Possible Effects of Larger Vehicles on the CO_2 Mitigation of Compact Hybrid Vehicles in California

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Abstract This project investigates whether the increase in larger, less efficient vehicles in California over the next twenty years will adversely effect carbon dioxide mitigation despite clean technology improvements in compact vehicles. Given different projections for our states population growth, I assessed the overall carbon dioxide mitigation effects of clean vehicle technology given various rates of growth and efficiency improvement across compact vehicles, sport utility vehicles, and commercial transportation. California is the most prolific of all states with regards to automobile travel and commercial vehicle usage. Californians have an average of one vehicle for every two persons in the population. As a response to the increasing number of vehicles in the state, California is also on the forefront of environmental legislation for mitigation of pollutants such as carbon dioxide and other ozone depleting substances found in smog. However, as our burgeoning population continues to grow, the number of vehicles on the road will increase as well as the consumption of fuels and the polluting effects of burning these fuels. The sport utility sector (SUV) has been the fastest growing sector of the automobile sales in the United States for the past ten years. SUVs although much more efficient than in earlier times, have lacked the clean technology investment of smaller compact vehicles. Compact clean technologies have been successful in California, but not as prolific as SUV sales. My scenarios illustrated that environmental gains of compact hybrid technologies are significantly offset by the lack of clean technology in larger vehicles and the overall increase in the number of large vehicles in California. This indicates a need for significant attention for both the high growth rate of larger vehicles as well as the efficiency of large vehicle engines.

Introduction

Since the advent of hybrid and electric vehicles into mainstream American automobile industry, there has been a general acceptance of these technologies as a suitable means to mitigate global warming and ozone depletion caused buy the consumption of fossil fuels (Harrison, 2003). California, the most prolific of all the states in terms of automobile sales and usage (Rand McNally, 2001), has been at the forefront of the nation in adopting environmental legislation regarding automobile pollution (Waterman, 1998). As automobile sales continue to grow, many in California look to hybrid and electric vehicles as the "savior of our environment" (Waterman, 1998). Studies have definitively shown that hybrid and electric vehicles pollute much less point source carbon dioxide than their traditional internal combustion counterparts (DOE, 1998). However, even in light of those studies, the electric vehicle market has failed to become a successful economic venture in California (Parker, 2003).

The failure of electric vehicles to become a viable option for mainstream transportation has lead to large research and economic investments on the part of many automobile manufacturers into clean technologies (Diem, 2003). Automobile corporations in America and abroad have focused their main attention on hybrid technologies for smaller vehicles which has lead to many successful ventures in that sector (Friedman, 2003). Although this strategy would certainly be more sensitive to the environment than disregarding environmental concerns and clean technologies, there is still the fact that these corporations have not placed as much emphasis on green technology for larger vehicles (Friedman, et al., 2003). Sport utility vehicles are the largest growing sector automobile sales in the United States (R. L. Polk, 2003). In addition, as the population of California grows, and commerce expands, so will the need for long haul trucking. These vehicle types represent some of the most inefficient of traditional combustion engines (Mark and Morey, 2000).

Many studies such as GREET and HEVCOST (ATTA, 2003) have demonstrated the environmental and economic efficiency of hybrid vehicles. However, few of these studies have taken into account how growth in larger traditional vehicles will affect the carbon dioxide mitigating potential of the mostly compact hybrid vehicles. I believe that the numbers of these larger vehicles are especially important in California, where growth in those sectors is projected to be the greatest.

California' population is expected to grow more than any other state in the union (US Census, 2000). As population increases, so will the number of drivers, and the amount of vehicles on the road. California already has the most registered vehicles of any other state (US Census, 2000).

Economic prosperity in California has also led to an increase of families with more than one car (Falon, 2003). Commercial transportation (trucking) has expanded in California to meet the burgeoning needs of our economy (Levin, et al., 2001). These factors are very important to consider when examining the effectiveness of hybrid vehicles in California transportation. The cornerstone of my study is my belief as population increases and the number of additional larger, more inefficient, traditional private and commercial vehicles increases, the carbon dioxide mitigating potential of hybrid vehicles will be significantly reduced. This study will present a variety of scenarios based on various population projections for California and the growth of commercial and private transportation.

Methods

My research examines the CO_2 mitigation effectiveness of hybrid vehicles in California over the next twenty years. At specific intervals (2005, 2015, and 2025), scenario projections will be examined and discussed. I choose population models representing distinctive and comprehensive growth trends for California from five different publication sources: the *Congressional Quarterly* [2003], *Information Publications* [2003], *California Statistical Abstract* [2002], *US Databook Series* [2002], and the *California Senate Office of Research* [2001].

With these projections, I applied the EPA benchmark values for vehicles per capita (.593 per capita for private and .16 per capita for commercial) (EPA, 2000). This yielded a number for the total amount of private and commercial vehicles for a given state population. I then applied the current market share percentages for compact vehicles and SUV, and hybrid vehicles to the amount of private vehicles to extract a number for compact cars, hybrids, and SUVs. I recorded the data for each specific population projection and made a scenario for each of the five based on these values which represented my starting quantity for 2005.

To yield an accurate gas mileage, I averaged the mileages of the three best selling hybrid vehicles and used that value to represent hybrid vehicle gas mileage for this study. For the SUV's , I averaged the top ten best selling SUV mileages to represent the SUV gas mileage in this study. For the rest of the study, I used the Mobile6 benchmark of 19.35 mpg (EPA, 2000) for the rest of the private vehicles (non-hybrids and non-SUVs) and 7.25 mpg (EPA, 2000) for the commercial vehicles.

Using EPA projected growth trends for SUVs and Mesak and Hsu's growth rates for new technology for hybrids (Mesak and Hsu, 2003) I extrapolated values for SUVs and hybrids as their representation within the private vehicle sector changed with the population for each of the different projections. For hybrids, I employed both the low (.19%/yr) standard (.24%/yr) and high (.43%/yr) rates from the Mesak/Hsu study (Mesak and Hsu, 2003). This yielded a value for SUV vehicles as well as three separate values for hybrids given the three various growth rates. For commercial vehicles, I used the Mobile6 standard of vehicles per capita (EPA, 2001) at the different population values at 2005, 2015, and 2025.

In each population model, I combined the SUVs with the commercial vehicles to get a value for large vehicles. Using the percentage of that value represented by SUV's I averaged together my SUV fuel economy with the Mobile6 value for commercial vehicles to get a large vehicle miles per gallon. Using the percentage of compact vehicles represented by hybrids given my three various growth rates, I averaged together my hybrid fuel economy with the EPA Mobile6 standard to get a compact vehicle miles per gallon. I then divided the Mobile6 benchmark for miles traveled per year (13500 miles per year for private vehicles and 14000 miles per year for commercial vehicles) (EPA, 2001), by the miles per gallon values to get a value for total fuel used per year for compact and large vehicles.

I then multiplied this value by the amount of compact and large vehicles to get a total fuel use value for each category (in gallons). Applying the Mobile6 benchmark for lbs CO_2 produced per gallon of fuel (.047 lb/gal for compact engines and .388lb/gallon for large engines) (EPA, 2001) gave me a value for total CO_2 emissions per year for each category. This resulted in several values for CO_2 pollution based upon varying rates of population growth (the differences of the five models I used) as well as the variance in the growth of the hybrid vehicle and SUV market shares in California.

The resulting data is presented in graphical form for comparison depicting various rates of CO_2 pollution mitigation given various population projections and rates of new technological incorporation into mainstream production. The data is such that classes of vehicles can be separated out and those with the greatest and least effect on CO_2 pollution can be discussed and compared.

Results

The various population estimates and growth rates for California over the next twenty years resulted in varying levels of carbon dioxide pollution although yielding similar trends in pollution growth for both vehicle sectors. The *Congressional Quarterly* estimations yielded the highest population estimations ranging from 36.5 million in 2005 to 52.7 million in 2025 (Hovey and Hovey, 2003). At .593 private vehicles and .16 commercial vehicles per capita (EPA, 2002), these projections yielded 17.1 million compact vehicles and 10.4 million large vehicles in 2005 declining to 16.6 million compact vehicles in 2025 and growing to 23.1 million large vehicles in 2025. This generated an average decline in compact vehicle pollution, from 700 million lbs CO_2 in 2005 to 667 million lbs CO_2 in 2025, and a growth in pollution in the large vehicle sector from 5.5 billion lbs CO_2 in 2005 to 10.9 billion lbs CO_2 in 2025.

California Statistical Abstract estimations yielded population estimations ranging from 35.6 million in 2005 to 50.3 million in 2025 (DOF, 2002). At .593 private vehicles and .16 commercial vehicles per capita (EPA, 2002), these projections yielded 16.6 million compact vehicles and 10.1 million large vehicles in 2005 declining to 15.8 million compact vehicles in 2025 and growing to 22.1 million large vehicles in 2025. This generated an average decline in compact vehicle pollution, from 541 million lbs CO_2 in 2005 to 517 million lbs CO_2 in 2025, and a growth in pollution in the large vehicle sector from 5.5 billion lbs CO_2 in 2005 to 10.4 billion lbs CO_2 in 2025.

Information Publications estimations yielded population estimations ranging from 35.7 million in 2005 to 49.3 million in 2025 (Hornor, 2003). At .593 private vehicles and .16 commercial vehicles per capita (EPA, 2002), these projections yielded 16.7 million compact vehicles and 10.2 million large vehicles in 2005 declining to 15.5 million compact vehicles in 2025 and growing to 21.6 million large vehicles in 2025. This generated an average decline in compact vehicle pollution, from 541 million lbs CO_2 in 2005 to 522 million lbs CO_2 in 2025, and a growth in pollution in the large vehicle sector from 5.4 billion lbs CO_2 in 2005 to 10.2 billion lbs CO_2 in 2025.

US Databook estimations yielded population estimations ranging from 34.8 million in 2005 to 45.0 million in 2025 (US Census, 2002). At .593 private vehicles and .16 commercial vehicles per capita (EPA, 2002), these projections yielded 16.3 million compact vehicles and 9.9 million large vehicles in 2005 declining to 14.1 million compact vehicles in 2025 and growing to 19.7 million large vehicles in 2025. This generated an average decline in compact vehicle pollution, from 520 million lbs CO_2 in 2005 to 507 million lbs CO_2 in 2025, and a growth in pollution in the large vehicle sector from 5.3 billion lbs CO_2 in 2005 to 9.3 billion lbs CO_2 in 2025.

California Senate Office estimations yielded the lowest population estimations ranging from 34.1 million in 2005 to 44.2 million in 2025 (US Census, 2002). At .593 private vehicles and .16 commercial vehicles per capita (EPA, 2002), these projections yielded 16.0 million compact vehicles and 9.1 million large vehicles in 2005 declining to 13.9 million compact vehicles in 2025 and growing to 12.3 million large vehicles in 2025. This generated an average decline in compact vehicle pollution, from 518 million lbs CO_2 in 2005 to 426 million lbs CO_2 in 2025, and a growth in pollution in the large vehicle sector from 5.2 billion lbs CO_2 in 2005 to 9.2 billion lbs CO_2 in 2025. Of note in this projection is that with the high hybrid growth projection and low population growth, there was a significant decline in CO2 pollution of compact vehicles (from 518 million lbs CO_2 in 2005 to 404 million lbs CO_2 in 2025), the only of its kind in all projections.

All CO_2 pollution findings are represented graphically on the following page in Figure 1 with average CO2 reductions and growth represented from 2005 to 2025 and an additional data reading at 2015.

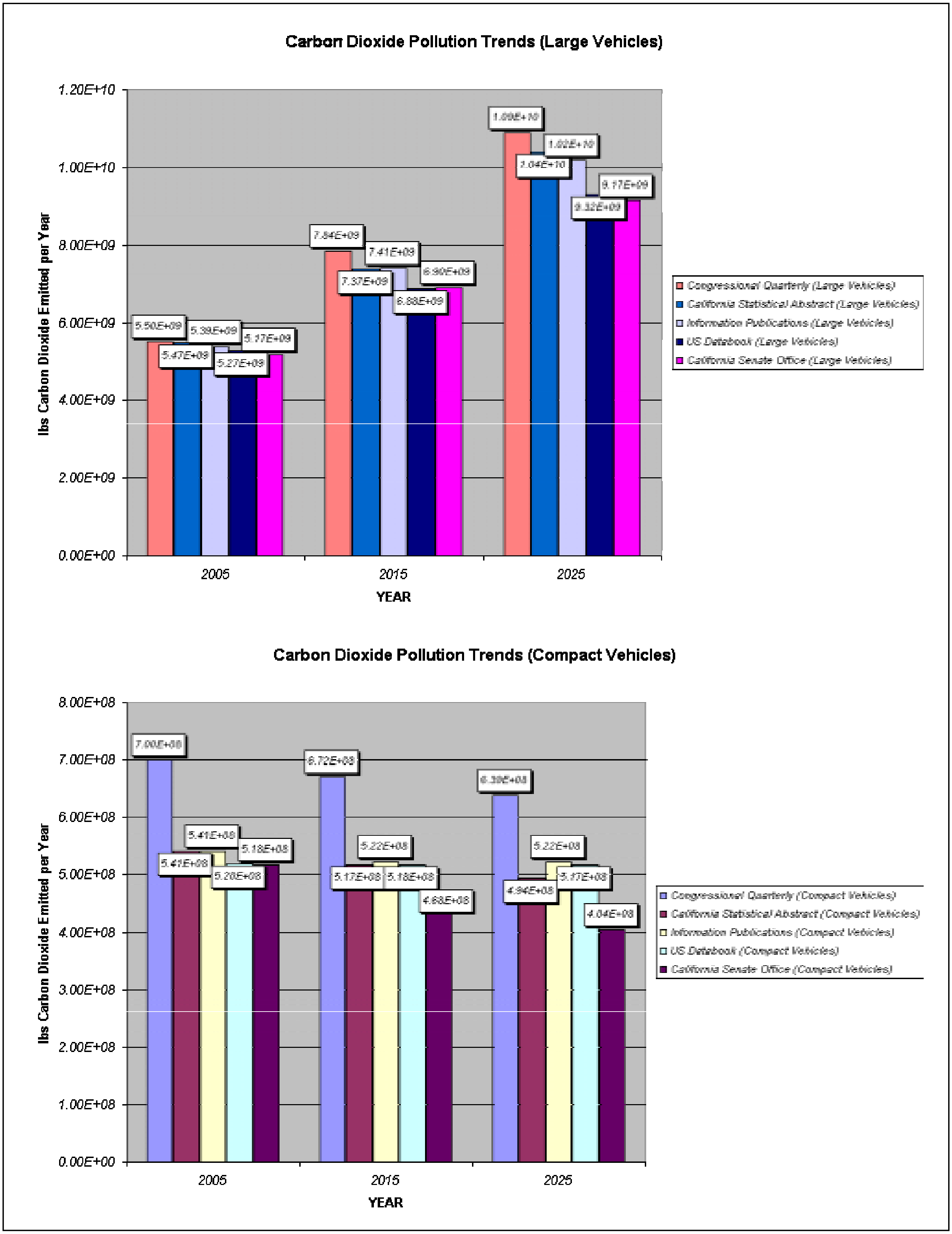
Carbon Dioxide Pollution Trends (Large Vehicles)
lbs Carbon Dioxide Emitted per Year
YEAR
2005
2015
2025
1.20E+10
1.00E+10
8.00E+09
6.00E+09
4.00E+09
2.00E+09
0.00E+00
5.50E+09
5.47E+09
5.39E+09
5.27E+09
5.17E+09
7.84E+09
7.37E+09
7.41E+09
6.88E+09
6.90E+09
1.09E+10
1.04E+10
1.02E+10
9.32E+09
9.17E+09
Congressional Quarterly (Large Vehicles)
California Statistical Abstract (Large Vehicles)
Information Publications (Large Vehicles)
US Databook (Large Vehicles)
California Senate Office (Large Vehicles)
Carbon Dioxide Pollution Trends (Compact Vehicles)
lbs Carbon Dioxide Emitted per Year
YEAR
2005
2015
2025
8.00E+08
7.00E+08
6.00E+08
5.00E+08
4.00E+08
3.00E+08
2.00E+08
1.00E+08
0.00E+00
7.00E+08
5.41E+08
5.41E+08
5.20E+08
5.18E+08
6.72E+08
5.17E+08
5.22E+08
5.18E+08
4.68E+08
6.39E+08
4.94E+08
5.22E+08
5.17E+08
4.04E+08
Congressional Quarterly (Compact Vehicles)
California Statistical Abstract (Compact Vehicles)
Information Publications (Compact Vehicles)
US Databook (Compact Vehicles)
California Senate Office (Compact Vehicles)

Figure 1

Conclusions

The data illustrates that there was a significant effect on CO_2 mitigation by large vehicles in all of my projections. There was an average drop off in CO_2 pollution by a rate of 6.7 million pounds of CO_2 per year by compact vehicles. There was an average growth of 599 million pounds of CO_2 per year in large vehicles, eclipsing the hybrid CO_2 mitigation by about 90 times.

Only in the high hybrid growth/low population growth projection for the *California Senate Office* was the mitigation of carbon dioxide significant in relation to the growth of CO_2 pollution in large vehicles (about a 20 million lb reduction in CO_2 per year to a 350 million lb increase in CO_2 per year in large vehicles).

Discussion

My scenarios suggest that strategies that curb vehicular usage or focus on improvements in efficiency of larger vehicles may be very effective in amplifying the environmental benefits of smaller clean vehicles. The results show that the reduction in CO_2 in larger engines is not enough to keep pace with the growth that these sectors will achieve in the coming years despite even a fast uptake of new technology in that sector. The lack of current efficient technology in that sector prohibits a make up of this “efficiency gap” (Levin et al., 2001) which points to the current issue of research, development, and incorporation of clean technologies today, drastically changing the start point of these projections that would allow for a make up of that deficiency.

Across both sectors, the growth of the automobile industry is shown to also significantly effect CO_2 mitigation. Even within the compact sector, the growth of the hybrid vehicle incorporation cannot keep up with growth of the entire sector unless a high growth ate for these new technologies are achieved. This illustrates that either the number of vehicles needs to be reduced, or a large public interest in clean technology needs to be realized to ensure that the CO_2 mitigation potential of hybrid vehicles is reached.

Possible Solutions One of the most striking factors that my results illustrated was the staggering amount of vehicles that will be on California roads as the population increases. If the private vehicles in California continue to grow at a rate of .59 per capita per year, CO_2 mitigation will be increasingly difficult to accomplish despite technological improvements. This problem exists despite vehicle size and transcends all types of transportation. More emphasis on carpooling may arrest the rapid growth in private vehicles by allowing more incentives for the public to carpool during commute hours (Poole, 2002). Programs such as free bridge tolls on the Oakland-Bay Bridge for carpools during peak hours can be extended to more toll roads across the state into non peak hours which will encourage drivers to refrain from driving their vehicles.

Another program that can be considered is a reduced registration rate for vehicles logging low mileages over the yearly term of their vehicle registration. Programs rewarding commuters who drive only when necessary will provide further incentive for drivers to think carefully before driving their vehicles. This way, the state can establish specific tiers for discounted rates which will serve to decrease the amount of miles driven and fuel consumed. An interesting statistic was the growth rate of commercial vehicles per capita (.16 per capita) in California. These vehicles represent the most fuel inefficient motors contributing to CO2 pollution in our state. Possible solutions to curb this growth rate includes an increase in double rig vehicles (trucks with two rigs), doubling the hauling efficiency of these engines (Railpage, 2001).

A more drastic approach to cleaning up commercial transportation would involve an investment by trucking companies into hybrid and dual fuel commercial trucks for their fleets. As compensation for their investments, Cal Trans can furnish rest stops along the sates major highways with free truck recharge stations for vehicles requiring electric battery recharges. Also, the state could reduce the apportioning fees for commercial trucking companies with a certain percentage of clean technology vehicles in their fleet.

There is still a greater concern for the growing SUV sector of private automobile transportation. SUVs and large luxury cars have typically had less fuel efficient engines because the people that purchase these vehicles generally are not concerned with the cost of gasoline. However, these vehicles must be addressed if California is to seriously mitigate CO_2 emissions. The largest automobile producers in the United States have placed little emphasis on the inclusion of cleaner hybrid technologies in their larger vehicles and SUVs. The costs of producing large hybrid engines are seen as too great to pass along a competitive price to the consumer. However, again, it is within the power of the state to provide incentives for consumers purchasing these clean vehicles. Imposing a tax on vehicles exceeding established “acceptable” fuel efficiency will promote the purchase of more fuel efficient cars of a higher price (UCS, 2003). This would shift the importance of remaining cost effective off of the producers while also providing tax dollars for the economy to improve infrastructure.

Fundamentally, all of these solutions require that the public be educated of the possible environmental detriments if we continue to ignore the lack of responsible driving and purchasing choices that exist within our state. Without adequate knowledge of possible environmental degradation, we cannot expect the approval of new fuel taxes or the approval of funds to improve public transportation. Educating the public is the most important aspect in fighting all forms of degradation to the environment, especially those requiring the usage of public funds (PEO, 1999).

Low cost programs in public education are important to instruct people of responsible driving choices and driving alternatives emphasizing the savings they will receive in lower gasoline costs. This can help to reduce the amount of driving which will in turn increase the mitigating effectiveness of hybrid vehicles without relying on large growth rates.

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