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"Efficiency - Equity - Clarity"

Comparing Transportation Emission Reduction Strategies

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Abstract
This paper examines how the evaluation of transportation emission reduction strategies changes as an analysis becomes more comprehensive. Four categories of transportation emission reduction strategies are considered. Increasing vehicle fuel efficiency leads to increased vehicle travel (a rebound effect) which exacerbates many other transport problems. Alternative fuel vehicles provide mixed costs and benefits. Revenue-neutral tax shifts can reduce total vehicle travel, reducing most transport problems, and can provide significant economic development benefits by reducing more burdensome taxes. Transportation demand management strategies can cause the greatest range of benefits. Several "Win-Win" no regrets strategies are identified, which are justified for their economic and social benefits while also providing significant environmental benefits. Most also increase equity. Although their individual impacts may be modest, a package of Win-Win strategies could meet emission reduction targets and solve many of our current transport problems.

Introduction

There are often many possible ways to address a problem. Which is considered "best" often depends on the evaluation criteria used. In practice, many organizations use a limited set of criteria. For example, transportation agencies have a mandate to maximize mobility while environmental agencies have a mandate to reduce pollution. Transportation agencies often give environmental objectives little consideration, while environmental agencies often place little weight on mobility objectives. Yet, both mobility and environmental protection are important to society, as are other objectives, such as safety, affordability and equity.

Focusing on a limited set of criteria is called "reductionist." This may be acceptable when comparing options that are overall similar. For example, it may be appropriate to evaluate alternative highway or rail route alignments based on just construction costs, travel time and local environmental impacts, since most other costs and benefits will be similar for each of the alternatives. But transport policy decisions that affect the amount or type of travel that occurs require a more comprehensive analysis framework. The following factors should generally be considered when evaluating transport polices:

- Consumer costs.
- Consumer choice (e.g., mobility options for non-drivers and low income people).
- User travel time, comfort and convenience.
- Equity impacts.
- Congestion.
- Accidents.
- Road and parking facility costs.
- Government costs (public services, subsidies, etc.).
- Environmental impacts (air, noise and water pollution, wildlife habitat).
- Economic development.
- Land use impacts (such as sprawl).

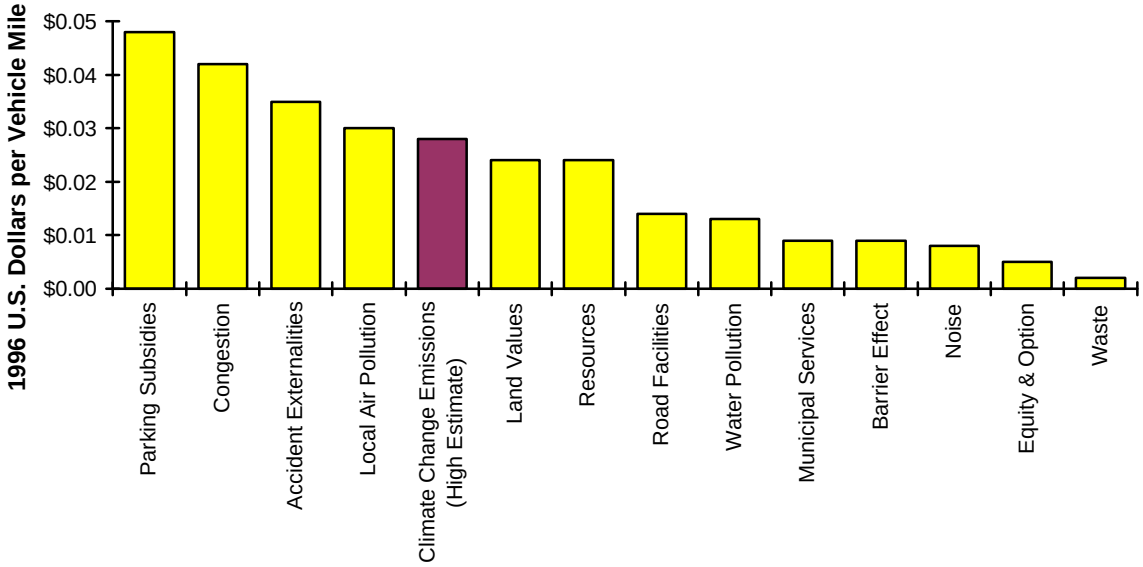
This paper examines how the evaluation of transportation emission reduction strategies changes as an analysis becomes more comprehensive. A reductionist approach simply ranks strategies according to direct costs per unit of emission reduction. A more comprehensive analysis considers a wider range of impacts. Although comprehensive analysis tends to be more difficult, it is far more effective at identifying strategies that provide the greatest overall social benefit.

Comprehensive analysis can identify "no regrets" actions, which are emission reduction strategies justified for their economic or social benefits and thus deserve implementation regardless of the value assigned to climate change impacts. No regrets strategies are common in the transport sector because vehicle use imposes so many external costs. Economists identify "double dividends" from tax shifts that reduce carbon emissions and

increasing economic activity.[1] Some transportation emission reduction strategies can be considered to provide *triple* dividends by also reducing transport problems, such as traffic congestion, infrastructure costs and accidents, and even *quadruple* dividends if they also help achieve social objectives such as increased equity and consumer choice.

These additional benefits can be significant. For example, a major international study estimates climate change emission costs at 18¢ to 56¢ U.S. per gallon of gasoline, or about 0.9¢ to 2.8¢ per mile for an average automobile.[2] Even the higher estimate is lower than many other external automobile costs, as indicated in Figure 1. This implies that policy changes that only reduce climate change costs may provide much smaller overall benefits than strategies that address a wider range of transportation issues.

Figure 1 **Automobile External Costs Ranked by Magnitude**[3]



Even the higher estimate of climate change emission costs is moderate compared with other estimated external costs from automobile use.

Because transportation has so many external impacts, basing transportation policies on any one objective is like "the tail wagging the dog," since no single external cost represents more than a small portion of the total, as illustrated in Figure 2. A reductionist approach, which considers just one external cost when evaluating strategies, has the risk of selecting solutions which inadvertently increase other costs, offsetting some or all of the projected benefits. Conversely, a comprehensive analysis can identify strategies that reduce several external costs, resulting in far greater social benefit, and the potential for broad political support, since a broader range of interest groups can support them.

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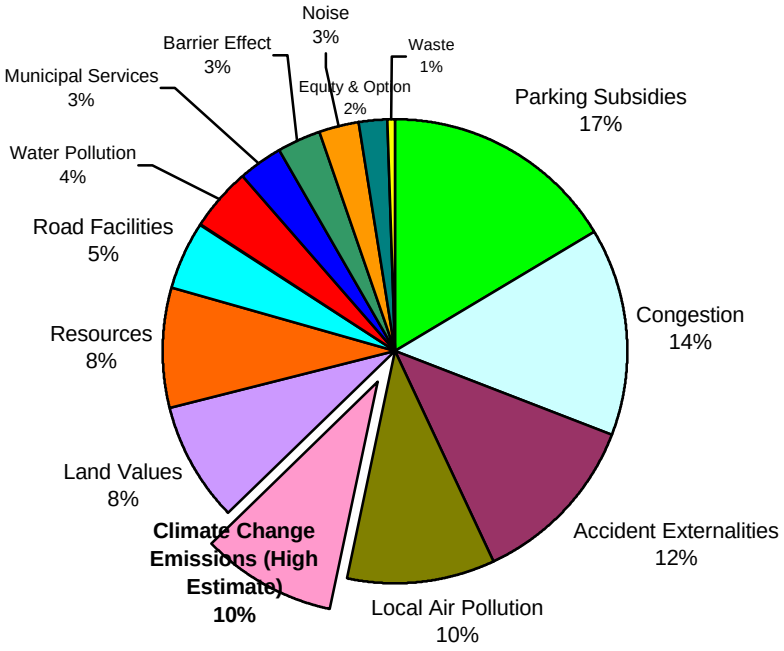
[1] Alan Durning and Yoram Bauman, *Tax Shift*, Northwest Environment Watch (Seattle; www.northwestwatch.org), 1998; Center for a Sustainable Economy (www.sustainableeconomy.org).
[2] *ExternE; Newsletter 6*, European Commission (http://externe.jrc.es), March 1998.
[3] Todd Litman, *Transportation Cost Analysis; Techniques, Estimates and Implications*, VTPI (www.vtpi.org), 1998.

Figure 2 **Automobile External Costs**[4]



This figure illustrates that motor vehicle transportation imposes a number of external costs, no one of which is dominant. Even the high estimate of climate change emission costs represents only about 10% of total externalities.

[4] Todd Litman, *Transportation Cost Analysis; Techniques, Estimates and Implications*, VTPI (www.vtpi.org), 1998.

Emission Reduction Strategies

This section describes various ways to reduce climate change emissions.

1. Fuel Efficiency Standards and Feebates

Fuel efficiency standards require manufactures to sell more fuel efficient vehicles. Feebates provide a rebate on the purchase of fuel-efficient vehicles funded by a surcharge on fuel-inefficient vehicles.

Fuel efficiency standards and feebates have been widely promoted by many energy conservation and environmental advocates. Such "technology forcing" solutions have successfully reduced other tailpipe emissions. These strategies are considered relatively easy to implement since they place the responsibility for emission reductions on manufacturers and require minimal change in consumers' behavior.

However, as vehicles become more fuel-efficient and their operating costs decline, annual mileage usually increases. This "rebound effect" offsets a portion of the expected energy savings.[5] The magnitude of this effect depends on various factors. Historical data show a relatively low elasticity of vehicle travel to fuel price, implying a rebound effect of approximately 20% (i.e., a 10% increase in fuel efficiency leads to a 2% increase in vehicle mileage, resulting in net fuel savings of 8%).[6] However, this reflects a period when fuel prices were low and declining in real terms. If real fuel prices increase, as many experts predict will happen within a decade,[7] the rebound effect is likely to increase.

For example, when fuel prices are just $1 per gallon, a 20 mpg vehicle and a 30 mpg vehicle may be driven approximately the same amount. But if fuel prices increase to $3 per gallon, the 20-mpg vehicle is likely to be driven significantly less than the 30-mpg vehicle, due to the larger difference in per-mile costs.

Despite the rebound effect, increasing vehicle fuel efficiency still provides a net reduction in energy consumption and most tailpipe emissions. However, the increased vehicle travel increases other external costs, including traffic congestion, infrastructure costs, roadway deaths,[8] urban sprawl, and overall automobile dependency. Consumer costs are mixed – although vehicle operating costs decline this is partly offset by higher vehicle purchase prices to cover the higher manufacturing costs. They provide few apparent equity benefits.

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[5] A.P.A. Musters, *The Rebound Effect: An Introduction*, Netherlands Energy Research Foundation (Petten; www.ecn.nl), 1995. It is also sometimes called a "take back" effect.

[6] David Greene, "Why CAFE Worked," *Energy Policy*, Vol. 26, No. 8, 1998, pp. 595-613.

[7] Colin Campbell and Jean Laherrere, "The End of Cheap Oil; Global Production of Conventional Oil Will Begin to Decline Sooner than Most People Think," *Scientific American*, March 1998, pp. 78-83.

[8] Roadway deaths increase both due to increased mileage and the relatively smaller crash protection from smaller vehicles. Dagmar Buzeman, David Viano and Per Lovsund, "Car Occupant Safety in Frontal Crashes," *Journal of Accident Analysis & Prevention*, Vol. 30, No. 6, 1998, pp. 713-722.

2. Alternative Fuel Vehicles

Requirements or incentives for manufacturers to produce and sell, or consumers purchase, alternative fuel vehicles, such as electric, natural gas or ethanol drive.

This is another popular solution because it too places most responsibility for emission reductions on manufacturers. However, most alternative fuels have only modest net climate change emission reduction benefits based on lifecycle analysis, and most produce some additional externalities.[9] Even "zero" emission electric vehicles often cause significant CO_2 emissions through power production.[10]

Another problem is that selling alternative fuel vehicles does not necessarily maximize their use. For example, since most current electric vehicles tend to have reduced performance (speed, capacity, distance), households are expected to use electric vehicles significantly less than their gasoline vehicles. Thus, even if 10% of the fleet becomes electric they are likely to provide only about 5-6% of vehicle travel.

Alternative fuel vehicles have mixed impacts on safety, reducing some risks and increasing others. For example, electric vehicles reduce risks associated with petroleum fires and burns from hot engine surfaces, and increase those associated with battery chemicals, electrical shocks, and crashes with pedestrians and bicyclists (because electric vehicles are quiet at lower speeds).[11] They have virtually the same impacts on traffic congestion or road and parking facility costs. Consumer impacts are mixed – they tend to increase purchase costs while reducing perceived operating costs. They do not provide equity benefits, since they have financial costs and skill requirements similar to conventional automobiles.

[9] Mark Delucchi, *Emissions of Criteria Pollutants, Toxic Air Pollutants, and Greenhouse Gases, from the Use of Alternative Transport Modes and Fuels*, UC Transport. Center (Berkeley), No. 344, 1996, Tables 16 & 19.

[10] Frank Kreith, Paul Norton and DenaSue Potestio, "Electric Vehicles: Promise and Reality," *Transportation Quarterly*, Vol. 49, No. 2, Spring 1995, pp. 5-21; Todd Litman, *A Critical Evaluation of Electric Vehicle Benefits*, VTPI (www.vtpi.org), 1998.

[11] Amy Bricker, et al. *Environmental Impacts and Safety of Electric Vehicles*, International Center for Technology Assessment (Washington DC), 1997.

3. Increase Fuel Taxes/Revenue Neutral Tax Shift[12]

Increase fuel taxes and use the revenue to reduce existing taxes, such as income or sales taxes.

Higher fuel taxes are the most direct way to encourage energy conservation. They provide an incentive to increase vehicle fuel efficiency and change travel patterns in combinations that reflect consumer preferences. Revenue-neutral tax shifts can stimulate economic development by encouraging energy efficiency and technological innovation, reducing petroleum import costs, and reducing more economically burdensome taxes (such as income and sales tax) which encourages employment, investment and trade. One study found that increasing fuel taxes and using the revenues to replace more economically harmful income taxes could increase GDP by 7.7% and average household wealth by 5.5%, while reducing fossil-fuel use by 38%.[13]

One particular tax/price shift strategy justified on economic and equity grounds is to charge motorists directly for a greater share of roadway costs. Many people assume incorrectly that fuel taxes pay all roadway costs. In fact, local roads are mostly funded through local property and sales taxes. Automobile user fees would need to increase more than 40% in the U.S. to pay their share of roadway costs.[14] Increased fuel taxes or a weight-distance mileage fee to pay for local roads would be more economically efficient and equitable, and reduce other transportation costs.

However, there are practical limits to this strategy. It is politically difficult to raise fuel taxes in North America. This strategy is inappropriate for individual jurisdictions, since drivers can respond by simply purchasing fuel across borders in other jurisdictions. Vehicle travel reductions tend to be modest since most energy savings tend to result from more fuel-efficient vehicles.

[12] Alan Thein Durning and Yoram Bauman, *Tax Shift*, Northwest Environment Watch (Seattle; www.northwestwatch.org), 1998.
[13] Douglas Norland and Kim Ninassi, *Price It Right; Energy Pricing and Fundamental Tax Reform*, Alliance to Save Energy (Washington DC; www.ase.org) 1998.
[14] *1997 Federal Highway Cost Allocation Study*, USDOT (www.fhwa.dot.gov).

4. Transportation Demand Management (TDM) Strategies

TDM includes a wide range of specific strategies that encourage more efficient travel behavior.[15] *Win-Win solutions are TDM strategies that provide a combination of economic, social and environmental benefits.*[16] *Examples are described below.*

Distance-Based Vehicle Insurance And Registration Fees[17]
Converting vehicle insurance and registration fees from fixed charges into per-mile charges approximately doubles variable vehicle expenses (for example, a motorist who now pays $900 per year for insurance and registration would pay about 7.5¢ per mile). This provides a significant financial incentive to reduce driving, while making these charges more fair and affordable. This is predicted to reduce vehicle travel by approximately 12%, reduce crash rates by a greater amount, increase equity, and provide consumer savings.

Least-Cost (Or "Integrated") Transportation Planning And Funding[18]
Least-cost planning means that demand management options are considered as alternatives to facility investments, that all significant impacts are considered, and that the public is involved in developing and evaluating alternatives. This allows demand management strategies to receive appropriate consideration and investment.

Reform Motor Carrier Regulations[19]
Many jurisdictions limit transportation service competition. Private bus and jitney services are often prohibited or restricted in order to favor public monopoly transit. Regulations should be minimized and focused to address specific problems while encouraging competition, consumer choice and innovation.

Local And Regional Transportation Demand Management (TDM) Programs[20]
TDM programs include a wide variety of services, including rideshare matching, transit improvements, bicycle and pedestrian facility improvements, parking management and promotion of alternative modes.

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[15] Todd Litman, *Potential Transportation Demand Management Strategies*, VTPI (Victoria; www.vtpi.org), 1998.
[16] *Win-Win Transportation Management Strategies*, VTPI (Victoria; www.vtpi.org), 1998.
[17] Patrick Butler, *Operation of an Audited-Mile/Year Automobile Insurance System Under Pennsylvania Law*, National Organization for Women (Washington DC; www.now.org), 1992; Aaron Edlin, *Per-Mile Premiums for Auto Insurance*, Dept. of Economics, University of California at Berkeley (http://emlab.berkeley.edu/users/edlin), 1998; Todd Litman, *Distance-Based Charges; A Practical Strategy for More Optimal Vehicle Pricing*, VTPI (www.vtpi.org), 1998.
[18] *What Is Least Cost Planning?* www.wsdot.wa.gov/regions/northwest/planning/least_cost_planning.htm), 1999; *The Integrated Transport Planning Beginner's Handbook*, International Institute for Energy Conservation (Washington DC; www.iiec.org), 1996.
[19] Daniel Klein, Adrian Moore and Binyam Reja, "Free to Cruise: Creating Curb Space for Jitneys," *Access*, No. 8, Spring 1996, pp. 2-6.
[20] Reid Ewing, *Transportation and Land Use Innovations; When You Can't Build Your Way Out of Congestion*, Planners Press (Chicago; www.planning.com), 1997; The **TDM Resource Center** (www.wsdot.wa.gov/Mobility/TDMhome.html); Todd Litman, *Potential TDM Strategies*, VTPI (www.vtpi.org), 1998.

More Efficient Land Use[21]
Current zoning and development practices tend to increase vehicle travel by separating land uses. More mixed-use and infill development can help reduce travel requirements and increase travel choices by placing common destinations closer together, such as having schools and small retail shops in or adjacent to residential neighborhoods.

Parking "Cash Out"[22]
"Cashing out" means that commuters who receive free parking are also offered a cash alternative if they use other modes. This typically reduces driving by 10-30%, and provides non-drivers with a benefit comparable in value to what drivers receive.

Location Efficient Housing and Mortgages[23]
Location Efficient Housing consists of residential development in areas with good access. This provides potential transportation and parking cost savings to consumers. Location Efficient Mortgages recognize these potential savings in credit assessments. This gives home-buyers an added incentive to choose location efficient residences.

Carsharing[24]
Carsharing services provide affordable, short-term (hourly and daily rate) motor vehicle rentals in residential areas. This gives consumers a convenient and affordable alternative to private ownership. Because it has lower fixed costs and higher variable costs than private vehicle ownership, carsharing encourages users to limit their vehicle use to those trips in which driving is truly the best option, and use alternative modes as much as possible. Drivers who join such organizations typically reduce their mileage by 50%.

Although no one Win-Win strategy can solve all transportation problems, a combination of them could have significant impacts. If fully implemented to the degree that they are economically justified these Win-Win strategies could reduce motor vehicle impacts by 15-30%, or more if implemented in conjunction with other TDM policies.[25] They could achieve Kyoto emission reduction objectives while *increasing* consumer benefits and economic development.

[21] Reid Ewing, *Best Development Practices; Doing the Right Thing and Making Money at the Same Time*, Planners Press (Chicago; www.planning.org), 1996.
[22] USEPA **Commuter Choice Program** (www.epa.gov/oms/traq); *Local Government Guide to Parking Cash Out*, International Council for Local Environmental Initiatives, (www.iclei.org/us), 1998.
[23] Kim Hoeveler, "Accessibility vs. Mobility: The Location Efficient Mortgage," *Public Investment*, American Planning Association. (Chicago; www.planning.org), September 1997.
[24] K. Steininger, C. Vogl and R. Zettl, "Car Sharing Organizations," *Transport Policy*, Vol. 3, No. 4, 1996, pp. 177-185; The Car Sharing Net (www.carsharing.net).
[25] Todd Litman, Charles Komanoff & Douglas Howell, *Road Relief*, EOC (Olympia; www.eoc.org), 1998.

Comparing Strategies

The table below evaluates these emission reduction strategies. All can provide significant energy savings and climate change emission reductions but they differ in terms of other types of impacts, primarily because of differences in total motor vehicle travel.

Table 1 **Comprehensive Evaluation of Impacts**

Objectives	Fuel Efficiency Standards	Alternative Fuel Vehicles	Increase Fuel Taxes	Win-Win TDM
Energy Savings/CO2 Emission Reduction	*2*	*2*	*2*	*2*
Consumer costs	0	0	-1	1
Consumer choice	0	0	0	2
User travel time, comfort and convenience	0	0	0	1
Equity impacts	0	0	0	2
Congestion	-1	0	1	2
Accidents	-1	0	0	2
Road and parking facility costs	-1	0	1	2
Government costs	0	0	1	1
Other environmental impacts	-1	0	1	2
Economic development impacts	0	0	2	1
Land use impacts	-1	0	1	2
	-3	*2*	*8*	*20*

Key: 2=Excellent, 1=Good, 0=No or Mixed Impacts, -1=Bad, -2=Very Bad

Fuel efficiency standards and feebates tend to receive low ratings in most categories because they increase total vehicle travel which increases most transportation costs (congestion, accidents, facility costs, other environmental impacts and sprawl). They provide little net consumer benefit, since fuel cost savings are at least partly offset by increased vehicle production costs. Alternative fuels have modest benefits and no significant impact on most transportation costs. Their effect on other environmental impacts are mixed, depending on the fuel type and conditions.

Increased fuel taxes increase direct consumer costs, although this can be offset by other tax reductions. This strategy causes moderate reductions in vehicle travel, providing moderate transportation and other environmental benefits. If matched with reductions in income or sales taxes it can provide significant economic development benefits. Most Win-Win strategies provide some combination of consumer savings, consumer choice and increased equity. Win-Win strategies cause the greatest reduction in vehicle travel, providing the greatest total transportation and environmental benefits.

It is not necessary for policy makers to choose between these strategies. They can be implemented in combinations that provide the greatest overall benefits. For example, the rebound effect from fuel efficiency standards can be avoided if matched with increased fuel taxes and TDM strategies. Similarly, higher fuel taxes are likely to be more effective if matched with TDM strategies that increase consumer's travel choices.

Conclusions

Transportation activities have numerous impacts so it is important to use a comprehensive analysis framework when evaluating transport policy options. Some strategies that rank high when evaluated in terms of a single objective may exacerbate other problems, making society worse off overall, while those that rank lower may turn out to be best when all impacts are considered.

This paper describes four major categories of transportation climate change emission reduction strategies. Each can reduce a significant portion of emissions but their other impacts vary significantly. In general, technological solutions tend to provide a narrow range of benefits. Increasing vehicle fuel efficiency leads to increased vehicle travel (a rebound effect) which exacerbates many other transport problems. Alternative fuel vehicles provide mixed costs and benefits.

Pricing and management strategies tend to provide a wider range of potential benefits. Revenue-neutral tax shifts can reduce total vehicle travel, addressing a most transport problems, and can provide significant economic development benefits by reducing more burdensome taxes. Transportation demand management strategies can cause the greatest reduction in vehicle travel and the greatest reduction in other transport problems. Many TDM strategies can be considered “no regrets” measures because they are justified for economic and social benefits, providing “free” environmental benefits.

We have identified a number of these “Win-Win” strategies, which are cost effective, technically feasible changes in current policies and practices that use market principles to help solve transportation problems. Most simply reduce current market distortions that encourage excessive vehicle travel. They provide multiple benefits, including reduced traffic congestion, accidents, facility costs, consumer savings, and various environmental benefits. Most also increase equity. Although their individual impacts may be modest, a package of Win-Win strategies could solve many of our current transport problems.

These solutions may be politically viable if supported by the full range of interest groups that would benefit. People and organizations concerned with congestion, road and parking facility costs, safety, economic development, consumer costs, environmental quality, and equity issues all have reasons to support these strategies. A well-organized coalition could provide the public education and political support needed to implement Win-Win solutions as a significant part of climate change emission reduction efforts.

Here are related reports available from VTPI:

The Costs of Automobile Dependency

A Critical Evaluation of Electric Vehicle Benefits

Distance-Based Vehicle Insurance; A Practical Strategy for More Optimal Pricing

Exploring the Paradigm Shift Needed to Reconcile Transportation and Sustainability Objectives

Potential TDM Strategies

Socially Optimal Transport Prices and Markets

Win-Win Transportation Solutions

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- Typographical errors or confusing wording.
- Concepts that were not well explained.
- Analysis that is inappropriate or incorrect.
- Additional information, ideas or references that could be added to improve the report.

Thank you very much for your help.

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