Southwest Energy Efficiency Project

Saving Money and Reducing Pollution through Energy Conservation

NET ECONOMIC BENEFITS OF REPLACING GASOLINE VEHICLES WITH PLUG-IN ELECTRIC VEHICLES SUPPORT POLICIES TO REDUCE BARRIERS TO ELECTRIC VEHICLE OWNERSHIP

Presented to House Committee on

Summary of Cost Differences Based on Vehicle and Energy Costs.

- Primarily because of the significantly lower cost of domestically produced electricity compared to petroleum fuels, Plug-In Electric Vehicles (PEVs) will reduce the overall cost of transportation for each vehicle owner, and provide significant economic benefits for the Colorado economy.
- Today the cost of electricity in Colorado to power a vehicle the same distance as a gallon of gasoline is about $1.25, which is more than 60% less than the cost of the gasoline ($3.30).
- The difference in cost of energy needed to power a PEV compared to a gasoline vehicle is expected to increase between now and 2035 by between 15% and 100%, depending primarily on how rapidly the global price of petroleum rises.
- Average annual fuel savings for different PEV models purchased in 2012 will range between $316 and $1,340 depending on the difference between electricity and gasoline costs during the useful life of the vehicle.
- The cost of EV batteries are expected to continue to decline as technology advances.
- Lower battery costs are expected to reduce incremental PEV purchase costs by up to 47% by 2017, 75% by 2025 and 80% by 2030.
- Net cost of ownership (purchase price and energy costs during useful life) for a PEV will be less (between $2,583 and $20,310) compared to comparable gasoline vehicles depending on different PEV models.
- Rising gasoline prices will cost the Colorado economy between $48 and $120 billion between 2012 and 2035.
- Aggregate net fuel savings from displacing gasoline with electricity as the energy source for light duty vehicles will range from $4.8 billion to $11.8 billion between now and 2035 depending on –
    1. how rapidly petroleum fuel costs rise faster than the cost of domestically produced electricity; and
    2. the share of the light duty vehicle fleet operating on electricity.
- A portion of these fuel cost savings will be spent on the capital investment needed to replace gasoline light duty vehicles with electric vehicles, and the cost of electric charging infrastructure.
- Taking account of these investments, the aggregate net economic benefits to Colorado from PEVs will range from $1.6 to $6.3 billion depending on fuel costs and the total

vehicle miles travelled using domestically generated electric power instead of petroleum fuels.

- H.B. 1258 will help Colorado achieve the large fuel savings benefits to the State's economy by encouraging commercial interests to offer electricity for sale as a power source for EVs without having to incur the cost burden associated with being regulated as a public utility, and convincing the PUC to break the utility monopoly over power sales.

H.B. 1258 Will Help Achieve a Multi-billion Dollar Boost for Colorado's Economy by Overcoming One of the Two Major Barriers to EV Adoption.

The two biggest barriers to EV adoption are 1) the incremental purchase price of an EV compared to a comparable gasoline vehicle, and 2) limited access to energy to recharge the battery away from home which contributes to the fear that the battery cannot be recharged before destinations are reached.

In this analysis, SWEEP investigates the magnitude of the differences in the cost of ownership between PEVs and traditional gasoline vehicles. From this analysis, SWEEP demonstrates that --

- fuel cost savings ranging from $4.8 to $11.8 billion will far exceed the incremental purchase cost of battery-powered vehicles;
- the net savings achieved by using domestically generated electricity to power the vehicles will significantly reduce the annual cost of transportation to vehicle owners;
- net transportation cost savings will retain in the local economy from $1.6 to $6.3 billion of wealth that would otherwise leave the State to purchase petroleum fuels;
- retaining this large pool of wealth in the local economy will provide a major boost for job creation in Colorado's economy.

These economic benefits to the State justify public policies designed to reduce the barriers to EV ownership and use, such as the de-regulation of the retail sale of electricity to power electric vehicles as proposed in H.B. 1258.

METHODOLOGY.

This analysis compares electric vehicles with gasoline vehicles using the two most significant factors that determine the cost of ownership: (i) the purchase price of the vehicle, and (ii) the cost of energy to operate the vehicle during its useful life. Other factors that will affect the cost of ownership -- maintenance, mid-life battery replacement and highway user fees -- are not addressed here because they are not expected to change the fundamental conclusions drawn from the largest costs of ownership.[1]

---

[1] Maintenance Costs: Electric vehicles are expected to have lower annual maintenance costs than gasoline powered ICE vehicles due to the simplicity of the electric motor compared to the ICE. Routine maintenance operations such as oil changes, tune-ups and spark plug replacements will not be necessary for electric vehicles. Several sources estimate the reduction in maintenance costs for electric vehicles at 50%. Electric vehicles driving 11,000 annually would save about $500/year.

RESULTS.

This assessment of the major costs of ownership demonstrates that family transportation costs can be reduced from $2,583 to $20,310 over the life of a PEV compared to owning a gasoline vehicle. This cost reduction is achieved primarily from the lower cost of electricity compared to petroleum fuel as the source of energy. Taking into account both the savings that result from using locally generated electricity instead of petroleum as the energy source, and the incremental capital cost of purchasing a battery operated vehicle, the incremental net benefits to the state (compared to the baseline cost of gasoline vehicles) will range from $1.6 to $6.3 billion between now and 2035, depending on the price of fuel and the rate that gasoline vehicles are replaced with electric powered vehicles. These cost savings will mostly be spent on other goods and services in Colorado, and then reinvested in Colorado's economy. Generating more electricity locally, together with retaining this wealth in Colorado's economy, will create thousands of additional in-state jobs.

Fuel Cost Savings.

Electric vehicles' achieve significant reductions in fuel costs both because electric motors use less energy, and because the electricity used to power a vehicle costs nearly 2/3 less per mile driven than petroleum fuels. Electric motors use energy more efficiently than gasoline-powered internal combustion engines. Electric powered vehicles can cover the same distance as gasoline powered vehicles using between 35% and 60% less energy (measured in BTUs), depending on the efficiency of the source generating the electricity.

Pure electric vehicles (EVs) operate entirely on power from the grid. Plug-in hybrid EVs (PHEVs) operate on battery power until the battery is empty (PHEV-10s have a 10 mile electric range and PHEV-40s have a 40 mile electric range), and then switch to liquid fuel. Both pure EVs and hybrid PEVs reduce gasoline consumption and will provide significant savings to drivers by reducing both fuel costs and overall lifecycle vehicle costs.

Electric Rates

The reduced cost of fueling a PEV will in part depend on the electric rates available to PEV

Battery Replacement: A potential significant additional cost for PEVs is the replacement of the battery. Batteries for electric vehicles may not operate at desired capacities over a full fifteen year average vehicle life. Replacing the battery after 8-10 years will add significantly to the lifetime costs of PEVs. Current battery costs (per kWh) are estimated at $450 but may fall by 2020 or earlier. The announcement in March 2012 of new developments in battery technology suggest that cost reductions to $200/kWh are now only four years away from being available to the market.

Future Mileage Based User Fees: Currently, PEVs pay vehicle registration fees, but no fuel tax on their electric miles. Compared to a new ICE gasoline vehicle, an electric vehicle would have annual savings over the life of the vehicle of $83 from not paying gasoline taxes. If mileage based user fees for all vehicles are adopted this would add to the lifetime costs of PEVs.

owners. Table 1 shows the major utilities in Colorado (over 50,000 customers) along with their average residential rate in 2010.

Table 1. Major Colorado Utilities[2] and the Cost per kWh for Residential Customers in 2010

	Number of Customers	% of State's Customers	Price per kWh, 2010
Xcel	1,156,123	54.3	$0.1115
City of Colorado Springs	187,426	8.8	$0.1011
Intermountain Rural	127,483	5.9	$0.1182
Black Hills	81,833	3.8	$0.1219
City of Ft Collins	57,949	2.7	$0.0779
United Power	57,871	2.7	$0.1151

The average retail price per kWh for all residential customers in Colorado in 2010 was $0.1104.[3] This price was used as the basis to estimate the fuel costs associated with operating PEVs in Colorado.[4]

At the current average residential electricity price compared to an average new gasoline powered passenger vehicle that meets the latest federal fuel efficiency standards, an EV driver in Colorado will spend $1.25 on electricity to travel the same distance covered by a gallon of gasoline (32.3 miles).[5] If time of use rates were available for charging during the nighttime hours when there is much unused electric power generating capacity, the cost of driving a PEV would fall further.

Cost Benefits to Individual Electric Vehicle Owners.

The average driver in Colorado travels about 11,000 miles annually. At current electricity and gasoline prices, an EV driver travelling 11,000 miles/year would save around $650 annually in fuel costs compared to a new gasoline vehicle which will pay $1,100 annually at the current price ($3.30/gallon). If EV owners were allowed to pay the average cost of electric power at night by charging their vehicle during the off-peak nighttime period when the cost of power

---

[2] Energy Information Administration. 2010).
Class of Ownership, Number of Consumers, Sales, Revenue, and
Average Retail Price by State and Utility: Residential Sector, 2010 Retrieved from
http://www.eia.gov/electricity/sales_revenue_price/pdf/table6.pdf

[3] Energy information Administration. (2010). Residential Average Monthly Bill by Census Division, and State 2010. Retrieved from http://www.eia.gov/electricity/sales_revenue_price/xls/table5_a.xls

[4] Future electricity prices were estimated using the Energy Information Administration's estimates for the percentage increase expected for electricity prices in the Mountain region.

[5] A new passenger vehicle has an estimated efficiency of 32.3 mpg. To travel 32.3 miles, an electric vehicle will require 11.33 kwh (32.3 mpg*.3508 kwh/mile) which will cost $1.25 (11.33 kwh * $0.1104), based on the statewide average residential rate.

generation is lowest, then the annual fuel cost for the average EV owner would be reduced by about another 20-30% less than today's electric power cost. These fuel savings will increase year-by-year as petroleum prices are expected to continue their long-term pattern of rising faster than electricity prices. This price differential is expected to increase even faster in the future as a result of Colorado's renewable energy standard which will shift the source of power generation from fossil fuels priced in global markets to 30% wind and solar energy which are free goods.

As the future price differential between electricity and gasoline increases, the fuel cost advantage for an electric vehicle purchased in 2012 and driven 11,000 miles per year is expected to average more than $1,300 over the useful life of the vehicle.

Table 2 provides the fuel cost avoided for each 11,000 miles driven by each of the three types of PEVs currently available. The values represent the difference between the gasoline cost that would have been paid and the cost of the electricity to drive the same distance using the current average statewide residential electricity rate of $0.01104 per kwh

Table 2. Individual Vehicle Average Annual Fuel Savings Compared to New Gasoline Vehicle Over the Vehicle's Lifetime

	Reference Gasoline Price	Current Trend Gasoline Price
PHEV-10 (Prius Plug-In)	$316	$499
PHEV-40 (Volt)	$664	$1,059
BEV (Leaf)	$799	$1,340

Figure 1. Average Annual Fuel Savings for PEVs Under Two Gasoline Price Scenarios

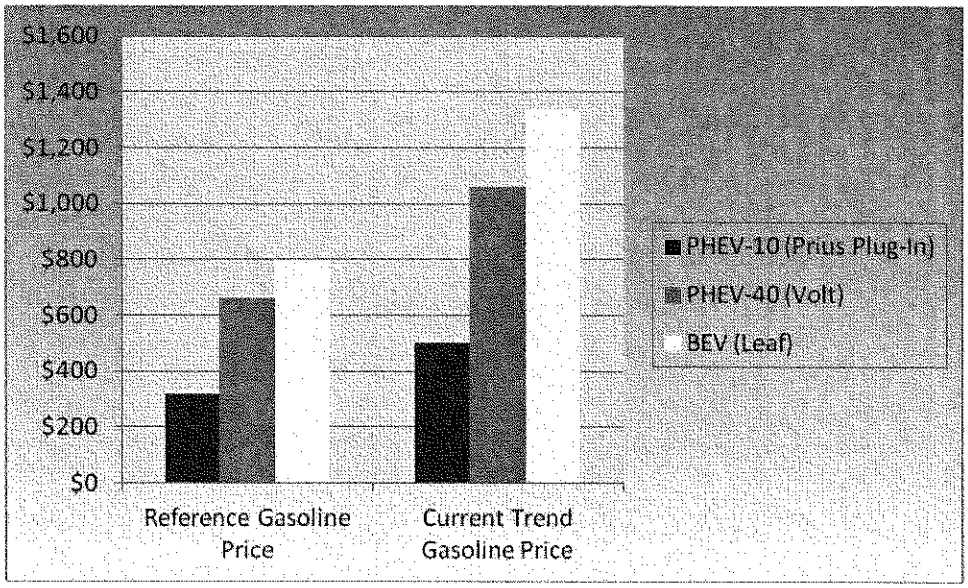
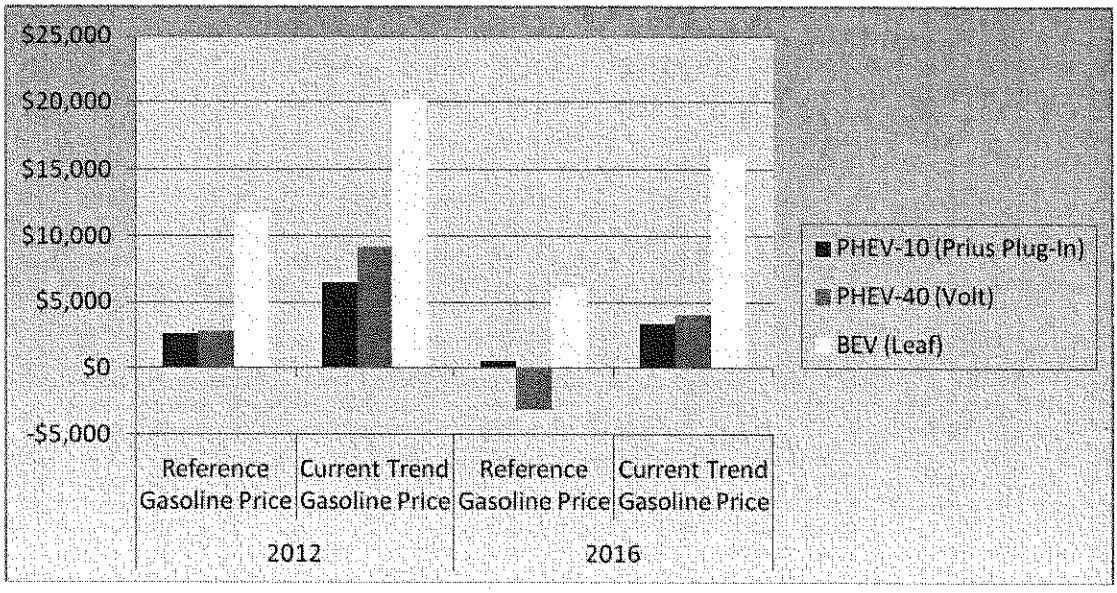


Table 3 shows the lifecycle benefits of PEVs less the incremental capital costs. During the average 15 year life of an EV, these energy savings will more than offset the additional cost of most PEVs. The average lifecycle benefit of an EV purchased in 2012 and operated for 15 years compared to a gasoline powered vehicle is between $11,611 and $20,310 depending on the difference in the costs of electricity vs. petroleum fuels. As gasoline prices are expected to increase at much greater rates than electricity and natural gas prices, electric vehicles will achieve a significantly greater fuel price advantage in future years even as new gasoline powered light duty vehicles become more fuel efficient due to the proposed federal fuel efficiency standard that will be fully in effect by 2025.

Table 3. Individual Vehicle Lifecycle Cost Benefits Compared to New Gasoline Vehicle

	Reference Gasoline Price	Current Trend Gasoline Price
Purchased in 2012[6]		
PHEV-10 (Prius Plug-In)	$2,583	$6,465
PHEV-40 (Volt)	$2,823	$9,156
BEV (Leaf)	$11,661	$20,310
Purchased in 2016[7]		
PHEV-10 (Prius Plug-In)	$566	$3,391
PHEV-40 (Volt)	-$3,090	$4,020
BEV (Leaf)	$6,085	$16,050

Figure 2. Lifetime Cost Savings for PEVs Under Two Fuel Price Scenarios, With and Without Current Federal and State Tax Credits for PEVs



[6] Vehicle capital cost reduced by federal and state tax credits

[7] Under current law, federal and state tax credits are expected to expire by 2016.

Aggregate Economic Benefits to Colorado from Replacing Gasoline Vehicles with PEVs. When the economic benefits to individual PEV owners are aggregated through 2035, significant statewide economic benefits are realized due to the use locally generated electricity in place of petroleum fuels. Table 4 and Figure 3 show the billions of dollars that the state could be expected to save in fuel costs under three different scenarios for the market penetration of PEVs over the next 25 years. The three Electric Vehicle Market Penetration Scenarios are --

1) Baseline scenario based on the Energy Information Administration's forecast of PEV sales under a fuel price scenario that approximates the recent trend in global petroleum prices;
2) A medium scenario exactly halfway between the baseline and aggressive marketing scenario; and
3) Expected potential PEV sales under markets where barriers to EV use are eliminated and motor vehicle manufacturers implement aggressive marketing strategies.

Table 4. Total PEVs in Colorado Under Different Market Penetration Scenarios

	2025	2035
Baseline-Recent Gasoline Price Trend	103,881	220,772
Medium	287,679	807,809
Aggressive Marketing	471,477	1,394,846

Table 5. Cumulative Incremental Net Fuel Savings[8] (Billions of $), 2012 – 2035

	Reference Gasoline Price	Current Trend Gasoline Price
Baseline-Recent Fuel Price Trend	NA	3.0
Medium	4.8	5.9
Aggressive Marketing	8.5	11.8

[8] The Baseline savings are those savings above zero PEVs being sold and the savings for the Medium and Aggressive Scenarios are those above the Baseline

Figure 3. Cumulative (2012-2035) Incremental $ Fuel Cost Savings from Different Electrification Scenarios

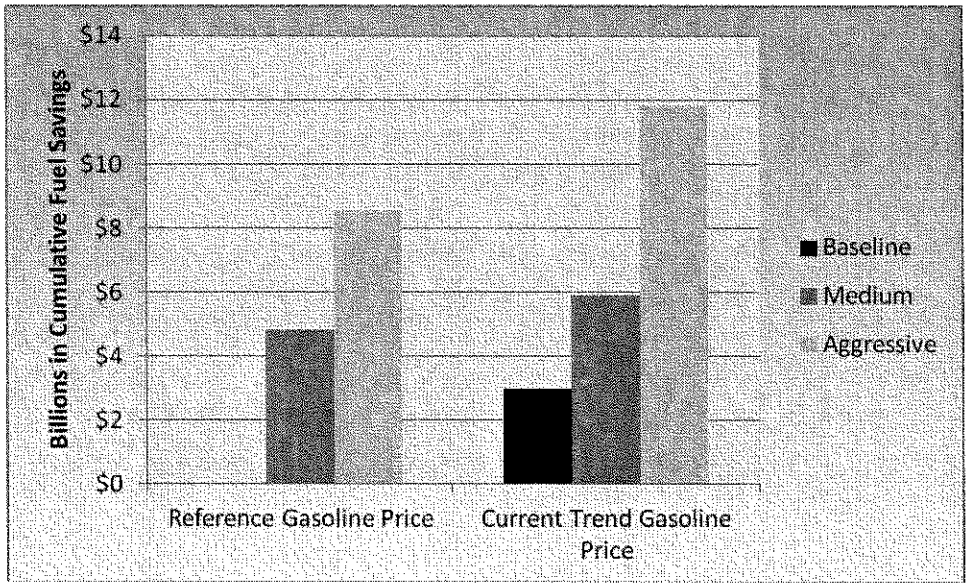


Table 6. Net Incremental Fuel Cost Savings After Deducting Incremental Capital Cost (Billions of $), 2012-2035.[9]

	Reference Gasoline Price	Current Trend Gasoline Price
Baseline	NA	1.9
Medium	1.8	4.6
Aggressive Marketing	4.2	10.9

Reducing the Barriers to EV Ownership are Justified by the Aggregate Economic Benefits of Electric Vehicles

Rising Petroleum Fuel Prices Will Have Significant Adverse Impact on Colorado's Economy. According to the federal Energy Information Administration's (EIA) High Oil Price Scenario which is closest to the recent price trend, gasoline prices will increase to $5.10 per gallon in 2020 and to $5.52 in 2030, compared to $3.83 by 2030 in the EIA's Reference Case Scenario (see dotted and dashed lines in Figure 1).

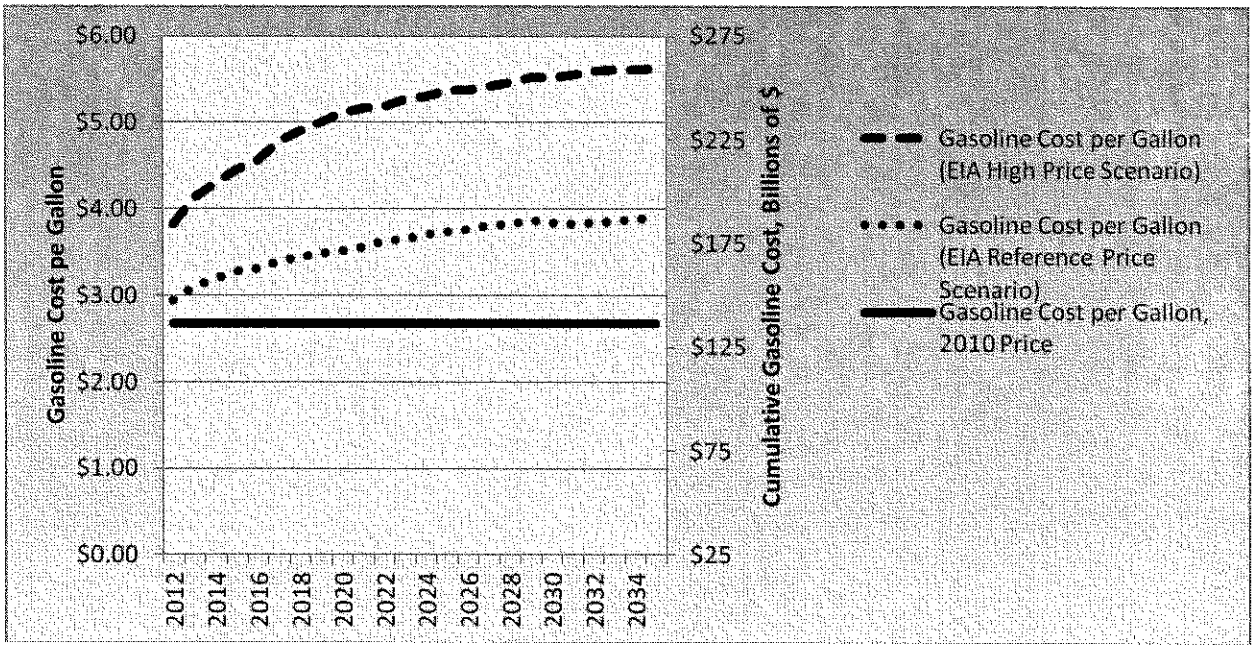
At these prices, the annual cost of gasoline to the statewide economy will rise from $5.5 billion in 2010, to between $8.4 and $11.5 billion (in real 2009 dollars) in 2035 depending on the price

[9] The Baseline savings are those savings above zero PEVs being sold and the savings for the Medium and Aggressive Scenarios are those above the Baseline.

of gasoline.[10] Assuming the EIA price scenarios, cumulative gasoline costs for the state are expected to range between $186 and $258 billion for the period from 2012 and 2035. This is compared to a cumulative fuel cost of $138 billion over the same period if gasoline prices were to remain at 2010 levels. This projected near doubling of the cost of transportation fuels will impose a significant negative impact on the State's economy, unless petroleum fuels in the transport sector can be replaced with less expensive alternative fuels.

Figure 4 shows both the expected increase in gasoline prices over the next 25 years and the expected cumulative cost of gasoline to the state over this time period. The three lines represent three different scenarios for the price of gasoline (left side axis) which show how much would be spent cumulatively in each scenario (right side axis) by 2035.

Figure 4. EIA Estimated Gasoline Price per Gallon and Cumulative Fuel Costs for Colorado (constant 2009 $): 2012-2035



As a result of the anticipated rise in driving costs, families will be required to pay an increasing share of household income for transportation. In response to these higher transportation costs, households will reduce spending on other goods and services, and reduce the discretionary miles they drive. Together, less disposable income and less willingness to drive will negatively

[10] Estimated fuel consumption in 2035 assumes 1) that population grows at rates forecast by the Colorado State Demography Office, 2) that annual VMT per vehicle increases from 10,900 in 2011 to 14,000 in 2035, and 3) that fuel efficiency for gasoline vehicles will be at the average level required to meet current federal fuel efficiency standards, which are estimated at 54 mpg by 2025. If VMT per vehicle is held constant at 2011 level, annual gasoline expenditures in 2035 would be $8.9 billion under the high price gasoline scenario.

impact economic activity in the State. In addition, much of the economic resources spent on motor fuels will leave the State and not contribute significantly to economic activity in the State. A report by Next 10 found that fuel savings are spent on local goods and services and have a strong multiplier effect, creating more jobs than are displaced.[11]

Colorado Can Buffer its Economy from Impacts of Petroleum Fuel Price Shocks by Promoting Alternatives to Petroleum-Powered Transportation.

Petroleum prices are determined by global market forces that can no longer be controlled by the United States. Economic growth in developing nations has increased global demand for personal vehicles and petroleum fuels. In 2009, China replaced the U.S. as the largest market for motor vehicles. Vehicle sales in China alone are expected to exceed 20 million units in 2011, nearly double expected U.S. sales. In China 24 of every 1,000 people own a vehicle, and in India ownership is 8 per 1,000, compared to nearly 800 vehicles per 1,000 people in the U.S. Almost all vehicles purchased in Asia are replacing bicycles and mopeds, adding more vehicles to the highway and driving up global demand for petroleum fuels. In the U.S. 19 of 20 new vehicles are replacing existing vehicles. Because of more stringent national fuel efficiency standards, new vehicles sold in the U.S. use less fuel than the vehicles they replace. U.S. demand for petroleum fuels has stabilized. But global long-term factors are driving both higher global demand and prices for petroleum fuels.

The economies of U.S. States and metropolitan areas need not be victimized by global market forces if actions are taken to buffer these impacts by reducing dependence on petroleum fuels. U.S. states and metropolitan regions that promote alternatives to petroleum powered transport will develop an economic advantage over areas that remain primarily dependent on oil for their transportation needs. By investing today in alternative modes of travel and locally produced domestic sources of energy for motor vehicles, decision makers will lay the groundwork for substantial economic benefits over the next 25 years. States and metropolitan regions that make these investments will buffer their economies from the adverse economic shocks of expected increases in the global price of petroleum fuels.

Transportation is the second largest cost in the family budget after housing. In April 2011, the average Colorado resident was estimated to spend 5.5% of his/her annual income ($2,352) on gasoline.[12] For a family with two cars, this cost is nearly doubled. For low income families, this cost is a significantly larger share of the family budget. The percentage of fuel cost as a share of the family budget will increase as fuel prices rise faster than the inflation rate for all goods and services. At the gasoline prices estimated by EIA, families will pay $8,000 or more annually for gasoline by 2035.

---

[11] Roland-Holst, D. (2011, May). How Fuel Economy and Emissions Standards Will Impact Economic Growth and Job Creation. Retrieved from http://next10.org/next10/publications/vehicle_efficiency.html

[12] Natural Resources Defense Council. (2011). Fighting Oil Addiction: Ranking States' Gasoline Price Vulnerability and Solutions for Change. Retrieved from http://www.nrdc.org/energy/states/files/Oil_Vulnerability_May_2011.pdf, Table 2.

By adopting policies that reduce petroleum consumption, Colorado will benefit economically by retaining greater financial resources in the State's economy. Currently, Colorado produces enough oil to satisfy approximately one-third of its consumption.[13] By replacing petroleum consumption with local sources of energy less money will be spent on imported fuel and more money will remain in the state's economy both to produce the energy locally, and because the cost of locally generated electricity is less. Most funds not spent on importing fuel are expected to remain in the local economy to be spent on better nutrition, housing, entertainment, education and other goods and services which will, in turn, generate employment opportunities. Reducing oil consumption for transportation will also reduce the United States' dependence on imported petroleum and strengthen our national energy security.

Replacement of Gasoline Vehicles with Plug-in Electric Vehicles is the Most Available Option for Reducing Petroleum Dependence.

SWEEP considered three options for reducing petroleum dependence in Colorado: 1) plug-in electric vehicles (PEVs), 2) natural gas vehicles, and 3) increased domestic petroleum production. PEVs are the best available option for a number of reasons.
First, the state is not a net petroleum producer, and cannot protect its economy from global price increases by expanding local petroleum production. Second, even if the U.S. were to expand domestic petroleum production by 20% (a very aggressive target) from 10 to 12 million barrels/day, these additional 2 million barrels/day would not be enough to offset demand growth in developing economies, and would have little impact on oil price in a global market where 89 million barrels/day are now consumed. Aggressive policies to increase U.S. domestic production will not protect U.S. consumers from future global petroleum market price shocks.

Second, consumers have no choice but to buy only one natural gas light duty vehicle offered by an original equipment manufacturer in the U.S.[14] Consumers will soon be able to choose from as many as 55 models of PEVs that are expected on the market by 2015.[15] Manufacturer commitments to produce PEVs are driven, in part, by the requirement in California's clean car standards requiring that original equipment manufacturers achieve minimum sales targets for "zero emission vehicles" (ZEVs). This program is also in effect in eleven other states. Together with California, these states comprise nearly one-third of the U.S. vehicle market. All major vehicle manufacturers are marketing PEVs to meet ZEV sales targets in these states. This is one reason why Nissan and Chevy dealers have not previously been able to offer the Leaf and Volt in Colorado.

---

[13] In 2009, Colorado produced 28.3 million barrels of oil and consumed 89.8 million barrels. See http://www.eia.gov/state/state-energy-profiles.cfm?sid=CO.

[14] Honda Civic.

[15] Citi. (2011, February 23). Electric Vehicles: Perspectives on a Growing Investment Theme. Retrieved from http://www.ceres.org/resources/reports/electric-vehicles-report

Third, consumers are reluctant to invest in natural gas vehicles because few fueling stations exist, and access to fuel is not convenient. By comparison, virtually every home has access to the power grid. EVs can be charged from standard 110 volt outlets, or from higher voltage charging stations with faster charging times. Charging units are easy to install for most homeowners. Garages are not needed. Charging stations can be installed wherever a vehicle is routinely parked.

CONCLUSION.

SWEEP asks the committee to approve H.B. 1258 to eliminate current regulatory barriers to an open market for the sale of electricity to the public for use in electric vehicles. Similar legislation has been enacted in Minnesota, Washington and California. The effect has been to encourage the installation of public charging stations by independent vendors that are not public utilities. Currently only utilities are allowed to sell power to end users in their service areas. This bill will open the market to other commercial vendors to provide this service.

Opening the EV market to a broad range of commercial vendors will help eliminate one of the barriers to public acceptance of EVs: fear that the vehicle will not provide reliable access to destinations more distant than the range of a single battery charge.

The transportation cost reductions, economic benefits to the state's economy, and reducing Colorado's dependence on imported fuels that will be achieved by replacing vehicles dependent on petroleum fuels with electric vehicles provide ample justification for adopting policies designed to reduce the barriers to public acceptance of EVs. H.B. 1258 eliminates one of those barriers.