Colorado Transportation Blueprint for the New Energy Economy

Cost-effective Strategies for Meeting Mobility Needs, Saving Energy, Minimizing Climate Impacts, and Achieving Energy Independence

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July 2009

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Preface

This Blueprint is an investigation of the strategies available to the state of Colorado to reduce greenhouse gas (GHG) emissions from the transport of people and freight. The 2020 and 2050 timelines for achieving reductions, and the 20% (2020) and 80% (2050) reduction targets have been proposed by Governor Ritter in the Colorado Climate Action Plan, and by the President. The 80% target was adopted by the G-8 heads of state (July 2009), and is likely to become the target of the international agreement proposed for adoption at the U.N. Climate Conference in Copenhagen. The climate bill passed by the U.S. House of Representatives sets 83% below 2005 as the targeted reduction for 2050.[1]

In this Blueprint the Southwest Energy Efficiency Project (SWEEP) accepts these targets as a reasonable assessment of the science of climate change derived from the 2007 report of the International Panel on Climate Change. These targets reflect the best understanding of the safe limit for CO_2 in the global atmosphere that must not be exceeded if climate warming is to be stopped at a temperature that will not risk the collapse of the food and water supply systems that support human civilization. As the science evolves, new evidence may support the need to achieve these targets sooner or later, or even change the magnitude of CO_2 reductions from fossil fuel combustion. But for the purpose of this Blueprint, SWEEP does not question or attempt to reassess the scientific basis for these targets.

This inquiry is focused solely on the policy options available to Colorado to achieve the CO_2 reductions needed to meet the currently defined global CO_2 targets. SWEEP makes no effort here to assess the political feasibility of any of the strategies analyzed in this Blueprint. Our task is not to pick winners and losers. The purpose is to present decision-makers and the public with an assessment of each strategy identified by other States in their Climate Action Plans, and by metropolitan planning organizations that have developed long range regional transportation plans for the acknowledged purpose of reducing GHG emissions from transportation.

The strategies included here are assessed with respect to three primary criteria:

1. The potential reduction in CO_2 emissions that can be achieved in Colorado from implementation of the strategy, and the extent to which these potential reductions contribute to meeting the overall emission reduction targets in 2020 and 2050. The estimated future reductions are quantified for 2020 and 2040 for comparison with the targets for 2020 and 2050. The quantified estimates of each strategy do not extend to 2050 because the reductions achievable from strategies quantified in this Blueprint, taken alone, will not achieve the 80% reduction target in 2050. The strategies in the Blueprint provide the basis for envisioning a transportation system powered primarily by electricity that will achieve the 80% by 2050 target when the CO_2 emitted to generate electric power is reduced by 80% as well. But the transformation of electric power generation is outside the scope of this Blueprint.
2. The public and private costs of implementing each strategy; and

[1] American Clean Energy and Security Act of 2009, H.R. 2454, § 311, adding § 702(4) to the Clean Air Act.

3. The cost savings to the State's economy and the job creation potential of each strategy based on the liberation of resources for productive investment opportunities within Colorado that would otherwise not be available because such resources would be consumed by fuel costs that would transfer employment and wealth outside the State.

The Blueprint does not attempt to quantify other benefits of the strategies, even though some benefits may have high economic value. For example, by powering most vehicle travel with electricity, the public health impacts of vehicle-related air pollution, and the associated personal and public costs of health care, can largely be eliminated. By eliminating most transportation-related air pollution, these strategies may also significantly reduce the cost of air pollution control to other emission sources in the State. Another example is the benefit that will accrue from focusing new development in locations served by regional transit which avoids increased food costs that will otherwise result if productive agricultural lands continue to be converted to non-agricultural uses. Thus the full range of public health and economic benefits of implementing these strategies are not included.

SWEEP welcomes your response to this Blueprint as part of the open public dialogue that can lead to decisions to take actions needed to protect and preserve the natural systems on which human civilization depends. Comments may be made to 303-999-0788, or email to msalisbury@swenergy.org.

Acknowledgements

This Blueprint was prepared under the guidance of Howard Geller, Executive Director of SWEEP.

SWEEP acknowledges contributions from reviewers of the Blueprint: Therese Langer of the American Council for an Energy Efficient Economy, Roger Freeman of Davis, Graham and Stubbs LLP, Stephanie Thomas of the Colorado Environmental Coalition, and Paulette Middleton of Panorama Pathways.

SWEEP also thanks the Sea Change Foundation and the Argosy Foundation for their generous support of SWEEP's Transportation Program which made this report possible.

Cover Design by Gene Dilworth.

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Acronyms

AFV	Alternative Fueled Vehicle
APU	Auxiliary Power Unit
BEV	Battery Electric Vehicle
CAA	Clean Air Act
CAP	Climate Action Plan
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board
CDOT	Colorado Department of Transportation
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
DOT	Department of Transportation
DRCOG	Denver Regional Council of Governments
ECO	Employee Commute Option
EIA	Energy Information Administration
EISA	Energy Independence and Security Act of 2007
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
GHG	Greenhouse Gas
GM	General Motors
HB	House Bill
HEV	Hybrid Electric Vehicle
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
kWh	kilowatt-hour
LDV	Light Duty Vehicle
MMT	Million Metric Tons
MPG	Miles Per Gallon
MPO	Metropolitan Planning Organization
NMHC	Non-Methane Hydrocarbons
NHTSA	National Highway Traffic Safety Administration
NOx	Nitrogen Oxides
NPV	Net Present Value
OE	Original Equipment
PAYD	Pay As You Drive
PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate Matter
RTD	Denver Regional Transportation District
SB	Senate Bill
SUV	Sports Utility Vehicle
SWEEP	Southwest Energy Efficiency Project
TWh	Terawatt-hour
TOD	Transit Oriented Development
UGB	Urban Growth Boundary
VMT	Vehicle Miles Traveled

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Executive Summary

Governor Ritter has identified climate change as a major threat to the future of Colorado's economic and environmental health. Colorado is already experiencing the effects of warming with a significant increase in average temperature in the Rocky Mountain region since 1980, a reduction in regional precipitation, destructive insect infestations in lodge pole pines with a widespread loss of native forests across the state, and increased wild fire hazards. With future warming currently observed impacts are expected to accelerate, and new threats are expected. A recent report published by the Colorado Water Conservation Board anticipates future warming will likely shift the temperature regime along the Front Range to match today's summer temperatures in western Kansas. This warming will in turn reduce snow pack and lower stream flows by 6% to 45% by 2050 depending on the rate of warming, which is expected to impact water supplies, increase the severity of droughts, and shorten the ski season.[2]

CO_2 Reduction targets

The Governor's Climate Action Plan (CAP) identified the statewide reductions in GHG needed to minimize Colorado's contribution to the effects of global climate warming. To slow the warming, and ultimately stabilize the climate once again, the Climate Action Plan seeks to reduce GHG emissions 20% below 2005 levels by 2020, and 80% by 2050.

The Plan shows the transportation sector accounts for 23% of CO_2 emissions in Colorado, and is the fastest growing contributor to CO_2 emissions.[3] In 2005, Colorado emitted 118 million metric tons (MMT) of CO_2 equivalent gases, with 27 MMT coming from the transportation sector. Transportation emissions in 2010 will likely increase to 29.6 MMT, are currently expected to grow to 33.5 MMT in 2020, and to 51.6 million by 2050. This emission growth is driven largely by two factors: 1) population growth from 4.7 million in 2005 to 9.4 million in 2050, and 2) miles driven increasing almost 50% faster than population largely because of sprawl development that contributes to longer daily trips. To achieve significant emissions reductions in the face of population growth, major new policy initiatives will be needed to reduce the distance of daily trips and decrease the fossil carbon fuels used to power vehicles.

To reduce greenhouse gas emissions 20% below the 2005 level by 2020, transportation emissions must be reduced to 21.6 MMT. To meet this goal, emissions must be reduced by 12 MMT compared to expected levels in 2020. Over the longer term, to reduce CO_2 emissions to 80% below 2005 levels by 2050 requires that the transportation sector emit only 5.4 MMT, or 46 MMT less than expected levels in 2050.

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[2] Climate Change in Colorado, Colorado Water Conservation Board (2009): wwa.colorado.edu/CO_Climate_Report/index.html.

[3] The CAP was based on the 2005 Greenhouse Gas Inventory report. This report characterized transportation emissions as those from on road gasoline and diesel vehicles as well as the train freight and aviation sectors. Off-road gasoline and diesel vehicles emissions were considered part of other sectors such as residential and construction.

Parallel to Colorado's plan is the goal articulated by President Obama to reduce greenhouse gas emissions to 1990 levels by 2020. This target is slightly more ambitious than Colorado's plan and would require transportation related emissions to fall to 20 MMT rather than 21.6 MMT. Currently, the Waxman-Markey bill passed by the U.S. House of Representatives calls for a 17% cut below 2005 levels by 2020, and an 83% cut by 2050.[4] If enacted, this target would require transportation emissions in Colorado to be reduced to 4.6 MMT assuming that all sectors of the economy make proportionate reductions.

Available Measures

In a search to identify the strategies and policies that could achieve the reductions from transportation needed to meet these targets, SWEEP has investigated all the transportation-related strategies and policies adopted or proposed as part of every state climate plan, and the transportation plans adopted by the metropolitan planning organizations that have adopted GHG emission reductions as a goal. SWEEP has evaluated the emission reduction potential of each of these strategies if applied in Colorado.[5] Most of these strategies fall under the general categories of transportation policies necessary to reduce greenhouse gas emissions outlined by the Colorado Transportation Finance and Implementation Panel: improving vehicle efficiency, improving and modifying the transportation system to reduce vehicle miles traveled (VMT), and expanding low-carbon fuel options.[6]

This Colorado Transportation Blueprint describes the most promising policy options, the energy savings and CO_2 emission reductions available from each strategy or policy, estimated costs compared to fuel cost savings, and the level of government at which each option could be implemented. The strategies generally fall into three broad approaches:

1) Reducing the steep growth in annual vehicle miles driven by expanding transit services, locating new housing and jobs in convenient proximity to transit services, and adjusting current transportation system user fees to reflect miles driven and CO_2 emissions.
2) Eliminating or minimizing the need for fossil carbon fuels in the transportation sector by promoting conversion of automobile and truck fleets to electric motors powered by batteries charged nightly from unused generating capacity on the grid, and by advanced bio-fuels produced from non-food vegetation sources of bio-carbon.
3) Requiring the use of vehicle enhancements and operating conditions that improve fuel efficiency, e.g., more efficient tires, aerodynamic improvements on trucks, reducing the need to run engines at idle as a source of power, and lower legal speeds.

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[4] American Clean Energy and Security Act of 2009, H.R. 2454, § 311.
[5] The Blueprint does not evaluate the California fuel standard which was published after the review of State measures had been completed.
[6] Colorado Transportation Finance and Implementation Panel's "Report to Colorado". 2008. Available at: http://www.colorado.gov/cs/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobheadername1=Content-Disposition&blobheadername2=MDT-Type&blobheadervalue1=inline%3B+filename%3D442%2F774%2FCDOT_BPRFullReportFNL.pdf&blobheadervalue2=abinary%3B+charset%3DUTF-8&blobkey=id&blobtable=MungoBlobs&blobwhere=1227308932919&ssbinary=true

To meet the 5.4 MMT target by 2050, the first major objective is the electrification of the light and medium duty vehicle fleets. An evaluation of the CO_2 reduction potential of all the engine technologies and fuel strategies currently under development suggests that electrification of the light duty fleet provides the only likely option for achieving the 80% reduction target by 2050. Appendix 2 provides a comparison of fuel alternatives based on a number of energy, infrastructure cost and environmental parameters. This assessment cannot anticipate future technological breakthroughs, but based on known factors it appears that no other fuel option creates the potential for achieving the 80% target by 2050.

The Blueprint explores the market-based strategies available to the State to stimulate the purchase of plug-in electric hybrid and electric vehicle options. At best, State strategies to stimulate market demand for electric vehicles alone have the potential to advance the penetration of electric vehicle technologies to 40% of new vehicle sales by 2040. Since market strategies alone are not expected to achieve full electrification of light and medium duty vehicle fleets by 2050, regulatory action by 2030 will be necessary to achieve this result.

Improving the fuel efficiency of gasoline vehicles will not be sufficient to achieve the 5.4 MMT target. The Blueprint analyzes emissions reductions expected from both the 35.5 mpg standard proposed by the Obama Administration for 2016, and a probable extension of either the federal fuel efficiency standards or the California GHG vehicle emission standards beyond the 2016 model year to at least 54 mpg by 2030. Reductions of average vehicle emissions to meet the probable 2030 standard reflect the potential fleet average efficiency achievable with currently demonstrated hybrid electric technology. The Blueprint compares the expected CO_2 emission reductions from all strategies if fuel efficiency standards remain fixed at the 35.5 mpg corporate average set for 2016 (see Table ES-1A) with the reductions expected if the standards are advanced to achieve 54 mpg by 2030 (see Table ES-1B).

Given the more likely outcome that standards will continue to advance after 2016 to reflect advances in vehicle technology, and to test the extent to which more stringent light duty vehicle standards could eliminate the need for other emission reduction strategies, these potential future standards are used as the basis for estimating fleet average light duty vehicle emissions for each year after 2016, and the baseline for estimating the emissions and economic impacts of all other CO_2 reduction strategies. It is clear from Table ES-1B that adopting more stringent standards after 2016 reduces gasoline emissions by 9% more than the 2016 standards in 2040 and avoids 20 MMT of CO_2 emissions between 2010 and 2040. But when combined with the reductions from all other strategies achieves only 54% of the reductions needed by 2050. This reduction is not enough to eliminate the need for any of the other strategies. However, market strategies to stimulate sales of plug-in hybrids could be eliminated after 2030 if no fossil fuel technology could meet the 54 mpg standard.

Advancing the minimum fuel efficiency of all vehicles sold in the U.S. is not a strategy that Colorado is free to pursue independently, but Colorado through various actions can play an important role in communicating to federal and California regulators that vehicle standards must continue to improve beyond 2016.

Table ES-1A – Potential Emission Reductions from Strategies Assessed-

No Extension of Fuel Efficiency Standards beyond 2016

		2020			2040		
	State Strategies 1-10	% of reduction achieved in 2020 towards CAP Goal	Reduction of Emissions in 2020 (1000s of Tons)	Total Reduction of CO_2 Emissions (1000s of Tons) 2010-2020	% of reduction achieved in 2040 towards CAP goal	Reduction of Emissions in 2040 (1000s of Tons)	Total Reduction of CO_2 Emissions (1000s of Tons) 2010-2040
1	**Promotion of Fuel Efficient Vehicles**						
A	**Feebate/PHEV**	2.7%	321	1,106	14.3%	4,900	45,933
B	**Accelerated Retirement**	2.5%	277	1,743	0.4%	125	1,743
	VMT Reduction						
2 3 4	**Transit Development, Urban Design User Fees**	11.2%	1,335	6,642	14.7%	5,020	69,437
5	**PAYD**	12.8%	1,523	6,750	5.6%	1,912	40,880
	Vehicle Enhancements & Operating Conditions						
6	**55 Speed Limit**	13.3%	1,589	17,805	6.1%	2,101	54,561
7	**Efficient Tires**	4.1%	490	4,684	1.8%	619	15,722
	Heavy Duty Trucks						
8	**Efficiency Requirement**	7.0%	834	6,301	4.1%	1,418	29,667
9	**Diesel Hybrid & Longer, Heavier Trailers**	3.4%	401	2,220	2.7%	925	17,177
10	**Clean Car Standards 2010-2011**	1.1%	132	1,800	0.0%	0	1,990
	Cumulative	**58.0%**	**6,901**	**49,051**	**49.7%**	**17,019**	**277,110**
	TARGET	**100.0%**	**11,919**		**100.0%**	**34,221**	

Table ES-1B – Potential Emission Reductions from Strategies Assessed- Fuel Efficiency Standards Extended through 2030

		2020			2040		
	Federal and State Strategies	% of reduction achieved in 2020 towards CAP Goal	Reduction of Emissions in 2020 (1000s of Tons)	Total Reduction of CO_2 Emissions (1000s of Tons) 2010-2020	% of reduction achieved in 2040 towards CAP goal	Reduction of Emissions in 2040 (1000s of Tons)	Total Reduction of CO_2 Emissions (1000s of Tons) 2010-2040
	Extending Clean Car Standards beyond 2016	1.1%	126	387	18.3%	6,273	66,393
	State Strategies 1-10						
1	**Promotion of Fuel Efficient Vehicles**						
A	**Feebate/PHEV**	1.7%	199	832	6.7%	2,300	20,203
B	**Accelerated Retirement**	2.5%	277	1,743	0.4%	125	1,743
	VMT Reduction						
2 3 4	**Transit Development, Urban Design User Fees**	11.1%	1,327	6,625	11.3%	3,874	59,860
5	**PAYD**	12.7%	1,515	6,731	4.3%	1,475	36,271
	Vehicle Enhancements & Operating Conditions						
6	**55 Speed Limit**	13.3%	1,582	16,416	5.2%	1,764	49,631
7	**Efficient Tires**	4.1%	487	4,676	1.4%	477	14,229
	Heavy Duty Trucks						
8	**Efficiency Requirement**	7.0%	834	6,301	4.1%	1,418	29,667
9	**Diesel Hybrid & Longer, Heavier Trailers**	3.4%	401	2,220	2.7%	925	17,177
10	**Clean Car Standards 2010-2011**	1.1%	132	1,800	0.0%	0	1,990
	Cumulative	**57.9%**	**6,880**	**47,730**	**54.4%**	**18,633**	**297,164**
	TARGET	**100.0%**	**11,919**		**100.0%**	**34,221**	

The second suite of four integrated strategies is designed to bring statewide VMT growth in line with population growth. If vehicle miles driven continue to increase at the historical trend since 1980—47% faster than population—CO_2 emissions from light duty vehicles alone will grow from 19 MMT in 2005 to over 24 MMT in 2050, even after accounting for the benefits of advancing fuel efficiency standards to 54 mpg between now and 2030. If VMT is allowed to grow at the rate that would drive annual light duty CO_2 emissions to 24 MMT, there is no foreseeable engine technology or fuel option that can reduce emissions to the levels needed to meet the 5.4 MMT target by 2050. The four VMT-reduction strategies offer the potential to cumulatively reduce per capita VMT 1% annually in the three largest urbanized areas where more than three-quarters of statewide VMT occurs. These reductions can be achieved in a growing region when travel is switched from a personal auto to a transit bus because personal CO_2 emissions are reduced an average 87% per trip.

This reduction in urban VMT would make it possible to offset even more rapid VMT growth among rural residents and maintain statewide per person VMT at current levels. Unlike technology standards that are subject to federal pre-emption, these four strategies—comprehensive transit services, channeling new development into locations with convenient access to transit, user fees that create price incentives to use transit, and pay-as-you-drive insurance—are entirely within the authority of the State. Emissions could be reduced by 5 MMT in 2050 compared to the baseline projection if implementation of these strategies begins in 2010, but the benefits are diminished with each year implementation is delayed because effectiveness depends on the amount of new development channeled into transit-accessible service areas. These strategies are essential to make the 5.4 MMT target for the entire sector at least possible by 2050.

The third suite of strategies is designed to provide nearly all the reductions in CO_2 emissions available between now and 2020 by improving the fuel efficiency of existing vehicles. These include accelerating the implementation of the Environmental Protection Agency's (EPA) SmartWay program by truck owners, and the single largest emission reduction strategy available between now and 2020—reducing the speed limit by 10 mph to 55/65.

The impact of the major policy options on future emission trends are demonstrated in Figure ES-1. The top line represents the expected emissions if no actions are taken. Each color band represents the CO_2 reductions that are expected to be achieved from the implementation of each strategy evaluated in this Blueprint. The grey bands represent remaining emissions after implementation of the reduction strategies assessed in each section based upon three primary assumptions: 1) each model year of light duty vehicles will be progressively more efficient to meet the advanced fuel efficiency standards between 2017 and 2030; 2) market strategies will stimulate the expected penetration of electric vehicle technology before further regulatory action requires that all new vehicles be battery powered; and (3) all new light duty vehicles will achieve 54 mpg after 2030. Gasoline consumption drops steadily throughout the period 2010-2040 as a result of the VMT reduction, vehicle electrification and operational strategies, but light duty emissions begin to increase again beyond 2040 if no further actions are taken to reduce fossil carbon used to generate the electric power for plug-in vehicles, and to produce the liquid fuels used for on-board generation of battery power. CO_2 emitted from aviation and trucks continue to grow. Without the development of bio-diesel for trucks and another bio-alternative for aviation fuel, emissions in these two sectors will exceed 15 MMT by 2050, well above the 5.4 MMT CO_2 target for all transportation sources.

No federal or California standards apply to the fuel efficiency of trucks. The 2007 amendments to the Energy Act require federal standards to be set by the National Highway Transportation Safety Administration, but deadlines for regulatory action have not been met. Federal law does not pre-empt Colorado from exercising authority to require the implementation of fuel efficiency measures such as tire standards, streamlining vehicles, relaxing vehicle weight and length standards, and accelerating the use of electric vehicles.

Emission trends from the aviation sector are not evaluated in detail because options for reducing emissions from this sector are not well-defined, and the role the State may play in implementing strategies is limited. Improved fuel efficiency in new aircraft engines is being developed, but overall emissions are not expected to decrease because of travel demand. It is important to note that aviation emissions are likely to consume a significant fraction of the 5.4 MMT target by 2050.

Additional reductions beyond the strategies identified in the Blueprint will be needed to achieve the targets set out in the Climate Action Plan. Strategies to achieve these additional reductions are explored in the final section of this Blueprint, but not fully quantified. The 2050 CAP target can be achieved if the entire light duty and medium duty vehicle fleets are electrified after 2030, 75% or more of the miles travelled are powered with electricity from the grid with the remainder from advanced bio-fuels, advanced efficiency measures are applied to long-haul trucks, some long-haul freight is shifted to rail and/or magnetic levitation freight systems powered by electricity, and 80% or more of the power generated for the grid is obtained from renewable sources. To achieve the 5.4 MMT target in 2050, the State must begin now to lay the foundation for the transformation of the energy sources used to power the transport sector and to expand the role of transit in providing personal mobility.

Figure ES-1 – Potential Reductions in CO_2 Emissions from Transportation Policies

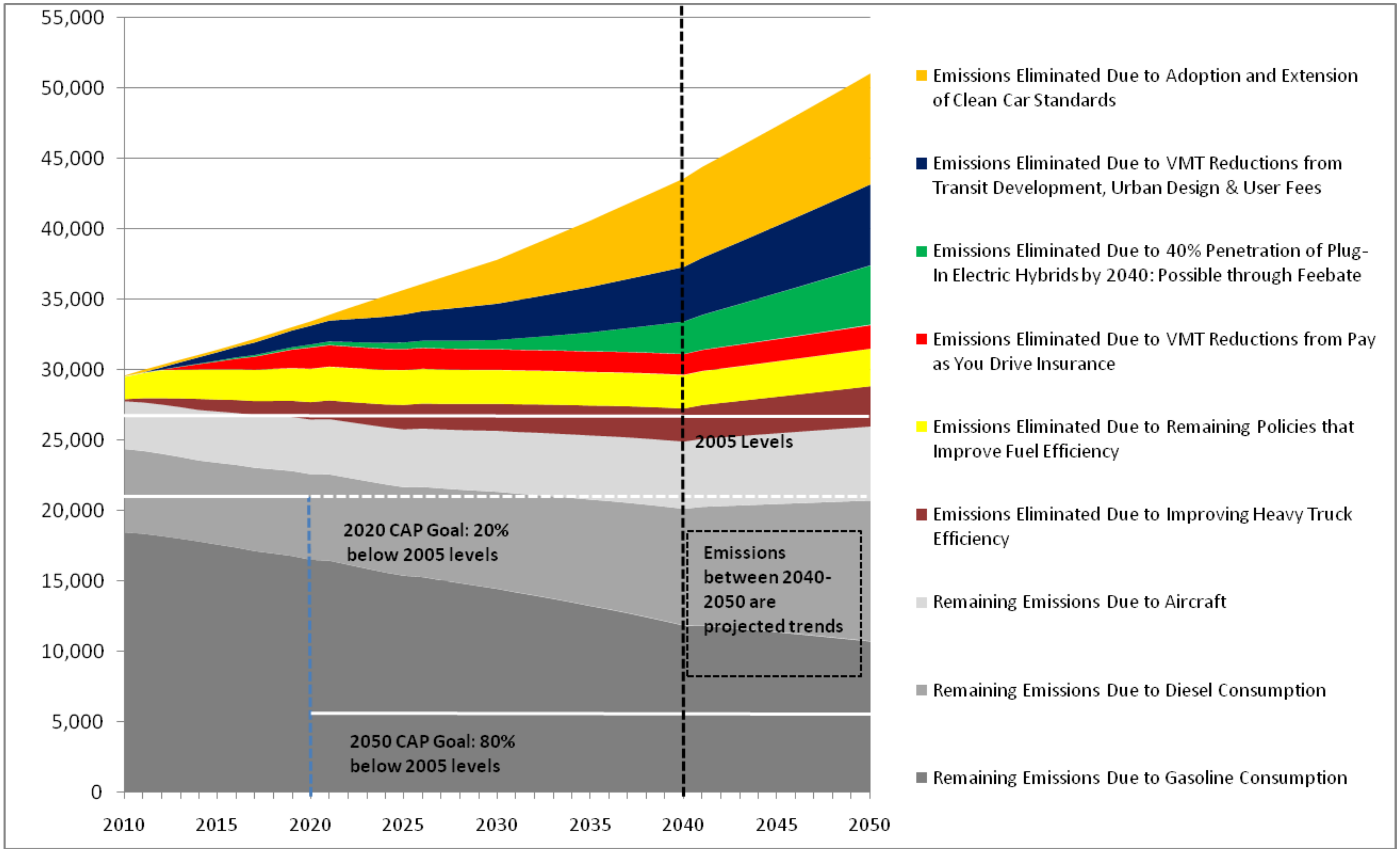


Table ES-2 – Cumulative Costs and Savings by 2040

	Federal and State Strategies	Total Costs ($ millions)	Total Benefits ($ millions)	Net Benefits ($ millions)	$ Benefit per ton of avoided CO_2
	Extending Clean Car Standards beyond 2016	3,190	6,598	3,408	51
	State Strategies 1-10				
1	**Promotion of Fuel Efficient Vehicles**				
A	**Feebate/PHEV**	386	4,643	4,257	211
B	**Accelerated Retirement**	246	1,085	839	481
	VMT Reduction				
2 3 4	**Transit Development Urban Design User Fees**	6,200	10,239	4,039	67
5	**PAYD**	6	6,397	6,391	176
	Vehicle Enhancements & Operating Conditions				
6	**55 Speed Limit**	0	7,980	7,980	161
7	**Efficient Tires**	64	2,240	2,176	153
	Heavy Duty Trucks				
8	**Efficiency Requirement**	1,130	4,300	3,170	107
9	**Diesel Hybrid & Longer, Heavier Trailers**	781	2,282	1,501	87
10	**Clean Car Standards 2010-2011**	40	569	529	266
	Cumulative	**12,043**	**46,333**	**34,290**	**100**

Table ES-3 – 1000's of Barrels of Oil Saved, Fuel Costs Saved, Job Creation Potential

		2020			2040		
	Federal and State Strategies	Cumulative 1000s of barrels saved	Cumulative Benefits ($ millions)	Job Creation Potential in 2020	Cumulative 1000s of barrels saved	Cumulative Benefits ($ millions)	Job Creation Potential in 2040
	Extending Clean Car Standards beyond 2016	881	66	91	179,475	6,598	4,535
	State Strategies 1-10						
1	**Promotion of Fuel Efficient Vehicles**						
A	**Feebate/PHEV**	4,244	355	292	100,574	4,643	2,460
B	**Accelerated Retirement**	4,715	413	200	18,417	1,085	91
	VMT Reduction						
2 3 4	**Transit Development Urban Design User Fees**	17,926	1,436	959	161,962	10,239	2,801
5	**PAYD**	18,211	1,434	1,095	98,139	6,397	1,382
	Vehicle Enhancements & Operating Conditions						
6	**55 Speed Limit**	42,980	4,038	1,105	129,287	7,980	1,218
7	**Efficient Tires**	12,652	1,111	352	38,500	2,240	345
	Heavy Duty Trucks						
8	**Efficiency Requirement**	14,898	1,519	527	70,147	4,300	896
9	**Diesel Hybrid & Longer, Heavier Trailers**	5,249	519	253	40,614	2,282	584
10	**Clean Car Standards 2010-2011**	4,872	432	127	7,134	569	0
	Cumulative	**126,630**	**11,321**	**5,001**	**844,247**	**46,333**	**14,311**

Economic Savings and Job Growth

The best news is that implementation of every strategy contributes a net cost benefit to the economy of Colorado. The Blueprint estimates both the cost of each strategy to vehicle owners, transportation system users, and taxpayers, and the fuel cost savings achieved by implementation of the strategy. For every strategy the fuel cost savings (without considering the public health, environmental and climate benefits of not burning the fuel) exceed the cost to vehicle users or taxpayers. The cumulative fuel cost savings exceed $46 billion from an investment of $12 billion, producing net cost savings of more than $34 billion during 2010-2040 (2008 dollars). This 270% return on investment would be attractive to any smart investor.

The cost savings derived from implementation of these strategies are resources freed up to be spent on other goods and services or invested in Colorado. Disposable income not spent on fuel mostly remains in the local economy where it is used for purchasing food, housing, entertainment, and other goods and services. Retaining these resources in the State's economy will generate jobs in the State that would otherwise not be created. A recent study estimated that for every 3,700 barrels of gasoline saved through vehicle efficiency improvements, 1 new job is created in Colorado.[7] Investments in transit and other measures that save fuel by reducing VMT should produce similar benefits.

As shown in Table ES-3, implementation of all the strategies would reduce total fuel consumption in 2020 by 126 million barrels, resulting in a net increase of approximately 5,000 jobs in the state as of that year. Some of the new jobs result from the $12 billion investment in public transit, hybrid-electric vehicles, efficient tires and other costs incurred to generate the savings. But the majority of the new jobs result from the net benefits obtained from lower fuel consumption (money that now mostly leaves the state) that enables consumers to purchase more food, housing, entertainment, etc. (money that mostly stays in the state). Together these effects would increase the employment rate in the state in 2020 by approximately 0.2%. In addition, these new jobs will generate increased tax revenues that in turn could offset a portion of the public costs of implementing these strategies.

Conclusions

The strategies analyzed in the Blueprint are not untried or untested. As discussed in the outline of actions being taken by other western states, all of the strategies analyzed here have been implemented in other states, and are proving effective. Indeed, their experience provides the basis for concluding that these strategies are available and will produce results.

All these strategies, taken together, will not achieve the 20% reduction target by 2020. Indeed, the strategies quantified in the Blueprint are not sufficient to achieve the 20% reduction target in 2050. But if 2020 is seen as a milestone toward the 80% reduction needed to stabilize the climate, the reductions achievable by 2020 represent an essential and necessary step toward the ultimate target. Equally important, the major

[7] H. Gellar, M. Goldberg. "Energy Efficiency and Job Creation in Colorado." Methodology April 2009. Available at: http://www.swenergy.org/pubs/EE_and_Jobs_Creation_in_Colorado-April_2009.pdf

Strategies analyzed in the Blueprint each establish the initial stages of the transformations needed to achieve the 2050 targets by promoting the technological breakthroughs that can achieve the electrification of most VMT, and the policy foundation for designing human settlements around transportation systems that can provide non-polluting, cost-effective mobility options for a growing population. All the measures identified in the report must be implemented to make progress toward the climate plan targets for 2020, and establish the foundation for the ultimate transition to a sustainable transportation system by 2050.

Continuing with the strategies in the Blueprint to reduce VMT, the 80% reduction target can likely be achieved by 2050. The final transition will require regulatory action to achieve the electrification of all light and medium duty vehicles after 2030, powering 70% of VMT with power from the grid, the generation of 80% of the electric power used in the transportation sector by renewable sources, and the powering of all the remaining miles driven on a liquid fuel with advanced bio-fuels derived from non-food vegetation.

For all these reasons, implementing every strategy in the Blueprint to reduce CO_2 emissions makes good public policy. These strategies will:

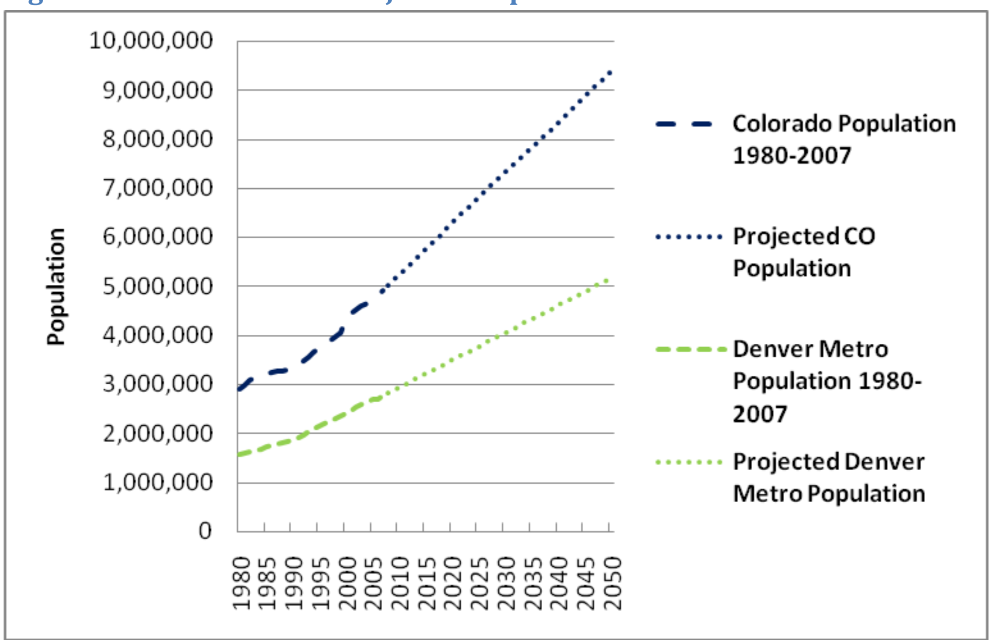
- make significant progress toward achieving the CO_2 reductions needed to stabilize the climate;
- achieve significant net public and private cost savings from reduced fuel use;
- reduce the cost of transportation as a share of the household budget for every Colorado family;
- free up resources once spent to purchase petroleum products from imported oil for investment in Colorado to generate alternative job-creating economic activity in Colorado; and
- reduce in the near term, and possibly eliminate by 2050, the economic threat from the current dependence of Colorado's economy on fuel imported from outside North America.

Transforming the trends: CO_2 emissions, VMT and fuel efficiency

What is Driving the Rising Transportation CO_2 Emission Trend?

The starting point for developing strategies to reduce the climate impacts of GHG emissions from the transportation sector is to understand the factors that most affect current emission trends. National and Colorado transportation CO_2 emission[8] trends are determined largely by two factors: 1) the number of miles that people drive their vehicles each year (vehicle miles traveled--VMT), and 2) the amount of carbon combusted in the fuel used to power each vehicle. Vehicle fuel efficiency for liquid fueled vehicles is expressed as miles per gallon (mpg). GHG emissions from the U.S. transportation system are growing more rapidly than from any other sector of energy use. Between 1990 and 2007, while national CO_2 emissions from all sectors grew by 21.8%, transportation emissions increased by 27.1%.[9] The increase in transportation emissions accounted for about 41% of the total national increase during this period.[10]

Figure 1 – Historical and Projected Population for Colorado and Denver Metro Area



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[8] Over 94% of the climate forcing impact of GHG emissions from transportation is carbon dioxide (CO_2) that results from the combustion of carbon fuels (gasoline, diesel, ethanol, and natural gas). To simplify this report, transportation emissions and the reductions available from the implementation of potential emission control strategies are calculated solely with respect to fuel consumption and CO_2 emissions.

[9] See EPA's Annual Greenhouse Gas Emission Inventory Report (http://epa.gov/climatechange/emissions/downloads09/TrendsGhGEmissions.pdf).

[10] Increased transportation emissions (403 Tg CO_2) between 1990 and 2007 contributed 41% of the total increase in U.S. emissions (1027 Tg CO_2) during this period.

In Colorado, statewide vehicle fuel consumption and CO_2 emissions increased by 85% since 1980,[11] and by 52% since 1990, which is almost twice the national average. This growth in emissions is partly driven by Colorado's rapid population growth, but over half of the statewide emissions increase is linked to increases in miles travelled that exceed population growth.

By 2050, statewide population is expected to grow to 9.4 million residents, a 90% increase above 2007. If statewide VMT continues to increase 47% faster than population, and the fleet wide fuel efficiency increases to meet the 35 mpg standard required by current law for automobiles, fuel use for transportation is expected to double by 2050 and annual CO_2 emissions from transportation alone will double to 51 million tons.[12]

A. Reducing VMT Growth Is Essential to Meet CAP CO_2 Reduction Targets

This dramatic historical increase in global warming pollutants was driven primarily by increased vehicle travel which grew 117% from 22.4 billion miles in 1980, and 79% from 27.2 billion in 1990, to 48.7 billion miles in 2007.[13] At the same time, statewide population grew only 70% from 2.9 million in 1980 to 4.9 million in 2007. Per person VMT increased 47% faster than population in Colorado.

While statewide VMT increased 117%, VMT in metro Denver increased by 147%, or about 25% greater than the rate of statewide VMT growth.[14] In 1980, the Denver metro area was home to 1.6 million of Colorado's 2.9 million residents, or 54% of the State's population. By 2007, 2.8 million of Colorado's 4.9 million residents called the Denver metro area home.[15] Denver metro's share of the population had grown slightly to 56% of the State. Of the State's 2 million new residents, 1.2 million came to metro Denver expanding the metro population by 77%, and the other 1.0 million new residents moved to other parts of the State increasing the non-metro population by 61%.[16,17]

During this period, VMT in the Denver metro area increased nearly two times faster than the population.[18] This means that 52% of the VMT growth was attributable to increased travel demand resulting from a growing population. But the other 48% of VMT growth is a product of urban design that can be reduced or eliminated without reducing personal mobility by providing public access to convenient alternatives to the personal auto for most trips. This planned contribution to VMT growth

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[11] CO_2 Emissions from gasoline and diesel increased from 13.8 MMT in 1980 to 25.4 MMT in 2007.

[12] CO_2 emissions per mile are calculated using Argonne National Laboratory's VISION Model for fleet efficiency multiplied by EPA's calculations of pounds of CO_2 per gallon of fuel. See Appendix 1 for further details

[13] FHWA Policy Information. Publication Archive Available at: http://www.fhwa.dot.gov/policy/ohpi/hss/hsspubsarc.cfm

[14] DRCOG. "2035 Metro Vision Regional Transportation Plan." Available at: http://www.drcog.org/documents/2035%20MVRTP_revisedMarch09.pdf

[15] Ibid.

[16] State Demography Office. Population Totals for U.S. & States. http://www.dola.state.co.us/demog/pop_us_estimates.html

[17] DRCOG. "2035 Metro Vision Regional Transportation Plan." Available at: http://www.drcog.org/documents/MetroVision2035FinalPlanIntro-Ch%202.pdf

[18] DRCOG reported metro area VMT in 1980 as 29 million miles per day, or 9.8 billion miles annually, and 72 million miles per day in 2007, or 24.3 billion miles annually.

can be dramatically reduced with growth policies designed to provide pedestrian, bicycle and neighborhood vehicle access to most neighborhood destinations, and regional transit services for longer trips as the preferred source of local and regional mobility.

Future growth in VMT is the single most important factor driving the projected growth in GHG emissions from the transportation sector. Historically, statewide VMT grew 2.95% annually from 1980 to 2005. If VMT continues to grow at this rate, VMT will increase from 48.7 billion miles in 2007 to 71 billion miles in 2020, and 170 billion by 2050. If VMT were to grow at a rate 47% greater than population growth (the average statewide between 1980 and 2007), VMT would reach 69.8 billion by 2020 and 126 billion by 2050. If statewide VMT were to grow at a rate 23% greater than population (as predicted by DRCOG for the Denver metro region between now and 2035), VMT would reach 65.7 billion by 2020 and 107.5 billion by 2050. If VMT is slowed to the rate of population growth, VMT will reach only 62.2 billion miles in 2020, and 93 billion miles by 2050.

Only DRCOG projects that historical VMT growth rates will not continue in the future. Beginning in 2007, the Denver Regional Council of Governments (DRCOG) projects that VMT growth rates will slow compared to historical rates. Based on DRCOG's projected VMT trends, VMT in the Denver metro area would reach 52.3 billion by 2050,[19] compared to 24.3 billion in 2007. Between 2007 and 2050 annual VMT per capita is expected to grow from 8,779 miles in 2007 to 10,093, which is an increase of 15% compared to the 40% growth in per person VMT observed since 1980. DRCOG does not explain why historical VMT growth trends are not expected to continue in the metro area. A preliminary assessment suggests that the reduced projected rate of future Denver metro VMT growth compared to historical trends can be traced to no further growth in the proportion of women entering the workforce, a regional growth boundary and the provision of new regional transit services through the completion of FasTracks corridors. Similar growth policies and levels of transit investment are not currently planned outside the DRCOG planning region. Therefore VMT growth trends outside metro Denver are expected to continue at historical rates.

When growth from the Denver metro area and the other Front Range urban metropolitan planning organizations (MPOs) (Pike's Peak, North Front Range and Pueblo) is grouped together a trend is shown for urban versus rural growth in the state. In 2008, the urban areas of Colorado made up 69% of the state's VMT[20] and 80% of the state's population.[21] By 2050, the urban areas are expected to make up 58% of statewide VMT and 79% of the population. This demonstrates that while population distribution between urban and rural areas is expected to remain constant, rural areas are estimated to have greater VMT growth than urban areas. Given the slower rate of VMT growth among residents in the State's

[19] DRCOG. "2035 Metro Vision Regional Transportation Plan." Available at: http://www.drcog.org/documents/2035%20MVRTP_revisedMarch09.pdf

[20] Information on VMT from Pike's Peak, North Front Range and Pueblo came from personal communication with staff members from each MPO.

[21] Pike's Peak: http://www.ppacg.org/cms/index.php?option=com_content&task=view&id=161&Itemid=51
North Front Range: http://www.nfrmpo.org/DocumentLibrary/GetDocument.aspx
Pueblo: http://www.pacog.net/images/Ch%204%20Socio-economic%20Profile%20and%20Trends.pdf
Denver Metro: http://www.drcog.org/documents/2035%20MVRTP_revisedMarch09.pdf

urbanized areas, VMT per person outside the urbanized areas is expected to accelerate at a rate nearly double the growth of per person travel within the urban areas. Based on these factors it appears reasonable to assume that statewide VMT growth will continue at historical rates unless policies are adopted to modify the trend.

Figure 2 – Historical and Projected VMT for Colorado and Denver Metro Area

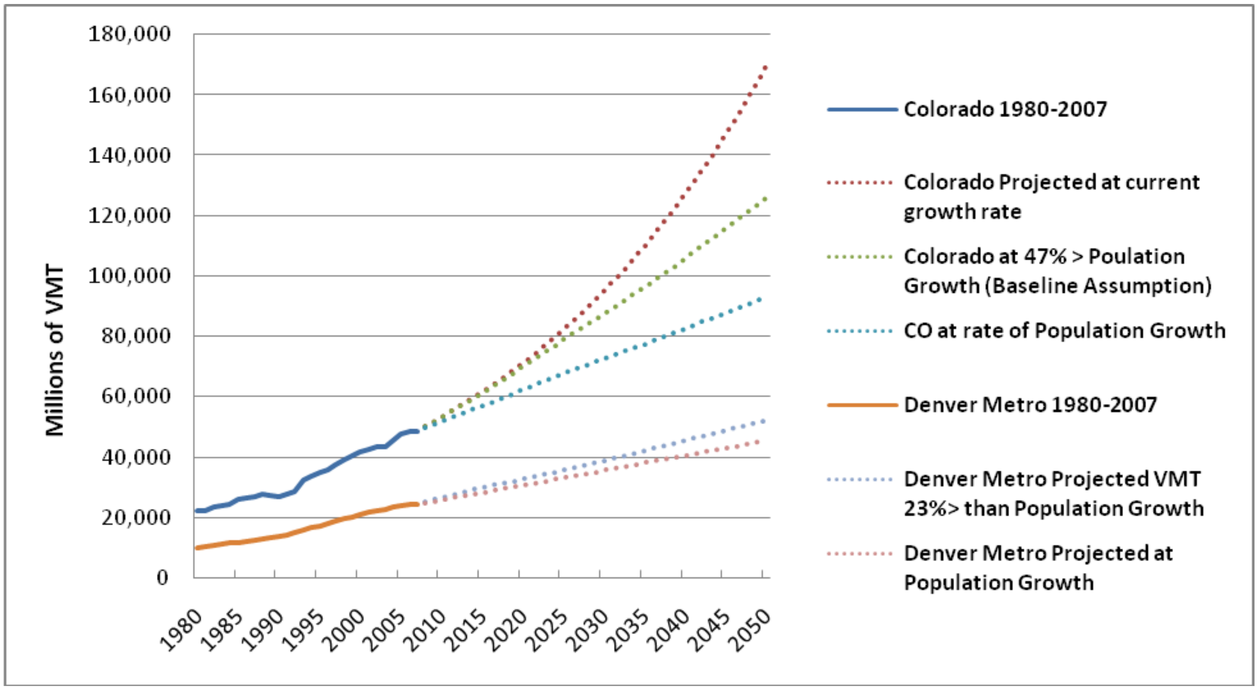
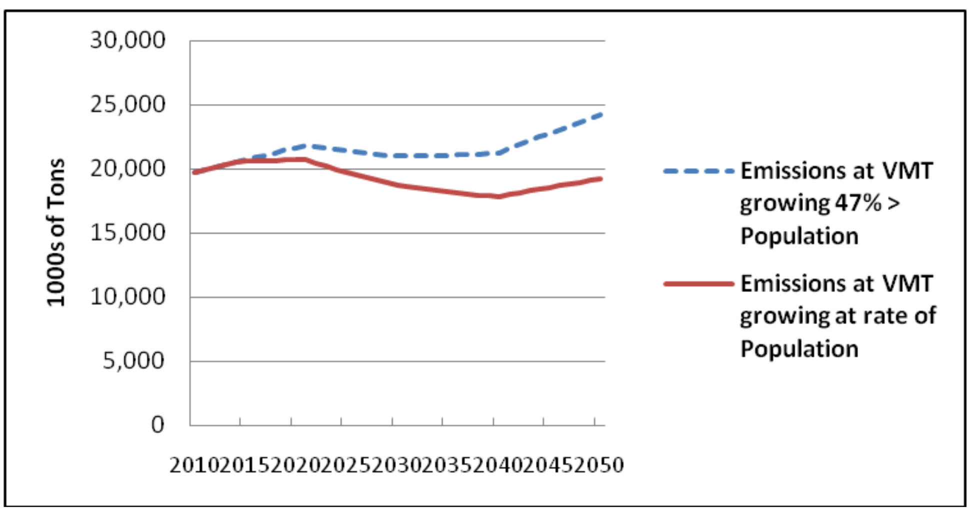


Figure 3 – CO_2 Emissions from Light Duty Vehicles for 2 VMT Growth Scenarios



The baseline case used for estimating future emissions from light duty vehicles in the Blueprint assumes that statewide VMT will continue to grow 47% faster than population. Using this VMT growth trend, by

2050 annual CO_2 emissions from gasoline vehicles will reach 32 MMT, compared to 20 MMT in 2005, if vehicles are required to only meet the fuel efficiency standards promised by the Obama administration by 2016. If the national standards continue to be tightened to 54 mpg by 2030 as discussed in the analysis of standards, CO_2 emissions from light duty vehicles will be lower by 7 MMT, but will nonetheless rise from 20 MMT to nearly 25 MMT by 2050.

To reverse fuel use trends and reduce CO_2 emissions expected from VMT growth, a set of cost-effective policies can be implemented that have the potential to reduce VMT growth to the rate of population growth. Figure 3 shows the expected statewide CO_2 emissions due to continued growth in VMT at historical rates compared to growth at the rate of population growth. These emissions estimates assume that national fuel efficiency standards for light duty vehicles will continue to advance from 35.5 mpg in 2016 to 54 mpg in 2030. See discussion of efficiency standards, below. The emission reduction benefits of advanced fuel efficiency standards are overwhelmed by VMT growing 47% faster than population.

Net CO_2 emission reductions from light duty vehicles are achieved between 2010 and 2040 only if VMT is reduced to the level of population growth. After 2040, even VMT at the rate of population growth again begins to drive up emissions from light duty vehicles. This demonstrates the importance of policies designed to maintain VMT per person at current levels as well as the need for further reductions in the use of fuels containing fossil carbon after 2030.

The four strategies grouped under "VMT Reduction" are evaluated for their ability to maintain personal VMT at constant levels. This objective has been achieved in Portland, OR and some European cities. Policies supporting this objective include designing urban habitats around low-emitting public transport, combined with land use policies that prevent sprawl development. User fees also play a powerful role if they reflect the comparative impacts on emissions and transportation system performance of driving alone compared to riding transit. Other benefits of these strategies include reduced net transportation costs to the economy, significantly lower infrastructure costs for public services other than transportation, better travel performance for the highway system, fewer adverse health outcomes caused by dangerous tailpipe pollutants, and major reductions in climate impacts.[22]

Urban design and convenient access to public transport are powerful factors that affect each personal decision to select travel mode. The factors affecting why people choose to drive a personal auto or opt for other modes are well demonstrated by many investigations to quantify these choices. Convenient access, travel time and cost are the most important factors governing the travel decisions of most people.[23] When urban development is coordinated with public transport so that housing and jobs are

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[22] Ewing et al. Growing Cooler: The Evidence on Urban Development and Climate Change. Urban Land Institute. 2008;
Litman, T. "Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications." Victoria Transport Policy Institute. 2009. Available at: http://www.vtpi.org/tca/;
Puget Sound Regional Council. "Information Paper on the Cost of Sprawl." 2005. Available at: http://psrc.org/projects/vision/pubs/costofsprawl.pdf
[23] Stopher, P. "Predicting Travel Mode Choice for the Work Journey." Traffic Engineering and Control. Vol 9. Pp. 436-439;

located within easy access to public transit, then it becomes more convenient, sometimes faster, and usually less expensive to use public transport than to drive a personal vehicle.

This effect of urban design is demonstrated by travel patterns in the Denver region. DRCOG reported data from its 1996 interviews with thousands of regional residents showing that daily VMT among residents of the pre-WW II urban core, bounded by Havana, Hampden, Sheridan and US 36/I-270 averaged 13 miles, whereas VMT for residents from outside the original urban core averaged over 20 miles per person, or 50% more vehicle travel per person. The urban core designed before the age of freeways was compact, with small lot sizes, mixed land uses providing nearby access to many needs and services, and offered convenient access to ubiquitous transit options. The features of modern transit oriented development preserve these benefits while enhancing access to open space, streams, bicycle trails and other amenities that make higher density human settlements appealing to young adults, families, empty-nesters and elders alike.

Today the growing metropolitan population cannot fit into a single urban core, but the region can plan to serve the needs of new residents for housing, employment and services in multiple urban cores scattered across the region, each urban center focused on a modern transit station, and linked by fast and clean regional rail and bus rapid transit. As discussed later, this pattern of development can slow the growth in VMT to the rate of population growth, thereby reducing the CO_2 emissions impact of new residents and the development needed to meet their needs.

The emission reduction potential, and the costs and savings of reducing VMT are explored in Strategies 2, 3, 4 and 5.

B. Reducing Fossil Fuel Use with More Efficient Engines and Electric Vehicles

The other critical factor that determines CO_2 emissions from fossil fuels is how much fossil carbon is burned for each mile traveled. Ultimately, meeting the 5.4 MMT emission target for all transportation sources may require that all light duty vehicles be powered by energy sources that do not rely on fossil carbon. But historically, and at least until 2030, policy will most likely focus on reducing the amount of fossil carbon combusted per mile traveled.

Trends in Light Duty Vehicle Fuel Efficiency and CO_2 Emission

The United States first adopted a program to improve vehicle fuel efficiency in 1975 after the first oil embargo sent a shockwave through the U.S. economy. The standards first took effect in the late 1970s, improving fuel economy from less than 15 miles per gallon to over 26 miles per gallon by 1985. During the six years from 1978 to 1983, U.S. petroleum consumption for transportation dropped year after year for the last time in history.[24] The last tightening of the national fuel efficiency standards for passenger cars applied to the 1985 model year, while standards for light trucks were increased slightly at two

Vredin, M. et al. “Latent Variables in a Travel Mode Choice Model: Attitudinal and Behavioral Indicator Variables.” Upsalla University. 2005.

[24] U.S. Department of Energy, Transportation Energy Book, Table 1.12, p. 1-15.

points during President George W. Bush's Administration. Since then U.S. consumption of petroleum fuels has marched steadily higher year after year driven by VMT growth while average vehicle efficiency for new vehicles declined as less efficient SUVs, minivans and pickups took market share from cars. By 2007, U.S. gasoline consumption and CO_2 emissions from transportation had grown by 39% above the post-Corporate Average Fuel Economy (CAFE) low in 1983.[25]

More protective fuel economy standards were blocked by oil industry interests who sought to increase their margins at the expense of the U.S. consumer, and by U.S. automakers that saw their market advantage over foreign imports in heavier, more powerful, fuel guzzling models. Since 2005, Japan advanced the global regulatory benchmark by requiring new vehicles to meet fuel efficiency standards 60% below current U.S. standards by 2015. California enacted legislation in 2004 requiring that the Air Resources Board adopt standards for CO_2 emissions that would achieve levels more than 30% better than U.S. standards by 2016. California's standards were blocked under the federal Clean Air Act by the Bush Administration, and have been challenged by oil companies and auto manufacturers in numerous law suits.

Then in 2007 Congress broke ranks with the auto manufacturers and oil producers and enacted the Energy Independence Security Act which requires new standards to achieve a corporate average fuel efficiency of 35 mpg target for new cars and light duty trucks no later than 2020. In May 2009, the Obama administration announced a comprehensive agreement with California and the automakers to revise the proposed federal fuel efficiency standards to achieve a uniform national standard aligned with California's standards from 2012 to 2016, to "coordinate" with California in developing new standards beyond 2016, and to quickly complete the national rulemaking to reconsider the Bush denial of California's request for a waiver of federal pre-emption of the California standards. As their part of the deal, the automakers agreed to dismiss their suits challenging the California standards. This agreement will finally begin a new era of declining fuel use for passenger vehicles in the U.S. beginning in the next decade.

Table 1 lists both the adopted and expected (post-2016) emission standards into two categories by size of the vehicle. The second phase of the Clean Car standards from 2017 until 2020 is based on suggested standards published, but not yet adopted by the California Air Resources Board (CARB). If adopted, the average new vehicle would achieve a fuel efficiency of 40 mpg in 2020.[26] It is assumed that the standards will be further tightened through 2030 to 54 mpg because some innovative technologies are already achieving efficiencies greater than those suggested by CARB for 2020, and other advances in battery technology and renewable power generation would be expected to achieve further efficiency advances for plug-in vehicles. These projections assume that the rate of tightening from 2012 to 2020 will continue to 2030, achieving 54 mpg. For the purpose of the projections used to estimate future emissions in the Blueprint, no further improvements in fuel economy standards are assumed beyond 2030.

[25] Energy Information Administration. Annual Energy Outlook, 2009

[26] California Air Resources Board. Comparison of Greenhouse Gas Reductions under CAFE Standards and ARB Regulations Adopted Pursuant to AB 1493. Available at: http://www.arb.ca.gov/cc/ccms/reports/ab1493_v_cafe_study.pdf.

Table 1 – Clean Car Standards (CARB) for Greenhouse Gas Emissions, 2009-2030

	Year	CO_2-equivalent emissions standard (g/mi)	
		Passenger cars and small trucks/SUVs	Large Trucks/SUVs
Near-Term	2010	301	420
	2011	267	390
	2012	233	361
Mid-Term CARB, EPA and NHSTA standards aligned	2013	227	355
	2014	222	350
	2015	213	341
	2016	205	332
Long-Term (promised by CARB, but not yet adopted)	2017	195	310
	2018	185	285
	2019	180	270
	2020	175	265
SWEEP Projections of likely future standards	2021	171	261
	2022	166	256
	2023	162	252
	2024	158	247
	2025	154	243
	2026	150	239
	2027	147	235
	2028	144	231
	2029	140	228
	2030	137	228

If California continues to increase standards until 2030 along the established trend shown in Table 1, even greater savings would result compared to the new CAFE standards as shown in Table 2 below. If the CAFE standards promised by the Obama administration by 2016 are used in the baseline case that estimates future emissions assuming that statewide VMT will continue to grow 47% faster than population, annual CO_2 emissions from gasoline vehicles will reach 32 MMT by 2050, compared to 20 MMT in 2005. If the CARB or national standards continue to be tightened to 54 mpg by 2030, CO_2 emissions from light duty vehicles will be lower by 7 MMT, but will nonetheless rise to nearly 25 MMT by 2050.

Table 2 shows the aggregate savings due to Colorado adoption of CARB's Clean Car Standards for model years 2009-2011 and the expected tightening of the standards between 2017 and 2030.

Table 2 – Fuel and CO_2 Emission Savings from Adopting and Extending CARB's Clean Car Standards

Year	% Gasoline Savings	Gasoline Savings (1000s of barrels)	Reduced CO2 Emissions (1000s of tons)
2010	0.3%	147	54
2015	2.0%	1,146	424
2020	3.7%	2,180	806
2025	7.3%	4,564	1,687
2030	10.3%	6,721	2,484
2035	15.0%	10,424	3,853
2040	18.9%	14,092	5,208

EPA has now granted the Clean Air Act (CAA) waiver. Other states are now able to join California in making their tailpipe standards more aggressive than federal standards between 2009 and 2011. From 2012 to 2016, the Obama/CARB agreement promises that federal standards will match California's Clean Car Standards. Colorado could adopt the California standards to achieve the incremental emission benefits that would result from vehicles meeting those standards from 2009 through 2011. While only 3 years of vehicle sales would be governed by CARB's more aggressive Clean Car Standards, over the lifetime of these vehicles, the savings would be approximately 5,454 thousand barrels of gasoline and 2 MMT of CO_2 emissions.[27] The costs and benefits of adopting the current California Clean Car Standards for the years before the federal standards catch up are explored in Strategy 9.

As Figure 3 above demonstrates, both fuel efficiency standards (either the extended California Clean Car standards or a parallel federal standard) reaching 54 mpg by 2030, and holding personal VMT at current levels are necessary to stop light duty vehicle emissions from rising above 2005 levels between now and 2040. While it is unclear what direction the federal government will take with regards to further tightening of national fuel efficiency standards after 2016, Colorado may achieve significant progress without waiting for new federal standards if California continues to adopt better standards and Colorado requires that new vehicles meet the CARB standards.

But if Colorado's emissions from light duty vehicles are to be reduced significantly below 2005 levels to allow transportation emissions to reach the 5.4 MMT target, gasoline emissions may need to be completely eliminated. Whether some portion of the 5.4 MMT target will be available for light duty vehicles will depend on the share of the target consumed by emissions from trucks and aviation.

[27] After 2011, annual savings from these 450,000 vehicles would be approximately 363 thousand barrels of gasoline and 134 thousand tons of CO_2 emissions.

Trends in Truck Emissions

No Regulation of CO_2 Emissions and Fuel Efficiency for Trucks

Unlike light duty vehicles, the federal government has not yet undertaken any regulatory activity to set fuel efficiency standards or limit CO_2 emissions from medium or heavy duty trucks. The Energy Policy and Conservation Act of 1975 required the development of corporate average fuel economy standards for light and medium duty passenger vehicles less than 10,000 pounds in weight, but no authority was enacted at that time to limit CO_2 emissions or set fuel efficiency standards for trucks. Medium Duty trucks between 8,501 and 10,000 pounds in weight will be subject to new fuel economy standards beginning in 2011. In 2007, Congress amended the Act to require federal standards for heavier medium and heavy duty highway vehicles and work trucks. However, these standards have not yet been proposed, and even if adopted expeditiously are not expected to apply to vehicles produced prior to the 2016 model year.[28]

EPA is now recognized as having authority to regulate GHG emissions from motor vehicles under the CAA as a result of the Supreme Court decision in Massachusetts v. EPA. Regulation of trucks engines and their emissions have focused on pollutants that contribute to urban air pollution, including nitrogen oxides (NO_x), sulfur, non-methane hydrocarbons (NMHC) and particulate matter (PM), but not on fuel efficiency or CO_2 emissions. In response to these regulations, trucks are often equipped with filters or scrubbers to reduce or trap these pollutants at or before the tailpipe.[29, 30] There have not been regulatory efforts targeting improved fuel efficiency for heavier trucks. Only light duty vehicles have both tailpipe emission standards and fuel efficiency standards set at the federal level.

CAA standards have yet to be proposed for trucks. In keeping with the Administration's decision to coordinate the development of light duty vehicle standards for CO_2 under the CAA with fuel efficiency standards under EISA, it is anticipated that EPA will likely propose truck standards under its CAA authority concurrently with the development of fuel efficiency standards under EISA. However, no schedule has been announced for the development of truck standards.

California has initiated requirements to directly reduce greenhouse gas emissions from heavy-duty trucks by measures designed to improve fuel efficiency other than emission standards. The state requires trailers 52 feet or longer to install SmartWay[31] efficiency improvements such as low resistance

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[28] EISA requires a four year lead time before new standards apply to new vehicles. 49 U.S.C. § 32902(k)(3).

[29] In 2000, the EPA established regulations for heavy-duty diesel engines. EPA. "Diesel Exhaust in the United States" Available at http://www.epa.gov/otaq/retrofit/documents/f02048.pdf. An additional regulation limits the sulfur content of diesel fuel to 15 ppm which refiners were required to produce by 2006.

[30] In 2001, California adopted similar standards. The PM standards are effective for the 2007 and later model years while the NOx and NMHC standards are to be phased in for new engines between 2007 and 2010. Diesel Net. Heavy-Duty Trucks and Bus Engines. Available at: http://www.dieselnet.com/standards/us/hd.php. In addition to the air pollution standards for new heavy-duty diesel engines, the state of California has established several laws to improve emission levels in existing trucks and buses heavier than 14,000 pounds.[30]

[31] Information available at: http://www.epa.gov/smartway/transport/basic-information/index.htm

tires and aerodynamic devices. The EPA's SmartWay program is a collaboration between the federal government and the freight industry to help reduce emissions and improve fuel efficiency in the freight sector. SmartWay for tractors and trailers certifies trucks, trailers and equipment that helps meet the above goals. The California requirements are directed at long-distance drivers who will realize the greatest savings from the efficiency improvements. Trucks that operate less than 50,000 miles/year are exempt as well as most tractors and trailers that operate within 100 miles of their home base. This regulation was adopted to help implement Assembly Bill 32, California's "Global Warming Solutions Act," that required the State to develop a comprehensive plan to reduce GHG emissions across the statewide economy.[32] Finally, California requires that engines have an idling off feature that shuts down idling engines automatically after 5 minutes.[33]

Diesel Use and Emissions in Colorado

In 2007, Colorado used 16.1 million barrels, or 678.4 million gallons, of diesel fuel. Nationwide, heavy (26,000 pounds or greater) and medium (10,000-26,000 pounds) trucks use approximately 75% of diesel consumed and heavy trucks alone use approximately two-thirds of all diesel fuel in the United States.

Table 3 – Estimates of Diesel Use by Sector in Colorado, 2008

	1000s of barrels	%
Heavy Trucks	9,577.5	66.7
Medium Trucks	1,216.2	8.5
LDV	560.0	3.9
Transit Buses	213.6	1.5
Intercity Buses	111.2	0.8
School Buses	264.4	1.8
Commuter Rail	21.5	0.2
Freight Rail	1319.6	9.2
Miscellaneous	775.4	5.4
Total	14,359.5	100

Accurate data on heavy duty truck operations in the state of Colorado is difficult to obtain due to poor or non-existent data and the interstate nature of most long haul heavy duty truck traffic. Therefore national averages have been used to provide estimates of VMT by heavy and medium duty diesel trucks[34] as well as VMT by long and short distance trucks[35] combined with Colorado specific estimates of VMT by fuel type.[36] This allowed reasonable estimates of the VMT traveled in Colorado by long-

[32] http://www.arb.ca.gov/cc/HDGHG/HDGHG_Genl_Fact_Sheet.pdf

[33] http://www.arb.ca.gov/msprog/truck-idling/truck-idling.htm

[34] Energy Information Administration. Annual Energy Outlook, 2009. Supplemental Tables. Table 67. Available at: http://www.eia.doe.gov/oiaf/aeo/supplement/stimulus/suparra.htm

[35] Vehicle Inventory and Use Survey, 2002. United States. Table 6: Truck Miles by Vehicle Size Available at: http://www.census.gov/prod/ec02/ec02tv-us.pdf

[36] Western Regional Air Partnership. 2008 On Road Emissions by State. Available at: http://www.wrapair.org/forums/ef/UMSI/index.html

distance, heavy-duty trucks. Table 3 provides estimates of diesel use in Colorado and Table 4 gives a more detailed breakdown.

Table 4 – Diesel Use in the Truck Sector by Weight and Distance Traveled

	Local (Less than 100 miles daily); 1000s of barrels	Long Distance (Greater than 100 miles daily); 1000s of barrels
Heavy Trucks	3,700.9	5,444.4
Medium Trucks	974.2	199.8

Future Projections of Diesel Use and Fuel Efficiency

Between 2008 and 2030, diesel consumption in the United States by medium and heavy trucks is expected to increase an average of 1.2% annually and 29% overall. Over this same period, VMT for heavy diesel trucks is forecast to increase from 184 billion to 281 billion miles (a 53% increase), while medium trucks are expected to increase from 35 billion to 45 billion miles (a 29% increase) annually.[37]

The rate of diesel consumption in Colorado is expected to increase by approximately 2% annually according to estimates by the Energy Information Administration (EIA) and Western Regional Air Partnership.

Table 5 shows the EIA's forecast for fleet wide changes in efficiency for trucks as well as Wal-Mart's planned improvements in their heavy truck fleet's efficiency:

Table 5 – Fuel Efficiency Forecast for Trucks

	2008 mpg	2030 mpg	% change
Fleet Wide Heavy Trucks[38]	5.48	6.49	16%
New Heavy Trucks[39]	5.6	6.6	18%
Fleet Wide Medium Trucks[40]	8.41	8.94	6%
New Medium Trucks[41]	8.5	9.17	7.7%
Wal-Mart[42]	6.5	13 (by 2015)	100%

The relatively small future improvements in fuel efficiency estimated by EIA are not expected to result in overall decreases in CO_2 emissions from heavy and medium duty trucks due to increasing VMT. Assuming that annual increases in freight transport continue, CO_2 emissions from medium and heavy duty trucks are expected to rise by 54% from 4.7 MMT in 2008 to 7.2 MMT by 2030, and rise by 139% to

[37] Energy Information Administration. Annual Energy Outlook 2009. Regional and Other Detailed Tables. Table 67.
[38] Energy Information Administration. Annual Energy Outlook 2009. Regional and Other Detailed Tables. Table 67.
[39] Ibid.
[40] Ibid.
[41] Ibid.
[42] Wal-Mart. Climate and Energy. http://walmartstores.com/Sustainability/7673.aspx

10.7 MMT by 2050.[43] These increases will more than cancel out reductions from gasoline fueled light duty vehicles, preventing the overall decreases from the transportation sector needed to achieve the 5.4 MMT target by 2050 unless new electric hybrid technologies are introduced, or commercial scale sources of bio-diesel become available to replace petroleum-derived diesel as the source of energy for trucks. Strategy 8 discusses the potential for reducing the trends for medium and heavy-duty trucks between now and 2040.

Trends in Aviation Emissions

According to the Greenhouse Gas Inventory Report, greenhouse gas emissions from the aviation sector in Colorado are expected to increase from 3.4 MMT in 2010 to 3.9 MMT in 2020, which is a 15% increase.[44] Over the same period, the Energy Information Administration (EIA) estimates that energy use by the aviation sector will increase by 17%.[45] If aviation emissions continue to increase at 15% per decade after 2020, by 2050 aviation emissions will reach 5.9 MMT, exceeding the allowable emissions for all transportation sources by 0.5 MMT. While efficiency improvements are anticipated in the aviation industry, additional demand for flying is expected to cancel out those gains leading to an overall increase in emissions as air service increases.[46] This trend could be modified by the development of advanced liquid bio-fuels with a high energy density similar to aviation fuel derived from oil, but we do not make any assessment of this possibility because such fuels are not being commercially produced, and their future development is too speculative for this Blueprint. The only policy option available to the state to reduce aviation emissions is to limit the number of daily flights. The demand for air service and aviation fuel could be reduced without reducing the number of passenger trips if high speed electrified rail or magnetic levitation service were provided in the I-70 and I-25 corridors.

[43] In 2008, medium duty trucks used an estimated 53 million gallons of diesel. Diesel truck fuel consumption is estimated to increase to 80 million gallons by 2030 and to 119 million gallons by 2050. In 2008, heavy-duty trucks consumed an estimated 412 million gallons of diesel. Their consumption is estimated to increase to 637 million gallons by 2030 and to 946 million gallons by 2050. These estimates are derived from calculating Colorado's approximate share of national diesel fuel use projections adopted by the EIA.

[44] Colorado Greenhouse Gas Inventory and Reference Case Projections 1990-2020. Available at: http://www.cdphe.state.co.us/ap/down/GHGEIJan07.pdf

[45] Energy Information Administration. "Annual Energy Outlook 2009." Supplemental Tables: Table 45

[46] Federal Aviation Administration. "Aviation and Emissions: A Primer." 2005. Available at: http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/aeprimer.pdf

Goals and Actions by other States and Municipalities

Other states and municipalities have set more ambitious targets, already adopted more aggressive policies than those adopted by the state of Colorado, and have already achieved reductions in emission growth. The aggressive strategies recommended in the Blueprint are similar to what other states have already undertaken. Table 6 shows the targets set by several different entities.

Table 6 – Greenhouse Gas Emissions Reduction Targets

	2020 Reduction Goal	2050 reduction Goal
California	1990 levels	80% below 1990 levels
Washington	1990 levels	50% below 1990 levels
Portland/Multnomah County	25% below 1990 levels	80% below 1990 levels
Colorado	20% below 2005 levels (This target is 2.6 MMT higher than 1990 levels)	80% below 2005 levels

More important than the targets and goals set by these other entities are the actual policies that have been implemented in order to achieve the goals.

California

In 2006, Assembly Bill (AB) 32 or the Global Warming Solutions Act became law in California. This law set the state's 2020 emissions reduction target and instructed the CARB to develop both short and long term strategies to meet the target and to lay out a scoping plan of all the strategies that will be implemented by the end of 2010.

The measures in the scoping plan that affect the transportation sector include:[47]

- The Clean Car Standards (discussed in detail in Trends section and Strategy 9)
- Requiring all long haul heavy duty tractors and trailers to implement SmartWay fuel efficiency improvements;
- Low Carbon Fuel Standard reduces the greenhouse gas intensity in fuels by 10% by 2020;

[47] CARB. "Scoping Plan Measures Implementation Timeline." 2009. Available at: http://www.arb.ca.gov/cc/scopingplan/sp_measures_implementation_timeline.pdf; CARB. "Climate Change Scoping Plan Appendices." 2008. Available at: http://www.arb.ca.gov/cc/scopingplan/document/appendices_volume1.pdf#page=94

- Requiring automotive maintenance services to check tire air pressure;
- Reducing hydroflurocarbon (HFC) emissions from mobile air conditioning systems;
- Requires all new vehicles sold after 2012 to feature heat diverting glass to reduce AC use;
- Requiring replacement tires to have the same rolling resistance as OEM tires;
- Limiting long-term cold storage of goods in internal combustion engine powered trucks;
- Requiring low-friction engine oils;
- Proposing regulation or incentive to promote hybrid technologies in certain categories of heavy and medium duty trucks;
- Requiring heavy duty trucks not to idle for more than 5 minutes;
- Requiring MPOs to achieve GHG reductions targets through integrated land use and transportation planning in accord with S.B. 375;
- Supporting high speed rail line between Northern and Southern California;
- Retirement and retrofit of older drayage vehicles used at ports;
- Electrification of ship's power while at Port.

Washington

The state of Washington has established aggressive goals for the reduction of greenhouse gas emissions and to reach those goals has set targets for reduction of VMT per capita as part of the program mandated by HB 2815, enacted in 2008. While specific policies are being developed to achieve these goals, the Transportation Implementation Working Group (TIWG) has recommended complementary strategies that fall into three categories:

- "Expanding and Enhancing Transit, Rideshare, and Commuter Choice"
- "Compact and Transit Oriented Development (Including Bicycle and Pedestrian)"
- "Transportation Funding"[48]

Table 7 – State of Washington VMT Reduction Goals

Year	VMT/capita reduction (below 2008 levels)
2020	18%
2035	30%
2050	50%

Both California and Washington are participating members of the consortium of states within the Western Climate Initiative (GHG cap and trade program).

[48] Washington State Department of Ecology. "Reducing Greenhouse Gas Emissions and Increasing Transportation Choices for the Future." 2008. Available at: http://www.ecy.wa.gov/climatechange/2008CATdocs/IWG/tran/110508_transportation_iwg_final_report.pdf.

Portland/Multnomah County

The experience of Portland and Multnomah County shows that long-term commitments to greenhouse gas emission reductions are possible. Below are detailed some of the achievements of this area over the last 20 years.

- Portland established its Urban Growth Boundary in 1980 and since 1990 only 8% of residential growth in the region has gone beyond the Boundary.[49] In 1993, Portland was the first city to develop a CO_2 reduction strategy.
- Portland and Multnomah County lowered CO_2 emissions from the transportation sector by 1.6% below 1990 levels in 2005 despite population growth rates of 15.4%.[50] Over the same period, per capita income growth increased at the same rate as the state of Oregon, showing that reducing rates of CO_2 emission growth does not lead to negative economic consequences. Over the same period, CO_2 emissions across the United States rose by 17%.[51]
- Between 1990 and 2007, per capita VMT in Portland region fell by 8-10% while national VMT per capita grew by 8%.[52]
- Between 1992 and 2008, Portland built 300 miles of bikeways and experienced annual increases in bicycling of 10%.[53]
- Have added additional light rail lines and a central city streetcar system, resulting in a 90% growth in public transit ridership since 1990.[54]

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[49] Center for Clean Air Policy. "Cost Effective GHG Reductions through Smart Growth and Improved Transportation Choices." 2009. Available at: http://www.ccap.org/docs/resources/677/CCAP%20Smart%20Growth%20-$%20per%20ton%20CO2%20_June%202009_%20FINAL.pdf

[50] Natural Resources Defense Council. 2005. Measuring Success: Portland and Multnomah County's Climate Policy Achievements.

[51] City of Portland and Multnomah County. "Climate Action Plan 2009." Available at: http://www.portlandonline.com/bps/index.cfm?c=49989&a=249251

[52] Center for Clean Air Policy. "Cost Effective GHG Reductions through Smart Growth and Improved Transportation Choices." 2009. Available at: http://www.ccap.org/docs/resources/677/CCAP%20Smart%20Growth%20-$%20per%20ton%20CO2%20_June%202009_%20FINAL.pdf

[53] Center for Clean Air Policy. "Cost Effective GHG Reductions through Smart Growth and Improved Transportation Choices." 2009. Available at: http://www.ccap.org/docs/resources/677/CCAP%20Smart%20Growth%20-$%20per%20ton%20CO2%20_June%202009_%20FINAL.pdf

[54] City of Portland and Multnomah County. "Climate Action Plan 2009." Available at: http://www.portlandonline.com/bps/index.cfm?c=41917&a=140409

Strategies

Each strategy, except Strategies 2, 3 and 4, is evaluated to estimate the CO2 emissions that could be avoided by implementation, the costs of implementation, the fuel savings that would result from implementation, and an estimate of the job creation potential created by spending or investing in Colorado the revenues that would have been transferred outside the State's economy by the purchase of fossil fuels. The VMT reduction Strategies 2, 3 and 4 are evaluated together to estimate their CO2 reduction potential because their impact is synergistic, but they are examined separately because under State law each of the strategies would require actions by different actors.

Strategy 1: Market Strategies to Increase Demand for Fuel Efficient Vehicles

Background

This overall strategy combines incentives for purchasing plug-in hybrid electric vehicles or comparable high-efficiency vehicles with incentives to scrap older, gas-guzzlers, funded by a revenue-neutral fee-bate program that imposes a modest fee on purchasers of new high-emitting, low efficiency vehicles.

Emission Reductions Available from Electric Vehicle Technology

Many alternative fuel technologies offer some potential reductions in CO_2 emissions, but none offer the potential to reduce CO_2 emissions as much as plug-in hybrids. At the outset, the first original manufacture plug-in hybrid promised by General Motors (GM) to be commercially available in November of 2010, the Chevy Volt, is expected to meet the California CO_2 emission standards that first apply to the 2020 model year.[55] This is a 44% reduction from the California standards for 2010, and 46% lower emissions than the national fuel efficiency standards expected to apply to the 2011 model year.

Plug-in hybrid electric vehicles (HEVs) offer significant decreases in CO_2 emissions compared to traditional internal combustion engine vehicles. Based on Colorado's electricity mix, which is approximately two-thirds coal, it is estimated that each Plug-in HEV on the road will reduce CO_2 emissions by 2-3 metric tons annually (46%) compared to a new gasoline powered vehicle.[56] As the

[55] The Volt's CO2 emissions are estimated to be 175 grams/mile for the gasoline engine and 173 grams/mile for the electric engine based on Colorado's electricity mix. 175 grams/mile is the standard proposed by the California tailpipe standards for new small vehicles by 2020. A new small gasoline powered vehicle in 2010 would be allowed to emit 301 grams/mile, on average.

[56] Using the design features of the Chevy Volt as an example, the vehicle is designed to travel 40 miles per charge before using the liquid fuel engine to recharge the battery. Assuming the average Volt owner travels the average annual VMT for Colorado drivers (11,500 mi/yr, and that 75% of daily travel can be accommodated solely by the electric motor, the vehicle will be driven 40 mi/day on battery and 12 mi/day on liquid fuel if no daytime charging

average Colorado citizen is responsible for approximately 25 metric tons of CO_2 emissions annually, 3 tons is a significant (12%) reduction in each person's carbon footprint.

By operating on energy obtained from the electric power grid, plug-in hybrid technology offers the additional benefit of achieving additional long-term reductions in CO_2 emissions as the electricity grid is "greened." As coal is displaced by natural gas and renewable sources of electricity (wind, solar, geothermal, wave power), the CO_2 emissions per mile when the vehicle fleet is powered by electricity will drop proportionally.[57] And as gasoline is displaced by bio-fuels,[58] the fossil carbon emissions per mile will also drop proportionally when the vehicle fleet operates off the on-board engine-generator. Thus once the vehicle fleet is converted to the plug-in technology currently being prepared for market, significant further CO_2 reductions will be available without requiring another conversion of the vehicle fleet to a different technology to achieve the 80% reduction target by 2050.

The Volt's fuel efficiency measured in miles per gallon starts at 50 mpg if the vehicle is operated 100% of the time from the on-board engine-generator used to charge the batteries. No liquid fuel is required if the vehicle is operated less than 40 miles between each charge from the grid. The average vehicle in Colorado is driven 11,500 miles annually. At 50 miles per day, 80% of these miles driven by a plug-in can be operated on power drawn from the grid. When operated in this manner, a plug-in can cover approximately 200 miles on 1 gallon of gasoline. By reducing average liquid fuel consumption by 75% or more, the plug-in technology offers the opportunity to virtually eliminate US reliance on imported oil which currently supplies 58% of US transportation fuel.[59]

Fuel savings are estimated based on gasoline costs of $3.21 per gallon (average price in CO in 2008) and electricity costs of $0.102 per kilowatt hour (kWh) (the average residential price in CO). (See footnotes 55 and 56 above for assumptions made about plug -in hybrids.) To charge a Plug-in Hybrid nightly for one year will require approximately 1,750 kWh of electricity, which would cost the consumer approximately $175. To drive 25% of miles traveled using gasoline would cost approximately $185 due to the high fuel efficiency of the fossil-fueled engine (an estimated 50 mpg). A driver of an average new internal combustion engine vehicle would require 429 gallons of gasoline at a cost of $1,380 to travel an

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station is available. To charge a Plug-in Hybrid nightly for one year will require approximately 1,750 kWh of electricity, which with Colorado's current electricity generating mix would result in 1.4 tons of CO2 emissions. To drive 25% of miles traveled using gasoline (approximately 3,000 miles) would require 58 gallons of gasoline, resulting in .6 tons of CO2 emissions. A driver of an average new internal combustion engine vehicle would require 429 gallons of gasoline to travel the same distance which would emit 4.2 tons of CO2. Therefore, the average plug-in HEV driver should emit about half (2 tons less) per year than the average new gasoline powered vehicle.

[57] See Appendix 2 for further details about the effect of greening the grid on CO_2 emissions per mile.

[58] Currently, there is a significant amount of research regarding advanced biofuels from sources such as cellulose, algae and recycled food wastes. These advanced biofuels have not reached commercialization and it is expected that many more years of research and development will be necessary before widespread development and use will be possible. Biofuels are expected to play an important role in the long-term in replacing petroleum based fuels in all transportation applications as demand for liquid fuels is reduced by the electrification of the transportation system. See Appendix 2 for more information on biofuels.

[59] Energy Information Administration. "Annual Energy Outlook 2009." Available at: http://www.eia.doe.gov/oiaf/aeo/pdf/trend_4.pdf

equal number of miles. Therefore, the average plug-in HEV driver should save approximately $1,000 annually at 2008 fuel costs for their vehicle. This will allow purchasers of plug-in HEVs to payback the remaining incremental cost[60] of the vehicle in 2 to 3 years and provide annual cost benefits for the remaining lifetime of the vehicle. If gasoline were to stay at a lower price of $2/gallon, annual estimated fuel savings would be approximately $600.

Another benefit of plug-ins is zero emissions of the air pollutants responsible for ozone and fine particles (PM 2.5) during the 40 miles per day when the vehicle is operating from the battery charge. For the average vehicle miles of travel, these emissions will also be reduced about 75-80% per day. Achieving these emissions reductions from motor vehicles should greatly reduce the public health damage associated with ozone and fine particles in metropolitan areas.

Plug-in hybrids offer other important advantages. First, the fuel infrastructure needed to support the complete replacement of the current fleet of personal vehicles is in place. Because the vehicles can be refueled at any gasoline pump, or from any 120 volt electrical outlet, fuel sources are readily available throughout the range of expected vehicle use. To aid in the expansion of infrastructure to support the charging of vehicles, Colorado offers a tax incentive for up to 20% of the cost of the installation of refueling infrastructure for alternative fueled vehicles such as plug-in hybrids.[61] If the entire light duty vehicle fleet became plug-in hybrids, national electricity generation would increase by 12%, well short of the 50% of electrical generating capacity that remains available for additional generation during off-peak hours.[62] As long as plug-in hybrids are charged during evening and off-peak hours, there would be no need to add electrical generating capacity to the system[63] and thus no new major infrastructure investments are required.[64]

Why Market Based Strategies?

Because the state of Colorado lacks the authority to directly regulate fuel efficiency standards beyond the adoption of the California standards, providing financial incentives to drivers is the most effective way to improve the fuel efficiency of vehicles on the road. Each of the policies discussed below provides

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[60] The initial incremental cost of Chevy Volt is estimated to be approximately $8,000. Federal and state tax credits are expected to cover the majority of the incremental costs for plug-in hybrids. Information on federal tax credit available at: http://www.energy.gov/taxbreaks.htm. Information on state of Colorado tax credit available at: http://www.colorado.gov/energy/index.php?/policy/category/motor-vehicle-incentives/.

[61] Alternative Fuels and Advanced Vehicles Data Center. Colorado Incentives and Laws. http://www.afdc.energy.gov/afdc/progs/view_ind.php/CO/5247

[62] If the average plug-in hybrid used 2,000 kWh/year, then upon conversion of the entire 230 million light-duty vehicle fleet, approximately 500 TWh of electricity would be required to power the fleet. The United States currently generates over 4,000 TWh of electricity and has the installed capacity to hypothetically produce almost 9,000 TWh of electricity annually.

[63] A study conducted by NREL on Xcel Energy's Colorado service area showed that even if plug-in hybrids made up 30% of the light duty vehicle fleet, as long as they were charged during off-peak hours no additional capacity would be necessary and that such a charging pattern would actually be beneficial to the utility's operations. Available at: http://www.nrel.gov/docs/fy07osti/41410.pdf

[64] A detailed comparison of plug-in hybrids with other advanced vehicles technologies and fuel types appears in Appendix 1.

incentives for the purchase of a highly efficient vehicle or for scrapping inefficient vehicles. These incentives are funded by a fee assessed on the least fuel efficient new vehicles sold in the state. This range of incentives will push consumers away from the least efficient vehicles and towards the most efficient vehicles on the market which will annually reduce each driver's fuel consumption by hundreds of gallons, and CO_2 emissions by thousands of pounds.

Funding for Market Based Strategies

To fund the purchase incentive rebate and Vehicle Retirement Program discussed in detail below, a tiered set of fees would be assessed on low efficiency vehicles. To make these two proposals revenue neutral, the fee portion of the fee-bate will need to generate approximately $40 million.

A fee would be charged to each new vehicle sold that was rated less than 26 mpg, the current standard for new light-duty vehicles. To increase the fairness of the fee, the lower the efficiency of the vehicle, the higher the assessed fee would be. Table 8 shows a potential fee schedule that could generate the necessary revenues.

Table 8 – Fees for Inefficient New Vehicles Sold in Colorado

Average Fuel Efficiency	Fee
23.1- 26 mpg	$150
20.1 - 23 mpg	$300
17.1 - 20 mpg	$450
14.1 – 17 mpg	$600
Under 14 mpg	$900

These fees would raise approximately $40 million annually, which would offset the revenue lost to the state from the Alternative Fuel Vehicle Tax Credit enacted in H.B. 1331 (2009), and the Vehicle Retirement Program. The amount of the fees should be adjusted annually to ensure the program is revenue neutral to the state. As the vehicle fleet becomes more efficient due to increasing federal CAFE standards aimed at achieving average vehicle efficiency of 35.4 mpg by 2016, the efficiency threshold at which the fee is assessed should be shifted upwards to match the federal fuel efficiency standard. Purchasers of vehicles less efficient than the national standard would therefore fund the cost of the programs.

Another funding alternative would be to establish a revolving loan fund to provide the resources to fund vouchers for replacement vehicles, with loans secured by a lien on title to be repaid by a supplemental annual charge added to the vehicle registration fee.

Market Strategy A: Feebate

The tax credit/rebate program enacted in HB 09-1331 (2009) will lower the cost of a highly fuel efficient vehicle so that its sticker price will be marginally greater than a similar vehicle with much lower fuel efficiency. While highly fuel efficient vehicles will likely pay for their incremental purchase cost over the lifetime of the vehicle due to lower fuel costs, most consumers give much more attention to initial cost. In order to move highly efficient vehicles from niche vehicles to the mainstream, approaching initial price parity is critical to attract consumer interest, and convince manufacturers to expand production and thereby achieve cost reductions through economies of scale.

Specific Proposal

House Bill 09-1331 extended Colorado's tax credit and rebate program for fuel efficient vehicles to 2016, classified qualifying vehicles by fuel efficiency, and defined plug-in hybrids as a category 1 vehicle that qualifies for the highest (75% of the vehicle's incremental cost) tax credit. This program supplements any federal tax credit, and is estimated to cost $15 to $25 million in foregone revenues. To ensure the long-term viability of the tax credit for plug-in HEVs, it is proposed to fund the current tax credit and rebates by implementing a fee to make the incentive revenue neutral by shifting the burden from the general taxpayer to the purchasers of high CO_2-emitting vehicles. Then the tax credit program should be extended through 2020.

In 2008, the tax credit reduced tax revenues by $12.5 million. If the current policy continues as a tax incentive and Alternative Fueled Vehicle (AFV)/HEV sales continue to escalate in Colorado as they have over the last 5 years (a 725% increase from 2003 to 2008 and a 47% increase from 2007 to 2008), the incentive could become a significant long-term budgetary burden. A feebate program would establish a fuel efficiency threshold, and then charge a fee on vehicles purchased with lower fuel efficiency to compensate for the revenue lost from the tax credit or rebate currently provided on qualifying low-emitting vehicles. The fee would also add a slight disincentive for the purchase of low-efficiency vehicles.

An alternative or supplement to assessing a fee on the least-efficient vehicles would be to establish a loan program for highly efficient vehicles. The voters of Boulder County adopted a loan program that allows homebuyers to purchase energy efficiency products and renewable energy systems with the loan repaid as a part of their property taxes. This amortizes the cost over many years and sets up a revolving fund that the county can use to fund purchases by other homeowners. A similar program for highly efficient vehicles would remove the cost from taxpayers while realizing the goals of making highly efficient vehicles cost competitive with average vehicles. In the case of new vehicles, loans for the incremental cost of highly efficient vehicles could be repaid over say 10 years as a supplement to the annual registration fee. The loan obligation would pass with title and not need to be repaid when the original owner sells the vehicle. Any remaining loan balance would be due in full in case a vehicle owner moves out of state with the vehicle.

Under HB 09-1331, rebates and tax credits are offered only for the most fuel efficient vehicles. The program currently supports vehicles with fuel economies over 30 mpg, but will quickly limit the incentives to vehicles achieving 40 mpg. While this may currently include only a small number of vehicles, many more advanced technology vehicles (Plug-in hybrids, electric vehicles, diesel-hybrids) will arrive on the market in the next few years. The incentives will stimulate sales of vehicles that significantly push fuel economy higher.

Energy and CO_2 Savings

Table 9 – Gasoline and CO_2 Emission Reductions from Aggressive Promotion of PHEVs (40% market penetration by 2040)

Year	Gasoline Savings (1000s of barrels)	Reduced CO_2 Emissions (1000s of tons)
2010	21	6
2015	279	60
2020	1,092	199
2025	2,658	455
2030	4,148	649
2035	6,531	1,338
2040	9,206	2,300

By 2020, promotion of Plug-in HEVs that achieved 5% market penetration would provide 1.6% and 1.5% of the CO_2 emissions reductions necessary to achieve the CAP's and President Obama's reduction goals respectively. Assuming 40% market penetration by 2040, the program would provide 6.7% and 6.6% of the CO_2 emissions reductions necessary to achieve the CAP's and President Obama's reduction goals respectively.[65] By 2050, Plug-in HEVs (PHEVs) could help achieve the 80% reduction target for light-duty vehicles if this technology powers 90% of the light duty vehicle fleet, the grid is 80% less carbon intensive than 2005 levels, and the liquid fuel used in the on-board generator is derived from biomass which reduces emissions by 75%.

For these reasons, public policies should focus on promoting the rapid adoption of plug-in hybrids as the technology of choice to replace vehicles powered by traditional internal combustion engines. Given that plug-in hybrid vehicles are not yet offered by any major vehicle manufacturers, this recommendation assumes that plug-in technology will have costs, battery lifetime and performance, etc. that are cost effective on a lifecycle basis and satisfy the needs of most drivers, once such vehicles are manufactured on a large scale.

[65] Assuming average fuel efficiency standards reach 54 mpg by 2030, the mpg equivalent efficiency of PHEVs when powered by electricity from the grid will continue to improve beyond 2010 emissions due to the decarbonization of the grid. To meet the 80%/2050 reduction target, by 2030 the electric grid is estimated to be 35% less carbon intensive than 2005 levels. This will mean that a PHEV operating on battery power alone would achieve a mpg equivalent of 78.2, allowing PHEVs to continue to provide emission benefits above and beyond average vehicles.

Costs and Benefits

Assuming PHEV vehicle sales increase annually to 40% of the market by 2040, consumers will have saved \$4.6 billion in liquid fuel costs. Electric energy costs are estimated at \$386 million and the net cost to taxpayers should be \$0,[66] resulting in a net economic benefit of \$4.2 billion. Additional fuel savings from vehicles in use after 2040 would continue to accrue. Due to the revenue neutral nature of the feebate the promotion of PHEVs by Colorado through tax credits and rebates is not expected to have a fiscal impact. However, the \$4.2 billion in fuel savings would be available for other economic activities in Colorado that would stimulate job creation and increased tax revenues.

Market Strategy B: Accelerated Vehicle Retirement

Background

Policies that improve light-duty fuel economy through technology improvements, such as the Clean Car Standards and the feebate program to promote Plug-in Hybrid Electric Vehicles discussed above, are directed at new vehicles, because efficiency technologies such as plug-in use of electric power typically cannot be cost-effectively retrofitted onto existing vehicles. Consequently, the benefits of these policies are fully realized only after many years, given that the vehicle fleet takes about fifteen years to be replaced. A program that could accelerate the retirement of inefficient vehicles and ensure their replacement by efficient vehicles is therefore a way to accelerate the introduction of efficient technologies available from the new vehicle market.

States have promoted early vehicle retirement for years as a means of reducing tailpipe emissions. California and Texas, among other states, currently have programs to provide monetary incentives for owners of older vehicles to scrap their vehicles. Vehicle emissions standards have become much more stringent over the past three decades and vehicles' emissions performance deteriorates over time, so the oldest vehicles usually emit 15 to 60 times more pollution than newer ones, and retiring them is an effective means of reducing emissions.[67]

Vehicles having high CO_2 emissions, unlike high air pollution emitters, are just as likely to be of recent vintage. Average new vehicle fuel economy reached its peak in the U.S. in 1987-1988, and subsequently declined as SUVs' share of vehicle purchases soared in the 1990s. Thus, an accelerated retirement program to raise fuel economy cannot be aimed simply at the oldest vehicles, but must rather define the target vehicle population explicitly in terms of poor fuel economy. Moreover, retiring an inefficient vehicle brings fuel savings only if its replacement has higher fuel economy. The federal government

[66] Because the feebate will transfer fees from one set of taxpayers to another set of taxpayers it would not have any net costs. If the feebate were not enacted, then the cost to taxpayers would be approximately \$12 million annually, which will total \$178 million (net present value in 2008 dollars) between 2010 and 2040.

[67] Environmental Protection Agency. Mobile Source Emissions – Past, Present and Future. Available at: http://www.epa.gov/OMS/invntory/overview/results/onroad.htm

passed a vehicle retirement program, the Consumer Assistance to Recycle and Save (CARS) Act in June 2009. The bill does not have stringent fuel economy requirements. It allows vehicle buyers to receive credits as long as the new vehicle purchased is only 4 mpg more efficient than the traded in vehicle. Light trucks need only be 2 mpg more efficient to qualify for the credit. The federal program will be in place until either the end of October or when the government has issued $1 billion in rebates. The federal program will expire without exhausting the demand for trading in of vehicles in 2010 and beyond. The trade-in program detailed below is more aggressive regarding fuel efficiency.

Specific Proposal

A statewide Accelerated Retirement Program for Inefficient Vehicles is proposed. The program would provide a voucher for the purchase of either a new fuel efficient vehicle or for a multi-year free transit pass in exchange for the voluntary retirement of fuel-inefficient vehicles from the current pool of about 3.8 million light-duty vehicles registered in Colorado. To be eligible vehicles would need to 1) be in drivable condition, 2) currently registered in Colorado, and 3) have a fuel economy rating of 15 miles per gallon or less. Nationwide approximately 4% - 5% of the vehicles on the road fit this category. After 5 years, the maximum miles per gallon would increase slowly to allow more vehicles to be eligible for the program so that drivers would maintain an incentive to remove the least efficient vehicles from the road. Increasing CAFE standards will increase the efficiency of new vehicles and should lower the number of highly inefficient vehicles. A list of such vehicles would be posted by the state to facilitate promotion and implementation by auto dealers.

Owners of vehicles presented for destruction (crushing, shredding) would receive a voucher from the state redeemable upon the purchase of a new or used vehicle having fuel economy greater than the then-current national average fuel efficiency standard (e.g., > 35.5 miles per gallon by 2016). These owners could also receive vouchers of higher face value to be used for multi-year free access to public transit in Colorado. An additional incentive or revolving loan program should be targeted at lower income residents who would not benefit as much from the tax credit (discussed above) due to little or no income tax liability.

The minimum fuel economy for eligible new vehicles would increase each year so that it would remain approximately 10 mpg higher than the current model year's combined CAFE standard. For the 2009 model year there were 70 cars and 8 light trucks with an EPA mileage rating greater than 35 mpg.[68] Such vouchers would be eligible for redemption by auto dealers for 3 years from the date of issuance. Vouchers presented at the time of purchase would be collected by the vehicle dealer and redeemed by the dealer at full value from the Department of Revenue. The vouchers would not be considered income for tax purposes, but would lower the owner's basis in the vehicle.

[68]American Council for an Energy Efficient Economy. "Accelerated Retirement of Fuel-Inefficient Vehicles Through Incentives for the Purchase of Fuel-Efficient Vehicles." 2009. Available at: http://www.aceee.org/transportation/Crusher%20white%20paper%20fin.pdf.

Vouchers would need to be valued at an amount somewhat greater than the Blue Book value of the trade-in vehicle to create an incentive for current owners to trade-in early, and to transfer title to the state to ensure destruction of the vehicle. During the first year of the program (2010), the vouchers are estimated at the amounts shown in Table 10.

Table 10 – Value of Vouchers Offered to Retire Inefficient Light-duty Vehicles

Model Years	Voucher Amount (Trade-ins)	Voucher Amount (face value Public Transit pass)
2005 and later	$4,500	$5,000
2002 through 2004	$3,000	$3,500
1999 through 2001	$1,500	$2,000
1998 and earlier	$500	$1,000

In each subsequent year of program operation (2011, 2012, and 2013 etc…), the model years indicated above would be advanced by 1 year. In any year, participating operators of vehicle destruction equipment will be eligible for a non-refundable tax credit of $50 per removal from operation and recycled vehicles.

Energy and CO_2 Savings

Under this Vehicle Retirement Program, vehicles achieving less than 15 miles per gallon would be replaced by vehicles achieving at least 35 miles per gallon. Assuming an average of 11,500 miles per year, each voucher would result in a savings of 442 gallons per year (4 tons of CO_2). Further assuming a program participation rate of 7,000 vehicles per year (which is anticipated to decline over time), savings of motor fuel should reach approximately 40.3 million gallons (961 thousand barrels) per year in the program's peak year. The energy savings are shown in Table 11.

Table 11 – Gasoline Savings and CO_2 Emission Reductions from Vehicle Trade-In Incentive

Year	% Gasoline Savings	Gasoline Savings (1000s of barrels)	Reduced CO_2 Emissions (1000s of tons)
2010	0.1%	74	27
2015	0.8%	440	163
2020	1.3%	750	277
2025	1.6%	961	355
2030	1.1%	724	267
2035	0.7%	476	176
2040	0.4%	291	108

It is also assumed that the average vehicle retired by the program is 6 years old and that it would have remained on the road for an additional 10 years in the absence of the accelerated retirement program.

Thus fuel savings are greatest in the initial years of the program, and provide significantly greater progress toward achieving the 2020 target than other strategies that provide greater reductions after 2020. Reductions from this program begin to fall off if the difference between the least and most efficient vehicles in each model year decreases as the fleet becomes more efficient.

Costs and Benefits

The anticipated annual cost of the program is expected to be about $21 million, which is expected to decline over time based on the assumption that the numbers of vehicles in any model year that would qualify (i.e., that are at least 11 mpg less efficient than the national standard) would decline. But the cost would be revenue neutral based on the fees proposed above.

If the assumed number of credits is issued each year and the average value of each voucher is $3,000, plus the $50 credit for each scrapped vehicle, the total cost of the program over the period 2010 to 2040 would be $246 million (Net Present Value (NPV)) in 2008 dollars. Total fuel savings over the lifetime of the vehicles that are replaced would be $1 billion, resulting in a net benefit of $754 million. Because the policy is designed to be revenue neutral, it should have minimal impact on the state's budget.

By 2020, the tax credit, rebate and vehicle trade-in programs together would provide 4.1% of the CO_2 emissions reductions necessary from a business as usual scenario to achieve the CAP's 20% reduction goal, and 3.6% of President Obama's reduction goal. By 2040, these programs would provide incentives to achieve the CO_2 emissions reductions available from 40% market penetration of the plug-in hybrid technology.

These savings are in addition to those achieved by the more stringent fuel efficiency standards extended to 2030.

VMT Reduction: Strategies 2, 3, 4, and 5

The following 4 strategies—expanded transit services, transit oriented urban design, incentive-based user fees, and Pay-As-You-Drive auto insurance—are all geared towards reducing VMT growth to the rate of Colorado's population growth. If the State's VMT growth rate since 1980 continues through 2050, CO_2 emissions will reach a level (over 51 MMTs) which cannot realistically be reduced by foreseeable engine and fuel technology systems to achieve the Governor's 5.4 MMT target by 2050. Reductions from the trend described by the historical VMT growth curve are necessary complements to improvements in vehicle technology and fuel efficiency if the state is to significantly reduce CO_2 emissions by 2050.

The baseline case used for estimating future emissions from light duty vehicles in the Blueprint assumes that statewide VMT will continue to grow 47% faster than population unless policies are implemented to modify that trend. By 2050, annual CO_2 emissions from gasoline vehicles will reach 32 MMT, compared to 20 MMT in 2005, if vehicles are required to only meet the fuel efficiency standards adopted by the Obama administration by 2016. If the national standards continue to be tightened to 54 mpg by 2030 as discussed in the trends analysis, CO_2 emissions from light duty vehicles will be lower by 7 MMT, but will nonetheless rise to 25 MMT by 2050. If this increase were allowed to occur, meeting the 5.4 MMT target for the entire transportation sector by 2050 would require that motor and fuel technologies be developed that reduce emissions from light duty vehicles by over 95% between 2030 and 2050.[69] No currently foreseeable technology option offers the possibility of achieving this level of reduction.

When VMT doubles, CO_2 emissions will increase unless technology can cut emissions per mile by more than half during the same period. The reductions in per vehicle emissions expected from the Obama/CARB agreement to adopt federal fuel efficiency standards that will match the California standards by 2016 will barely reduce emissions faster than VMT growth during the 12-15 year period when older, less efficient vehicles are being replaced by vehicles meeting the 35.5 mpg standard. But once the period of fleet efficiency upgrade ends (during the mid-2020s), emissions will again be driven higher by VMT growth. A similar trend is found even if fuel efficiency standards continue to increase through 2030. Once the majority of the fleet has turned over (by approximately 2040), VMT growth begins to drive emissions up again.

Therefore to achieve significant progress in reducing CO_2 emissions beyond that available from the fuel efficiency standards, the growth in VMT must be reduced as well. If VMT growth were reduced to the level of population growth, then annual statewide emissions from the light duty (gasoline) sector would reach 19 MMT rather than rise to 24 MMT by 2050. Reducing VMT reduces emissions by 100% for every mile not driven.

The transit, urban design and user fee strategies analyzed in the Blueprint offer the potential to reduce VMT growth even below population growth in the State's three largest urban areas as a means of achieving statewide VMT growth no greater than population growth. The 5 MMT in CO_2 emissions eliminated from this magnitude of VMT reduction is one of the most important strategies available to the State to reduce CO_2 emissions. Most important, achieving this 5 MMT reduction from VMT strategies makes it possible to achieve the 5.4 MMT target by 2050. By reaching a peak below 20 MMT, rather than nearly 25 MMT, the reduction needed from advanced technology between 2030 and 2050 is closer to 80%. As discussed in the envisioning section, the technology options available beyond the 2030 fuel efficiency standards make an 80% reduction in light duty emissions by 2050 appear feasible. Without the VMT reduction policies described in the next four strategies, there is no apparent path to achieving the 5.4 MMT target by 2050.

VMT growth is driven by two primary factors: 1) growth in population which increases the number of people and goods that need to travel; and 2) urban design which either forces travel demand to be satisfied only by individual vehicles or provides widespread opportunities for travel demand to be satisfied by walking, biking and multiple forms of public transport. Some successful, vibrant, thriving

[69] This conclusion assumes that a significant portion of the 5.4 MMT of CO_2 allowed from the transportation sector in 2050 must be allocated to aviation for which electrification is not an option, and to long-haul trucks which receive little benefit from electrification.

cities such as Portland, Oregon have reduced VMT growth to levels no greater than population growth.[70] In most Colorado cities, VMT growth exceeds population growth by as much as 50%. Most of that increment above population can be traced to sprawl development that supplies housing at greater and greater distances from employment and activity centers, without providing access to employment and activities with clean, fast and efficient alternatives to the personal automobile.

The three elements of successful and sustainable urban design are well-understood. Urban VMT can be reduced to levels below population growth where 1) transportation resources are invested primarily in creating fast, clean and efficient transport services; 2) land use policies direct residential and commercial development into neighborhoods that are within walking and biking distance of transport services; and 3) price signals create incentives for travelers to prefer public transport and disincentives for single occupant vehicle travel. When alternative modes of travel are integrated with future development so that access to public transit is convenient for a large portion of the metropolitan population, and price signals create incentives to use transit services, many more travelers will be able choose low or non-polluting alternatives over the personal automobile without sacrificing the freedom to choose. Equally important, studies from other metropolitan areas demonstrate that these policies reduce infrastructure costs, improve system performance while reducing travel delay, and provide net economic benefits for the metropolitan region.

These strategies explore the opportunities for applying these policies in Colorado to reduce CO_2 emissions from the transportation sector. Since the first three strategies discussed are complementary in nature and can only maximize their impact if instituted comprehensively, the discussion of the emission reductions, costs and benefits of the three strategies is reserved until the conclusion of the final strategy, Regional and Corridor Use Fees.

Colorado's Largest Metro Areas

The state's largest metropolitan planning organizations (MPOs) (DRCOG, Pike's Peak and North Front Range) are the focus of this analysis because the State's urbanized areas provide the most potential for VMT reduction due to greater population density and the fact that they are responsible for two-thirds of the state's VMT and 77% of its population. Targeting these 3 areas for VMT reduction offers the potential for achieving a somewhat greater aggregate VMT reduction than attempting to keep VMT/capita level across all areas of the state. Applying these VMT strategies in the 3 urban areas would optimally reduce VMT by 17.6 billion vehicle miles in 2040 compared to a 15.4 billion vehicle miles reduction through keeping VMT/capita flat across the state.

Of these 3 MPO regions, the Denver metro area is by far the largest. The Denver metro area accounts for 50% of statewide VMT and provides the greatest opportunity to reduce VMT in Colorado. The Denver Regional Council of Governments (DRCOG) expects that VMT will rise by 35% (from 71 million

[70] Center for Clean Air Policy. "Cost Effective GHG Reductions through Smart Growth and Improved Transportation Choices." 2009. Available at: http://www.ccap.org/docs/resources/677/CCAP%20Smart%20Growth%20-$%20per%20ton%20CO2%20_June%202009_%20FINAL.pdf

miles per day in 2005 to 96 million miles) by 2020, and by 74% to 124 million miles by 2035. This increase from 2005 to 2035 is greater than the expected population growth in the metro area of 59% over the same period (2.7 million to 4.3 million). Assuming these projections are on target, metro area VMT will grow 23% faster than population. Reducing VMT growth to the rate of population growth is one of the most effective strategies for reducing fuel use and CO_2 emissions during this period. Achieving this objective will also avoid worsening traffic congestion, and help reduce metro Denver's air pollution problems.

The two other most urbanized MPOs in Colorado, Pike's Peak Area Council of Governments and North Front Range Metropolitan Planning Organization are also included as they both have potential for integrated transit and land use policies in their areas.

Strategy 2: Reduce Vehicle Miles Traveled through Improved Transit

Background

Providing Access to Efficient, Convenient and Clean Travel Options

FasTracks is the Denver metro's area plan to build and expand light-rail service in the metro area while also improving bus availability and service by 2017. When completed, the system will consist of 122 miles of light rail lines, 18 miles of bus rapid transit service, 61 new transit stations and over 20,000 new Park and Ride spaces.[71]

The complete build-out of FasTracks over the next 7 years is one of the most important investments that Colorado can undertake to reduce greenhouse gas emissions from the transportation system. A comprehensive system of light and commuter rail lines, complemented by Bus Rapid Transit and expanded bus service will serve as the foundation for Denver metro's sustainable transportation system for the 21st century. This investment provides an extraordinary opportunity to reduce per capita VMT if it is coordinated with regional land use policies that channel new development into the 61 regional centers and communities served by FasTracks stations. Making a 40 mile daily commute alone in a vehicle with average fuel efficiency emits 36 pounds of CO_2[72], whereas making the same trip on a full RTD bus emits 4.7 pounds per rider.[73] Providing personal mobility as an alternative to using the personal vehicle achieves dramatic reductions in emissions per person/mile traveled.

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[71] RTD. FasTracks. see: http://www.rtd-fastracks.com/main_1.

[72] The average vehicle with a fuel efficiency of 21.3 mpg would use 1.87 gallons of gasoline for a 40 mile commute. CO_2 emissions = 1.87 gallons of gasoline x 19.4 lbs/gallon.

[73] An RTD bus has a fuel efficiency of 4.59 mpg. Over the length of a 40 mile trip it will use just under 9 gallons of diesel. This will emit 193 lbs of CO_2. If there are 5 riders on the bus the emissions per person would be 38.7 lbs,

While the completion of FasTracks will lay the foundation for a sustainable transportation infrastructure, it will only create the *potential* for reducing growth in vehicle travel to the rate of population growth. Without coordinated land use planning policies to guide new housing and commercial development into the areas served by FasTracks, ridership and reducing VMT growth will not reach optimal levels. To make ridership convenient and preferable to driving it is critical that Transit-Oriented Development (TOD) policies are implemented. Clustered development within a quarter to half mile radius of rail stations and bus terminals ensures easy access to regional travel destinations while also eliminating the need for many shorter vehicle trips by locating shopping and services within comfortable pedestrian and bicycle travel distances. TOD policies reduce VMT and emissions by increasing the population density surrounding transit stations, encouraging the development of mixed commercial and residential development and facilitating easy access to transit by pedestrians and cyclists.

In the Pike's Peak area, centered on Colorado Springs, there are plans for an expanded mass transit system including four fixed rapid transit corridors, an expanded fixed-route network, call and ride services and inter-city rail service. However, most of these expanded services would only be realized as part of their non-fiscally constrained plan. Pike's Peak estimates that with its current budget it would only be able to fund $1.08 billion of the $2.8 billion required for this expanded transit network. In the fiscally constrained budget there are plans for only two fixed-guide way rapid transit corridors. Additional funding would provide the area the resources to develop mass transit that served a much larger proportion of the population and would offer more convenient and extensive travel alternatives to individual vehicle use.

In the North Front Range, centered on the Ft. Collins, Loveland and Greeley region, the current Regional Transportation Plan does not call for any expansion of transit service. From 2008 to 2035, the area anticipates spending $369 million to maintain its current transit system.

The two other urbanized MPO planning areas of the state are Mesa County and Pueblo. Together, these five areas anticipate investing $22.7 billion on transit between 2008 and 2035 as part of their fiscally constrained plans. Of this amount, $15.1 billion is planned for the maintenance of the current system and $7.6 billion for expansion of transit service. However, the MPOs have identified an additional $12.4 billion in transit funding in their non-fiscally constrained plans that could be used to further improve and expand the services needed to accommodate the new development that will come with population growth. To provide the areas with the funding to optimize their transit systems would require approximately $450 million annually.

Not identified in the MPO transit plans is the need for inter-regional service to reduce VMT on the major corridors that link the State's metropolitan areas with each other, and with recreational destination communities. This need should be addressed by the new Transit and Rail Division in the Colorado

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just above the 36.4 emitted by the single occupancy vehicle. However, if there are 20 riders on the bus, the per passenger emissions would fall to 9.7 lbs, and on a full bus with 41 riders per passenger emissions are 4.8 lbs.

Department of Transportation (CDOT) as part of their development of a comprehensive statewide transit plan.[74]

Specific Proposal

Transit

Since transit oriented urban design and pricing incentives offer little if any benefit unless transit services are available as alternatives to driving a personal vehicle, this section examines financing options to complete FasTracks and expand transit services in the other MPOs as well.

Transit Funding Need

Transit projects are traditionally paid for with a combination of local and federal revenue, with a majority of the burden falling on the local community to provide funding for transit. The local share of FasTracks is funded by the sales tax increase passed by the voters in 2004. The state has provided little support for transit projects and has maintained its focus on building and maintaining highway infrastructure. CDOT's primary contribution to transit services has been the construction of HOV lanes for use by transit vehicles on I-25 and US 36.

A dedicated source of transit funding from the state of Colorado is necessary to help metropolitan regions reduce regional VMT, and reduce VMT from inter-regional travel on the major travel corridors that link the metropolitan areas with each other and with destination communities.

As discussed above, approximately $450 million is needed annually to fund expansion of transit services in the five largest MPOs. Assuming the state could obtain at least half of these funds from the US Department of Transportation, the State would need $225 million annually to provide the transit services needed to reduce VMT growth.

For comparison, the current gasoline tax (22 cents per gallon) costs the average driver $119 ($0.22 x 11,500 miles/21.3 mpg) and supplied the state with $449 million in revenue in 2008. FASTER, Senate Bill 09-108 passed in 2009, dedicates $5 million annually to the new state transit program to be developed by the new Transit Division at CDOT. A comprehensive statewide transit plan should assess the State's role in supporting the creation of these transit options.

An analysis of several different funding proposals is outlined below and provides a better idea of which policies would be best suited to provide such a dedicated revenue stream for transit projects.

Transit Funding Revenue Options

The state has recently debated replacing or supplementing the gasoline tax with alternative sources of revenue. Consideration of alternative revenue sources is prompted by the expected decrease in gasoline

[74] See S.B. 09-94, creating the Division of Transit and Rail.

sales in Colorado resulting from the federal fuel efficiency standards. Sales will drop at about the rate that CO_2 emissions are reduced which will have a negative impact on revenue derived from this source.

VMT is expected to continue to increase at least at the rate of population growth, even as growth in gasoline consumption is expected to decline. Gasoline consumption is expected to increase in Colorado at least through 2023, at which point the improved fuel efficiency of the fleet will begin to result in decreasing gasoline consumption.

Mileage-Based User Fees

Each vehicle could be charged a fee (periodically, annually or at the pump) based on the number of miles it had traveled during the previously reported time period. The number of miles could be determined in a number of different ways including annual odometer readings or installation of an on-board wireless device that records the miles traveled (but not location to avoid invading privacy), and periodically downloads the mileage data for the collection of user fees.

To achieve the necessary levels of statewide funding, each mile traveled would cost approximately $0.005. The average vehicle (driven 11,500 miles annually) would pay $57. The fee would apply to all light duty vehicles registered in the state. If all light duty vehicle miles traveled in the state were assessed at the $0.005 rate then approximately $222 million in revenue would have been generated in 2008. As long as statewide VMT continues to increase, the revenue source would continue to grow and not lose purchasing power over time. As a safeguard against flattening VMT and loss of purchasing power due to inflation, the $0.005 charge per mile could be indexed to inflation. The flattening of VMT could result from the expansion of transit services as more drivers are given more transportation options. Also, charging for each mile driven will give drivers an incentive to drive less which could also reduce VMT and threaten the growth of the revenue source. While a tax on VMT would give drivers an incentive to drive fewer miles, it would not encourage drivers to drive more fuel efficient vehicles.

However, some interests argue that the state constitutional provision requiring that revenues assessed based on vehicle operation be used exclusively for construction and maintenance of the highways of the State would bar their use to fund transit.

CO_2 Emissions fee

A dual fee, assessed at a vehicle's inspection, on the amount of CO_2 each vehicle emits would address both goals. This would apply a fee based on the vehicle's fuel efficiency and how far it had traveled, giving consumers a motivation to increase their fuel efficiency while driving fewer miles. A lifeline exemption, such as 2,500 miles driven each year, could create an incentive for vehicle owners to minimize their driving to avoid paying the fee.

In order to collect $220 million per year each vehicle would be charged $15 per ton of CO_2 emitted. For the average vehicle with a fuel efficiency of 21 mpg which traveled 9,000 non-exempt miles, this would result in a fee of $57. The fee per ton could be increased as the fuel efficiency of the fleet improves to maintain the revenue stream necessary for expanding transit infrastructure.

Integrated CO_2 and Mileage-based Fee

User fees could be based on a CO_2 emissions fee combined with a mileage-based fee: For each mile driven, each vehicle would be charged $0.003. For the average vehicle driven approximately 11,500 miles annually (9,000 miles with 2,500 miles exempted from the fee), this would result in a fee of $27. For each ton of CO_2 emitted vehicles would be charged $7.50, resulting in an annual fee of $28.

If these average fees were assessed to all light-duty vehicles in Colorado (approximately 3.86 million in 2008), $220 million in revenue would be generated.

This fee could be indexed to inflation to ensure a sustainable revenue stream. This option would likely be subject to the same constitutional objections as the VMT-only option.

Gasoline Sales Tax

A sales tax on gasoline and diesel could be added to the current excise tax resulting in an overall increase in the price of gasoline and diesel. The primary reason for adding a sales tax based on the price of the fuel rather than an excise tax based on the volume of the fuel sold is to allow the revenue to be dedicated to transit. The constitution requires that revenues from an excise tax on fuel be dedicated for the construction and maintenance of the highways of the state. If this limitation is ultimately construed to bar the use of a fuel excise tax for transit purposes, a sales tax on fuel would allow revenues to be dedicated to transit.

To supply the revenue necessary for funding the State half of planned transit projects a $0.10 increase in the tax derived from a gallon of gasoline would be necessary. This would result in the average driver paying $54 annually and would have generated $220 million in revenue in 2008.

To maintain revenue levels as fuel efficiency increases, the annual percentage increase in fuel efficiency must be matched by either an equal increase in VMT or the same percentage increase in the sales tax.

Net revenues from a sales tax on fuel will likely increase even after fuel consumption declines because it will be based on the price of fuel. As global oil supplies are depleted, fuel prices are expected to increase even if US fuel consumption begins to decline after 2020. If the sales tax does not maintain adequate revenues, the sales tax could be indexed to either the federal fleet wide fuel efficiency standards or the statewide VMT.

The ability of the sales tax on gasoline to be used for transit projects (as well as other transportation) projects makes it the best choice to create a dedicated revenue stream for transit. Table 12 below lays out some of the pros and cons of each of the funding options.

User Fees by Region and/or Highway Segment

A system of user fees linked to highway segments, major arterials or specific metropolitan areas could be established in the three metro areas and on the inter-regional corridors to fund expanded transit projects in each region or corridor. A more detailed discussion of regional and corridor-based user fees is provided in Strategy 4.

To fund expanded transit service in the DRCOG area proposed in the MPO's 2035 Vision Plan would require approximately $196 million annually[75] (assuming the federal government provides 100% matching funds). There are approximately 760 miles of freeways and major arterials in the Denver metro region.[76] To collect the necessary funds via tolling on the region's freeways and major arterials a fee of approximately $0.016 would need to be charged for each vehicle mile traveled on these roads.[77] It is difficult to estimate the per driver or per vehicle annual cost of tolling because some traffic will be local while other traffic will be through.

Table 12 – Comparison of Transit Funding Sources

	Annual Fee for average driver/vehicle	Total Revenue millions of $ (2008)	Encourages less driving	Encourages more fuel efficient vehicles	Constitutionally able to be used for transit
Mileage-based Fee	$54	222	Yes	No	Uncertain
CO_2/mileage Fee	$58	220	Yes	Yes	Uncertain
Gasoline Sales Tax	$54	220	Yes	Yes	Yes
Regional/corridor User fee	NA	196	Yes	No	Yes

All of the three statewide strategies send fairly weak price signals to system users so the price increase by itself is not expected to have a significant effect on driving behavior. However, regional and corridor-based user fees offer much greater flexibility, and can be tailored to send strong price signals in areas where transit services are available as alternatives (see Strategy 4).

A new revenue stream for transit projects is critical. The new revenue stream would need to be dedicated to achieving the level of transit services needed to accomplish the VMT growth rate for each region, but would not necessarily all have to be earmarked for transit if that target is met. The flexibility to split the revenue stream between transit and general transportation projects should be linked to meeting the VMT growth reductions goals for a region.

[75] DRCOG's 2035 Metro Vision Regional Transportation Plan estimated $10.5 billion would be necessary between 2008 and 2035 to realize the transit expansion in their non-fiscally constrained plan. Dividing this total by 27 years would give $388 million, which if the federal government provided half the necessary funds would require $196 million in funding for the DRCOG area.

[76] T. Litman. 2009 Urban Transport Performance Spreadsheet. Available at: http://www.vtpi.org/Transit2009.xls

[77] There are approximately 12.2 billion annual VMT traveled on the Denver metro area's freeways and arterials.

Strategy 3: Transit Oriented Urban Design

Background

Locating homes, jobs and other destinations within convenient public access to transit services by walking, biking, neighborhood shuttles or small battery-operated personal vehicles is an essential element to optimize the VMT-reducing potential of regional transit investments such as FasTracks. The Denver metro population is expected to double between now and 2050, suggesting that the region will also double the housing stock, commercial and industrial space, educational facilities, hospitals and other medical facilities, and popular services such as libraries and recreational facilities. Where this new development is located will play a major role in determining whether VMT and CO_2 emissions continue to grow at rates that exceed population growth. Land use policy will determine where this growth occurs. Land use decisions can ensure that most of this new development is located within walking, biking, or neighborhood electric vehicles (like a golf cart) driving distance from regional transit. Without land use policies that guide growth into areas served by regional transit, there is little possibility that CO_2 emissions from transportation can be reduced to meet the targets of the State climate action plan.

Currently land use authority in Colorado is exercised by local governments with little or no role for the State or regional planning agencies such as metropolitan planning organizations. No provisions of state or local law require that land use decisions be coordinated with the development of transportation plans, or that land use decision makers be informed of the impact their decisions will have on travel demand, VMT, traffic congestion on regional highway networks, emissions of ozone precursors that contribute to violations of national ambient air quality standards that result in potential exposure by the State to sanctions under the Clean Air Act, or emissions of greenhouse gases. However, at least 17 jurisdictions (including states and MPOs) across the country have developed initiatives to link land use and transportation planning to reduce unsustainable land use practices that contribute to the problems noted above.[78]

Metropolitan planning organizations are required under federal law to consider development plans adopted by jurisdictions with land use authority.[79] When estimating future travel demand and the traffic loads on regional highways DRCOG attempts to assign the geographic distribution of expected future population and employment in a manner that reflects local land use plans. But this is a challenging exercise because local land use plans collectively anticipate significantly more growth than can reasonably be expected to occur. Therefore transportation plans historically were based primarily on the MPO's best judgment of where new development was likely to occur. DRCOG staff has been reluctant to test the impact of different land use scenarios not currently reflected in the comprehensive plans adopted by cities and counties. As a result, the transportation system investments selected in the regional transportation plan reflect the travel demand generated by a regional pattern of sprawl

[78]Binger et al. Connecting Transportation Decision Making with Responsible Land Use: States and Regional Policies, Programs and Incentives. Mineta Transportation Institute 2008.
[79] 23 U.S.C. § 134(g)(3).

development, and not the many benefits that could be achieved by a pattern of transit-oriented development. In other words, the current planning procedures favor maintenance of the status quo.

This reliance on adopted land use plans to estimate where travel demand will occur creates an inherent bias toward sprawl development that drives transportation investments into highways. This in turn contributes to regional VMT growth rates significantly greater than population growth, and in turn exacerbates GHG emissions. The regional planning assessment undertaken by DRCOG in the 1990s in response to Governor Romer's Smart Growth initiative demonstrated that sprawl development carries with it high incremental infrastructure costs in addition to adverse impacts on VMT, more sever traffic congestion, air pollution and GHG emissions. Of the four growth scenarios analyzed by DRCOG for the 2020 Plan update, infrastructure costs alone ranged from $2 billion for compact development that would limit the urban footprint to 550 square miles to nearly $5 billion for unconstrained sprawl development that would extend the urbanized area to 1500 square miles. The unconstrained growth policy would have significantly increased VMT growth, worsened air pollution, and located large segments of the population outside the reach of cost-effective public transit.[80]

This recognition of public costs generated support from the public, business interests and local elected officials for a regional consensus to constrain the expansion of the urban footprint in the Denver metro area by the voluntary adoption of regional growth policies. This consensus resulted in the regional growth boundary established by the Mile High Compact among metro governments. The Compact effectively limits the portion of the metro planning area where regional transportation investments will be made.[81]

The adoption of the Urban Growth Boundary (UGB) provides an example of a cooperative effort among local governments in the metro area to achieve commonly accepted regional goals. However, the UGB was not designed to achieve the kind of transit-oriented growth pattern needed to achieve the targets for reducing GHG emissions. A regional consensus to adopt a transit-oriented growth pattern to optimize the investment in FasTracks could emerge if the public demands that limiting climate impacts become a priority for regional planning, and the economic benefits of transit-oriented development are once again fully disclosed as the costs of sprawl were highlighted in 1996.

If a new regional consensus to focus new development into the 67 communities served by FasTracks does not emerge, State action may be necessary to ensure that future development is planned to minimize climate impacts.

[80] DRCOG. "Metro Vision 2020: Urban Growth Boundary. Available at: http://www.drcog.org/documents/UGBHistoryAnd%20Process_2004Report.pdf

[81] DRCOG. "Metro Vision 2020: Mile High Compact." Available at: http://www.drcog.org/documents/MHC%20signature%20page%208.5%20x%2011.pdf

Specific Proposal

State Level Policies

While most of the policies that encourage development around transit stations are the purview of city and county governments, there are some policies the state government can implement to promote Transit-Oriented Development (TOD). Colorado could impose on new development such that the developer bears the incremental infrastructure costs attributable to development outside of designated urban service areas. These costs should include the costs imposed by generating travel demand that cannot be served by public transit. Incentives might include allowing local property taxes to be credited against state sales taxes for commercial developments within walking and bike access to regional transit services, and grant programs from the Department of Local Affairs that assist local governments in developing, adopting and implementing TOD plans.

Colorado already uses federal funds to offer a Low Income Housing Tax Credit Program. Some states only allow developments to qualify for this credit if the development is within the service zone of regional transit. This credit could be used to create mixed income housing developments near transit stations. Low income housing residents expend a larger portion of their household income on transportation and benefit the most from convenient access to regional transit.[82] Convenient access to regional transit often increases access to more employment opportunities for low income households that cannot afford personal vehicles. The state can also offer expertise and funding support for local governments interested in policies such as expedited permitting for TOD or Smart Growth projects.

These are examples of other state governments providing financial incentives for TOD. Oregon offers partial property tax abatements to mixed use development located in areas designated for growth by local communities that are consistent with the regionally adopted growth policy.[83] Oregon has also established an Employee Commute Options (ECO) program that requires employers with over 100 employees to offer commuting alternatives that will reduce VMT in and around Portland.[84] As part of its Smart Growth program, Massachusetts offers state funding to cities and municipalities that adopt streamlined permitting for TOD and smart growth zoning policies.[85]

The state could also offer incentives to local governments to encourage them to implement the local policies discussed below.

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[82] G. Giuiano. 2001. "The Role of Public Transit in the Mobility of Low Income Households." University of Southern California. Available at: http://www.metrans.org/research/final/99-11_Final.pdf
[83] Oregon Housing and Community Services. Vertical Program Housing Fact Sheet. Available at: http://www.ohcs.oregon.gov/OHCS/HD/HFS/pdfs/HFS_Factsheet_Vertical_Housing_Program.pdf
[84] Oregon Department of Environmental Quality. Employee Commute Options. Available at: http://www.deq.state.or.us/nwr/ECO/eco.htm
[85] State of Massachusetts. Smart Growth/Smart Energy Toolkit. Available at: http://www.mass.gov/envir/smart_growth_toolkit/pages/state-policy.html

Local Policies

Local policies that could be implemented along transit corridors to further optimize the investment in FasTracks include: parking ceilings, decoupling parking and housing costs, allowing for flexible and multi-use vertical zoning, density thresholds or bonuses and tax incentives for aspects of TOD.

Parking ceilings place a limit on how much parking can be provided by developers. Currently, most parking regulations focus on mandatory parking minimums (a certain number of spaces per square foot of space) to ensure that maximum demand for free parking can be met by the development. Often these ratios are derived from suburban parking demand or are generic numbers that do not reflect actual parking demand around transit corridors. These mandates often overestimate demand for parking or establish levels that would only be met during a few peak times each year while the remainder of year there would be surplus parking that create incentives for driving, increase the land cost of commercial and residential development, and limit the potential for greater residential density in areas with the easiest pedestrian access to regional transit. A parking ceiling would limit the amount of land dedicated to parking, promote more pedestrian friendly development, reduce the need for two vehicle households, and encourage use of alternative modes of transit.

Developers and landlords often include the cost of parking places with the cost of housing so that residents pay for parking whether or not they use it. This creates an incentive to use automobiles. If residents were able to opt out of paying parking costs, they would essentially receive a premium for not using a motor vehicle. If they did choose to own a vehicle they would then pay the same price as before, but it would come in two bills so the resident would be made aware of how much parking actually costs.

Flexible zoning laws allow municipalities to promote mixed use zoning which helps create heavier use of transit systems. If an area around a transit station is all zoned residential then there is likely to be limited use of the system except for single-direction travel during rush hours. The remainder of the day and evening would see little traffic as there would be little reason for people not residing there to travel to a residential area. With mixed use zoning including residential and commercial properties co-located in one area and in the same buildings, steadier volumes of transit riders would be more likely throughout the day as workers would be coming into the area for employment and businesses such as service providers, restaurants and entertainment venues would draw customers during the entire day and night. Mixed use also will give people the option to walk and bike to businesses that are located close to their homes. Zoning tools such as density thresholds and density bonuses can be used by governments to encourage developers to create denser housing and mixed uses around transit stations. California, for example, requires local jurisdictions to offer incentives to developers for denser housing.[86]

If state and local governments aggressively support focused development along public transit corridors then the VMT reduction benefits of implementing FasTracks can be fully realized.

[86] California Government Code Section 65915-65918. Available at: http://www.leginfo.ca.gov/cgi-bin/displaycode?section=gov&group=65001-66000&file=65915-65918

Strategy 4: Regional and Corridor User Fees

Holding statewide VMT growth to the rate of population growth, i.e., maintaining VMT per capita at current levels, is fostered by the use of user fees to create a price signal that gives most travelers an incentive to choose alternatives to driving alone. Charging user fees for access to the highways and major arterials of the Denver metro area complements the investment in transit services by making it cheaper for travelers making routine trips to choose transit, walking, biking or neighborhood-sized battery vehicles for local trips. These incentives are necessary to achieve the potential reduction in VMT made possible by the expanded transit and TOD strategies.

User fees provide an opportunity to have drivers pay their fair share of the costs of maintaining the transportation system[87], and setting fees for the use of the system that fairly reflect the GHG emissions from the decision to drive a personal vehicle.

Asking users to pay a fair share of the costs of maintaining the system and to bear a cost that is related to their impact on climate adds an element of fairness that is currently missing from the transportation funding scheme. Consider the fees now collected by state and local authorities for two alternative modes of personal transport. Currently the traveler choosing to make a daily 40 mile regional roundtrip commute by driving a vehicle with average fuel efficiency pays a charge of $0.41 in gasoline tax on the fuel used.[88] By contrast, the traveler who chooses to make the same roundtrip on RTD will pay between $5.80 and $7.50 for each round trip.[89]

The traveler driving alone in a vehicle with average fuel efficiency will emit 36 lbs of CO_2.[90] For the transit ride the emissions per trip will vary depending on the number of passengers sharing the bus. During the peak travel periods when buses are full, each passenger round trip will emit 4.7 lbs, [91] or 13% as much as the car driver. As long as there are more than 5 passengers on the bus during the 40 mile commute, the emissions per rider will be less than those of a vehicle with one driver and no passengers. The climate impact of this mode choice is currently inverse to the fees collected by public agencies.

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[87] A national study found that taxes and payments related to vehicle use and operation made to governments do not match the government expenditures supporting motor vehicle use and would require additional motor fuel taxes of $0.20-0.70 per gallon to make up the shortfall.

Delucchi, M. 2007. Do motor-vehicle users in the US pay their way?. Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RP-07-17

[88] The average vehicle with a fuel efficiency of 21.3 mpg would use 1.87 gallons of gasoline for a 40 mile commute. With a $0.22 per gallon gas tax, this commuter would pay $0.41 in gas tax for each 40 mile commute

[89] The cost depends on what type of monthly pass the commuter purchases. Assuming that each month has an average of 22 work days that number is divided by the cost of the pass. A 40 mile commute on an Express route would cost $5.81 per roundtrip and the Regional Pass would cost $7.45 per roundtrip.

[90] CO_2 emissions = 1.87 gallons of gasoline x 19.4 lbs/gallon.

[91] An RTD bus has a fuel efficiency of 4.59 mpg. Over the length of a 40 mile trip it will use just under 9 gallons of diesel. This will emit 193 lbs of CO_2. If there are 5 riders on the bus the emissions per person would be 38.7 lbs, just above the 36.4 emitted by the single occupancy vehicle. However, if there are 20 riders on the bus, the per passenger emissions would fall to 9.7 lbs, and on a full bus with 41 riders per passenger emissions are 4.8 lbs.

To encourage use of the lower emitting travel choice, vehicle tolls and transit fares should be set to send a price signal that reflects the impacts of the choice. It is well demonstrated that travel costs weigh heavily on personal mode choice. At a minimum, fares and tolls should be set at a level that requires users to pay for the operating and maintenance costs of the system. If user fees fail to at least cover operating and maintenance (O&M) costs of the system, then user trips on the system for which costs are not recovered from users are subsidized from other sources of revenue.

Establishing a user fee system for access to all regional arterials and limited access highways will ensure that drivers pay their fair share of the cost of maintaining the system, providing an incentive for drivers to switch to other modes of travel such as mass transit, carpooling, rideshares and strategies that reduce trips such as four ten-hour work days, and telecommuting. A reduction in VMT from less vehicle traffic will reduce CO_2 emissions while improving system performance by cutting congestion. It is equitable to allocate the operating costs of the system to the drivers who use highways because these users are responsible for the operating and maintenance costs, and are the primary beneficiaries from reduced congestion.

User fees should be comprehensive, covering all major highways and arterials rather than a limited number of roads so that drivers cannot simply shift their driving to free roads. A comprehensive approach best serves the primary objective which is to reduce VMT per capita by 1% annually in the three largest urbanized areas. By imposing a fee when single occupant fossil-fueled vehicles are used on all regional arterials and limited access highways, the price signal creates an incentive to choose much lower CO2 emitting alternatives, including transit and shared ride services.

Revenue collected from user fees could be another source of the transportation funding needed to create the transit services described in Strategy 2. Planned transit services must have a dedicated source of funding in order for local governments to be willing to adopt land use policies that channel new development into locations that are accessible to transit by walking and biking. Developers must be assured that planned transit services will be provided within a reasonable period of time. Toll revenues can provide the necessary confidence to ensure that transportation services and land development can be successfully coordinated.

Once the core transit services are in place, and future development is coordinated with these services, then most of the new travel demand from a growing population can be accommodated on the transit system without VMT growing faster than population. With well-designed land use policies, future growth in travel demand will be addressed first by expanded transit capacity, and not new highway capacity. After the initial capital investment required to develop an integrated, regional transit system that provides service to 80% of all new residential and commercial development, the cost of new transit capacity will be more cost-effective than expanding highway capacity.

The FHWA estimates that the cost of adding a new lane in an urban area averages $10-15 million per lane mile, while the approximate funds generated by gas taxes from use of the lane would only be

$60,000 annually.[92] By comparison, adding new capacity to an existing light rail system can generally be accomplished by adding more rolling stock to the rail or High Occupancy Vehicle (HOV) corridor at a significantly lower capital cost than adding highway lane miles. User fees should not be used as a new general revenue source to fund new highway capacity across the state, but should be dedicated to expand system capacity that serves new travel demand with the least climate impact.

An example of this approach to meeting future travel demand has been provided by the Puget Sound Regional Council (PSRC, the MPO for the Seattle area), in its proposed 2040 Transportation Plan.[93] The proposed Plan update examines five alternatives for the region's transportation system. The fifth alternative is demonstrated to achieve an absolute reduction of VMT (an 11% decrease from the baseline) by adopting comprehensive regional tolling, the smallest expansion of roadway capacity and the greatest expansion of transit services. Perhaps most important, alternative 5 also demonstrates the greatest net economic benefits to the region ($9.5 billion, almost 50% more than the next highest alternative). The Puget Sound plan shows the potential for reduction of VMT growth rates below population growth when aggressive transit, land use and tolling policies are adopted in an integrated manner. These policies also reduce infrastructure development costs, and provide the greatest net benefit while improving system performance, reducing travel delays and achieving significant reductions in GHG emissions. In Colorado's urban areas, reducing VMT/person 1% annually as population grows is similar to the Seattle scenario, is achievable, and is a necessary strategy for achieving the ultimate 80% CO_2 reduction target by 2050.

The enactment of the 2009 FASTER bill[94] provides statutory authority to implement a comprehensive program of user fees in growth areas around the State, and to allocate revenues obtained from users to support the development of transit services. The newly created High Performance Transportation Enterprise is authorized to collect fees for the use of existing and new State highways. Collecting user fees on previously fee-free highway segments requires the agreement of all the local governments affected by the collection of user fees.[95] Currently, the only completely tolled roads in Colorado are E-470 and the Northwest Parkway. On Interstate 25 north of downtown Denver, High Occupancy Toll (HOT) lanes require users in single occupant vehicles to pay a toll to travel in the less congested HOV lane. DRCOG reports that the use of the HOT lanes has greatly exceeded initial expectations.[96]

FASTER requires that any user fees collected in a corridor that are used for transit services, must be spent on providing transit services in the corridor of origin.[97]

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[92] Federal Highway Administration. "Congestion Pricing: A Primer." Available at: http://ops.fhwa.dot.gov/publications/fhwahop08039/fhwahop08039.pdf

[93] Puget Sound Regional Council. "Transportation 2040: Draft Environmental Impact Statement." 2009.

[94] S.B. 108 (2009).

[95] See C.R.S. § 43-4-808(3).

[96] DRCOG. "Highway Tolling and Congestion Pricing." Available at: http://www.drcog.org/documents/issuespaperHighway%20Tolling5-09.pdf

[97] See C.R.S. § 43-4-812 (The Enterprise "may use revenues generated by the user fee or toll for transit-related projects that relate to the maintenance or supervision of the highway segment or highway lanes on which the user fee or toll is imposed.")

User Fees to Fund Transit

To fund the expanded transit service proposed for metro Denver in the MPO's 2035 Vision Plan would require approximately $196 million annually[98] (assuming the federal government matches local funds dollar for dollar). To collect this amount via tolling on the region's freeways and major arterials a fee of approximately $0.016 would need to be charged for each vehicle mile traveled.[99] For proposed tolling on US Highway 36 between Denver and Boulder capital costs are estimated at $18.5 million and annual operating and maintenance costs at $1.55 million.[100] Costs would be paid from tolls collected. Extrapolating from the US 36 costs, a regional toll collection system would likely cost $100-150 million to install, and $10 million to operate.

Variable Tolling

Using congestion pricing or variable rate tolling to charge higher rates during peak travel times would increase the efficiency of the transportation infrastructure. Drivers would have an incentive to either choose transit or travel during non-peak hours. Both responses will reduce congestion during peak rush hours. In the Denver metro area, DRCOG estimates that 360 miles of roads and arterials currently suffer from severe congestion and that twice as many miles will suffer from high levels of congestion by 2035.[101] The costs of congestion in the Denver metro area due to lost time and increased fuel use are estimated at $1.7 billion annually and are expected to reach nearly $8 billion annually by 2035.[102] The aggregate negative drag on the metro economy from the cost of travel delay alone is expected to exceed $100 billion between now and 2035.

A pilot project conducted by the PSRC found that variable tolling reduced weekly VMT by 12%, reduced total number of trips by 7%, reduced total hours of travel by 5% and significantly shifted travel outside of peak hours.[103] Benefits from variable tolling included "less emissions, fewer accidents, travel time savings, improved roadway performance reliability and lower operating costs."[104] The net present value

[98] DRCOG's 2035 Metro Vision Regional Transportation Plan estimated $10.5 billion would be necessary between 2008 and 2035 to realize the transit expansion in their non-fiscally constrained plan. Dividing this total by 27 years would give $388 million, which if the federal government provided half the necessary funds would require $196 million in funding for the DRCOG area.
[99] Annually, users drive approximately 12.2 billion miles on the Denver metro area's freeways and arterials. From T. Litman. 2009 Urban Transport Performance Spreadsheet. Available at: http://www.vtpi.org/Transit2009.xls
[100] Colorado Tolling Enterprise. "US 36 Managed Lanes." Available at: http://www.drcog.org/documents/CTE%20Submittal%20for%20US%2036%20Managed%20Lanes%20_2_.pdf.
[101] Twice as many roads are expected to be in corridors with congestion mobility grades of D or F by 2035, resulting in an increase from 45 to 133 annual vehicle hours of delay. DRCOG estimates the cost of one hour of vehicle delay at $26.50 per vehicle hour http://www.drcog.org/documents/2035%20MVRTP_revisedMarch09.pdf
[102] DRCOG. "2008 Annual Report on Traffic Congestion in the Denver Region." Available at: http://www.drcog.org/documents/DRAFT%202008%20Annual%20Report%20on%20Traffic%20Congestion.PDF
[103] Puget Sound Regional Council. "Traffic Choices Study-Summary Report." 2008. Available at: http://www.psrc.org/projects/trafficchoices/summaryreport.pdf
[104] Ibid.

of all the benefits that were monetized from variable tolling for the Puget Sound planning region was estimated to be $28 billion over a 30 year period.[105]

Variable fees based on factors such as time of day, number of passengers per vehicle, and CO_2 emission rate, could be charged either by individual lanes or entire roadways for separate highway segments. Variable user fees on highways should be set up with a tiered pricing schedule, with the highest rates applicable during rush hours and with lower rates during off-peak travel times.[106] Fees could also dynamically be adjusted to charge higher rates on roads experiencing the greatest levels of congestion, and no fees at all during hours when regional transit service is not provided. Tiered pricing should encourage the optimal use of the existing roadway's capacity.

Examples of variable tolling in the United States include the New Jersey Turnpike which provides discounts to off-peak drivers and the Cape Coral and Midpoint bridges in Fort Myers, Florida which have seen a 20% increase in traffic during non-peak rate time when a 50% discount is offered.[107]

All transportation system users are now required to pay to use the system by paying vehicle registration fees, fuel taxes or rider fares. However these fees are not designed to require users to pay their fair share of capital, operating and maintenance costs, or to reflect the impact that users impose on climate as a result of GHG emissions. State law now authorizes user fees to be applied based on the actual use of the system, the impacts on other users that result from the period of use, and on the GHG emissions for which each user is responsible. This authority provides the opportunity for the Transportation Enterprise and the Transportation Commission to develop a much more rational user fee-based source of revenue that is designed to maintain VMT per person at current levels by expanding transit services and providing price incentives for system users to choose transit for routine local and regional trips.

Energy and CO_2 Savings for Strategies 2, 3 and 4

Several studies have shown that with aggressive policies to support TOD, contain sprawl and disincentives to driving alone, regional VMT can be reduced up to 30% over a long term period of 30 years.[108] The full implementation of FasTracks and other transit systems in the state, along with land

[105] Ibid.

[106] For example, the proposed user fee schedule for the HOT lanes to be added to US 36 between I-25 and Boulder would charge a fee equal to RTD's regional bus fare ($$4.50) during the 6 peak travel hours, half of the RTD regional bus fare during the "shoulder hours" before and after the peak travel hours, and $.50 during all other hours.

[107] Federal Highway Administration. "Congestion Pricing: A Primer." Available at: http://ops.fhwa.dot.gov/publications/fhwahop08039/fhwahop08039.pdf

[108] M. Zhang, Y. Chang. 2006. "Can Transit Oriented Development Reduce Austin's Traffic Congestion?" Southwest Regional University Transportation Center, Center for Transportation Research. University of Texas at Austin. Available at: http://swutc.tamu.edu/publications/technicalreports/167869-1.pdf;
California Department of Transportation. "Statewide Transit-Oriented Development Study: Factors for Success in California." 2002 Available at:
http://transitorienteddevelopment.dot.ca.gov/PDFs/Statewide%20TOD%20Study%20Final%20Report%20Sept.%2002.pdf.

use policies designed to concentrate new development in areas served by transit and the adoption of user fees for major roadways could reduce VMT growth in metro areas by up to 1% annually compared to the current VMT growth trend. Each year, VMT per capita would decrease by 1% from the previous year, so overall VMT could still increase depending on the rate of population growth, but each individual's contribution would decrease. If Colorado's 3 largest urban areas adopted land use policies that channel 80% of new development into corridors where residents have easy pedestrian, bike and neighborhood vehicle access to frequent transit services, cumulative reductions would continue to accrue through 2050. By 2020, 3.9 billion miles of expected annual VMT growth could be avoided (a 9% reduction[109] compared to the currently expected trend for the 3 MPOs), resulting in an annual reduction of 1.3 million tons of CO_2 emissions and $251 million savings in fuel costs. This reduction is 11.1% of the reductions necessary to meet the Colorado Climate Action Plan goal of 20% below 2005 levels by 2020 and 9.8% of President Obama's reduction goal. By 2040, 17.6 billion miles of travel would be avoided annually (a 29% reduction) compared to the expected VMT, 3.8 million tons of d CO_2 emissions would be avoided and $276 million in fuel cost savings would result. This reduction is 11.4% of the reductions necessary to reach the CAP 2040 goal and 11.2% of the reductions necessary for President Obama's reduction goal. By 2050, annual CO_2 reductions would nearly reach 6 MMT assuming VMT in metro areas continues to decline 1% annually as a result of the policies proposed here.

The reductions achieved by reducing VMT/capita in the 3 largest MPOs would make it possible to limit statewide VMT to below the rate of population growth. By 2040, keeping statewide VMT/capita flat would reduce annual VMT by 15.4 billion miles compared to VMT/capita growing at 47%.

Table 13 – VMT, Gasoline and CO_2 Reductions from Transit, TOD and User Fees

Year	% Reduction in VMT	Gasoline Savings (1000s of barrels)	Reduced CO_2 Emissions (1000s of tons)
2010	0.0%	0	0
2015	4.0%	1,594	589
2020	9.0%	3,590	1,327
2025	14.0%	5,357	1,980
2030	19.0%	6,958	2,572
2035	24.0%	8,727	3,226
2040	29.0%	10,483	3,874

In the long term, of all the transportation polices analyzed for CO_2 emission reduction potential, aggressive land use planning coordinated with the development of transit and user fees is one of the most effective strategies. If this level of VMT reduction is achieved it will have a significant impact on the region's emissions from the transportation sector. Reducing VMT and vehicle travel through the

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Center for Clean Air Policy. "Transportation Emissions Guidebook." Available at: http://www.ccap.or/guidebook/downloads/guidebook.pdf

[109] The VMT reductions would not begin to take effect until 2012 as it would require several years for improved transit options to be established and for supportive policies to have an effect. From 2012 to 2020, an annual 1% reduction in VMT would result in a 9.0% reduction.

above policies has other benefits such as the reduction of Nitrogen Oxide (NOx) emissions, ground level ozone and particulate matter which in turn will improve health, lower health care costs and reduce traffic congestion.

Costs and Benefits

It is difficult to assess with precision the costs and benefits of the policies that would lead to an annual 1% reduction in VMT per capita in metro areas. The wide variety of policies needed to achieve these results would add administrative functions and costs to local government, but would not be expected to add to the costs of housing or commercial development. Indeed, the 1996 DRCOG cost analysis, and DRCOG's recent evaluation of transportation investment and growth scenarios released in 2007 demonstrate that transit combined with regional growth policies reduce the public and private costs of development by billions of dollars over the long term.[110] These benefits far exceed the administrative costs of administering land use policies.

Compact communities require fewer new roadways and shorter water, sewer and electrical connections as well as fewer new services such as schools and police and fire stations. Research conducted in other fast growing metropolitan areas show that the costs of infrastructure and public services associated with infill and compact development range from one quarter to one half of the costs of sprawl patterns of development.[111] Other costs associated with sprawl include the loss of open areas and agricultural land and the environmental damage to waterways due to increased impervious surfaces as well as loss of groundwater.

If the expected level of VMT reduction is achieved, the fuel savings by regional users of the transportation system would further reduce the costs of development. For the areas covered by the3 largest MPOs in the plan, $7.2 billion (in 2008 dollars) in fuel savings would be realized from 2012 to 2040 with average annual fuel savings of $257 million (in 2008 dollars).

Together, the avoided infrastructure costs and fuel savings are expected to produce net cost benefits close to $10 billion between now and 2040. These savings more than offset the additional costs that will be necessary to fund the expansion of transit services across the state, which are estimated to cost $6.2 billion. Thus the estimated net benefit from Strategies 2, 3 and 4 combined will be nearly $6 billion.

Fully implementing the policies that will lead to an ongoing annual 1% reduction in VMT per capita will be more challenging than other strategies discussed in this Blueprint. Many different policies at several different levels of government in different jurisdictions must be coordinated to optimize the results. Counties and cities with land use authority must work together with state and regional transportation agencies and the private sector to create an environment where transit services can expand and most new development concentrated around developing and existing transit corridors.

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[110] DRCOG. "2035 Metro Vision Regional Transportation Plan." See http://www.drcog.org/documents/2035%20MVRTP_revisedMarch09.pdf.

[111] Puget Sound Regional Council. "Information Paper on the Cost of Sprawl." 2005. Available at: http://psrc.org/projects/vision/pubs/costofsprawl.pdf.

Over the next year SWEEP plans to develop a more comprehensive assessment of the costs and benefits of land use options available to local governments, and their benefits to the residents of metropolitan regions and the State.

Strategy 5: Adopt Pay-As-You-Drive Auto Insurance

Background

One reason that people use their vehicles as much as they do is that a high percentage of total driving costs are fixed costs; that is, they are independent of the number of miles driven. The impacts of driving, however, are highly dependent on how much people drive. One effective approach to reducing miles driven is to convert a largely fixed cost, such as insurance, to a variable cost. Pay-as-you-drive (PAYD) insurance accomplishes this by adjusting the premium paid by vehicle owners to reflect the number of miles driven. Drivers would pay a portion of their premiums up front, and the remainder would be charged in proportion to mileage, as determined by a global positioning device, transmitters or periodic odometer readings.

This approach eliminates the subsidy currently paid by low mileage drivers to reduce the premiums paid by high mileage drivers. Claims and payouts by insurance companies closely track miles driven, but most policies currently in force have modest discounts for vehicles driven less than a specified threshold (e.g., 8000 m/yr), but generally premiums for all drivers above the threshold are the same regardless of the annual miles driven. Adjusting the premium to closely track mileage is much more fair to low mileage drivers, and makes sense from the insurance industry's perspective as well, because those who drive fewer miles have lower accident exposure and claims, on average. Converting fixed insurance costs to variable costs through PAYD insurance allows drivers to reduce insurance premiums by reducing miles traveled. Studies conducted in states where PAYD insurance is widely available suggests that vehicle use is reduced by 10-12%.[112]

A PAYD program could be an insurance company policy or product, but some action on the part of the state may be required to remove regulatory obstacles to changing the basis for premiums or to promote the program. Few insurance companies currently offer PAYD coverage, but some policies are offered. GMAC Insurance offers a mileage-based discount to drivers of GM vehicles that are also OnStar subscribers in 34 states. Progressive Insurance offers a mileage based insurance policy through its MyRate program[113] which is currently available in 9 states. A new company, known as MileMeter, provides mileage-based insurance in Texas and is interested in doing the same in other states.[114] In late

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[112] T. Litman. 2005. *"*Pay-As-You-Drive Vehicle Insurance: Converting Vehicle Insurance Premiums Into Use-Based Charges." Available at: http://www.vtpi.org/tdm/tdm79.htm. Victoria Transportation Policy Institute**.**
[113] Progressive. My Rate Home. Available at: http://www.progressive.com/myrate
[114] MileMeter. Available at: http://www.milemeter.com

2008, California's Insurance Commissioner released a plan to create a voluntary pay-as-you-drive program,[115] and Oregon is providing tax credits to insurers offering pay-as-you-drive policies.

While PAYD insurance is not currently available in Colorado, it is anticipated that it will be offered commercially in the near future.

Specific Proposal

This policy would phase in PAYD insurance in Colorado, beginning with a pilot program in 2010. The state would grant $200 to insurance agencies for each 1-year policy they write for which 80% or more of the pre-program policy cost is scaled by the ratio of annual miles driven in the covered vehicle to average annual miles driven. The incentive is necessary so long as PAYD is optional, because insurance companies may lose money on the high mileage customers who would not choose such a policy because their premiums would increase. Without the ability to offset the higher claims with higher premiums for high-mileage customers, insurers could lose revenues by offering optional PAYD coverage. Should the pilot program prove successful, it is recommended that a mandatory PAYD insurance program be phased in over the next 10 years to provide drivers with the option to reduce their insurance costs by driving less, and to eliminate the unfair subsidy for high mileage drivers currently paid by low mileage drivers.

Assuming the pilot program is successful, a mandatory program should be instituted beginning in 2013. Insurance companies would be responsible for converting a percentage of their policies to PAYD, with the percentage increasing each year until PAYD is universal in 2020. Along with implementing PAYD insurance, the state should educate vehicle owners on how they can reduce their insurance payments by driving less.

Energy and CO_2 Savings

Estimates concerning how much a PAYD program would reduce VMT in Colorado depend on the price elasticity of travel demand, or how much driving is reduced due to an increase in the cost of driving. There are a large number of studies that estimate the elasticity of travel demand. Following a thorough review of the current literature as well as a number of meta-studies done over the years, a conservative figure of -0.2 has been chosen to represent the long-term elasticity of travel demand.[116] A -0.2 elasticity signifies that for every 10% increase in the cost of gasoline, VMT will be reduced by 2%. The long-term

[115] California Department of Insurance. "Insurance Commissioner Poizner Sets Framework For Environmentally–Friendly Automobile Insurance, Increased Options For Consumers". August 27, 2008. Available at: http://www.insurance.ca.gov/0400-news/0100-press-releases/0070-2008/release089-08.cfm

[116] D. Graham, S. Glaister. 2002. "The Demand for Automobile Fuel: A Survey of Elasticities" Journal of Transportation Economics and Policy, Vol. 36, Number 1;
K. Small, K. Van Dender. "If Cars Were More Efficient Would We Use Less Fuel?" Access Publication of University of California Transportation Center, No 31, Fall 2007, pp. 8-13.
P. Goodwin et al. 2004. "Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: a Review" Transport Reviews. Vol. 24, No. 3. Pp.275-292.

elasticity is usually a lower number (resulting in greater reductions) than the short term elasticity (-0.3 rather than -0.2). Research on the price elasticity during periods of high gas prices in 2008 indicates that during this period the short-term elasticity of demand for gasoline was approximately -0.3.[117] The average price of gasoline in Colorado in 2008 was $3.21, the average fuel efficiency of the vehicle fleet was 20.6 mpg, the average cost of an auto insurance policy in the state was $785 per vehicle and the average number of miles traveled by vehicles in Colorado is approximately 11,500. For the average vehicle, this results in fuel costs of $0.156 per mile and an average insurance cost per mile of $0.077.

If 80% of the cost of the insurance premium were mileage based, the average insurance cost per mile would be $0.054, which is approximately 35% of the per-mile cost of fuel. Adopting the PAYD policy would result in a 35% increase in the variable cost of driving, similar to an equivalent increase in the cost of gasoline. With an assumed long-term elasticity of -0.2 this would result in a nearly 7% reduction in driving within 10 years.

The proposed program would begin with a 3-year pilot program supported by the state to encourage insurance companies to offer PAYD policies to their customers. The state would set the goal of having 2,000 PAYD policies in 2010, 10,000 in 2011 and 20,000 in 2012. After this time, if the policy was found to effectively reduce participants' VMT, a mandatory program would be phased in between 2013 and 2020, resulting in a 7% reduction in statewide VMT by 2020.

Table 14 – VMT, Gasoline and CO_2 Emission Reduction from PAYD Auto Insurance

Year	% Reduction in VMT	Gasoline Savings (1000s of barrels)	Reduced CO_2 Emissions (1000s of tons)
2010	0.01%	3	1
2015	2.7%	1,488	550
2020	7.0%	4,098	1,515
2025	7.0%	4,027	1,488
2030	7.0%	3,948	1,459
2035	7.0%	3,956	1,462
2040	7.0%	3,992	1,475

Adopting universal PAYD insurance by 2020 would provide 12.7% of the CO_2 emissions reductions necessary from a business as usual scenario to achieve the CAP's 20% reduction goal and 11.2% of President Obama's reduction goal. By 2040, the program would provide 4.4% and 4.3% of the CO_2 emissions reductions necessary to achieve the CAP's and President Obama's reduction goals respectively.

[117] C. Komanoff. "Spreadsheet Tracking U.S. Gasoline Demand." Available at: http://www.komanoff.net/oil_9_11/Gasoline_Price_Elasticity.xls

Costs and Benefits

It is assumed that the state would pay a $200 per policy subsidy for the 3 year voluntary phase in period. This would cost the state and taxpayers approximately $400,000 in 2010, $2 million in 2011 and $4 million in 2012. The total net present value in 2008 dollars of these costs would be $5.7 million. While this would reduce the insurance company's costs of introducing the coverage, benefits would also accrue to drivers who purchase PAYD coverage in the form of lower premiums. Due to the incentive to reduce VMT it is estimated that the average driver would lower their premiums by approximately $35 annually, which would result in premium savings of $67,000 in 2010, $319,000 in 2011 and $607,000 in 2012 for a total of $993,000 savings in 2008 dollars. It is anticipated that the earliest adopters would be those drivers who drove less than the median driver, which would result in greater premium savings than average making the above savings a conservative estimate. Other savings from a PAYD program would be the fuel saved from reduced VMT. Total estimated fuel savings from PAYD policies written between 2010 and 2040 would be approximately $4.9 billion. The estimated benefits to consumers in the form of reduced insurance premiums over the 2010 to 2040 time period would be $1.5 billion. While this savings from reduced premiums will result in less revenue for insurance companies, it is expected that there would be a parallel decline in insurance claims. The total net benefits from the program would be $6.4 billion.

Reducing VMT will reduce vehicle accidents and congestion. In fact, by some accounts, the value of these benefits of PAYD insurance is of the same order as the benefit of reduced energy consumption.[118] Preliminary studies on the correlation of insurance claims and miles driven confirm a linear relationship, although the results may not justify the relative sizes of fixed and variable components of insurance premiums assumed here.[119]

Some stakeholders express concerns that rural and/or poorer people would be disadvantaged by the adoption of PAYD insurance. On a national level, low-income drivers actually drive less on average than do high-income drivers. In 2001, households (with vehicles) that earned $75,000 per year or more drove 31,900 miles on average, while those that earned $25,000-$35,000 drove 19,300 miles on average.[120] Under current flat-rate premium schedules, the premiums paid by low income households are subsidizing the claims filed by higher income families. Thus PAYD insurance would be more equitable, on average, than the current means of setting insurance rates. Eliminating this subsidy would reduce the cost of insurance to low-income households making insurance more affordable for currently uninsured motorists. The extent to which national income statistics apply in Colorado warrants further investigation. In individual cases, as when the high cost of housing forces those in low-wage jobs to live far from their places of work, PAYD may increase the burden of transportation costs.

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[118] I. Parry, "Is Pay-As-You-Drive Insurance a Better Way to Reduce Gasoline than Gasoline Taxes?" Resources for the Future, RFF DP 05-15, 2005.

[119] Progressive Insurance. Texas Mileage Study: Relationship Between Annual Mileage and Insurance Losses.*;* . 2005. Available at: http://www.nctcog.org/trans/air/programs/payd/PhaseI.pdf.

[120] Energy Information Administration. Household Vehicles Energy Use: Data Tables.. Available at: www.eia.doe.gov/emeu/rtecs/nhts_survey/2001/tablefiles/page_a02.html

With regard to high driving rates in rural areas, it should be noted that insurance rates under PAYD could be determined by miles driven relative to other drivers in the same region, rather than relative to state averages. To the extent that claims are related to traffic density as well as VMT, claims per mile driven might be lower in rural areas. Such claims patterns should be reflected in insurance rates. Rural residents need not be disproportionately penalized relative to urban drivers under a PAYD program.

One common objection to PAYD insurance policies are privacy concerns about tracking an individual's vehicle travel. While installing a GPS tracking device in vehicles would be one method of tracking mileage there are other methods that are less intrusive by providing information on miles traveled without recording the routes traveled. The Progressive MyRate program uses a device to wirelessly transmit information on speed, time of day and the number of miles driven and does not record location. Other methods for verifying mileage could be periodic odometer readings or submitting vehicle maintenance records.

Strategy 6: Reduce Highway Speed Limits

Background

While all vehicles have different speeds at which they obtain optimal fuel efficiency, the average vehicle's optimal speed is between 45 and 55 mph. At speeds above 55 mph a vehicle's fuel efficiency begins to drop off rapidly. According to the U.S. Department of Energy, every 5 mph over 60 mph increases the fuel cost by $0.24 per mile.[121] Federal Highway Administration (FHWA) tests of 9 light-duty vehicles in 1997 found that fuel economy declined on average by 3.1% when speed increased from 55 mph to 60 mph and by 8.2% increasing from 65 to 70 mph.[122] A Government Accountability Office report found that reducing one's speed limit by 5 mph (when driving faster than 45 mph can increase fuel economy by 5-10% because the drag, or air resistance, that vehicles experience increases exponentially as they go faster.[123] Surveys have shown that, on highways, 50% of vehicles typically exceed the speed limit.[124] The maximum speed limit on Colorado's open highways is 65 mph and 75 mph on rural interstates.

Specific Proposal

This policy proposes lowering the speed limit on all state highways and interstates to 55 and 65 mph. This was the speed limit that the federal government set in 1974 in response to the oil crisis in 1973.

[121] FuelEconomy.gov. Driving More Efficiently. Available at: http://www.fueleconomy.gov/feg/driveHabits.shtml
[122] Oak Ridge National Laboratory. Transportation Energy Data Book, 2006.
[123] Government Accountability Office. "Energy Efficiency: Potential Fuel Savings Generated by a National Speed Limit Would Be Influenced by Many Other Factors." Available at: http://www.gao.gov/new.items/d09153r.pdf
[124] Transportation Research Board. "Design Speed, Operating Speed, and Posted Speed Practice." National Cooperative Highway Research Program Report 5042003

The 55 mph speed limit was in place until 1987 when states were given the right to set their own speed limits. In addition to lowering current speed limits, this policy also proposes more stringently enforcing the existing highway speed limits. Doing so could both increase highway safety and provide fuel savings.

Given demands on the time of police and highway patrol, additional enforcement would best be approached through other means, including increased use of radar, lasers and speed cameras, speed signs and education.

Energy and CO_2 Savings

To estimate energy savings from reducing the speed limit, it is assumed that: 1) the average reduction in speed limit would be 10 mpg; and 2) that fuel economy would be 10% higher than it would be at the previous speed limit. In Colorado, 59% of driving is done on highways, which leads to an estimate of a 5% reduction in energy use if all vehicles slowed down to comply with the new speed limit. The estimated fuel savings are shown in Table 15 below.

By 2020, lowering the speed limit would provide 13.3% of the CO_2 emissions reductions necessary from a business as usual scenario to achieve the CAP's 20% reduction goal and 11.7% of President Obama's reduction goal. By 2040, the program would provide 5.2% of the CO_2 emissions reductions necessary to achieve the CAP's and President Obama's reduction goals. While the energy savings and CO_2 emissions reductions from this policy are limited, the benefits would be fully realized as soon as the policy is adopted.

Table 15 – Fuel Savings and CO_2 Emission Reductions from Speed Limit Reduction

Year	% Fuel Savings	Gasoline Savings (1000s of barrels)	Diesel Savings (1000s of barrels)	Reduced CO_2 Emissions (1000s of Tons)
2010	5.4%	2,862	817	1,404
2015	5.4%	3,003	902	1,491
2020	5.4%	3,140	996	1,582
2025	5.4%	3,107	1,100	1,613
2030	5.4%	3,046	1,214	1,639
2035	5.4%	3,052	1,341	1,695
2040	5.4%	3,080	1,480	1,764

Costs and Benefits

Lowering the speed limit would have only minimal costs such as replacing signage. The use of speed detection and management devices, together with an education program, could minimize the cost to the state for this effort, by limiting the role of public safety personnel in enforcement. It could be paid for in full or in part from additional revenue from speeding fines. Cumulative fuel cost savings from lowering the speed limit from 2010 through 2040 would be $8.3 billion (2008 dollars).

Strategy 7: Require Energy-Efficient Replacement Tires for Light-Duty Vehicles

Background

Poor tire rolling resistance reduces the overall fuel efficiency of light duty vehicles. Some tires perform significantly better than others in this regard, however. In particular, original equipment (OE) tires (those sold with a new vehicle) typically have lower rolling resistance than aftermarket replacement tires, because energy-efficient tires help manufacturers comply with CAFE standards. In 2003, the California Energy Commission issued a report on tire efficiency that found significant potential for oil savings through low rolling resistance tires.[125] The National Academy of Science issued a National Tire Efficiency Study that reached similar conclusions in 2006.[126] Goodyear recently released a new "Assurance FuelMax" tire that can improve fuel efficiency by up to 4%.

Specific Proposal

Starting in 2010, the state would require that replacement tires sold in Colorado have rolling resistance less than or equal to the average OE tire in the U.S. California instituted a similar law that went into effect in 2008.

Energy and CO_2 Savings

Each 10% reduction in tire rolling resistance leads to roughly a 1-2% increase in fuel economy.[127] While data on the efficiency of tires now on the road is limited, analysts estimate that the average OE tire has a rolling resistance on the order of 20% lower than that of the average replacement tire. Thus, if aftermarket tires were as efficient as the average tires on new vehicles, vehicle fuel economy would improve by 2-4%.

The average life of a tire is about 36,000 miles, or about one-quarter of lifetime vehicle miles. This means that at any given time, about three-fourths of all miles driven are driven on replacement tires. It

[125] California Energy Commission. "California State Fuel-Efficient Tire Report." 600-03-001F.2003.
[126] National Research Council. 2006. "Tires and Passenger Vehicle Fuel Economy." Transportation Research Board Special Report 286.
[127] California Energy Commission. "California State Fuel-Efficient Tire Report." 600-03-001F.2003.

is assumed that replacement OE tires raise fuel efficiency by 3% on 75% of vehicles, which will increase overall vehicle efficiency by 2.25% after about 3 years, when all replacement tires on the road will have been purchased subject to the new requirements. Table 16 shows the resulting gasoline and energy savings. The estimated gasoline savings would reach 1.3 million barrels per year by 2020.

Table 16 – Gasoline Savings and CO_2 Emission Reductions from High Efficiency Tires

Year	% Gasoline Savings	Gasoline Savings (1000s of barrels)	Reduced CO_2 Emissions (1000s of tons)
2010	0.8%	400	148
2015	2.3%	1,260	466
2020	2.3%	1,317	487
2025	2.3%	1,303	482
2030	2.3%	1,278	472
2035	2.3%	1,280	473
2040	2.3%	1,292	477

By 2020, requiring high efficiency replacement tires would provide 4.1% of the CO_2 emissions reductions necessary from a business as usual scenario to achieve the CAP's 20% reduction goal and 3.6% of President Obama's reduction goals. By 2040, requiring high efficient replacement tires would provide 1.4% of the CO_2 emissions reductions necessary from a business as usual scenario to achieve the CAP.

Costs and Benefits

The extra cost of a low-rolling-resistance tire is small, roughly $1 to $2 per tire.[128] If replacement tires were purchased for one-quarter of light-duty vehicles registered in Colorado each year beginning in 2010, the extra cost of low rolling resistance tires through 2040 would be $64 million (2008 value). Fuel savings from tires purchased over this period would be $2.24 billion, resulting in a net savings of $2.17 billion.

Heavy Duty Trucks – Strategies 8 and 9

Background

The majority of strategies laid out in the Blueprint address emissions from light-duty vehicles (LDV) which run almost entirely on gasoline. These policies have the potential to both improve the efficiency of the fleet and reduce vehicle miles traveled so that CO_2 emissions from gasoline use could be reduced

[128] National Research Council. 2006. "Tires and Passenger Vehicle Fuel Economy." Transportation Research Board Special Report 286.

by 72% from 2010 to 2040. Without the Blueprint's strategies gasoline emissions would be expected to increase by 39% above expected 2010 levels. Over the same period, emissions from diesel fuel are forecast to rise 29%, compared to the expected 81% increase without the Blueprint's strategies.

New electric power technologies are rapidly becoming available for trucks which should provide opportunities for significant reductions from this source sector. The Blueprint only attempts to make general estimates about the potential for truck emission reductions because the available technology options depend upon the particular operating characteristics of each vehicle. Technology options differ depending on whether vehicles are in long-haul vs. short-haul service, and whether the daily duty cycle provides opportunities for periodic recharging of batteries. The policy options available to the State also depend on whether vehicles are based in Colorado and registered with the state, or are registered in other states and primarily operate in interstate service. Data regarding truck operating characteristics are limited unfortunately.

Better data about truck duty cycles in the state will be needed to more accurately assess policies to reduce emissions from medium and heavy duty trucks. To date, requests to state agencies have not identified sources of such data.

While the state of Colorado can take some important initiatives to reduce emissions from existing diesel trucks, it is likely that aggressive action by the federal government will be necessary to significantly reduce diesel emissions from new vehicles. This is partly due to the interstate nature of most truck travel which makes it more difficult for individual states to effectively regulate the vehicles traveling through their state. The federal government also possesses the obligation to set fuel efficiency standards for all new medium and heavy trucks. Colorado is not federally pre-empted from setting fuel efficiency standards for medium or heavy duty trucks until federal standards for such vehicles are in effect.[129] However, Colorado's 1% share of the national new vehicle market is too small to likely have an impact on manufacturers' decisions to build more fuel efficient engines or electric power systems. To the extent that such engines and electric power systems are currently available, Colorado could establish regulatory requirements or economic incentive programs to promote the purchase and use of

[129] "When an average fuel economy standard prescribed under this chapter is in effect, a State or a political subdivision of a State may not adopt or enforce a law or regulation related to fuel economy standards or average fuel economy standards for automobiles covered by an average fuel economy standard under this chapter." 49 U.S.C. § 32919(a). This pre-emption provision was enacted as part of the 1975 Energy Policy Conservation Act which only authorized federal fuel efficiency standards for passenger vehicles and light duty trucks. The Act limits pre-emption only to "standards for automobiles."

When the Act was amended in 2007 to require fuel efficiency standards for medium and heavy duty trucks, this pre-emption provision was not amended to extend its reach to trucks. Therefore Congress has not explicitly federally pre-empted State regulation of fuel efficiency for new or existing trucks. Congressional failure to enact a statutory declaration of pre-emption does not foreclose arguments that the federal government has implicitly pre-empted State action by "occupying the field." However, it is likely that the courts would apply to trucks the explicit policy enacted for automobiles for the purpose of determining when the federal government effectively occupies the field. Mere enactment in 2007 of agency authority to issue regulations is not likely to be the event that triggers federal pre-emption. Regulatory action to adopt fuel standards under this statutory authority will be needed before courts are likely to recognize under traditional pre-emption case law that the federal government has occupied the field.

more fuel efficient trucks in the State. Improving the efficiency of freight movement in Colorado is critical as the movement of freight in Colorado is expected to increase 25% more than the nationwide increase in freight movements by 2035.[130] Tractor-trailers dominate heavy-duty fuel use and CO_2 emissions due to their high annual mileage and relatively low fuel economy. In addition, Colorado experiences a significant amount of through state traffic along its major interstate corridors, I-25, I-70 and I-76.

The current state of diesel use and regulation and how that is expected to change over the next twenty years is discussed in the section Transforming Trends, Truck Emission Trends (p. 10). Here the Blueprint assesses some of the upcoming technologies that are available or may be able soon to reduce diesel emissions. When proposed policies require an estimate of the actual number of heavy-duty, long-distance trucks on the road to estimate savings, national averages have been used in conjunction with data available on the number of heavy trucks in Colorado from the Department of Revenue.[131]

Wal-Mart and Heavy Truck Efficiency

Between 2005 and 2008, Wal-Mart reports that the fuel efficiency of its heavy-duty fleet increased by over 25%. Their next goal is to increase fuel efficiency by 100% from its 2005 baseline by 2015. These dramatic improvements in fuel efficiency for Wal-Mart's heavy duty fleet show that significant improvements in fuel economy are possible if strong action is taken.

Wal-Mart has achieved these increases with a variety of strategies focused on improving the efficiency of existing trucks. They have installed aerodynamic fairings on their truck trailers to reduce drag, replaced regular tires with single wide tires that reduce the weight and rolling resistance , installed Auxiliary Power Units (APUs) on the rigs to reduce the need for engine idling, and use tire inflation devices that automatically stay inflated to optimum levels.

These strategies mirror those recommended by EPA's SmartWay program and have the potential to increase fuel efficiency by 16-24%.[132,133] In addition to these strategies, Wal-Mart is also using lighter and more compact packaging to reduce vehicle load weight and the number of trips needed to transport the same volume of freight. They are also using software designed to identify the most efficient routes for drivers to follow.

[130] Ibid.
[131] The Department of Revenue provides data on the number of trucks over 16,000 pounds GVW. Using national averages of the breakdown of the number of trucks over 16,000 pounds that were over 26,000 pounds estimates were made about how many of Colorado's heavy trucks would be classified as heavy duty (26,000+ pounds). Colorado Department of Revenue. 2008 Annual Report. Available at: http://www.colorado.gov/cs/Satellite?c=Page&cid=1213867975035&pagename=Revenue-Main%FXRMLayout
[132] Rocky Mountain Institute "Profitable GHG Reduction Through Fuel Economy" Available at: http://www.rmi.org/images/PDFs/Transportation/T07-11_TruckingEffOpps.pdf
[133] EPA. Smartway Transport Savings Calculator. Available at: http://www.epa.gov/smartway/transport/calculators/smartwaycalculator.xls

All of the efficiency enhancing equipment that Wal-Mart has installed on its trucks has relatively short payback periods between 9 and 28 months. This should make them attractive to fleet operators and truck drivers who can realize significant savings over the lifetime of trailers and tractors.

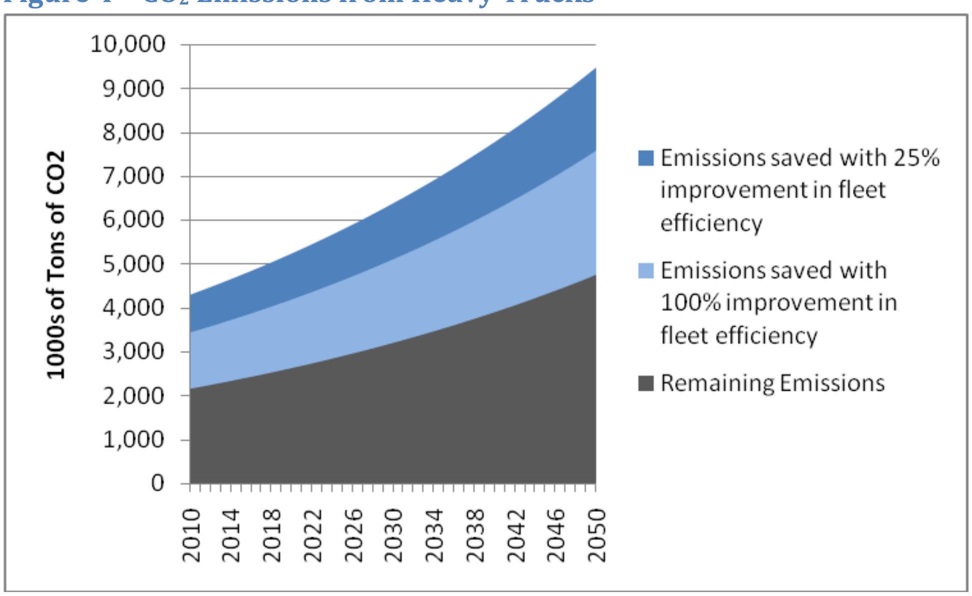
Finally, Wal-Mart is testing hybrid-diesel engines, trucks that run on LNG (Liquefied Natural Gas) and engines that can run on used cooking grease from their stores.[134] Their expectation is that new, advanced technologies will allow them to continue improving fleet efficiency.

Table 17 – SmartWay Truck Efficiency Improvements

Efficiency Improvement	% Fuel Savings	Cost	Payback Period
Aerodynamic Fairings	5%	$2,400	9 months
Single-Wide Tires	4%	$5,600	26 months
APU	9%	$8,500	19 months
Self-inflating tires	0.6%	$900	28 months

If Wal-Mart reaches their 100% improvement goal they expect to save $494 million annually and 26 billion pounds of CO_2 between 2008 and 2015. The graph below shows the savings that could be achieved if all the heavy duty trucks in Colorado achieved the same fuel efficiency gains as Wal-Mart's fleet. By 2050, emissions would be reduced by 50% compared to expected emissions, but those improvements would not be sufficient to achieve net reductions in truck emissions compared to the 2005 baseline. Figure 4 below shows the scale of the reductions achieved by the 25% and 100% improvements.

Figure 4 – CO_2 Emissions from Heavy Trucks



[134] Wal-Mart. Fuel Leadership Fact Sheet. Available at: http://walmartstores.com/Sustainability/7674.aspx

Potential Reductions from Electrification of Truck Fleet

Diesel-Hybrids

While the technologies to electrify medium and heavy duty trucks are only beginning to emerge there is potential for these technologies to replace traditional diesel trucks within the next decade. Currently there are commercially available diesel-hybrid, plug-in diesel electric and full electric trucks. Production of these technologies is currently small which reflects both the recent development of these power systems and the limited demand for these technologies.

Diesel-hybrid vehicles have been developed in mostly the medium duty range for work as utility vehicle, delivery trucks and refuse pickup. These types of vehicles maximize the benefits of hybrid technology by operating in stop and go traffic and utilizing electrical equipment that can be powered by batteries rather than the diesel engine. Estimates are that hybrid-diesel technology has the potential to improve fuel efficiency anywhere from 30-60%. These types of vehicles have been developed by companies such as ArvinMeritor,[135] NaviStar,[136] EVI,[137] Peterbilt,[138] ISE,[139] Kenworth[140] and Eaton.[141]

Heavy-duty diesel hybrids are being tested and developed currently by Eaton, Peterbilt and ArvinMeritor for use by Wal-Mart's fleet. The Eaton/Peterbilt hybrid assist is estimated by the manufacturer to increase efficiency by up to 7%[142] while the ArvinMeritor's hybrid-diesel engine may increase fuel efficiency by 25%[143] according to the manufacturer.

Plug-in Diesel-Hybrids

Eaton has developed and is testing a plug-in hybrid electric utility truck. It is expected to improve fuel economy up to 70%[144] compared to conventionally fueled utility trucks and have an all electric range of 20 miles between charges.[145] Dueco has also developed a series of plug-in diesel hybrids for heavy duty trucks. Currently they offer several trucks with hydraulic powered equipment which are powered by the battery without needing to run the diesel engine.[146]

All Electric

The Port of Los Angeles, in partnership with the Balqon Corporation, has produced an all-electric heavy-duty truck that is being used for short haul applications between the Port and local freight distribution

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[135] ArvinMeritor: http://www.meritorhvs.com/Product_CVS.aspx?product_id=70&top_nav_str=hvs.
[136] Navistar. DuraStar Hybrid.
http://www.internationaltrucks.com/portal/site/ITrucks/menuitem.a1d4a3932b46e05831f8e968121010a0/?vgnextoid=945d07aafbfe6110VgnVCM10000085d0eb0aRCRD&vgnextnoice=1
[137] http://www.evi-usa.com/
[138] Hybrid Models.   http://www.peterbilt.com/index.aspx
[139] http://www.isecorp.com/hybrid-technology/overview/
[140] http://www.kenworth.com/flashpopup.asp?name=KWHybrids&w=680&h=480
[141] www.eaton.com/EatonCom/OurCompany/NewsandEvents/NewsList/NewsArticle/CT_296949
[142] Wal-Mart. Fuel Leadership Fact Sheet. Available at: http://walmartstores.com/Sustainability/7674.aspx
[143] Ibid.
[144] www.eaton.com/EatonCom/OurCompany/NewsandEvents/NewsList/NewsArticle/CT_296949
[145] http://mydocs.epri.com/docs/public/000000000001016496.pdf
[146] http://www.dueco.com/hybrid_plugin.html

centers. On one charge, the truck can travel up to 30 miles when fully loaded, and up to 60 miles when empty. It requires one hour of charging to restore 60% of its battery capacity and 3-4 hours for a full recharge. If used in Colorado, this vehicle is expected to reduce CO_2 emissions by 14% compared to a diesel vehicle.[147]

Because of insufficient data regarding the makeup of Colorado's medium and heavy duty truck fleets and their operating characteristics, it is difficult to estimate the number of current trucks that could be replaced with each of these technology options. Thus, no reliable estimate of the CO_2 impact of converting Colorado's trucks to the above technologies can be made.   For certain specific truck and bus fleets, information is available to allow estimates.   For most truck uses, however, national level data is applied to Colorado to provide a rough estimate of potential savings.

Utility Vehicles

In 2002 there were approximately 3,800 medium duty utility trucks in Colorado that traveled an average of 10,950 miles annually,[148] or less than 50 miles per day. With an average fuel efficiency of approximately 8.5 mpg, each consumed approximately 1,288 gallons of fuel. Switching these vehicles over to hybrid or plug-in hybrid technology would achieve significant fuel savings. The hybrid utility vehicles on the market are estimated to improve fuel efficiency 50%. This would give the vehicles a fuel efficiency of 12.75 mpg which would use an average of 859 gallons of diesel per year, an annual savings of 429 gallons per vehicle. If over time, the entire fleet was converted to this technology there would be an annual fuel savings of approximately 1.6 million gallons of diesel fuel. This translates into almost 39 thousand barrels of diesel savings and 18,000 tons of avoided CO_2 emissions annually.

If the greater savings of plug-in hybrid utility vehicles were achieved, each vehicle would use 552 less gallons of fuel annually and the entire fleet would save approximately 2.1 million gallons (50 thousand barrels) and 23 thousand tons avoided of CO_2 emissions annually.

Other potential applications for medium duty hybrid electric power sources would be waste management and delivery vehicles.

If heavy duty trucks in the state transitioned to diesel hybrid technology there also could be significant savings in fuel use. There are approximately 18,000 heavy duty trucks registered in Colorado and these are mixed between local and long distance trucks. These vehicles are estimated to travel approximately 629 million miles annually and therefore use approximately 112 million gallons of diesel fuel (which is about 16% of diesel use in the state). If these trucks switched to diesel hybrid engines that increased fuel efficiency from 7-25%, savings could range from 7.4 to 22.9 million gallons. This would translate to 175 to 545 thousand barrels and from 82 to 254 thousand tons of avoided CO_2 annually.

[147] www.portoflosangeles.org/DOC/Electric_Truck_Fact_Sheet.pdf. This Fact Sheet rates the trucks' efficiency at 2 kwh/mile . This was converted to pounds of CO2 per mile (based on Colorado's electricity mix and compared to an average heavy duty truck to arrive at the all electric truck savings.

[148] Vehicle Inventory and Use Survey. 2002.

It is difficult to say how many vehicles could be replaced by the shorter range all electric medium and heavy duty vehicles as there is not sufficient data on the duty cycles of truck fleets to determine how many vehicles could be operated exclusively on electric power.

Transit Buses

The Denver Regional Transportation District (RTD) buses could be converted to hybrid-diesel technology. RTD owns a fleet of 1,039 buses, some of which it operates and other are leased to private carriers to operate.[149]

The average bus consumes 9,662 gallons of diesel fuel annually. RTD has been testing hybrid diesel buses and they have shown a 30% savings in fuel compared to regular buses.[150] With this 30% reduction, each bus would save 2,898 gallons of fuel annually which translates to 32 tons of CO_2. If all of RTD's buses were converted to hybrid-diesels it would save an estimated 34,000 tons of avoided CO_2 annually.

Strategy 8: Efficiency Improvement Requirements for Heavy Duty Trucks

The SmartWay efficiency improvements provide an opportunity to improve fuel efficiency from heavy duty trucks significantly more than is expected through the replacement of current diesel vehicles with newer diesel vehicles. Other strategies outside of the SmartWay program were considered and included based on having payback periods of less than 5 years.[151]

Specific Proposal

The state could require all new and existing trailers and tractors that operate in Colorado to install SmartWay approved efficiency improvements such as efficient and auto inflating tires for all heavy duty trucks and aerodynamic retrofits and APUs (for long distance trucks). In addition other technologies such as variable valve actuation, advanced exhaust gas circulation and advanced aerodynamic packages could be required.

A statewide requirement is necessary because despite the short payback period for these measures there are disincentives for current owners and operators to install them. Trucks are likely to have several owners over their lifetime, limiting the benefits that any one owner will realize from adoption of efficiency measures. In addition, tractors and trailers are often owned by different parties, creating a split incentive that discourages either party from investing in efficiency improvements from which they

[149] http://www.rtd-denver.com/factsAndFigures.shtml
[150] http://www.rtd-denver.com/PDF_Files/Fact_Sheets/Clean_Air_Facts.pdf
[151] Cooper et al. 2009. "Reducing Heavy-Duty Vehicle Fuel Consumption and Greenhouse Gas Emissions". Air and Waste Management Association.

will not receive the full benefits. It is assumed that there would be five year phase in period to give truck and fleet owners sufficient time to retrofit their fleets.

While the SmartWay and other efficiency improvements have short payback periods, to ease the upfront financial burden of installing these technologies the state could offer a low-interest loan program to amortize the costs for truck and fleet owners. A bank, under a loan guarantee from a state agency, could provide the loans at or below the best market interest rate. Loans would be secured by leins on title, and the loan repayments could be recovered at the time of annual vehicle registration if the owner is in default. This scheme will ensure that even small fleet operators would have access to inexpensive financing, banks will provide the credit and administer the loans, and the State's cost would be limited to collecting payments in cases of default or reimbursing banks for loans gone bad.

The U.S. EPA has demonstrated that a low-interest loan program would allow truckers purchasing equipment in the SmartWay package to realize fuel cost savings that would exceed their monthly loan payments.[152] HB 1331 (2009) also established a tax credit for the purchase of APUs.

An effort should be made to implement parallel policies in neighboring states. As discussed above, California has already established requirements for efficiency improvements on trucks primarily operated in the State, and Oregon is considering a similar set of measures as part of HB 2186. If most western states adopt similar programs, there will be no scofflaw-havens.

Energy and CO_2 Savings

Table 18 – Diesel Savings and CO_2 Emission Reductions from Efficiency Requirements for Heavy Duty Trucks

Year	% Diesel Savings	Diesel Savings (1000s of barrels)	Reduced CO_2 Emissions (1000s of tons)
2010	1.8%	274	116
2015	9.3%	1,558	659
2020	10.6%	1,971	834
2025	12.1%	2,491	1,053
2030	12.1%	2,750	1,163
2035	12.1%	3,036	1,284
2040	12.1%	3,352	1,418

Table 18 shows the potential energy savings from heavy truck efficiency requirements. The installation of all the efficiency technologies would result in the fuel efficiency of long-distance heavy duty trucks improving by 28%[153]and local heavy duty trucks' efficiency could improve by up to 6.8%. Heavy duty

[152] EPA. "SmartWay Transport." Benefits: Innovative Financing. Available at: http://www.epa.gov/smartway/transport/what-smartway/financing-benefits.htm

[153] Cooper et al. 2009. "Reducing Heavy-Duty Vehicle Fuel Consumption and Greenhouse Gas Emissions." Air and Waste Management Association.

trucks make up approximately two-thirds of the state's diesel use. By 2020, requiring trucks to improve their efficiency would provide 7.0% of the CO_2 emissions reductions necessary from a business as usual scenario to achieve the CAP's 20% reduction goal and 6.2% of President Obama's reduction goal. By 2040, the program would provide 4.2% of the CO_2 emissions reductions necessary to achieve the CAP's goal and 4.1% of the reductions necessary for President Obama's goal.

Costs and Benefits

The fuel savings expected from 2010-2040 from requiring efficiency improving retrofits would be $4.3 billion (2008 dollars), while the total cost of installing these technologies is estimated at $1.1 billion, giving the program a net benefit of $3.2 billion from 2010 to 2040.

Strategy 9: Tax Credit and/or Low Interest Loan Program for Heavy Duty Diesel-Electric Hybrids and Longer, Heavier Trailers

Specific Proposal

To accelerate the benefits achievable by conversion of truck fleets to electric vehicle technology, Colorado could require that after 2020 all heavy duty trucks operating in the state with daily ranges of less than 100 miles achieve a minimum of 25% fuel efficiency improvement.[154] This level is achievable using a diesel-electric hybrid engine, and likely will be achieved by other technologies before 2020.

In addition, Colorado should consider allowing heavier and longer heavy duty trucks to operate in the state if safety concerns were properly addressed. Allowing trucks to transport more freight per trip has the potential to reduce the fuel consumption of heavy-duty, long haul trucks between 16% and 20%.[155] While there would be no requirement for fleet owners to use larger capacity trailers, it is assumed that the long haul fleets that would benefit the most from fewer trips would readily adopt the new trailers.

Colorado could support the fleet owners in making this conversion by providing a tax credit and/or low interest loan program for the purchase of heavy and medium-duty diesel hybrids as well as longer trailers. The hybrid technologies are still in development and due to high initial incremental purchase costs their adoption could be incentivized to facilitate entry into the marketplace. There is currently a federal tax credit for these vehicles that is set to expire at the end of 2009. It also includes vehicles with weights as low as 8,501 pounds. The state tax credit should focus on heavier (above 14,000 pounds)

[154] See Footnote 129 for a discussion of pre-emption that would allow Colorado to set standards for trucks.
[155] Cooper et al. 2009. "Reducing Heavy-Duty Vehicle Fuel Consumption and Greenhouse Gas Emissions." Air and Waste Management Association.

vehicles and especially those over 26,000 pounds that are responsible for the majority of diesel consumption. Like the federal tax credit it would offer the highest credits for the heaviest trucks and those that provided the greatest improvements in fuel efficiency. The low interest loan program could be structured similar to the program discussed above for SmartWay improvements.

The efficiency requirement would go into effect by 2020, at which point all heavy duty trucks would comply with the regulation. This would give truck and fleet owners eleven years to bring their fleets into compliance. If necessary, a hardship waiver could be included in the program to allow extended use of newer non-compliant vehicles who could demonstrate that the costs of compliance, after the tax credit and low-interest loan, would likely cause bankruptcy. Because some trucks are not expected to be in compliance by 2020, the maximum benefits of the strategy are only realized in 2025.

Energy and CO_2 Savings

Table 19 – Diesel Savings and CO_2 Emission Reductions from Adoption of Diesel-Hybrid Heavy Duty Trucks and Longer, Heavier Trailers

Year	% Diesel Savings	Diesel Savings (1000s of barrels)	Reduced CO_2 Emissions (1000s of tons)
2010	0.46%	69	29
2015	2.73%	459	194
2020	5.11%	949	401
2025	7.92%	1,625	687
2030	7.92%	1,794	759
2035	7.92%	1,980	838
2040	7.92%	2,186	925

By 2020, requiring heavy trucks to be 25% more efficient and allowing larger capacity trailers would provide 3.4% of the CO_2 emissions reductions necessary from a business as usual scenario to achieve the CAP's 20% reduction goal and 3.0% of President Obama's reduction goal. By 2040, the program would provide 2.7% of the CO_2 emissions reductions necessary to achieve the both CAP's and President Obama's reduction goals.

Costs and Benefits

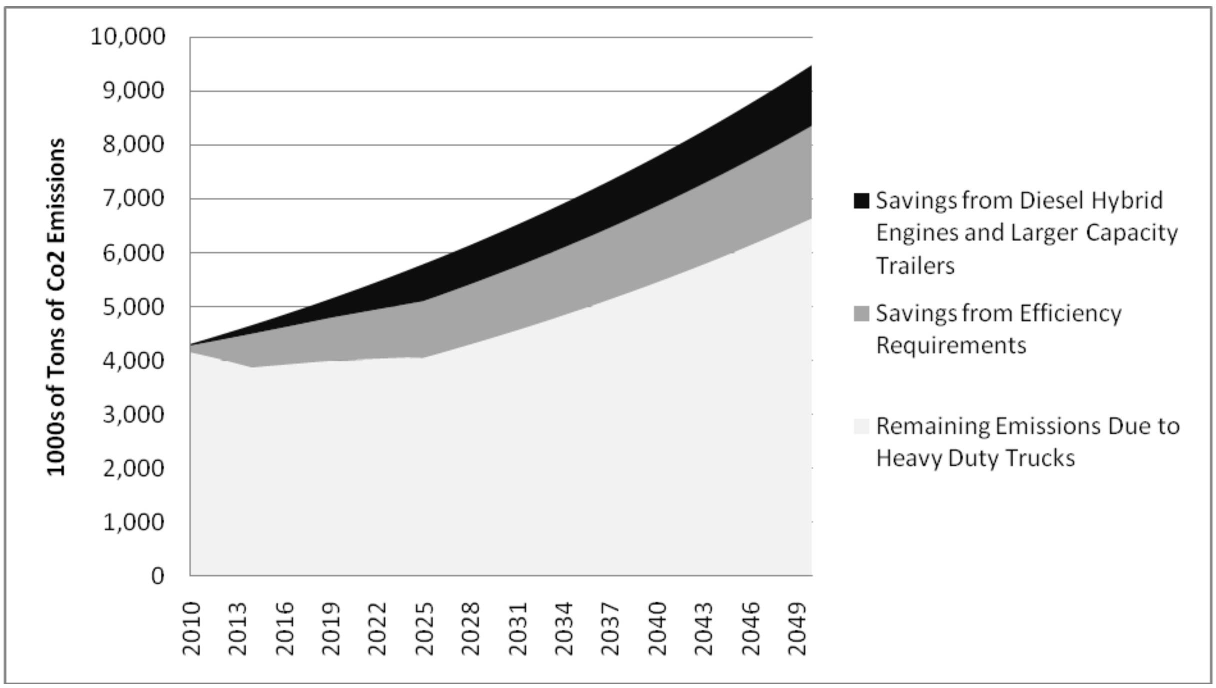
The value of fuel savings between 2010 and 2040 from using longer trucks and requiring more fuel efficient heavy duty local trucks would total $2.3 billion (2008 dollars) and with an incremental cost of an average heavy duty diesel hybrid engine of $45,000 and the incremental cost for longer trailers of $17,500 the purchase of these items would cost $781 million, resulting in a net benefit of $1.5 billion (in 2008 dollars). If other more cost effective technologies become available, the net economic benefits would be even greater.

Costs and Benefits for Individual Trucks

An average local heavy duty truck travels approximately 23,500 miles annually and uses approximately 4,200 gallons of diesel each year. A diesel hybrid engine that improves fuel economy by 25% would save approximately 840 gallons, which would result in savings of $3,200 annually. With an incremental cost of $45,000, it would take approximately 14 years to payback the additional cost of this technology.

For the heavy-duty long haul truck owner who installed the efficiency measures discussed above they would see approximately a 28% improvement in fuel efficiency. This would result in annual fuel savings of 3,450 gallons of diesel and $12,400 in fuel costs. The estimated total cost of all the efficiency measures is $26,200 which could be recovered in just over two years through fuel savings.

Figure 5 – CO_2 Reductions from Heavy Duty Trucks



Strategy 10: Adopting Clean Car Standards

Background

In May 2009, the Obama administration announced a comprehensive agreement with California and the automakers to revise the proposed federal fuel efficiency standards on cars and light trucks to achieve a uniform national standard aligned with California's standards from 2012 to 2016, to "coordinate" with California in developing new standards beyond 2016, and to quickly complete the national rulemaking to reconsider the Bush denial of California's request for a waiver of federal pre-emption of the California standards. As their part of the deal, the automakers agreed to dismiss their suits challenging the California standards. This agreement will finally begin a new era of declining gasoline use for personal transportation in the U.S. beginning in the next decade.

California has published its intention to adopt a second phase of the Clean Car standards to extend until 2020 at which point the average new vehicle would achieve a fuel efficiency of 40 mpg.[156] It is assumed that the standards will be further tightened through 2030, after which there will be no further improvements in fuel economy.

The California Air Resources Board (CARB) estimated the increase in the purchase cost of vehicles as the current standards are phased in over the period 2009-2016. The incremental vehicle cost is less than $100 in the early years (2009-2010), but then rises to about $277-367 by 2012 and about $1,000 by 2016.[157] Increased vehicle purchase cost is extrapolated to $3,000 by 2030, the last year a tightening of the standard is assumed. Using these incremental costs to estimate the average cost of light duty vehicles and using vehicle sales projections for Colorado, the Clean Car Standards will lead to a 6.3% increase in vehicle costs on average in the period 2016-2030.

The resulting savings in fuel costs over the lifetime of these vehicles (on average 15 years) would equal about $6.9 billion on a net present value basis, based on the average price of a gallon of gasoline in Colorado in 2008 ($3.21). This results in a net cost benefit to vehicle owners of $3.18 billion (2008 dollars) over the life of the vehicles purchased in 2010-2030, or an even greater benefit if fuel prices return to 2008 peak levels. Here the state gasoline tax (22 cents per gallon) is not included in the savings calculation because the State loses this revenue while the vehicle owners save from not paying the gasoline tax. As a result there is no net savings to the state economy associated with gas tax savings. Additional net benefits accrue to the Colorado economy from more efficient new vehicles purchased after 2030.

Specific Proposal

Adopt the CARB standards. The Air Quality Control Commission could adopt the standards by rule to take effect in 2010 without legislative action. While only 2 years of vehicle sales would be governed by the more aggressive Clean Car Standards, these vehicles would remain on the road for 10-15 years and their greater fuel efficiency would add up to significant fuel savings and emission reductions over this time.

[156] California Air Resources Board. "Comparison of Greenhouse Gas Reductions under CAFE Standards and ARB Regulations Adopted Pursuant to AB 1493." Available at: http://www.arb.ca.gov/cc/ccms/reports/ab1493_v_cafe_study.pdf

[157] Ibid.

Table 20 – Comparison of Federal and California Clean Car Standards for 2010-2011

Year	Federal Fuel Efficiency for New Light Duty Vehicles	California Fuel Efficiency for New Light Duty Vehicles
2010	24.5	26.3
2011	25.4	29.2

Energy and CO_2 Savings

In Colorado, these two years of new vehicle sales would result in approximately 320,000 more efficient vehicles on the road. Over the lifetime of these vehicles (estimated at 15 years), the savings would be approximately 5,385 thousand barrels of gasoline and 1.99 MMT of CO_2 emissions. After 2011, annual savings from these 320,000 vehicles would be approximately 359 thousand barrels of gasoline and 132 thousand tons of CO_2 emissions. This is approximately 1.1% of the emission reduction necessary in 2020 to achieve the CAP reduction goals.

Table 21 – Fuel and CO_2 Savings from Clean Car Standards 2009-2011

Year	% Gasoline Savings	Gasoline Savings (1000s of barrels)	Reduced CO2 Emissions (1000s of tons)
2010	0.3%	116	43
2015	0.7%	359	132
2020	0.7%	359	132
2025	0.7%	359	132

Envisioning the Final Transition to a Sustainable Transportation System

The CO_2 emission reductions expected by 2040 from implementation of the Strategies described in this Blueprint may seem small from the perspective of 2005 because they would not achieve the 20% reduction target set for 2020. But they would achieve a massive reduction of nearly half the emissions that would otherwise be expected in 2040 if no action were taken.

More importantly, these policies would establish a new trend line by promoting the introduction and widespread use of battery-powered light duty vehicles and trucks that operate most or all of the time on electric power from the grid. To approach the 5.4 MMT target in 2050, virtually all light and medium duty vehicles would need to be powered from the grid for 70% or more of the miles driven. This outcome could be achieved if federal standards required that all new vehicles beginning about 2031 achieve a range of at least 40 miles per day using batteries charged from the grid. The 20-30% of miles not powered from the grid will need to be powered with bio-fuels derived from native, non-food crops and algae. Together, these strategies can reduce gasoline emissions to 2.8 MMT, saving another 774 million barrels of gasoline and $11.8 billion (constant 2008 dollars) in net fuel cost savings.[158] These gasoline savings could generate another 14,800 jobs in the state in 2050 in addition to the jobs created from the savings achieved by implementation of the Strategies in the Blueprint.

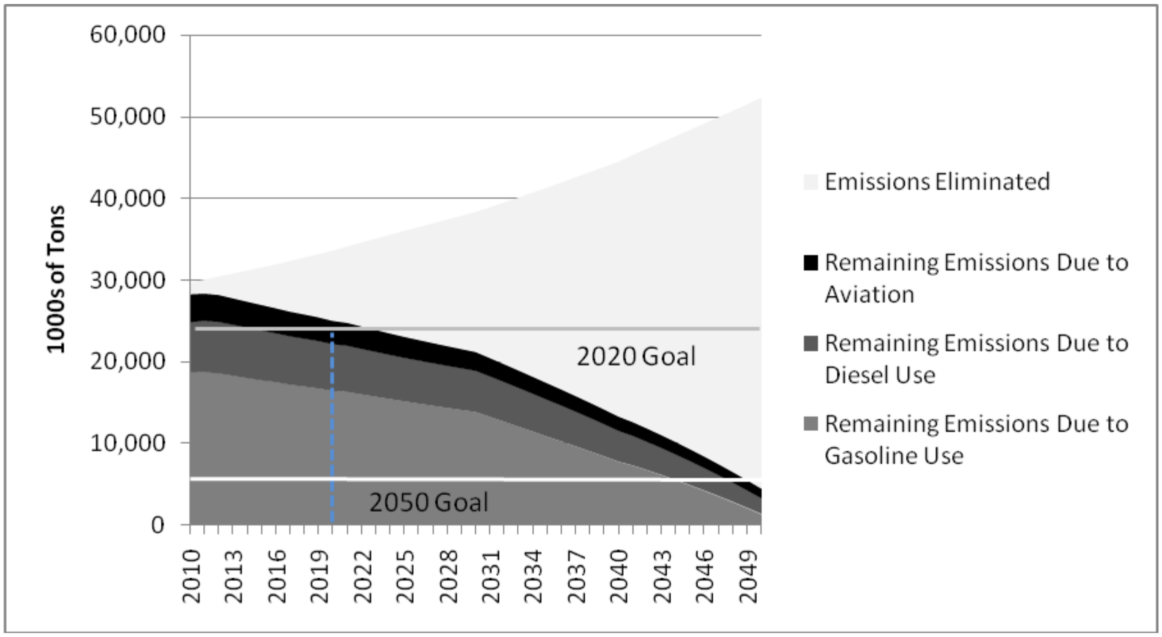
In addition, truck emissions can be reduced by 1) shifting freight off of highways onto fixed guideway systems, 2) electrifying all trucks in short-haul and service applications, and 3) using bio-diesel for long-haul transport. Significantly more of the freight carried in interstate commerce can be transported by electrified rail and magnetic levitation technology already in use in Japan and Europe. These technologies require as much as 90% less energy than diesel trucks to move the same load, and could reduce the safety hazards of heavy duty trucks in traffic with personal vehicles. Hybrid and full time electric trucks can displace most of the liquid fuel used in applications where daily travel is less than 100 miles. Emissions from long-haul applications will require the development of bio-fuel substitutes for petroleum fuels. Together, these policies could reduce diesel truck emissions to about 2.7 MMT, saving 268 million barrels of diesel fuel and $5.4 billion (constant 2008 dollars) in diesel savings. These diesel savings could generate 5,800 additional jobs in the state in 2050.

This conversion of both passenger and freight transport to electricity makes possible significant further reductions in CO_2 emitted from transportation as the grid itself is transformed by displacing coal generation with non-polluting power generated from the sun, wind, tides and heat stored in the earth. Colorado has already initiated policies designed to reduce coal for electric power generation. If Colorado's target for reducing CO_2 emissions by 80% from electric power generation is met, then the target will be met for the miles of travel powered by electricity as well.

[158] The total gasoline savings from 2030-2050 would total $18.1 billion, while the incremental cost of plug-in hybrid vehicles over this period would total $6.3 billion. Each plug-in hybrid is estimated to cost an additional $8,000 (in 2008 dollars).

In aviation, if 25% of projected passenger trips can be served by high speed rail, and high energy density bio-fuels can be blended to displace 70% of aviation fuel while maintaining the energy density needed for aircraft engines, then aviation emissions could be reduced to 1.2 MMT by 2050.

Figure 6 – Potential Reduction in Emissions in Envisioning Scenario



Transforming the technology that provides mobility, when combined with urban designs that provide for the housing, employment and other needs of a growing population in a manner that minimizes the need for personal vehicle travel, can together reduce CO2 emissions to levels that come close to the 80% reduction needed to stabilize the climate by 2050. The billions of dollars saved in avoided fuel costs, the avoided infrastructure costs required to support sprawl development, and the increased income from employment that will be generated in the State by fuel savings will fund the investment in new transit and new vehicle technologies needed to achieve the 80% target. The jobs shipped abroad with the massive outflow of wealth to pay for fuel will be at an end.

By reducing liquid fossil fuels to these low levels, America will no longer depend on oil imported from politically hostile regions of the world to sustain its economy.

Conclusions

The task ahead is challenging, but not beyond the reach of a great people with a history of great achievements. To preserve a planet for our grandchildren and great grandchildren that will continue to provide not just the water and food that sustains us, but also offer the beauty and joys it provides to Earth's current residents, this generation must now turn to the task of transforming the way we use energy to provide mobility.

The strategies analyzed in the Blueprint are not untried or untested. As discussed in the outline of actions being taken by other western states, all of the strategies analyzed here have been implemented in other states, and are proving effective. Indeed, their experience provides the basis for concluding that these strategies are available and will produce results.

All these strategies, taken together, will not achieve the 20% reduction target by 2020. Indeed, the strategies quantified in the Blueprint are not sufficient to achieve the 20% reduction target in 2050. But if 2020 is seen as a milestone toward the 80% reduction needed to stabilize the climate, the reductions achievable by 2020 represent an essential and necessary step toward the ultimate target. Equally important, the major Strategies analyzed in the Blueprint each establish the initial stages of the transformations needed to achieve the 2050 targets by promoting the technological breakthroughs that can achieve the electrification of most VMT, and the policy foundation for designing human settlements around transportation systems that can provide non-polluting, cost-effective mobility options for a growing population. All the measures identified in the report must be implemented to make progress toward the climate plan targets for 2020, and establish the foundation for the ultimate transition to a sustainable transportation system by 2050.

Continuing with the strategies in the Blueprint to reduce VMT, the 80% reduction target can likely be achieved by 2050. The final transition will require regulatory action to achieve the electrification of all light and medium duty vehicles after 2030, powering 70% of VMT with power from the grid, the generation of 80% of the electric power used in the transportation sector by renewable sources, and the powering of all the remaining miles driven on a liquid fuel with advanced bio-fuels derived from non-food vegetation.

For all these reasons, implementing every strategy in the Blueprint to reduce CO_2 emissions makes good public policy. These strategies will:

- make significant progress toward achieving the CO_2 reductions needed to stabilize the climate;
- achieve significant net public and private cost savings from reduced fuel use;
- reduce the cost of transportation as a share of the household budget for every Colorado family;
- free up resources once spent to purchase petroleum products from imported oil for investment in Colorado to generate alternative job-creating economic activity in Colorado; and
- reduce in the near term, and possibly eliminate by 2050, the economic threat from the current dependence of Colorado’s economy on fuel imported from outside North America.

Appendix 1: Methodology and Assumptions

Fuel Efficiency

The baseline fuel efficiency against which the strategies are measured is the fuel economy of the fleet if the Clean Car Standards are extended until 2030. This standard was used to avoid double counting of benefits coming from other strategies that would overlap with increased fuel efficiency. For example, the benefits from reduced VMT discussed in Strategies 2, 3, 4 and 5 would be reduced if the fuel efficiency of the fleet was higher so that each VMT would result in fewer emissions. The 2030 Clean Car Standards were used as the baseline for all the strategies impacted by the fuel efficiency of the light duty fleet.

The Clean Car Standards are assumed to raise the average fuel efficiency of new light duty vehicles to 44 mpg by 2020 and 54.5 mpg by 2030. After 2030, fuel efficiency standards are assumed to stay flat. The overall fleet fuel efficiency is expected to reach 33.4 mpg in 2030 and 40 mpg in 2040. The fuel economy of the fleet lags that of new vehicles due to the time required to turnover the vehicle stock.

To determine the effects of new vehicle efficiency standards on future fleet wide efficiency, Argonne National Laboratory's VISION Model was used.[159]

VMT

Data about the state's VMT was taken from the State Department of Transportation Fact Books and the FHWA's historic records of state level VMT. Based on the lack of any policies to shift the VMT growth rate outside the DRCOG region, and the more rapid rate of VMT growth outside the DRCOG region, it is assumed that baseline statewide VMT will continue to grow 47% greater than the rate of population growth which was the average from 1980-2007. To convert daily (weekday) VMT (the measure used by MPOs to report VMT) to annual VMT the following formula used by DRCOG was used. The weekday VMT is multiplied by .93 and then multiplied by 365 to allow for the lower VMT observed on weekends.

Fuels

Assumption: gasoline consumption will change as a function of population growth, VMT per person and the fuel efficiency of the vehicle fleet. See Fuel Efficiency.

Assumption: diesel consumption will increase at approximately 2.0% annually in the baseline scenario. This assumption is based on diesel consumption projections from EIA's 2009 Annual Energy Outlook for the Mountain region[160] (CO, etc…) and from the Western Regional Air Partnership's inventory of on road

[159] The Model is available at: http://www.transportation.anl.gov/modeling_simulation/VISION/index.html
[160] Energy Information Administration. "Annual Energy Outlook 2009." Supplemental Tables 46 and 47. Available at: http://www.eia.doe.gov/oiaf/aeo/supplement/stimulus/regionalarra.html

emissions in the state which tracked VMT from diesel vehicles in Colorado.[161] The EIA showed diesel consumption growing at a rate of 1.9% annually, while the WRAP's estimate showed growth rates of 2.1% annually. The average of these two numbers, 2.0% was used for the Blueprint.

Population

Colorado's population is forecast to grow from 5.01 million in 2008 to 7.81 million in 2035 by the state's Demographer's office.[162] After 2035, it is assumed that population would continue to grow along the same trend line to reach 8.33 million by 2040, and 9.4 million by 2050.

Future Vehicles

In 2008, Colorado had 3.8 million registered light duty vehicles and 145,700 new light duty vehicles were sold. To project future numbers of registered and new vehicles, the historical sale of new light duty vehicles in Colorado was examined and compared with new light duty sales figures from the EIA from the Mountain region. Colorado has made up historically an average of 18.5% of new light duty vehicle sales in the region so this percentage was used to project forward using the EIA's estimates of future vehicle sales in the region.

Future total vehicle registrations for Colorado were obtained in a similar way. Current State registrations were compared with national registrations to determine Colorado's share of national vehicle registrations. The EIA does not provide vehicle registration by region. Historically, Colorado has made up 1.6% of the nation's light duty fleet. This percentage was projected forward using future national registration estimates from the EIA.

Emissions

3 different fuels: gasoline, diesel and aviation fuel contribute CO_2 emissions from the transportation sector. Gasoline and diesel emissions were estimated as described under Fuels and Fuel Efficiency. Emissions estimates from the aviation sector from 1990 to 2020 were taken from the state's Greenhouse Gas Inventory and projected forward along the current trend line.

Energy Conversions

1 gallon of gasoline contains 19.4 pounds of CO_2
1 gallon of diesel contains 22.2 pounds of CO_2
42 gallons in a barrel
2204.6 pounds in a metric ton
1 barrel of gasoline contains .4 tons of CO_2
1,000 barrels of gasoline contain 400 tons of CO_2

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[161] Western Regional Air Partnership. Emissions Forum: Updating Mobile Source Inventories. Available at: http://www.wrapair.org/forums/ef/UMSI/index.html

[162] State Demography Office. Population Totals for U.S> and States. Available at: http://www.dola.state.co.us/demog/pop_us_estimates.html

1 barrel of diesel contains .46 tons of CO_2
1,000 barrels of diesel contain 460 tons of CO_2
1 gallon of gasoline contains 124,884 BTUs
1 gallon of diesel contains 138,874 BTUs
1 kWh of electricity contains 3,412 BTUs

Economic Analysis

The costs and fuel savings of the different strategies examined in the report were evaluated assuming a discount rate of 5%. All monetary values are given in 2008 dollars. Energy prices for all years were assumed to be the average cost in 2008. For example the average price of gasoline in Colorado was $3.21 ($2.99 without the state's gasoline tax) in 2008 while statewide average residential electricity prices were $0.10 per kWh.

Appendix 2: Comparison of Advanced Vehicle Technologies and Fuel Types

All of the non-fossil fuels and advanced vehicle technologies discussed below have barriers to overcome before they will significantly displace the current gasoline-internal combustion engine based system. Each vehicle/fuel option is evaluated on its:

- potential reduction of CO_2 emissions,
- the timeframe over which it can have an impact on CO_2 emissions,
- whether new infrastructure investments are necessary to support the technology or fuel,
- current feasibility of the technology/fuel,
- whether the fuel source is also a human food source and will adversely affect food prices and availability, and
- whether production of bio-mass is contributing to loss of forests and species habitat.

Based on comparison of these factors, plug-in hybrid electric vehicles offer the best opportunity to achieve an 80% reduction in CO_2 emissions from the light duty vehicle fleet with the least likely adverse impact on the human food supply and forest destruction.

Ethanol

- Ethanol derived from corn competes with food supply
- Large investments needed for new infrastructure to transport and distribute fuel because ethanol cannot be transported in existing pipeline networks.
- Current vehicles can use up to 10% blend but only 3% of the current fleet can accept higher blends without engine modification.
- Corn ethanol reduces CO_2 emissions by 19% on average because fossil fuels are used to plant, fertilize, harvest, transport crop and distill ethanol. If coal is used to power ethanol plants there is a 3% increase in lifecycle CO_2 emissions.
- Cellulosic ethanol not yet developed for commercial scale production
- Cellulosic ethanol could reduce CO_2 emissions by 86%
- Cellulosic ethanol can be long term solution

Biodiesel

- Biodiesel from soy competes with food supply
- Large investments needed for production, transportation and distribution of fuel
- Cultivation of soy and other feedstocks in developing countries resulting in negative climate impacts, habitat loss and other environmental degradation from clear cutting and burning of forests and loss of CO_2 sinks

  - Tropical deforestation is responsible for 20% of human CO_2 emissions,[163] so expansion of biofuel feedstock production in tropical climates will lead to increased CO_2 emissions
- Engines must be modified to accept blends higher than 20% biodiesel
- Reduces CO_2 emissions by 15 to 75% depending on the percentage blended, not accounting for emissions from converting forest carbon to CO_2

Compressed Natural Gas (CNG)

- Significant infrastructure investments (estimates range between $30 and $100 billion) necessary to establish nationwide refueling capacity.
- Very limited availability of new CNG-capable vehicles. New vehicle fleets need to be built, but manufacturers unwilling to build because fuel infrastructure not available, which seriously limits public acceptance.
- Reduces Greenhouse Gas Emissions by 10-25%
- Competes with primary source of residential heating; will accelerate expected depletion of affordable fuel supply. Medium Term Solution (estimated 20-40 years), requiring additional conversion of vehicle fuel system before 2050.

Plug-in Hybrid Electric Hybrids

- New vehicle fleets need to be built (commercially available 2010).
- Ubiquitous established refueling infrastructure, except some improvements are necessary such as charging capacity at rental properties which may cost $5 to $10 billion.
- Reduces CO_2 emissions by 35-47% depending on assumptions concerning the all electric range and the efficiency of the electric and gasoline engines. Basic power train design needs no further modification to reduce net CO_2 emissions from Plug-in HEVs to near zero as electric power generation is converted to renewable sources, and gasoline is displaced by cellulose-derived liquid fuels.
- Medium to Long Term Solution – significant CO_2 reductions available at rate current internal combustion engines can be replaced with plug-in HEVs. No long term limitations to affordable, reliable, domestic fuel supply.

Hybrid Electric Vehicles

- Existing technology
- Uses existing refueling infrastructure
- Reduces CO_2 emissions by 25-47% depending on the vehicle's fuel efficiency.
- Heavy Duty Hybrid Truck can reduce CO_2 by 24%
- Short to Medium Term Solution – immediately available to expand market share, can contribute to additional future emissions reductions as fossil liquid fuels are displaced by cellulose-based fuels.

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[163] S. Lewis et al. "Increasing Carbon Storage in Intact African Tropical Forests." Nature 457. 1003-1006. February 19, 2009.

100% Battery Electric Vehicles (BEV)

- Very limited availability of electric vehicles
- Heavy Duty Electric Trucks can reduce CO_2 emissions by 16% if electricity is generated mostly from coal (as is the case in Colorado), with potential for future reductions as the more electricity is generated by renewables.
- Medium to Long Term Solution-commercial vehicles must increase their market penetration over the next 10-20 years before having a significant impact.

Table A-1 presents a comparison of factors related to the choice of preferred technologies and fuels.

Table A-1 – Comparison of Non-fossil Fuels and Advanced Vehicle Technologies

	Infrastructure Required for Public Access	**% Reduction in CO_2 emissions compared to gasoline/diesel**	**Current Availability?**	**Other Considerations**
Non-fossil Fuels				
Corn Ethanol	Significant	19%	Yes, but only 10% blend compatible with current fleet	Competes with food supply
Cellulosic Ethanol	Significant	86%	No	
Biodiesel (B20)	Significant	15%	In small amounts and can be used in existing engines	Competes with food supply-clearing of forests for biofuel crops has negative climate impact
Biodiesel (B100)	Significant	75%	In small amounts but requires slight engine modifications	
Advanced Vehicles				
CNG light duty	Significant	10-25%	In small numbers	
CNG heavy duty	Significant		In small numbers	
Plug-in Hybrid	Minimal	35-47%	Available 2010-2011	Reductions for Plug-ins, reflect Colorado's current electricity mix, which is 66% coal; further reductions are expected as more electricity is generated from renewables
Hybrid	None	25-47%	Yes	
Heavy Duty Hybrid Truck	None	24%	In very small numbers	
BEV Heavy Duty	Minimal	16%		

About the Authors

Robert E. Yuhnke is Director of the Transportation Program at SWEEP.

After graduating from Yale Law School (1972), Yuhnke first served as an Assistant Attorney General in the Pennsylvania Department of Environmental Resources where he specialized in bringing the steel industry into compliance with the Clean Air Act. Then he served as Assistant Regional Solicitor at the U.S. Department of Interior with responsibility for the implementation of the federal coal mining control program in 15 western states. For 12 years beginning in 1980, Yuhnke served as regional counsel for the Environmental Defense Fund's Rocky Mountain office. He developed a Clean Air Act citizen's enforcement strategy to protect western wilderness lakes from acid rain caused by SO2 emissions from the copper industry that lead to a 50% reduction in SO2 emitted in the 11 western states. Governor Lamm appointed Yuhnke to the Metropolitan Air Quality Council, and Governor Romer appointed him to the Regional Air Quality Council and to the Governor's 1996 blue ribbon panel on transportation funding. Yuhnke served on the national Alternative Fuels Council appointed by the Secretary of Energy in 1989 to develop strategies for the commercialization of bio-fuels, and authored parts of the 1990 Clean Air Act Amendments and Intermodal Surface Transportation Efficiency Act in 1991, including the conformity program requiring that metropolitan transportation plans achieve the emission budgets for motor vehicle emissions contained in State air quality plans. DRCOG appointed Yuhnke as a member of its Transportation Advisory Committee (1997-2001), and he represented environmental organizations during the re-write of federal transportation law in 1998 and 2003-05.

Mike Salisbury is Program Associate for the Transportation Program at SWEEP.

Mike received a Masters' degree from the University of Delaware's Center for Energy and Environmental Policy, where his research focused on transportation systems and renewable energy. His thesis focused on major transitions in the US transportation sector in the 20^{th} century and how lessons from those transitions can be applied to current attempts to alter transportation in the United States. He also worked on projects studying Vehicle Miles Traveled estimation methodologies, green buildings and the potential for diverse renewable energy technologies in Delaware.

Previously he worked as a Fellow in the office of Congressman Mike Castle (DE) focused on energy and environmental issues, the League of Conservation Voters in Washington, D.C. and also served as a Peace Corps Volunteer in West Africa. He received a Bachelor's degree from Pomona College in French Literature.

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