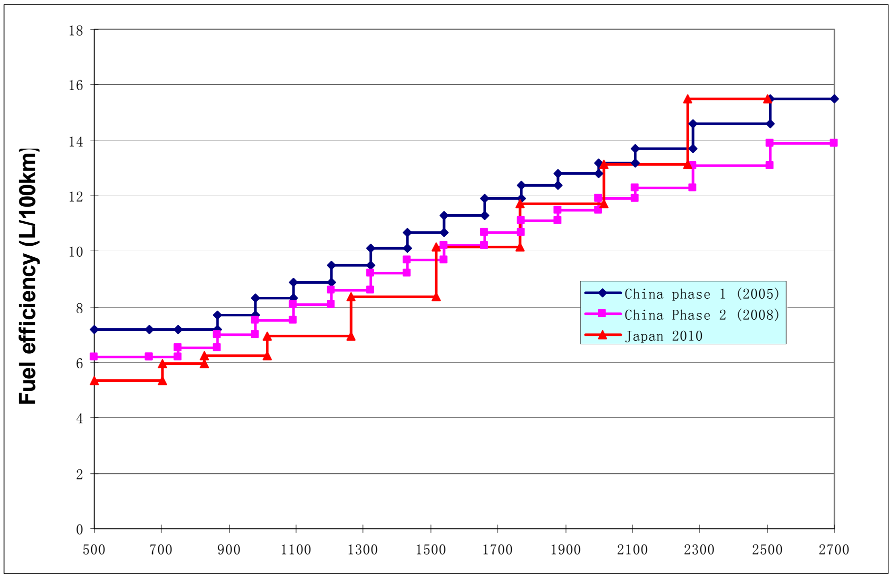
Passenger car, van, and light duty truck shall be tested in accordance with the FTP 75 test cycle of the United States; motorcycles shall be tested in accordance with the National Standard CNS 3105 of the Republic of China.

B. China

Under the sponsorship of the Energy Foundation, China has been developing a fuel economy program. After almost two years of effort, a draft proposal has been developed. A basic description of the proposed program is as follows:

- It will have two phases, with the first effective in July 2005 and the second in July 2008
- It will be weight based with 16 weight classes
- The standards are considered to be fairly lenient at the lower weights but very stringent at higher weights
- As illustrated below, the technical level required for middle weight vehicles (from 1000kg-1700kg) in the second phase (2008) is similar to the current level (2002) of developed countries, and the technical level required for high-weight vehicles (heavier than 1700kg) in the second phase is more stringent than that required by Japan in 2010.

According to the current proposed standard, about 50% of current Chinese vehicle models can not pass the first phase standard, and about 82% can not pass the second phase standard at the present time.

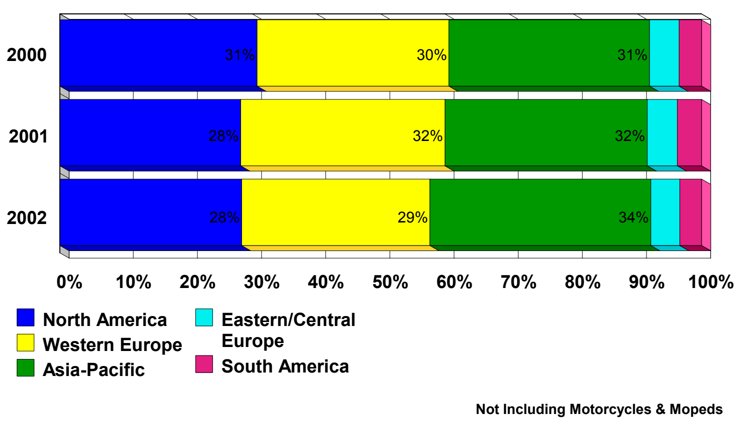


The first phase fuel efficiency standard is estimated to improve fuel efficiency by about 5-10% and the second phase by about 15-20% by 2008.

In response to pressure from auto industry, CATARC gave a 6% concession to automatic transmissions, vans and SUVs (4x4); that means the fuel efficiency standard limits are 6% higher than those for cars (for example, in a certain weight class, the standard for a car is 10.7 l/100km, whereas for those vehicles is 11.3 l/100km).

6. Globalization – What Does It Mean To The Car Industry

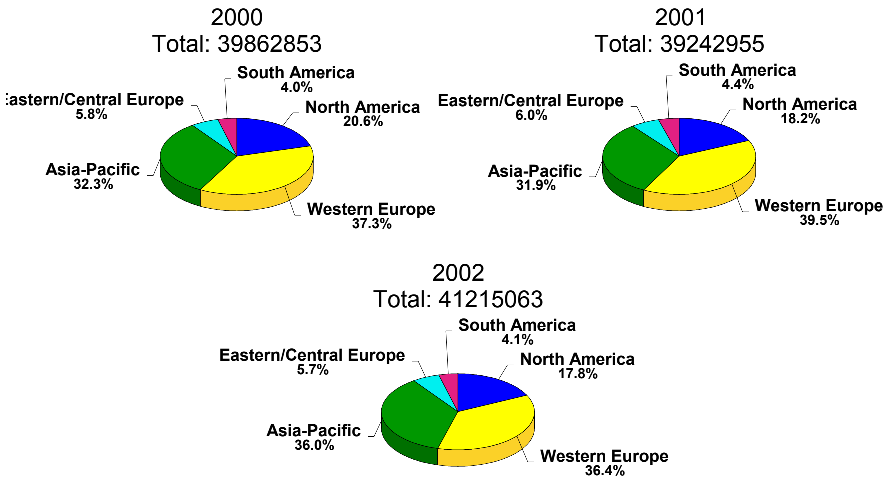
Figure 8: World Vehicle Production By Region



Overall growth in the production of motor vehicles, especially since the end of World War II, has been quite dramatic, rising from about 5 million motor vehicles per year to almost 60 million. Between 1950 and now, approximately 1 million additional vehicles has been produced each year compared to the year before.

Over the past several decades, motor vehicle production has gradually expanded from one region of the world to another. Initially and through the 1950's, it was dominated by North America. The first wave of competition came from Europe, and by the late 1960s European production had surpassed that of the United States. Over the past two decades the car industry in Asia, led by Japan, has grown rapidly and now rivals both those in the United States and Europe. In fact, as illustrated in Figure 8, Asia has now

World Car Production By Region

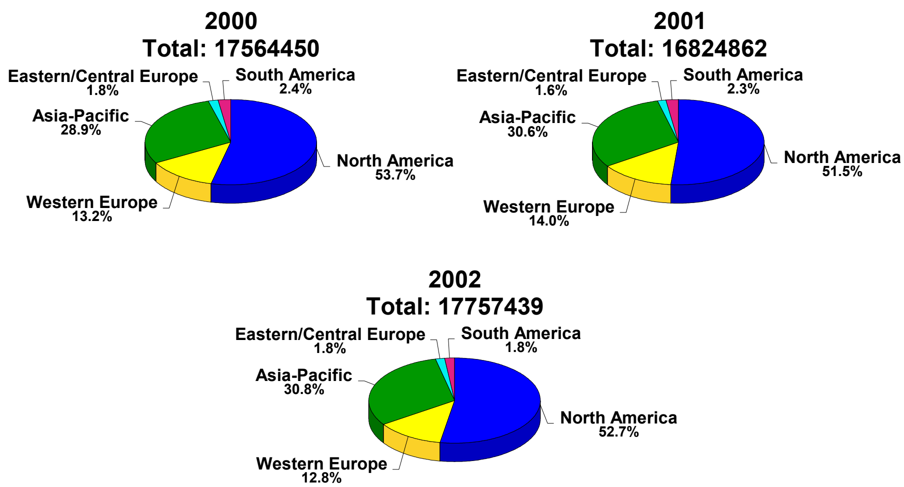


Asia Pacific Region Largest Producer of Cars

surpassed both North America and Europe, and is now the largest vehicle producing area in the world.

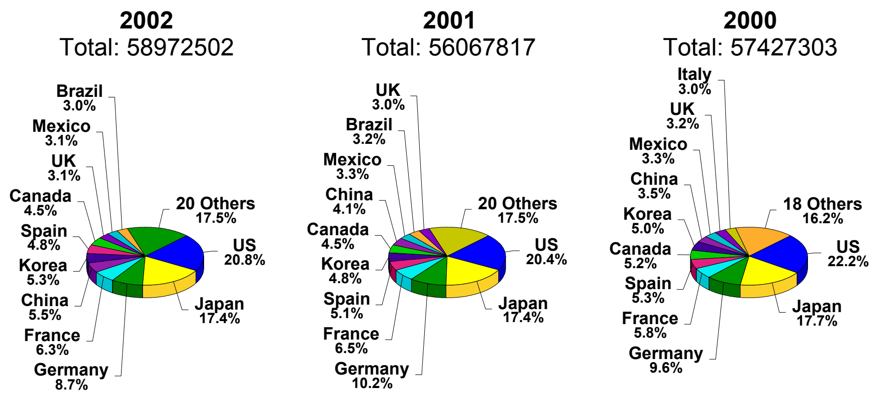
This is especially true for cars, with Asia now producing 36% of the global total, twice as many as in North America. With regard to trucks, however, North America retains its global dominance, producing more than half the global output; most of these trucks are SUVs.

World Truck Production By Region



North America Largest Producer of Trucks (SUVs)

Vehicle Production By Country



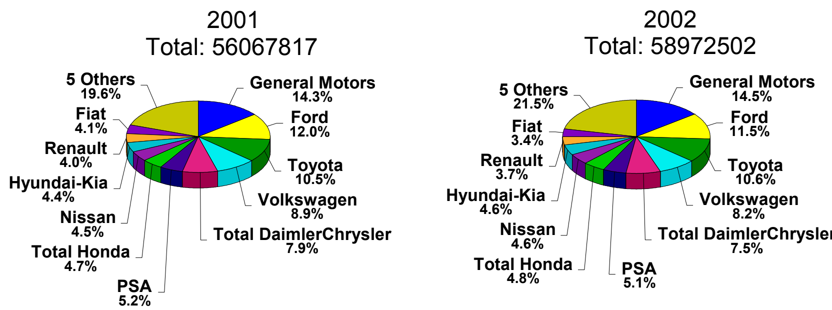
China is Now #5 Worldwide

Not Including Motorcycles, Mopeds

Looking to individual countries, it is clear that China is the fastest growing in the world. In the past three years alone, China has climbed from the 9th largest producer to the 5th and in spite of the SARS epidemic earlier this year is on a record pace to break last years sales records by a substantial amount. VW recently noted, for example, that they now produce more cars in China than they do in Germany.

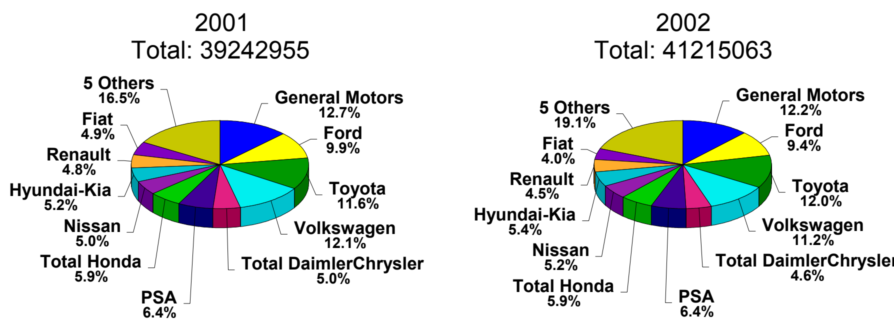
GM and Ford remain the largest global motor vehicle producers but this is primarily because of their dominance in the light truck and SUV markets. Toyota and VW actually produce more cars than Ford and are gaining on GM.

World Vehicle Production By Manufacturer



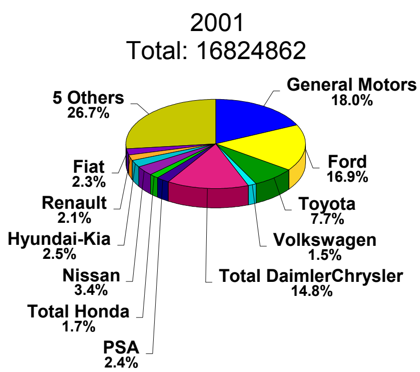
GM, Ford Remain Largest Producers of Vehicles

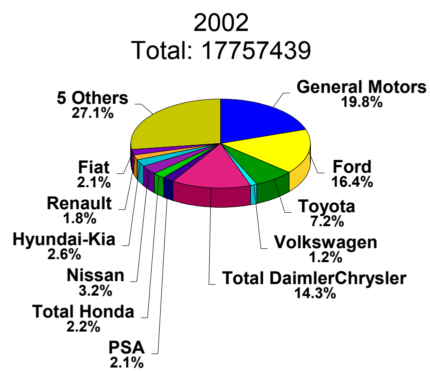
World Car Production By Manufacturer



Toyota, VW Produce More Cars Than Ford

World Truck Production By Manufacturer

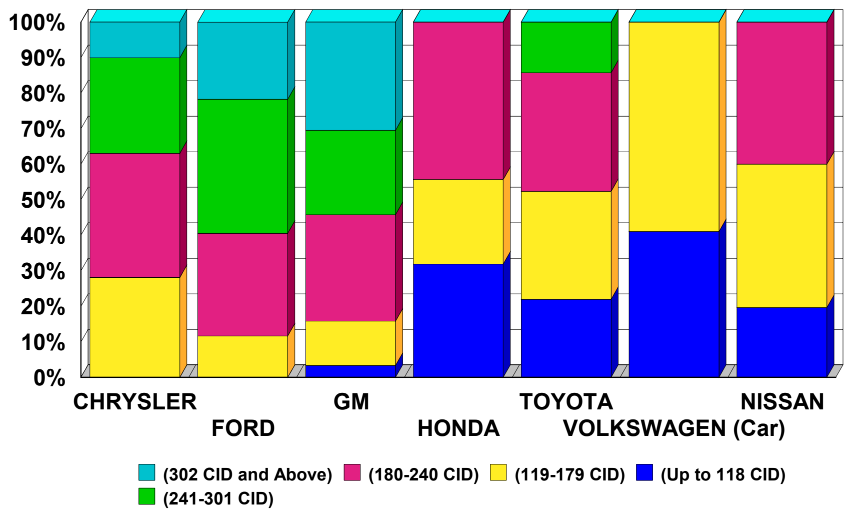




GM, Ford Most Dominant in Trucks (SUVs)

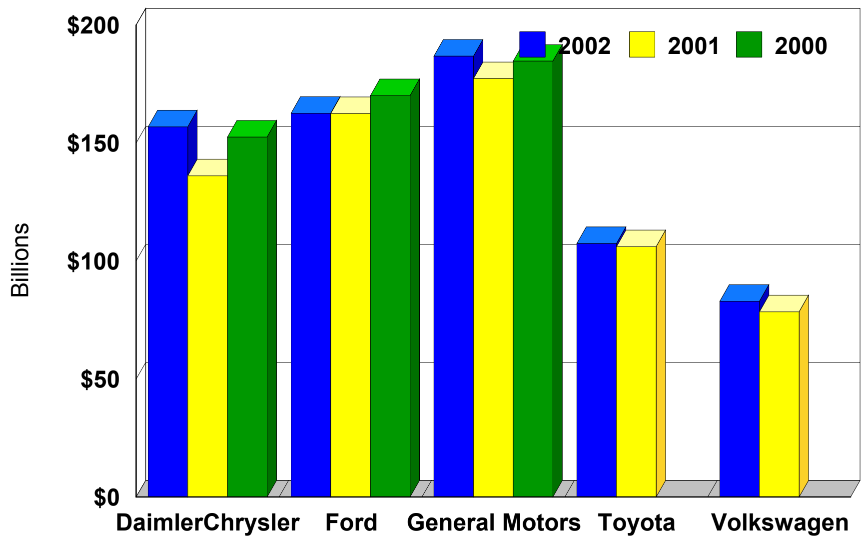
Considering only production in the US, it is clear that Ford, GM and Chrysler produce mainly large vehicles with large and powerful engines whereas Honda, Toyota, VW and Nissan produce mainly smaller vehicles with smaller engines.

Domestic Light Vehicle Production By Engine Displacement



Ford, GM and Chrysler Produce Mainly Large Vehicles Whereas Honda, Toyota, VW & Nissan Produce Mainly Small

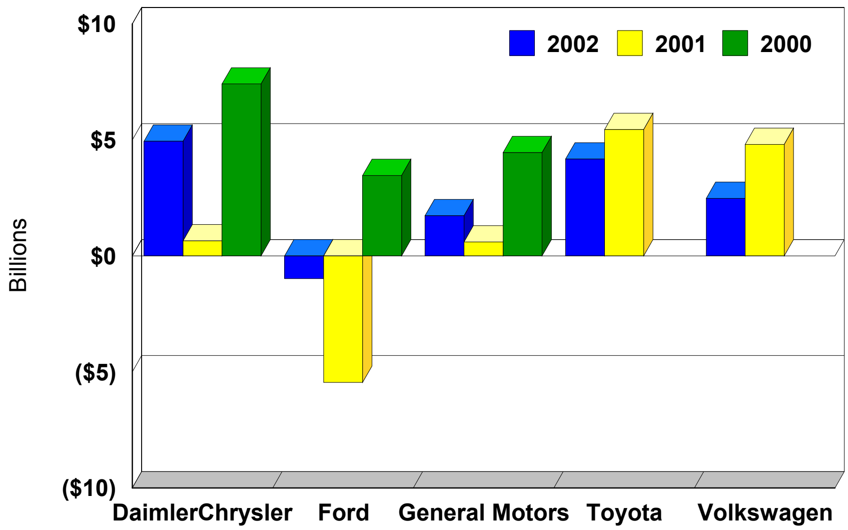
Net Sales By Manufacturer



Sales Revenue Dominated by GM, Ford and DaimlerChrysler

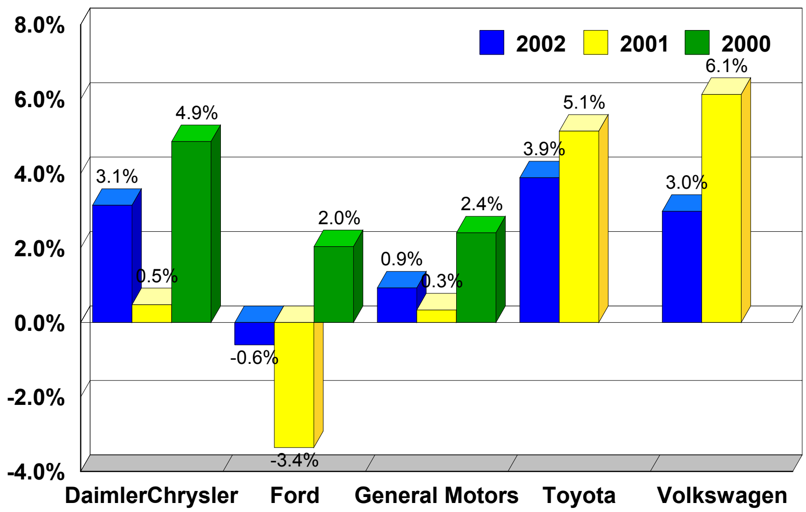
While GM, Ford and DaimlerChrysler have the highest net sales revenue by far, Toyota and VW have higher net income and much higher income as a percentage of sales revenue, as illustrated below.

Net Income By Manufacturer



But Toyota & VW Have Higher Income Than GM, Ford

Net Income As A Percent of Sales By Manufacturer



And Much Higher Income as Fraction of Sales Revenue

7. Conclusions

In considering the above information, several conclusions seem apparent:

1. Through a variety of mechanisms – tax or other incentives, regulatory mandates, “voluntary” agreements, etc. – Europe and Japan are stimulating the increased production of more fuel efficient vehicles by their domestic manufacturers.
2. Several other developed and developing countries – Australia, Taiwan, China – are also beginning to address vehicle fuel efficiency and or greenhouse gas emissions from the transportation sector.
3. While the US had an aggressive fuel efficiency program for many years, starting in the mid 1970’s, it is now clearly the world’s laggard.
4. Within the US, only in California is there a serious effort focused on reducing greenhouse gases before the end of this decade; a serious effort to improve fuel economy is also underway in Canada.
5. Because of government pressures to improve fuel economy, the European vehicle industry has become dominant in diesel technology and the Japanese vehicle industry is out front with regard to advanced technologies such as hybrids.
6. The US remains the clear worldwide leader in terms of reducing vehicle emissions of “conventional” pollutants.

7. Should there be a need for a rapid transition to fuel efficient vehicles worldwide, the US industry appears to be in the weakest position with all of its short term capabilities apparently focused on large fuel inefficient vehicles.
8. The fastest growing vehicle producing region of the world is Asia, with China rapidly becoming a global powerhouse.
9. GM and Ford remain the largest vehicle producers worldwide but they have lost dominance in car production and sales, with Toyota and VW already ahead of Ford and gaining on GM.
10. The only segment of the fleet where the US industry continues to dominate is with light trucks and SUVs.

Flexibility Mechanisms for Fuel Economy Standards

Executive Summary

Since 1975, when Congress enacted the Energy Policy and Conservation Act, the Corporate Average Fuel Economy (CAFE) program has been the main policy tool in the U.S. for coping with the problems of increasing fuel consumption and dependence on imported oil. The program mandates average fuel economy requirements for the new vehicle sales of each manufacturer's fleet. Despite technological progress, car standards have remained unchanged at 27.5 mpg since 1990. Light trucks have enjoyed a lower standard of 20.7 mpg, and their rising share of new vehicle sales has led to a decline in overall fuel economy.

The fact that each manufacturer must on its own meet separate standards for cars and light trucks means that the incentives to improve fuel economy are different across manufacturers and vehicle types. For automakers that have a comparative advantage in and sell more large vehicles, the standards can be costly, forcing them to sell less profitable small vehicles and to spend more resources on improving fuel economy. For automakers that are more competitive at making smaller, fuel-efficient vehicles, the standards do not provide incentives to make additional improvements. Similarly, if an automaker can more cost-effectively improve fuel economy of its SUVs, it cannot use overcompliance with that standard to offset efforts toward the car standard, and vice-versa. If the goal is for the overall vehicle fleet to meet a fuel economy target, this system makes little sense—fuel is fuel, no matter what kind of vehicle burns it. This paper evaluates different mechanisms to offer automakers the flexibility of joint compliance with nationwide fuel economy goals. In each case, fuel economy has the same value for all vehicles, so efforts to improve fuel economy are directed wherever they are most cost effective, be it in small or large cars, trucks, imported or domestic.

Tradable CAFE credits would allow for joint compliance with the standards, both across passenger car and light-duty truck fleets and also across different manufacturers. Automakers that find it relatively costly to meet the fleet standard would buy credits from those that cost-effectively exceed current fuel economy requirements, for either cars or trucks. This option provides significant savings to manufacturers and consumers at no additional harm to the environment, since the same fleetwide standard is met. However, absent regular increases, CAFE standards will not provide incentives to continue innovating better ways to improve fuel economy over time.

Feebates would set the price of a CAFE credit. Manufacturers would get a rebate to the extent they exceed the current standard, and they would pay a fee to the extent they undercomply. Initially, this option functions much like tradable CAFE credits; however, over time, as technological progress makes standards easier to meet, the fixed fee would continue to provide incentives to improve fuel economy. The current standard is the "pivot point" around which vehicles require a net tax or refund; over time, regulators must adjust the standard for the program to maintain revenue neutrality. If the costs of improving fuel economy are uncertain, feebates will generate uncertain reductions in fuel consumption.

Output-rebated fees would automatically ensure ongoing revenue neutrality. Manufacturers would pay the fee based on the entire fuel consumption rate of each vehicle, but all of the revenues would be rebated back to manufacturers according to market shares. The net effect is that automakers with above-average fuel economy would get a net rebate, while those with below-average fuel economy pay a net fee. That average is updated automatically by the market, driven by the costs of improving fuel economy.

A drawback of such automatic adjustments is that manufacturers will expect it. As a highly concentrated industry, auto manufacturers will recognize that their own behavior affects the pivot-point adjustment—whether it is automatic or by policy rule. For example, a carmaker with 30% of the market will know that 30% of its fee payments will be rebated, making it less costly to maintain higher rates of fuel consumption. Just as they would prefer that CAFE standards not rise, manufacturers will want to keep the pivot point reflecting higher average allocations, and they may use their market power to influence that average. To ensure that the incentives of the fee have their full effect—and the same effect across all manufacturers—pivot points should be fixed, and any adjustments should be credibly prescribed in advance.

Tradable CAFE with Banking to Phase in Higher Standards would achieve essentially the same goals as a feebate system. Combining a phased-in tightening of CAFE standards with tradability could make a larger increase in stringency more palatable. Furthermore, with the option to bank credits, the expectation of more stringent future standards would provide consistent incentives to improve fuel economy and smooth costs over time. This mechanism offers more certainty of reaching fuel economy goals and maintaining revenue neutrality; on the other hand, the cost of improving fuel efficiency will be less certain.

Recommending flexible compliance mechanisms is straightforward, since the same environmental goals can be met with lower costs. The more difficult policy question is how much to raise fuel economy targets and incentives. From an efficiency standpoint, when the goal is reducing fuel consumption, taxes on gasoline are preferred to fuel economy mandates, since they more directly discourage fuel use. The welfare effects of tighter CAFE standards can be ambiguous for several reasons. The "rebound effect," in which greater fuel economy lowers the cost of driving and increases miles traveled, negates part of the fuel savings and adds to traffic congestion and ancillary pollution, which are incurred on a per-mile (not per gallon) basis. Opinions conflict on the impacts of the CAFE program on safety as well, depending on the relative importance of downweighting and the mix of differently weighted vehicles on the road.

However, to the extent that consumers systematically undervalue fuel consumption costs when purchasing a vehicle—for which there is some evidence—additional incentives for providing fuel economy are unquestionably appropriate. A fixed fee serves the goal of providing equal incentives to all manufacturers and for maintaining ongoing incentives for innovation and adoption of cost effective technologies. Alternatively, a phased-in tightening of standards with banking and trade could achieve the same goals.

Although finding the right standard—or the right price tag for fuel consumption—is a difficult policy problem, the case for allowing flexible, joint compliance toward any standard is clear. The benefits are lower costs, a better distribution of efforts across cars and trucks and across manufacturers, and more transparency. These features should allow for better choices and better public debate in weighing the costs and benefits of fuel economy standards.

Findings:

- CAFE credits should be fully fungible across manufacturers and vehicle types to provide equal incentives to improve fuel economy in a cost-effective manner.
- The value of a credit (or the fee) should at least reflect the degree to which markets systematically undervalue fuel economy; other social costs of driving are better addressed by gasoline or per-mile charges.
- With feebates, the fixed fee offers ongoing incentives for progress in fuel economy, while tradable standards would have to be increased over time.
- If revenue neutrality is important, adjustments to standards or the pivot point are best set in advance to avoid manipulation on the part of large manufacturers.
- Tradable CAFE credits with banking could be an effective way to phase in more ambitious fuel economy targets over time, with incentives very similar to feebates.
- While credit prices (and the incentive to improve fuel economy) are less certain with tradable CAFE, average fuel economy would be more certain than with feebates.
- Either market mechanism will improve the transparency of the costs of improving fuel economy. Neither should have administrative costs that differ significantly from the current system.
- Making CAFE standards fully tradable may be easier to implement than feebates, as a simpler modification of the existing program and given recent successful experiences with tradable emissions permit systems. Raising mandatory standards is likely to be contentious, but levying a new fee—even a rebated one—will also be controversial.

Contents

Flexibility Mechanisms for Fuel Economy Standards[1]

Carolyn Fischer[*]

Introduction

Concerned about increasing fuel consumption and dependence on imported oil, Congress initiated the Corporate Average Fuel Economy (CAFE) program in the Energy Policy and Conservation Act of 1975 (EPCA). The CAFE program mandated that each manufacturer's passenger new-car fleet, weighted by sales, had to average 18 miles per gallon (mpg) by Model Year 1978, a standard that rose steadily to 27.5 mpg for Model Year 1985 and beyond. Congress delegated authority to the National Highway Traffic Safety Administration (NHTSA) to establish fuel economy standards for light-duty trucks as well. Today each manufacturer's fleet of pickup trucks, minivans and sport utility vehicles (or SUVs) must average at least 20.7 mpg.[2]

Working in concert with sharply increasing gasoline prices in the early years of the program, the CAFE standards resulted in significant improvements in fuel economy for both passenger cars and light-duty trucks. For instance, by 1986 passenger car fuel economy was nearly double its pre-1975 level, while light-duty truck fuel economy had increased by nearly half. Along other conservation-oriented policies, the CAFE program contributed to significant reductions oil consumption; as a consequence, between 1977 and 1986, net oil imports fell from 47 percent to 27 percent of total oil consumption.

Today, energy security and foreign oil dependence remain important policy issues, and they are compounded by other environmental concerns related to fuel consumption. In particular, the burning of fossil fuels in the transportation sector is a major contributor to greenhouse gas emissions, the pollutants of concern for global climate change. Thus, serious attention is being given to the costs and benefits of raising CAFE standards. Yet the CAFE

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[1] This paper was prepared for the consideration of the National Commission on Energy Policy (NCEP) and benefited from their support. However, it does not necessarily reflect the views of the NCEP or RFF;

[*] Resources for the Future, Washington, D.C.

[2] Truck standards are slated to rise to 22.2 mpg by 2007 MY. Vehicles weighing more than 8,500 pounds are exempt from CAFE.

program is not without critics; many allege that it is ineffective and plagued by unintended consequences.

Economists often point out that, when the goal is reducing fuel consumption, taxes on gasoline are more efficient than mandating fuel economy increases.[3] The reasoning is due to the "rebound effect"—that greater fuel economy lowers the cost of driving and increases vehicle miles traveled (VMT), negating some part of the fuel savings. More costly is the effect of the increased incentive to drive on adding to traffic congestion. A fuel tax, on the other hand, raises the cost of driving, although a tax per mile would be a better answer to congestion costs.

Recent research also indicates that the welfare effects of tighter CAFE standards are ambiguous and difficult to determine.[4] It can be argued that current gasoline taxes likely overcompensate for the marginal external effects of CO2 (at $50/ton) and energy security costs, so improving fuel economy does not create additional gains, since consumers already take these costs into account. Even if these funds are earmarked for road construction, the effect of fuel economy improvements reducing this valued revenue source causes some degree of welfare losses on the margin.

Another question is whether improved fuel economy would create ancillary benefits of lower tailpipe emissions and better local air quality. New results indicate that among current vintages, although emissions rates deteriorate somewhat as vehicles age, these emissions rates have become decoupled from fuel economy, since tailpipe emissions are regulated on a per-mile (not per gallon) basis.[5] Thus, the rebound effect can not only increase congestion costs, but also increase emissions of other pollutants. On the other hand, to the extent overall fuel consumption decreases, emissions of air pollution from refineries will fall; however, for those pollutants regulated under a cap-and-trade approach, the reductions can allow for expansion elsewhere.

A final concern regards the impacts of the CAFE program on safety. Some have argued, on the one hand, that safety in crashes may have been compromised by the rapid downsizing of vehicles to meet the standard. The NRC study reviews this argument and offers options to deal with these issues, such as weight-based standards. However, they also prominently note dissenting opinions to this presumption (the only area of broad disagreement among the panel).

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3 See, e.g., Austin and Dinan (2003).

4 Fischer et al. (2004).

5 ibid.

Others have argued that the lower standards for light trucks and the subsequent shift of vehicle sales toward SUVs may have led to a more dangerous mix of differently weighted vehicles on the road, leading to higher fatality rates. Gayer (2004) finds evidence to this effect and suggests that more uniform fuel economy standards would help correct for this problem.

Of the several open questions regarding the true welfare impacts of CAFE standards, one issue would unambiguously call for policy-induced incentives to improve the fuel economy of new vehicles. That is whether—and to what extent—consumers undervalue fuel consumption costs when making their vehicle purchasing decisions. Greene et al (2004) indicate that industry and government surveys reveal an expectation of a 3-year payback time, rather than the 14-year lifespan of the vehicle. In this case, Fischer et al. (2004) show that tighter CAFE standards can indeed offer welfare gains. However, if fuel economy improvements come at a cost of diverting technologies from providing other qualities that consumers value—power, acceleration, towing capacity, etc.—both the RFF and CBO studies indicate that these opportunity costs could swamp the fuel savings. Thus, a qualifying issue is how important these unknown costs are.

While major revisions to CAFE standards have always created controversy, there are several opportunities to improve upon CAFE, regardless of the prevailing fuel economy target or its prevailing costs. Changes in the way CAFE is implemented, particularly by introducing mechanisms to offer manufacturers flexibility in achieving the nationwide target, can reduce the overall costs of complying with CAFE. Certain mechanism designs can also create ongoing incentives to improve fuel economy over time, as technical progress makes current standards easier to meet. In fact, Congress could make the CAFE standard self-adjusting, letting the market drive what the cost-effective increase in fuel economy should be.

This White Paper details three options for introducing flexible compliance options for CAFE standards:

1. **Tradable CAFE credits** would allow for joint compliance with the standards, both across passenger car and light-duty truck fleets and also across different manufacturers. Automakers that find it relatively costly to meet the fleet standard would buy credits from those that cost-effectively exceed current fuel economy requirements, for either cars or trucks. This option provides significant savings to manufacturers and consumers at no additional harm to the environment, since the same fleetwide standard is met.

2. **Feebates** would set the price of a CAFE credit. Manufacturers would get a rebate to the extent they exceed the current standard, and they would pay a fee to the

extent they undercomply. Initially, this option functions much like tradable CAFE credits; however, over time, as technological progress makes standards easier to meet, the fixed fee would continue to provide incentives to improve fuel economy. The current standard is the "pivot point" around which vehicles require a net tax or refund; over time, regulators must adjust the standard for the program to maintain revenue neutrality.

3. **Output-rebated fees** would ensure ongoing revenue neutrality by making the adjustment process of the standard automatic. Manufacturers would pay the fee based on the entire fuel consumption rate of each vehicle, but all of the revenues would be rebated back to manufacturers according to market shares. The net effect is as before: automakers with above-average fuel economy would get a net rebate, while those with below-average fuel economy pay a net fee. That average is updated automatically the market, driven by the costs of improving fuel economy.

4. **Tradable CAFE Standards with Banking to Phase in Higher Standards** would create incentives very similar to feebates. The expectation of higher costs of meeting more stringent standards in the future, coupled with the option to bank credits, creates incentives to improve fuel efficiency beyond current standards, save the credits to offset future compliance, and smooth costs over time.

We discuss each of these flexibility mechanisms in greater detail in the following sections. We note that the first adjustment—making CAFE credits tradable—may be within the regulatory scope of the NHTSA as a modification to the current program, while the feebate options would likely require an act of Congress, which enacted the standards program in 1975. Legal differences notwithstanding, from the standpoint of economic incentives, the options are quite similar. Each imposes some sort of price on actual fuel consumption rates, while simultaneously offering a per-vehicle allocation of credits based on average fuel consumption. The price creates incentives to improve fuel economy, while the credit allocation mitigates the fee's impact on average vehicle costs.[6] The differences lie in whether the marginal incentive to improve fuel economy changes over time (as with the tradable standard), or whether the average fuel economy changes over time (as with the feebate options). There are potential drawbacks to

[6] For more analysis of output-based rebating mechanisms, see Fischer (2001).

automatic updating of fuel economy standards, which we also enunciate. However, allowing for joint compliance arguably offers unqualified benefits. We begin by discussing the rationale behind flexibility mechanisms.

Rationale

An important feature of the current CAFE program is that it requires each manufacturer separately to meet the standards for each of its own car and light truck fleets. In implementing the program, NHTSA did allow some limited flexibility by taking into account the fact that some automakers might produce higher fleetwide fuel economy in a given year than is required. To reward such performance, NHTSA offers "credits" for excess compliance and allows the automaker to "bank" them to offset its own possible future shortfalls against the CAFE standards. However, this offset system is currently is limited in several very important ways. First, any credits that are earned must be used within three years; after that time the credits expire. Second, credits earned in the passenger car segment of the market cannot be used to offset possible shortfalls in light-duty truck fuel economy, and vice versa. Since most carmakers produce both types of vehicles, this restriction is significant. Third, credits earned by one manufacturer cannot be traded to another. The three flexibility options essentially remove these restrictions.

To understand the rationale behind allowing flexibility options for CAFE compliance, it is important to realize that some carmakers, if allowed to do so, might elect to specialize in the large-vehicle segment of either or both of the passenger car and light-duty truck markets because of a comparative advantage they feel they have in manufacturing and/or marketing such vehicles. They cannot do so now; if an automaker is able to sell 1 million vehicles that average 26 mpg, it has to sell another million vehicles averaging 29.2 mpg in order to hit the 27.5 mpg standard.[7] This has resulted in a situation in which at least some carmakers end up producing and selling for

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[7] CAFE standards are calculated based on harmonic averaging, in effect making it the average fuel consumption rate that must meet the standard (gallons per mile) rather than mpg, hence the slight difference with simple averaging of mpg. Automakers are allowed to pay a penalty of $5.50 per vehicle for every tenth of a mile that their fleet falls short of the relevant standard. Domestic manufacturers have never taken advantage of this option, however, choosing always to make and sell enough small vehicles to ensure that they are in compliance with the fleet average requirement.

little or no profit (or even a loss) significant numbers of smaller cars or light-duty trucks to enable them to produce the larger cars or trucks on which they make their money.

Indeed, CAFE has not had equal effects on all manufacturers. Some foreign automakers that initially penetrated the market with fuel-efficient small cars and compact SUVs have been able to leverage the popularity of their small vehicles into an advantage for their larger ones. The fact that their fleets had been overcompliant has allowed them to expand their market share in sedans and light trucks of all sizes without incurring additional costs to remain within CAFE standards. Meanwhile, domestic manufacturers have closely paced their fuel economy gains in line with the CAFE requirements, having to expand production of smaller cars in order stay in compliance while producing the large cars their consumers demand. These disparities result from the fact that each manufacturer must on its own meet the requirement for each of its fleets, even if it is more costly for that manufacturer than for its competitors. Similar disparities apply with respect to cars and light trucks: if the car standard is more difficult to meet than the truck standard, more effort will be put into improving car fuel economy than light truck fuel economy.

Yet fuel is fuel, no matter what kind of vehicle burns it. Since what we care about is whether the overall vehicle fleet is meeting the fuel economy goals the nation feels are appropriate, this system makes little sense. With the flexibility of joint compliance, fuel economy has the same value for all vehicles, so efforts to improve fuel economy are directed wherever they are most cost effective, be it in small or large cars, trucks, imported or domestic.

Flexibility Mechanisms for Fuel Economy

Tradable Credits

The first option for introducing flexibility—making CAFE credits tradable—has precedents in other areas of environmental regulation. For example, tradable performance standards were used with great success to phase out lead in gasoline. In 1982, the Environmental Protection Agency set an inter-refinery average for lead usage among importers and refineries producing leaded gasoline. Refineries using less lead than the standard could sell these credits to others using more than average. Unlike a cap-and-trade system of emissions permits, which fix the total allocation of permits, tradable performance standards allocate to each manufacturer permits for each unit of production according to an average emissions rate (or in this case, an average fuel consumption rate[8]). At the same time, the manufacturer must turn in permits for all of its emissions; hence it becomes a net seller if it has below-average emissions intensity, and a net buyer with above-average emissions intensity. The market price of a permit adjusts to ensure that the overall average emissions rate in the industry equals the standard.

Tradable credits could be implemented by amending the regulations, making the "credits" that automakers can earn for exceeding current fuel economy requirements fully saleable, both between a given manufacturer's passenger car and light-duty truck fleets and also between different manufacturers. This kind of modification to the existing program may be within the regulatory scope of the NHTSA, which promulgates new standards and procedures.

The expansion of this credit banking system to full credit trading would improve the allocation of resources in the auto industry by offering automakers another option to comply with the standard. If an automaker decided that it could not profitably compete in the small car (or light-duty truck) market, it could use any fuel economy credits that it had generated in the other segment of the new vehicle market, or it could purchase credits from another automaker that had exceeded its passenger car or light-truck targets in a previous year. Automakers purchasing credits would be those who would find it difficult to manufacture and sell enough smaller vehicles to offset their large-vehicle sales. The automakers choosing to sell credits would be those for whom exceed the standard is less expensive than purchasing credits. Both kinds would benefit from the exchange.

Not only would automakers be more free to choose the composition of their fleets, but they can collectively better allocate their efforts for improving fuel economy. For example, currently, a manufacturer that easily meets the standard receives little or no reward for further improving the fuel economy of any of its vehicles. Meanwhile, a manufacturer struggling to meet the standard due to many large car sales has more incentive than its competitors to improve the fuel economy of its small and large cars. With trading, all manufacturers have the same incentive to improve fuel economy in all vehicles, so the efforts are directed where they offer the greatest value at least cost.

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[8] As CAFE standards are calculated based on harmonic averaging, in effect making it the average fuel consumption rate that must meet the standard (gallons per mile) rather than mpg, hence the slight difference with simple averaging of mpg.

The benefits of credit trading would flow through to consumers, as well. The lower manufacturing costs from better specialization and more effective allocation of technologies for fuel economy will translate into lower prices for consumers. Furthermore, the environmental impact would be negligible. The overall fleet of passenger vehicles will have the same average fuel economy. Although some foreign manufacturers have overcomplied with the standards in the past, their average fuel economy has been declining toward the mandate in recent years as they sell more large vehicles, so trading is unlikely to forego "free" overcompliance. While part of the response to lower prices may be for consumers to own more vehicles, much of the response will be to buy new vehicles sooner and retire older vehicles. This will help speed the transition to a more fuel-efficient vehicle stock, leading to better performance with respect to other emissions in the meantime, since newer vehicles are cleaner.

Just as the costs of complying with CAFE increase with the stringency of the standards, so do the benefits of trading. Technical progress has helped to ease the costs of achieving greater fuel economy, and emerging technologies will continue to do so as they become more widely available. However, technical progress can also be applied to other vehicle qualities that consumers value, like power, acceleration, towing capacity, etc. Trading can help ensure that all qualities—including fuel economy—are applied where they are most valued. These potential savings become more important if increases in CAFE standards will be relied upon to respond to heightened concerns about oil consumption and dependence. A recent study by the Congressional Budget Office (Austin and Dinan, 2003) suggests that the costs of tightening CAFE to 31.3 for cars and 24.5 for trucks would be about 17% lower if credits were tradable.

A recommendation to allow trading does not need to hinge on raising (or lowering) CAFE standards. Nor need we weigh in on the question of separate standards for cars and light trucks to promote trading. Those standards determine the free credits the policy allocates to each vehicle type. That allocation may well be worth debating—whether SUVs should receive more fuel consumption credits than cars, or whether all vehicles should receive the same, or whether that allocation should be based on weight and safety factors. But whatever the standards are, we can do better—if with tradable credits we allow the automakers and drivers to decide collectively how best to meet the challenge.

To the extent that cost savings are available today, trading could allow the US to raise fuel economy standards somewhat without raising costs beyond current levels without trading. Consequently, combining a change in the standard with tradability could make a larger increase in stringency more palatable.

CAFE standards will not provide incentives to continue innovating better ways to improve fuel economy, since the standards lose their power once they can be met cheaply. In recent years, technological advances have led to increases in horsepower and other features, but fuel economy has remained flat. Consequently, the standards would have to be tightened continually over time in order to offer ongoing incentives to improve fuel economy. However, in practice, such adjustments do not come easily or frequently—car standards have not changed in 14 years, an entire lifetime for a vehicle.

If markets systematically undervalue fuel economy—which is itself an important issue of debate—a fixed price for fuel economy can better serve the goal of ongoing innovation and adoption of cost effective technologies. The next two options explore this kind of mechanism.

Feebates

Feebates are a natural progression from a tradable CAFE standard, the modification being that the value of a credit is fixed by the regulation. Vehicles with fuel consumption rates above a standard rate—the "pivot point"—are charged fees based on that deviation while vehicles below receive rebates. Feebates have been under discussion since the early 1990s as an alternative to CAFE in the U.S.; several studies have evaluated their potential effects, the latest of which is a draft by Greene et al. (2004).[9] They also have some precedent in practice: the province of Ontario implemented a kind of feebate in 1991, a modest, sliding-scale tax based on a vehicle's fuel consumption.[10]

The fee component of the system ensures that all vehicles face the same marginal incentive to improve fuel economy, playing the same role as the value of a fuel economy credit in the tradable CAFE program. The pivot point behaves like the standard in the tradable CAFE case, allocating for free to automakers credits equal to an average rate for each vehicle. While a tradable CAFE standard is automatically revenue neutral, feebate systems can be made revenue neutral by targeting the pivot point to the standard that manufacturers achieve on average, given

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[9] Earlier studies include Greene (1991); DeCicco et al. (1993); Train et al. (1997); Davis and Gordon (1992); Davis et al. (1995); and a study by HLB Decision Economics Inc. (1999) commissioned by Natural Resources Canada. The Greene (2004) draft is preliminary, but we refer to it here since it is among the papers available to NCEP.

[10] The State of Maryland also attempted to institute a gas guzzler tax / sipper rebate in 1993, but it was repealed due to allegations that it interfered with NHTSA's authority to regulate fuel economy.

the fee. In fact, if the fee were set at the price of a CAFE credit, the current standard would be that pivot point.

Initially, then, this option functions much like tradable CAFE credits. However, over time, the differences reveal themselves. As technological progress makes standards easier to meet, the price of a tradable CAFE credit would fall; if ever the standards would be exceeded, credits would be worthless. However, with the fixed fee, there would continue to be incentives to improve and go beyond the standard, as long as it is more cost effective to do so than pay the fee. As technical progress makes this easier, more vehicles will receive net rebates than pay net fees, and the overall feebates program will go into deficit, paying net subsidies to automakers. Regulators would have to adjust that standard (pivot point) to maintain revenue neutrality. Although such a move would deprive automakers of some subsidy, this adjustment process arguably may be easier than raising the standard in a tradable CAFE program, which also means raising the effective fee. Revenue neutrality can also be built into a feebate scheme by making the rebate a share of total revenues, as the next section will discuss. However, the expectations by manufacturers of a pivot-point adjustment—whether automatic or by policy rule—can lessen and even distort the incentive effects of a feebate system.

Output-Rebated Fees

Output-rebated fees would ensure ongoing revenue neutrality by making the adjustment process of the standard automatic. As with the feebate, the price of fuel economy would be fixed. Manufacturers would essentially pay the fee based on the entire fuel consumption rate of each vehicle, but all of the revenues would be rebated back to manufacturers according to market shares. The net effect is as before: automakers with above-average fuel economy would get a net rebate, while those with below-average fuel economy pay a net fee. That average is updated automatically by the market, driven by the costs of improving fuel economy.

An output-refunded tax has some precedent in environmental policy. For example, in 1990, the Swedish government announced the implementation of an environmental charge on nitrogen oxide (NOx) emissions beginning in 1992, its first fee to be based on actual emissions.[11] The revenue is refunded to the affected plants in proportion to the amount of energy produced, so producers with a relatively high emissions rate will pay a net tax, while those with low emissions rates will receive a refund. The intent of the fee is to promote emissions reduction, contributing to a 40% decline in NOx emissions in seven years. The intent of the rebate is to ameliorate the distributional impact of the fee; only large producers are affected, due to the cost of continuous emissions monitoring equipment, and the government did not want to create perverse incentives to use smaller, dirtier sources of generation. Part of the intent was also political: Swedish analysts argue that the refunding was instrumental in achieving acceptability of a tax rate high enough to provide real incentives to mitigate NOx emissions.[12] As a result of the program, utilities invested heavily in NOx control equipment and became net beneficiaries from the tax, while the pulp and paper industry became net taxpayers. This seems to have caused some grumbling in that sector, but presumably they avoided costlier control efforts as a consequence.

Despite the appeal of automatic updating of the pivot point, there may be some important drawbacks to administering output-based rebating in an industry as highly concentrated as auto manufacturing. Fischer (2003) shows that combining an emissions tax with an automatic output-based rebate can lead to distorted incentives, compared to a fixed feebate, when market shares among program participants are significant and different. These distortions occur because firms then know that part of any fees they pay will be returned to them with their rebate. For example, if GM has 30% of the market, it would receive 30% of the fee revenues under output-based refunding. Therefore, the effective tax rate on the fuel consumption of its cars is only 70% of the fee rate. In other words, since changing fuel economy changes the total revenues that will be refunded, the expectation of a large rebate share reduces the incentive effect of the fee.

Furthermore, when market shares differ, firms no longer have equal incentives to improve fuel economy. A firm with a larger market share expects more of its fee payments to be returned, implying less incentive to reduce fuel consumption rates than a firm with a smaller

[11] The rate of SEK 40 per kilo (currently about Euro 4.3 or $2.09/lb) was set to approximate the cost of reducing (and asserted to be the marginal damage of) NOx emissions. The charge applies only to large combustion plants, since the measurement equipment is costly. Initially, the program applied to heat and power producers with a capacity of more than 10 MW and production exceeding 50 GWh. The latter threshold was lowered to 40 GWh in 1995 and 25 GWh in 1997. The participating installations are responsible for about 5% of total Swedish NOx emissions (SEPA 2000).

[12] Sterner and Högland (1998).

market share and a higher net tax. To expand on the previous example, if Honda has 9% of the market, its effective rate is 91% of the fee, leaving it with more incentive to increase the fuel efficiency of its vehicles than GM. Consequently, a second effect of the exercise of market power in an automatic refunding system is then to shift efforts to improve fuel economy to smaller producers.

In choosing between the two rebate designs, the fixed rebate is generally preferred when market power is an issue. However, in practice, if manufacturers expect regulators to update the pivot point to maintain revenue neutrality, the incentive effects become essentially the same between the feebate and the output-based rebated fee.

In the case of the Swedish NOx charge, these concerns do not weigh too heavily. Although participants include large producers in industries that may not be perfectly competitive, no producer has more than roughly 2% of the rebate market, since the tax refund program includes several industries.[13] Thus, by using a broad program, this scheme avoids the market-share issues that could arise with sector-specific programs. This breadth would be absent in a program for vehicle manufacturers, in which market shares are significant and disparate.[14]

If revenue neutrality is important, the preferred solution to this problem is not to have automatic updating, but rather to set a path of pivot points that, in expectation, would maintain revenue neutrality for the program over time. For example, if technical progress will likely lead to, say, a 2% reduction in fuel consumption rates per year, the pivot point could be set to increase by the corresponding impact on mpg. In this manner, if the path of fees were credibly fixed, auto manufacturers would be less tempted to manipulate the program for higher rebates.

Tradable Credits with Banking to Phase in Higher Standards

With this option, we discuss how to close the circle between feebates and tradable CAFE standards. As noted previously, the important differences are how the policies and incentives adjust over time. In reality, though, both mechanisms can be designed to allow for ongoing, consistent incentives to improve fuel economy over time. For tradable CAFE standards, this

[13] Participating industries are food, wood, pulp and paper, metals, chemicals, combined heat and power, and waste incineration. Approximately 250 plants are involved. (SEPA, 2000.)

[14] Data from Wards for the 2000 model year indicates the following market shares: Chrysler, 11%; Ford, 22%; GM, 33%; Honda, 6%; Toyota, 9%; All others, 19%.

means utilizing (and possibly expanding) the current provisions for banking in conjunction with phasing in higher standards over time.[15] The expectation of higher costs when standards are tighter in the future, in combination with the option to bank, gives incentives to go beyond current standards in order to save credits for later use. As a result, prices and incentives to improve fuel economy are smoothed over time, just as with feebates.

This combination was implemented successfully in the Acid Rain program, which was implemented in two phases along with permit banking. Since the targets were much more stringent in the second phase, participating utilities began banking immediately, resulting in overcompliance in the first phase and a more gradual adjustment to the targets of the second phase. When today's permits can be used to offset future emissions, the price of current permits reflects the discounted expected value of permits in the future.

Banking was also utilized in the lead phasedown from 1983 to 1987. To ease the transition for refineries, the EPA allowed two kinds of flexibility in meeting the performance standards, intra-industry averaging and banking. Trading among refineries was allowed as of 1983, and banking began in 1985, along with an increase in the speed of the phasedown. Kerr and Newell (2001) show evidence that the introduction of market-based mechanisms themselves, and not just greater stringency in the standards, sped adoption of control technologies.

Since allowing credit trading makes CAFE standards more cost effective, an increase in standards could be made more palatable. By fixing the future target, incentives to manipulate regulatory adjustment are avoided. Banking allows a smooth transition; although the ultimate targets will not be reached until after the official date, that delay is offset by improvements beyond current standards early on.

Comparing Tradable CAFE and Feebates

Economic Incentives

From the standpoint of economic incentives, the options are quite similar; in fact, with the proper choice of fee and standard, they could be designed to be equivalent. Each imposes some sort of price on actual fuel consumption rates, while they offer a per-vehicle allocation of credits based on average fuel consumption. The price creates incentives to improve fuel

[15] For example, the expiration of banked credits could be extended from its current three-year lifetime.

economy—a manufacturer will want to reduce fuel consumption rates as long as the cost of doing so is lower than the price of a credit or the fee. We note that unless the price is higher than today's effective prices (the internal marginal cost to a manufacturer of improving fuel economy in its fleets), not all manufacturers will prefer to increase fuel efficiency. Some may find that the cost of additional fuel economy may be higher than the fee, meaning that they can produce cars more cheaply by relaxing their own fuel economy targets and buying more credits or paying more in fees instead. Other manufacturers may find that they can raise profits and lower overall costs by improving fuel economy and reducing net fee/permit payments (or increasing rebates).

Meanwhile the credit allocation mitigates the impact of the fuel consumption price on average vehicle costs.[16] That way, the price of a car does not reflect the full cost of the fuel consumption rate, but only the cost of fuel consumption above the standard allocation, which may also be negative—a net subsidy—for relatively fuel efficient vehicles. Since each vehicle confers an additional allocation equal to the standard, the value of that allocation represents a kind of production subsidy. With full trading or with the feebate, although the price of fuel economy remains the same across all vehicles, the allocation value will differ across cars and light trucks if the standards or pivot points differ. For example, with current standards, light trucks receive a larger average fuel consumption allocation; with the same price or fee, that implies a larger production subsidy for light trucks than cars. From an efficiency standpoint, differential subsidies are difficult to justify, especially since cars and SUVs have become substitutes, as these vehicles are used for the same purposes.[17] The relative allocations have important impacts on vehicle sales behavior, as well as distributional impacts on consumers and producers. Consequently, the choice of standards and pivot points remain important policy decisions in any of these programs.

The main difference in incentives regards how they change over time as technology progresses and costs change. If not updated regularly, tradable standards do not offer incentives to go beyond the prevailing average; rather, credit prices fall. Feebates provide ongoing incentives to raise fuel economy as costs fall; net subsidies must be paid as a consequence. Regular updating can again make the programs equivalent in practice—and in expectations. Since firms in a highly concentrated industry may strategically want to manipulate fuel economy

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[16] For more analysis of output-based rebating mechanisms, see Fischer (2001).

[17] In fact, if there is a fuel consumption externality, any subsidy may be hard to justify on efficiency grounds.

to keep down the net costs of the system and avoid regulatory adjustment, in both cases it is preferred to plan out reasonable paths of future standards and pivot points ahead of time. Finally, in the context of raising standards over time, allowing banking in a tradable CAFE system would make it functionally more equivalent to feebates, since the expectation of higher costs when standards are tighter in the future gives incentives to go beyond current standards in order to save credits for later use. In both cases then, prices and incentives to improve fuel economy are smoothed over time.

Since the economic incentives are the same at equivalent combinations of standards and tradable credit price or fee and pivot points, one should not expect the impacts on individual manufacturers of a feebate system to differ from that of an equivalent tradable CAFE program. It is true that the flexibility mechanisms will change relative prices, better reward specialization, and cause some redistribution of vehicle fleets and sales. However, these effects do not depend on which form the flexibility mechanism takes. It would not be consistent for a manufacturer to argue that tradable CAFE standards would help competitors while a similar feebate system would not; rather, any special interest opposed to one would likely oppose the other as well. Of course there are several subtleties in the different mechanisms, and they might not be implemented at equivalent standards and prices. It is important to point out that these differences—the actual price of fuel consumption, the value of the per-vehicle credit allocation, and the manner in which they adjust over time—are what drive the policy impacts, not whether they are implemented through fees or tradable credits.

Transparency

A notable feature of these market-based flexibility mechanisms is their transparency. With either a fixed fee or a market price of CAFE credits, both the marginal cost of reducing fuel consumption rates and the value of the per-vehicle allocations are observable. Policymakers would not have to rely on industry reports of what the cost of increasing the standard would be. They would be able to set the marginal cost themselves, or see from the permit price the marginal cost of fuel economy at the prevailing standard. This information would help policymakers set the most appropriate fee, such as by targeting a price that reflects our best estimate of the extent to which consumers undervalue the full present discounted value of fuel consumption costs at the time they make their purchasing decision.[18]

Implementation

An important issue for changing CAFE lies in the question of how much authority NHTSA has over critical aspects of designing and managing the CAFE program, which was enacted by Congress in 1975. Since credit banking already exists, making CAFE credits fully tradable *may* be within the regulatory scope of NHTSA. However, combining tradability with tighter standards may be more difficult. While NHTSA was delegated authority to set light truck standards, raising the car standard lies in the domain of Congress. One possibly feasible option would be for NHTSA to raise the light truck standard at the same time as implementing tradable credits, which would have the effect of raising the overall standard—however, it would imply a loss of some preferential treatment for light trucks.[19] Although trading is a simpler modification to the existing regulation, any major change to the program—including a significant increase in any standard—is likely to be subject to review and authorization by Congress.

Changing CAFE to a feebate system would almost certainly require an act of Congress. It would also require fixing a price for the value of fuel consumption, rather than a fuel economy target. As a fee—even a rebated one—there may be resistance to implementing a tax, whereas permit systems enjoy greater support in recent history.

Administrative and Transaction Costs

The information required to administer either of these programs is essentially the same at that required today. Automakers must report vehicle sales and fuel economy; regulators must collect and verify this information and either retire the credits or assess fees and rebates.

With tradable credits, they must turn in permits according to the fuel consumption of their vehicles. To the extent their fuel consumption rates are higher than their standard allocation, they will have to buy credits from other firms that have below-average fuel

[18] As noted in the introduction, this undervaluation is the main market failure that fuel economy programs are well equipped to correct.

[19] This change in the relative allocation could create some political resistance on the part of large SUV manufacturers; on the other hand, some research suggests that safety and consumer welfare could be improved by eliminating the preferential allocation for light trucks (Gayer, 2004).

consumption rates. Although a CAFE credits registry would have to be maintained, these costs are quite low, as evidenced by the Acid Rain program. Already there is some credit tracking capabilities for the current banking mechanism. Transaction costs are also likely to be modest; Kerr and Maré (1999) estimate that transaction costs offset roughly 10% of the efficiency gains from trading in the lead phasedown. Importantly, a transaction will not occur unless both parties gain from the trade, after transaction costs, so the option to trade cannot raise costs. Many transactions may occur within manufacturers across fleets, avoiding any broker fees or bilateral negotiations.

The feebate system would require a transfer of revenues between manufacturers and the regulators. The administrative costs should be similar in proportion to those of the CAFE trading system. Transaction costs would not be an issue.

Uncertainty

Perhaps the greatest difference between the mechanisms lies in how the outcomes differ under uncertainty. Since today we do not know the true cost of improving fuel economy, we do not really know how manufacturers and consumers will respond. That true cost includes not only the direct costs of producing more fuel efficient vehicles, but also how consumers value the fuel savings and the alternative uses of the technologies. The recent NRC study offers a range of reasonable cost estimates for emerging technologies when applied to fuel economy improvements. They also consider different scenarios for consumer behavior, ranging from 3 to 14 year payback horizons and varying discount rates, reflecting a lack of consensus over the extent to which consumers internalize the costs of fuel consumption when making their vehicle purchases.[20] Even less is known about the technological tradeoffs between fuel economy and other vehicle qualities and how consumers value each, but Austin and Dinan (2003) argue that it is likely to be enough to divert new technologies toward other quality improvements, rather than fuel economy. Without knowing all these aspects about how manufacturers and consumers will respond, it is difficult to ensure that overall fuel economy targets will be met.

For example, the same scenario of a \$500 fee per 0.01 gallon, with revenue-neutral pivot points for cars and trucks, can generate different results in different models and with different assumptions. Greene et al. (2004) estimate such a feebate would induce a car fleet of 31.8 mpg

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[20] The recent study by Greene et al. (2004) indicates some coalescing of industry expert opinion around a 3 year payback horizon.

and a light truck fleet with 26.0 mpg, at a cost to consumers of about $2.0 billion. Using the same 3-year undiscounted payback assumptions and cost curves derived from the NRC study, the model from Fischer (2004) estimates that this feebate would lead to cars averaging 30.2 mpg and trucks at 23.7 mpg, at a cost to consumers of $1.2 billion. However, if society values the fuel savings over the full 14-year lifetime with a 12% discount rate, the additional savings of $3.4 billion outweigh these costs. On the other hand, if we adopt an assumption like the CBO study—that fuel economy technologies have some opportunity costs—the results are fewer gains in fuel economy and higher costs. This scenario produces cars with 29.1 mpg, light trucks with 22.7 mpg, and a cost to consumers of $1.6 billion. Similarly, for a $1000 feebate, Greene et al. estimate improvement to 32.3 mpg overall (cars and trucks), while the model from Fischer (2004) estimates responses of 28.9 mpg without opportunity costs and 27.6 mpg with opportunity costs taken into account.[21] These numbers—all based on similar data from the NRC report on technology costs—reveal the range of uncertainty over outcomes based on slightly different modeling assumptions. Since the cost estimates themselves are uncertain, as are several parameters regarding the assumed behavior of consumers and producers, the actual range of outcomes is likely to be much wider.

We can also use these different assumptions about consumer preferences and technological tradeoffs to compare the effects of a feebate with a tradable CAFE standard. As an example, the following table uses the model in Fischer (2004) and the aforementioned central assumptions about consumer behavior. When there is uncertainty about the influence of opportunity costs, the policy options have different effects, particularly on the costs borne by consumers. We consider two cases, one in which there are no opportunity costs, implying that the new technologies are only useful for improving fuel economy, and another in which we assume that opportunity costs would be just large enough to dissuade markets from exceeding current standards. Suppose we think there are no opportunity costs and design the feebate to be revenue neutral at the expected average fuel economy. If there turn out to be opportunity costs, the feebate would have less effect on fuel economy than expected, a larger loss of consumer surplus, and less net welfare gain when undervalued fuel savings are taken into account—and it would generate revenue. For comparison, we also consider the impact on a tradable CAFE standard, which we set to be equivalent to the expected gains under a $500 feebate without

[21] The results from both of these papers are preliminary and should not be cited or quoted without permission from the authors.

opportunity costs. The tradable standard ensures the same overall fuel economy is met, but opportunity costs mean instead that the marginal social cost of reducing fuel consumption to meet the standard is $766,[22] resulting in a greater fall in consumer surplus, and smaller net welfare gains.

Table 1: Comparison of Feebate and Tradable CAFE: Alternative Opportunity Cost Assumptions

Fischer (2004) model, 3-year undiscounted payback	*Overall Fuel Economy (Cars, Trucks)*	*Consumer Surplus Change*	*Undervalued Fuel Savings[23]*	*Net Welfare Change[24] (Net Revenues)*
	MPG	*Billions of 2000 $, Annually*		
No Policy, market driven implementation of emerging technologies				
no Opp. Costs	24.5 (28.5, 21.6)			
w/ Opp. Costs	23.6 (27.5, 20.5)			
$500 feebate, pivot points set to be revenue neutral for each vehicle type if no opportunity costs				
no Opp. Costs	26.6 (30.2, 23.7)	-$1.2	$3.4	$2.3
w/ Opp. Costs	25.4 (29.1, 22.7)	-$2.9	$3.4	$1.3 ($0.7)
Tradable CAFE with standards equal to previous pivot point				
no Opp. Costs	26.6 (30.2, 23.7)	-$1.2	$3.4	$2.3
w/ Opp. Costs	26.5 (30.0, 23.9)	-$3.2	$3.8	$0.6

Thus, part of the tradeoff for policy makers is to decide whether certainty about the costs of additional improvements to fuel economy is more important than certainty about the targeted fleetwide fuel economy. In this case, we only compared different opportunity cost assumptions; uncertainty over actual technology costs would generate similar differences in outcomes. The benefits are also uncertain—to the extent that consumers internalize fuel consumption costs more than expected, the net costs will be higher; if they internalize less than the first three years, the benefits would be higher. Factors like gasoline prices, interest rates, VMT, and others also affect the range of net benefits. Nonetheless, by implementing a market-based mechanism, policy makers and researchers would benefit from gathering actual cost data that could inform better target setting in the future.

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[22] This overshoots the social value, detailed in the next footnote.

[23] The difference between the NAS scenario for a 14-year payback, roughly $1418 per gallon saved per 100 miles, and the 3-year undiscounted payback scenario, in which consumers are willing to pay $671 per gallon saved per 100 miles.

[24] This estimate excludes other welfare effects like congestion, ancillary pollution, etc.

Revenue Neutrality and Policy Updating

Revenue neutrality is not necessarily an economically efficient feature. There may be some argument for mitigating the price impacts of CAFE regulation so that consumers are not discouraged from buying newer, overall cleaner vehicles, particularly if they do not take into account the full value of the fuel savings when they view the sticker price. Still, if an offsetting subsidy is justified, 100% rebating is unlikely to be optimal. That said, revenue neutrality is likely to be a politically desirable feature, implying no net fee payments from producers and no net subsidy payments from the Federal government.

An important concern for the feebate is that the pressure to maintain revenue neutrality through frequent updating (or though automatic output-based rebating of a fuel consumption fee) can invite gaming on the part of large manufacturers. Similar concerns can be raised for tradable CAFE credits if regulators respond to falling credit prices by ratcheting standards. If firms with major market shares recognize their influence on the updating process, they will have less incentive to reduce fuel consumption rates, thereby slowing the tightening of the standard (and/or the reduction of the rebate). If, on the other hand, the pivot point of a feebate does not move, the government will be paying net subsidies for vehicle sales as fuel economy improves. At the other extreme, one could set a fixed fee on fuel consumption rates, without any rebate or a very low pivot point, implying a net tax of vehicles. This alternative would raise revenue at the expense of consumers, who might also choose to delay purchases of newer (and cleaner) cars in the short run.

The preferred solution to this problem would be set a path of pivot points that, in expectation, would maintain revenue neutrality for the program over time. For example, if technical progress will likely lead to, say, a 2% reduction in fuel consumption rates per year, the pivot point could be set to increase by the corresponding impact on mpg. In this manner, if the path of fees were credibly fixed, auto manufacturers would be less tempted to manipulate the program for higher rebates.

Alternatively, one could plan a schedule of increases in CAFE standards in conjunction with trading and banking. This option mimics the feebate incentives and automatically achieves revenue neutrality over time. Essentially, the excess subsidies when fuel economy surpasses initially lower standards take the form of banked credits, and these offset what would be excess payments when tighter standards take effect.

Summary

It is easy for economists to recommend that CAFE credits be made fully tradable, across vehicle types and across manufacturers. Given any fleetwide targets that society demands, allowing trade in fuel economy credits will minimize the costs of meeting these targets. Since each manufacturer still has the option to continue as before and meet the standards on its own for each fleet, trading only occurs if it makes both parties better off. Manufacturers and their customers will benefit from lower costs, while the same environmental goals are met.[25]

The more difficult policy question is whether and how to raise CAFE standards or the incentives to surpass current levels. When the goal is reducing fuel consumption, taxes on gasoline tend to be much more efficient than mandating fuel economy increases, although the difference is significantly smaller when such mandates are implemented with flexible mechanisms.[26] The difference between fuel economy standards and a gasoline tax is exacerbated when incorporating the welfare effects of the rebound effect, like additional congestion and pollution, which increase with miles traveled. Even though the rebound effect itself is modest, the additional costs related to driving appear to be more important than those related to fuel consumption.[27] However, to the extent that consumers undervalue fuel consumption costs when they purchase vehicles, fuel economy policy is arguably the most appropriate response.

Furthermore, that policy response should generate a financial incentive—beyond what markets are willing to provide themselves—to offset the market failure. To provide additional incentives that are ongoing, adjustments to fuel economy and/or net revenue targets must be made in a manner that also provides good incentives. Having regulators (or Congress) regularly update standards invites more contention. Implementing feebates offers continual incentives for improvement. However, frequent updating can invite manipulation of the process by large manufacturers. Recognize the influence of their market power on average fuel economy and costs, large players in auto markets may prefer to drag their feet and slow the updating process, keeping standards lower and rebates higher. The preferred solution is rather to set in advance a path of pivot points that, in expectation, would maintain revenue neutrality for the program over

[25] We assume that the current trend continues, making overcompliance insignificant. Otherwise, trading could be combined with a formalization of the current average fuel economy as the new standard.

[26] Austin and Dinan (2003). However, they did not include other welfare effects.

[27] Fischer et al. (2004).

a reasonable time period. Alternatively, one could plan a schedule of increases in CAFE standards in conjunction with trading and banking, allowing manufacturers to smooth compliance costs over time and across fleets, much as with the feebate. This option automatically achieves revenue neutrality within the program over time.

In summary, finding the right standard—or the right price tag for fuel consumption—is a tricky problem with no clear answer yet in the current literature. However, given any standard, the case for allowing flexible, joint compliance is clear. The benefits are lower costs, a better distribution of efforts across cars and trucks and across manufacturers, and more transparency. These features should allow for better choices and better public debate in weighing the costs and benefits of fuel economy standards. Either tradable CAFE credits or feebates could be designed to effectively achieve these results, with little difference in the administrative costs. Tradable credits may be somewhat easier to implement as a regulatory modification, since they remain based in the current system. Feebates may be easier to design to reflect the problem of systematic undervaluation of fuel savings by consumers in a consistent manner over time. The main tradeoffs depend on whether for energy policy purposes it is more important to achieve specific fuel economy goals with certainty, or to limit the risks of unexpectedly high (or low) costs of additional fuel economy improvements. Politically, there may be the question of whether fuel economy targets or marginal cost targets are more acceptable to stakeholders. Economically, however, either flexibility mechanism, properly designed, can offer important improvements in incentives and cost savings over the current system, particularly when more ambitious fuel economy targets are being considered.

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NCEP Staff Background Paper –
CAFE Safety Valve

Overview:

As part of its recommendation for a significant increase in new passenger vehicle fuel economy standards, the Commission is proposing a two changes to the 30-year old CAFE program that are intended to lower the cost of higher standards to consumers and auto manufacturers. Similar to the "safety valve" provision included in the Commission's climate proposal, we envision a system in which manufacturers could purchase credits toward CAFE compliance from the government at a pre-determined price. The safety valve is in addition to another significant CAFE reform the Commission proposes — allowing manufacturers to trade credits with each other and across the light truck and car fleets — that would also increase the flexibility and lower the compliance costs associated with the current program.

Function of the Safety Valve:

The function of the proposed CAFE safety valve is precisely analogous to the function of the safety valve in a tradable permits system for greenhouse gas emissions. It trades certainty about future oil savings for certainty about costs, just as the proposed climate program trades certainty about future emissions for certainty about costs. As soon as the marginal cost of achieving the next increment of efficiency improvement across the fleet as a whole exceeds the safety valve price, manufacturers would begin purchasing credits from the government in lieu of making further technology investments. The appeal of the safety valve mechanism is that it helps move the debate beyond an unproductive and ultimately irresolvable argument about the cost of future technological change: if costs prove lower than anticipated, the safety valve is never triggered and desired standards are achieved. If, on the other hand, costs are higher than anticipated, a lower level of fuel economy improvement is achieved but society has not paid more for fuel savings than it was willing to when it adopted the policy in question.

Importance of the Safety Valve Price:

If a safety valve mechanism is added to CAFE, the price at which it is set, in combination with the level of the standards themselves, becomes a critical determinant of the overall stringency of the program. If the price is set too low, manufacturers will under-invest in efficiency relative to what is optimal from a societal perspective; if the price is too high, manufacturers may over-invest to meet CAFE standards — effectively paying more for fuel savings than was intended. This memo explores possible approaches to setting the safety valve price and finds that approximately $150 per mpg is likely to be justified based on an assessment of the costs of technologies available to improve light-duty vehicle fuel economy and/or taking into account the value of associated fuel savings.

Safety Valve vs. Compliance Penalty:

Arguably, the CAFE program already has a safety valve in the form of a monetary penalty for non-compliance that is currently set at $55 per mpg. The penalty is calculated by multiplying $55/mpg by the manufacturer's CAFE compliance shortfall (in mpg), multiplied by the number of vehicles sold. While some manufacturers of imported luxury or high-performance cars have routinely paid this penalty, domestic full-line manufacturers generally have opted to meet CAFE standards and avoid penalties out of concern that non-compliance could expose them to shareholder lawsuits. For this reason, the existing compliance penalty has not functioned to cap compliance costs for most major manufacturers and may not be a useful guide in setting the appropriate level for a safety valve intended to serve that purpose — indeed, preliminary analysis suggests that to function properly a safety valve mechanism, divorced from any stigma of non-compliance, would need to be set two to three times higher than the current penalty. Obviously, relevant statutes would also need to be amended to clarify that purchasing CAFE credits from the government, or from other manufacturers, is a legitimate compliance option and does not constitute a non-compliance penalty.

Setting a CAFE Safety Valve:

Two possible approaches that could be used to set the level of a CAFE safety valve are explored below. The first takes as a starting point the technology cost assumptions that various studies have used in arriving at estimates of cost-effective fuel economy potential. The second derives a safety valve price by assigning a dollar value to every gallon of avoided fuel consumption resulting from a given increment of mileage improvement.

Before proceeding it is worth noting two complexities inherent in applying either of these approaches. One is that the marginal technology cost associated with each additional increment of fuel economy improvement tends to rise: in other words, it is generally more costly to go from 32 to 33 mpg than from 22 to 23 mpg. A second complexity is that the additional fuel savings associated with each mpg increment in fuel economy diminish at higher levels of fuel economy. Thus, a 23 mpg vehicle saves 296 gallons of fuel over its lifetime (assuming it travels a total of 150,000 miles) compared to a 22 mpg vehicle, whereas a 33 mpg vehicle compared to a 32 mpg vehicle saves only 142 gallons over the same number of miles. As a result, the appropriate level of the safety valve using either of these approaches — whether selected on the basis of marginal technology cost or by assigning a value to avoided fuel consumption — will vary depending on where new fuel economy standards are set. Given these complexities, the Commission does not attempt to reach specific conclusions about the right figure for the safety valve price; rather the point of the brief analyses described below is to suggest a range that might be justified in concert with a CAFE increase on the order of 10 mpg.

a. Setting Safety Valve Based on Marginal Cost Technology Supply Curves

Past studies have come to a range of conclusions about how much fuel economy improvement might be achievable and cost-effective in the U.S. light-duty vehicle fleet. Their differing results have primarily reflected different underlying assumptions about the cost and effectiveness of the technologies available to increase vehicle efficiency, although different choices of discount rate and different assumptions about vehicle life and miles traveled also help explain the variation in results. In one respect, however, nearly all available studies have taken a consistent approach: they have defined the cost-effectiveness threshold for fuel economy improvement in terms of the point where discounted fuel savings over the life of the vehicle offset incremental vehicle cost. The presumption here is that cost-effectiveness, though perhaps not the only criterion taken into consideration in the regulatory process is likely to serve as the primary basis for any future increase in CAFE standards.

Once a standard has been selected on the basis of cost-effectiveness, the rationale for setting the safety valve price according to the marginal cost assumptions implicit in the cost-effectiveness calculation can be summed up as follows: In setting a new standard regulators have assumed that the marginal cost of reaching a particular standard is justified by the resulting fuel savings.[1] Put another way, if the regulatory process arrives at 34 mpg as the appropriate level for a new standard, the presumption must be that spending the $X required to get from 33 mpg to 34 mpg is "worth it." But what if regulators are wrong and the cost of improving fuel economy from 33 mpg to 34 mpg is in fact higher than $X? In that case, society would be over-paying to achieve a 34 mpg standard. The safety valve insures against this possibility. If set at $X, manufacturers across the fleet as a whole[2] will spend up to $X for an additional mpg of improvement, but no more than that. (By the same token, setting the safety valve at more or less than $X, creates the possibility that manufacturers will either under-invest or over-invest relative to what regulators have decided society should be willing to pay for the last increment of fuel economy improvement.)

Figure 1 shows marginal technology cost curves developed by the National Academy of Sciences for a 2002 report on the cost-effective potential for future fuel economy improvements. Each point on the graph shows the marginal cost at a given level of fuel economy to achieve the next increment of fuel economy improvement. The same numbers for representative levels of fuel economy are summarized in Table 1 for the NAS study's high, low, and mid-range technology cost scenarios.

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[1] In most studies, the value of avoided fuel consumption is defined by cost savings to the consumer and depends on the price assumed per gallon of fuel consumption. Some studies, however, have also added an externality figure to capture energy security, environmental, or other benefits associated with avoided fuel consumption. . The NAS CAFE study estimated an oil externality of 26 cents per gallon, while much higher estimates are made by those who include the strategic and military costs of oil consumption.

[2] It is important to keep in mind throughout this discussion that manufacturers would also be allowed under the Commission's proposal to buy and sell CAFE compliance credits from each other. Thus, a manufacturer would begin to buy credits from the government only when the price of surplus credits available from other manufacturers who might be in a better position to meet new standards rises to the same level as the safety valve price. This additional flexibility could significantly reduce compliance costs for individual manufacturers and (assuming that regulatory cost assumptions are not significantly off for the fleet as a whole) is likely to mean that those manufacturers who fall short of the standards pay something less than the safety valve price, on average, for the credits they need to demonstrate compliance.

Figure 1. Marginal Cost Curves from the 2002 NAS Study
(Note that High Cost/Low Benefit Case represents pessimistic technology assumptions; Low Cost/High Benefit Case represents optimistic assumptions)

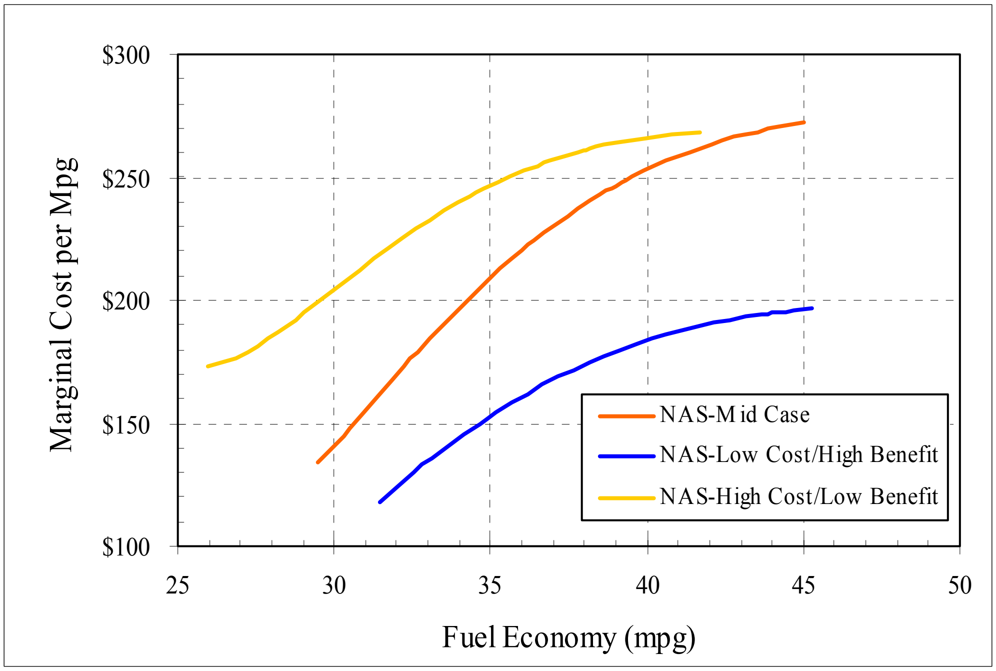

Table 1 – Selected Approximate Marginal Cost Levels from the 2002 NAS Study

Combined car/ truck fuel economy	Pessimistic Technology Case	Mid-range Technology Case	Optimistic Technology Case
25 mpg	$170	<$130	<$120
30 mpg	$210	$140	<$120
35 mpg	$250	$210	$150
40 mpg	$270	$260	$200

This analysis of the 2002 NAS mid-range technology cost assumptions suggests that — depending whether one assumes fuel costs of $1.50 or $2.00 per gallon — the fuel economy of the combined new car and light truck fleets could be cost-effectively improved to 31-34 mpg. If this finding were to serve as the basis for a 34 mpg standard, basing the safety valve price on expected marginal technology costs at that point would suggest a figure of $195/mpg. If one wanted to ensure that manufacturers paid no more than the amount implied by the NAS study's more optimistic low-cost technology case, the appropriate figure would be something closer to $145/mpg.

b. Setting the CAFE Safety Valve Level Based on the Value of Avoided Fuel Consumption

An alternative basis for calculating the appropriate level of the safety valve is to simply assign a value to each additional gallon of fuel consumption implied by falling short of applicable fuel economy standards. Under this approach, technology cost assumptions — while critical to selecting a particular standard — are not involved in determining the safety valve price. As noted earlier, fuel savings diminish for each incremental mpg of improvement at higher levels of fuel economy. Table 2 shows gallons of fuel saved over the lifetime of the vehicle for an incremental mpg of fuel economy at different levels of fuel economy from 24 mpg (the current combined new car and light-truck average) to 34 mpg. For purposes of the table, future fuel savings are discounted at a rate of 8% per year, vehicle life is assumed to be 12 years, and annual miles traveled are assumed to start at 15,000 miles for the first year and decline by 4.5% per year thereafter. The two right-hand columns of Table 2 show the value of avoided fuel savings assuming fuel prices of $1.50 per gallon and $2.00 per gallon, respectively.

Table 2 – Setting a CAFE Safety Valve Based on Value of Gasoline Saved per MPG

Starting Fuel Economy	**Discounted Lifetime Fuel Savings Associated with Next MPG Improvement in Fuel Economy** (in gallons at 8% discount rate)	**Value of Incremental Fuel Savings from Next MPG of Improvement at $1.50 per Gallon**	**Value of Incremental Fuel Savings from Next MPG of Improvement at $2.00 per Gallon**
24 mpg	162	$244	$325
25 mpg	150	$225	$300
26 mpg	139	$208	$278
27 mpg	129	$193	$258
28 mpg	120	$180	$240
29 mpg	112	$168	$224
30 mpg	105	$157	$209
31 mpg	98	$147	$196
32 mpg	92	$138	$184
33 mpg	87	$130	$174
34 mpg	82	$123	$164

Using this approach, the government could simply sell compliance credits based on its willingness to pay for avoided future fuel consumption. Assume, for example, that avoided fuel consumption is valued at $1.50 per gallon, that new CAFE standards are equivalent to combined car and light truck fuel economy of 34 mpg, and that a manufacturer needs to purchase additional credits to make up for a 3 mpg shortfall in meeting the 34 mpg standard (in other words, the manufacturer's fleet average is at 31 mpg). In this case, the average per vehicle shortfall in avoided lifetime fuel consumption across the manufacturer's fleet is 277 gallons (the sum of 98+92+87 from the table above). If the 277 gallon per vehicle shortfall is valued at $1.50/gallon, the manufacturer would have to pay $415.50 per vehicle in safety valve credits to make up the difference (or an average of $138 per mpg of shortfall for each vehicle).

(Note that while the above calculation is mathematically straightforward and accurately reflects the diminishing returns to additional mpg improvements at higher levels of fuel economy, it might be simpler for purposes of implementation to assign a single safety valve price per mpg of CAFE credit. In the context of a 10 mpg increase from current CAFE levels and assuming that most manufacturers will be able to at least partway meet the new standards, it might be reasonable to average avoided fuel savings over the last 4 mpg of improvement — that is from 30 to 34 mpg. Using the figures shown in Table 2, average per mpg fuel savings across this range are 95.5 gallons; valuing these fuel savings at $1.50 per gallon yields a per mpg safety valve price of $143.)

Impacts of the Safety Valve on Auto Manufacturers:

One of the generic advantages of a market-based, tradable credits program is that it makes the costs of achieving a given policy target transparent. Adding a safety valve to such a program provides the additional advantage of cost-certainty: the cost of the policy is not only transparent, it is capped. Importantly, however, neither of these mechanisms makes the policy costless. Thus, the starting point for debate concerning any fuel economy program is the decision that society is willing to assume certain costs in exchange for certain benefits (in this case, future oil savings). If, as the Commission believes, a substantial increase in existing CAFE standards is justified on a variety of public interest grounds and can be cost-effectively achieved in the sense that future fuel-savings can be expected — according to a number of technology assessments — to more than offset incremental, up-front vehicle costs, manufacturers will need to make substantial investments as a result. Adding the safety valve merely ensures that if those technology assessments prove unduly optimistic, manufacturer investment will be limited to the amount of fuel economy improvement that remains cost-effective.

It is important here to forestall the incorrect impression that any payments by manufacturers to the government for safety valve compliance credits represent an *additional* compliance cost. On the contrary, if manufacturers are purchasing compliance credits under the safety valve to meet a certain standard, it must be the case that absent the safety valve they would be spending *even more* to achieve the same standard. In other words, if regulators have correctly assessed technology costs, the safety valve neither reduces nor increases compliance costs compared to a tradable permits system without a safety valve. If, on the other hand, technology proves more expensive than regulators expect, then the safety valve reduces compliance costs compared to the alternative program with no safety valve. (In the event that compliance costs are lower than expected — which is perhaps the likeliest scenario of all, given the past history of automobile regulation — overall compliance costs are simply lower than expected and the safety valve has no impact.)

Fuel-Saving Technologies and Facility Conversion: Costs, Benefits, and Incentives

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November 2004

A report prepared for:
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Executive Summary

We, as others in the industry, predict there will be many more hybrids and advanced diesels sold in the United States in five to eight years from now, maybe as many as 1.8 million more. Given Japan's substantial technological and production lead in hybrids and Europe's lead in smaller displacement diesels, offshore-based automakers and suppliers are likely to make the majority of these vehicles and their powertrain components outside the United States. As a result, the United States stands to lose 38,000 to 207,000 jobs depending on the future U.S. market size of hybrids and passenger diesels. These job losses are characterized either as direct losses of existing jobs or as jobs associated with the overseas production of vehicles that will be sold in the United States to meet a growing market demand. To promote the U.S. production of hybrids and passenger diesels, we propose the development of a policy that would provide all automakers and suppliers—foreign and domestic—with a tooling and equipment investment tax credit to be used to convert existing U.S. facilities toward the production of hybrid and advanced diesel vehicles and components.

In this report, we examine the ramifications of a manufacturer tax credit that covers two-thirds of the tooling and equipment investment costs. Our analysis suggests that such a credit would cost the federal government about $1.1 billion over five years from 2005 to 2009. However, our analysis reveals that such a credit could:

- Position the United States to gain share in the hybrid and advanced diesel markets
- Cause half the powertrain components to be made in the United States rather than abroad, resulting in about 10 percent fewer jobs being lost
- Induce one-quarter of the hybrid and advanced diesel vehicles that would otherwise have been made in Europe and Asia instead to be made here, saving another 15 percent of jobs
- Save at least 27,659 barrels, ,and up to 117,265 barrels, of oil per day, assuming that fuel savings will not be cancelled out by manufacturers backsliding in other vehicle segments
- Recoup federal tax incentives over roughly 10 years through increased revenues and new jobs

We believe such credits would prove attractive to manufacturers despite the allure of offshoring labor because at least two-thirds of the value of vehicles and parts sold in the United States are made in the United States. Because this proposed tax credit policy would be made available to both foreign and domestic manufacturers around the world, we also think it is unlikely to run counter to international trade laws. Our research has convinced us that hybrids and advanced diesels will play a substantial role over the next several decades of the auto industry's evolution. A policy such as that proposed clearly states to the world's automakers and suppliers that the United States is seeking to build its capacity and capability in the vehicles of the future and that the U.S. Treasury is prepared to make it significantly less burdensome to do so.

1.0 Introduction

Raising the fuel efficiency of the U.S. light vehicle fleet is a critical strategic option to reduce both the United States' reliance on foreign oil and greenhouse gas emissions. There are numerous ways to raise fuel efficiency in the U.S. vehicle fleet, including making vehicles smaller, utilizing more lightweight materials, and developing more efficient powertrains[1]. The project reported here examines how we may convert motor vehicles and the industry that produces them to one of those alternatives, higher efficiency powertrains. This is a promising alternative to downsizing in terms of consumer acceptance and to major material substitution in terms of technical uncertainty and cost.

To help ease the transition costs to automakers in moving to a more fuel-efficient fleet, a number of stakeholders have proposed federal manufacturer tax credits. This report is intended to provide analysis that should inform and guide manufacturer incentive policies aimed at increasing U.S. production of fuel-efficient vehicles and the powertrain components they require. We provide such an analysis with the following three key objectives in mind:

- Provide incentives for capital investments in new tooling and equipment to convert existing facilities to the production of more fuel-efficient powertrains
- Benefit both automakers and their suppliers
- Cover a "substantial percentage" of the capital investment for vehicles or components that exceed some minimum performance criteria

We have chosen to focus our research on two specific fuel-efficient powertrain technologies: gas-electric hybrids and advanced diesels (HADs). We selected these technologies for three reasons: 1) both are currently in or close to entering the market, 2) advanced diesel vehicles are widely accepted in the European market, and gas-electric hybrids are gaining acceptance in Europe, Japan, and the United States, and 3) beyond incremental improvements to conventional internal combustion engines (ICEs), most analysts agree these two technologies are the most likely near-term solutions to fuel economy and emissions challenges. They have been proven effective and have fuel infrastructures already in place or readily adaptable for use. We hereafter refer to these hybrids and advanced diesels as HADs.

This report is built on separate but complementary analyses designed to answer two key questions. First, what is the potential opportunity cost to the United States in terms of jobs and economic development associated with the future U.S. market for more HADs? Second, what would be the cost of a policy that would effectively encourage U.S. and foreign auto manufacturers to locate new production at existing U.S. production facilities? To answer the first question, the analysis addressed three issues: (1) the likely size of the U.S. HAD market by 2009 and the probable location of production plants for components and assemblies, (2) economic development associated with location of HAD production plants, and (3) losses to U.S. auto

[1] Loosely defined, the powertrain of a vehicle is a label used to group those components that power a vehicle. Traditionally, powertrain components include the engine, transmission, drive axle, and other supporting power electronic subsystems such as an engine control unit. With new technologies such as gas-electric hybrids, motive power may also be provided by an electric motor, thus broadening this traditional component list.

manufacturing from displaced sales and U.S. production of traditional vehicles and their major powertrain components.

To answer the second question, the analysis also targeted three issues: (1) What are the necessary capital investment requirements for assembly plants and for component suppliers to produce HADs?; (2) Assuming a tax credit is designed to offset a "substantial portion" of this necessary capital investment, how quickly would the federal government recoup its investment through increased tax revenues?; and (3) What are the associated oil savings, assuming that manufacturers do not use the fuel economy improvements from these vehicles to offset relaxed fuel economy performance of other vehicles in their fleets?

2.0 Project Approach and Methodology

To conduct an opportunity cost analysis for the first question and the policy analysis for the second, we needed to complete several tasks. These included:

HAD Opportunity Cost Analysis

- Identify a set of fuel-efficient vehicles and illustrative technologies (Section 3)
- Develop market forecasts and explore their implications by production location forecast (Section 4)
- Identify the high-value add HAD powertrain components and provide estimates of their costs (Section 5)
- Develop estimates of the economic benefits and job effects associated with the production of these new vehicles using a broad U.S. economic model (Section 6)

HAD Policy Cost Analysis

- Estimate the potential oil savings associated with encouraging more fuel-efficient vehicles for our various market forecasts (Section 7)
- Estimate the investment required to convert existing powertrain component and assembly manufacturing facilities into HAD facilities (Section 8)
- Recommend effective policies to encourage U.S.-based HAD production (Section 8)

Brief descriptions and approaches for each of these tasks follow.

2.1 Opportunity Cost Analysis – Key Tasks

Fuel-Efficient Powertrains. In considering several fuel-saving technology alternatives, we have chosen to examine hybrids and advanced diesels as illustrative examples. Thus, our intent is not to pick technology winners or suggest that other fuel-saving technologies are not worthy of manufacturer tax credit incentives to encourage their development. Rather, we believe these technologies provide a useful framework for examining the challenges and the potential opportunity gains (or losses) to the U.S. economy associated with a shift toward more fuel-efficient technologies, particularly if the high value-added components and vehicles themselves are produced outside the United States.

Market Forecasts. To explore the potential economic impacts of increased demand for HADs, we develop a baseline and two additional market configurations, or market size and segmentation scenarios, for passenger cars and light trucks, and situate them in calendar year 2009. We believe 2009 allows for a useful analysis. By then, HADs are projected to experience significant increases in demand and availability, though their actual levels still could vary widely due to cost challenges and consumer demand uncertainties. In addition, we believe our analysis results for 2009 would be similar if such consumer purchasing shifts occur any time between 2009 and 2012.

Our 2009 baseline forecast takes into account our projections for the overall economy, as well as a variety of automotive specific factors including underlying consumer demand, shifts in product demand, new product introduction schedules, market shifts among the various manufacturers, and the most likely sales forecast of The Planning Edge.[2] In terms of sales, our 2009 baseline scenario projects that HADs will constitute approximately 2.7 percent of the light vehicle market, up from about 0.5 percent in 2003. This baseline scenario is largely driven by the manufacturers' interest and risk assessment in introducing various HAD technologies to meet their perceived expectation of consumer demand, or as part of their strategy for meeting and/or precluding additional regulatory requirements, such as higher Corporate Average Fuel Economy (CAFE) standards.

Our two additional market forecasts for 2009, which we label as Consumer Shift Low and Consumer Shift High, represent plausible, yet significant shifts in consumer behavior. The Consumer Shift Low forecasts an increase in the market share for hybrids and advanced diesels by approximately 2 percent each or nearly 7 percent total (from 2.7 percent baseline). Our third scenario involves increasing HAD market share another 2 percent each to approximately 11 percent. Any number of factors could account for these consumer shifts. Among them are higher sustained oil prices, greater consumer enthusiasm, or more desirable prices relative to other vehicles. HADs could even become style-lead vehicles, as happened with minivans and SUVs in their early stages.

Production Location. Based on our market forecasts by vehicle model, we also forecast the likely supplier production locations for the key HAD components we studied. These component location forecasts are largely based on where the full vehicles are likely to be assembled and on any historical sourcing patterns for the powertrain components. For example, if we forecast the addition of a hybrid option to a particular model that is currently assembled outside the United States and uses hybrid components produced outside the United States, we assume that this supplier location pattern will not likely change. In generating our production location forecasts, we classify by United States, Canada, Mexico, or Other (e.g., Europe, Japan, etc.).

[2] The Planning Edge is an automotive consultancy that maintains a database and forecasting tool for both U.S. production and sales. It is used by many automotive suppliers and has proved quite accurate. We rely on The Planning Edge forecast rather than developing some arithmetical consensus because its market forecasts can be tied to forecasts of production locations. In addition, one of the project's researchers, Alan Baum, is in charge of maintaining that database for The Planning Edge.

Our production location forecasts also are influenced by existing manufacturing operations. The Japanese manufacturers have led the way with sales of gas-electric hybrid models such as Toyota's Prius and Honda's Civic hybrid, while European manufacturers like PSA Peugeot Citroën and Volkswagen have led the way with advanced diesel models in Europe. As a result, most of the major gas-electric hybrid and advanced diesel components are produced outside the United States.

For example, hybrid components are largely produced in Japan by such companies as Aisin, Denso, and Panasonic. Advanced diesel components also are largely produced outside the United States by suppliers such as Bosch, Faurecia, and Siemens. Even suppliers with a large U.S. manufacturing capability, such as Delphi, produce the majority of their advanced diesel components outside the United States for European-assembled vehicles.

We should note that there is some U.S. production capability for advanced diesel components to support modest volumes of diesel exports (e.g., by DaimlerChrysler) and for medium- and heavy-duty trucks. It is an open question whether this production forms a basis for components for light-duty vehicles, given the largely differing manufacturers in the two vehicle markets.

Component Costs. For our opportunity-cost analysis, we obtained estimates for various component unit costs through a literature review and interviews. We interviewed manufacturers and a range of suppliers, making every effort to secure responses from suppliers that are major producers of key HAD components and systems. Altogether we were able to conduct face-to-face interviews and telephone surveys with 12 individuals representing 12 companies: four manufacturers, seven suppliers, and one forecasting/consulting firm.[3] We compared our interview findings to other sources to identify representative estimates of key hybrid and advanced diesel powertrain components.

We also explored various factors that could affect HAD component cost estimates. These include the powertrain configuration: the number of cylinders and displacement; the amount of electric power and system architecture for hybrids; planning volumes; whether the vehicle is a passenger car or a light truck; and, in the case of advanced diesels, which emission bin standard it meets. While these factors clearly are not all-inclusive, they provide a useful range for analysis purposes.

Economic Opportunity Gains/Losses. We then input our market forecasts, vehicle and component cost data, and production location forecasts into a broader economic model of the U.S. economy, known as the REMI[4] model. This model may be used to track economic effects for the total U.S. economy, and to explore them by region and industry, permitting an assessment of the direct and indirect economic effects of lost U.S. production of conventional gasoline

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[3] We also had more limited and focused conversations with experts who either would not, or could not, agree to a full interview.

[4] The model is built, maintained, and updated by Regional Economic Models, Inc. of Amherst, MA, under the direction of University of Massachusetts economics professor George Treyz. The project team wishes to acknowledge the contribution of REMI staffer Adam Cooper, who spent countless hours tweaking the model to incorporate our incessant changes as the project progressed.

internal combustion engines (ICEs). The model permits estimating the income, employment by industry classification, and fiscal effects of market shifts to HADs.

In assessing the potential opportunity gains and losses associated with a shift toward greater HAD vehicles, we examine the effects of both the addition of new vehicle components (such as hybrid batteries and electric drive motors), and the displacement of other existing powertrain component systems. For example, we assume that advanced diesels replace gasoline engines, and that power-split devices replace automatic transmissions in certain hybrid applications. In examining displaced components, we also estimate the effects for three states (Indiana, Michigan, and Ohio), as they account for nearly 50 percent of U.S. engine production and almost 88 percent of transmission production.

Although not explicitly modeled, we do explore two kinds of job loss. First, there is the actual loss of current jobs where the manufacturer of traditional vehicles and powertrain components fall as HAD sales rise. This could result either through a loss of U.S. vehicle assembly volume or displacement of current powertrain components such as conventional gasoline engines and transmissions. Second, there are the opportunity job losses if the United States fails to capture production for a growing HAD market share.

2.2 Policy Cost Analysis – Key Tasks

Fuel Savings. Next, we use our market forecasts to estimate the potential benefits in terms of fuel savings. Here, we apply conventional assumptions regarding typical usage and fuel savings for our various HAD types. We should note that while the purpose of the producer policy examined in this report is largely aimed at affecting production location sourcing decisions, the overall justification for such a policy is clearly related to the potential environmental benefits resulting from reduced fuel consumption and emissions. Hence, such a policy might incorporate a provision designed to discourage manufacturers from using the CAFE-positive performance of HADs to support increasing the CAFE -negative performance of other vehicles in their fleets.

Tooling and Equipment Investment Costs. Our next task involved estimating the tooling and equipment investment costs for converting existing facilities to HAD production facilities. As described earlier with obtaining component cost data, we used both a survey and a structured interview to identify the tooling and equipment investment requirements for key HAD powertrain component systems. Similar to component costs, these investments are highly dependent on numerous factors including production volumes and degree of automation. For purposes of our analysis, we asked interviewees to provide representative numbers based on past experience with both conventional production facilities and HAD production facilities overseas.

Effective Policy Recommendations. Using the various market volume and location forecasts, and the analysis of the economic effects of such forecasts, we conducted a policy analysis for a manufacturer tax credit. The capital investment tax credit we propose is based on the tooling and equipment investment information for converting existing automotive assembly and component plants into HAD production facilities. We use this investment cost data and our opportunity cost analysis to consider the potential costs and benefits to federal and state treasuries for greater U.S.

production of key HAD powertrain components and their assemblies. Hence, we put some parameters on the actual public cost of various conversion credits to accelerate production of HADs into U.S. manufacturing plants.

Figure 1 summarizes the data flow within our various tasks toward our policy analysis. In the following sections, we present the analysis and findings for each of the tasks.

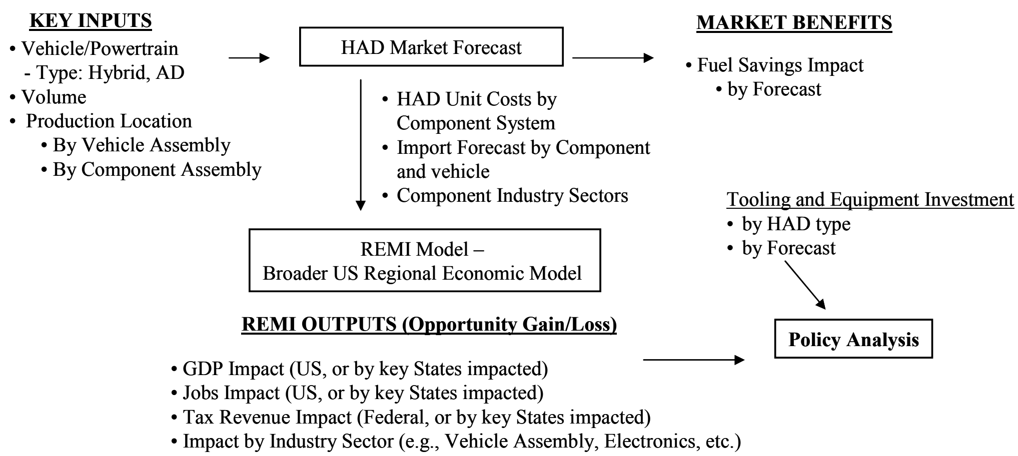

Figure 1. Project data flow chart

3.0 Gas-Electric Hybrids and Advanced Diesels

To effectively forecast and model the impact of hybrids and advanced diesels, we first stratified these technologies into subsystems. These subsystems provide high-level groupings to help distinguish significant differences in likely volumes, unit cost, or tooling and equipment investments. We use the following classifications for these subsystems:

- Minimal hybrid
- Medium hybrid
- Full hybrid
- Advanced diesels (Note: costs developed for three sample engine configurations)

We classify minimal hybrids, like the planned GM Silverado, as those that perform efficiently by using stop/start capability and regenerative braking, and require significant changes to the electrical system architecture (e.g., 42-volt versus 12-volt electrical system). These minimal hybrids typically boost fuel economy by approximately 10 to 15 percent. Some industry-specific names for these systems include Integrated Starter Alternator Damper (ISAD) and Integrated Starter-Generators (ISGs). Importantly, these hybrid types rely on the internal combustion engine to provide motive power and require fewer new components. Thus, they have lower incremental costs when compared with a non-hybrid option of the same vehicle model. We've chosen to include minimal hybrids in our report because the changes to the electrical system carry significant cost and because ISGs represent a major market introduction strategy by GM; however, not all analysts consider ISGs true hybrid electric vehicles (Lipman and Hwang, 2003). Similar to minimals, medium hybrids do not provide all-electric drive. These hybrids, like the Honda Civic hybrid, provide acceleration boost, rely less on their internal combustion engines, and can therefore perform even more efficiently. Medium hybrids generally utilize higher voltage systems and require larger electric motors and greater battery power (e.g., 144 V nickel metal hydride battery packs). These systems also require more sophisticated power inversion and control electronics. In terms of fuel economy, medium hybrids such as the Integrated Motor Assist system used by Honda may boost fuel economy by approximately 20 to 30 percent.

In comparison, full hybrids provide some all-electric power using electric motors. These full hybrid systems, such as in the Toyota Prius, are projected to be more costly than minimals or mediums as they involve more substantial changes in terms of the powertrain and electrical system architecture changes. However, they may boost fuel economy by 30 to 40 percent (Greene, Duleep, and McManus, 2004).

We should note that other hybrid technologies exist, and that yet others are still evolving. For example, systems have been developed to provide basic stop/start capability and electrical power to non-motive components. These systems may boost fuel economy by approximately 5 percent. However, they generally do not involve significant changes to the electrical system architecture and require less investment. In addition, there is not widespread acceptance among industry experts as to whether these systems should be classified as gas-electric hybrids. Thus, we do not consider them in this analysis.

In addition to hybrids, we also examine "advanced" or "clean" diesels. We use the term advanced diesels to represent diesel-powered passenger vehicles capable of meeting Tier II, bin 5 emission levels and which require the low-sulfur fuel due in the market in 2006 (Kliesch and Langer, 2003). We acknowledge that existing diesels do not meet these requirements, but we assume manufacturers will be able to meet these criteria by 2009 and beyond, at which time improvements in diesel fuel (i.e., lower sulfur content) and engine emission systems are assumed to occur. In terms of fuel economy, advanced diesels typically are 25 to 30 percent more fuel-efficient than the conventional engines they replace, but provide lower greenhouse gas benefits because of the higher carbon content in diesel fuel.

4.0 Market Forecasts

In this section, we present our market forecasts for calendar year 2009 that will be used to study the potential economic impacts of HADs. One challenge in developing such forecasts is vehicle weight classification. Most policies draw a distinction for light vehicles based on a Gross Vehicle Weight Rating[5] (GVWR) less than 8,500 pounds. This categorization is particularly important for an analysis of passenger diesel vehicles as the large majority of their existing applications is in vehicles with GVWR over 8,500 pounds. Table 1, below, indicates that approximately 95 percent of calendar year 2003 diesel sales were for such vehicles.

[5] Gross Vehicle Weight Rating represents the vehicle weight plus rated cargo capacity.

Similar to other studies, we have chosen to exclude sales of vehicles with GVWR greater than 8,500 pounds. In doing so, we are not suggesting that such vehicles have minimal economic impact or are unlikely or inappropriate candidates for the application of fuel-saving technologies. Clearly, tremendous opportunities exist for the increased use of advanced diesel and hybrid technologies for these applications. However, since our primary purpose is to examine the potential usefulness of manufacturing facility tax-credit incentives for producing light vehicles (passenger cars and light trucks) utilizing more fuel-efficient powertrain systems, we consider these particular vehicles outside the scope of this study.

Table 1. Diesel production and sales, 2003

	Units	% Diesels Sold	Vehicle models (*n*)	Avg. volume per model
US Diesel Sales	567,998		10	56,800
GVWR > 8500	538,114	95%	7	76,873
GVWR < 8500	29,884	5%	3	9,961

After excluding passenger vehicles with GVWR over 8,500 pounds, we project total U.S. sales figures for calendar year 2009 of 16.6 million, up from 15.5 million in 2003. Table 2 summarizes our HAD forecasts within these total market sizes, showing the number of CY2003 hybrids and diesels (none of which are "advanced" in 2003, but all of which are expected to be in CY2009), and projecting them for our three 2009 scenarios. Our first scenario calls for a penetration of 2.7 percent in a 16.6 million market (2.1 percent hybrids, 0.6 percent advanced diesels), the second for an increase in HAD market share to 6.9 percent, and, finally, a HAD share of 11.1 percent (6.3 percent hybrids, 4.8 percent advanced diesels). The development of the Consumer Shift Low and High scenarios is fairly straightforward. We consider a 2 percent increase in sales (or about 350,000 units) a consumer shift in demand. Thus, in our Consumer Shift Low scenario, we add 700,000 HADs (350,000 hybrids and 350,000 advanced diesels) to our baseline forecast. Thus, the Consumer Shift High adds another 700,000 hybrids, resulting in a total projection of 1.84 million HADs.

Table 2. U.S. market configuration forecasts for HADs

		Hybrids					
Market configuration	Units sold (in millions)*	Full	Medium	Minimal	Total hybrids	Diesels	Total HADs
2003	15.5**	24,627	22,897	0	47,524	29,884	77,408
2009							
Baseline	16.6	213,200	81,800	55,000	350,000	93,400	443,400
Consumer Shift Low	16.6	428,300	176,700	95,000	700,000	443,400	1,143,400
Consumer Shift High	16.6	670,380	252,620	127,000	1,050,000	793,400	1,843,400

* Excludes vehicles with GVWR > 8500

** ~70% are assembled in U.S.

Various other industry reports have made projections for the growth of hybrids and advanced diesels in both the relatively near term (2008-10) and longer term (2012-15). For example, in a study by the Oak Ridge National Laboratory, Greene, Duleep, and McManus (2004) forecast a hybrid market share of 2.5 percent (about 400,000 units) for 2008. In terms of diesels, the report cites a projection by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) of about 179,000 light-duty diesels (i.e., those with GVWR less than 8,500 pounds) in 2010, or about 1 percent in a sales market of 18 million). However, this same report projects a rapid increase thereafter. By 2012, they estimate hybrids at 10 to 15 percent and advanced diesels at 4 to 7 percent (or 14 to 22 percent HADs).

In comparison to these estimates, our baseline forecast is more conservative for both hybrids and advanced diesels, although within a reasonable margin of error. Similarly, our forecasts for the Consumer Shift Low and High scenarios, while possibly a stretch for 2009, also may be viewed as conservative relative to other projections. We forecast a HAD market share of 11 percent in our Consumer Shift High scenario which is toward the lower end of their 2012 projection (14 to 22 percent). Differences in forecasts are not surprising given the inherent risk and uncertainties of introducing new technologies with unknown consumer acceptance. Thus, we will summarize our economic analysis on a per-100,000-units basis to allow for some scaling to our various market projections, or to other sources.

In generating our market scenarios, we also provide forecasts for specific vehicles and/or market segments (e.g., midsize cars, crossover utility vehicles, etc.). These detailed forecasts are important to our analysis because they influence projections for the likely manufacturing locations of vehicles and their high value-added powertrain components.[6] Japanese manufacturing plants are currently the leading producers of small to midsize hybrids, and European assemblers have the lead in the production of diesel passenger cars[7]. U.S. manufacturers have some existing capability for advanced diesel trucks, though currently in the medium- and heavy-duty classifications. Thus, a consumer shift in demand toward midsize hybrid or advanced diesel cars would more likely be filled by imports versus an increase in advanced diesel light-duty pickup trucks.

The production location forecasts for vehicles and key powertrain components drive growth and/or shifts in jobs and income based on whether the production location is inside or outside the United States. We further distinguish production location outside the United States by Canada, Mexico, or Other (mainly Europe and Asia). We do this for several reasons. First, vehicles imported from within North America, whether Canada or Mexico, have considerably higher U.S. supplier content than vehicle imports from other countries. Thus, the potential economic multiplier to the United States is smaller for these vehicles. Second, the production location region of the major powertrain component systems shipped to vehicle assembly plants historically correlate with vehicle assembly location. In other words, vehicles assembled in North America are more likely to have high value-added powertrain components produced in North America. Furthermore, vehicles assembled outside North America in, say, Japan or Europe,

[6] High value-added powertrain components represent those components or modules supplied to vehicle assembly plants that reflect the large majority of the total unit cost related to our diesel and hybrid classifications. See the section in this report on Major Diesel and Hybrid components for a more detailed discussion.
[7] In Europe, diesels account for approximately 40 percent of passenger car sales.

traditionally obtain their high value-added powertrain components from manufacturing locations in their respective regions. For example, the high value-added components for the Toyota Prius, such as the battery and power split transmission device, are produced in Japan where the vehicles are assembled. Consequently, the potential economic loss associated with the displacement of a U.S.-assembled vehicle is higher if that import comes from outside North America, and we reflect this in our broader models of the U.S. economy.

In some instances, we forecast differences in the production region location of the powertrain components versus the vehicle assembly, i.e., we allow for imported components into U.S.-assembled HAD vehicles. While this may occur for either hybrids or advanced diesels, we consider it more likely in the case of advanced diesels and thus we project fewer advanced diesel *vehicle* imports relative to hybrid vehicles. One reason for this projection relates to current availability. Since more U.S. assemblers already utilize existing diesel engines and powertrain components for similar models sold in the European market, we would expect them to meet initial demand for specific vehicles (say, less than 30,000 units) using imported components from largely existing facilities. In the case of hybrids, which involves more new powertrain components, we predict that the production location of the high value-add suppliers will more closely follow the assembly location. Of course, if U.S. production volumes increase for component manufacturers either to supply a particular vehicle or a family of vehicles with similar requirements, this sourcing assumption may change. We explore this issue later in our tooling and equipment investment costs analysis and our policy analysis.

4.1 Hybrid Vehicle and Powertrain Forecast

In generating our forecasts, we classified hybrids into three categories: minimal, medium, and full. Recall that our minimal hybrid classification involves significant changes to the drivetrain power electronics, and that minimal hybrids are expected to boost fuel economy by 10 to 15 percent. This classification is important in considering our forecast as the total number of hybrid vehicles would be significantly higher if we included any vehicle using a basic hybrid-related technology such as start/stop capability.

Table 3 provides estimates for the number of U.S. hybrid sales and the projected number of vehicle models by type for our various market configurations. Through 2003, only three hybrid models have been sold (Honda Insight and Civic, and Toyota Prius). However, given the announced and probable future hybrid models, we expect a significant increase in this number from three to 18 by our baseline calendar year 2009 forecast. Our Consumer Shift Low and High forecasts project even larger increases, to 28 and 35 models, respectively. For these scenarios, we project that most of this growth will be toward full hybrids. These hybrids tend to have wider appeal across all major manufacturers whereas medium and minimal hybrids appear to be more manufacturer specific, with Honda emphasizing mediums and GM minimals.

Table 3. U.S. hybrid vehicle sales and number of projected models

Market configurations	Volume**	Hybrid vehicle models (*n*)*				Average volume per model	Engine Platforms	Average volume per platform
		Full	Medium	Minimal	Total			
2003	47,524	1	2	0	3	15,841***	3	15,841***
2009								
Baseline	350,000	11	3	4	18	19,444	15	23,333
Consumer Shift Low	700,000	17	6	5	28	25,000	23	30,435
Consumer Shift High	1,050,000	22	6	5	33	31,818	28	37,500

* 2003 actual sales; 2009 forecasted sales

** Composite of full, medium, and minimal

*** If exclude Honda Insight, average sales per model in CY03 was ~23,000

In April 2004, these three vehicles accounted for 6,700 sales in the United States, or half a percent of total light vehicles sold. These sales figures are more than twice those posted in April 2003.[8] Although we would not expect these growth rates to continue on a per-vehicle basis, we do forecast sales per-announced hybrid model to increase in addition to the number of model offerings with a hybrid option. Interestingly, if we exclude the Honda Insight, the average 2003 volume of the Prius and the Civic is approximately 23,000. Thus, our baseline configuration actually projects a slight decline in sales volume per model as nearly all manufacturers have plans to become "hybrid" producers. However, if a consumer shift toward more hybrids develops, we would expect the average volumes per vehicle model to reach closer to 32,000 units. We should note that a few of the models in our forecast share a common platform with another model. Thus, the table above also provides estimates of average volumes per platform. Although higher, we still expect average volumes to remain relatively low at 37,500 per platform.

Although certain vehicles, such as a Honda Civic (or Camry, if Toyota begins offering a full hybrid version), may sell in larger volumes (e.g., more than 60,000), we expect the majority of vehicles to have low to modest per-model sales volumes. These projections are significant because the leading Japanese OEMs currently are producing their hybrid versions of existing models outside the United States and likely would continue to do so given relatively modest growth forecasts on a per-vehicle model basis. Even in the case of vehicles with higher potential volumes such as the Camry, Toyota currently sources about 10 percent of its U.S. sales from Japan (Automotive News, 2004). Thus, we believe it is reasonable to expect that if Toyota begins selling a hybrid Camry in the United States, it still may draw initially from imports to meet demand because its manufacturing experience currently resides in Japan, both in terms of vehicle assembly and component production.[9]

Our projections by particular hybrid vehicle model nameplates are further detailed in Table 4. Here, we provide a list of likely candidates for hybridization in our Consumer Shift Low and/or

[8] From J.D. Power & Associates, U.S. Hybrid Sales History 2004.

[9] This projection is purely a speculation by the authors of this report and is not based on any discussions with representatives of Toyota.

High scenarios. This list is based primarily on announced (or likely) plans and current offerings. Our forecasts also provides for an "unassigned vehicle" category. Here, we project volumes for a market segment without assigning them to a specific vehicle nameplate.

Table 4. List of potential hybrid vehicles for Consumer Shift Low and/or High scenarios

Company	Type	Name plate (model)	Type	Segment	Baseline	Likely vehicle assembly location	Likey powertrain manufacturing location
Chrysler	Truck	Ram Pickup	MEDIUM	Pickup Truck	*	US	US
Ford	Truck	Escape	FULL	Crossover Utility Vehicle	*	US	US
Ford	Car	Futura	FULL	Midsize Car	*	Mexico	Mexico
Ford	Truck	Mercury Mariner	FULL	Crossover Utility Vehicle	*	US	Mexico
GM	Truck	Equinox	MINIMAL	Crossover Utility Vehicle		Canada	Canada
GM	Car	Malibu	MINIMAL	Midsize Car	*	US	US
GM	Truck	Saturn VUE	MINIMAL	Crossover Utility Vehicle	*	US	US
GM	Truck	Sierra	MINIMAL	Pickup Truck	*	US	US
GM	Truck	Silverado	MINIMAL	Pickup Truck	*	US	US
GM	Truck	Tahoe	FULL	Sport Utility Vehicle	*	US	US
GM	Truck	Yukon	FULL	Sport Utility Vehicle	*	US	US
Honda	Car	Accord	MEDIUM	Midsize Car	*	Japan	Japan
Honda	Truck	Acura MDX	MEDIUM	Crossover Utility Vehicle		Canada	Canada
Honda	Truck	Acura RDX	MEDIUM	Crossover Utility Vehicle		Canada	Canada
Honda	Car	Civic	MEDIUM	Small Car	*	Japan	Japan
Honda	Truck	Pilot	MEDIUM	Crossover Utility Vehicle		Canada	US
Mazda	Truck	Tribute	FULL	Crossover Utility Vehicle	*	US	US
Mercedes	Car	Mercedes S-class	FULL	Large/Luxury Car		Europe	Europe
Nissan	Car	Altima	FULL	Midsize Car	*	US	Japan
Toyota	Car	Camry	FULL	Midsize Car	*	Japan	Japan
Toyota	Truck	Highlander	FULL	Crossover Utility Vehicle	*	Japan	Japan
Toyota	Car	Prius	FULL	Small Car	*	Japan	Japan
Toyota	Truck	RX400H	FULL	Crossover Utility Vehicle	*	Japan	Japan
Toyota	Truck	Sienna	FULL	Van	*	US	US
Toyota	Truck	Tundra	FULL	Pickup Truck		Japan	Japan
Unassigned	Car	Crossover Utility Vehicle		Crossover Utility Vehicle		Non US	Non US
Unassigned	Truck	Large/Luxury Car		Large/Luxury Car		Non US	Non US
Unassigned	Truck	Midsize Car		Midsize Car		Non US	Non US
Unassigned	Car	Pickup Truck		Pickup Truck		Non US	Non US
Unassigned	Truck	Small Car		Small Car		Non US	Non US
Unassigned	Car	Sport Utility Vehicle		Sport Utility Vehicle		Non US	Non US

Note: * indicates vehicle in CY09 baseline forecast

The reason for an "unassigned vehicle" category is that in the event of an initial shift toward hybrids, we expect demand to be met by adding hybrid options to existing vehicle models. Thus far, the manufacturers that have announced hybrid plans have made the technology optional, rather than standard (Brooke, 2003). For instance, Ford and Honda chose to add hybrid versions to their existing Escape and Civic models rather than build entirely new hybrid-only models. GM plans to offer hybrid versions of its largest SUVs, like the Chevy Avalanche and Cadillac Escalade, starting in 2007 (Kiley, 2003). The Prius—a vehicle that is exclusively hybrid—appears to be the exception to this strategy, but going forward even Toyota will likely add hybrid options to existing nameplates rather than introducing new hybrid-only option vehicles.

We should further note that the intended volumes for these hybrid versions are expected to account for relatively small percentages of the total volume for a given vehicle model or nameplate. For example, the hybrid version of the Ford Escape is expected to represent only about 12 percent of total sales (about 20,000 of 165,000) (O'Dell, 2004). Thus, even in this unassigned category, we project that hybrid demand will be met largely by relatively low-volume hybrid options of 20,000 to 40,000 units spread over a number of vehicle nameplates.

Although it is difficult to predict actual hybrid options by vehicle nameplate, given Toyota's and Honda's current lead in hybrid technology, we expect that these volumes will likely be met by additional imports, at least over the next five to eight years. For example, increased hybrid demand would likely result in Honda providing Acura MDX hybrids to compete in the Crossover Utility Vehicle category. Of course, General Motors, Ford, and DaimlerChrysler could also increase hybridization, but given Toyota's and Honda's relative position in hybrid technologies, we believe they are more likely in the near term to be met by imports.

In terms of our economic opportunity cost analysis, the specific vehicle model and its assigned volumes are actually less important than the production location for full vehicles and key hybrid components. For example, in the case of Toyota, the number of hybrid vehicles that it would likely produce outside the United States is actually more important to our economic modeling of jobs and tax revenue than is the number of units for a particular nameplate.

Figure 2, below, displays the total hybrid sales forecast for each of our three scenarios and their projected market share. Again, we project total hybrid sales to rise from 2.1 percent in our baseline scenario (CY09-Baseline) to 6.3 percent in Consumer Shift High (CY09-High).

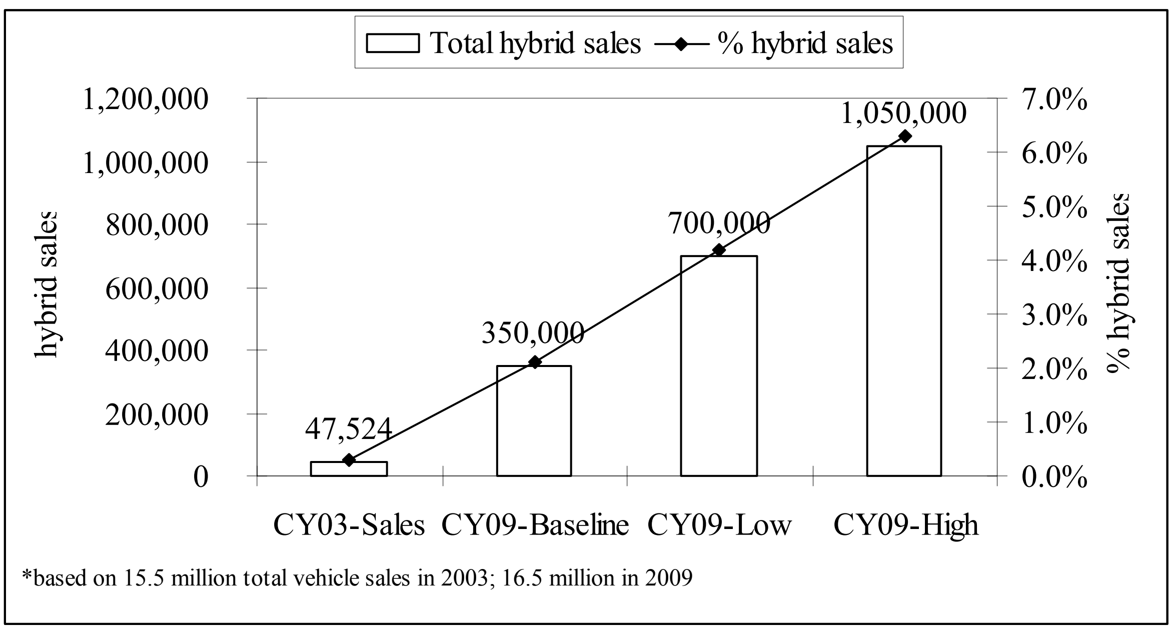

Figure 2. U.S. hybrid sales, 2003 and 2009 projections

Table 5 further stratifies the hybrid vehicle forecasts by their likely manufacturing locations (United States; Canada/Mexico; Other). We project that imported hybrid vehicles (from Canada, Mexico, or Other) will represent nearly 60 percent of hybrid sales in the 2009 baseline scenario.

More importantly, we forecast this import percent to increase to nearly 75 percent in the Consumer Shift High scenario. In particular, we forecast Toyota and Honda as the leading importers in a Consumer Shift High scenario based on their current positioning and hybrid production operations. While these manufacturers could shift some of their hybrid production to U.S. facilities, we predict they will initially meet most of this demand through non-U.S. production facilities. Based on analyses by The Planning Edge, these two manufacturers currently import over 1 million units for U.S. sales and some hybrid imports would likely offset other imports for similar models. In addition, several manufacturers are exploring the possibility of assembling gas-electric hybrids (Tierney, 2004).

Table 5. U.S. hybrid vehicle sales by likely vehicle assembly production location

	CY03 Sales		CY09-Baseline		CY09-Low		CY09-High	
	n	%	*n*	%	*n*	%	*n*	%
Total hybrid sales	47,524	100	350,000	100	700,000	100	1,050,000	100
U.S. assembled	0	0	150,000	43	217,500	31	271,500	26
Other assembled								
Mexico and Canada	0	0	10,000	3	30,000	4	46,000	4
Non-North America	47,524	100	190,000	54	452,500	65	732,500	70
Subtotal	47,524	100	200,000	57	482,500	69	778,500	74
Total	47,524	100	350,000	100	700,000	100	1,050,000	100

Although the Consumer Shift High scenario constitutes a significant total volume increase, we expect that the volumes per model will continue to remain relatively modest and probably insufficient to spur U.S. investment. We maintain that this trend is especially likely if Toyota, Honda, and perhaps Nissan capture the majority of this market because their component production facilities and manufacturing experience largely reside in Japan. Of course, historical patterns in terms of converting imports to U.S.-siting would suggest that if hybrid demand reaches higher levels (perhaps 100,000 units for a specific model or vehicle platform), then the percentage of U.S.-assembled hybrid vehicles would likely increase. A later section of this report explores the potential impact in terms of jobs and tax revenues should such scenarios materialize.

Some additional considerations in our hybrid forecasts relate to market segment mixes. In the case of hybrids, we project the majority of initial hybrid growth will occur in passenger cars (primarily small and midsize cars) and crossover vehicles like the Ford Escape (see Table 6). Here, we project that the majority of hybrids will fit vehicles with 4- and 6-cylinder engines and displacements in the 1.5 to 4.0 liter range.

Table 6. Hybrid forecasts by vehicle segment

		Calendar Year 2009					
	CY03-Sales	Baseline	Consumer Shift Low	Low vs. Baseline (Δ)	Consumer Shift High	High vs. Baseline (Δ)
Small car	47,524	53,000	98,100	45,100	149,180	96,180
Midsize car	0	142,000	253,400	111,400	342,520	200,520
Large/Luxury car	0	0	10,000	10,000	38,000	38,000
Total car	47,524	195,000	361,500	166,500	529,700	334,700
Pickup truck	0	25,000	55,600	30,600	100,080	75,080
Van	0	20,000	30,000	10,000	38,000	18,000
Crossover Utility Vehicle	0	85,000	218,500	133,500	325,300	240,300
Sport Utility Vehicle	0	25,000	34,400	9,400	56,920	31,920
Total truck	0	155,000	338,500	183,500	520,300	365,300
Total	47,524	350,000	700,000	350,000	1,050,000	700,000

The spread of hybrid volumes over many manufacturers and models reflects realistic market analysis, but it has a downside production corollary. While domestic production of hybrids increases across our three scenarios, the percent of total hybrids that are imported also increases. We believe that the market share for hybrids will be more concentrated at lower levels, perhaps leading to a fairly early production shift for one or perhaps two manufacturers. As the market for hybrids grows, additional sales will be more dispersed over models and manufacturers, and it could take considerably longer for another manufacturer to reach scale.

It is difficult to predict at what point any given manufacturer would bring hybrid production to the United States. Those with more flexible manufacturing capabilities may move production at lower volumes, fitting the hybrid line into an existing assembly plant with other vehicles. Others may need to wait until volumes grow substantially. But, in either case, the chance of production being U.S.-sited increases with higher volumes per model, especially if a comparable ICE model is already built in a U.S. facility.

Discussions with vehicle assemblers and component manufacturers suggest that shifting production to the United States is more volume-sensitive for components than for vehicles. In terms of plant tooling and equipment, adding a hybrid (or advanced diesel) option in a vehicle assembly plant is relatively minor relative to the total vehicle tooling and equipment cost. Body shop tooling and equipment costs represent the large majority of assembly plant tooling and equipment investment costs for a new vehicle model, particularly when a new model is added to an existing assembly plant. Thus, to add a hybrid version, assembly plants only need to allow for a few additional assembly stations and some increased logistical demands associated with multiple models. Still, plants routinely handle numerous vehicle options in their general assembly areas and thus this is not considered a major challenge.

In contrast, decisions by suppliers of key hybrid components about where to locate production facilities are more heavily influenced by sales volumes. For example, many hybrid component manufacturers have already established operations in Japan where most hybrid vehicles are assembled. As volumes increase initially, these manufacturers will likely expand capacity at those existing facilities, particularly if the vehicles continue to be assembled there. Some companies indicated that they would need U.S. production volumes (i.e., vehicle assembly orders) to reach 200,000 to 250,000 units before they would likely shift and/or expand production operations to the United States for their hybrid components.

However, these volume requirements are by component family (a collection of particular components for different models at one manufacturer), and not necessarily for a specific vehicle. Thus, U.S.-siting could occur faster if multiple vehicle models require particular components of similar specifications. For example, a particular nickel metal hydride battery pack might, with minor alterations, serve multiple vehicle models, either within or across vehicle manufacturers. For example, a hybrid battery for a Ford Escape may, with some minor modification, also be used for a Mazda Tribute. As the total U.S. volume requirements for a component family increase, the likelihood of investing in a U.S. production facility also would increase.

Although these consumer shift configurations forecast a large percent of imported hybrid *vehicles*, we do consider the potential impacts of hybrid *components* produced outside the United States, and assembled into vehicles in U.S. facilities. Section 6.0 provides estimates of the economic impact on a per-100,000-unit basis for the key components in the various hybrid classifications. These estimates may be used to assess the potential impact of losing high-value-added components regardless of their vehicle assembly location.

4.2 Advanced Diesel Vehicle and Powertrain Forecast

Again, we have chosen to exclude vehicles with GVWR over 8,500 pounds. Using this criterion, the number of diesels sold in the United States in 2003 was only about 44,000 units. These vehicles were largely sold by Volkswagen (Beetle II, Golf, and Jetta) and Mercedes (E-Class). Some additional models (e.g., Chrysler PT Cruiser and Mercedes M-Class) have diesel options that are assembled in North America but the cars are exported. These particular models are of interest to note as they represent likely candidates for future advanced diesel sales should significant consumer shifts occur.

Although we exclude vehicles with GVWR over 8,500 pounds, we believe it merits mention that several of them, including the Dodge Ram, Ford F-Series, and GM Silverado/Sierra, sell versions above and below the 8,500-pound cutoff. Interestingly, they all sell versions with GVWR above 8,500 pounds in a diesel option, but their models under 8,500 pounds all use conventional gasoline engines. Still, these models represent natural candidates for advanced diesels in light-duty truck applications.

Table 7 provides estimates for the number of advanced diesel vehicles sold for our various market configurations. In comparison to hybrids, our baseline forecast for advanced diesels is much lower, at 93,400 versus 350,000 for hybrids. In addition, while we expect a modest increase in sales from calendar year 2009 versus our baseline forecast, we expect only 27 percent of HAD vehicles to be assembled in the United States, with all of the engines imported. Even as the sales forecasts grow in the Consumer Shift Low and High scenarios for U.S.-assembled vehicles, we still project the majority of engines to come as imports (e.g., 62 percent of engines forecasted as imports).

Table 7. Advanced diesels sold in the United States

	Sales volume	Engine platorms (*n*)	Avg. volume per platform	Vehicles assembled and sold in U.S. (%)	with engines produced in U.S. (%)
2003	29,884	1	29,884	0	0
2009					
Baseline	93,400	9	10,378	27	0
Consumer Shift Low	443,400	28	15,836	43	33
Consumer Shift High	793,400	33	24,042	58	38

One reason for our lower projections for advanced diesels relates to our interview discussions. Manufacturers and suppliers are cautious with their advanced diesel projections partly due to concerns about the costs necessary to meet passenger-vehicle emission standards. Most diesel vehicles produced in the United States are work vehicles with over 8,500 GVWR and are not required to meet the stringent emission standards required of passenger vehicles. The "advanced" characterization of diesels in this study is associated with bringing diesel-powered vehicle emissions up to the emissions performance of gasoline-powered passenger vehicles. Of interest, while diesel passenger-vehicle manufacturers currently are not meeting advanced standards (e.g., Tier II, bin 5), there is general acceptance that these standards can be met, particularly with the expected rises in the quality of diesel fuel. However, the likely additional costs for diesels to meet future emission standards increase uncertainty in predicting consumer demand. In Europe, where diesel vehicles now represent over 40 percent of passenger cars, consumers face a wider gap in prices at the pump than do U.S. consumers, due to differences in European fuel taxes between diesel and conventional gasoline blends. This wider disparity in pump prices makes diesels more attractive when comparing their higher initial prices to their payback in fuel savings.

Interestingly, the challenge for current U.S. assemblers to increase their sales mix of diesel engines is probably less burdensome than in the case of hybrids. Diesels are variants of a known and well-understood technology and require comparatively less re-design effort than hybrids to "drop-in" or integrate into an existing vehicle platform. In addition, most vehicle manufacturers have diesel versions in Europe of similar U.S.-sold models. For example, the Opel Vectra sold in Europe shares a similar platform as the General Motors Malibu which is produced and sold in the United States. Thus, while our projections for advanced diesels in the baseline case are lower than for hybrids, the ability to quickly respond to consumer shifts in the near term is actually higher for advanced diesels.

Some important uncertainties related to advanced diesels are the likely production locations for vehicles and those key powertrain components that make them advanced, as well as the vehicle segments that they would likely target. In Table 8, we project that the number of diesel *vehicle* imports is likely to decline with increased volumes though *component* imports are expected to remain high, in contrast to our projections for hybrids where we project high imports for both cases. Again, a fundamental driver here is that many vehicles currently assembled in the United

States have similar diesel versions in Europe (at least more so than is likely to be the case with hybrids), and these vehicles can be made "advanced" by importing engines and components.

Table 8. U.S. advanced diesel vehicle sales by likely vehicle assembly production location

	CY03 Sales		CY09-Baseline		CY09-Low		CY09-High	
	n	%	*n*	%	*n*	%	*n*	%
Total advanced diesel sales	29,884	100	93,400	100	443,400	100	793,400	100
U.S. assembled	0*	0	25,300	27	188,800	43	462,320	58
Other assembled								
Mexico and Canada	29,884	100	49,600	53	109,200	24	156,880	20
Non-North America	0	0	18,500	20	145,400	33	174,200	22
Subtotal	29,884	100	68,100	73	254,600	57	331,080	42
Total	29,884	100	93,400	100	443,400	100	793,400	100

Note: There are U.S. built diesels that are exported

Another reason for forecasting more U.S.-assembled advanced diesel vehicles with imported components when compared to hybrids relates to our vehicle segment sales forecasts. Our interviews with manufacturers and diesel suppliers indicate that they expect stronger growth in the light-truck market (particularly sport utility vehicles and pickup trucks) for vehicles with 6- and 8-cylinder engines with displacements in the 4.0 to 6.0 liter range. Thus, for advanced diesels, we assign a significantly larger demand for pickup trucks and sport utilities (see Table 9) than for hybrids which we project as more proportionately passenger cars (reference Table 6 on page 15). Here, we consider U.S. vehicle assembly manufacturers better positioned to respond to future advanced diesel demand in this light-truck market, even if they import the key powertrain components. So, while we project nearly 74 percent hybrid vehicle imports in Consumer Shift High, we forecast 40 percent advanced diesel vehicle imports with 62 percent of the key components imported. Of note, since many European advanced diesels have strong brand recognition, we still would expect a significant level of imports (about 20 percent for Non-North America) to remain, even in the Consumer Shift High forecast.

Table 9. Advanced diesel forecasts by vehicle segment

		Calendar Year 2009					
	CY03-Sales	Baseline	Consumer Shift Low	Low vs. Baseline (Δ)	Consumer Shift High	High vs. Baseline (Δ)
Small car	29,884	46,000	75,000	29,000	98,200	52,200
Midsize car	0	0	85,000	85,000	159,720	159,720
Large/Luxury car	0	14,500	20,000	5,500	46,400	31,900
Total car	29,884	60,500	180,000	119,500	304,320	243,820
Pickup truck	0	0	75,000	75,000	175,000	175,000
Van	0	0	0	0	20,000	20,000
Crossover Utility Vehicle	0	10,400	65,000	54,600	102,680	92,280
Sport Utility Vehicle	0	22,500	123,400	100,900	191,400	168,900
Total truck	0	32,900	263,400	230,500	489,080	456,180
Total	29,884	93,400	443,400	350,000	793,400	700,000

4.3 Vehicles Versus Component Imports

While our projections for the number of advanced diesel vehicle imports are lower than for hybrids, we do expect a similarly high number of key component imports. For example, due to relatively low current U.S. diesel vehicle production, most existing advanced diesel components (such as engines, advanced turbochargers, and diesel particulate filters) are produced outside the United States for sale in other markets. In addition, even if volumes are shared across multiple vehicle lines, the total volumes for component suppliers still are likely to be insufficient for U.S.-siting as interviews with component manufacturers suggest they generally require volumes over 100,000 for engines and more than 200,000 for most other components to make an effective business case for retooling an existing facility or building a new U.S. facility. Of course, we recognize that these import trends, particularly for engines, could change if different assumptions are invoked (e.g., government incentives).

Table 10 displays our projections for the number of import vehicles and HAD components. By combining imported components for both U.S. and imported vehicles, we project that nearly 80 percent of our forecasted 1.8 million HAD sales will involve *imported* HAD components. The large number of component imports relative to vehicles is critical in our subsequent policy analysis as our manufacturing tax credit policy analysis would apply largely to component manufacturers where the large majority of tooling and equipment expenditures are necessary.

Table 10. HAD component imports versus vehicle assembly location

	CY03 Sales	CY09-Baseline	CY09-Low	CY09-High
Total HAD vehicles	77,408	443,400	1,143,400	1,843,400
U.S. assembled HAD vehicles	0	175,300	406,300	733,820
Imported components for U.S. vehicle assemblies	0	135,300	200,700	355,740
Non-U.S. assembled HAD vehicle imports	77,408	268,100	737,100	1,109,580
Total HAD components imported	77,408	403,400	937,800	1,465,320
% HAD components imported	100	91	82	79

5.0 HAD Major Components

In determining which components to include in our opportunity cost analyses, we first identified those key components or subsystems that define a hybrid or advanced diesel (i.e., which powertrain components are necessary in order for a vehicle to be described as a hybrid or advanced diesel). We further examined those components that carried a significant cost as they yield the majority of influence in economic modeling. In many cases, we tried to group various individual parts into major component modules or systems. These component modules or groupings made it easier for interviewees to estimate cost information. The lists below summarize these components (or modules):

<u>Gas-Electric Hybrid Components Studied:</u>

Full Hybrid Components

- *Battery.* The battery pack in a hybrid vehicle acts as an energy storage unit through which the generator stores energy and the electric motor draws energy. Batteries can be made from a variety of compounds, but nickel-metal hydride (NiMH) is the most widely used compound particularly for full and medium hybrids.

- *Electric Motors/Generators.* An electric motor/generator supplements the power provided by the internal combustion engine. The motor supplies power to the engine by drawing energy from the battery, and the generator returns power to the battery.

- *Power Control Unit.* The power control unit controls the power electronics of the system. For instance, it contains an inverter that converts DC from the battery into AC to drive the electric motor. Two common types of technology used in power electronics are Insulated-Gate Bipolar Transistors (IGBTs), which are often used in full- and medium-hybrids, and Metal Oxide Semiconductor Field Effect Transistors (MOSFETs), which are used in minimal hybrids.

- *Power-Split Device.* The power-split device in a full hybrid replaces the conventional transmission. The device acts as a gearbox between the engine, electric motor, and generator. It allows the electric motor and engine to power the vehicle separately or together.

Medium Hybrid Components

A medium hybrid involves many components similar to a full, including an advanced hybrid battery, motor/generator, and a power control unit. However, it requires lower performance levels (e.g., a smaller battery) as its components do not provide all motive power. One significant difference is that medium hybrids do not involve switching between electric motor and conventional drivetrain, and thus use a conventional transmission (as opposed to a full hybrid's power-split device).

Minimal Hybrid Components

A minimal hybrid uses even fewer and less sophisticated components. It essentially requires an integrated starter-generator (ISG), a power control system, and a small hybrid battery. The ISG replaces the conventional starter and alternator. It functions as both an electric motor to start up the combustion engine and as a generator to power non-motive energy-consuming systems such as lights, air conditioning, radio, etc. An ISG also allows the engine to shut off and start again at idle. It does not provide motive power.

Major Advanced Diesel Components Studied:

- *Base Engine.* We loosely have defined the base engine as the engine system, which is similar to a conventional gasoline engine, excluding its more sophisticated diesel fuel injection system and advanced turbocharger.

- *Fuel Injection System.* The two most commonly used injection systems are direct injection and common rail fuel injection. Both compress the fuel-air mixture so intensely that it combusts to provide engine torque.

- *Turbocharger.* Turbochargers are centrifugal compressors used to improve engine power by boosting the charge air pressure.

- *Aftertreatment System.* In addition to the base engine (see above), advanced diesels require an aftertreatment system to meet emission standards. These systems work to eliminate harmful diesel exhaust emissions by trapping and "cleaning" them. For the purposes of our study, we consider an aftertreatment system to include an oxidation catalyst, a diesel particulate filter, and a NOx adsorber. Filters particulate matter from the exhaust stream and then "clean" it through the oxidation of the captured particles. A NOx adsorber traps and adsorbs nitrogen oxides. Although numerous technologies exist for these aftertreatment systems, they all provide similar basic functions.

Given the wide disparity in specific hybrid and advanced diesel technologies used by manufacturers and suppliers, we identified basic specifications to obtain approximate cost estimates for key HAD components. We asked interviewees for estimates by hybrid type rather than by engine size. For full hybrids, we specified a 65 kW system with 300V; for medium hybrids, a 20 kW generator with a 144V electrical system. For minimal hybrids, we assumed the use of an 8 kW generator and 42V electrical system.

For our advanced diesel cost estimates, we identified three basic configurations: an I4 cylinder configuration with 2.0 liter displacement, a V6 cylinder configuration for a 3.0 liter engine, and a V8 configuration for a 5.3 liter engine, all with automatic transmissions.

We used these basic specifications to allow us to model some variation in cost by HAD type. Clearly, the specifications used across our various vehicle forecasts vary from these and thus our cost estimates should be viewed as more general than detailed. Still, since most of these components represent new technologies or have yet to be produced in large volumes, we believe that trying to identify cost estimates in greater detail would have been overly speculative and, in any case, unnecessary to perform our broader economic analyses.

In developing our cost estimates, we initially used existing literature and then confirmed the findings via surveys and interviews with knowledgeable industry executives. Each interviewee was asked to provide cost estimates for key HAD components from the standpoint of an assembler buying powertrains and components from suppliers. Hence our estimates include supplier profit margins as well as capital and manufacturing elements, but not necessarily markups between the vehicle manufacturer and end customer.

Tables 11 and 12, below, describe the cost of each HAD component and approximate costs for any traditional components being displaced. Not surprisingly, the NiMH battery has the highest hybrid component cost. This component cost is one of the biggest hurdles facing manufacturers and suppliers in creating hybrid appeal.

Table 11. Cost of hybrid components and displaced ICE components

Component system	Full	Medium	Minimal
Electric Motor/Generator	$ 900	$ 500	
Power Split Device	$ 1,000		
Displaced component (transmission)	$ (900)		
Power Control Unit (controller/inverter)	$ 500	$ 400	
Power Controls			$ 300
Integrated Starter Generator (ISG/ISA)			$ 750
Displaced starter alternator			$ (150)
Nickel-metal hydride Battery	$ 2,025	$ 1,725	$ 375
Total	$ 4,425	$ 2,625	$ 1,425
Net	$ 3,525	$ 2,625	$ 1,275

Table 12. Cost of advanced diesel components and displaced ICE components

	Cylinders		
Component system	3/4	5/6	8+
Diesel engine module			
Diesel base engine	$ 2,000	$ 2,400	$ 3,000
Displaced component (gas engine)	$ (1,000)	$ (1,200)	$ (1,500)
Turbocharger	$ 300	$ 310	$ 360
Fuel injection system	$ 550	$ 650	$ 750
Total	$ 2,850	$ 3,360	$ 4,110
Aftertreament system (with particulate filter and NOx reduction systems)	$ 900	$ 1,000	$ 1,100
Total	$ 3,750	$ 4,360	$ 5,210
Net	$ 2,750	$ 3,160	$ 3,710

Various other sources provide costs for hybridization or diesel engine options (e.g., Lipman and Delucchi, 2003; Greene, Duleep, and McManus, 2004; Science Applications International Corporation, 2003; Lienert and Lienert, 2004; and Markus, 2004). Not surprisingly, these sources often differ widely based on experiences of the interviewee, specifications used in estimating costs, and other assumptions related to production locations and volumes. Still, most sources predict incremental costs in the $2,000 to $4,000 range for hybrid or advanced diesel options versus the conventional applications they replace. Thus, we consider our estimates representative based on these sources, as well as our surveys, interviews, and private communications with industry experts. Most importantly, we believe our estimates provide a sufficient level of precision for the REMI model to effectively study the effects of HAD components at a fairly high aggregation level.

We should also note that our various survey respondents and interviewees often provided different estimates for the same components. This, of course, is not surprising given that neither manufacturers nor suppliers have significant pricing experience with many of these components. In addition, the costs associated with HAD production will almost certainly fall as the industry increases its volumes and gains production experience. Increased volumes almost always mean lower component and investment costs per unit, and continuous improvement efforts to lower costs with experience is typically a reality, not just an industry slogan. Still, since most vehicle manufacturers will have low HAD volume expectations, they still face major uncertainties in estimating the mature production costs.

Although we forecast low volumes for most specific vehicle models, we do expect some component manufacturers to capture scale economies in investment, materials, and manufacturing by spreading volumes over multiple applications (e.g., across different manufacturers or over multiple models within a manufacturer). HAD technologies are relatively new to the industry, and suppliers may well find opportunities to combine components into systems or modules that capture a higher value share and permit them to travel down the cost curve. The higher the value, the more readily a component can be exported, offering suppliers the opportunity to build volumes through supplying even one customer at multiple locations. And these are high-value components. Finally, simple part consolidation might let some suppliers gain a greater share of the HAD business and build their production volumes over multiple parts.

6.0 Domestic Economic Impacts

In this section, we now use our various market and production location forecasts along with the component cost estimates to examine U.S. economic impacts. Again, while we have chosen our consumer shift scenarios for calendar year 2009, we should recognize that this is primarily to allow for effective comparisons. We would expect the potential impacts in terms of jobs, tax revenue, and fuel economy to be similar if such consumer-purchasing shifts occur sometime between 2009 and 2012.

To understand and estimate the size of the economic impacts, we utilized a well-respected and often-used economic model from Regional Economic Models, Inc. (REMI).[10] The REMI model is based on the pairing of two complicated sets of data. The first is the latest version of the national input-output matrix that links the output of every final goods industry (e.g., cars and light trucks) with inputs from every other industry. The second is the latest edition of the Census of Transportation, which measures the flow of products into and out of the United States from and to any other country. By mating these two sources of information, REMI can answer questions such as "If more washing machines are made in the United States, how many more jobs will there be in the electric motor industry in North Carolina, and how much more state taxes will be collected there?" This modeling capacity is perfectly suited to our inquiry here: We want to know how much GDP, how many jobs, and how much tax revenue hinges on the U.S.-versus-non-U.S. mix of the HADs sold in the United States in and after 2009.[11]

We began by having REMI run baseline scenarios for 2003 and 2009. Because the industry groups that include the sectors making HADs and their components are sometimes part of broader industries (e.g., the electric motors used in full and medium hybrids are not the only electric motors, and electric motors dominate, but are not the only product in, motors for the sector SIC 362), the study team worked closely with REMI to customize the model to make it reflect what we knew about the current location of HAD- and other auto-related component manufacturing. Thus, while we have no idea where in the United States the power-split devices that replace conventional transmissions in full hybrids will be made (if they are made in the United States at all), we do know where current transmissions are made (e.g., 43 percent are made in Ohio). Thus, we know that if full hybrids take market share from conventionally-powered cars and trucks in 2009, Ohio is likely to lose out unless it can capture a like share in power-split devices (see Table 13). We also know that, because the vast majority of advanced

[10] Organizations such as the State of Michigan and various industry associations use the REMI model to understand the role of different industries in the economy of a state, region, or the nation and the effects of different policies upon them. OSAT has used the model on a number of projects for different clients.
[11] For the convenience of the reader, we have updated REMI's 1996 dollars to 2004:Q2 dollars using the U.S. DOC, BEA's GDP: Implicit Price Deflator series.

diesels sold in 2009 and beyond will replace gasoline engines, Indiana's dominant position in current diesels (68 percent) is likely to make it a winner *if* the advanced diesel share rises, and those diesel powertrain suppliers currently making components for vehicles with GVWR over 8,500 pounds expand their engine production capability for light vehicle application.

Table 13. Geographic distribution of U.S.-made vehicle and powertrain production, 2003

Location	Vehicles (%)	Gasoline Engines (%)	Transmissions (%)	2003 diesel engines (%)*	2009 diesel engines (%)**
Michigan	23.29	27.31	24.20	7.97	5.31
Ohio	15.86	19.75	42.99	12.04	8.03
Indiana	6.08	3.61	20.31	67.98	45.32
Total	45.23	50.67	87.50	87.99	58.66
Other U.S. Locations	54.77	49.33	12.50	12.01	41.34

*For vehicles less than 10,000 lb GVWR

**For vehicles less than 8,500 lb GVWR

Because the REMI model uses analogous functions for adding and subtracting U.S. production scenarios, we can interpret REMI results to tell us what the United States (and particular states) could gain from more U.S. production and what they stand to lose if that production is instead done elsewhere. Further, because the REMI model is linear in the relevant range, we may simulate the impacts per 100,000 units of vehicles, hybrid powertrains of various types, and advanced diesel powertrains. Thus, we may then think of the three different market configurations as scalars, or multiples, of these per-100,000 figures. Table 14 presents economic impacts on this per-100,000-unit basis.

To reflect the fact that vehicles assembled in Canada and Mexico contain, on average, much more U.S.-made-parts content than models assembled in Europe and Asia, we also have been able to make the REMI model distinguish between the impact of vehicles imported from our North American neighbors and those from elsewhere (see Table 14). For example, vehicles lost to Mexico or Canada represent about 10,600 jobs, whereas vehicles lost outside North America may result in about 21,000 fewer jobs per 100,000 vehicles.

Table 14. Economic impact per 100,000 units imported

	Vehicle Production		Hybrid Powertrain			Advanced diesel powertrains
	Non-North America	Mexico or Canada	Full	Medium	Minimal	
Gross Domestic Product ($04 millions)	2,296	1,148	462	344	168	367
U.S. Employment	21,270	10,635	3,219	2,375	1,188	2,141
Federal Tax Collections ($04 millions)	290.0	145.0	49.0	36.1	18.0	26.6
3-State Employment	6,959	3,485	193	365	158	633
3-State tax collections ($04 millions)	69.74	34.88	1.64	3.18	1.41	6.23

6.1 REMI Results for the Three Market Configurations

As explained earlier in this report, the study team has looked at three configurations of the 2009-and-later U.S. market for cars and light trucks with GVWR under 8,500 pounds. For each, we have made careful estimates of where both HAD vehicle assemblies and powertrains are likely to be produced. While the U.S. share of HAD powertrains is forecasted to rise from essentially zero today to roughly 40 percent by 2009, the 60 percent import share of these components is well above the overall import share, and thus poses a risk to U.S. production. Of even more concern, we forecast that the U.S. share of many vehicles containing HAD powertrains would be lower than that 40 percent.

Table 15, below, shows the economic impact of this anticipated rise in import HAD vehicles and powertrains. We believe that in 2009 the U.S. GDP would be from -$4.25 billion to -$22.77 billion lower per year, because relative to 2003:

- between 176,000 and 1,018,000 more HAD-equipped vehicles will be imported into the United States (i.e., full vehicle and HAD powertrain imported), and
- between 135,000 to 356,000 HAD powertrains-without-vehicles will also be imported.

While even the latter figure is a small proportion of a $12 trillion economy, it is not a small number in absolute terms, representing something like 38,000 to 207,000 U.S. jobs, between the Baseline and Consumer Shift High scenarios, respectively.

Table 15. Economic impact across three HAD scenarios

		2009			
	2003	REMI	Baseline (Δ)	Consumer shift low (Δ)	Consumer shift high (Δ)
Gross Domestic Product ($04 million)	$11,356.82	$14,022.37	$4.25	$14.37	$22.77
Federal Tax Collections ($04 million)	$2,226,575	$2,393,588	$523	$1,793	$2,829
U.S. Employment	165,493,953	175,501,969	38,046	131,039	207,055
3-State Employment	15,478,020	16,282,136	11,634	41,752	66,308

These employment impacts, and the resulting drop or lack of growth in federal and state tax collections, would furthermore be concentrated in the three states—Michigan, Ohio, and Indiana—that make a disproportionate share of cars, light trucks, engines, transmissions, and other auto parts. These three states today are host to 45 percent of U.S. light vehicle assemblies, 51 percent of gasoline and 88 percent of diesel engine production, and 88 percent of transmission production (reference Table 13 on page 25). Thus any large increase in imports, HAD or otherwise, would hit these states particularly hard, as shown in Table 16 (vehicles) and Table 17 (powertrains), below. Nearly one in three of the jobs that hang in the balance of the U.S.-versus-imported decision are represented in one of these three states. Their stake in a higher U.S. market share in HADs is thus obvious, even though they are unlikely to capture the same shares of HAD vehicles or components that they enjoy today in conventional vehicles and powertrains.

The job losses are large, ranging from approximately 38,000 to just over 207,000, depending on the market configuration. Again, these estimates include two kinds of job losses, the loss of actual existing jobs as traditional vehicle and component production falls in the face of increasing HAD production, and the opportunity loss, the failure to capture production and jobs associated with HADs. We explore this distinction at the end of this section.

Table 16. Job losses associated with vehicle imports by industry and location per 100,000 units

		Non-North American Full Vehicles			Canada/Mexico Full Vehicles		
SIC	Sector Description	U.S.	3 States	47 States	U.S.	3 States	47 States
371	Final assembly, ICEs, transmissions & power-split devices, most parts	3,603	1,581	2022	1,802	791	1,011
351	Diesel engines & parts	12	4	8	6	2	4
362	Motors	20	4	17	10	2	9
367	Electronics, including controller/inverter	128	9	119	64	5	60
369	Batteries, other engine electricals	28	5	23	14	3	12
	Subtotal	3,791	1,603	2189	1,896	802	1,095
	All Other Sectors	17,478	5,366	12112	8,739	2,683	6,056
	Total	21,270	6,969	14301	10,635	3,485	7,151
	% of Total		32.8				

Table 17. Job losses for powertrain imports by industry / location per 100,000 units

		Full Hybrids			Medium Hybrids			Minimal Hybrids			Advanced Diesels		
SIC	Sector Description	U.S.	3 States	47 States	U.S.	3 States	47 States	U.S.	3 States	47 States	U.S.	3 States	47 States
371	Final assembly, ICEs, transmissions & power-split devices	39	-75	114	14	1	13	7	1	6	-165	-116	-49
351	Diesel engines & parts	2	0	2	1	0	1	1	0	1	240	108	132
362	Motors	47	12	35	36	9	27	17	4	14	11	1	11
367	Electronics, including controller/inverter	296	25	271	226	19	207	110	8	102	71	2	69
369	Batteries, other engine electricals	65	15	50	50	12	38	24	5	19	16	1	14
	Subtotal	449	-23	472	327	41	286	160	18	142	173	-4	177
	All Other Sectors	2,770	216	2,554	2,048	324	1,724	1,028	140	888	1,968	637	1,331
	Total	3,219	193	3,026	2,375	365	2,010	1,188	158	1,030	2,141	633	1,508
	% of Total		60.0%	40.0%		15.4%	84.6%		13.3%	86.7%		29.6%	70.4%

Of interest, if the other 47 states would suffer less from more imported HADs, they also stand to gain much more than the three current core automotive states from more U.S. HAD production. Referring again to Tables 16 and 17, the 47 less auto-dependent states stand to gain between 70 and 94 percent of the jobs if more HAD powertrains are made in the United States. This simply reflects the current location of the facilities in the industries that include most of the other HAD powertrain components. For example, a higher proportion of power electronics jobs are currently located outside these three states, resulting in greater opportunity for job growth.

In short, the United States—and especially its three core auto states—faces large losses if many more HADs are sold in and beyond 2009 than today. The United States—and especially its 47 non-auto-producing states—could reap large gains if more of the HADs sold in 2009 have powertrains made in the United States. Beyond these powertrain jobs and their economic spin-offs lies the possibility that more U.S. production of these components could function as the "tail" that wags the "dog"—that by becoming a powerhouse in HAD powertrain production, global automakers might decide to assemble more HAD-equipped cars and light trucks in the United States as well. Since HAD powertrain component system jobs only represent 8 to 30 percent of the value of a complete vehicle[12], winning more U.S. production of the full vehicle has to be a high priority.

6.2 REMI Results: Opportunity Jobs versus Direct Job Losses

An increase in HAD vehicles and their associated key powertrain components could affect U.S. jobs in multiple ways. It could involve nothing more than "lost opportunity" jobs if future HAD market demand can be fully accommodated by the normal market growth expected between 2003 and 2009. Alternatively, actual job losses could occur if future HAD vehicle imports displace existing U.S.-made vehicles. Although it is difficult to predict the mix, we can offer some plausible scenarios and provide a spectrum of possibilities.

One scenario is that our future HAD import projections in the Consumer Shift High scenario may consist entirely of opportunity jobs (or lack of job increases). The number of imported HAD vehicles, even in the Consumer Shift High forecast, amounts to just about 1.1 million units (and 1.47 million key component sets as referenced in Table 10 on page 20). But 1.1 million units is relatively minor when compared to market growth and the current number of imports. Specifically, we expect the market to grow by over 1 million units by 2009, and U.S. sales already include over 4.5 million units from Canada, Mexico, and the rest of the world (Automotive News, 2004). Thus, one could argue that all of the jobs associated with HADs merely represent lost opportunity rather than loss of already existing jobs. Instead of importing about 29 percent of the vehicles sold here (4.5 out of 15.5 million) as it did in 2003, by 2009 the United States would import about 5.9 million (29 percent of 16.6 million, plus 1.1 million HADs), or about 36 percent.

But it is probably more plausible to expect that at least some HAD imports will displace actual jobs, and not merely reduce the opportunity for future U.S. jobs. Although determining the extent of displacement is speculative, a reasonable starting point would be to expect new HAD imports to displace vehicles in approximately the same proportion as the current sales/production mix. Thus, since about 70 percent of vehicles currently sold in the United States are built in the United States (Automotive News, 2004), we would expect about 70 percent of the losses to incur in the United States. On the other hand, since hybrids and advanced diesels are a growth segment, we believe this 70 percent figure is probably too high.

[12] While we have modeled a full vehicle at a value of three to 12 times that of a HAD powertrain, this datum is somewhat misleading. The typical U.S.-assembled car is only on the order of two-thirds American in value:

- Europe- and Japan-based automakers assembling cars and light trucks in the U.S. make some of their engines, most of their transmissions, and about half of their other parts outside the U.S.
- At least 20 percent of the value of the traditional domestic vehicles assembled in the U.S. by GM, Ford, and the Chrysler part of DaimlerChrysler is produced in Mexico, Canada, or offshore.

Another, less severe and arguably more plausible, scenario suggests that U.S. job losses could occur if growth is attributed to a shift in market share away from the traditional "Big Three." For example, our forecast of imported HAD vehicles projects a greater rise in hybrid sales for Toyota and Honda, and in advanced diesel sales for manufacturers such as Volkswagen and Mercedes. Given that these manufacturers already have HAD manufacturing capability outside the United States, it is plausible that these additional imports may start to involve U.S. job losses, particularly if sales are not large enough to justify U.S. expansion. If we consider our vehicle import forecast for these manufacturers and attribute volumes over 30,000 as likely candidates for U.S. job losses, we might predict that HAD growth will result in about 20 percent actual job losses and 80 percent lost opportunity jobs (i.e., absorbed by normal market growth or by displacing current imports).[13] This 20 percent figure is the one that the study team feels is the most credible estimate of actual job displacement.

7.0 Fuel-Saving Benefits

Although fuel savings would result from more hybrid and advanced diesel vehicles regardless of their production location, a manufacturer tax credit policy could also be viewed as a means to foster or accelerate a shift in U.S. HAD demand from say our Baseline to Consumer Shift High scenario, or to even higher levels as discussed earlier.

To estimate the potential oil savings associated with encouraging more fuel-efficient vehicles for our various market forecasts, we may apply some conventional assumptions regarding current fuel usage and expected improvements for the various HAD technologies considered. Regarding general fuel usage, we assume that the average light vehicle gets approximately 20 miles per gallon, is driven 15,000 miles per year, and has a useful life of approximately 120,000 miles. Determining the fuel saving improvements by HAD technology clearly depends on many factors including vehicle size and driving conditions (e.g., mix of city versus highway driving). Still, we may assume some standard improvements to estimate fuel savings. For our study, we assume a 10 percent fuel savings for minimal hybrids, 30 percent for medium, and 45 percent for full. For advanced diesels, we assume a 30 percent savings.

Using these assumptions, Table 18 provides an estimate of the oil saving benefits for our various market configurations. These estimates examine our market forecasts projected over a 10-year period from 2009-2018[14] relative to a fleet with no HADs over the same period. In addition, we assume that fuel savings for future HAD offerings will not be cancelled out by manufacturers backsliding in other vehicle segments. Based on these assumptions, the U.S. should save from four to 18 billion gallons (or 117,000 barrels per day) between our Baseline and Consumer Shift High scenarios.

[13] Actual job losses are estimated by using the total forecasted volume of HAD vehicles that are non-North American built, not made by the "Big Three," and have HAD volumes projected above 30,000 (~400,000/1,843,000 HADs).

[14] For estimation purposes, we assume a constant demand rate for the subsequent years beyond 2009, and that vehicles will cease to be driven after 120,000 miles.

Table 18. Estimated fuel savings with a HAD-enhanced fleet

Configurations modeled (2009)	HADs sold in U.S. per year: 2009-2018	HADs sold in U.S. per year: Over 10 Years	Fuel savings[*]: Billion gallons	Fuel savings[*]: Barrels/day
Baseline	443,000	4,434,000	4.24	27,659
Low	1,143,000	11,434,000	10.57	68,947
High	1,843,400	18,434,000	17.98	117,265

[*]Fuel savings vis-à-vis all ICE fleet over a ten-year period

In addition to the above mentioned fuel-saving benefits, we should recognize that hybrids allow for higher torque at low speeds (e.g., a 15 to 20 percent improvement). In some cases, we might expect manufacturers to even downsize an existing engine application with hybridization and still achieve performance similar to a larger conventional gasoline engine. Thus, even greater fuel savings than shown above could occur with engine downsizing (e.g., downsize a V6 conventional engine with a 4-cylinder full hybrid).

8.0 Investment Requirements and Policy Analysis

Americans generally recognize the environmental and security problems associated with our consumption of fossil fuels; however, there is less recognition that these problems could also lead to significantly reduced economic activity in the U.S. automotive industry.

We believe that there is a cost-efficient, effective policy initiative that can sharply increase HAD powertrain and HAD-equipped vehicle production in the United States. As discussed earlier, body shop tooling and equipment costs represent the large majority of assembly plant tooling and equipment investment costs for a vehicle model. Thus, in terms of examining the tooling and equipment investment requirements for more HAD powertrain production, we focus our analysis of the component requirements as a basis for a policy initiative. Of course, a policy to lower the investment risk for component suppliers also clearly benefits the manufacturers in terms of their costs to end customers.

For our policy analysis, we first need to estimate the tooling and equipment investment requirements for a conversion of existing component facilities to HAD facilities. Next, we examine the effects if a policy that could switch imports to the United States. Finally, we explore the timing of expenditures should the United States adopt such a policy.

8.1 Tooling and Equipment Investment Requirements

Recall that in our discussions with suppliers, the interviewees indicated that they would likely require that volumes reach 200,000 to 250,000 units to justify adding new production lines for components in the United States. These units would likely represent multiple customers or vehicles. Of course, manufacturers might begin adding U.S. capacity at lower volumes if they expect volumes to ramp up quickly. Tables 19 and 20 provide estimates of the tooling and equipment investment needed for 100,000 and 200,000 units of each component system. Collecting these estimates was challenging. Most of these components are not currently produced at high volumes, so our interviewees based their estimates on their experience with both conventional production facilities and HAD production facilities overseas.

Table 19. Estimated tooling and equipment investment for advanced diesel components (in 2004 millions of U.S. dollars at mature production levels)

	Number of units	
Component system	100,000	200,000
Motor/Generator	$ 20	$ 30
Powersplit Trans	$ 50	$ 90
Power Control Unit	$ 30	$ 50
ISG	$ 30	$ 50
Battery	$ 90	$ 160
Total (Full)	$ 190	$ 330
Total (Medium)	$ 140	$ 240
Total (Minimal)	$ 90	$ 153

Table 20. Estimated tooling and equipment investment for advanced diesel components (in 2004 millions of U.S. dollars)

	Number of units	
Component system	100,000	200,000
Engine	$ 65	$ 110
Fuel system	$ 50	$ 80
Aftertreatment system	$ 30	$ 50
Total	$ 145	$ 240

In Table 21, we indicate that the one-time tooling and equipment investment necessary to create capacity for 100,000 HAD powertrains using the HAD mix contained in our Consumer Shift High scenario is about $144 million. Clearly, this estimate provides an aggregate view of the required tooling and equipment investment requirements for modeling purposes. Actual cost could easily be higher as manufacturers would likely need to build initial excess capacity in anticipation of rising demand. In other words, if demand for a particular component across several manufacturers were only say 80,000 units, they still would likely invest in tooling and equipment capable of higher production levels. Thus, while our investment costs may not be accurate in a specific case, we believe they are sufficient to explore the potential benefits if the U.S. Treasury chose to enact a policy that would reduce such investments made to increase the U.S. stake in the production of future HAD powertrains.

Table 21. Estimated one-time tooling and equipment investment

60% Hybrids: Of which: 60% Full, 25% Medium, 15% Minimal	**40% Advanced Diesels:**
Investment Cost ~ $144 million per 100,000 HAD Units Note: ~ Weighted Average of 100K & 200K Units by HAD Mix	
Federal Treasury Opportunity Revenue (versus imported HAD powertrains) **~ $35 million per 100,000 HAD units** (weighted average of federal tax revenue)	

Table 21 also provides a weighted average estimate of having U.S.-built HAD components versus imported powertrains in terms of tax collection revenue. From our REMI results presented earlier, we may estimate the opportunity revenue in terms of tax collections for every 100,000 units at approximately 35 million. This revenue may be used to estimate the payback period in terms of years of production for a one-time investment in tooling and equipment capacity. Note, the opportunity revenue in this table is for the powertrain components only. In the next section, we consider the potential impact and policy payback for both powertrains and full vehicle assemblies.

8.2 Manufacturer Investment Tax Credit Policy Analysis

While we have not attempted in this study to address every possible detail of a manufacturer investment tax credit policy, we believe that we have explored it enough to satisfy ourselves, and hopefully our readers, that it can be designed in legislation and implemented in the real world. The policy would have the following key features:

- Producers of HAD powertrains and their identifiable components would be able to reduce their corporate tax liability by a certain percentage of their expenditures for the tooling and equipment (T&E) associated with launching or adding to HAD capacity.
- In order to avoid having the transition from conventionally- to HAD-powered vehicles add to the problem of excess capacity in the automotive sector, and to help address local concentrations of manufacturing job loss, the credit would be tied and limited to T&E investments made after a certain date in manufacturing facilities built prior to a specific date.

We leave it to the legislative development process to fill in full credit design details. What are important are the principles of tying tax relief to lumpy, easily measurable up-front capital outlays, and to induce both component suppliers and the assemblers they supply to prefer U.S. over non-U.S. production siting for their HAD capacity. Because *this credit would be available to any manufacturer, based anywhere in the world*, and because it does not favor companies currently operating in the United States over companies not yet producing here that could rent or buy existing factory facilities, it is likely not to run counter to international trade laws.

We believe that this approach should be attractive to all Americans that wish to reconcile the nation's interests in saving fuel and stemming manufacturing decline. Because these are both *public* interests even more than they are private ones, it strikes us as only fair that the federal government help to underwrite some of the cost of the transition to a more HAD-intensive U.S. capacity mix.

Whatever its details, the usefulness of a policy of this kind depends, of course, on the extent to which it actually causes component suppliers and assemblers to change their behavior; in this case, to produce in the United States more of the HADs they expect to sell in the United States. Much as we might like to treat this as a simple question with an easily researchable answer, it is not. Tooling and equipment costs make up no more than half, and usually less than that (perhaps one-fifth), of the total investment costs of launching new capacity. (The additional investment costs are for items such as research and development and product and process engineering.) Would a policy that promised to reduce these investment costs by, say, two-thirds—and therefore unit HAD costs by something between 5 percent and 15 percent—be enough to change producers' behavior? Would such a savings be enough to make up for labor costs in the United States that are multiples of those in Mexico, and an order of magnitude higher than in China?

We believe that such a policy could well be effective. Despite the apparent attractiveness of cheaper, non-U.S. labor, at least two-thirds of the value of the vehicles and parts sold in the United States are made in the United States. Despite market share losses in recent decades by the traditional Detroit-based automakers, there is more assembly capacity in the United States today than there was a decade ago. Automotive part-sector employment was essentially unchanged in 2003 from its 1978 peak, even as other sectors shed four million factory jobs in the same 25-year period. Europe-, Japan-, and Korea-based assemblers continue to add U.S. capacity, as do their foreign-based first-tier suppliers. A large and unyielding U.S. trade deficit may portend a lower U.S. dollar in the decade ahead, which may further tilt the economics in favor of U.S. production. Thus the question of a producer tax credit's effectiveness really comes down to whether, on the margin, tax relief for HAD-related investment makes it more likely that global automakers and their suppliers will place in the United States a larger proportion of their large, and growing, investment in HADs.

Our work for this study convinces us that HADs will play a large and perhaps fast-growing role in the next 10, 20, and 50 years of the auto industry's evolution. Even if we are wrong and a HAD producer tax credit policy has no effect on the absolute level of U.S. production or even production capacity, if it only makes more of the capacity *HAD capacity*, then it will still pay off. The United States will be a producer, and not merely a passive consumer, of vehicles embodying core advanced powertrain technologies. Such a policy states clearly to the world's automakers and suppliers: "The United States is seeking to build its capacity and capability in the vehicles of the future. It is your decision, but if you plan to build such vehicles, or supply automakers that plan to build them, then the U.S. Treasury will make it significantly less burdensome for you to do so."

Despite our conviction that a producer tax credit for HAD investment would be effective, we have no way to predict precisely *how* effective. We have chosen to model the impact of the credit on two assumptions:

1. It is set at the 67 percent level, so that the Treasury would reduce the tax liability of a manufacturer making eligible investments by two-thirds of their allowable tooling and equipment expenditures.
2. It is effective enough to induce 50 percent of the powertrains that would otherwise be imported from outside the United States instead to be produced here.

Because the REMI model is linear in the relevant range, it is a simple matter to think about the implications if the credit is, instead, set at 33 percent or 100 percent, rather than 67 percent, or if it is 25 percent or 75 percent, rather than 50 percent, effective. (The cost of the credit is likewise proportional to its effectiveness: If it is 100 percent rather than 50 percent effective, then its cost doubles, but so do its benefits.)

We must acknowledge, however, that as with all tax expenditure policies, some companies will be paid to make some investments that would have been made without a credit. This classic opportunism problem actually turns out to be something of an advantage in this case: Producers of HADs and their components are rewarded for their "base investments," increasing their ability and inclination to add on to existing investment plans and drive toward volumes at which economies of scale, which are needed to permit the unit cost reductions on which a larger HAD market share will depend, can be achieved.

Table 22, below, summarizes the credit we propose. Over the period of years—presumably 2005-2009—during which manufacturers would be investing $348 million to $1,599 million in the tooling and equipment with which to make more HAD powertrain components in the United States, the U.S. Treasury would forego $233 million to $1,072 million in corporate income tax receipts (67 percent of investment cost) in order to induce the switch of 201,700 to 732,660 HAD powertrains from imported to U.S.-made.[15] These switched powertrain components would cause the United States not to lose the 4,999 to 18,158 jobs that it otherwise would lose, at an apparent cost of just under $59,000 per job.[16]

[15] Careful readers will note that a comparison of Tables 10 and 22 suggests that a 50 percent effective powertrain credit would actually result in switching more than 100 percent of the powertrain component packages that would otherwise be imported. This reflects the fact, which we discuss beginning just after Table 22, that the credit also results in some full HAD vehicles being re-sourced from Europe and Japan to the U.S.

[16] Estimated by the cost to the Treasury of $1,072 million for 18,158 component-related jobs

Table 22. Powertrain component credit summary (in millions of dollars)

Configurations modeled (2009)*	HAD powertrain components** Planned U.S.	Switched to U.S.	US Jobs Gained***	Investment ($)****	Cost to treasury ($)****	Annual gain in revenue to treasury in tax collections ($)
Baseline	40,000	201,700	4,999	348	233	72
Consumer Shift Low	205,600	468,900	11,621	971	651	165
Consumer Shift High	378,080	732,660	18,158	1,599	1,072	259

*Based on powertrain components

**Per year over entire product lifecycle

***U.S. jobs gained due to switched HAD powertrins. Jobs assumed over entire product lifecycle.

****One-time investment spread over several years (2005-2009). Cost to treasury assumed at 67% of manufacturer investment.

As we noted earlier, there is a credible prospect that a larger U.S. role in HAD powertrain production could be the "tail that wags the dog," inducing some automakers to locate more of their HAD-equipped vehicle assembly here. Just as we illustrated the likely impact of our HAD powertrain component credit by assuming it would be 50 percent effective at inducing the switch of imported, we can gauge the potential impact of switched imported vehicles by assuming 25 percent effectiveness. (Readers may wish to double, or halve, the resulting impacts if they object to the 25 percent assumption.)

We assume that the vehicles switched are from outside North America, as it would largely be Europe- and Japan-based automakers that might be tempted by the emerging U.S. hybrid market and powertrain role. We recognize, however, that even switching such vehicles to the United States would not switch 100 percent of their content. Based on the fact that the 75 percent of light vehicles assembled in the United States by the U.S.-based manufacturers have approximately 80 percent U.S. content, while the 25 percent assembled here by foreign-based automakers have about 40 percent U.S. content, we get a weighted average content of 70 percent. We can apply this 70 percent to the 21,270 jobs the United States foregoes per 100,000 vehicles imported, yielding a content-corrected figure of 14,889.[17] Thus, in our Consumer Shift High scenario, switching 25 percent of the imports would equate to 41,301 jobs and an annual Treasury gain of $565 million (Table 23). In comparing potential job benefits for components versus vehicles (reference Tables 22 and 23), we may observe that switching even one vehicle in four results in about twice the number of jobs as does switching one of every two HAD powertrain component sets.

[17] It is not necessary to net out the weighted average 2,478 jobs per 100,000 powertrain packages from the 21,270 jobs per 100,000 vehicles. The 21,270 is for a conventional ICE-powered car or light truck; each 100,000 HAD vehicles are associated, on average, with 21,270 + 2,478 = 23,748 jobs.

Table 23. Economic effects by projected vehicle assembly location (in millions of dollars)

Configurations modeled (2009)*	HAD vehicle assembly switched**	Jobs gained***	Annual gain to treasury in tax collections ($)
Baseline	67,025	9,979	137
Consumer Shift Low	184,275	27,436	374
Consumer Shift High	277,395	41,301	565

*Based on HAD vehicles

**HAD assembly switched to U.S. assembly plants. Assume 25% of imports are switched.

***U.S. jobs gained due to switched HAD full vehicle assemblies (excludes powertrain jobs shown in prior table). Jobs assumed over entire product lifecycle.

Next, we consider the combined effect of a 50 percent imported powertrain and 25 percent imported vehicle switching over roughly the 10-year period that the powertrains and vehicles produced would result from a credit-induced investment. Under these assumptions, over 10 years, the net Treasury gain could be between $1.86 billion and $7.17 billion (see Table 24). In terms of jobs, the result would be to preserve between 14,978 and 59,459 jobs that would otherwise be lost to imported HAD vehicles and powertrain components. Instead of foregoing between 38,000 and 207,000 jobs (see Table 15 on page 26), with the credit the U.S. foregoes a much more modest 23,000 to 147,600 jobs, winning for the nation 15,000 to 59,500 jobs it otherwise would not have.

We should note that under a 50 percent switching of powertrains with only a 25 percent vehicle assembly switch, the U.S. could become a net exporter of HAD powertrains. We believe this is plausible when considering that we forecast around 200,000 HAD vehicles in Consumer Shift High to be assembled in Mexico and Canada and we would expect this number to increase more with U.S. HAD component production switching.

Table 24. Ten-year impact of producer credit policy (in millions of dollars)

Configurations modeled (2009)	10-Year gain in tax collections For Switched Components	Cost to treasury*	10-Year net gain For Switched Components	Additional 10-Year gain For Switched Vehicles	10-Year net gain Components + Vehicles	Jobs gained Components + Vehicles
Baseline	718	233	485	1,370	1,855	14,978
Consumer Shift Low	1,653	651	1,002	3,740	4,742	39,057
Consumer Shift High	2,588	1,072	1,516	5,649	7,165	59,459

*One-time investment spread over several years (2005-2009). Cost to treasury assumed at 67% of manufacturer investment.

8.3 Investment Timing Policy

The timing of investment policy is often important. By combining our investment cost estimates for each type of HAD and the Consumer Shift High market configuration, we may approximate an expenditures timeline based on reasonable assumptions related to how manufacturers would likely introduce fuel-saving powertrain technology options.

Figure 3, below, provides a projected timeline for investment expenditures based on the following assumptions:

- Most future hybrid and advanced diesel applications would be introduced as options to vehicles with conventional gasoline engines (e.g., Ford Escape).
- Expenditures for particular option applications would likely coincide with the launch year of a major model and/or platform change. Component tooling and equipment investment payments usually begin six to 18 months prior to the start of regular production, but final payments and investment costs often are not complete until the final six months.
- Expenditure level per 100,000 vehicles is approximately $144 million.
- Expenditures for projected switched HADs (as opposed to those already planned for U.S. production facilities) would have a lower policy usage rate. As discussed above, we assume a 50 percent policy usage rate in projecting expenditures.
- Although we chose 2009 for comparison purposes, recall that this introduction date is somewhat arbitrary and could as easily occur in 2010 to 2012. Thus, for the projected consumer shift in 2009, we spread its usage over 2009 and 2010 for illustrative purposes.

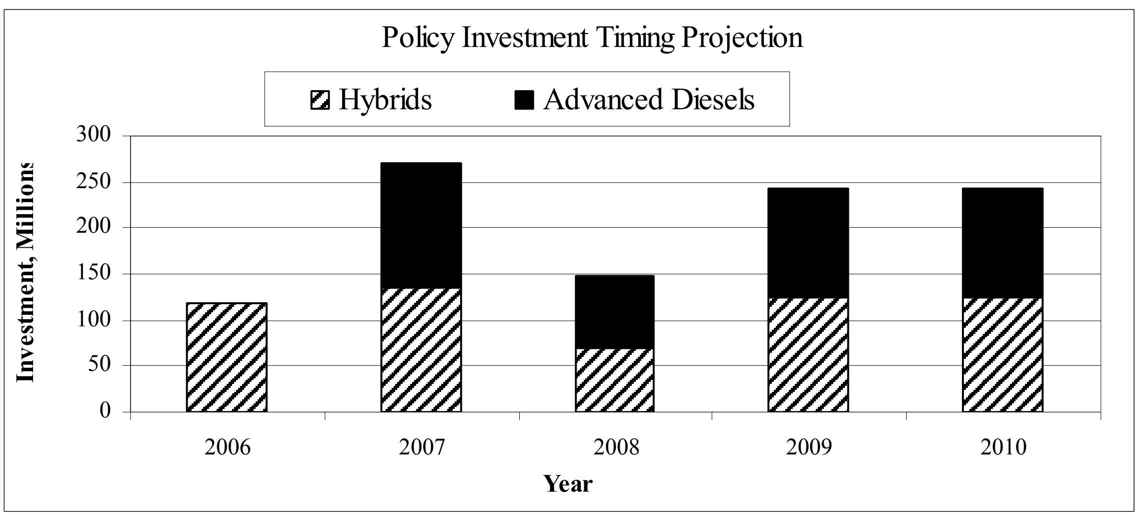

Figure 3. Timing of projected policy investment expenditures

Overall, we expect yearly expenditures from $300-$600M based on our above assumptions and current timing plans of new vehicle introductions for hybrids and advanced diesels. One should not react to the apparent dip in 2008 in the figure above. This simply reflects the fact that fewer actual vehicle announcements for HADs currently are scheduled for this calendar year. In addition, the larger expenditures in 2009 and 2010 simply reflect the typical time needed for developing production plans for new vehicle models. In other words, should a policy be enacted in 2005, we would expect that manufacturers would require a few years to ramp up to the levels of a Consumer Shift High scenario.

8.4 Policy Extension Considerations

We have studied the possible impact of a generous tax credit applied to the tooling and equipment investments associated with U.S. production of more hybrid and advanced diesel powertrains and their components that would otherwise be made in other countries. We estimate that between 5,000 and 18,200 jobs (see Table 22) would be preserved for component manufacturers by such a credit, depending on HAD market penetration late this decade. We have also estimated that, if such a policy also were to induce even one imported HAD vehicle in four instead to be made in the United States, an additional 10,000 to 41,300 jobs (see Table 23) could be saved, raising the total number of jobs preserved to between 15,000 and 59,500 (see Table 24).

If our assumptions are realistic, this would mean that roughly one in four jobs placed at risk by the rising import share likely to be associated with a rapid increase in HAD penetration could be kept in the United States rather than lost. We estimated this from our job preservations of 59,500 out of our total potential opportunity job loss of 207,000 in our Consumer Shift High scenario (see Table 15 on page 26). We also think, though we have not studied this closely, that many of the other jobs could plausibly be preserved if more vehicles could be switched to the United States where, after all, they are to be sold. There are, no doubt, a number of options for extending our approach beyond powertrains in an effort to induce more vehicle-switching. For example, the Treasury could offer automakers a credit for the total tooling and equipment investments in their *assembly plants* for a new HAD vehicle model if, and to the extent that, those plants make HAD-equipped vehicles. Since some of those plants might have full-hybrid vehicles achieving 40 percent better fuel economy that account for 50 percent of their output, while others might have minimal-hybrids achieving only 10 percent better mileage for 20 percent of their output, the credit should be scaled. The 50 percent full-hybrids plant might deserve a large percentage credit, while the 20 percent minimal-hybrids plant might rate a lower percentage credit.

In light of the cost-effectiveness of the proposed producer credit, it might also make sense to keep it on the books beyond 2009. The Oak Ridge National Laboratory study discussed earlier forecasts that HAD market share in the United States could be as high as 22 percent by 2012. Extending the credit by three more years could help shift more than a million more HAD powertrains annually to the United States than even our 2009 Consumer Shift High configuration. While the cost of the credit would rise from less than $1.1 billion to about $3.45 billion, the benefits in terms of U.S. jobs and long-term Treasury collections would amply repay the difference. In principle, policy makers could simply put the credit in place and have it expire in 2012 or when an agreed-upon level of "claims" against the credit (e.g., $2.5 billion) had been made.

Not only are the economics such that a producer credit of this type would prove over time to be revenue-neutral or better, we also believe that this is precisely the right moment to consider enacting such a policy. As Americans approach a second year of much more expensive gasoline, more of them than ever before are entertaining the possibility that prices may remain high. Residual values of low-mileage vehicles have dropped, imposing a negative "wealth effect" on their owners. There is bipartisan agreement that the gains to the United States in reduced oil imports, emissions, and greenhouse gases may justify tax-advantaging consumer decisions to purchase high-mileage HAD vehicles that, at current prices, many might not consider. Thus the odds of much higher U.S. HAD sales are clearly improving.

On the producer side, the technologies involved are still immature, favoring advanced-technology countries such as the United States, Japan, Germany, and France. Establishing a strong position early could help the United States capture R&D as well as manufacturing capacity. Japan, and especially Toyota and the companies working with it, enjoys a clear early advantage in some hybrid designs. Ford, which has courageously invested in the first full-hybrid SUV but had to go offshore for its key hybrid drive components, has publicly warned of the impact to the U.S. economy of our technical backwardness. Europe has a lead, though smaller, in the smaller diesel engines that will power sub-8,500-pound vehicles in and beyond 2009. But in both cases, there are capable U.S.-based suppliers looking for a signal, and customers waiting for those suppliers to wade deeper into the fray. Europe- and Japan-based auto suppliers have a large and growing U.S. presence that does not, but easily could, include HAD components. These suppliers, and others that will join them, *will* build these powertrains and their components ... somewhere. We believe that the producer tooling and equipment tax credit proposal we have evaluated would materially increase the proportion of that production that is done in the United States.

9.0 Conclusion

This report is explored two fundamental questions. First, what is the potential opportunity cost to the United States in terms of jobs and economic development associated with the future U.S. market for more HADs? Second, what would be the cost of a policy that would effectively encourage U.S. and foreign auto manufacturers to locate new production at existing U.S. production facilities? These questions resulted in an opportunity cost analysis which fed into a policy analysis of a proposed manufacturer tax credit incentive toward tooling and equipment investments in the conversion of existing facilities to produce hybrid and advanced diesel vehicle assemblies and components.

For our opportunity cost analysis, we forecasted a most-likely scenario for 2009 and then developed two contrasting scenarios that could represent 2009 to 2012. Our baseline scenario calls for a modest consumer interest toward HADs resulting in a forecast of just under 450,000 HAD-equipped light vehicles per year in a market of 16.6 million vehicles, compared with about 90,000 vehicles in 2003. We compare this with a significant, but not huge, consumer shift that increases HAD sales to some 1.14 million units. We then consider an even larger consumer shift, such as might result from sustained higher fuel prices, increased environmental concerns, and/or a generous consumer tax credit. In this high growth scenario, we explore the effects of HAD sales reaching 1.84 million units (or about 11 percent of the market).

While the United States would realize significant benefits in terms of fuel savings from such significant shifts toward these levels of HAD vehicles, negative economic consequences would occur if this demand were largely met by imports. Our forecast predicts that the first 700,000 additional HAD vehicles would likely be primarily imports, with an estimated 70 percent of hybrids and 55 percent of advanced diesel vehicles imported. Moreover, we predict that 82 percent of HAD powertrains will be produced outside the United States, and thus many U.S.-assembled HADs vehicles will still contain imported high value-add powertrain components. We forecast that the imported hybrids will come largely from Japan, and diesels largely from Mexico, and other non North-American markets (e.g., Europe). We further explore the effects of another 700,000 increment. Here, we believe that these vehicles would still be substantially import-supplied, but some automotive OEMs would begin building U.S. HAD powertrains and sourcing more vehicles from the United States.

These projections for increasing HAD sales could result in a loss (likely some combination of direct jobs and lost opportunity jobs for missed growth) to the United States of as many as 207,000 jobs and $2.8 billion per year in federal tax receipts. Moreover, job and tax losses would be concentrated, affecting some states much more than others. Three states (Michigan, Ohio, and Indiana) would be especially hard-hit.

These losses could be ameliorated by policies designed to encourage more U.S. HAD production. For example, a tooling and equipment investment tax credit for HAD components made in existing U.S. plants could help mitigate these potentially large and concentrated adverse job and tax effects. Indeed, the gains from higher HAD production would be spread quite broadly across the states.

Specifically, in the event of a major consumer shift that raises the HAD share from levels of less than one percent in 2003 to 11 percent by 2009, or about 1.8 million vehicles, a 67 percent investment tax credit that was 50 percent effective at switching projected imports to U.S. production would cost just under $1.1 billion spread out from 2005 to 2009. However, that credit could save almost 18,000 U.S. jobs and increase federal tax collections over a future 10-year period by almost $2.6 billion. If this same credit were also to have a positive effect on the production location of related HAD vehicle assemblies, the public benefits would increase substantially. For example, if it were effective at switching 25 percent of the projected vehicle assembly imports presented here, then the Treasury could, over the same 10-year period, gain an additional $5.65 billion in tax revenues and preserve an additional 41,300 jobs.

Appendix:

Project Team

This project is a cooperative one involving OSAT and the Michigan Environmental Council (MEC) represented by the Michigan Manufacturing Technology Center (MMTC) and The Planning Edge. Two groups guided the activities of the project. First, a working group was drawn from the above organizations along with other representatives from interested organizations. Second, a more formal advisory board of industry experts was organized as well. This board was comprised of representatives from two vehicle manufacturers, three supplier organizations, and one industry consultant. The authors wish to thank the members of this advisory board for their contributors and insights. We have chosen to leave their names off this formal report to protect their confidentiality.

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MEMORANDUM

TO: National Commission on Energy Policy

FROM: Robert R. Nordhaus
Kyle W. Danish

DATE: July 28, 2004

RE: Manufacturer Facility Conversion Credit -- International Trade Law Issues

---

The National Commission on Energy Policy is considering a Federal policy under which automakers and component suppliers would be eligible for a new facility conversion tax credit if they modify an existing U.S. manufacturing facility to produce advanced fuel-saving technology vehicles or components of such vehicles. You asked us to analyze whether such a policy implicates international trade laws and, if so, how the NECP should fashion the policy to avoid trade law problems. We assume for purposes of this memorandum that the facility conversion tax credit would be available not only to U.S.-based companies but also to foreign companies that own U.S. facilities.

As explained below, the tax credit would be governed by certain World Trade Organization (WTO) rules aimed at ensuring that government subsidies do not distort global trade. These rules allow a WTO member country to challenge another member's subsidy if the complaining member can demonstrate that the subsidy is causing serious prejudice to its economic interests. Whether the facility conversion tax credit would have such effects is questionable, because the major U.S. trading partners with companies in the automotive industry also have facilities in this country and therefore could benefit from the credit. In any event, even if the tax credit would have impacts on trade, it might be possible to design the credit so as to take advantage of a set of exclusions in the WTO rules.

I. <u>WTO Agreement on Subsidies and Countervailing Measures</u>

A. Background

As a government subsidy, the facility conversion tax credit is subject to certain WTO disciplines aimed at ensuring that such subsidies, and the countervailing duties that governments enact in response to subsidies, do not distort international trade. The primary set of disciplines on subsidies is the Agreement on Subsidies and Countervailing Measures.[1] The SCM Agreement establishes conditions under which a WTO member government may work through the WTO's Dispute Settlement Mechanism to impose a countervailing duty on imports from another WTO member. Only governments, not companies, can challenge subsidies under the Agreement.[2]

In addition, the SCM Agreement addresses only "specific" subsidies, *i.e.*, subsidies solely available to "an enterprise or industry or group of enterprises or industries . . . within the jurisdiction of the authority granting the subsidy."[3] If a subsidy is not "specific," it is presumed not to distort international trade.

The SCM Agreement establishes three categories of subsidies. Certain kinds of subsidies are *per se* prohibited – another WTO member state can challenge such subsidies without a showing of economic injury. Falling into this category are those subsidies that are contingent, in law or in fact, upon export performance[4], and those that are contingent, in law or in fact, on the use of domestic over imported goods.[5]

The second category comprises "actionable" subsidies. These are subsidies that may or may not be trade distorting, depending upon how they are actually applied. Actionable subsidies may be considered trade distorting by the WTO if they: (1) injure a domestic industry of the complaining member government; (2) impair tariff concessions and other benefits due to the other member under the 1994 General Agreement on Tariffs and Trade; or (3) cause or threaten to cause "serious prejudice" to the interests of the other member.[6] "Serious prejudice" may arise in any case in which one or more of the following conditions occur: (1) the subsidy impedes imports of a like product of the complaining member into the market of the subsidizing member; (2) the subsidy impedes exports of the complaining member from a third country market; (3) the subsidy results in significant price undercutting, significant price suppression, price depression, or lost sales; or (4) the subsidy increases the world market share of the subsidizing member in a

[1] Agreement on Subsidies and Countervailing Measures, *opened for signature* Apr. 15, 1994, 1869 U.N.T.S. 14 [hereinafter SCM Agreement or the Agreement] (entered into force Jan. 1, 1995). Under the Agreement, a subsidy exists if there is a "financial contribution by a government . . . where government revenue that is otherwise due is foregone or not collected (e.g., financial incentives such as tax credits) . . . and a benefit is thereby conferred."

[2] *See id.* at art. 1902. Note that the North American Free Trade Agreement (NAFTA) does not address domestic subsidies for manufacture of goods. It also does not establish a separate set of rules that apply countervailing duties. Rather, the NAFTA provides that each of its signatories may continue to apply its particular rules on countervailing duties – subject to the WTO agreements – but establishes an alternative mechanism for dispute resolution regarding such duties. *See* art. 1902.

[3] *See id.* at art. 2.

[4] See *id.* at art.3.1(a). An example of a dispute relating to a prohibited subsidy contingent on export performance is Australia – Subsidies Provided to Producers and Exporters of Automotive Leather (WT/DS 126/R). This dispute is not germane to the issues raised by the facilities conversion credit proposal, since the credit is not contingent on export performance.

[5] *See id.* at art. 3.1(b).

[6] *See id.* at art. 5.

particular subsidized product as compared to the average share.[7]

The SCM Agreement sets forth detailed provisions on how a complaining member must make these demonstrations.[8] In addition, the Agreement provides that a challenge to a subsidy must be terminated if the amount of the subsidy is *de minimis*, *i.e.,* if the subsidy amount is less than 1 percent ad valorem or where the volume of subsidized imports or the injury is otherwise negligible.

The third category of subsidies comprises "non-actionable" subsidies. This category encompasses subsidies that are non-specific and subsidies that fall into any one of three sub-categories: (1) assistance for industrial research and pre-competitive development activity; (2) assistance to disadvantaged regions within the territory of the subsidizing member; or (3) assistance to promote adaptation of existing facilities to new environmental requirements.

B. Implications of the SCM Agreement for the Facility Conversion Tax Credit

Because it is a tax credit that would confer a benefit, there is little question that the facility conversion tax credit is a "subsidy" under the SCM Agreement. In addition, it is "specific" because it is – at least as proposed – tailored to a specific industry.[9] However, it is not clear that it would be invalidated under the Agreement.

Would the subsidy result in distortion of trade? First, the facility conversion tax credit does not meet the description of a "prohibited" subsidy. Thus, the tax credit is either an "actionable" or "non-actionable" subsidy. Assuming for the sake of argument that the subsidy is "actionable," the question arises whether it would result in any distortion of trade – and, thus, whether any country could mount a successful challenge to it. Unlike, for example, recently-disputed U.S. subsidies for steel or cotton, the facility conversion tax credit would benefit not only U.S. companies but also European Union (EU) and Japanese companies that have U.S. facilities. For some of these companies, sales of products from their U.S. facilities already exceed those from their home-country facilities. For this reason, it might be for difficult for the EU or Japan to demonstrate that the tax credit has resulted in a more than negligible harm to its economic interests. In addition, the EU and Japan might forgo a challenge to the subsidy for

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[7] *See id.* at art. 6. Under certain circumstances, "serious prejudice" is deemed to exist and the burden shifts to the subsidizing member to prove otherwise. These circumstances are: (1) total ad valorem subsidization of a product exceeding 5 percent; (2) subsidies to cover operating losses sustained by an industry; and (3) subsidies to cover operating losses sustained by an enterprise. *See id.* at art. 6.3.

[8] *See id.* at arts. 11-23.

[9] Art. 2.1(b) of SCM Agreement provides that a subsidy is *not* "specific" if eligibility for the subsidy is subject to "objective criteria," which are defined as "criteria or conditions which are neutral, which do not favor certain enterprises over others, and which are economic in nature and horizontal in application." *See id.* at art. 2.1(b). Under a "plain language" interpretation, the facility conversion tax credit would seem to be characterized by such "objective criteria." However, it is our view that the credit likely would still be viewed as "specific" – at least as proposed – because it would be available only to enterprises in a particular industry. To this end, note that art. 2.1(c) provides that it is possible to challenge even a subsidy that meets some of the conditions of non-specificity if "there are reasons to believe that the subsidy may be in fact be specific" and that factors that may be considered in such a challenge are "predominant use by certain enterprises." *See id.* at art. 2.1(c).

environmental policy reasons because they may view a U.S. commitment to efficient vehicles as a welcome development.

Could the subsidy be designed so as to be "non-specific"? Assuming, for the sake of argument, that the subsidy *could* distort trade, one approach to avoiding application of the SCM Agreement disciplines would be to design the subsidy so that it is not "specific," *i.e.,* so that it is not solely available to a particular industry. This could be done by, for example, making the credit available to an enterprise in any industry to the extent that: (1) the enterprise manufactures a product subject to an energy efficiency standard and (2) the facility conversion would make it possible for the enterprise's product to exceed the relevant standard. However, establishment of such a broad-based credit program might not be affordable – or the credit might have to be set at such a low level that the program would have little impact. In addition, development and implementation of such a credit program could be administratively complex.

Another approach would be to keep the credit within the range of 10 to 20 percent of investment, so that it could be one of the many investment tax credits under the Internal Revenue Code. The investment tax credits under the current Code are 10% for certain capital investments in energy property, reforestation and rehabilitated buildings. (Rehabilitated historic buildings qualify for the 20% credit.)[10] While the types of investments are narrowly defined – for example, "energy property" is limited to solar and geothermal equipment and facilities – the credits cut across industry lines. They apply to electric power generation, the construction industry, and the forest products industry. An expansion of the investment tax credit to include the automobile industry arguably does not convert the multi-industry credit into a specific subsidy.

Could the subsidy be designed to be de minimis? Even if the tax credit were considered "specific," it might be possible to design the credit so that it was *de minimis* in the sense of the SCM Agreement, *i.e.,* so that the subsidy amount would be less than 1 percent ad valorem. Under the SCM Agreement, the value of tax-related subsidies is determined by calculating whether the amount of the tax credit is less than 1 percent of the value of the product – where the value of the product equals the total value of the recipient firm's sales in the fiscal year in which the tax-related measure was earned.[11] If the credit were scaled to stay within the 1 percent ad valorem safe harbor, any challenge to it would be required to be terminated.

Could the subsidy constitute assistance for adaptation to environmental requirements? Another option would be to use the tax credit to assist automakers in adapting to new environmental requirements. Under such circumstances, the tax credit – even if "specific" and non-negligible in amount – could fall within the category of a "non-

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[10] *See* I.R.C. §§ 46-48 (1986).

[11] *See* SCM Agreement, *supra* note 1, at Annex IV, para. 2. A different rule, which relates to subsidies for a particular product appears in paragraph 3 of Annex IV. That rule bases the ad valorem calculation on sales of the particular product rather than on the firm's overall sales. Further inquiry is required to determine which rule applies to a tax-related subsidy for a particular product.

actionable" subsidy. To qualify for this exclusion, the subsidy would have to be designed to "promote adaptation of existing facilities to new environmental requirements imposed by law and/or regulations which result in greater constraints and financial burden on firms."[12] In addition, the tax credit policy would have to:

> (1) be a one-time non-recurring measure;
>
> (2) be limited to 20 percent of the cost of adaptation;
>
> (3) not cover the cost of replacing and operating the assisted investment,[13] which must be fully borne by firms;
>
> (4) be directly linked to and proportionate to a firm's planned reduction of pollution, and not cover any manufacturing cost savings which may be achieved; and
>
> (5) be available to all firms which can adopt the new equipment and/or production processes.[14]

This exclusion might be applicable if the credit were designed to help automakers address the financial burdens resulting from, for example: (1) more stringent fuel economy standards for motor vehicles or (2) an "upstream" cap on the carbon content of transportation fuels that increases motor fuel prices and, in turn, necessitates increased capital investment to produce fuel-efficient vehicles.

At least two issues arise with this approach. First, it is unclear whether the use of the word "constraints" in this provision implies that the environmental requirements in question must apply *directly* to the facilities. If so, then the subsidy might not qualify for the exclusion if the environmental requirements take the form of an upstream cap because such a requirement would not directly regulate automakers. Second, even if regulation need not be direct, policy-makers might establish an upstream cap at such a modest level – *e.g.*, a level corresponding to a 5 cent/gallon increase in the price of gasoline – that the WTO would determine that the requirements do not cause a significant enough "financial burden" to justify adaptation assistance in the form of a subsidy.

III. Conclusions

As explained above, the proposed facility conversion tax credit might implicate the WTO SCM

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[12] *See id.* at art. 8(c).

[13] The phrase "replacing and operating the assisted investment" is undefined, but presumably deals with costs of operation, maintenance, and ultimate replacement after a period of use, of the facilities that were constructed or improved by the subsidy.

[14] *See* SCM Agreement, *supra* note 1, at art. 8(c).

Agreement. However, it is not clear that any the principal governments involved (the EU countries and Japan) could sustain – or would even bring – a challenge to the tax credit. In addition, it may be possible to fashion the credit so as to avoid application of the SCM Agreement, (1) by making the subsidy non-specific (either by applying it to all consumer products subject to efficiency standards or folding it into the existing investment tax credit), (2) by keeping it within the *de minimis* range, or (3) by coupling it with new regulatory requirements.

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Memorandum

TO: National Commission on Energy Policy

FROM: Robert R. Nordhaus

DATE: August 16, 2004

RE: Facility Conversion Tax Credit – Usability Issues

One option the National Commission on Energy Policy is considering is a Federal income tax credit for refitting existing manufacturing facilities to produce high-efficiency automobiles and components for such automobiles. An important issue that arises in the context of this and similar proposals is whether structural limitations embedded in Federal tax law will limit the ability of manufacturers of vehicles and components to use the credit. This memorandum reviews these structural limitations, their effect on the automobile industry, and the options for making such a credit more useable by the companies most in need of it.

The Facility Conversion Credit Proposal

The UAW, the Energy Future Coalition ("EFC"), and others have proposed a facility conversion tax credit to provide incentives to vehicle and component manufacturers to refit existing manufacturing facilities to produce high-efficiency automobiles. In concept, these credits would be investment tax credits that are based on a percentage of taxpayer investment in specified equipment and facilities.[1] Assuming that this credit follows the model of the existing investment tax credit provisions of the Internal Revenue Code of 1986 ("Code" or "IRC"), a number of significant limitations on the allowability of the credit would apply. These are spelled out below.

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[1] EFC proposal for example provides:

> Automobile manufacturers and component suppliers are eligible to receive a facility conversion tax credit for capital investment to re-equip or expand an existing manufacturing facility to produce components specially designed for those vehicles. The amount of the credit would be set as a substantial percentage of the capital investment directly related to production of vehicles (or components for vehicles) that meet statutory performance criteria. The credit should be increased for facilities that produce vehicles (or components for vehicles) that exceed the performance criteria. A facility that produces both advanced vehicles and conventional vehicles would receive credit for the portion of the investment attributable to production of advanced vehicles.
>
> In order for the manufacturing credit to be fully effective as an incentive, alternative minimum tax relief will need to be provided, or a transferable tax credit (or similar mechanism) must be provided.

ENERGY FUTURE COALITION, CHALLENGE AND OPPORTUNITY: CHARTING A NEW ENERGY FUTURE, at 48 (2003).

Investment Tax Credit Limitations
The investment tax credit is one of 18 business tax credits that are allowable against regular income tax otherwise payable by corporations and other business taxpayers.[2] (These credits include, among others, the renewable energy production credits, solar and geothermal tax credits, alcohol fuel credits and enhanced oil recovery credits.) The investment tax credits under the current Code are 10% for certain capital investments in energy property, reforestation and rehabilitated buildings. (Rehabilitated historic buildings, however, qualify for a 20% credit.)[3] The types of property are narrowly defined – for example, "energy property" is limited to solar and geothermal equipment and facilities.[4] Under current law, the use of the investment tax credit and most other business credits is constrained by a number of important limitations:

(1) Limitation Based on Amount of Tax. – The long-standing general rule under the Code is that business tax credits (which include the investment credit) may not exceed 25% of regular tax otherwise due.[5] Thus, a taxpayer who has no tax liability because of an unprofitable year will be unable to use the credit in the year in which it is earned. In addition, if the taxpayer reaches the 25% limit through use of other credits, the additional facility conversion credit will not be useable in the current year. The Code, however, provides for a 1-year carryback and a 20-year carryforward that mitigate the impact of this limitation.[6]

(2) Alternative Minimum Tax. – The alternative minimum tax ("AMT") provisions of the Code[7] impose a supplemental tax on taxpayers who make intensive use of tax preferences, such as accelerated depreciation, percentage depletion, intangible drilling costs, and certain tax-exempt interest. The business tax credits generally are not allowable against AMT.[8] Thus, to the extent a company pays AMT rather than regular tax in a taxable year, under the Code's general rules, an investment tax credit will not provide it any benefit in that year. However, carrybacks and carryovers may be available, and the Code provides exceptions for certain favored credits.[9]

(3) Other Limitations. – The "recapture" rules permit the IRS to recover all or part of the investment tax credit if the property is sold or otherwise ceases to be used for the purpose that qualified it for the credit.[10] In addition, the Code's "at-risk" rules limit the availability of the investment tax credit in cases where the property is financed with non-recourse debt.[11]

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[2] I.R.C. § 38(b) (1986).
[3] *See id.* § 46, 47, 48.
[4] *See id.* § 48 (a)(3).
[5] *See id.* § 38 (c)(1)(B). "Regular tax" excludes the alternative minimum tax and certain other special tax provisions. *See id.* § 26(b). The 25% rule does not apply to the first $25,000 of regular tax otherwise due.
[6] *See id.* § 39.
[7] *See id.* § 55, et. seq.
[8] *See id.* § 38 (c). The provisions of the Code that deal with the interaction of the 25 % limitation and the AMT limitation are complex and are not described in detail in this memorandum.
[9] *See id*. §38 (a)(3).
[10] *See id.* § 50(a).
[11] *See id.* § 49.

Applicability of Investment Credit Limitations to Manufacturers of Automobiles and Components

A preliminary review of financial reports of nine manufacturers of automobiles and components[12] indicates that net income for the U.S.-based companies (GM, Ford, and Delphi) and for Daimler-Chrysler has been highly volatile. All but Delphi were profitable, in 2003 but because of net operating loss (NOL) carryforwards,[13] several have no current tax liability.[14] In addition, because of carryovers of already-earned tax credits, several of them are likely to be unable to use new tax credits for some years to come. The foreign-based companies (other than Daimler-Chrysler) have been profitable on a worldwide basis in the last several years, but we are unable to determine from their financial reports what their U.S. tax situation is.[15]

This volatility of profits and tax liability, combined with the structural limitations on the investment tax credit described above, can have important implications on the usability of the proposed facilities conversion credit. Companies that have no taxable income in the taxable year in which the reconverted facility is placed in service will be unable to benefit from the facility conversion credit in that year (but may be able to carry it back one year, or forward for up to 20 years). In addition, profitable companies may not be able to use the facility conversion credit if other credits to which they are entitle use up their 25% limit. Finally, companies subject to AMT rather than regular tax generally are unable to use the credit against AMT liability.

Thus, absent a departure from certain of the generally applicable provisions of the Code, [16] the facility conversion credit may not be immediately useable by the principal U.S.-based companies or for Daimler-Chrysler. Arguably, the companies most in need of the tax credit – because their financial difficulties limit their access to capital markets – may be those least able to use it. For those reasons, the Commission may wish to consider modification of certain of the structural limitations that would otherwise apply to investment tax credits.

Options for Making Credit More Widely Useable

A legislative proposal to provide for a facility conversion credit can also include a proposed modification of the Code's current structural limitations on the use of the investment credit. But, because these limitations in many cases reflect long-standing tax policy considerations, any proposed modification will have to address these tax policy considerations and provide assurance

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[12] This information is derived from the most recent annual financial reports filed with the Securities and Exchange Commission by the following companies: General Motors Corp.; Ford Motor Company; Daimler-Chrysler; Honda Motor Co.; Toyota Motor Corp.; Aisin; Bosch; Delphi and Denso.

[13] I.R.C. § 172. NOL carryovers permit a taxpayer to reduce income and tax in a future year if losses in a prior year are unused. The effect of the NOL carryover on a company that has large losses is to push back the earliest year in which it has taxable income and the ability to use tax credits.

[14] General Motors had Federal income tax liability for 2003. Ford had loss carryovers. Daimler-Chrysler had worldwide tax liability; but its U.S. tax situation could not be readily determined from its financial reports, though it appears that it has substantial U.S. NOL carryforwards.

[15] The situation for companies based outside of the United States is further complicated by the operation of the foreign tax credit (I.R.S. §§ 27,901) and of tax treaties with Japan and the EU countries.

[16] The at-risk rules and recapture rules do not appear to be major constraints on the usability of the credits and do not require modification in that regard. However, the recapture rule may present some administrative problems in the context of the facility conversion credit, if eligibility for the credit is tied to performance of vehicles produced after the year in which the facility is placed in service.

that the modifications will not result in unacceptable revenue losses. A number of options to modify these rules are discussed below:

> Option 1: Modify 25% Rule. – The current rule limiting business tax credits to 25% of regular tax otherwise due could be modified to permit the facility conversion credit to be useable against a higher percentage – or all – of regular tax liability. This change would be useful to profitable companies that are constrained by the 25% rule, but will not help companies in financial difficulty until such time as they return to profitability and use up their carryovers.

> Option 2: Allow Credit Against AMT. – Current law could also be modified to permit use of the facility conversion credit as a credit against AMT as well as regular tax. This option – like the first one – will help profitable companies take full advantage of the credit, but will not be immediately helpful to unprofitable companies. In addition, it raises tax policy questions – the purpose of AMT is to ensure all taxpayers pay a minimum level of tax. However, there is ample precedent for proposing AMT relief.[17]

> Option 3: Refundable Credit. – One mechanism for making the credit useable to companies in financial difficulty is a refundable credit – that is, a tax credit that can entitle the taxpayer to a refund in the event the credit exceeds the tax otherwise due. There are several examples in the current Code of refundable credits available to individual taxpayers.[18] Refundable credits are available to corporations under the income tax provisions of the Code under limited circumstances—primarily where necessary to provide for refunds of overpayments of excise taxes.[19] Allowing the facility conversion credit to be refundable to corporate taxpayers is likely to be resisted by the tax committees and Treasury as an undesirable legislative precedent.

> Option 4: Transferable Credit. – Another option that could make the facility conversion credit more useable for companies that currently pay no tax is a transferable credit – *i. e.,* a tax credit that may be transferred by a company that is otherwise entitled to the credit, but unable to use it, to another company that is able to use the credit. This mechanism permits an unprofitable company to sell its credits to a profitable company at a price that reflects the value of the tax credit to the buyer. Treasury and the tax committees have had strong tax policy objections to this device because of their experience in the 1980s with a similar mechanism – called "safe harbor leasing" – which enabled a number of profitable corporate taxpayers to eliminate their Federal income tax liability. Notwithstanding these objections, the Senate Finance Committee in this year's energy tax legislation approved transferability of renewable energy credits in certain limited circumstances.[20]

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[17] *See* § 1347 of H.R. 4503, 108th Cong., which allows certain energy-related credits to be used against AMT. The EFC facility conversion credit proposal specifically recommended AMT relief. See note 1.
[18] *See* I.R. S. § 32 (earned income credit) and § 35 (certain health insurance costs).
[19] *See id.* §§ 33, 34.
[20] *See* § 801(c) of S. 1637 108th Cong. (allowing renewal energy production credit to tax-exempt entities and permitting them to transfer credit to other entities). The EFC proposal suggested transferable credits as an option. See Note 1.

Option 5: Credit Transferable to Suppliers and Customers. — A more limited and potentially more palatable approach to transferability would be to permit manufacturers unable to use facility conversion credits they earn to transfer them upstream to equipment suppliers or downstream to customers. The upstream transfer of the credit could, for example, permit the manufacturer to obtain a discount on machine tool purchasers. The downstream transfer could permit the manufacturer to use the tax credit as a sales tool for high-efficiency vehicles.

Conclusion

The Code's current structural limitations on use of investment tax credits may limit the overall usefulness of a facility conversion tax credit. Arguably, unless these limitations are modified, companies most in need of the tax benefit are likely to be those least able to use it. A carefully defined policy on transferability of credits (Option 5), combined with a liberalization of the 25 percent rule (Option 1) and the AMT rule (Option 2) can deal with these issues. However, an articulate case for these rules changes needs to be put forward in order to deal with possible tax policy and revenue loss concerns.

8/16/04

RRN NOTES

MANUFACTURER AND SUPPLIER FINANCIAL DATA

[Based on Preliminary Review of Most Recent Annual Financial Reports Filed with the Securities and Exchange Commission]

MANUFACTURERS

GENERAL MOTORS CORP.

GM reported a U.S. loss in 2001, net income in 2002 and 2003 and taxes due in each year. GM has substantial tax credit carryforwards (as much as $2 billion), indicating that it may not be able to use additional tax credits in the near future.

FORD MOTOR COMPANY

Ford reported U.S. losses in 2003 and 2001 and a little over $1 billion in net income for 2002. For 2001 Ford reported a federal income tax expense of $22 million, for 2002 a tax benefit of $423 million and for 2003 a tax benefit of $149 million. Ford reported substantial operating loss carry forwards ($4.6 billion) and substantial tax credits available to offset future liabilities ($2.4 billion) indicating that Ford may not be able to use additional credits in the near future.

DAIMLER CHRYSLER

Daimler Chrysler reported net income in 2003 ($564 million) and 2002 ($5.943 billion in 2002) and losses in 2001 ($637 million). The Chrysler group reported $637 million in losses in 2003 verses $767 million in profits for 2002. The company reported substantial corporate tax net operating losses ($3.8 billion) and carry forwards ($2.1 billion) and stated that both are substantially related to losses of U.S. companies.

HONDA MOTOR CO.

From 2002 through 2004 (year ending March 31) Honda reported steadily increasing net income ($4.4 billion in 2004). Honda incurred significant current and deferred income taxes in all three years.

TOYOTA MOTOR CORP.

Toyota has reported growing and very substantial net income over the past three years ($5.3 billion in 2002 to $11 billion in 2004 (year ending March 31)). For North America, Toyota reported $2.6 billion in net income for 2004. Toyota also reported income tax expenses for all three years for both its parent/domestic companies and its foreign subsidiaries.

COMPONENT SUPPLIERS

AISIN

Aisin Seiki Co., Ltd. reported before-tax profits in 2002 and 2003, and income taxes paid in each year. Both income and taxes are reported on a worldwide basis. Operating income from North American operations (about 4 percent of worldwide) was positive in 2003 but not in 2002. Whether Aisin could use tax credits cannot be determined from its financial reports.

BOSCH

Bosch reported worldwide pre-tax profits for 2002 and 2003 and income taxes paid worldwide in each of those years. North American operations account for less than 20 percent of worldwide sales. Usability of tax credits cannot be determined from Bosch’s financial reports.

DELPHI

Delphi shows net income before taxes in 2000 and 2002, losses in 2001 and 2003, and income tax expense in the profitable years. Delphi has about $800 million in net operating loss carryforwards. Delphi may not be able to use additional tax credits in the near term.

DENSO

Denso was profitable worldwide in its last two fiscal years and paid income taxes on a worldwide basis. Less than 15 percent of Denso operating income comes from U.S. operations. We are unable to determine whether Denso may be able to use additional tax credits.