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Smart Transportation Emission Reductions

Identifying Truly Optimal Energy Conservation And Emission Reduction Strategies

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Summary

This report describes an evaluation framework for identifying optimal (best overall, taking into account all benefits and costs) transportation emission reduction strategies. Current evaluation methods tend to undervalue *mobility management* (also called *Transportation Demand Management* or *TDM*) strategies that change travel behavior to increase transport system efficiency, due to biases that include (1) ignorance about these strategies; (2) failure to consider co-benefits; (3) failure to consider rebound effects of increased fuel economy; (4) belief that mobility management impacts are difficult to predict; (5) belief that mobility management programs are difficult to implement; and (6) belief that any reduction in vehicle travel harms consumers and the economy. More comprehensive and objective analysis tends to rank mobility management strategies among the most cost-effective emission reduction options. This report describes ways to correct current planning bias so mobility management solutions can be implemented to the degree optimal.

Introduction

Imagine two neighbors with different transportation profiles. One is a sportswoman who drives a 15 mpg SUV, but she commutes by bus and runs errands by bicycle, and so drives only 4,500 miles and consumes only 300 gallons of fuel annually, producing about three tons of CO_2 each year. Another owns a small 50 mpg car, but because he drives about 100 miles each day for commuting and errands, he consumes 600 gallons of fuel annually, producing about six tons of CO_2 each year. Which travel pattern is best overall?

The lower mileage driver not only consumes less fuel and produces less pollution, she also imposes less traffic congestion and accident risk, reduces road and parking costs, and gets more exercise through walking and cycling. As a result, her transportation profile is best for society overall.

However, most current transportation emission reduction programs focus on changing vehicle and fuel type rather than the amount people drive. Such programs generally ignore the additional external costs that result when increased fuel efficiency stimulates additional vehicle travel, and the additional benefits (besides energy conservation and emission reductions) resulting from travel reductions. This is inefficient and unfair.

Mileage reduction strategies tend to be ignored because many people assume that they are difficult to implement and would harm consumers. That is not necessarily true. Many high-mileage motorists would prefer to drive somewhat less and rely more on alternative modes, provided those alternatives are convenient, comfortable and affordable. Improving travel options and rewarding mileage reductions can benefit consumers directly, as well as reduce emissions and other transport problems.

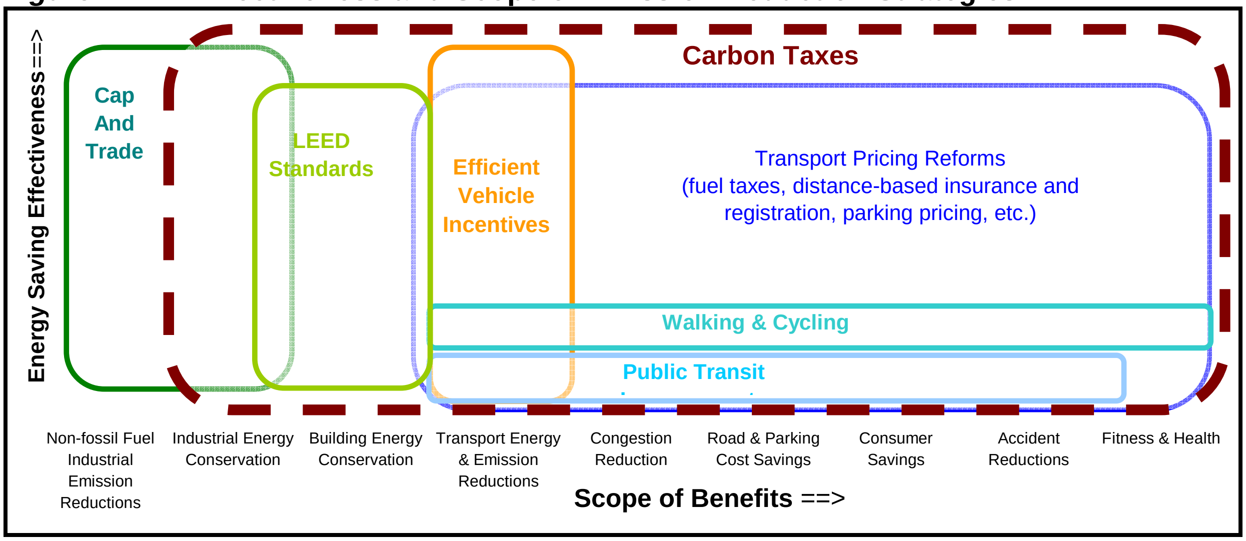
This paper is concerned with identifying the *best* (i.e., overall optimal, taking into account all factors) way to reduce transportation energy consumption and pollution emissions. It complements related reports that describe cost-effective emission reduction strategies (Litman, 2007). This report focuses on the process used to evaluate emission reduction strategies. It identifies common biases that favor *efficient vehicle* solutions (which change what people drive) over *efficient transportation system* solutions (which change how much they drive).

This has huge implications because transportation activity has many economic, social and environmental impacts. It is wrong to ignore any significant impacts when evaluating potential emission reduction options, yet, this is commonly done, resulting in the solutions to one problem (such as air pollution) that exacerbate other important problems (such as traffic congestion, accident risk or consumer costs), and undervaluing solutions that provide many modest benefits. This is good news, because it means that by applying more comprehensive analysis it is possible to identify truly optimal emission reduction strategies that maximize overall benefits to society.

Effectiveness and Scope

There are many possible ways to conserve energy and reduce emissions. They differ widely in terms of their effectiveness (ability to reduce energy consumption and emissions), and their impacts (total costs and benefits), as illustrated in Figure 1.

Figure 1 **Effectiveness and Scope of Emission Reduction Strategies**



Cap-and-trade programs generally only support industrial emission reductions. LEED standards support building energy conservation. Efficient vehicle incentives reduce transport energy consumption but provide few other benefits, and by stimulating more driving can exacerbate traffic problems. Transportation pricing reforms (fuel taxes, distance-based insurance and registration fees, parking pricing, etc), and carbon taxes, reduce energy consumption and traffic impacts. Public transit and nonmotorized improvements provide modest energy savings but many additional benefits.

Cap-and-trade programs generally focus on industrial emissions and some building emissions, due to administrative convenience (it is easier to contract with a few large emitters than numerous small companies and households). Incentives to purchase fuel efficient vehicles, such as CAFE standards and feebates, can significantly reduce motor vehicle energy consumption per vehicle-mile but provide few other benefits, and by reducing per-mile vehicle operating costs they tend to increase total vehicle traffic which increases problems such as congestion, roadway costs and accidents (Litman, 2005). Transportation pricing reforms (fuel taxes, distance-based insurance and registration fees, parking pricing, etc) reduce energy consumption and traffic impacts. Carbon taxes encourage energy conservation in all sectors. Improving travel options, such as public transit and nonmotorized travel, individually provide relatively modest energy savings but by reducing vehicle traffic provide many additional benefits.

Strategies that help achieve various planning objectives (congestion reductions, road and parking cost savings, accident reductions, improved mobility for non-drivers, improved public fitness and health, etc.), rather than just energy conservation and emission reductions, represent true sustainable transportation policies (Litman and Burwell, 2006).

Current Emission Reduction Evaluation Activities

Numerous current efforts implicitly or explicitly evaluate the cost effectiveness of potential emission reduction strategies:

- Various studies and catalogues provide information on the effectiveness, costs and benefits of various emission reduction strategies (CCAP, 2005; Dalkmann and Brannigan, 2007; VTPI, 2007; Gallagher, et al. 2007; *Mayors Climate Protection Center*).
- Studies provide an *emission reduction supply curve* (strategies ranked from lowest to increasing cost per ton of emissions reduced), so decision-makers can select the set of policies and programs that achieve emission reduction targets at the lowest total cost (BTRE, 2002; Jansen and Denis, 1999; McKinsey, 2007; NAO, 2007).
- Legislation that implements emission reduction policies, regulations, taxes and trading programs (CAB, 2006; RFF, 2007).
- Emission markets allocate or auction emission rights that participants can buy or sell, to help implement the most cost-effective strategies (WRI, 2007).
- Carbon offset programs through which consumers and businesses finance emission reductions, which often emphasize cost effectiveness (www.carbonfund.org).

These efforts use various analysis methods to evaluate potential strategies. How options are analyzed affects results. A strategy that ranks high by one methodology may be ignored or undervalued by another. To identify truly optimal solutions, analyses should consider all potentially significant emission reduction options and their impacts.

Table 1 lists various transportation emission reduction strategies. These fall into two major categories: *cleaner vehicles* (more efficient and alternative fuel vehicles which per-mile emission rates), and *mobility management* (strategies that reduce total vehicle travel).

Table 1 **Transportation Emission Reduction Strategies** (CCAP, 2005; VTPI, 2007)

Cleaner Vehicles	**Mobility Management**		
	Improved Transport Options	*Incentives To Choose Efficient Options*	*Land Use Management*
Efficient vehicle technology development Fuel efficiency standards (such as CAFE). Alternative fuel requirements and incentives. Feebates (financial rewards for purchasing efficient and alternative fuel vehicles) Fuel tax increases.	Transit improvements Walking & cycling improvements Rideshare programs HOV priority Carsharing Telework & flextime Taxi service improvements	Congestion pricing Distance-based fees Commuter financial incentives Parking pricing Parking regulations Fuel tax increases Transit encouragement	Smart growth policies Transit oriented development Location-efficient development Parking management Carfree planning Traffic calming

This table lists various emission reduction strategies. Cleaner vehicle strategies reduce emission rates per vehicle-mile, while mobility management strategies reduce total vehicle travel.

Most comprehensive studies indicate that both cleaner vehicles and mobility management strategies are needed to achieve energy conservation and emission reduction targets (Robèrt and Jonsson, 2006). However, most current emission reduction analysis is biased against mobility management because:

- *It ignores mobility management or only considers a few strategies.* Emission reduction planning sometimes ignores mobility management altogether, or only considers a limited number of potential strategies.
- *It ignores co-benefits.* Current analysis gives little consideration to benefits such as congestion reduction, road and parking facility cost savings, consumer savings, reduced traffic accidents, and improved mobility for non-drivers, although these benefits are often larger in total value than emission reduction benefits.
- *It ignores induced travel impacts.* Current analysis generally ignores the additional external costs that result when increased vehicle fuel efficiency and subsidized alternative fuels stimulates additional vehicle travel, called a *rebound effect*.
- *It considers mobility management emission reductions difficult to predict.* Although case studies and models exist for many of these strategies, this information is not widely applied to energy planning.
- *It considers mobility management programs difficult to implement.* Such programs often involve multiple stakeholders, such as regional and local governments, employers and developers, and various special interest groups. As a result, they tend to seem difficult and risky compared with other emission reduction strategies that only require changes to utility operations, fuel production or vehicle designs.
- *It assumes that vehicle travel reductions harm consumers and the economy.* In fact, many mobility management strategies benefit consumers directly and increase economic productivity. There is plenty of evidence that, with improved travel options and efficient incentives, consumers would choose to drive less, rely more on alternative modes, and be better off overall as a result.

For these reasons, many current emission reduction planning efforts ignore mobility management altogether (Gallagher, et al., 2007) or only mention them incidentally (McKinsey, 2007). As a result, currently proposed emission reduction efforts will fail to implement mobility management as much as optimal and so will miss an opportunity to help address other planning objectives, such as congestion reduction, traffic safety, consumer savings and improved mobility for non-drivers. More comprehensive analysis will give mobility management strategies the support they deserve.

The next section of this report examines these biases in more detail.

Biases Against Mobility Management

This section discusses in more detail various biases in current emission reduction evaluation.

Mobility Management Overlooked

Many energy analysts are unfamiliar with mobility management, are only aware of a small portion of total potential strategies, or significantly underestimate mobility management's potential emission reductions. There is often confusion over what it is called and how it is defined; efforts to reduce vehicle travel are sometimes referred to as *demand management* or *transportation demand management,* or described as *driving disincentives, road pricing, commute reduction, transit improvements,* or *land use management*. As a result, analyses often consider only a limited set of mobility management strategies.

Fortunately, this problem is relatively easy to correct. A variety of resources now exist which identify potential mobility management strategies and provide information on their costs, benefits and implementation requirements (CCAP, 2005; Dalkmann and Brannigan, 2007; VTPI, 2007; *European Program for Mobility Management*).

Co-benefits Ignored

Current analysis often gives little consideration to additional (besides emission reduction) benefits provided by mobility management, although they are significant in value ("TDM Evaluation," VTPI, 2007). These include congestion reductions, road and parking cost savings, consumer cost savings, increased traffic safety, improved mobility options for nondrivers, improved physical fitness and health, and support for strategic land use objectives (reduced sprawl). Not every mobility management strategy provides all of these benefits, but most provide many.

Induced Travel Impacts Ignored

Current analysis generally ignores the additional external costs that result when increased vehicle fuel efficiency or alternative fuel subsidies stimulate additional vehicle travel, called a *rebound effect* ("Rebound Effects," VTPI, 2007). Long-term rebound effects typically range from 15-30% (Small and Van Dender, 2005). For example, with a 20% rebound effect, a 50% increase in fuel economy will cause mileage to increase 10%, resulting in 40% net energy savings. Some recent analysis acknowledge that rebound effects will reduce net energy savings, but other induced travel impacts, such as increased congestion, accidents and facility costs are seldom considered or quantified (CBO, 2003).

Table 2 compares different types of transportation emission reduction strategies, taking into account co-benefits and rebound effects. More efficient or alternative fuel vehicles conserve energy, reduce air pollution, and may save consumers money (if fuel savings offset any additional vehicle costs), but because they tend to increase total annual mileage they tend to exacerbate other problems such as traffic congestion, road and parking facility costs, accidents and sprawl. By reducing total vehicle travel, mobility management strategies provide a wider range of benefits.

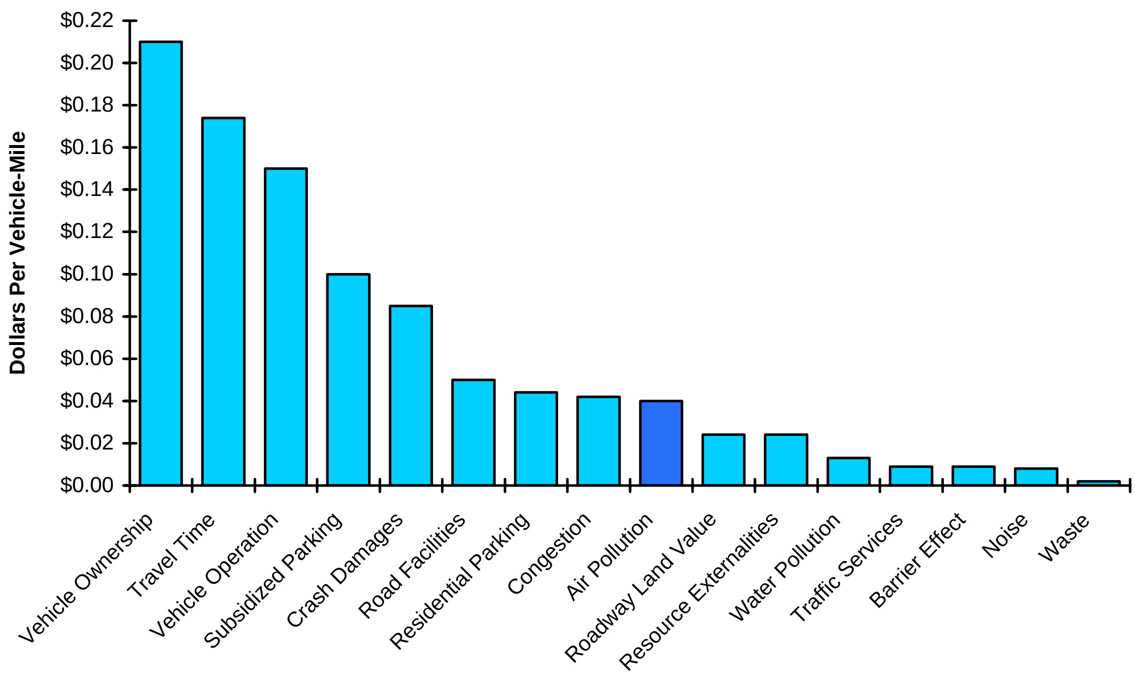
Table 2 **Comparing Benefits** (Litman, 2007)

Benefits	Efficient And Alternative Fuel Vehicles	Mobility Management
Congestion reduction	✗	✓
Road and parking cost savings	✗	✓
Consumer cost savings	✓/✗	✓
Reduced traffic accidents	✗	✓
Improved mobility options for nondrivers		✓
Energy conservation	✓	✓
Pollution reduction	✓	✓
Improved physical fitness & health (exercise)		✓
Land use objectives (reduced sprawl)	✗	✓

Efficient and alternative fuel vehicles only provide a few benefits, and by increasing total vehicle travel tend to exacerbate problems such as congestion, accidents and sprawl. Mobility management provides far more benefits. (✓ = achieves benefits; ✗ = reduces benefits)

Figure 2 indicates estimates of various transportation costs, measured per vehicle-mile. The largest category is vehicle ownership (the fixed costs of owning a vehicle, including purchase costs, financing, depreciation and registration fees), totaling about $2,700 per year or 21¢ per vehicle-mile, followed by other costs such as travel time, vehicle operation, crash damages, roadway costs, vehicle parking, congestion, air pollution, resource externalities (economic costs of importing petroleum), traffic services, water and noise pollution.

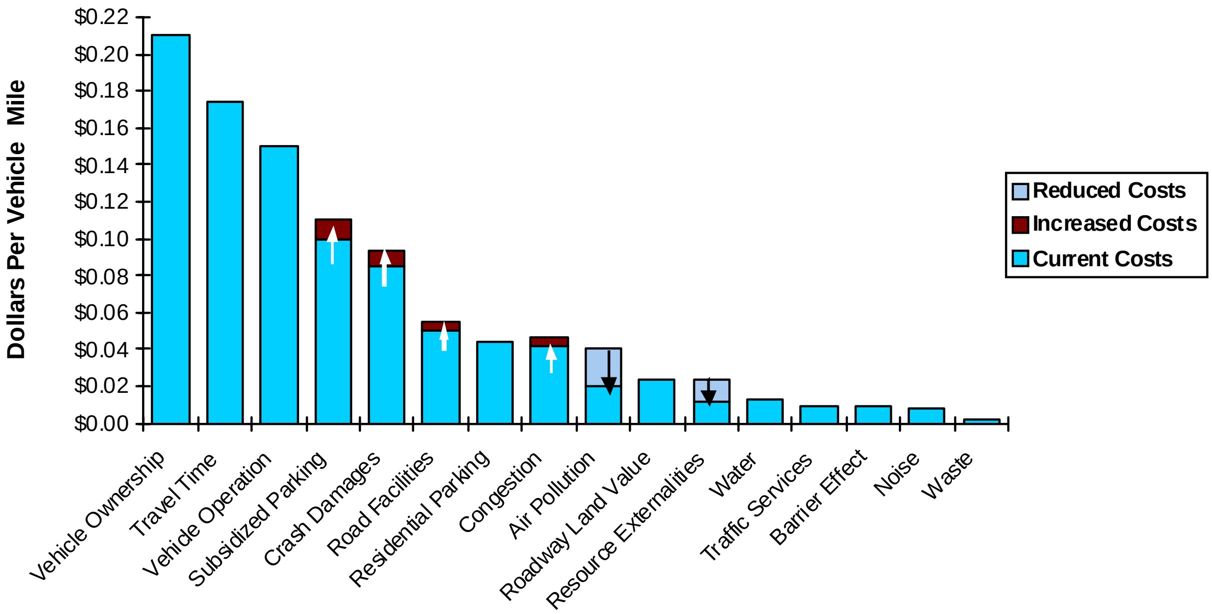
Figure 2 **Per-Mile Automobile Costs** (Litman, 2006)



This figure illustrates estimated automobile costs averaged per vehicle-mile.

Air pollution is a moderate-size cost, typically estimated at 2-4¢ per vehicle-mile for an average automobile, with higher values for dirty vehicles in urban areas and lower values for cleaner vehicles in rural areas (EDRG, 2007). Adding climate change emission costs does not significantly change air pollution's ranking. For example, $100 per metric tonne of *carbon* equals about $27 per ton of *carbon dioxide equivalent*, which equals about 25¢ per gallon of gasoline or about 2.2¢ per average vehicle-mile. This represents the upper range of carbon price estimates. Although *damage costs* may be higher, *control costs* (the marginal cost of reducing or sequestering a tonne of carbon) is likely to stay below this level and rational prices reflect whichever is cheapest (Litman, 2006). Incorporating upper-bound carbon values increases average automobile air pollution costs from 2-4¢ to 4-6¢ per vehicle-mile. This is not to ignore vehicle emission costs, but indicates the importance of considering other impacts too. An emission reduction strategy is worth much less if it increases other costs and worth much more if it reduces other costs.

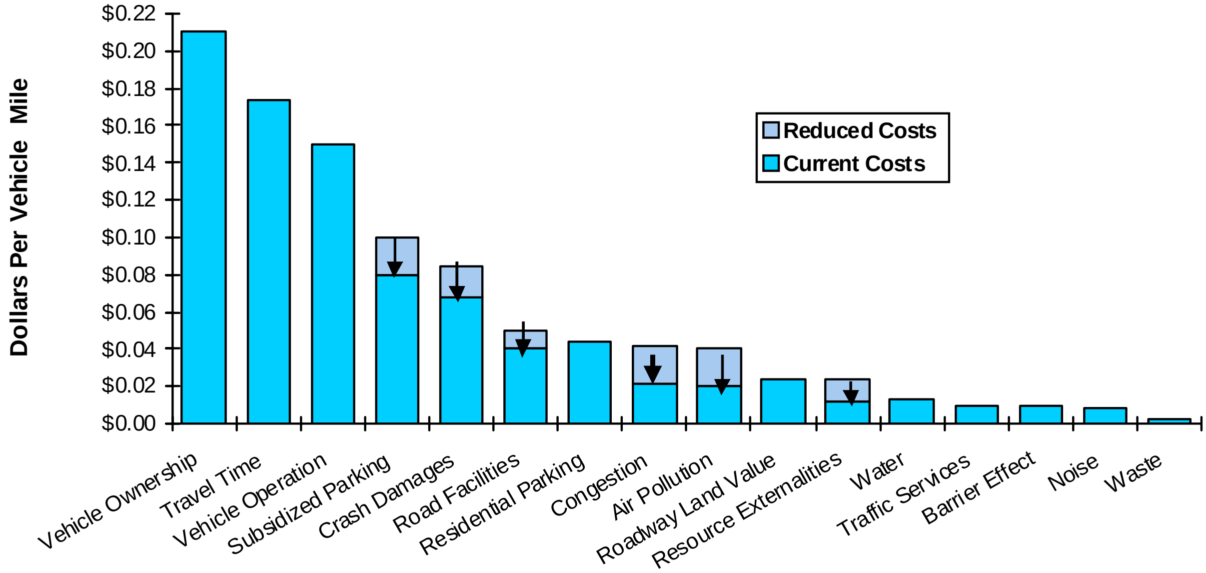
Figure 3 **Efficient Automobile Use** (Litman, 2006)



This figure illustrates estimated impacts of reduced emissions per vehicle-mile. (Light blue indicates reduced costs, red indicates increased costs)

For example, if pollution and resource externalities total 6¢ per vehicle-mile, a strategy that halves per-mile energy consumption and emissions by raising fuel economy from 20 to 30 mpg provides benefits worth 3¢ per vehicle-mile, or $375 per year for a vehicle driven 12,500 annual miles. However, if motorists respond by driving 10% more miles (a typical rebound effect), energy and emission reduction benefits decline 10% to $338, and mileage-related costs increase (Figure 3). A 10% increase in congestion, crash, road and parking externalities totals 2.7¢ per vehicle-mile or $338 per year, offsetting the energy and emission reduction benefits. On the other hand, a mobility management strategy that reduces vehicle travel 20% provides energy conservation and emission reduction benefits worth 6¢ per vehicle-mile reduced, or $150 annually, *plus* 20% reductions in mileage-related costs, totaling $675, or $825 in total annual benefits (Figure 4).

Figure 4 **Reduced Mileage Automobile Costs** (Litman, 2006)



This figure illustrates estimated impacts of reduced vehicle-mileage. (Light blue indicates reduced costs)

Emission Reductions Considered Difficult to Predict

Mobility management emission reduction effects are considered difficult to predict since they rely on behavior change, as opposed to technological changes. This perceived uncertainty makes it difficult for mobility management strategies to qualify for emission trading credits. These problems can be overcome (Donoso, Martinez and Zegras, 2006). Case studies and models can be used to predict mobility management travel impacts and emission reductions (Pratt, 2007; VTPI, 2007). Different types of mobility management strategies require different prediction methods.

- Conventional travel models can predict the effects of some mobility management strategies, such as transit service improvements, transit fare reductions, and increases in road or parking prices, and newer models can predict the impacts of other strategies such as transit service quality improvements ("Travel Model Improvements," VTPI, 2007).
- Catalogues of mobility management strategies often include case studies that indicate their travel impacts and emission reductions (CCAP, 2005; VTPI, 2007)
- Specialized models are available to predict the effects of specific combinations of incentives in a particular trip reduction program (USF, 2006).
- Price elasticity models can be used to predict the effects of price changes on travel behavior ("Transportation Elasticities," VTPI, 2007).
- Models and case studies can be used to predict the effects that land use changes have on travel behavior and per capita emissions (Ewing, et al., 2007; DKS Associates, 2007; "Land Use Impacts On Travel," VTPI, 2007).

Mobility Management Programs Considered Difficult To Implement

Mobility management strategies often involve multiple stakeholders and new organization relationships, such as various levels of government, employers, developers, various special interest groups, and transportation management associations, and so often seem difficult and risky compared with changes to vehicle designs or fuel (Wright and Fulton, 2005). Energy analysts sometimes assume incorrectly that these strategies require new technologies, such as GPS-based pricing or high-speed rail (Lash, 2007). These perceived difficulties often make it difficult for mobility management strategies to qualify for emission trading credits.

However, there is now extensive experience with various mobility management strategies (CCAP, 2005; VTPI, 2006; Association for Commuter Transportation; European Program for Mobility Management). Mainstream transportation organizations now recognize the value of mobility management (often under the name of *transportation systems operations*) and increasingly implement it as a way to solve problems such as traffic congestion and inadequate mobility for non-drivers (CUTR, 2007; Poorman, 2005).

Vehicle Travel Reductions Considered Harmful

People often assume mobility reduction must harm consumers and the economy, and so should be avoided (CAB, 2006). However, this assumption is not necessarily true. Many mobility management strategies directly benefit the people who reduce their vehicle travel by improving their travel options or providing positive incentives. For example, if people drive less due to improvements in alternative modes or in response to positive incentives such as *parking cash out* (commuters who use alternative modes receive the cash equivalent of parking subsidies), they must be better off overall since they could otherwise continue driving. Similarly, many consumers will choose more accessible, walkable communities, and drive fewer miles, if such communities have other attributes they value such as security, affordability and prestige. Even strategies that apply negative incentives, such as higher prices, can benefit consumers overall, if revenues are used to reduce other taxes or provide new services they value.

Several current trends are increasing the value of alternative modes, including an aging population, rising fuel prices and increasing traffic congestion. Although few motorists want to give up driving altogether, at the margin (compared with their current travel patterns) many people would prefer to drive less, and rely more on other forms of transport, provided that they are convenient, comfortable and affordable. As a result, mobility management strategies are increasingly justified to meet consumer demands.

Accurate mobility management evaluation requires *consumer surplus* analysis to measure the value consumers place on a change in the price or quality of their consumption (in this case, of vehicle travel). These methods are well established and widely used in economic evaluation (Small, 1999; “Evaluating TDM,” VTPI, 2007).

Improving Emission Reduction Evaluation

This analysis indicates that, in various ways, current emission reduction planning tends to overlook and undervalue mobility management solutions. Fortunately, all of these biases can be corrected. Although this involves overcoming a variety of obstacles, the potential benefits are very large, making the effort worthwhile. More comprehensive analysis allows planners to identify the truly optimal emission reduction strategies, which provide far greater benefits than what would be selected by current, biased evaluations.

Table 3 summarizes the various types of biases against mobility management emission reduction strategies, and ways to correct them for more comprehensive and objective analysis.

Table 3 **Correcting Biases Against Mobility Management**

Type of Bias	Corrections
Mobility management ignored	Become more familiar with potential mobility management strategies and their impacts.
Co-benefits ignored	Become more familiar with the full benefits of vehicle travel reductions, including reduced congestion, road and parking facility costs, consumer costs, accidents, noise and water pollution, and sprawl, as well as improved mobility options for non-drivers, and improved public fitness and health. Develop methods to quantify these benefits for economic evaluation.
Induced travel impacts ignored	Become more familiar with rebound effects and develop methods to quantify these impacts for economic evaluation.
Mobility management impacts considered difficult to predict	Become more familiar with various models and case studies available for predicting the impacts of mobility management strategies. Improve these models so they are more flexible, accurate and easier to use.
Mobility management programs considered difficult to implement.	Become more familiar with case studies of mobility management implementation. Improve access to these resources.
Vehicle travel reductions considered harm consumers and the economy.	Become more familiar with methods used to evaluate the impacts of mobility management on consumer welfare. Develop better tools for applying this analysis for transport policy evaluation.

This table indicates how existing biases can be corrected for more comprehensive and accurate analysis of optimal transportation emission reduction policies.

Optimal Emission Reduction Strategies

Although there are many possible ways to reduce energy consumption and pollution emissions, some are much better overall than others because they provide additional benefits and avoid exacerbating other problems.

One of the most appropriate emission reduction strategies is to gradually and predictably increase fuel taxes, at least to reflect all public expenditures on roadways and traffic services, or to apply a carbon tax on all fossil fuels ("Fuel Tax Increases," VTPI, 2006; Sterner, 2006; Metschies, 2005; *Carbon Tax Center*). Other cost-effective mobility management strategies include (Leotta, 2007; Litman, 2007):

- *Pay-As-You-Drive Pricing* - Convert fixed vehicle charges into mileage-based fees.
- *Parking Cash-Out* - Offer commuters financial incentives for using alternative modes.
- *Parking Pricing* - Charge users directly for parking facility use, often with variable rates.
- *Road Pricing* - Charge users directly for road use, with rates that reflect costs imposed.
- *Transportation Demand Management* - Programs that encourage alternative mode use.
- *Transit and Rideshare Improvements* - Improve transit and rideshare services.
- *Walking and Cycling Improvements* - Create more walkable and bikeable communities.
- *Smart Growth Policies* – Encourage more accessible, multi-modal land use development.
- *Freight Transport Management* - Encourage more efficient freight transport options.
- *Planning Reforms* – Implement more comprehensive and neutral planning practices.

Policies that encourage fuel efficient vehicle purchases are justified now to prepare for higher future fuel prices, and to reduce the relative disadvantage of driving efficient vehicles (if the entire fleet becomes more efficient there is less stigma and risk to smaller vehicle users). These include vehicle *fuel efficiency standards* (or carbon emission limits), *feebates* (surcharges on less efficient vehicles with revenues used to rebate efficient vehicle purchases), and *efficiency-based vehicle taxes and fees*. To minimize rebound effects and maximize total benefits it will be important to implement fuel tax increases and mobility management strategies in conjunction with efficient vehicle policies.

Alternative fuels should be encouraged primarily by higher gasoline and diesel prices, particularly with carbon taxes (Toman, Griffin, Lempert, 2008). Some alternative fuels may deserve public support for basic development, but these should be evaluated critically to insure they are justified, taking into account all economic, social and environmental costs. Electric vehicle development should be encouraged but their production and use should not be subsidized since their overall benefits are modest; they reduce tailpipe emissions but increase electric generation emissions and already receive about 2.5¢ per vehicle-mile subsidy because they pay no road use taxes. Propane and LPG also provide only modest benefits and so deserve only modest support.

Conclusions

There are many potential energy conservation and emission reduction strategies. Which are best? Which deserve the greatest support? Some have far more total benefits than others, because they provide significant co-benefits and avoid undesirable, unintended consequences. In general, a gallon of fuel conserved by reducing vehicle travel provides an order of magnitude greater benefits than the same energy savings provided by increased vehicle fuel efficiency or shifts to alternative fuels. This occurs because mileage reductions provide other economic, social and environmental benefits, such as reduced traffic congestion, facility costs, accidents and sprawl. Many mobility management programs are justified for their economic benefits, and so provide essentially *free* environmental benefits. In contrast, increased vehicle fuel efficiency tends to stimulate more total vehicle travel, which exacerbates other transportation problems: emissions decline but congestion, parking costs, accidents and sprawl increase.

A number of current trends increase the value of mobility management, including aging population, rising fuel prices, increased traffic congestion and changing consumer preferences. Mobility management strategies help communities respond to future consumer demands and economic conditions.

Most current evaluation tends to overlook and undervalue mobility management benefits. More comprehensive analysis allows mobility management strategies to be implemented to the degree justified. Mobility management is often excluded from emission trading altogether or bears an unreasonably high burden of proof. We need better tools to predict mobility management emission reduction impacts and co-benefits, and protocols to implement mobility management programs within emission markets.

This paper identifies specific biases in most current emission reduction analyses and provides recommendations for correcting these errors. The result can provide a framework for identifying truly optimal solutions.

References

Jillian Anable (2007), *The Cost-Effectiveness Of Non-Technological Policies To Abate Carbon From The Transport Sector – The State Of The Evidence*, presented at the UKERC Workshop, 30th October 2007; UK Energy Research Center (www.ukerc.ac.uk).

Association for Commuter Transportation (www.actweb.org).

BTRE (2002), *Greenhouse Policy Options for Transport*, Bureau of Transport and Regional Economics (www.btre.gov.au).

CAB (2006), *Assembly Bill 23*, State of California, Air Resources Board (www.arb.ca.gov/cc/cc.htm).

CBO (2003), *Fuel Economy Standards Versus A Gasoline Tax*, Congressional Budget Office (www.cbo.gov); at www.cbo.gov/ftpdocs/49xx/doc4917/12-24-03_CAFE.pdf.

CBO (2005), *Limiting Carbon Dioxide Emissions: Prices Versus Caps*, Congressional Budget Office (www.cbo.gov).

CCAP (2005), *Transportation Emissions Guidebook: Land Use, Transit & Transportation Demand Management*, Center of Clean Air Policy (www.ccap.org/guidebook).

Carbon Tracker (www.carbontracker.com) describes standards for carbon offset programs.

CUTR (2007), *Economics of Travel Demand Management: Comparative Cost Effectiveness and Public Investment*, Center for Urban Transportation Research (www.nctr.usf.edu); at www.nctr.usf.edu/pdf/77704.pdf.

Holger Dalkmann and Charlotte Brannigan (2007), "Transport and Climate Change: Module 5e," *Sustainable Transportation Sourcebook: A Sourcebook for Policy-Makers in Developing Countries*, by the Sustainable Urban Transport Project – Asia (www.sutp-asia.org); at www.sutp.org/component/option,com_docman/task,doc_details/gid,383/lang,uk.

DKS Associates (2007), *Assessment of Local Models and Tools For Analyzing Smart Growth Strategies*, California Department of Transportation (www.dot.ca.gov); at www.dot.ca.gov/newtech/researchreports/reports/2007/local_models_tools.pdf.

Pedro Donoso, Francisco Martinez and Christopher Zegras (2006), "The Kyoto Protocol and Sustainable Cities: Potential Use of Clean-Development Mechanism in Structuring Cities for Carbon-Efficient Transportation," *Transportation Research Record 1983*, TRB (www.trb.org), pp. 158-166; at http://web.mit.edu/czegras/www/Donoso_et_al_TRR_06.pdf.

S. Donovan, et al. (2008), *Managing Transport Challenges When Oil Prices Rise*, Research Report 357, New Zealand Transport Agency (www.ltsa.govt.nz); at www.ltsa.govt.nz/research/reports/357.pdf.

EDRG (2007), *Monetary Valuation of Hard-to-Quantify Transportation Impacts*, NCHRP 8-36-61, National Cooperative Highway Research Program (www.trb.org/nchrp); at www.statewideplanning.org/_resources/63_NCHRP8-36-61.pdf.

EEA (2008), *Success Stories Within The Road Transport Sector On Reducing Greenhouse Gas Emission And Producing Ancillary Benefits*, European Environment Agency (www.eea.europa.eu); at http://reports.eea.europa.eu/technical_report_2008_2.

ETAAC (2007), *California Global Warming Solutions Report: 12/21/07 Draft*, Economic and Technology Advancement Advisory Committee, California Air Resources Board (www.arb.ca.gov); at www.arb.ca.gov/cc/etaac/012508pubmeet/etaac_discussion_draft_12-21-07.pdf.

European Program for Mobility Management (www.epommweb.org).

Reid Ewing, Keith Bartholomew, Steve Winkelman, Jerry Walters and Don Chen (2007), *Growing Cooler: The Evidence on Urban Development and Climate Change*, Urban Land Institute and Smart Growth America (www.smartgrowthamerica.org/gcindex.html).

Kelly Sims Gallagher, et al. (2007), *Policy Options for Reducing Oil Consumption and Greenhouse-Gas Emissions from the U.S. Transportation Sector*, ETIP Discussion Paper, Belfer Center for Science and International Affairs (www.belfercenter.org), Harvard University; at www.belfercenter.org/files/policy_options_oil_climate_transport_final.pdf.

Garry Glazebrook and Peter Rickwood (2006), *Options for Reducing Transport Fuel Consumption and Greenhouse Emissions for Sydney*, SOAC; at www.fbe.unsw.edu.au/cityfutures/SOAC/optionsforreducingtransportfuel.pdf.

Halsnæs, et al. (2001), *Transport and the Global Environment: Accounting for GHG Reductions in Policy Analysis*, UNEP Collaborating Centre on Energy and Environment (www.uccee.org).

ITS (2007) *Asilomar Conference Presentations*, UC Davis Institute of Transportation Studies (www.its.ucdavis.edu/events/outreachevents/asilomar2007/presentations%20list.php)

Heinz Jansen and Cecile Denis (1999), "A Welfare Cost Assessment of Various Policy Measures to Reduce Pollutant Emissions from Passenger Road Transport," *Transportation Research D*, Vol. 4, No. 6, Nov. 1999, pp. 379-396.

Jonathan Lash (2007), *Statement To the US House Select Committee on Energy Independence and Global Warming*, World Resources Institute (www.wri.org); at www.wri.org/publication/jonathan-lashs-statement-us-house-select-committee-energy-independence-and-global-warmin.

Kathleen Leotta (2007), *Implementing the Most Effective TDM Strategies to Quickly Reduce Oil Consumption*, Post Carbon Cities (http://postcarboncities.net); at (http://postcarboncities.net/files/Leotta_ImplementingTDMtoQuicklyReduceOilConsumption.pdf).

Todd Litman (2005), "Efficient Vehicles Versus Efficient Transportation: Comparing Transportation Energy Conservation Strategies," *Transport Policy*, Volume 12, Issue 2, March 2005, Pages 121-129; at www.vtpi.org/cafe.pdf.

Todd Litman (2006), *Transportation Cost and Benefit Analysis; Techniques, Estimates and Implications*, Victoria Transport Policy Institute (www.vtip.org/tca).

Todd Litman (2007), *Win-Win Emission Reduction Strategies*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/wwclimate.pdf.

Todd Litman (2008a), *Appropriate Response To Rising Fuel Prices*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/fuelprice.pdf.

Todd Litman (2008b), *Carbon Taxes: Tax What You Burn, Not What You Earn*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/carbontax.pdf.

Todd Litman and David Burwell (2006), "Issues in Sustainable Transportation," *International Journal of Global Environmental Issues*, Vol. 6, No. 4, pp. 331-347; at www.vtpi.org/sus_iss.pdf.

Mayors Climate Protection Center (www.usmayors.org/climateprotection).

McKinsey (2007), *Reducing U.S. Greenhouse Gas Emissions - How Much at What Cost - US Greenhouse Gas Abatement Mapping Project*, McKinsey & Company (www.mckinsey.com); at www.mckinsey.com/clientservice/ccsi/pdf/US_ghg_final_report.pdf.

Gerhard Metschies (2005), *International Fuel Prices*, German Agency for Technical Cooperation (www.internationalfuelprices.com).

MRC, et al. (2008), *Managing Transport Challenges When Oil Prices Rise*, McCormick Rankin Cagney for the New Zealand Transport Agency (www.ltsa.govt.nz); at www.ltsa.govt.nz/research/reports/357.pdf.

NAO (2007), *Cost-Effectiveness Analysis In The 2006 Climate Change Programme Review*, U.K. National Audit Office (www.nao.org.uk); at www.nao.org.uk/publications/nao_reports/06-07/Climate_Change_analysis.pdf

The NOUS Group (2007), *Understanding the Potential to Reduce Victoria's Greenhouse Gas Emissions*, Department of Premier and Cabinet, Victoria, Australia; at www.climatechange.vic.gov.au/summit/Resources/Wedges%20Report.pdf.

OECD/IEA (2001), *Saving Oil and Reducing CO2 Emissions in Transport: Options & Strategies*, Organization for Economic Cooperation and Development (www.oecd.org) and the International Energy Agency (www.iea.org).

John Poorman (2005), "A Holistic Transportation Planning Framework For Management And Operations," *ITE Journal*, Vol. 75, No. 5 (www.ite.org), May 2005, pp. 28-32.

Richard H. Pratt (2007), *Traveler Response to Transportation System Changes*, Third Edition, TCRP Report 95, DOT-FH-11-9579, TRB (www.trb.org); at www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=1034.

RFF (2007), *Summary of Climate Change Bills Introduced in the 110th Congress*, Resources for the Future (www.rff.org), at www.rff.org/rff/News/Releases/2007Releases/July2007ClimateChangeBillsinCongress.cfm.

Amanda Ripley (2008), "10 Things You Can Like About $4 Gas," *Time Magazine*, July 2008; www.time.com/time/specials/packages/article/0,28804,1819594_1819592_1819582,00.htm.

Markus Robèrt and R. Daniel Jonsson (2006), "Assessment of Transport Policies Toward Future Emission Targets," *Journal of Environmental Assessment Policy And Management* (www.worldscinet.com/jeapm/jeapm.shtml), Vol. 8, No. 4, December 2006, pp. 451-478.

Kenneth Small (1999), "Project Evaluation," in *Transportation Policy and Economics*, Brookings (www.brookings.edu); at www.uctc.net/papers/379.pdf.

Kenneth Small and Kurt Van Dender (2005), *The Effect of Improved Fuel Economy on Vehicle Miles Traveled: Estimating the Rebound Effect Using U.S. State Data, 1966-2001*, University of California Energy Institute's (UCEI); at www.ucei.berkeley.edu/PDF/EPE_014.pdf.

Thomas Sterner (2006), "Fuel Taxes: An Important Instrument for Climate Policy," *Energy Policy*, Vol. 35. pp. 3194–3202; at www.hgu.gu.se/files/nationalekonomi/personal/thomas%20sterner/a78.pdf.

TCRP (2003), *Travel Matters: Mitigating Climate Change With Sustainable Surface Transportation*, TCRP Report 93, Transit Cooperative Research Program, Transportation Research Board (http://trb.org/publications/tcrp/tcrp_rpt_93.pdf).

Michael Toman, James Griffin, Robert J. Lempert (2008), *Impacts on U.S. Energy Expenditures and Greenhouse-Gas Emissions of Increasing Renewable-Energy Use*, Environment, Energy and Economic Development Program, Rand Corporation (www.rand.org); at www.rand.org/pubs/technical_reports/2008/RAND_TR384-1.pdf.

USF (2006), *TRIMMS* (Trip Reduction Impacts of Mobility Management Strategies) *Model*, University of South Florida (www.nctr.usf.edu). Evaluates the travel impacts, benefits and costs of various mobility management strategies; at www.nctr.usf.edu/abstracts/abs77704.htm.

VIBAT (www.vibat.org), *Visioning and Backcasting for UK Transport Policy*, Bartlett School of Planning, University College London. Evaluates various policies to achieve 60% transportation climate change emission reductions, including new technologies and travel reduction incentives.

VTPI (2007), *Online TDM Encyclopedia*, Victoria Transport Policy Institute (www.vtpi.org).

WBCSD (2004), *Mobility 2030: Meeting the Challenges to Sustainability*, The Sustainable Mobility Project (www.wbcsd.org/web/publications/mobility/overview.pdf)

Steve Winkelman (2007), *Travel Demand and Urban Form: Lessons and Visions*, Asilomar Conference on Transportation and Climate Policy August 22, 2007; at www.its.ucdavis.edu/events/outreachevents/asilomar2007/presentations/Day%201%20Session%203/Winkelman%20Intro%20to%20Asilomar%20Demand%20Session%20(8.22.07).pdf.

WRI (2007), *Emissions Markets*, World Resources Institute (www.wri.org); at www.wri.org/project/emissions-markets.

Lloyd Wright and Lewis Fulton (2005), "Climate Change Mitigation and Transport in Developing Nations," *Transport Reviews*, Vol. 25, No. 6, 691–717, November 2005; at www.cleanairnet.org/caiasia/1412/articles-70119_paper.pdf.

Christopher Yang, et al. (2008), *80in50 Scenarios for Deep Reductions in Greenhouse Gas Emissions from California Transportation: Meeting an 80% Reduction Goal in 2050*, Sustainable

Transportation Energy Pathways Project, Institute of Transportation Studies, University of California (http://steps.ucdavis.edu); at http://steps.ucdavis.edu/research/Thread_6/80in50.

www.vtpi.org/ster.pdf