GREEN CAR INSTITUTE

A Non-Profit Corporation

White Paper

A Review of the Methodology and Assumptions of the California Energy Commission Staff Report on Strategies to Reduce Petroleum Dependency

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Background

Green Car Institute is a non-profit 501(c)(3) corporation dedicated to research and educational projects in the automotive environmental field. Its mission is to foster greater public understanding of the relationship between low emission/ clean fuel vehicles and the environment, along with related automotive areas such as energy efficiency, recycling, and environmentally conscious manufacturing processes. The Institute's projects focus on partnering auto industry and utility/energy company clean fuel technology and research opportunities with public education programs.

The Institute's published studies include market research and analysis of industry trends and products. “The Current and Future Market for Electric Vehicles” and “Future EV Pricing” were both published in September 2000 and became a key part of the testimony for the California Air Resources Board’s decision at the time on the Zero Emission Vehicle (ZEV) mandate.

Proprietary research includes a comprehensive survey of “smart growth” communities in the fair-weather regions of the United States (Southeast, Deep South, Southwest, and West Coast), with the aim of measuring land use patterns and transportation infrastructure compatibility with new mobility tools such as neighborhood electric vehicles (NEVs). Similar research includes a published study of travel behavior of 28 families living in the smart growth community of Otay Ranch in Chula Vista, Calif., who were equipped with NEVs for 60 days. Focus group research found that NEVs replaced internal combustion engine vehicle trips 90 percent of the time during the two-month period.

Green Car Institute’s expertise is drawn from its members' considerable experience in fields directly related to this study, publicly available industry data, primary and secondary independent research sources, and direct interviews with industry personnel.

Summary of Findings

This White Paper reviews the California Energy Commission's (CEC) staff analysis of Petroleum Reduction Strategies and presents additional industry data. As a general conclusion, this White Paper finds that the need for a dramatic petroleum reduction "plan" on the part of the state, as outlined by the CEC staff analysis, may be premature in terms of the staff's policy recommendations.

From all indications, the reduction in the demand for petroleum in California is already underway, driven by statewide auto emissions regulations, a renewed industry and auto consumer attention to fuel efficiency, and new enabling technologies. Thus, the petroleum reduction measures recommended by CEC staff are, in the opinion of this White Paper's authors, not necessarily the best, most up to date or most economically efficient means by which the residents of the State of California can reduce their use of petroleum.

Market Overview

The overall view of the market as presented by the CEC appears to be taken from standard industry sources and tracks along the general assumptions of accepted models. It appears to take into account near-term market changes driven by the end of the "Baby Boomer" bulge and the acknowledgement that the automotive market in California – and the United States – is a mature market driven primarily by replacement vehicle sales.

The automotive market is undergoing a change in its core technology almost unprecedented in its 100-plus year history. At no time in recent memory have the automotive and fuel industries been under greater pressure to adopt new technologies or modify old ones. Indeed, at no time in the past 100 years have the leaders in these industries uttered declarations like those heard today, proclaiming an expectation that we will see the end of the reign of the gasoline-powered internal combustion engine.[1]

The timeframe for the transition to this "new" age is inexact, but the technologies are already with us and are enumerated in the same speeches as the ones cited above and amplified in dozens of others:

- Demonstration vehicles are in consumers' hands today with zero emission fuel cell technology.
- Hybrid vehicles are available today that increase the fuel efficiency of a given type of vehicle up to 50 percent (and many other new hybrid models are on the horizon).
- Near-zero emission, gasoline-powered internal combustion engines from the major automakers are proliferating and promise within five to 10 years to comprise a sizeable portion of the California market.
- Clean diesel vehicles and low-sulfur diesel fuel – with the potential to achieve significantly higher fuel economy and reduce greenhouse gas emissions 30 to 50 percent – are just beginning to come to market and hold great potential during the next decade.
- Alternative fuels from compressed natural gas to biodiesel can be purchased at public fueling stations.

These trends have substance and traction, and are leading the way to greater acceptance of these new technologies, often helped by government incentives that reduce incremental costs of advanced and often more expensive technologies. The adoption trends for these new technologies are quite accelerated, one point not fully integrated into the CEC staff analysis base case scenario and only partially referenced in the staff's alternative scenario. In fact one industry participant at a recent advanced technology gathering said the consumer hybrid adoption rate has "caught many industry experts by surprise."[2]

The Honda FCX and Toyota FCHV are examples of zero emission fuel cell demonstration vehicles in consumers' hands today.

Importantly, it should be noted that according to the CEC's own report, the average fleet fuel economy increased 64 percent from 1980 to 2000 (this on top of a similar proportion of increase during the previous decade). This improvement occurred at the same time the auto industry was meeting ever-increasing emissions requirements and responding to consumer demands for safer and more powerful vehicles. It is not an extraordinary leap to assume that this macro trend will continue.

It is true that corporate fleet fuel economy has declined in recent years.[3] However, public sensitivity to oil security issues, non-governmental organization focus on the issue, and existing state and federal government initiatives portend an ongoing spotlight on the role and contribution of the transportation sector in reducing fuel consumption and the automobile's contribution to global warming.

Another factor that should be added to the analysis is that increased consumption is not a given. Both upward and downward fluctuations can affect the overall trend. For example, by the end of the turbulent decade of the oil embargoes (1973-83), the decline in world oil consumption that resulted had reversed, returning consumption to the same level as 10 years earlier. While this does not negate the overall upward trend of petroleum consumption, it does indicate the volatility of the market and serves to highlight the potential for both downward and upward spikes in usage patterns.

What's Needed to Overcome Limitations of Current Technology

While the technology exists and market conditions seem to indicate we may be on the path to both increased fuel economy and reduced greenhouse gas emissions, there are hurdles that must be overcome before the automotive marketplace embraces these new technologies.

Ideally, a new automotive technology would be characterized by the following for maximum consumer appeal:

- Costs less than the technology it replaces
- Delivers more tangible benefits (e.g., horsepower, comfort, etc.)
- Does not make operation of the vehicle more complicated.

Most of the new technologies aimed at improving fuel efficiency and/or emissions fail on one or more of these points. In fact, many fail on all three, being more costly, offering negligible benefits to the consumer (though possibly they may provide environmental or technical benefits), and causing the operation of the vehicle to become more complicated (i.e., requiring regular inspections or different fueling operations).

Because of this, the auto industry is understandably reluctant to commit to large-scale implementation of these new technologies, particularly in times when operating margins and profitability are under intense scrutiny. This leads to the low-volume, cost-underwritten approach initially pursued by Toyota and Honda with their hybrid vehicles, and the similar stance of DaimlerChrysler in bringing in diesel models of the Jeep Liberty and Mercedes-Benz E-class. Failure is an expensive, unacceptable option in today's brutal automotive market.

Helping to overcome these potential stumbling blocks and encourage the adoption of such new technologies have been two key components:

1. Government incentives and
2. Regulations.

The former rewards the producer or purchaser of the new technology, creating a "pull" in the market. The latter merely requires a certain quantity of vehicles or fuel to be produced, a classic "push" to the market. To be effective, either one or a combination of both methods must be consistently applied, something many governmental agencies and administrations have found difficult to achieve.

Other, less quantifiable factors also affect new technology adoption rates. Extraordinary events such as the oil embargoes and crises of the 1970s and 1980s spurred consumer acceptance of smaller and more fuel efficient vehicles, the auto industry's move to produce such vehicles, and regulators' attempts to promote such moves.[4] Recent public opinion polls indicate that consumers are eager to try hydrogen-powered vehicles and are willing to pay a premium for them, although concerns remain about safety, cost, and range of the new vehicles.[5] Commentators have suggested that the move to new technology could be achieved from the industry side in much more rapid fashion if the issue were given the boost of becoming a national priority with commensurate federal funding.[6]

Review of Current Technology

The near-term technologies that promise to deliver increased fuel efficiency in vehicles need to be scrutinized based on the above criteria and analyzed as to the likelihood of their success. Following is a brief review of those technologies.

Clean Diesel

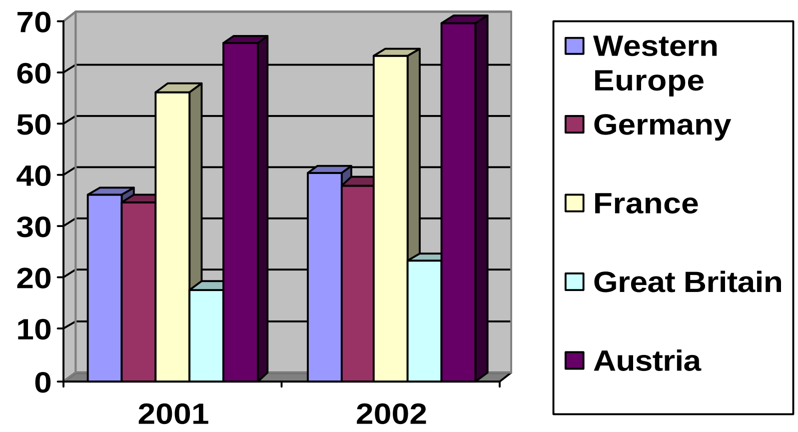
Modern clean diesel technology is essentially ready to go to market today. European sales of diesel-powered vehicles using low-sulfur diesel fuel have reached an approximate 40 percent market penetration due to high gasoline prices relative to diesel, and minimal incremental costs of diesel vehicles. Costs vary from country to country, but the premium for a diesel vehicle is slight and easily recovered through fuel savings in a short period of time. Modern clean diesel technology has the potential of increasing fuel efficiency (and decreasing petroleum use) up to 50 percent, with no loss of performance, slight additional vehicle cost, and minimal refueling inconvenience (since many gasoline stations in the United States carry diesel fuel).

The 2004 Jeep Liberty is one of a coming genre of clean diesel vehicles that have the potential to significantly increase fuel economy and reduce greenhouse gas emissions 30 to 50 percent.

The biggest hurdles to diesel penetration of the California market are presently two-fold – consumer acceptance and conflicting regulations for vehicle emissions and fuel. Marketing by automakers eager to bring European technology to the United States will attack the first, while on the second front regulators promise to have vehicle requirements and enabling low-sulfur fuel technology aligned over the next several years. While the 40 percent market penetration of European diesels may not be possible here, federal EPA officials have predicted that diesels could capture 20 percent of new car and light-truck sales by 2010.[7]

Even without government support, if that number rose significantly by the 2020 time period of the CEC report, the potential impact on fleet fuel efficiency numbers is large. As a supporting footnote to that conjecture, industry figures show comparable growth of the European diesel market in a shorter timeframe (1990-2002, 14 to 40 percent).[8]

European Diesel Passenger Car Registration Percentages in 2001 and 2002



According to Bosch market research, diesel vehicle ownership shows no sign of slowing down, with average new passenger car registrations up in Western Europe. Bosch found that, on average, diesels comprised 40.3 percent of new car registrations in Western Europe in 2002.
(Source: February 2003 Robert Bosch GmbH press release)

Hybrid Drivetrain Technology

Hybrid gasoline-electric propulsion systems are a relatively new introduction to the consumer market although they have shown up in experimental vehicles for many years. Toyota introduced the first production hybrid to the Japanese consumer market in 1997. Honda followed soon after with its two-seat Insight hybrid that debuted first in the United States, beating Toyota to the North American market by several months in the winter of 1999. While Toyota has introduced several additional hybrid models in its Japanese home market, only Honda has added to its U.S. hybrid fleet with a Civic model in 2002. Toyota in particular has announced the intention of expanding the number and variety of hybrids that it will have available over the next few years. While less committal to specific models, Honda has shown several concept vehicles that incorporate hybrid powertrains, and the company is also expected to roll out additional hybrid offerings over the short term.

Meanwhile, other manufacturers are ramping up to introduce their own hybrids. Ford and General Motors have committed to bringing hybrid propulsion to multiple platforms and potentially large numbers of vehicles starting late this year. Ford's CEO, William Clay Ford Jr., said recently he expects 75 percent of powertrains in 25 years to be hybrids (and the remainder fuel cells, with some possible variations between the two such as hydrogen-powered internal combustion vehicles).[9] General Motors announced it would be able to produce one million hybrids annually by 2007 with potential models running the gamut from small sedans to SUVs, along with previously announced full-size pickups.[10]

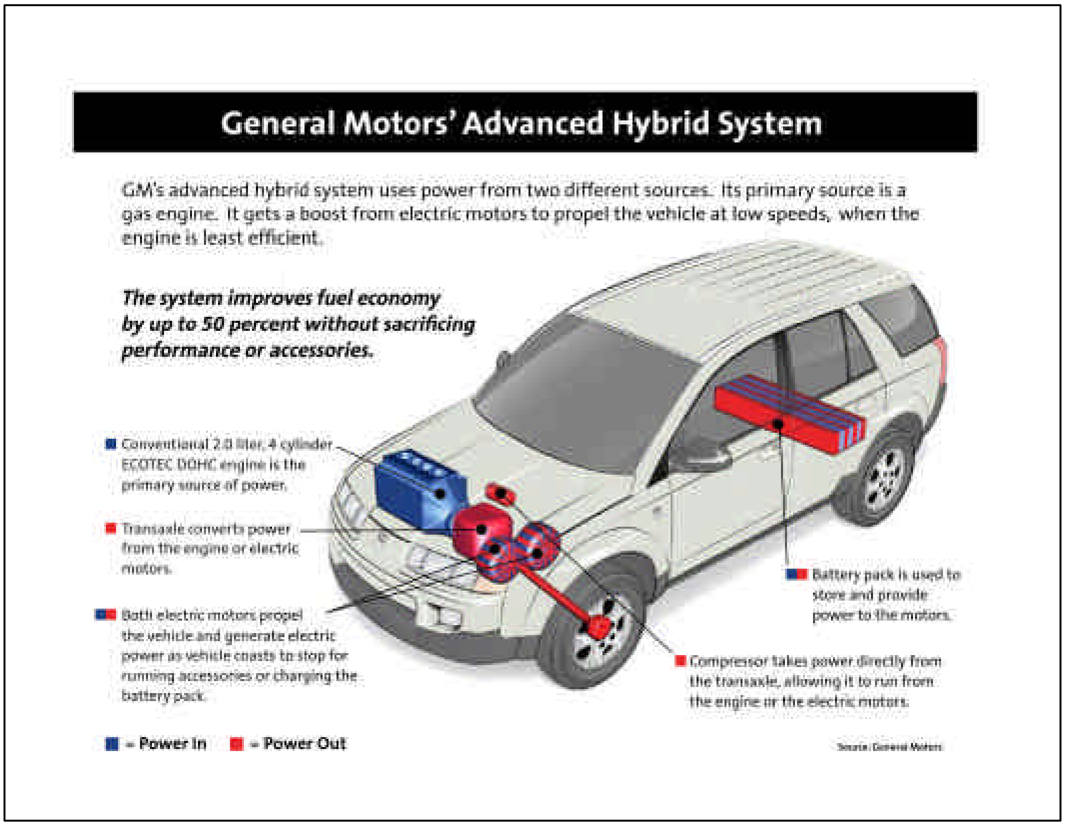
The Toyota Prius (left) and the Honda Civic Hybrid (right) are two examples of hybrid gasoline – electric vehicles available to consumers today. More hybrid models are on the way.

As these scenarios come to fruition over the coming years – or more likely, some modification of the two as the industry evolves – the shift in fuel efficiency and petroleum use by the automotive fleet will be tremendous. But this move to hybridization does need a footnote because not all hybrids are the same when it comes to fuel efficiency.

Some of the confusion in discussing the impact of hybrid technology rests on differing definitions and applications of hybrids. In the industry, hybrids are referred to as “full” or “mild” depending on the specific technology involved. Full hybrids – such as the Prius, Civic Hybrid and Insight, and coming Ford Escape HEV and Saturn Vue – have the potential to increase fuel economy from 25 to 50 percent, depending on the configuration. Mild hybrids, which typically incorporate less expensive technology such as an integrated starter-generator to augment the power of a gasoline engine, are expected to boost fuel economy by 10 to 25 percent.[11]

A report by a leading auto industry study/database company Freedonia Group predicts that nationwide hybrid market penetration will reach 8 percent in 2011, up from 0.1 percent today. Current market trending and industry predictions point to a continuing increase that could see hybrids conservatively hit 25 percent of the market by 2020 with a mix of full and mild hybrids depending on vehicle type, particularly if Toyota and Honda continue to assert their leadership in the face of mass marketing by Ford and General Motors.

The conclusion that can be reached from this industry intelligence is that hybrid technology, by design, increases the efficiency and fuel economy of an engine and therefore will have a direct impact on fleet fuel economy. From the numbers discussed and expected by the industry, it appears that the CEC report has seriously undervalued the impact of this burgeoning technology.



California also is recognized by the auto industry as a prime early-adopter target for hybrid vehicles, even though their hybrid marketing plans are aimed at a nationwide audience. Thus, the national hybrid penetration percentages quoted by industry could be considered low estimates of what can be expected in this state. For example, Toyota reports that approximately 35 percent of its Prius sales are in California. If similar trends hold with the introduction of new hybrid models, these high-efficiency hybrid vehicles will have a disproportionately positive impact on California fleet fuel economy.

Advanced Engine Technology

Internal combustion engine (ICE) technology continues to develop and challenge the presumption that ICEs will not play a major role in moving toward petroleum reduction goals. During the past three decades, engine advances have been focused primarily on meeting emissions goals and/or enhancing performance efficiency of the engine, since fuel efficiency has been a secondary (or even tertiary) consumer concern.

Current advanced engine technology has reached a new plateau where emissions concerns have been largely addressed. As a result of California Air Resources Board (CARB) regulations, automakers have developed partial zero emission vehicles (PZEVs) with tailpipe emissions that are often cleaner than the ambient air in most non-attainment areas. The PZEV technology is being widely applied as well. At this point in 2003, CARB has certified two advanced PZEVs, 12 different models, and eight different engines as PZEVs. CARB has also certified an additional four models and engines as super ultra-low emission vehicles (SULEVs), attaining a similar emissions level. These primarily gasoline-powered ICE vehicles achieve extremely low emissions levels thought impossible only a few years ago.[12]

Automakers achieve these low emission levels without sacrificing performance or driving attributes of the vehicle. For example, the Ford Focus PZEV engine features increased horsepower compared to its higher-polluting predecessor. Similarly, the BMW 325i PZEV delivers the performance expected from this so-called "ultimate driving machine."

Fuel efficiency is often enhanced by this quest to achieve stringent emissions levels because the same culprit is attacked by engineers in both cases – inherent engine inefficiencies. In many cases, it becomes a win-win situation. This is the case with Ford's 2003 Focus PZEV, for example, as this car's new 2.4-liter four-cylinder engine is larger than its predecessor, yet weighs less, features more horsepower, and gets better fuel economy than the previous model.

The BMW 325i PZEV (left) and the Ford Focus PZEV (right) prove automakers can achieve CARB-certified partial zero emission levels in gasoline-powered internal combustion engine vehicles. It is notable that the Focus PZEV engine offers more horsepower, lower emissions, and greater fuel economy than the engine it replaces.

With emissions concerns addressed, engineers are thus able to focus even more on enhancing engine and fuel efficiencies. At least some auto companies will continue delivering expected levels of performance while meeting emissions requirements and increasing fuel efficiency simultaneously. Competitive market pressure should then find the remaining major automakers following suit in much the same way this scenario is unfolding with hybrid electric vehicles.

Sales of PZEVs in California during 2003 calendar year are expected to reach 140,000 units, according to CARB staff reports based on manufacturer information. That number is roughly the equivalent of 10 percent of the state's new vehicle sales. Sales of PZEVs also are expected, according to CARB estimates, to double by 2007, and they will continue to increase after that point, reaching 660,000 in 2011.[13]

Other critical observers of the auto industry predict that relatively moderate "streamlining/design" changes incorporating advanced technologies and mass (size) reduction have the potential to deliver average fleet CO_2 reductions of 30 to 40 percent. Of course, since CO_2 emissions reductions have a direct relation to fuel burned, decreased CO_2 also means higher fuel economy. The calculations were based on "ample, affordable, existing technologies." This prediction is in spite of the overall observation that there are "no magic bullets for low CO_2 emissions, unlike the case of the catalytic converter for previously regulated pollutants."[14]

Analysis by the EPA's Energy Information Administration bore similar numbers in a December 2001 study, showing efficiency improvements ranging from 1.5 percent for advanced tires to 7.5 percent for electromechanical valve actuation and also listing accessory improvements, engine friction reduction, variable valve timing, advanced tires, gasoline direct engines, continuously variable transmissions, electromechanical valve actuation, intake valve throttling and variable compression radios as potential contributors to increased efficiency at relatively modest costs.[15]

Advanced engine technologies are also an attractive approach to increased fuel efficiency for automakers since – as shown in the above EPA report and others – it is the most cost-effective method of achieving progress in this area.

Other Advanced Technologies

In concert with engine technology advances, automakers continue to explore other advanced technologies that promise to aid the quest for energy savings and fuel efficiencies. One research firm reports that it expects one key component, non-steel automotive exterior panels, to more than double its market from 2000 to 2005.[16]

The significance of this component is its weight-savings potential. Plastics replacing steel components can reduce the weight of a given component by as much as 50 percent. The industry view is that a 10 percent overall weight reduction can mean as much as a 6 to 8 percent gain in fuel efficiency. The researchers' conclusion from studying the expected progression of this technology is that light-weight materials alone will "find more and more applications in vehicles" resulting in a 2 percent energy savings in the United States by 2005, and a 4.6 percent savings by 2030. But the researcher notes that "with time and technology development, performance levels of engines are likely to go up as well, leading to a further enhancement of fuel efficiency."[17]

Alternative Fuel Technology

The CEC report also appears to undervalue the potential impact of upcoming new technologies on the alternative fuel portion of the market. While currently quite small and isolated primarily to centralized fleets, natural gas vehicles (NGVs) running on compressed natural gas (CNG) have the potential to become a more significant part of the consumer fleet with the introduction of a simpler home-refueling system.

Honda is planning this fall to introduce Phill, a new concept for CNG home-refueling that is reputed to be relatively low-cost, easy-to-install, and safe.[18] It would remove the primary consumer impediment to expanded CNG acceptance, which is the lack of easily accessible public refueling facilities. In fact, Phill holds the potential to usher in an entirely new concept that could capture the imagination of new car buyers and spur sales of NGVs – forever eliminating the need to fuel up at a service station. Instead, a car running on CNG could be refueled via Phill at home.

FuelMaker Corp. (owned 20 percent by Honda) estimates that it could manufacture 20,000 to 40,000 Phill (left) home refueling units annually. Phill compresses the natural gas used in homes for use in vehicles such as the Honda Civic GX.

Combined with existing state incentives for advanced technology PZEVs, for which the natural gas Honda Civic GX qualifies, the company could make a compelling marketing case for promotion of its NGVs, emphasizing the benefits of this new refueling technology to help increase NGV market penetration. In addition, Honda's Phill technology could further encourage fleet applications of natural gas vehicles, increasing consumer and fleet market share not only of Honda's natural gas products but other CNG-fueled vehicles from Ford, General Motors, and DaimlerChrysler.

Finally, Honda's move may well serve to spur other automakers with experience in the natural gas vehicle market, such as Toyota and Volvo, to enter or re-enter the U.S. market. Honda's bold foray into the consumer market makes this especially likely.

FuelMaker Corp., the manufacturer of Phill (owned 20 percent by Honda), estimates that it could manufacture 20,000 to 40,000 home fueling units annually. Though the numbers are relatively small, the cumulative impact over a decade, and potential expansion of the individual consumer CNG vehicle market, could become an additional factor in petroleum reduction efforts.

Ethanol is another alternative fuel that has interesting potential, though probably more so in states other than California. Ethanol shows up as a blend in most California gasoline (replacing MTBE, the previously mandated oxygenate that's derived from petroleum). While its current use as a component in reformulated gasoline reduces petroleum consumption, ethanol's use as a primary motor fuel is minimal in spite of its ability to be used by millions of existing flexible-fuel vehicles.

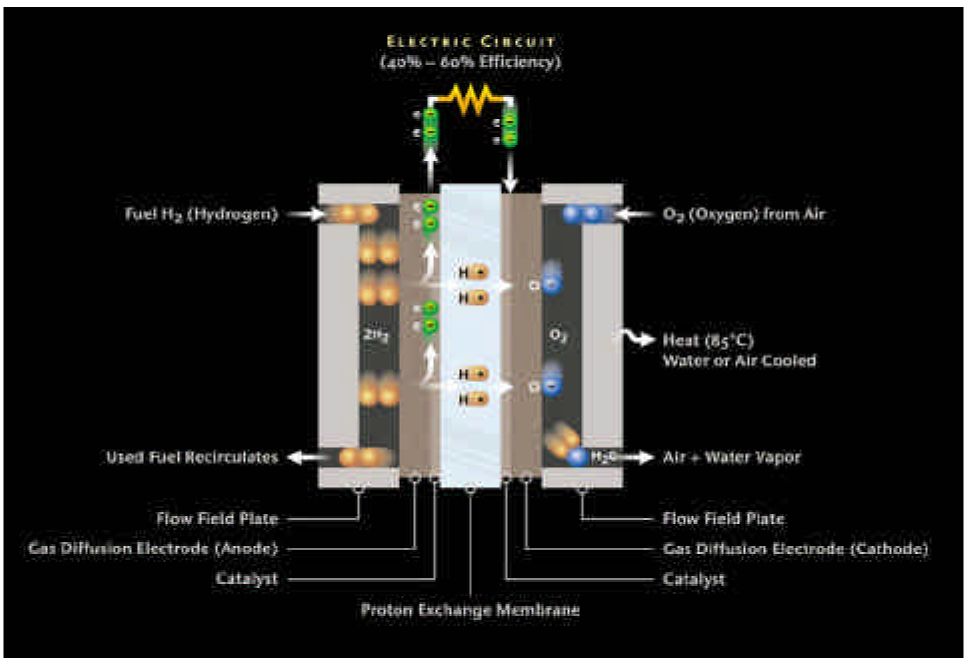
Automakers, primarily the Big Three (General Motors, Ford, and DaimlerChrysler) have been equipping certain mainstream models with engines that can run on E85 (an 85 percent ethanol/15 percent gasoline blend) for several years. This is driven by their ability to benefit from additional Corporate Average Fuel Economy (CAFE) credits, which are provided by the federal government to automakers that manufacture and sell alternative fuel vehicles. This is a good example of a technological push created by a combination of regulations and incentives.

Current estimates show that there are three million such vehicles on the road in the United States, although most are operated on gasoline since there are only about 140 ethanol stations in the nation, most in the Midwest close to production sources. That could change for the better, however, because it costs much less to build an ethanol infrastructure than the oft-discussed move to build a hydrogen infrastructure.

New, more environmentally-friendly ethanol production methods are being explored as the demand for this fuel increases. Other moves could also increase ethanol use and spur demand for a wider infrastructure. For example, General Motors, which claims to have produced about one million ethanol-capable vehicles and continues to have several high-volume models in its lineup, is teaming up with ethanol producers to initiate a two-year advertising campaign aimed at increasing ethanol use.[19] While there has been resistance to increased ethanol use in California, the reluctance to increase use of this fuel has been based primarily on political, not environmental grounds. Because so many vehicles that can use the fuel are already on sale or on the road, the potential impact of such a fuel shift could be truly significant.

Fuel Cell Technology

Over the past few years, fuel cell technology has become the automotive arena's hot topic and the new "Holy Grail" and Gold Standard for CARB's drive for zero-emission vehicles. All of the major automakers have both in-house and joint development programs, and the progress of fuel cell technology advances has been rapid and well-displayed.



How a fuel cell works. (Source: Ballard Power Systems)

As with many advanced technologies, fuel cells have been rapidly progressing through various stages and generations of development, usually at a significantly accelerated pace compared to traditional automotive engineering technology. In spite of this rapid progress, many hurdles remain for this technology to become ready for mass production or commercialization, including the need for drastic cost reductions, overcoming storage issues, proving its safety, and development of an infrastructure to support a large quantity of vehicles. That infrastructure and the source for the fuel cell vehicle's (FCV) hydrogen are directly related to the technology's ability to reduce petroleum consumption. Various feedstocks for hydrogen are currently being explored, ranging from fossil fuels like gasoline and natural gas to renewable or potentially renewable processes like electrolysis or biomass-generated methanol.

Cautioned by the large number of the hurdles in front of this technology, the state of California has followed conservative general industry predictions of a relatively slow ramp up of fuel cell vehicles. Because of this approach, these zero emission vehicles would have minimal impact on petroleum use in the state, according to the CEC study. But those predictions are dwarfed by the predictions of some automakers and the proposals of some advocates of a rapid shift to a hydrogen economy, including some in the federal government who could help make the numbers become reality.

A General Motors executive was one of the first into the forecasting fray when he predicted his company would be the first to sell one million fuel cell vehicles to consumers, though the exact timeframe was not given. He did go on to elaborate that General Motors planned to begin mass-producing fuel cell vehicles by 2010.[20] In the automotive context, mass production typically means volumes of at least 100,000 units, although Toyota has referred to the Prius as the first mass-produced hybrid while making approximately 30,000 units per year.

General Motors also believes it can begin volume sales to consumers early in the next decade with or without a fully developed fueling infrastructure, something other manufacturers have been reluctant to predict. Some industry studies point to significantly higher numbers than those shown in the CEC report. One study estimates there will be 800,000 fuel cell vehicles worldwide by 2012, though that number probably would be equally split between the United States, Europe, and Japan.[21]

If government makes the move to a hydrogen economy an issue of national security or pride – such as President Kennedy's challenge to put a human on the moon by the end of the 1960s – the scale and timeframe of fuel cell development could accelerate rapidly. One scenario suggests that we could have 200,000 fuel cell vehicles nationwide by 2023.[22] An even more radical version predicts that fuel cells could dominate the car marketplace by 2015.[23] The latter vision has been endorsed by proposed Congressional legislation that calls for a national goal of 2.5 million FCVs by 2020.[24] Of course, with its early endorsement and high-level support of fuel cells, a disproportionate (beyond the state's typical 12 percent share of the national automotive market) percentage of these FCVs will likely be on the roads of California.

Potential New Technologies

In the same way that hydrogen-powered fuel cells have eclipsed battery electric cars as the preferred zero emission vehicle technology in less than a decade, it is extremely difficult – and dangerous – to presume to predict the ascendancy or popularity of a technology too many years into the future. A large, entrenched industry like that of auto manufacturing responds to many diverse stimuli, but as a matter of course remains focused on delivering personal transportation vehicles to consumers as long as that is a profitable enterprise.

Its stake in perpetuating any current technology extends only to the logic and convenience of continuing in a comfortable mode of production, maximizing investment in personnel and assets in that technology. As was seen in the short-lived "dot-com" era, during which General Motors and Ford announced significant ventures extending beyond vehicles and into technology, automakers are willing to pursue any avenue that allows them to expand their business profitably, even if returns on investment are not immediate. This caveat is to suggest that prescribing or proscribing technologies is not a logical way of addressing technology advances in the auto industry.

"Smart Growth" Land Use and New Mobility

Other factors beyond the automobile and auto industry have the potential of impacting petroleum use in very noteworthy ways. Master-planned communities, "smart growth" transit-oriented developments, and other similar land use planning approaches have moved beyond the theoretical to become brick and mortar communities.

The Smart Growth movement that began in the late 1980s and early 1990s has taken root in the consciousness of most successful developers of large urban and suburban housing projects. These developers recognize the historic trend of urban growth, particularly in California, built around the automobile that helped create and fuel a phenomenon many land use professionals disdainfully refer to today as "urban sprawl."

Their new mantra is "smart growth," and one of their main tenets is taking communities back from the heavy, high-speed automobile and giving them over to front porches and chatty neighborhoods where inhabitants walk on low-speed, narrow streets ideally designed, incidentally, for vehicles like the neighborhood electric vehicle (NEV).

California has 21 master-planned communities of more than 1,000 homes – each in various stages of development from Sacramento to the Mexican border – representing a total build out of more than 167,000 single-family homes that are coming on line in the state within the next 10 to 15 years.[25] Neighborhood electric vehicle manufacturers such as Global Electric Motorcars LLC (a DaimlerChrysler company), have identified master planned communities as their top priority for marketing and sales efforts during the next five to 10 years, with market penetration goals of 15 percent.

If only 10 percent market penetration were achieved in these master planned communities, this would result in some 16,700 new California NEV users – each representing approximately five to 15 ICE vehicle trips (and attendant cold starts) eliminated each week. This is on top of the estimated 13,000 NEV owners in California today.

These new communities are changing vehicle use habits, feeding the growth of new vehicle niches like the NEV (a zero emission, zero greenhouse gas EV), programs like car-sharing, and increased transit and alternative transportation use. Coupled with ever-increasing congestion in urban areas and the decreasing ability of the state or federal governments to provide additional roadways, it is feasible to project that vehicle miles traveled (VMT) – a constantly increasing number for most of the past century – could reach a plateau or even decrease on a per-vehicle basis.

Such a radical change in demographics and personal mobility behavior would have a significant impact on petroleum use and emissions reduction – more significant than many of the technological advances discussed in this White Paper – because it would be accomplished with little cost to consumers, industry, or government (other than lost gas tax revenues).

Summary of New Technology, Market Impact, Trends

As has been alluded to above, an additional trend has the potential to make a major impact on future petroleum use in California – the combination of technologies that may deliver even more benefit than any one technology viewed individually. Different technologies may work together and/or morph from one into another, as has been seen with the use of electric vehicle components in fuel cell vehicles and prototype diesel-electric hybrid vehicles, which squeeze even greater efficiencies from the powertrain than either system could do separately.

Even if these advanced technologies do not create their own synergies, it is clear they have the potential to greatly reduce the state's petroleum use. Taken separately, and even at relatively low levels of market penetration, the cumulative impact of hybrid, clean diesel, and advanced ICE technology in the near-term – and fuel cell, alternative fuel, and other new technologies in the longer term – have the potential of not only halting the state's increasing petroleum consumption trends, but reversing them. That is even with an increased vehicle population and VMT growth (although, as noted in the “Smart Growth Land Use and New Mobility” section above, there may be reason to question those VMT growth projections as well).

Statistical Interpretation

The numbers are relatively simple to compute in a scenario that is not at all on the high end of estimates quoted above. This scenario is based on the assumption that both the auto and energy industries will continue on their current paths, avoiding any radical change in technology, and that consumers will respond based on current trends and the ability of both industries to promote their best technologies even if they are not dramatic changes from past gasoline-powered internal combustion engines. Here is the scenario based on estimates quoted above:

- Hybrids (with a variety of different models ranging from mild to full) grow in the California fleet from their current market share of less than 1 to 20 percent of the market by 2020, with a sales-weighted fleetwide average fuel efficiency increase of 20 percent for this segment.
- Clean diesels return to the marketplace in force and capture 20 percent of the market, resulting in a 30 percent fuel efficiency increase for this segment.
- Advanced engine technology continues to develop as the focus shifts from emissions work to increasing overall engine efficiencies. Coupled with vehicle design improvements, the result is a 35 percent fuel efficiency improvement for 50 percent of the market. This is the largest market segment because it is the most cost-effective means for automakers to achieve efficiency gains.
- Fuel cells advance more rapidly than some imagined, although not as fast as some predicted, taking 10 percent of the market by 2020. Most of these are fueled by hydrogen produced from either renewable sources at this point (though in earlier years natural gas or other fossil fuel-based methods of producing the hydrogen were used) . This fuel source can actually produce negative greenhouse gas emissions.[26]

The cumulative effect of this scenario would be a fleet that produces only 62.5 percent of the greenhouse gas emissions of its 2000 equivalent. Based on the CEC base case forecast of 19.6 billion gallons of on-road gasoline demand in 2020 and its estimate of a 900 million gallon reduction with a 16 percent mild hybrid market penetration, we estimate the above scenario could reduce that demand by about 9.5 billion gallons (1+ billion gallons from hybrids, 1.5 billion from diesels, 5 billion from advanced engine and design technology, and 2 billion from FCVs). This would effectively bring petroleum use 30 percent below the 2000 levels, a downward trend that would continue as the shift to fuel cells and hybrids continued.[27]

Conclusion

The California Energy Commission's (CEC) staff analysis of Petroleum Reduction Strategies has failed to take into account many of the emerging technologies, automotive consumer market trends, and demographic and land use movements identified above. This White Paper finds that the need for a dramatic petroleum reduction “plan” on the part of the state, as outlined by the CEC staff analysis, may be premature.

From all indications, the reduction in the demand for petroleum in California is already underway, driven by statewide auto emissions regulations, a renewed industry and auto consumer attention to fuel efficiency, and new enabling technologies. Thus, the petroleum reduction measures recommended by CEC staff are, in the opinion of this White Paper’s authors, not necessarily the best, most up to date or most economically efficient means by which the residents of the State of California can reduce their use of petroleum.

Understandably, assimilating all available knowledge on the subject, declaring victory over the perceived problems of increased petroleum use – and then “doing nothing” as a result – may on the surface seem to be an insufficient response to the legislative directive laid out in AB 2076. Ironically, though, in many respects, “victory” may actually be at hand, although possibly in an unrecognizable form, based on reasonable assumptions that technology, consumer, and land use trends will continue in the positive directions laid out in this White Paper.

The role of government in this scenario would best then be defined as one that continues to encourage these current positive directions, monitors them to assure they continue, or speeds them up as deemed necessary. The real challenge to California’s regulatory agencies, it seems, is in developing science-based policy language and implementation plans in response to political mandates that do not produce unintended consequences or countermand the positive trends already under way.

With these underlying thoughts in mind, the authors of this study would add the following comments to the dialogue over AB 2076:

CEC Staff Recommendation # 1. The Governor and Legislature should adopt the recommended statewide goal of reducing demand for on-road gasoline and diesel to 15 percent below the 2000 demand level by 2020 and maintain that level for the foreseeable future.

The two agencies recommend a goal of 15 percent below the 2003 demand level because that level can be achieved by using a set of cost-effective options.
If the Governor and Legislature adopt this goal, it will provide a framework to guide California down the path to reduced petroleum consumption. Achieving the goal will reduce California’s dependence on imported oil and petroleum

production, moderate price volatility, improve environmental quality, and demonstrate a positive leadership example reducing greenhouse gas emissions.

Green Car Institute Response # 1. Given the review of automotive propulsion technology outlined in this White Paper, any number of technologies and/or consumer/land use trends could emerge as a solution or a part of the solution to decreasing demand for petroleum in California. Thus, rather than focusing on establishing somewhat arbitrary goals, the state should focus its energy on validating and encouraging the current positive trends through non-prescriptive actions, monitoring progress as it develops, while avoiding the temptation of picking a technology or specific path toward the ultimate objective. As stated in the CEC staff recommendation, the state's ability to demonstrate positive leadership in this arena is one of the critical areas in which current trends can be validated. The buying power of the state and its fleet (as well as its influence on other governmental bodies) is a legitimate area of leadership and can serve to promote positive technologies and trends.

Recommendation #2. The Governor and Legislature should work with the California delegation and other states to establish national fuel economy standards that double the fuel efficiency of new cars, light trucks and SUVs.

The most effective way to improve vehicle fuel economy is to revise the federal CAFE standards. In cooperation with other states, California could press the Congress to adopt new standards, which double the fuel economy of new vehicles.

The goal in Recommendation #1 (15 percent below 2003 demand) assumes that the federal government doubles the current CAFE standard. Should the federal government fail to implement a CAFE standard that doubles the fuel efficiency of new cars, it would be necessary to reassess the goal in Recommendation #1.

Green Car Institute Response #2. As demonstrated in this White Paper's review of current trends, many technologies and social trends are contributing to improved fuel efficiency in vehicles. While fuel economy standards logically can and will move automotive fleets toward increased fuel efficiency, they cannot negate other social and purchasing trends. Witness the past two decades of increased sedan fuel efficiency in the face of a consumer movement toward truck-based vehicles like SUVs as car buyers increasingly chose vehicles with the capacity and versatility to satisfy their needs.

Clearly, fuel economy standards should not be viewed as a "cure-all" for increased fuel efficiency, particularly if they ignore consumer trends and vehicle preferences. Industry acceptance of fuel economy standards also is not universally assured. For example, several European carmakers have found it preferable to pay millions of dollars in federal penalties for failing to meet fleet fuel economy standards rather than produce vehicles they felt would not meet customer expectations of performance and size.

The goal of increasing fuel efficiency through mandated fuel economy standards has been controversial for some time and this has intensified in recent years. In light of this, it appears that the CEC staff recommendation to pursue standards that would require a doubling of fuel efficiency is quite optimistic, perhaps even naïve, considering the difficulty that historically has been experienced in seeking lesser fuel efficiency improvements from the auto industry. Any projections based on an assumption that adequate support will be generated for this are thus suspect.

Recommendation #3. The Governor and Legislature should establish a goal to increase the use of alternative fuels to 20 percent by 2020 and 30 percent by 2030.

California should act to increase the use of alternative fuels as a strategy to reduce petroleum demand and to hedge against the costs and risks of a growing dependence on petroleum fuels. The Governor and Legislature should adopt a goal establishing a minimum fraction of on-road transportation fuel that is derived from non-petroleum sources. Consistent with the petroleum reduction goal of Recommendation #1, the staff recommends an additional goal of 20 percent use of alternative fuels by the year 2020 and 30 percent by 2030. This recommendation is expressed as a percentage of fuel that is used, not as a percentage reduction in forecasted demand.

The goal of 20 percent non-petroleum fuel use in 2020, increasing to 30 percent in 2030, would include the non-petroleum portion of fuel blends such as Fischer-Tropsch diesel and conventional gasoline. By the end of 2003, California's gasoline will contain approximately 5.7 percent ethanol and that ethanol should be recognized as meeting a portion of the recommended non-petroleum fuel goal. In 2020, the 20 percent recommended goal equates to approximately 15 percent non-petroleum fuel in fuel blends (ethanol as a portion of conventional gasoline and Fischer-Tropsch fuel as a portion of the diesel) plus another 5 percent non-petroleum fuel such as hydrogen used in hydrogen fuel cell vehicles. The 30 percent goal in 2030 equates to approximately 13 percent non-petroleum fuel in fuel blends (again ethanol as a portion of conventional gasoline and Fischer-Tropsch as a portion of diesel) plus another 17 percent non-petroleum fuel such as hydrogen used in hydrogen fuel cell vehicles.

The goal would be met if the petroleum reduction strategy outlined in this report is implemented. The value of this goal is to assure that regardless of how petroleum reduction is achieved, a minimum percentage of the fuel used in California will come from non-petroleum sources. This provides for fuel diversity and helps pave the way towards a sustainable transportation fuel supply.

Green Car Institute Response #3. In this case, the CEC staff report recommendations come closest to our suggestion that they "declare victory" and move forward. They acknowledge that, by mandate, an alternative fuel will comprise almost 6 percent of the state's fuel this year, and they note other trends such as the federal (and state) moves to develop hydrogen fuel cell vehicles as contributors to positive trend in this area.

In addition, instead of promoting “alternative fuels” (i.e., again avoiding picking a specific technology as "winner"), the state should expand its definition's horizon by increasing the number of drivetrain offerings accepted under this category to include hybrid-electric, PZEV, clean diesel, fuel cell technology, and neighborhood electric vehicles, recognizing these technologies’ role in reduced petroleum.

Lastly, since the state of California is one of the largest vehicle fleet operators in the nation, it should first require that the state government fleet of vehicles begin to convert to these “alternative drive trains.” Such a move would provide a leadership example for other states and government agencies to follow. It also would help stimulate consumer market awareness and acceptance of these advanced, environmentally friendly, and fuel efficient vehicles.

Endnotes

[1] Two leaders have been outspoken in this area – William Clay Ford Jr., CEO of Ford Motor Company, and John Browne, CEO of BP. Ford said at the 5th Annual Greenpeace Business Conference on October 5, 2000, “Longer term, I believe fuel cells will finally end the 100-year reign of the internal combustion engine. Fuel cells, which run on hydrogen, a renewable resource, have zero emissions. We'll have a test fleet of fuel cell vehicles on the road by the end of next year. Fuel cells could be the predominant automotive power source in 25 years.” Browne said at his Stanford University speech on May 19, 1997, “The time to consider the policy dimensions of climate change is not when the link between greenhouse gases and climate change is conclusively proven – but when the possibility cannot be discounted and is taken seriously by the society of which we are part. We in BP have reached that point.” Browne, speaking at the Yale School of Management on Sept. 18, 1998, said, “That means that in our sector in particular we have to demonstrate that everything we do, and every product and service we provide, is delivered in an environmentally sound manner. That’s why we've seen a continuous improvement in the quality of the fuels we provide – an improvement which is set to go further … for instance as we make serious reductions in the sulphur content of gasoline. It’s why we've seen a shift in the balance of the energy products produced – in favour of gas, less carbon intensive products and now in favour of solar and other renewable energies. That shift has been going on for some time but it is far from over. We see solar in particular as a major contributor to world energy needs by the middle of the next century. And we have to do even more than that.”

[2] Reuters, “Lead fights back in hi-tech car battery race,” www.autonews.com (June 12, 2003).

[3] Hellman, Karl H., and Heavenrich, Robert M., "Light-Duty Automotive Technology and Fuel Economy Trends: 1975-2003," Advanced Technology Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency (April 2003), 1. "The average fuel economy of all model year 2003 light vehicles is six percent lower than it was in 1988."

[4] Fleet fuel efficiency for the Big Three automakers in 1973 (the time of the first oil crisis) was 13 mpg. By 1980, it increased to 20 mpg, an increase of more than 53 percent. The decade saw the rise of popularity of small cars like the Honda Civic and Toyota Corolla as well as domestic competitors. Sales of small subcompact cars rose during the decade from 10.65 percent of the market to 16.46 percent. Automakers shifted to front-wheel drive for mass-produced cars and government regulators instituted CAFE (Corporate Average Fuel Economy) standards that reinforced the industry directions and imposed penalties for failing to obtain the specified level of performance.

[5] Millennium Cell, “Harris Poll Shows Americans' Early Preferences and Requirements for Hydrogen Fuel-Powered Vehicles,” <http://www.millenniumcell.com/cgi-bin/news.pl?function=detail&id=06112003> (June 11, 2003).

[6] Stipp, David, “The Coming Hydrogen Economy,” *Fortune* (Oct. 28, 2001).

[7] Stoffer, Harry, “EPA: Rules won't bar diesels,” *Automotive News* (Feb. 11, 2002). Quoting Margo Oge, director of the EPA's Office of Transportation and Air Quality.

[8] Visnic, Bill, “Diesels for the U.S.: A Definite ‘Probably,’” *WardsAuto.com* (June 13, 2003).

[9] Lapham, Ed, “Bill Ford sees future of hybrids, hydrogen,” *Automotive News* (May 26, 2003), 1.

[10] Truett, Richard, “Detroit Auto Show: GM and Toyota turn up the heat on hybrids,” *Automotive News* (Jan. 6, 2003), 1.

[11] Ibid.

[12] One model is fueled by compressed natural gas and appears in the AT-PZEV and PZEV categories with slightly different engine controls.

[13] California Environmental Protection Agency Air Resources Board Staff Report, “2003 Proposed Amendments to the California Zero Emission Vehicle Program Regulations” (Jan. 10, 2003).

[14] DeCicco, John, “Systems Analysis of Low CO_2 Emission Designs,” presentation at California Air Resources Board International Vehicle Technology Symposium (March 11-13, 2003).

[15] "Analysis of Corporate Average Fuel Economy (CAFE) Standards for Light Trucks and Increased Alternative Fuel Use," Office of Integrated Analysis and Forecasting of the Energy Information Administration (March 2002), 10.

[16] Kamalaratnam, Jayanthi, “Assessment of Emerging Automotive Technologies,” Frost & Sullivan, Analyst Briefing (June 19, 2003).

[17] Interview w/Jayanthi Kamalaratnam, Frost & Sullivan (June 24, 2003).

[18] U.S. Dept. of Energy, “Alternative Fuel News,” <http://www.afdc.doe.gov/documents/altfuelnews/6_3auto_phill.html> (January 2003). Environmental News Network, <http://www.enn.com/news/wire-stories/2002/10/10092002/ap_48646.asp> (Oct. 9, 2002).

[19] Kachadourian, Gail, “GM to promote ethanol-based fuel,” *Automotive News* (Feb. 25, 2003).

[20] Truett, Richard, “GM sticks to 2010 fuel cell target,” *Automotive News* (Feb. 17, 2003).

[21] “Fuel Cell Vehicles to Number 800,000 by 2012, According to ABI.” *Clean Edge News* citing Allied Business Intelligence study, <www.cleanedge.com/story.php?nID=2238> (April 23, 2003).

[22] Schwartz, Peter, and Randall, Doug, “How Hydrogen Can Save America,” *Wired, Life in 2013* Special Section (April 2003), 3-13.

[23] King, Ralph, “Mary Tolan's Modest Proposal,” *Business 2.0* (June 2003), 116-122.

[24] Stoffer, Harry, "Senate votes to decrease oil consumption," *Automotive News* (June 16, 2003), 21.

[25] Green Car Institute, “NEV Roadmap to Master-Planned Communities,” San Luis Obispo, Calif. (Spring 2003).

[26] Browning, Louis, ICF Consulting, “Climate Change,” presentation at California Air Resources Board International Vehicle Technology Symposium (March 11-13, 2003).

[27] Using vehicle population and miles traveled projections from the CEC report, it is estimated that in 2020 California will have 30.6 million light-duty vehicles using 19.6 billion gallons of gasoline and diesel fuel. The same report indicates an alternative to its base case (which predicted no change in fleet fuel economy during the intervening years in spite of an increasing number of mild hybrid vehicles) in which the hybrid market penetration reaches 16% by 2020 (compared to its base case scenario of 6%). With that change, which is obviously supported by the evidence presented in this White Paper, gasoline demand is reduced by more than 900 million gallons in 2020. We believe even this alternative undervalues the potential market penetration of hybrids, which we predict will be 20% of the market in 2020. That 20% market share would yield a reduction in gasoline demand of 1.125 billion gallons based on CEC's calculations. Again, extrapolating from CEC figures for petroleum reduction from its mild hybrid alternative case (which are less than would be achieved by diesels), our projected clean diesel market share would deliver a 1.5 billion gallon reduction in demand. Using the same methodology, our estimated 50% market share of advanced ICE technology vehicles would further reduce petroleum demand by approximately 5 billion gallons. Finally, the 10% market share for fuel cell vehicles would reduce demand by another net 2.0 billion gallons. The total of this projected market is a demand level 9.625 billion gallons below the CEC base case or 9.975 billion gallons total demand, a 30% reduction from the 2000 demand level.

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