Public Interest Energy Research (PIER) Program

FINAL PROJECT REPORT

A WEB-BASED PORTAL FOR INFORMATION FOR LOCAL GOVERNMENTS TO REDUCE ENERGY USE AND EMISSIONS FROM LOCAL TRANSPORTATION SYSTEMS

Prepared for: California Energy Commission

Prepared by: Lawrence Berkeley National Laboratory and
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PREFACE

The California Energy Commission Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

A Web-based Portal for Information for Local Governments to Reduce Energy Use and Emissions from Local Transportation Systems is the final report for the Transportation Energy in Sustainable Communities: Making the Right Information Available to Local Governments project (contract number 500 - 99 - 013) conducted by Lawrence Berkeley National Laboratory and the University of California at Berkeley. The information from this project contributes to PIER's Transportation Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-654-4878.

ABSTRACT

This report summarizes the layout and content of a website created for the CEC to make the information in the *Energy Aware Planning Guide* readily available to California cities and counties, to assist them in their efforts to reduce energy use. The website consists of an electronic version of the entire *Planning Guide* that allows easy maneuverability among the many sections of the document, and quick downloading of references cited in the document. The website also contains individual briefing pages for 46 land use- and transportation-related measures, including 21 briefs that provide information on additional transportation-related measures that are not specifically identified in the *Planning Guide*. The website also summarizes estimates of the effectiveness of individual measures described in the briefings, as well as the cost-effectiveness of each measure, derived from a comprehensive national study of the potential to reduce energy use from the transportation sector.

Keywords: energy efficiency, transit-oriented development, smart growth, best management practices, renewables, local government, transportation, land use, land use planning, buildings, greenhouse gases, generation, adaptation planning,
policy, climate change.

Please use the following citation for this report:

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The *Energy Aware Planning Guide* is a comprehensive resource for local governments seeking to reduce energy consumption and increase usage of renewable energy across all sectors. The *Planning Guide* summarizes many strategies and practices to help local governments reduce energy use and enhance renewable sources of energy, including transportation and land use strategies; water use strategies; building strategies; and community energy strategies. Each strategy section contains general plan language ideas; implementation ideas; case studies; and resources. The guide also contains supporting information and references to help local governments organize strategies into an Energy Action Plan and estimate the likely energy and greenhouse gas reduction impacts.

This report summarizes the layout and content of a website created for the CEC to make the information in the *Planning Guide* readily available to California cities and counties. The website consists of an electronic version of the entire *Planning Guide* that allows easy maneuverability among the many sections of the document, and quick downloading of references cited in the document. The website also contains individual briefing pages for 46 land use- and transportation-related measures; 25 of these measures are derived from sections of the *Planning Guide*, while the remaining 21 briefs provide information on additional transportation-related measures that are not specifically identified in the *Planning Guide*. The website also summarizes estimates of the effectiveness of individual measures described in the briefings, as well as the cost-effectiveness of each measure; these estimates were derived from the Moving Cooler report, a comprehensive analysis of the potential to reduce energy use from national adoption of many land use- and transportation-related measures.

Chapter 1 of this report provides the layout used for each briefing of the 46 measures included on the website. Chapters 2 through 8 present additional information that is not currently included in the *Energy Aware Planning Guide*, that will be incorporated into the website. Chapter 9 provides information on additional resources for cities and counties on reducing the energy use of local transportation systems.

CHAPTER 1: Layout of Briefings of Measures to Reduce Transportation-Related Energy Included in the Website for the *Energy Aware Planning Guide*

This chapter provides the layout used for each briefing of the 46 measures included on the website. Each measure has its own webpage, which generally follows the layout of this chapter. If the measure is included in the *Planning Guide*, there are links to the appropriate sections of the html version of the *Planning Guide*. Any additional information not in the *Planning Guide* that was deemed useful to city and county governments is included in the briefings on the website, and in Chapters 2 through 8 of this report.

Chapters 2 through 8 present additional information that is not currently included in the *Energy Aware Planning Guide*, that will be incorporated into the website. Chapters 2 through 4 present the additional information on the Land Use, Transportation, and Community Energy measures, respectively, that are already included in the *Energy Aware Planning Guide.* Chapters 5 through 8 provide information on additional Transportation, Freight, Intelligent Transportation System, and Pricing measures, respectively, not included in the *Planning Guide.*

Name of Measure

The website includes 25 measures that are specifically identified in the *Energy Aware Planning Guide*, as well as an additional 21 transportation-related measures not identified in the *Planning Guide*. The *Energy Aware Planning Guide* summarizes 23 specific land use and transportation strategies for local governments to reduce energy use. Some of these strategies were combined, and some were separated into specific measures, for the website, based on the authors' judgment. The additional 21 measures not specified in the *Planning Guide* were developed based upon a review of the literature.

SUMMARY

This section is a brief summary of the measure, taken verbatim from the Energy Aware Planning Guide, if applicable.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

This section includes effectiveness (in million metric tons of greenhouse gas emissions reduced) and cost-effectiveness (in dollars per ton of greenhouse gas emissions reduced) estimates, which are calculated using cumulative greenhouse gas emission reductions and direct implementation costs by 2050, from the *Moving Cooler* study released by the Urban Land Institute in 2009. These estimates are national estimates, and are presented here to show the relative values of individual measures; the estimated results will not necessarily be realized in each California city or county that adopts the measure. For example, the current distribution of transportation emissions by economic sector, travel mode, and population density is different in the US than in California. And California may already have more widespread adoption of certain measures than the US average, so the potential emission reductions from further adoption of those measures in California will be different than estimated in *Moving Cooler*.

Implementation costs in *Moving Cooler* are the estimated cumulative cost to implement each strategy, including capital, maintenance, operations, and administrative costs. *Moving Cooler* also estimates the savings from forgoing vehicle and fuel purchases if certain measures are adopted; these savings are not shown here. Note that the cost-effectiveness estimates shown in the figures are the total costs of the measure divided by the reduction in GHG emissions. Many of the measures have additional, often large, co-benefits, which if included would make the measures more cost-effective.

It is important to note that the results shown for individual measures cannot be added together to estimate the cumulative impact of combining measures. *Moving Cooler* estimates the synergistic impact of six logical combinations, or "bundles", of measures: near-term/early results, long-term/maximum results, land use/transit/nonmotorized transportation, system and driver efficiency, facility pricing, and low cost. The impact of these six bundles is discussed in Chapter 4 of *Moving Cooler*.

Estimates under the three scenarios developed in *Moving Cooler* are included in the table: Expanded Current Practice; Aggressive Deployment Scenario, and Maximum Deployment Scenario.

- The Expanded Current Practice Scenario assumes expansion of current trends and state of innovation. This level of deployment assumes that the strategies are expanded and steadily implemented, consistent with existing practices for reducing GHG emissions, and focusing predominantly on major metropolitan areas.
- The Aggressive Deployment Scenario assumes faster, broader, and stronger implementation. Strategies are implemented sooner, more broadly, and more intensively. For example, pricing strategies would be implemented in a wide range of metropolitan areas, and requirements would be established for the penetration of PAYD in all 50 states.
- The Maximum Deployment Scenario assumes comprehensive, rapid, and intense implementation. At this level, substantial policy changes and significantly increased levels of investment—consistent with a singular commitment to reduction in GHGs—are assumed to implement strategies at very high levels of intensity nationwide.

Under each table there is a short summary of the assumptions used for the measure in the *Moving Cooler* report, as well as the pages that give more information on the modeling (Appendix B) and cost (Appendix C) assumptions.

Three figures, comparing the effectiveness and cost-effectiveness of each measure in *Moving Cooler*, are included on the website. Each figure shows the estimates under the three scenarios described above, and groups the measures into one of four categories:

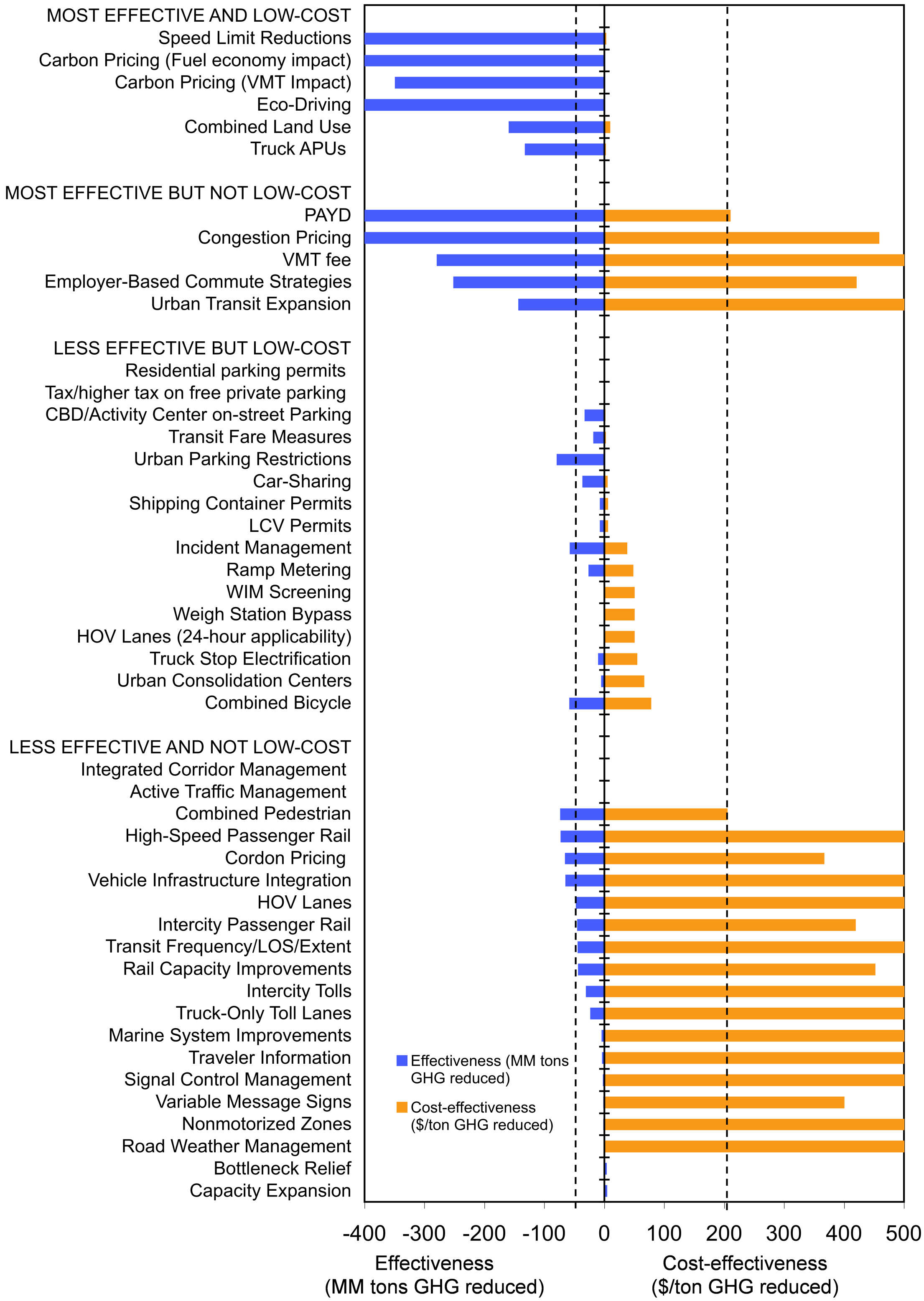
- Most effective and low-cost: >100 MM ton reduction and <$100/ton reduced
- Most effective but not low-cost: >100 MM ton reduction
- Less effective but low-cost: <$100/ton reduced
- Less effective and not low-cost: <100 MM ton reduction and >$100/ton reduced

Each figure shows the median effectiveness and cost-effectiveness of all the measures included in *Moving Cooler*. The cost-effectiveness of the measures can also be compared with the cost of carbon reduction across all sectors of the economy. CARB assumes a cost of carbon of $20 to $60 per metric ton, while federal agencies assume a social cost of carbon ranging from $5 to $65 per metric ton in their regulatory analyses. Clicking on the title of each measure in these figures on the website takes the user to the briefing description for that particular measure.

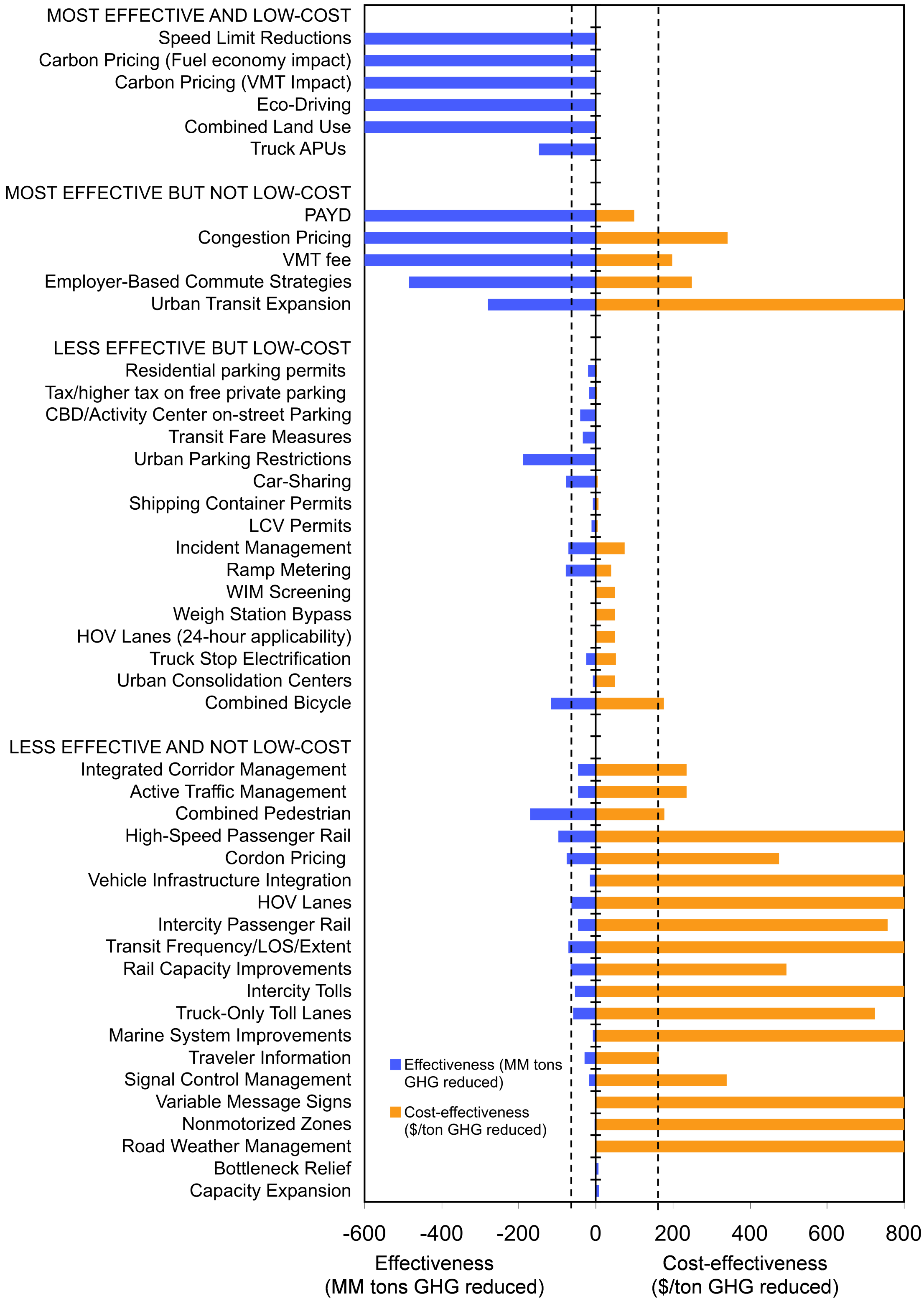
Slightly different versions of each figure are shown below.

The national estimates from *Moving Cooler* will eventually be replaced with estimates for California, perhaps based on an ongoing PIER study by UC Berkeley (Deakin and Schipper).

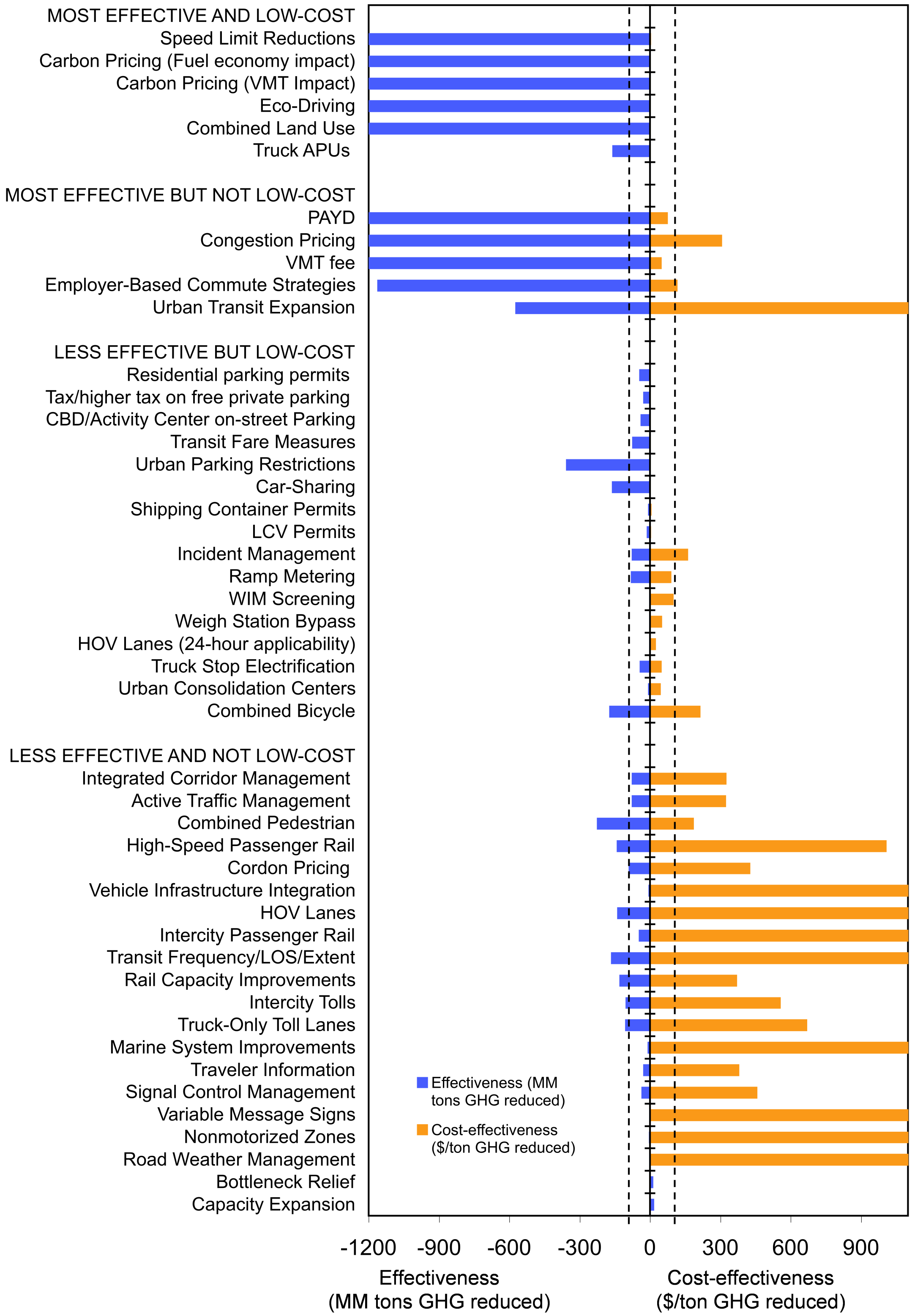
Moving Cooler estimates of effectiveness and cost-effectiveness of specific measures, Expanded Current Practice scenario



Moving Cooler estimates of effectiveness and cost-effectiveness of specific measures, Aggressive Deployment scenario



Moving Cooler estimates of effectiveness and cost-effectiveness of specific measures, Maximum Deployment scenario



Other Findings

Findings on effectiveness and cost from other research on the particular measure, that is not included in the *Energy Aware Planning Guide*, is summarized in this section.

Equity and Co-benefits

Findings regarding equity impacts and co-benefits of the measure are included in this section. Equity impacts are mostly taken from Appendix E of the *Moving Cooler* report.

POLICY CONTEXT

Existing regulations/policies

Any existing local, state, or federal regulations or policies that promote the specific measure are summarized here.

Implementation level

The jurisdictional level at which the measure can be implemented (state, regional, county, or city government) is listed.

Population density required

The population density necessary to make the measure effective (urban, suburban or rural) is listed here.

Implementation Details

This section gives additional details on how the measure can be implemented.

Model policy language

Specific language to include the measure in general plans is included here. This language is generally taken from the the 2008 report *CEQA & Climate Change*, and the 2009 report *Model Policies for Greenhouse Gases in General Plans*, both published by the California Air Pollution Control Officers Association (CAPCOA).

Model ordinances

Specific language for ordinances to encourage the adoption of the measure is included here. This model ordinances are generally taken from the the 2008 report *CEQA & Climate Change*, and the 2009 report *Model Policies for Greenhouse Gases in General Plans*, both published by the California Air Pollution Control Officers Association (CAPCOA). Where possible, links to specific ordinances adopted by governments are included.

Case studies

Examples of how these measures have been implemented in cities and counties are included here. Many of the case studies are already included in the *Energy Aware Planning Guide.*

RESOURCES

Energy Aware chapter and

Cross-references to other measures in Energy Aware

A link to the chapter for the measure, and chapters for related measures, in the html version of the *Energy Aware Planning Guide* are included here.

Other resources

Links to other resources, such as briefings by the California Air Resources Board, the Victoria Transport Policy Institute, are listed here.

CHAPTER 2:
Website Briefings of Land Use Measures in *Energy Aware Planning Guide*

Smart Growth Development

SUMMARY

Smart growth is a term used for compact, mixed-use developments where it is easy to get around on foot, bicycle, or by transit. Creating these types of environments can be an effective method of reducing greenhouse gas emissions and driving. Environments that mix commercial and residential land uses and put people within walking, bicycling or mass transit distance of their destinations can reduce driving by 20 to 40 percent.

A smart growth environment can be created by applying the “5 D’s”—density, diversity, design, destination, and distance to transit. However, a development may be subject to additional considerations and unique challenges depending on its context—whether the development is in an urban area, an industrial area, a commercial area, etc.

Density is the concentration of jobs or homes in a community or designated area. Higher densities are associated with shorter distances between destinations, leading to shorter trips and greater use of walking and bicycling.

Diversity refers to the mix of land uses in a given community or area and the balance of jobs, housing, shop ping, schools, and other daily needs and services. Greater land use diversity puts more destinations within a convenient walking or bicycling distance.

Design refers to the interconnectedness of the street network in a community and can be measured in terms of intersection density, sidewalk completeness, block size, and other factors that combine to determine how walkable a community is and how far one destination is from another—whether travel is by car, foot, bike, or transit.

Destination refers to a community's accessibility in the larger city or region and how connected it is to other centers of activity.

Distance to Transit is about the level and type of transit service in a community and is measured as the distance from home or work to the nearest rail or bus stop.

Cities can use knowledge of the Ds to assess development proposals and to look for opportunities to enhance walk ability, livability, accessibility and health.

KEY NUMBERS

Effectiveness and Cost/Effectiveness

Moving Cooler’s “combined land use strategies” combines aspects of three land use measures in Energy Aware (Smart Growth, Land Use Diversity, and Transit Oriented Development).

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Combined Land Use	160	865	1445	$9	$2	$1
Moving Cooler medians	45	59	83	$205	$163	$116

At least 43, 64, and 90 percent of new development in compact, pedestrian- and bicycle-friendly neighborhoods with high-quality transit.

Modeling Assumptions: *Moving Cooler* page B-16 to B-23
Cost Assumptions: *Moving Cooler* page C-13 to C-17

Other Findings

In 2009 a Joint Committee of the National Research Council and Transportation Research Board reviewed15 years of studies. Although they did not reach full agreement on the magnitude of compact development on driving behavior, they did conclude that "the most reliable studies estimate that doubling residential density across a metropolitan area might lower household VMT by 5 to 12 percent, and perhaps by as much as 25 percent, if coupled with higher employment concentrations, significant public transit improvements, missed uses, and other supportive demand management measures." National Research Council. 2009. *Driving and the Built Environment: the effects of compact development on motorized travel, energy use, and CO2 emissions.* August 2009.

Winkelman et al 2009 summarize current research findings on the expanding market for smart growth and its implications for reduced infrastructure costs and other economic benefits, reduced overall household expenses in addition to other social benefits.

The most recently published statistical meta-analysis on land use effects on transportation choice, a review of 20 years of research, concludes that "Consistent with prior work, …VMT is most strongly related to measures of accessibility to destinations, and secondarily to street network design variables. Walking is most strongly related to measures of land use diversity, intersection diversity (fewer 4-way intersections), and the number of destinations within walking distance. Bus and train use are equally related to proximity to transit and street network design variables, with land use diversity a secondary factor. Surprisingly, we find population and job densities to be only weakly associated with travel behavior once these other variables are controlled." [Ewing and Cervero, 2010]

Researchers have questioned whether neighborhood design in itself affects travel behavior, or whether households with lower than average VMT choose to live in dense neighborhoods, the so-called "self-selection" effect. A review of the self-selection literature finds evidence of statistically significant associations between the built environment and travel behavior, independent of self-selection influences." One half to 98% of the difference in vehicle miles driven is due to direct environmental influences such as neighborhood type, with self-selection being a significant but secondary factor. "Using travel diary data from northern California, Cao 2010 reported that on average, neighborhood type accounted for 61% of the observed effect on recreational walking"; Bhat and Eluru in 2009 found that 87% of VMT differences between conventional suburban and traditional urban neighborhoods is due to built environment, with only 13% attributable to self-selection. (Ewing and Cervero 2010, p. 266-267)

Portland, OR has documented the effects of 30 years of smart growth policies. Winkelman et al 2009 report that "while national VMT per capita grew by 8 percent, between 1990 and 2007 in the Portland-Vancouver region VMT per capita fell by 8 to 10 percent. During this same time, the region brought its GHG emissions back to 1 percent above 1990 levels by 2008, while population grew by 14 percent and the region grew as an economic center."

Litman provides an exhaustive and updated review of relevant implementation findings, best practices, and case studies. A minimum of 2000 persons per square mile, or 12 housing units/acre and employment centers with at least 50 jobs per acre are needed to support basic transit and have an effect on VMT. These figures are higher than earlier studies which looked at the density levels required to support transit. (Litman, 2010a).

Changes in local land use factors (neighborhood density, mix, design, etc.) can reduce per capita vehicle travel 10 to 20%, while regional land use factors (location of development relative to urban areas) can reduce automobile travel 20-40% compared with overall national average values at existing development standards. (Brownstone and Golob, 2009)

Three additional factors, development scale (the number of population and jobs), household demographics, and transportation demand management programs, also can affect the VMT and GHG reductions for specific projects. (Fehr & Peers 2010)

Equity and Co-Benefits

Combined land use and smart growth strategies offer modest to strong positive equity impacts on both low-income and inner-area populations by bringing jobs, retail, and health care closer, reducing travel times and costs, particularly for individuals who may not have reliable access to private automobiles. These policies also could increase housing costs which may be offset by policies allowing increased densities and smaller units and possible decreased transportation costs if car-use and ownership can be reduced. (*Moving Cooler*, pages E-26, E-31, and E-55.)

Residents of Portland pay 7% less in household transportation expenses than the national average, despite having comparable incomes.

To mitigate rising housing prices and impact on lower-income households, SB375 requires integration of 20% housing affordable to moderate income households; 10% low-income; 5% very low-income into new development, or contributions to a housing mitigation fund by developers.

Residents of transit-rich areas are more likely to meet minimum healthy activity levels daily, and are less likely to be obese, which translates to lower risk of related diseases, and contributing economic benefits to the individual and employers.

POLICY CONTEXT

Existing regulations/policies

Link to *Energy Aware Planning Guide*

Implementation level

City, County, Regional

Density Required

Urban, suburban

Implementation Details

Every community will implement smart growth development projects in ways that respond to what is already in place; existing context will also affect the amount of GHG reductions that are likely or possible.

Under SB375 regional GHG emission reduction targets are being established by the California Air Resources Board, with extensive input from regional planning agencies. [See http://www.arb.ca.gov/cc/sb375/rtac/report/092909/finalreport.pdf].

Regional planning data on current land use trends "business as usual" and where available, new sustainable community targets can be found at http://www.arb.ca.gov/cc/sb375/data/data.htm.

Regional targets should be released in September, 2010, and should be announced here: http://www.arb.ca.gov/cc/sb375/sb375.htm

Local communities can sign on to get updated on regional targets here: http://www.arb.ca.gov/cc/sb375/rtac/rtac.htm

Model Policy Language

Energy Aware provides specific model policy language in
L.1.2 Land Use Diversity
L1.3 Transportation Oriented Development
L.1.4 Design Sites for Pedestrian and Transit Access;
L.3.1 Complete Streets and Street Design,

CAPCOA. 2009. Model Policies. California Association of Pollution Control Officers. http://www.capcoa.org/wp-content/uploads/downloads/2010/05/CAPCOA-White-Paper.pdf

Land Use and Urban Design

LU-1.1 Urban Growth Boundary
LU-1.3 Infill
LU-1.5 Density
LU-1.6 Road Width
LU-1.7 Parking Spaces
LU-1.8 Bicycle Facilities
LU-1.9 Levels of Service
LU-2.1 Mixed-Use Development
LU-3.1 Housing Overlay Zones
LU-3.2 Transit-Oriented Development
LU-3.3 Transit-oriented Brownfield Development
LU-3.4 Public Transit Development Focus
LU-3.5 City-centered Corridors
LU-3.6 Transit-oriented Development Design Standards
LU-3.7 Affordable Housing
LU-4.1 Pedestrian oriented Character
LU-4.2 Pedestrian Access
LU-5.1 Developer Fees
LU-5.2 Admin Fees & Streamlining
LU-5.3 Incentives & Loans
LU-5.4 Infrastructure Preference

CAPCOA. 2008. CEQA and Climate Change. California Association of Pollution Control Officers. http://www.capcoa.org/wp-content/uploads/downloads/2010/05/CAPCOA-ModelPolicies-6-12-09-915am.pdf

Commercial & Residential Building Design Measures

MM-D-1 Office/Mixed Use Density
MM-D-2 Orientation to Existing/Planned Tranist, Bikeway or Pedestrian Corridor
MM-D-3 Services Operational
MM-D-4 Residential Density (sufficient to support public transit)
MM-D-5 Street Grid
MM-D-6 NEV Access
MM-D-7 Affordable Housing Component
MM-D-8 Recharging Areas
Mixed Use Development Measures
MM-D-9 Urban Mixed Use
MM-D-10 Suburban Mixed Use

MM-D-11 Other Mixed Use
MM-D-12 Infill Development
MM-D-17 Landscaping and Trees
MM-D-19 Community Gardens

Model Ordinances:

American Planning Association:
http://myapa.planning.org/smartgrowthcodes/pdf/chapter4.pdf

4.1—Model Mixed-Use Zoning District Ordinance
4.2—Model Live/Work Ordinance
4.3—Model Town Center Ordinance
4.4—Model Affordable Housing Density Bonus Ordinance
4.5—Model Unified Development Permit Review Process Ordinance
4.6—Model Transfer of Development Rights Ordinance
4.7—Model Cluster Development Ordinance
4.8—Model Pedestrian Overlay District (POD)
4.9—Model On-Site Access, Parking, and Circulation Ordinance
4.10—Model Shared Parking Ordinance
4.11—Model Street Connectivity Standards Ordinance

Orenco Station, a high impact transit village in Hillsboro, OR. Case study detailed in Energy Aware.
http://www.ci.hillsboro.or.us/Planning/htmlzonevol2/ZORD2Section140.I-II.aspx

Sacramento and San Diego have adopted strong smart growth regional planning. Although no complete evaluation of emissions exists, model forecasts and smaller scale evaluations document reduced VMT over "business as usual" trends.

City of Sacramento Smart Growth "Infill Strategy"
http://www.cityofsacramento.org/dsd/planning/division-infill/index.cfm

SACOG, Regional smart growth plan for Sacramento region
http://www.sacregionblueprint.org/sacregionblueprint/the_project/Blueprintspecialreport.pdf

A national site with links to a variety of zoning code documents for greenfields brownfields, redevelopment:
http://www.smartcommunities.ncat.org/greendev/codes.shtml#landuse

Case Studies

Portland introduced an urban growth boundary in the early 1980s, following that up over the last 3 decades with a strong and varied set of transportation and land use interventions including reduced transportation expenses for the average household over the last 20 years. Portland residents pay on average 7% less of their household budgets for transportation (and not significantly higher housing or other costs) as compared to national figures, or other west coast cities. http://library.oregonmetro.gov/files/co2_reduction_better_urban_desgn3.pdf

ICLEI's profile of Portland long-term strategies and its recently approved 2009 Climate Action Plan which costs only $20,000 a year to implement. --
http://www.iclei.org/index.php?id=9330

Vista, San Diego County, is updating its existing downtown specific plan to allow for much higher residential densities than envisioned in the original 1993 plan. Six projects (2 already approved will add increased residential densities and mix use around three transit stations.

Updated downtown specific plan emphasizes higher residential densities, higher quality commercial uses, and better pedestrian and bicycle connections. http://www.ca-ilg.org/node/1620

Other Multiple California case studies from the Local Institute for Government are at: http://www.ca-ilg.org/node/1659 -

RESOURCES

Energy Aware Chapter

Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware

L.1.2 Land Use Diversity
L1.3 Transportation Oriented Development
L.1.4 Design Sites for Pedestrian and Transit Access;
L.3.1 Complete Streets and Street Design,
L3.2 Trees,
L4.1 Bikeways,
L.4.2 Bicycle Parking and Facilities,
L.4.3 Pedestrian Facilities and Traffic Calming

Center for Creative Land Recycling – brownfields development project planning and financing resource: http://www.cclr.org/

Other resources

California Air Resources Board research on SB 375 implementation:
http://www.arb.ca.gov/cc/sb375/policies/density/resdensity.pdf
http://www.arb.ca.gov/cc/sb375/policies/density/resdensitybkgd.pdf
http://www.arb.ca.gov/cc/sb375/policies/transitaccess/transitaccess.pdf
http://www.arb.ca.gov/cc/sb375/policies/transitaccess/transitaccessbkgd.pdf

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Ewing, R. and Cervero, R. 2010. *Travel and the Built Environment – A Meta-Analysis*. Journal of the American Planning Association, Summer 2010, Vol. 75, No. 3.

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http://www.capcoa.org/wp-content/uploads/downloads/2010/05/CAPCOA-ModelPolicies-6-12-09-915am.pdf

Land Use Diversity

SUMMARY

Increasing land use diversity through mixing of land uses shortens the distance between origins and destinations, thereby encouraging less energy intensive transportation modes such as walking, biking, or public transit.

A quick assessment of land use diversity can be had by visiting www.walkscore.com. The website calculates "walkability" for any site based on the mix of non-housing destinations nearby.

Land use diversity, also known as mixed use or clustered development, has an effect on VMT that is independent of density.

KEY NUMBERS

Effectiveness and Cost Effectiveness

Moving Cooler's "combined land use strategies" combines aspects of three land use measures in Energy Aware (Smart Growth, Land Use Diversity, and Transit Oriented Development).

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Combined Land Use	160	865	1445	$9	$2	$1
Moving Cooler medians	45	59	83	$205	$163	$116

At least 43, 64, and 90 percent of new development in compact, pedestrian- and bicycle-friendly neighborhoods with high-quality transit.

Modeling Assumptions: *Moving Cooler* page B-16 to B-23
Cost Assumptions: *Moving Cooler* page C-13 to C-17

Other Findings

Land use diversity seems to be especially sensitive to issues of measurement and scale. Early meta-analysis of studies found mixed evidence of the relationship between land use diversity and VMT, concluding "Dense, mixed-use developments in the middle of nowhere may offer only modest regional travel benefits." (Ewing and Cervero (2001) cited in LFC 2008)

More recent meta-analysis document independent effects (Leck 2006; NRB, 2009; Ewing and Cervero 2010). For example, a meta-analysis of 18 studies confirmed the primary significance of residential density, but also found that the influence of mixed land use on travel to be "overwhelmingly" significant. These latter findings derived from 3 to 5 studies only. However, residential density is the most important built environment element which influence travel choices. Employment density was also significantly connected with fewer VMT and total vehicle trips, with a lower probability of commute by auto, but not of reduced travel times. Source: Leck, E. 2006. *The Impact of Urban form on Travel Behavior: a Meta-analysis.* Berkeley Planning Journal, vol. 19, 2006. Pp. 37-58.

Local land use mix does have a significant effect in reducing VMT, after taking into account larger scale factors such as distance to downtowns and major employment centers. One study found that VMT is most strongly related to the accessibility to destinations, and, to a lesser extent, to design aspects of the street network. On the other hand, walking is most strongly related to land use diversity, intersection diversity, and the number of destinations within walking distance. Bus and train use are equally related to proximity to transit and street network design, with land use diversity only a secondary factor. [Ewing and Cervero, 2010]

Changes in local land use factors (neighborhood density, mix, design, etc.) can reduce per capita vehicle travel 10-20%, while regional land use factors (location of development relative to urban areas) can reduce automobile travel 20-40% compared with overall national average values at existing development standards. [Brownstone and Golub, 2009)

Two extensive studies in the Seattle area (LFC2005a; LFC 2005b) also found that land use mix and street connectivity were better predictors of travel behavior than density. (LFC 2005b, p. 154).

Creating local clusters of mixed-use residential and commercial development around transit centers is more successful than mixed-use transit corridors or mixed-use neighborhoods not well-connected to transit. "Increased land use mix tends to reduce per capita vehicle travel, and increase use of alternative modes, particularly walking for errands. Neighborhoods with some kind of land use mix typically have 5-15% lower vehicle-miles than single use districts. Clustering [See Table 3: Travel Impact of Land Use Design Features,TDM Encyclopedia entry "Clustered Land Use): http://www.vtpi.org/tdm/tdm81.htm

Mixed use areas show reduced VMT and transit use independent of (though somewhat less than) that of residential density alone. "find that infill and compact development and mixing of land uses are both inversely related to VMT at the .05 probability level. Their coefficients predict that the presence of infill and compact development in the model pushes regional VMT 1.5% below trend and the presence of land-use mixing or mixed-use development pushes regional VMT 4.6% below trend after controlling for other variables. [Bartholomew and Ewing, 2009]

In a detailed analysis of destinations and walking behavior, Moudon (2006) states that "the walkable neighborhood seems geographically contained within a 1-km circle, an area smaller than 500 acres (2 km2)." Other studies which have examined land use mix at a fine-grained level such as this have found mix consistently significant in explaining VMT (Other original sources cited in LFC 2008)

A regression analysis of 90,000 home prices in 15 markets found that a 1-point increase in the "walk score" increased home prices by $500 to $3000. The walk score is based on how many destinations are located within a short distance (generally between one- quarter mile and one mile) of a home. [Cortright, 2009; Hilliard, 2010]

Equity and Co-Benefits

Reduced transportation costs and greater access to jobs without a car may offset higher housing costs; greater local options for safe walking and biking can improve health; reduced traffic can increase safety for low-income and inner-urban area populations of all incomes. Poor air quality and related health problems associated with living near high traffic corridors should be offset by ongoing increases in fuel standards and reductions in CO_2 emissions from fewer vehicle miles traveled overall.

Combined land use and smart growth strategies offer modest to strong positive equity impacts on both low-income and inner-area populations by bringing jobs, retail, and health care closer, reducing travel times and costs, particularly for individuals who may not have reliable access to private automobiles. These policies also could increase housing costs which may be offset by policies allowing increased densities and smaller units and possible decreased transportation costs if car-use and ownership can be reduced. (*Moving Cooler*, pages E-26, E-31, and E-55.)

Residents of transit-rich areas are more likely to meet minimum healthy activity levels daily, and are less likely to be obese, which translates to lower risk of related diseases, and contributing economic benefits to the individual and employers.

POLICY CONTEXT

Existing regulations/policies

State Housing Density Bonus Law - California Government Code Section 65915 - . Developers can increase the # of units over local density standards up to 35% over local standards by incorporating a minimum of 15% of below-market rate ("affordable") and renting or selling them to income qualified households. Senior housing also qualifies. The housing must remain affordable to qualifying households for 30 years. http://www.hcd.ca.gov/hpd/hrc/bonus.pdf

http://www.livableplaces.org/policy/densitybonus.html

Implementation Level

Cities, Counties

Population Density

Urban, Suburban, Rural (creating mixed-use clusters can occur at any scale and is independent of population density).

Implementation details

Link to Energy Aware

Model Policy Language

Link to Energy Aware

CAPCOA. 2009. Model Policies for Greenhouse Gases in General Plans, Chapter 6:
LU-2.1 Mixed-Use Development (pp 84-85); [contains many details]
LU-3.1 Housing Overlay Zones, (p. 86]
LU 3.2 Transit-Oriented Mixed-Use policies. (pp 87-89)

CAPCOA 2008 CEQA and Climate Change --- Mitigation Measures:
Commercial & Residential Building Design Measures

MM-D-1 Office/Mixed Use Density
MM-D-4 Residential Density (sufficient to support public transit)
MM-D-7 Affordable Housing Component

Mixed Use Development Measures

MM-D-9 Urban Mixed Use
MM-D-10 Suburban Mixed Use
MM-D-11 Other Mixed Use
MM-D-12 Infill Development
MM-D-17 Landscaping and Trees
MM-D-19 Community Gardens

Model ordinances

Fremont, CA Mixed Use Ordinance.

County of San Diego Density Bonus Program
http://www.sacog.org/projects/form-based-codes.cfm

La Mesa, CA Mixed Use Overlay Zone (Ch. 24.18, La Mesa Municipal Code).

Shared Parking

San Diego, CA Municipal Code Ch. 14, Article 2, Division 5 Parking Regulations - See Table 142-05D in sec. 142.053 and sec. 145.0545 on shared parking.

San Diego, CA Shared Parking Agreement.

Live-Work

Larkspur, CA Ordinance No. 940 - Conditional use in commercial and industrial districts.

Sonoma County, CA Proposed Work/Live Uses.

Petaluma, CA Purposed Building/Fire Policy for Live/Work Units.

San Francisco Planning Code Article 8, Mixed Use Districts (See sec. 813, 814, 815, 816, 817, and 818 and related tables).

San Francisco Budget Office - Industrial Protection Zones, Live/Work Projects and Community Plans, (problems with live work); Interpretations by Code Section – San Francisco Planning Code.; SF Resolution No. 0209-02 - Interim Zoning Controls – Live/Work Moratorium

Case Studies

San Diego (San Diego County)-- City of Villages concept that directs future growth to mixed-use communities that are pedestrian friendly and linked to regional transit. Some of the city's oldest malls, for example, are being planned for new mixed-use neighborhoods, including one whose redevelopment plan was approved by the city council and accepted into the LEED-ND (Neighborhood Development) pilot program. *San Diego "City of Villages" Strategy (*http://www.ca-ilg.org/node/1619)

Petaluma (Sonoma County *Central Petaluma Specific Plan*

Nearly 60 percent of Petaluma's greenhouse gas emissions are from transportation –almost twice the statewide average. The Central Petaluma Specific Plan concentrates development downtown in order to improve residents' ability to use transit and link to regional transportation network. http://www.ca-ilg.org/node/1640

Provide incentives and remove zoning and other barriers to mixed-use and higher intensity development at transit nodes and along transit corridors (existing and planned).

www.ca-ilg.org/ClimatePractices

(www.ca-ilg.org/ClimateLandUseStories):

Fremont Transit Oriented Development Overlay Zones

Sacramento County General Plan Update

Vista Downtown Specific Plan

Livermore Zoning Code Update

Petaluma General Plan 2025

Windsor Area Plans & Zoning Update

http://www.ca-ilg.org/ClimateTransportationStories

Other resources

Form Based Codes Institute, http://www.formbasedcodes.org.

American Planning Association model ordinances:
http://myapa.planning.org/smartgrowthcodes/

Municipal Research and Services Center of Washington offers model policies and codes related to transportation http://www.mrsc.org/Subjects/Transpo/transmain.aspx and mixed-use policies and codes in various U.S. cities, including specific information on parking reduction and work-live units. http://www.mrsc.org/Subjects/Transpo/MixedUse.aspx

More California case studies: *www.ca-ilg.org/ClimatePractices*

RESOURCES

Energy Aware Chapter

Link to Energy Aware

Cross-references to other measures in Energy Aware

L.1.1 Smart Growth Development
L.1.3 Transit-Oriented Development
L.1.4 Design Sites for Pedestrian and Transit Access
L.3.1 Complete Streets & Street Design
L.4.1 Bikeways
L.4.2 Bicycle Parking and Facilities
L.4.3 Pedestrian Facilities and Traffic Calming
T.2.1 Transportation Demand Management Programs

Other Resources

California Air Resources Board research on SB 375 implementation:
http://arb.ca.gov/cc/sb375/policies/policies.htm

www.walkscore.com.

This View of Density:
http://www.sflcv.org/density/index.html
An online tool for estimating community emissions and vmt. Based on neighborhood density, auto use, and land use mix.

VTPI. TDM Encyclopedia.
Clustered Land Use http://www.vtpi.org/tdm/tdm81.htm
Evaluating Transportation Land Use Impacts: http://www.vtpi.org/landuse.pdf
Location Efficient Mortgages: http://www.vtpi.org/tdm/tdm22.htm
New Urbanism: creating clustered mixed-use neighborhoods
http://www.vtpi.org/tdm/tdm24.htm
Land Use Density and Clustering: http://www.vtpi.org/tdm/tdm81.htm
Smart Growth: http://www.vtpi.org/tdm/tdm38.htm
Commercial Centers: http://www.vtpi.org/tdm/tdm117.htm
Smart Growth Reforms: http://www.vtpi.org/tdm/tdm95.htm
Location Efficient Development: http://www.vtpi.org/tdm/tdm22.htm
Transit Oriented Development: http://www.vtpi.org/tdm/tdm45.htm

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Bartholomew and Ewing, R.. *Land Use-Transportation Scenario Planning and Future Vehicle Travel and Land Consumption: A MetaAnalysis* (2009)
http://www.scag.ca.gov/pptac/pdfs/other/JAPA_LUTS.pdf

Brownstone, D. and Golub, T. 2009. "The Impact of Residential Density on Vehicle Usage and Energy Consumption," *Journal of Urban Economics*; at www.economics.uci.edu/~dbrownst/JUESprawlV3final.pdf

Cortright, J. 2009. How Walkability Raises Home Values in U.S. Cities. Impresa, Inc., for CEOs for Cities. August 2009 http://blog.walkscore.com/wp-content/uploads/2009/08/WalkingTheWalk_CEOsforCities.pdf

Hilliard, L.M. 2010. Rethinking California's Planning Frameworks to Support SB 375: A White Paper on Local, Regional, State and Federal Climate Change Policy Reform, Masters Thesis. University of California at Davis, March, 2010. http://regionalchange.ucdavis.edu/projects/teachingregionalism/Final%20UCD%20MS%20Thesis_Hilliard.pdf

Lawrence Frank and Company, Inc. (LFC), 2008. Reducing Global Warming And Air Pollution: The Role Of Green Development In California. Prepared for Environmental Defense Fund. www.edf.org/documents/8046_ISR-CO2review-FINAL-070208.pdf

Litman, Todd, with Rowan Steele. 2010. *Land Use Impacts On Transportation: How Land Use Factors Affect Travel Behavior*. Victoria Transport Policy Institute. http://www.vtpi.org/landtravel.pdf

Transportation Research Board. *Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions* (2009)

Update on SACOG – smart growth regional plan: http://www.sacregionblueprint.org/sacregionblueprint/the_project/Blueprintspecialreport.pdf

Transit Oriented Development

SUMMARY

Transit-oriented development (TOD) is the term used to describe moderate- to high-density development that incorporates a mix of land uses, compact design, pedestrian- and bike-friendly environments, and public and civic spaces around the hub of a transit station, or along a transit corridor. "Transit-ready development" refers to development that has the same characteristics as TOD, but is instead oriented toward planned or potential corridors and service.

While sites across all development conditions can be supported by transit, TOD specifically focuses new housing and jobs in the area one-quarter to one-half mile from a major transit station to encourage transit ridership and promote the creation of active neighborhoods.

In response to its many benefits and growing market demand, TOD has been on the rise across the country. Opportunities still abound, though, since many major transit stations in California are, as of yet, surrounded by existing parking lots and low-density, auto-oriented development.

By placing more housing and employment near existing and planned rail transit stations and express bus stops, more people are likely to use transit and walk to the station, rather than drive.[1] The intended result of successful TOD implementation means a higher share of transit use for those living in and around the TOD, a dynamic destination for residents, shoppers and employees, and reduced energy footprint through compact development. When coupled with other transportation demand management strategies such as parking and management policies, this could also mean reduced vehicle miles traveled and lower vehicle ownership. In an ideal situation, TOD should lead to value recapture for the site, a financial return for the developer, and increased residential choice.[2]

KEY NUMBERS

Effectiveness and Cost Effectiveness

Moving Cooler's "combined land use strategies" combines aspects of three land use measures in Energy Aware (Smart Growth, Land Use Diversity, and Transit Oriented Development).

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Combined Land Use	160	865	1445	$9	$2	$1
Moving Cooler medians	45	59	83	$205	$163	$116

At least 43, 64, and 90 percent of new development in compact, pedestrian- and bicycle-friendly neighborhoods with high-quality transit.

Methodology and Assumptions – -*Moving Cooler* page B-16 to B-23
Cost Assumptions: *Moving Cooler* page C-13 to C-18

Other Findings

Distance to transit is a consistent statistical indicator for predicting reduced VMT second to distance to downtowns and major employment centers and measures of connectivity of street intersections. "Consistent with prior work, …VMT is most strongly related to measures of accessibility to destinations, and secondarily to street network design variables... Bus and train use are equally related to proximity to transit and street network design variables, with land use diversity a secondary factor. [Ewing and Cervero, 2010]

Transit stations in the center of surrounding development generate the largest impact., but transit corridors also influence surrounding residents and workers. “Neighborhoods with some kind of land use mix typically have 5-15% lower vehicle-miles than single use districts. Clustering [See Table 3: Travel Impact of Land Use Design Features,TDM Encyclopedia entry “Clustered Land Use): http://www.vtpi.org/tdm/tdm81.htm

California Air Resources Board (ARB) concluded that TOD and other smart growth land use strategies could reduce emissions by at least 10-20 percent in suburban communities and by at least 20-30 percent in central cities. Caltrans (DOT). 2002.

A TOD centered household could consume 250 - 380 fewer gallons of gasoline each year, on average, and emit 2.5 - 3.7 tons less CO_2 yearly than its non-TOD counterpart. Caltrans (DOT). 2002

Multiple meta-analyses, since 1991, have documented VMT savings from smart growth development projects, including TOD. The very latest research review for CARB, [Boarnet and Handy, 2010-Draft] finds strikingly similar range of results to previous meta-analyses. Controlling for sociodemographic and other land use factors (mix, connectivity, walkability), a 1% increase in density of an area can reduce VMT .05 to .12%.

The self-selection critique has been studied as well; there is significant numbers of people who choose to live near transit in order to use it; these people may be politically active and therefore support furthering of the smart growth principles. However, for those not self-selecting there is still an effect on VMT and vehicle ownership. The extent of each, and the interaction effects (social learning among neighbors, exogenous factors such as rise in gas prices, policy interventions such as change in parking) are not yet fully understood. [Boarnet and Handy (2010-draft)]

Using 2000 household travel survey data, the Bay Area Station Area Residents Survey (STARS) grouped subjects into six categories based on proximity to a rail/ferry station and population density of the area surrounding the household. The study found that: people living close to a transit station are four times as likely to use transit; people that live and work close to transit use transit even more; the highest commute trip transit share was found for people who work in San Francisco but live in another county; households near transit are more likely to not own a vehicle, live in smaller households without children, and twice as likely to walk for short trips. http://www.mtc.ca.gov/planning/smart_growth/stars/index.htm

A comparative analysis of 17 TOD projects found consistent and statistically reductions in VMT, with an average of 3.8 trips (44% fewer trips than expected). A subsequent study of parking in 15 TOD projects in Portland and 16 in the Bay Area found no evidence that TOD households consistently own fewer cars, however. The study recommended that carsharing programs be integrated into TOD, as has been done in Zurich successfully, to give more opportunity for households to go without a second or any private car. Cervero 2008,

Early advocates of Transit Oriented Development reported TOD generally required at least 6 residential units per acre in residential areas and 25 employees per acre in Commercial Centers. Later best practices and modeling calls for about two times those figures for premium quality transit, such as rail service (Pushkarev and Zupan, 1977; Ewing, 1999; Cervero, et al, 2004; Reconnecting America and the CTOD, 2008) as cited in VTPI, TDM Encyclopedia: TOD]

Equity and Co-benefits

Combined land use and smart growth strategies offer modest to strong positive equity impacts on both low-income and inner-area populations by bringing jobs, retail, and health care closer, reducing travel times and costs, particularly for individuals who may not have reliable access to private automobiles. These policies also could increase housing costs which may be offset by policies allowing increased densities and smaller units and possible decreased transportation costs if car-use and ownership can be reduced. (*Moving Cooler*, pages E-26, E-31, and E-55.)

Residents of Portland pay 7% less in household transportation expenses than the national average, despite having comparable incomes.

Rising housing prices and redevelopment of existing housing stock to make way for new TOD projects may cause relocation of lower-income inner city residents into more remote but now cheaper outlying areas with fewer services. [See Pendall et al. 2010.] Bringing Equity to Transit-Oriented Development: Stations, Systems, and Regional Resilience Paper presented at *Urban and Regional Policy and its Effects*, Washington, DC, May 21, 2010 - Draft requests – Pending Permission to Cite -- Do Not Cite. http://www.gwu.edu/~gwipp/Pendall%20--%20TODequity_pengainlowenguy_0510.pdf

Residents of transit-rich areas are more likely to meet minimum healthy activity levels daily, and are less likely to be obese, which translates to lower risk of related diseases, and contributing economic benefits to the individual and employers.

Increased VMT and more buses may worsen air quality along commercial corridors, where concentrations of low-income households such as seniors and young families with children are likely to live in multi-family housing.

POLICY CONTEXT

Existing regulations/policies

TOD, as with other smart growth measures, is the focus of multiple policy initiatives, both regulatory and incentive based at federal and California state levels, regional and local levels.

The Obama administration launched a multi-agency initiative (EPA, DOT, and HUD) Partnership for Sustainable Communities in 2009, to help communities–rural, suburban and urban–gain better access to affordable housing, more transportation options, and lower transportation costs. Information on planning grants, other funding and resources available here: http://www.contextsensitivesolutions.org/content/topics/livability/

The California Transit Village Development Planning Act of 1994 and AB 1320 passed in 2004 encourage TOD statewide. Affordable housing tax credits are now awarded competitively, with more points awarded for projects close to transit, parks and other amenities.

Caltrans http://www.dot.ca.gov/hq/tpp/ has established goals and standards for locationally efficient siting and other land use aspects of "smart mobility." http://www.dot.ca.gov/hq/tpp/offices/ocp/smf_files/SmMblty_v6-3.22.10_150DPI.pdf

To mitigate rising housing prices and impact on lower-income households, SB375 requires developers integrate 20% housing affordable to moderate income households; 10% low-income; 5% very low-income, or that they add significant open space, or contribute to a housing mitigation fund.

Certain transportation projects can receive public funding priority and exemption or streamlining under CEQA if they meet requirements set out in SB375. To quality for Transportation Priority Projects Funding under SB375, projects must have a minimum net density of at least 20 units per acre; and be within a half mile of a major transit stop (existing or planned), or a "high quality" transportation corridor. [CAPCOA 2009, p. 25-26]

Regional GHG reduction targets are likely to be set by the CEC in Sept. 2010 under AB32; regional metro planning and transportation agencies (MPOs) and Air Districts will carry out these targets.

Some regional agencies have launched their own TOD initiatives. See for example:

MTC Resolution 3434 and ongoing study of Transportation Oriented Development
http://www.mtc.ca.gov/planning/smart_growth/tod/TOD_policy.pdf

Implementation level
Cities; Counties

Population Density
Urban, Suburban, Rural

Implementation Details
Link to *Energy Aware Planning Guide*

Model Policy Language
CAPCOA 2009 Model Policy Language

LU-2.1.1 Site Specific Standards
LU-3.6 Transit-oriented Development Design Standards

CAPCOA 2008 Mitigation Measures

TOD numerous related mitigation measures including:
MM T-4 Proximity to Bike Path/Bike Lanes
MM T-6 Pedestrian Barriers Minimized
MM T-7 Bus Shelter for Existing/Planned Transit Service
MM T-12 Pedestrian Pathway Through Parking
MM T-13 Off-Street Parking
MM T-14 Parking Area Tree Cover
MM D-2 Orientation to Existing/Planned Transit Bikeway or Pedestrian Corridor

Model ordinances
Portland TOD Zoning Code #33.450.010
(www.planning.ci.portland.or.us/zoning/ZCTest/400/450_Transit.pdf)

Sacramento Regional Transit: A Guide to Transit-Oriented Development, Draft Final, April 13, 2009.

Case Studies
While Fremont is a largely built-out suburban community, it has targeted remaining undeveloped and under-utilized sites for high density, mixed use, and transit-oriented development.. Future development targeted for sites near existing or future Bay Area Rapid Transit (BART) stations; TOD policies encourage densities up to 75 units per acre.

Mountainview, CA Whisman Station Precise Plan, 2005.

Nearly 60 percent of Petaluma's greenhouse gas emissions are from transportation – almost twice the statewide average. The Central Petaluma Specific Plan concentrates development downtown in order to improve residents' ability to use transit and link to regional transportation network. *Central Petaluma Specific Plan*; http://www.ca-ilg.org/node/1640

Cochrane Village is an affordable housing development located in Morgan Hill Ranch Business Park. In the late 1980s the business park struggled to find business occupants, in part because of the high cost of housing for employees. As a result, businesses, local government and a non-profit developer worked together to build 96 apartments and town houses, a playground and daycare facility within the office park, located with convenient access to retail shops.

Case studies of "Station Area" projects in Bay Area communities:
http://www.mtc.ca.gov/planning/smart_growth/tod/index.htm

Washington State - King County TOD Program
(www.metrokc.gov/kcdot/alts/tod/todindex.htm)

Other Resources

Reconnecting America and its main program, the Center for Transit Oriented Development has the latest research, case studies, and reviews of best practices, updated regularly:
http://www.reconnectingamerica.org/public/practices

Sacramento's Transit-Oriented Development Plan a Model for the Nation, Christopher B. Leinberger, Brookings Institute, March 18, 2009.

VTPI. *Transit Oriented Development - Using Public Transit to Create More Accessible and Livable Neighborhoods*. TDM Encyclopedia. Victoria Transport Policy Institute. Last updated June 2010. -- Exhaustive and frequently updated review of the latest research and case studies of TOD at different scales and time periods across the country.

Portland, Oregon Transit Oriented Development (www.trimet.org/inside/publications/sourcebook.htm)

http://www.epa.gov/smartgrowth/j - federal policies, funding programs and other resources in support of TOD and related smart growth/clean energy initiatives by local cities and counties.

RESOURCES

Energy Aware Chapter

Link to Energy Aware

Cross-references to other measures in Energy Aware

L1.1 Smart Growth Development
L.1.2 Land Use Diversity
L.1.4 Design Sites for Pedestrian and Transit Access
L.3.1 Complete Streets and Street Design
L.4.3 Pedestrian Facilities and Traffic Calming
T.2.1 Transportation Demand Programs
T.2.5 Carsharing

Other Resources:

California Air Resources Board research on SB 375 implementation:
http://www.arb.ca.gov/cc/sb375/policies/transitaccess/transitaccess.pdf
http://www.arb.ca.gov/cc/sb375/policies/transitaccess/transitaccessbkgd.pdf
http://arb.ca.gov/cc/sb375/policies/policies.htm

Victoria Transportation Policy Institute (*VTPI). TDM Encyclopedia.*
Transit Oriented Development: http://www.vtpi.org/tdm/tdm45.htm
Clustered Land Use http://www.vtpi.org/tdm/tdm81.htm
Evaluating Transportation Land Use Impacts: http://www.vtpi.org/landuse.pdf
Location Efficient Mortgages: http://www.vtpi.org/tdm/tdm22.htm
New Urbanism: creating clustered mixed-use neighborhoods
http://www.vtpi.org/tdm/tdm24.htm
Land Use Density and Clustering: http://www.vtpi.org/tdm/tdm81.htm
Smart Growth: http://www.vtpi.org/tdm/tdm38.htm
Commercial Centers: http://www.vtpi.org/tdm/tdm117.htm
Smart Growth Reforms: http://www.vtpi.org/tdm/tdm95.htm

Location Efficient Development: http://www.vtpi.org/tdm/tdm22.htm

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[Boarnet, M and Handy, S. May 9, 2010. "DRAFT Technical Background Document on the Impacts of Residential Density Based on a Review of the Empirical Literature. Accessed at:

www.arb.ca.gov/cc/sb375/policies/density/resdensitybkgd.5.9.pdf, May 15, 2010.]

Cervero, R. and Arrington, G. 2008. Vehicle Trip Reduction Impacts of Transit-Oriented Housing. Journal of Public Transportation, Volume 11, No. 3, 2008 ISSN 1077-291 [STUDY OF 17 TOD Projects; half in California --- MOST RECENT EVALUATION]

Ewing, R. and Cervero, R. 2010. *Travel and the Built Environment – A Meta-Analysis*. Journal of the American Planning Association, Summer 2010, Vol. 75, No. 3. – LATEST META-ANALYSIS

VTPI. Transit Oriented Development - *Using Public Transit to Create More Accessible and Livable Neighborhoods. TDM Encyclopedia*. Victoria Transport Policy Institute

CAPCOA 2009 Model Policy Language for Greenhouse Gas Reductions

CAPCOA. 2008. CEQA and Climate Change.

Design Sites for Pedestrians and Transit Access

SUMMARY

Strategy L.1.1 discussed the five D's of smart growth and highlighted how urban design features can contribute to higher rates of walking, bicycling, and transit use. This section focuses specifi cally on improving building site design to ensure convenient pedestrian and transit access. Street design is covered in strategy L.3.1 Complete Streets and Street Design.

To encourage pedestrian access, buildings should be adjacent to the street with minimal setbacks (no more than 10-15 feet for commercial and mixed-use or 20-25 feet for residential), rather than behind large parking lots. Primary entrances should open to the street and be located as close as possible to transit stops. Parking should be placed behind or to the side of the building to avoid impeding pedestrian access, and driveway widths should be minimized and sited so as to conflict as little as possible with pedestrian traffic. Ground floor uses facing the street should be "active" uses as much as possible (such as retail or community uses) and should be mostly transparent (e.g., windows, display cases) rather than blank walls facing the street.

Pedestrians and those accessing transit also benefit from good infrastructure (e.g., sidewalks and walkways), and a pleasant and safe walking environment. Strategy L.4.3 Pedestrian Facilities provides more detail.

Site design for new development should be consistent and facilitate with those measures in T. Complete Streets and Street Design, Transit Service Improvements, and Pedestrian Facilities for more details.

Transit stop design, including security, information and maintenance should be integral elements of transit-friendly sites. Transit operators and patrons may have different perspectives on priorities and crucial elements to encourage more active use.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler estimates that a combination of "smart growth" land use policies can reduce greenhouse gas emissions by 2% (at expanded current practice) to 6% (at maximum levels of deployment) of all identified reductions nationally, by 2050.

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Combined Land Use	160	865	1445	$9	$2	$1
Combined Pedestrian	74	171	227	$205	$178	$186
Combined Bicycle	59	117	176	$78	$176	$214
Moving Cooler medians	45	59	83	$205	$163	$116

Expanded Current Practice: At least 43% of new development is in compact, pedestrian- and bicycle-friendly neighborhoods with high-quality transit [i.e. in areas >=4000 persons/square mile] to reach the lowest reduction levels.

Moving Cooler estimates that a combination of "smart growth oriented" land use policies can reduce greenhouse gas emissions by 2% (at expanded current practice) to 6% (at maximum levels of deployment) of all identified reductions nationally, by 2050.

Modeling Assumptions: *Moving Cooler* page B-16 to B-23
Cost Assumptions: *Moving Cooler* page C-13 to C-17

Equity and Co-benefits

Moving Cooler does not have an equivalent measure, but based on its logic, Site design improvements in low income and minority neighborhoods will have greater equity benefits than improvements serving wealthier areas, as will public or community-serving buildings such as city hall, health clinic, libraries, and schools. Restricted environments such as private shopping centers or hotel complexes with security guards may overtly discourage the obviously indigent, or teenagers for example.

New transportation investments have been criticized for focusing on expensive technological improvements, or in high cost rapid transit (light rail) systems or Bus Rapid Transit in the hopes of drawing more middle class riders instead of improving conditions for transit-dependent users. "Ordinary" bus stops and surrounding pedestrian facilities that improve "Safe Routes to Transit" can be overlooked bus stops in many urban areas as an afterthought; in some cases only high traffic areas have actual shelters, lighting, or benches, because these stops are managed by ad companies. Neither bus company nor local government may "own" their own stops, despite their widespread presence, and potential as a pedestrian amenity.

Some populations, including the disabled, elderly, non-English speakers, and parents with children, and women desire and benefit from extra measures such as active security patrols, or designated waiting areas, to feel safe and fully enabled to wait for transit without fear of harassment or space conflicts.

Transit dependent populations are less likely to have access or ready/consistent access to web-based transportation information systems.

Thoughtfully designed bus stops, particularly when integrated into the security orbit of surrounding buildings, can help overcome barriers, real and perceived, that marginalizes bus riders and the systems they depend on.

Rail, bicycle and pedestrian users and advocates are more often middle-class and able to articulate their needs in public forums. That has not been true of bus riders; in most areas, a majority of bus riders, especially during non-commute hours are very low-income. Improving bus stops, particularly cleanliness, and lighting, affects passengers sense of being valued and respected by their community.

Advertising on buses and bus stops, can make passengers uncomfortable about how they are perceived since other types of public services do not carry advertising. [Dahlgren and Morris 2005]

POLICY CONTEXT

Existing regulations/policies

See Transit-Oriented Development

Implementation level

City, County, Regional Agencies

Population density required

Urban, Suburban, Rural

Implementation Details

A survey of bus stops and 1000 riders in Santa Clara County found that simple cost-effective measures are highly valued by bus passengers: a clean, well-lit (especially at night clear-sided shelter with up-to-date schedule information are the most common findings as to rider preferences. *Bus stops* should be located on the far side of intersections or at mid block locations in front of storefronts if possible, or close to buildings rather at the far end of a fringe parking lots. [Dahlgren & Morris 2004]

Multiple studies (see also Transit Level of Service Brief) find that real time information on the next bus also increases a sense of security, and reduces perceived waiting time (even when buses are late).

Model policy language

CAPCOA 2009 Model Policy Language

LU-2.1 Mixed-Use Development
LU-2.1.1 Site Specific Standards
LU-3.2.7 Redevelopment Incentives for parking lots
LU-3.2.8 Pedestrian/Bicycle Connectivity
LU-3.4.2 Links to Transit Stops
LU-3.6 Transit-oriented Development Design Standards
LU-4.1.4 Pedestrian Only Streets/Plazas
LU-4.1.6 Continuous Separated Sidewalks
LU-4.1.7 Bike/Walk Paths to Parks
LU-4.2 Pedestrian Access
LU-4.2.1 Connectivity of Development
LU-4.2.4 Entrances to New Development
LU-4.2.5 Location of Driveways
LU-4.2.6 Street Parking as Buffer
LU-4.2.7 Develop Pedestrian Connectors

CAPCOA 2008 Mitigation Measures

MM T-4 Proximity to Bike Path/Bike Lanes
MM T-6 Pedestrian Barriers Minimized
MM T-7 Bus Shelter for Existing/Planned Transit Service
MM T-12 Pedestrian Pathway Through Parking
MM T-13 Off-Street Parking
MM T-14 Parking Area Tree Cover
MM D-2 Orientation to Existing/Planned Transit Bikeway or Pedestrian Corridor

Model ordinances

Link to *Energy Aware Planning Guide*

Case studies

Link to *Energy Aware Planning Guide*

RESOURCES

Energy Aware chapter

Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware

L1.1 Smart Growth Development
L.1.2 Land Use Diversity
L.1.3 Transit-Oriented Development
L.3.1 Complete Streets and Street Design
L.4.3 Pedestrian Facilities and Traffic Calming

Other resources

California Air Resources Board research on SB 375 implementation: http://arb.ca.gov/cc/sb375/policies/policies.htm

VTPI: Streetscaping - http://www.vtpi.org/tdm/tdm122.htm

Universal Design

Universal Design refers to facility designs that accommodate the widest range of potential users, including people with disabilities and other special needs. Universal Design supports accessibility, community cohesion and equity objectives.

Evaluation researchers [Renne, 2008; Jefferson and Forsyth, 2008] have identified the need to include future users and a range of stakeholders in the design process, for both performance and political benefits.

Jefferson and Forsyth [2008] reviewed the literature on TOD design principles, and identify both shared principles and gaps. They then empirically analyzed seven American, TOD projects in terms of urban design and performance in meeting project goal. They provide twelve principles cataloged under Processes, Place-making, and Facilities. These draw on both the literature on TOD and the empirical work in their own study. It gives a quick critique in 2 California projects (Fruitvale Transit Village and 12th Street City Center BART station) in Oakland. For example, they note that segregating transit parking from the public and commercial areas of the site has hampered retail success.

Jefferson, J. and Forsyth*, A. Good practices for urban design in Transit-Oriented Development,* Journal of Transport and Land Use 1:2 (Fall 2008) pp. 51–88 Available at http://jtlu.org

https://www.jtlu.org/index.php/jtlu/article/viewFile/67/34 -- Review of TOD planning and evaluation literature and design evaluation/checklists.

TDM Encyclopedia Transit Station Improvements and Improving Public Transit. Updated January 2010. http://www.vtpi.org/tdm/tdm127.htm010

Additional Sources:

Dahlgren, J. and Morris, B. 2005. *Advanced Bus Stops for Bus Rapid Transit*, Institute of Transportation Studies, University Of California, Berkeley, UCB-ITS-PRR-2005-6.

Jefferson, J. and Forsyth*, A. Good practices for urban design in Transit-Oriented Development,* Journal of Transport and Land Use 1:2 (Fall 2008) pp. 51–88 Available at http://jtlu.org

Leck, E. 2006. The Impact of Urban Form on Travel Behavior: A *Meta-Analysis*. Berkeley Planning Journal, Volume 19. Winter 2006.

Reconnecting America (2008), *TOD 202: Station Area Planning: How To Make Great Transit-Oriented Places*, Reconnecting America (www.reconnectingamerica.org); at www.reconnectingamerica.org/public/download/tod202.

Michael Smart, Mark A. Miller and Brian D. Taylor (2009), "Transit Stops and Stations: Transit Managers' Perspectives on Evaluating Performance," *Journal of Public Transportation*, Vol. 12, No. 1, pp. 59-77; at www.nctr.usf.edu/jpt/pdf/JPT12-1.pdf.

TCRP (2009), *Literature Review for Providing Access to Public Transportation Stations*, TCRP Web-Only Document 44, Transit Cooperative Research Program, TRB (www.trb.org); at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_webdoc_44.pdf.

ICLIE has a number of measures in the CAPPA tool related to TOD site specific design and potential effects on GHG.

Freight Movement Time and Location Restrictions

SUMMARY

Time and location restrictions can be used to reduce traffic congestion and make freight operations more efficient, resulting in reductions in energy consumption and emissions.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler does not estimate the effectiveness or cost of this particular measure.

Other Findings

Some findings can be seen in a review of nighttime delivery restrictions in Europe.[1] In particular the review focuses on restrictions imposed by a local planning authority at the point of delivery. Some important results of the review include that:

1) Policy makers should consider the incremental effects of shifting timing restrictions by different durations, and in turn surveys of stakeholders should be designed in accordance.
2) Not all grocery store deliveries are likely to be shifted due to restrictions, since stores require some daytime replenishment.
3) There are many costs and benefits to a variety of stakeholders, such as retailers, shoppers, local residents and other drivers.
4) The effects of delivery time restrictions can greatly differ by factors such as street type, proximity to housing, store size, and ratio of selling to non-selling space.

Another study has investigated the impact of time windows on energy, GHGs and costs for freight operators in Belgium.[2] Results indicate that time windows can in fact increase GHG emissions along with costs. Therefore the reaction of logistics operators to potential time windows should be carefully considered.

During the early 1990s a proposal was debated in Southern California over whether or not to ban trucks during peak hours from highways. The proposal was rejected. One of the main reasons was that the restriction on heavy trucks was expected to result in increased use of smaller vehicles, which in turn would increase tailpipe emissions and energy consumption.[3]

Although nighttime policies are typically thought to be beneficial for the environment, it has been shown for examples in the San Francisco Bay Area that such policies can increase 24-hour diesel exhaust concentrations and human intake.[4] This would occur, since the atmosphere is more stable during the nighttime then the daytime. However, policies that shift freight from the morning commute period to the night are more likely to be beneficial.

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1 M. Browne, J. Allen, S. Anderson and A. Woodburn, 2006. Night-Time Delivery Restrictions: A Review. Recent Advances in City Logistics pp. 245-258 Elsevier.

2 H. J. Quak and R. de Koster, 2009. Delivering Goods in Urban Areas: How to Deal with Urban Policy Restrictions and the Environment. Transportation Science, 43(2), 211-227.

3 J. Campbell, 1995. Using Small Trucks to Circumvent Large Truck Restrictions: Impacts on Truck Emissions and Performance Measures. Transportation Research A, 29(6), 445-458.

[4] 4 N. Sathaye, R. Harley and S. Madanat, 2009. Unintended environmental impacts of nighttime freight logistics activities. Transportation Research A, In Press.

A study of off-peak freight operations in New York City found that charges to induce off-peak freight operations would have to be very high.[5] This is a result of the fact that carriers would spread the charge across multiple receivers. This conclusion is represented through a derivation of necessary conditions for receivers and carriers to agree to conduct off-peak operations. Instead of pricing being imposed on carriers, the paper proposes tax incentives to receivers willing to accept deliveries during off-peak hours, combined with freight road pricing as a revenue generating mechanism to finance the incentives.

Equity and Co-benefits

Truck routes and off-peak deliveries can generally help reduce local environmental impacts, however policy makers must make sure that trucks do not make their trips closer to sensitive populations.

POLICY CONTEXT

Existing regulations/policies

CalTrans office of truck services provides some information on truck routes.[6]
California's AB2650 encourages off-peak port operations to reduce truck idling.[7] AB2650 also encourages appointment systems as an alternative.

Implementation level

Region, county, or city

Population density required

Urban, suburban or rural

Implementation Details

Link to *Energy Aware Planning Guide*

Model policy language

Link to *Energy Aware Planning Guide*

Model ordinances

Link to *Energy Aware Planning Guide*

Case studies

The PierPASS program has been implemented at Port of Los Angeles and Long Beach (http://www.pierpass.org/).[8] A fee is charged for cargo movement between the hours of 3am and 6pm Monday through Friday. Five additional shifts were added to allow for operations outside these hours. These are Monday through Thursday from 6pm to 3am, and on Saturday from 8am to 6pm.

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5 J. Holguin-Veras, 2008. Necessary conditions for off-hour deliveries and the effectiveness of urban freight road pricing and alternative financial policies in competitive markets. Transportation Research A, 42(2), 392-413.

6 CalTrans Office of Truck Services. http://www.dot.ca.gov/hq/traffops/trucks/#2 Accessed 6/16/2010.

7 G. Giuliano and T. O'Brien, 2007. Reducing port-related truck emissions: The terminal gate appointment system at the Ports of Los Angeles and Long Beach. Transportation Research Part D, 12(7), 460-473.

8 PIERPASS. http://www.pierpass.org/ Accessed 6/16/2010.

RESOURCES

Energy Aware chapter

Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware

Regional smart growth policies to balance goods movement with urban residential development. Smart growth policies focus on concentrating residential development in dense urban centers to facilitate transit access, pedestrian and bicycle use, job-housing balances, and lower vehicle miles traveled (see strategies L.1.1 Smart Growth Development, L.1.2 Land Use Diversity, L.1.3 Transit-Oriented Development, and L.1.4 Design Sites for Pedestrian and Transit Access).

Other resources

Victoria Transport Policy Institute, Freight Transport Management: http://www.vtpi.org/tdm/tdm16.htm

Freight Villages

SUMMARY

In many California communities, especially those near ports or intermodal centers, motor vehicle-based freight traffic makes up a significant share of roadway traffic. By improving the efficiency of freight movement, communities can reduce energy consumption and help address other environmental problems including air pollution and global warming.

Rail and marine modes generally emit fewer greenhouse gas emissions per freight ton-mile, making the shift from trucks to these modes beneficial. This shift can be facilitated by enhanced rail and marine infrastructure and intermodal transfer facilities, and use of software that selects modes and routes in order to minimize greenhouse gas emissions.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Rail Capacity Improvements	44	66	131	$452	$494	$370
Marine System Improvements	5	8	12	$800	$1000	$1475
Moving Cooler medians	45	59	83	$205	$163	$116

Rail Capacity Improvements: Capacity restrictions are reduced by some percent by 2025.
Marine System Improvements: Maintain and restore the system.

Modeling Assumptions: *Moving Cooler* page B-71 to B-72
Cost Assumptions: *Moving Cooler* page C-47 to C-48

Other Findings

A life-cycle assessment of road, rail and air freight transportation in the United States has been conducted. The results account for emissions associated with the entire supply-chain for each mode including fuel combustion, fuel production, vehicle production, maintenance and salvage, and infrastructure construction and maintenance.[9] Per ton-mile emissions are shown to be lowest for rail and highest for air.

Equity and Co-benefits

One study provides estimates of the external costs of rail versus trucks for intercity freight movement[10] The conclusion is that the external costs of truck transport per ton-mile are much higher than that for rail.

POLICY CONTEXT

Existing regulations/policies

None identified

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9 C. Facanha and A. Horvath, 2007. Evaluation of Life-Cycle Air Emission Factors of Freight Transportation. Environmental Science and Technology, 41(20), 7138-7144.

10 D. Forkenbrock, 2001. Comparison of external costs of rail and truck freight transportation. Transportation Research Part A, 35(4), 321-337.

Implementation level

Policies are likely to implemented at the regional level.

Population density required

These policies are likely to implemented on the outskirts of metropolitan areas.

Implementation Details

Link to *Energy Aware Planning Guide*

Model policy language

CAPCOA: Locate shipping-intensive land uses in areas with rail access. Some modes of shipping are more GHG-intensive than others. Rail, for example, requires only about 15 to 25 percent of the energy used by trucks to ship freight equivalent distances and involves reduced transportation-related GHG emissions. Cities and counties have little direct control over the method of shipment that any business may choose. Nevertheless, as a part of the general planning process, cities and counties can address constraints on the use of rail for transporting goods. This policy language would likely be found in the Land Use and Circulation Elements.

Model ordinances

None identified

Case studies

The Alameda Corridor is a freight rail route that transports cargo from the Ports of Los Angeles and Long Beach to Downtown Los Angeles.[11]

RESOURCES

Energy Aware chapter

L.1.5. Transportation Demand Management Programs

Cross-references to other measures in Energy Aware

Regional smart growth policies to balance goods movement with urban residential development. Smart growth policies focus on concentrating residential development in dense urban centers to facilitate transit access, pedestrian and bicycle use, job-housing balances, and lower vehicle miles traveled (see strategies L.1.1 Smart Growth Development, L.1.2 Land Use Diversity, L.1.3 Transit-Oriented Development, and L.1.4 Design Sites for Pedestrian and Transit Access).

Other resources

Victoria Transport Policy Institute, Freight Transport Management:
http://www.vtpi.org/tdm/tdm16.htm

11 Alameda Corridor Transportation Authority. http://www.acta.org/

Urban Consolidation Centers

SUMMARY

Freight traffic presents a unique set of challenges for local government planners, particularly in California, where the Ports of Los Angeles, Long Beach, and Oakland handle some of the largest volumes of freight traffic in the country.

In many California communities, especially those near ports or intermodal centers, motor vehicle-based freight traffic makes up a significant share of roadway traffic. By improving the efficiency of freight movement, communities can reduce energy consumption and help address other environmental problems including air pollution and global warming.

Urban consolidation centers have previously been divided into three types:[12]

1. Special Projects: these are used for non-retail purposes, such as the delivery of construction materials across a city.
2. Single sites with one landlord: these have typically been at large facilities such as airports and malls
3. Service to a town or city: these centers are typically on the outskirts of the served region, and service businesses across the region

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Expanded Current Practices Deployment forecast in 2050 (*Moving Cooler* Table 4.1)

	Effectiveness (mmt GHG reduced)			**Cost-effectiveness ($/ton GHG reduced)**		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Urban Consolidation Centers	6	8	9	$67	$50	$44
Moving Cooler medians	45	59	83	$205	$163	$116

Establish in large urban areas.

Modeling Assumptions: *Moving Cooler* page B-77
Cost Assumptions: *Moving Cooler* page C-54

Other Findings

None identified

Equity and Co-benefits

Urban consolidation centers have no significant equity impacts.

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

This is likely to implemented by larger cities, counties or at the regional level.

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12 M. Browne, M. Sweet, A. Woodburn and J. Allen, 2005. Urban Freight Consolidation Centres Final Report. Transport Studies Group, University of Westminster.

Population density required

Urban, suburban

Implementation Details

Urban Freight Consolidation Centers – A facility, generally on an urban area's periphery where ground freight shipments from diverse origins are consolidated into a single processing center for all destinations in the city and surrounding area. Potential benefits include increasing load factors of vehicles making end destination deliveries, reducing the number of deliveries received at the end destinations, reducing unnecessary time and fuel consumption, reducing out-of-stock situations, and making urban areas more pedestrian- and bicycle-friendly.

Model policy language

None identified

Model ordinances

None identified

Case studies

A review of 100 urban consolidation centers has been conducted by researchers in the United Kingdom with multiple case studies.[13] These case studies are predominantly in European countries, and a few are in Japan and the U.S. The reviewed studies used a variety of metrics for assessing consolidation centers, such as changes in the number of vehicle trips, km traveled, number of vehicles used, travel time, goods delivered at a point, vehicle load factor, unloading/loading time and frequency, fuel consumed, emissions, and operating costs.

The Binnenstadservice,nl consolidation center is in Nijmegen, Netherlands. It differs from past initiatives in that it focuses on carriers instead of receivers.[14]

RESOURCES

Energy Aware chapter

L.1.5. Transportation Demand Management Programs

Cross-references to other measures in Energy Aware

Regional smart growth policies to balance goods movement with urban residential development. Smart growth policies focus on concentrating residential development in dense urban centers to facilitate transit access, pedestrian and bicycle use, job-housing balances, and lower vehicle miles traveled (see strategies L.1.1 Smart Growth Development, L.1.2 Land Use Diversity, L.1.3 Transit-Oriented Development, and L.1.4 Design Sites for Pedestrian and Transit Access).

Other resources

Victoria Transport Policy Institute, Freight Transport Management: http://www.vtpi.org/tdm/tdm16.htm

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13 M. Browne, M. Sweet, A. Woodburn and J. Allen, 2005. Urban Freight Consolidation Centres Final Report. Transport Studies Group, University of Westminster.

14 Van Rooijen, T, H. Quak, 2009. Binnenstadservice.nl –A New Type of Urban Consolidation Centre. Association for European Transport and contributors.

Parking Pricing

SUMMARY

The cost of parking heavily influences whether people drive alone, rideshare, or use transit, particularly when going to work every day. Reducing the amount of free parking and adjusting pricing policies for both public and private parking spaces can help to tip the balance toward increased ridesharing, transit, walking and cycling. Under California law, companies that pay for employee parking must offer the equivalent in cash to non-parkers.[15]

Parking pricing and parking supply work in combination. Parking pricing is easiest to implement where parking supply is limited, and is most effective as an environmental strategy if a large proportion of the parking supply is priced. Otherwise, travelers may be able to avoid fees by parking elsewhere.[16] Areas with priced parking can thrive if they are vibrant, attractive areas for people to live, work, and play – which can be supported by minimizing the amount of land devoted to surface parking lots. As a result, achieving priced parking – outside of a few existing employment/activity centers such as the city's central business district (CBD) – should be part of a regional land use strategy to focus growth in compact, mixed-use activity centers where parking can be managed and good alternative transportation services made available.

Parking pricing strategies include using smart curbside meters to vary parking prices according to demand, providing parking cash out programs to government employees and encouraging employers to provide, and taxing currently free private parking.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler estimates the effectiveness and cost of three measures that affect the price of parking: Charging for CBD on-street parking, residential parking permits, and taxing free parking.

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Charge for on-street parking in CBD/Activity Center	33	41	42	$2	$1	$1
Residential parking permits	NA	20	48	NA	$3	$1
Tax private parking that is currently free	NA	18	31	NA	$3	$2
Moving Cooler medians	45	59	83	$205	$163	$116

Assumes parking fees would be charged for all parking in central business districts (CBD), employment areas, and retail centers to encourage "park once" behavior or reduce single occupant trips. Other approaches include the introduction of taxes or higher fees on otherwise free private parking lots and parking management approaches, including requirements for residential parking permits, as well as permits for delivery and service vehicles and for visitors. The expanded current practice scenario is for pricing parking starting in 2015, complete in 8

15 Revenue and Taxation Code Sections 17503, 23605, 24343.5

16 ODOT. 2000. "Traffic Relief Options Study" Technical Appendix. Salem: Oregon Department of Transportation and Metro; As cited in TRB. 2004. TCRP 95, Chapter 13: Parking Pricing and Fees. Washington: Transportation Research Board.

years for LH and MH metropolitan areas. Starting in 2020 for LL, ML, SH, and SL metropolitan areas.

Modeling Assumptions: *Moving Cooler* page B-9
Cost Assumptions: *Moving Cooler* page C-8

Other Findings

Link to *Energy Aware Planning Guide*

Equity and Co-benefits

Moving Cooler estimates in the expanded best practice scenario that Parking Pricing (combined with land use, transit, operations, equity analysis) will have modest negative equity impacts on low-income groups – reduced access to jobs, health care, education, and retail. As deployed more aggressively, the negative equity impacts increase from modest to strong under the maximum effort scenario.

POLICY CONTEXT

Existing regulations/policies

Federal Highway Administration has a value pricing pilot program under SAFETEA-LU to encourage implementation and evaluation of value pricing pilot projects to manage congestion on highways through tolling and other pricing mechanisms. This is the only program that provides funding to support studies and implementation aspects of a tolling or pricing project. The program is limited to 15 slots (which FHWA has reserved for "states") of which only one vacancy remains. Each state can have multiple projects.

CARB Employer Parking Cash Out- State law requires certain employers who provide subsidized parking for their employees to offer a cash allowance in lieu of a parking space. The intent of the law is to reduce vehicle commute trips and emissions by offering employees the option of "cashing out" their subsidized parking space and taking transit, biking, walking or carpooling to work. For years, negative tax implications limited the implementation of the law. But in 1998, federal legislation fixed this problem. (http://www.arb.ca.gov/planning/tsaq/cashout/cashout.htm)

-CARB "An Informational Guide for Employers" (http://www.arb.ca.gov/planning/tsaq/cashout/cashout_guide_0809.pdf)

Implementation level

City or county.

Population density required

Urban or suburban.

Implementation Details

Link to *Energy Aware Planning Guide*

Model policy language

TR-5.1 Parking Policy: The City/County will adopt a comprehensive parking policy to discourage private vehicle use and encourage the use of alternative transportation CAPCOA, page 87.
TR-5.3 Parking Cash-out program. The City/County will require new office developments with more than 50 employees to offer a Parking "Cash-out" Program to discourage private vehicle use. CAPCOA, page 88.

Model ordinances

5.1.3 "Unbundle" parking (require that parking is paid for separately and is not included in the base rent for residential and commercial space);
5.1.4 Use parking pricing to discourage private vehicle use, especially at peak times;
5.1.5 Create parking benefit districts, which invest meter revenues in pedestrian infrastructure and other public amenities;
5.1.6 Establish performance pricing of street parking, so that it is expensive enough to promote frequent turnover and keep 15 percent of spaces empty at all times;

CAPCOA, page 87.

Case studies

As of 2009 FHWA was funding five parking pricing projects, including two in California:
San Francisco (http://tinyurl.com/35etcar)
San Diego (http://tinyurl.com/34wfj3o)
Minnesota (http://tinyurl.com/345x7ls)
New York (http://tinyurl.com/3ywnogy)
Washington (http://tinyurl.com/2uwhjwx)

RESOURCES

Energy Aware chapter

Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware

Link to *Energy Aware Planning Guide*

Other resources

California Air Resources Board research on SB 375 implementation:
http://www.arb.ca.gov/cc/sb375/policies/pricing/parkingpricing.pdf
http://www.arb.ca.gov/cc/sb375/policies/pricing/parkingpricingbkgd.pdf

Victoria Transportation Policy Institute: http://www.vtpi.org/tdm/tdm26.htm

Parking Supply Management

SUMMARY

The price, quantity, and location of parking have a direct impact on travel behavior as well as the characteristics and quality of an area's development. Because parking availability and prices strongly affect how travelers make transportation decisions, management and pricing of parking can be a powerful tool for reducing vehicle miles traveled (VMT), greenhouse gas (GHG) emissions, and automobile dependence, and increasing the use of ridesharing, transit, bicycling and walking.

Most cities approve zoning ordinances that set minimum parking requirements, usually based on standards that assume everyone drives alone, no one takes transit, walks or cycles to the destination, and no trips are generated internally within an area. While the intention is usually to avoid parked cars "spilling over" into neighborhoods, the larger impact is to provide infrastructure and financial incentives that favor driving. Transportation demand management (TDM) programs can reduce the number of people seeking parking, and thus the demand for parking spaces. Pricing parking, providing information and support for other modes, and limiting parking encourages people to use alternative modes to driving to work. Reducing the amount of parking also conserves energy by using fewer energy-intensive construction materials, and by reducing ambient temperatures and air conditioning needs. Providing parking on-street in lieu of off –street parking serves a number of beneficial functions from a trip reduction perspective. It helps support a pedestrian friendly environment by buffering pedestrians from street traffic, and further enhances the pedestrian environment by reducing the amount of land devoted to surface lots or structures.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Urban Parking Restrictions	80	189	359	$1	$0	$0
Moving Cooler medians	45	59	83	$205	$163	$116

Assumes a parking freeze on new spaces by 2025, 2020, and 2015.

Modeling Assumptions: *Moving Cooler* page B-58
Cost Assumptions: *Moving Cooler* page C-41

Other Findings

Restricting off-street parking, without increasing the price of on-street parking, can create an incentive for motorists to cruise looking for on-street parking, and exacerbate congestion. The City of Boston has implemented parking freezes since 1976 in several districts. However, the cap drives up the price of off-street parking and underprices curb parking, creating a price signal to motorists to cruise looking for parking. "Boston limits the private off-street parking supply, but fails to price its own public curb parking properly (482)". Shoup, D.C., "Cruising for parking." Transport Policy 13 (2006) 479–486.

Equity and Co-benefits

Urban parking restrictions will have negative equity impacts on inner-area groups and to some extent on low-income groups, who are more likely to live in those areas (Appendix E-32). *Moving Cooler* estimates modest negative equity impacts on low-income groups under an expanded best practice scenario and increasing to strong negative equity impacts under a maximum effort scenario (Appendix E-36 Table 3.1).

Urban parking freezes, similar to those implemented in Boston and San Francisco, set caps for the total number of commuter parking spaces in central business districts and employment centers. For *Moving Cooler*, it is assumed that there is zero cost for implementing this strategy. As part of a discussion of co-benefits of this strategy, it is recognized that urban parking restrictions lead to employers developing more expansive travel demand management programs for their employees to offset the impact of fewer parking spaces. While there may be some cost to the private sector in this case, it also is likely that there are significant savings resulting from leasing fewer parking spaces (Appendix C-41).

POLICY CONTEXT

Existing regulations/policies

Link to *Energy Aware Planning Guide*

Implementation level

City

Population density required

Urban or Suburban

Implementation Details

Link to *Energy Aware Planning Guide*

Model policy language

TR-5.1 Parking Policy: The City/County will adopt a comprehensive parking policy to discourage private vehicle use and encourage the use of alternative transportation CAPCOA, page 87.
TR-5.2 Event Parking Policies: The City/County will establish policies and programs to reduce onsite parking demand and promote ride-sharing and public transit at large events CAPCOA, page 88.
TR-5.4 Electric/Alternative Fuel Vehicle Parking: The City/County will require new commercial and retail developments to provide prioritized parking for electric vehicles and vehicles using alternative fuels CAPCOA, page 88.

Model ordinances

5.1.1 Reduce the available parking spaces for private vehicles while increasing parking spaces for shared vehicles, bicycles, and other alternative modes of transportation;
5.1.2 Eliminate or reduce minimum parking requirements for new buildings;
5.1.3 "Unbundle" parking (require that parking is paid for separately and is not included in the base rent for residential and commercial space);
5.1.4 Use parking pricing to discourage private vehicle use, especially at peak times;
5.1.5 Create parking benefit districts, which invest meter revenues in pedestrian infrastructure and other public amenities;
5.1.6 Establish performance pricing of street parking, so that it is expensive enough to promote frequent turnover and keep 15 percent of spaces empty at all times;
5.1.7 Encourage shared parking programs in mixed-use and transit-oriented development areas. CAPCOA, page 87.
5.2.1 Promote the use of peripheral parking by increasing on-site parking rates and offering reduced rates for peripheral parking;
5.2.2 Encourage special event center operators to advertise and offer discounted transit passes with event tickets;

5.2.3 Encourage special event center operators to advertise and offer discount parking incentives to carpooling patrons, with four or more persons per vehicle for on-site parking;
5.2.4 Promote the use of bicycles by providing space for the operation of valet bicycle parking service. CAPCOA, page 88.

Case studies

Link to *Energy Aware Planning Guide*

RESOURCES

Energy Aware chapter

T.2.1. Transportation Demand Management Programs

Cross-references to other measures in Energy Aware

L.2.1 Parking Pricing
T.2.1 Transportation Demand Management Programs

Other resources

California Air Resources Board research on SB 375 implementation:
http://www.arb.ca.gov/cc/sb375/policies/pricing/parkingpricing.pdf
http://www.arb.ca.gov/cc/sb375/policies/pricing/parkingpricingbkgd.pdf

VTPI TDM Encyclopedia http://www.vtpi.org/tdm/tdm28.htm

Complete Streets and Street Design

SUMMARY

Complete Streets refers to streets designed for all users: motorists, bicyclists, pedestrians, seniors, persons with disabilities, and users of public transportation. The energy it takes to travel between two points is partly dependent upon the length of the route. By providing a network of fully connected streets, shorter, more direct vehicle routes can be used and less energy is expended. If a system of connected and direct bicycle paths and sidewalks accompany those routes, people will be more likely to use energy efficient forms of transportation such as walking, bicycling, and transit. Designing for these non-motorized modes of travel can reduce vehicle miles traveled (VMT) and greenhouse gas (GHG) emissions.

Street design for roadways, driveways, and parking lots can include lane widths, curbs, sidewalks, cross-walks, paving, lighting, trees, drainage, landscaping, signage, legal speed limits and related traffic calming measures. In combination, these elements have environmental effects; smart street design can reduce GHG emissions and improve air quality, public health, and safety.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler does not estimate effectiveness or cost of this specific measure; estimates for Complete Streets are included in *Moving Cooler* estimates for Combined Bicycle Strategies, Combined Pedestrian Strategies, and Combined Land Use Strategies.

	Effectiveness (mmt GHG reduced)			**Cost-effectiveness ($/ton GHG reduced)**		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Combined Land Use	160	865	1445	$9	$2	$1
Combined Pedestrian	74	171	227	$205	$178	$186
Combined Bicycle	59	117	176	$78	$176	$214
Moving Cooler medians	45	59	83	$205	$163	$116

Combined Land Use: At least 43%, 60%, and 90% of new development is in compact, pedestrian- and bicycle-friendly neighborhoods with high-quality transit.
Combined Pedestrian: Audits and retrofits for pedestrian accessibility, more extensive pedestrian accesibility, and more extensive traffic calming.
Combined Bicycle: Bike lanes and paths at 1-, 0.5-, and 0.25-mile intervals in high density areas (>2000 persons per square mile).

Modeling Assumptions: *Moving Cooler* page B-16 to B-30.
Cost Assumptions: *Moving Cooler* page C-13 to C-23.

Other Findings

Complete streets can improve safety by reducing crashes. One study found that designing for pedestrian travel by installing raised medians and redesigning intersections and sidewalks reduced pedestrian risk by 28%. http://www.completestreets.org/complete-streets-fundamentals/factsheets/#benefits

Complete streets can encourage more walking and bicycling. One study found that 43 percent of people with safe places to walk within 10 minutes of home met recommended activity levels, while just 27% of those without safe places to walk were active enough. http://www.completestreets.org/complete-streets-fundamentals/factsheets/#benefits

CAPCOA estimates a moderate, between 1 and 2%, reduction in emissions from an improved Street Grid. [CAPCOA, 2008, MM D-5)

Equity and Co-benefits

Positive equity impacts also are shown for non-motorized transport, reflecting the improved mobility and access, and decreased cost of travel, for low-income groups and inner-area groups. The gains may not apply equally to all within low-income and inner-area groups; those with disabilities or the infirm may not be able to take advantage of non-motorized strategies as easily. *Moving Cooler* - Appendix E-31

Access to sidewalks, and living in transit-rich neighborhoods or within walking distance of a transit stop increases the likelihood of transit use, and associated walking. Repeated studies find these results, which in turn has been documented to increase likelihood of reaching recommended weight and activity levels. For example, a survey of more than 11,500 participants in 11 countries found that residents of neighborhoods with sidewalks on most streets were 47 percent more likely to get moderate-to-vigorous physical activity at least five days per week than were residents of neighborhoods with sidewalks on few or no streets. A review of 16 studies found that people who reported having access to sidewalks were 20 percent more likely to be physically active than those reporting no access to sidewalks. http://www.activelivingresearch.org/files/ALR_Brief_ActiveTransportation.pdf

POLICY CONTEXT

Existing regulations/policies

Caltrans regulates state highways; and sets standards for streets, roads, pedestrian and bicycle paths. Caltrans Deputy Directive 64 makes addressing the needs of bicyclists, pedestrians and transit users an implicit objective of all planning.

Implementation level

City and county.

Population density required

Urban, suburban, and rural. The biggest potential impacts will come from redesigning lower density areas to minimize auto-dependency.

Implementation Details

Integrate street engineering with tree planting and landscaping into streets, paved paths, and parking lots

Require/encourage 50% shading of all paved surfaces

Require/encourage use of paving materials with a Solar Reflective Index (SRI) of at least 29, or open grid paving systems (See CAPCOA Model Policies EE 3.1.1 and 3.1.2)

Model policy language

Examples from CAPCOA, 2009.

TR-1.1.1 Transportation Planning Project Selection: The City / County shall give priority to transportation projects that will contribute to a reduction in vehicle miles traveled per capita, while maintaining economic vitality and sustainability.
TR-1.2 System Interconnectivity: The City/County will create an interconnected transportation system that allows a shift in travel from private passenger vehicles to alternative modes, including public transit, ride sharing, car- sharing, bicycling and walking.

See also:

LU 3.2 Transit Oriented Development;
LU 4.1 Pedestrian Oriented Character;
LU 4.2 Pedestrian Access;
LU 5.1 Developer Fees
TR 4.1 Development Standards for Bicycles

Model ordinances

City of Riverbank, CA (Stanislaus County; Population: 21,492) Riverbank's 2009 General Plan Update focuses on increasing transportation choices. This includes increasing street "connectivity" (the frequency with which streets or roads intersect) and other strategies supporting non-automobile travel. The city works closely with developers to implement these goals. **http://www.ca-ilg.org/ClimateTransportationStories**

San Francisco has an integrated set of policies for improving bicycling, transit, walking conditions on all city streets, as well as bicycle parking San Francisco Municipal Transportation Authority Bicycle Plan and safe routes to schools programs. San Francisco Municipal Transportation Authority Livable Streets

In 1998 the City of Santa Barbara, CA adopted a goal in the circulation element of their general plan to "achieve equality of convenience and choice among all modes of transportation". http://www.santabarbaraca.gov/NR/rdonlyres/D4E3C1DC-AB2D.../Goal2.pdf

Case studies

Link to *Energy Aware Planning Guide*

Other resources

The National Complete Streets website provides information on model policies and case studies for complete streets. http://www.completestreets.org/

RESOURCES

Cross-references to other measures in Energy Aware

L.1.4 Design Sites for Pedestrian and Transit Access
L.3.2 Street Trees
L.4.1 Bikeways
L.4.2 Bicycle Parking and Facilities
L.4.3 Pedestrian Facilities and Traffic Calming
C 1.3 Cool Communities (Cool pavement)

Other resources

California Air Resources Board research on SB 375 implementation:
http://arb.ca.gov/cc/sb375/policies/policies.htm

VPTI -- TDM Encyclopedia
Connectivity Creating more connected roadway and path networks.
Streetscaping - http://www.vtpi.org/tdm/tdm122.htm

NADERI, J. R., KWEON, B.S., and Maghelal, P. 2008. The Street Tree Effect and Driver Safety ITE Journal on The web / February 2008

Bikeways

SUMMARY

Providing a safe and direct network of bikeways can reduce energy use and climate change impacts by shifting some personal vehicle trips to bicycle. Bicycles may be used for any type of trip, but are particularly convenient for shorter trips. The types most frequently made by bicycle include social, family and recreational trips; trips to schools and churches; light shopping trips; and trips to and from work.

Nearly one half of all trips taken in the United States are three miles or less in length, and 28 percent are less than one mile. Making these shorter trips by bicycle instead of automobile can be made even more attractive by providing safe, convenient bikeways off-street along with complementary policies such as bicycle parking, shower and lockers at job sites, trip reduction ordinances and a compact mixture of diverse land uses.

Other elements of a successful bikeway strategy include creating on-street bike lanes, ensuring bicycle access through large blocks, signal timing for bicyclists, and traffic calming measures for on-street bike routes. Successful bikeway systems are connected to the full circulation system of roads and streets.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Combined Bicycle	59	117	176	$78	$176	$214
Moving Cooler medians	45	59	83	$205	$163	$116

Combined Bicycle: Bike lanes and paths at 1-, 0.5-, and 0.25-mile intervals in high density areas (>2000 persons per square mile).

Modeling Assumptions: *Moving Cooler* pages B-27 to B-30
Cost Assumptions: *Moving Cooler* pages C-20 to C-23

Other Key Quantifiable Findings

Dill and Carr 2003 analyzed bike infrastructure and trips in 42 US cities. Four variablesaccounted for 30% of the variance in the number of trips. They note inconsistent findings across cities, but find that, excluding New York, each additional mile of Type 2 bike lanes per square mile is associated with a roughly one percent increase in the share of workers commuting by bicycle. This level of increase in Type 2 bike lane mileage is significant – almost four times the current average of 0.34 miles per square mile. However, increasing the share of workers commuting by bicycle by one percentage point would double the average number of bicycle commuters for many of these cities. Of course, as noted by Nelson and Allen and Pucher et al, the strong association between the existence of bike lanes and levels of bicycle commuting does not certify a cause-effect relationship. It does, however, imply that commuters will use bicycle lanes if they are provided.

Petritsch, et al. (2008a and 2008b) find that a cycling network's overall quality has a greater influence on the volume of cyclists in an area than any specific facility.

In a detailed literature review, Pucher, Dill and Handy (2010) conclude that improving cycling infrastructure (paths and lanes, bike parking, and bikes on transit) tends to increase cycling activity, although the impacts are often small and vary depending on specific types of improvements and additional support factors.

Equity and Co-benefits

Bicycle and pedestrian improvements and programs also should increase safety for non-motorized travelers, many of whom are lower income. Non motorized improvements will provide increased opportunities for, and will encourage, recreational activity as well as non-motorized transportation, thereby increasing physical activity and improving public health. The evidence from many studies on walking and bicycling demonstrate that regular participation in these activities provides a health benefit for people of all ages, genders, and races (Dunn et al., 1999). The gains may not apply equally to all low-income and inner-area groups; those with disabilities or the infirm may not be able to take advantage of non-motorized strategies as easily.

Where bicycle routes are created has equity issues. Recreational routes through more affluent suburban areas may be easier to create and finance and increase recreational bicycling; at the same time some upper income communities have resisted bicycle and walking paths out of a perception of encouraging greater crime; research finds a perception of greater risk in these areas. In low-income areas, working with an existing street grid and its obstacles can be expensive. Additional security measures along bicycle paths in higher crime/higher traffic areas may be needed.

A study of 30,604 people in Copenhagen showed that people who commuted to work by bike had 40 percent lower risk of dying over the course of the study period than those who didn't and bike commuters average a day fewer absences due to illness each year than non-bike commuters. As cited by Flusche. Darren. 2009. *The Economic Benefits of Bicycle Infrastructure Investments*. League of American Bicyclists. http://www.bikeleague.org/resources/reports/pdfs/economic_benefits_bicycle_infrastructure_report.pdf

POLICY CONTEXT

Existing regulations/policies

The California AB1358 (Chapter 657, 2008 Statutes), the Complete Streets Act and Caltrans Deputy Directive 64: 'Complete Streets: Integrating the Transportation System
http://www.dot.ca.gov/hq/tpp/offices/ocp/
http://www.dot.ca.gov/hq/tpp/
http://www.dot.ca.gov/hq/tpp/offices/ocp/smf_files/SmMblty_v6-3.22.10_150DPI.pdf

Caltrans 2010 "Smart Mobility Plan http://www.dot.ca.gov/hq/tpp/ sets new complete street performance standards to include equal weight to transit, bicycle, and pedestrian access and level of service for arterials, and corridors, including state highways. Projects should meet Caltrans' Bikeway Planning and Design Standards (see Resources section).

The Bay Area Metropolitan Transportation Commission (MTC) Resolution 3765 requires all project sponsors to complete a detailed Routine Accommodations Checklist, explaining how their project impacts bicycle and pedestrian access.

The National Highway Traffic Safety Administration has published a *Resource Guide On Laws Related To Pedestrian And Bicycle Safety.*
Http://Www.Nhtsa.Dot.Gov/People/Injury/Pedbimot/Ped/Resourceguide/Index.Html

Implementation level

City and County

Population density required

Urban, Suburban, Rural

Implementation Details

Police Officers on Bicycles Seattle was the first city to put police officers on bicycles. Since then, this strategy had spread to more than 200 cities by the early 1990s.

Bicycle Signal Timing - Several European cities, where up to 30% of the population bikes to work, synchronize some traffic signals for cyclists. In Copenhagen, a "green wave" system on the arterial street enables 30,000 cyclists to maintain a 12 mph (19.3 km/h) speed for 2.5 kilometers. In Amsterdam, cyclists riding at a speed of 15 to 18 km/h will be able to travel without being stopped by a red signal. Tests show that public transport can benefit as well and cars may travel slightly slower. [MTC 2009. BBay Area Transportation Greenhouse Gas Strategies, p 41]

Model policy language

CAPCOA Model Policy Statements (2009)

LU-1.8 Bicycle Facilities
LU-3.2 Transit-Oriented Development
LU-4.2.3 Safe Routes to Schools
TR-1.2 System Interconnectivity
TR-4.1 Development Standards for Bicycles
TR-4.2 Bicycle and Pedestrian Trails
TR-4.3 Bicycle Safety Program
TR-4.4 Bicycle and Pedestrian Project Funding
TR-4.5 Bicycle Parking
MO-3.2 Bicycle Transportation Support
MO-3.2.4 Bicycle Safety/Safe Routes
MO-3.2.3 Police-on-Bicycles
EO-2.2 Pedestrian and Bicycle Promotion

CAPCOA 2008. CEQA and Climate Change - Mitigation Measures

Bicycle/Pedestrian/Transit Measures
MM-T-1 Bike Parking
MM-T-2 End of Trip Bike Facilities
MM-T-3 Bike Parking and Multi-Unit Residential Building
MM-T-4 Proximity to Bike Path/Bike Lanes
MM-T-15 Valet Bicycle Parking
MM-T-16 Garage Bicycle Storage

Model ordinances

Burbank Updated Bicycle Master Plan The City of Burbank updated their Bicycle Master Plan in 2009, to accommodate more than 12,000 residents who work in the city but cannot traverse certain areas because of inadequate bike path infrastructure and need for links with neighboring cities to facilitate regional navigation by bicycle. Visit BurbankBike to learn more about the city's efforts to encourage bicycle use.

Riverside Bicycle Master Plan and . *(www.ca-ilg.org/ClimateLandUseStories):*

City of Petaluma Bicycle and Pedestrian Plan - part of an overall efficient transportation strategy for climate action, based on focusing developing downtown. http://www.ca-ilg.org/node/1640

San Francisco has an integrated set of policies for improving bicycling, transit, walking conditions on all city streets (San Francisco Municipal Transportation Authority Livable Streets), as well as safe routes to schools programs.

See also the Transportation Authority of Marin Safe Routes to Schools - http://www.tam.ca.gov/index.aspx?page=94

Case studies

MTC Regional Bicycle and Pedestrian Program:
http://www.mtc.ca.gov/planning/bicyclespedestrians/regional.htm#bikepedprog

WalkBikeMarin: http://www.walkbikemarin.org/

Santa Clara Countywide Bicycle Plan: http://www.vta.org/schedules/bikeways_plan.html

Alameda County 2010 Campaign for Active Transportation
www.actia2022.com/transportation.html

Other resources

The National Bicycling and Walking Study 15-Year Status Report. This report is the third status update to the National Bicycling and Walking Study, originally published in 1994 as an assessment of bicycling and walking as transportation modes in the United States. Following the 5-year status report (1999) and 10-year status report (2004), the 15-year update measures the progress made toward the original goals of lowering the number of fatalities while increasing the percentage of trips made by bicycling and walking. Injury and fatality statistics are presented to measure this progress, as well as results from surveys related to travel habits. The 15-year report, unlike its two predecessors, examines a range of efforts to increase bicycling and walking in the United States. Programs at the Federal, State, and local levels are included, as well as case studies on best practices. Finally, the report makes recommendations for research, policy, and other measures that can be taken to meet the goals of the original study. http://www.walkinginfo.org/15_year_report/

The Nonmotorized Transportation Pilot Program was established in the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act, and managed by the Federal Highway Administration. The program provides $25 million to each of four communities (Columbia, MO; Marin County, CA; Minneapolis Area, MN; and Sheboygan County, WI) to demonstrate how improved walking and bicycling networks can increase rates of walking and bicycling. An Interim Report on the program was submitted to Congress in January 2008; a Final Report will likely be submitted in 2011. The Final Report will include information concerning changes in: 1) vehicle and transit use; 2) rates of walking and bicycling; and 3) health and environmental measures. http://www.fhwa.dot.gov/environment/bikeped/ntpp.htm

RESOURCES

Energy Aware chapter

Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware

T.2.1. Transportation Demand Management Programs
L.1.1 Smart Growth Development
L.3.1 Complete Streets and Street Design
L.4.2 Bicycle Parking and Facilities

Other resources

California Air Resources Board research on SB 375 implementation:
http://arb.ca.gov/cc/sb375/policies/policies.htm

VTPI:
Evaluating Nonmotorized Transport: http://www.vtpi.org/tdm/tdm63.htm
Nonmotorized improvements: http://www.vtpi.org/tdm/tdm25.htm
Nonmotorized encouragement: http://www.vtpi.org/tdm/tdm3.htm

Both Pucher articles provide useful comparative information on bicycling infrastructure and behaviors in Europe vs. the United States.

Pucher, J., Dill, J. and Handy, S. 2010. "Infrastructure, Programs and Policies To Increase Bicycling: An International Review," *Preventive Medicine*, Vol. 48, No. 2, February; prepared for the *Active Living By Design Program* (www.activelivingbydesign.org).

Pucher, J., & Buehler, R. (2008). Making cycling irresistible: Lessons from the Netherlands, Denmark, and Germany. *Transport Reviews, 28*(4), 495-528. http://policy.rutgers.edu/faculty/pucher/irresistible.pdf

Wardman, M., Tight, M., & Page, M. (2007). Factors influencing the propensity to cycle to work. *Transportation Research Part A: Policy and Practice*, *41*(4), 339-350.

Theodore Petritsch, et al. (2008a), *Health Benefits of Bicycle Facilities*, Paper 08-1230 Transportation Research Board Annual Meeting (www.trb.org); at http://pubsindex.trb.org/document/view/default.asp?lbid=847922.

Active Living Research. Active Transportation: Making the Link from Transportation to Physical Activity and Obesity. Research Brief, Summer 2009. http://www.activelivingresearch.org/files/ALR_Brief_ActiveTransportation.pdf\

Bicycle Friendly Communities 2009. *American Bicyclist*

Garrard, J., Rose, G. & Lo, S. K. (2008). Promoting transportation cycling for women: The role of bicycle infrastructure. *Preventive Medicine 46*(1), 55-59.

Moudon, A. V., Lee, C., Cheadle, A. D., Collier, C. W., Johnson, D., Schmid, T. L. & Weather, R. D. (2005). Cycling and the built environment, a US perspective. *Transportation Research Part D-Transport and Environment*, *10*(3), 245-261.

Boarnet, M. G., Day, K., Anderson, C., McMillan, T., & Alfonzo, M. (2005). California's safe routes to school program: Impacts on walking, bicycling, and pedestrian safety. *Journal of the American Planning Association, 71*(3), 301-317.

Dill, J., & Carr, T. (2003) Bicycle commuting and facilities in major U.S. cities: If you build them, commuters will use them. *Transportation Research Record,* 1828, 116-123.

Bicycle Parking and Facilities

SUMMARY

In addition to a network of safe roadways and bikeways, cyclists need secure parking at their destinations. Additionally, facilities for changing and showering at job sites also can encourage more cycling to work. Local governments can require and encourage these facilities in new developments and existing areas. Bike strategies are popular and growing, although the level of GHG reduction is small, relative to costs.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler does not estimate effectiveness or cost of this specific measure; estimates for Bicycle Parking and Facilities are included in *Moving Cooler* estimates for Combined Bicycle Strategies.

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Combined Bicycle	59	117	176	$78	$176	$214
Moving Cooler medians	45	59	83	$205	$163	$116

Combined bicycle strategie: Bike lanes and paths at 1-, 0.5-, and 0.25-mile intervals in high density areas (>2000 persons per square mile).

Modeling Assumptions: *Moving Cooler* page B-27.
Cost Assumptions: *Moving Cooler* page C-21.

Other Findings

Petritsch, et al. (2008a and 2008b) have developed models to predict increases in cycling activity, reductions in motorized travel, and resulting health and energy conservation benefits likely to result from cycling facility improvements. They find that a cycling network's overall quality has a greater influence on the volume of cyclists in an area than any specific facility, indicating significant network effects. (detailed literature review). Cited in: TDM Encyclopedia 2010. *Evaluating Nonmotorized Transport: Techniques for Measuring Walking and Cycling Activity and Conditions.* Victoria Transportation Policy Institute.

Theodore Petritsch, et al. (2008a), *Health Benefits of Bicycle Facilities*, Paper 08-1230 Transportation Research Board Annual Meeting (www.trb.org); at http://pubsindex.trb.org/document/view/default.asp?lbid=847922.

Theodore Petritsch, et al. (2008b), *Energy Savings from Provision of Bicycle Facilities*, Paper 08-0219, Transportation Research Board 87th Annual Meeting (www.trb.org); at http://pubsindex.trb.org/document/view/default.asp?lbid=847915.

A comprehensive literature review by Pucher, Dill and Handy (2010) concluded that improving cycling infrastructure tends to increase cycling activity, although the impacts are often small and vary depending on specific types of improvements and additional support factors. Bike facilities (lockers, showers, parking) at destinations are a "promising strategy," with a monetary value to workers in terms of reduced stress, less money on gas, and lower travel time) between $.96 and $1.92 per bicycle trip. Source: John Pucher, Jennifer Dill and Susan Handy (2010), "Infrastructure, Programs and Policies To Increase Bicycling: An International Review," *Preventive Medicine*, Vol. 48, No. 2, February; prepared for the *Active Living By Design Program* (www.activelivingbydesign.org).

Equity and Co-benefits

Bicycle and pedestrian strategies can improve mobility by providing people with increased travel options, at a lower cost. Bicycle and pedestrian improvements and programs also should increase safety for non-motorized travelers, many of whom are lower income. Non-motorized improvements will provide increased opportunities for, and will encourage, recreational activity as well as non-motorized transportation, thereby increasing physical activity and improving public health. The evidence from many studies on walking and bicycling demonstrate that regular participation in these activities provides a health benefit for people of all ages, genders, and races (Dunn et al., 1999).

A study of 30,604 people in Copenhagen showed that people who commuted to work by bike had 40 percent lower risk of dying over the course of the study period than those who didn't and bike commuters average a day fewer absences due to illness each year than non-bike commuters. In recognition of these economic advantages and in an effort to attract and retain highly sought-after employees, employers are continuing to add wellness and health management programs to encourage healthy habits among employees. As cited by Flusche. Darren. 2009. *The Economic Benefits of Bicycle Infrastructure Investments*. League of American Bicyclists.
http://www.bikeleague.org/resources/reports/pdfs/economic_benefits_bicycle_infrastructure_report.pdf

POLICY CONTEXT

Existing regulations/policies

Passage of AB1358, the Complete Streets Act requires cities and counties to develop plans to ensure that roads are designed to serve the needs of all users.

Caltrans Deputy Directive 64 includes Bicycle Parking and Employer facilities are identified as an upcoming task of the Complete Streets Steering Committee. These are spelled out in Caltrans 2010 Strategic Plan, and in various regional MPO plans, for example, MTC Transportation Green House Gas Reductions 2010.]

Implementation level

Cities, counties, regional agencies

Population density required

Urban and suburban

Implementation Details

Non-residential projects should provide for peak season demand, e.g. 1 bike rack space per 20 vehicle/employee parking spaces [CAPCOA 2008];

4 clothes lockers and 1 shower for every 80 employee parking spaces; separate facilities by gender for projects with 160 or more employee parking spaces. [CAPCOA 2008];

Model policy language

CAPCOA 2009 has extensive policy language for bicycle facilities under land use and transportation. Bicycle facilities and bikeways are also recommended mitigation measures for development impacts.

CAPCOA Model Policy Statements (2009)

LU-1.8 Bicycle Facilities
LU-3.2 Transit-Oriented Development
TR-4.1 Development Standards for Bicycles
TR-4.4 Bicycle and Pedestrian Project Funding
TR-4.5 Bicycle Parking
MO-3.2 Bicycle Transportation Support
EO-2.2 Pedestrian and Bicycle Promotion

CAPCOA 2008. CEQA and Climate Change - Mitigation Measures

Bicycle/Pedestrian/Transit Measures

MM-T-1 Bike Parking
MM-T-2 End of Trip Bike Facilities
MM-T-3 Bike Parking and Multi-Unit Residential Building
MM-T-15 Valet Bicycle Parking
MM-T-16 Garage Bicycle Storage

Model ordinances

San Francisco has an integrated set of policies that address bicycle parking (San Francisco Municipal Transportation Authority Bicycle Plan), as well as improving bicycling, transit, walking conditions on all city streets (San Francisco Municipal Transportation Authority Livable Streets).

Several cities have policies requiring bicycle parking at large public or special events such as street festivals:
San Francisco Municipal Transportation Agency Events Parking
City of Berkeley Special Events Parking

Case studies

The city of Kansas City has put together a very detailed and ambitious proposal for Tiger funds for a Bicycle Improvements Plan

http://www.marc.org/Recovery/assets/tiger/APPENDIX_D_Bicycle_Pedestrian.pdf

Civic Bike Rental and Bike Sharing Programs: Several international cities have extensive short-term bike rental/sharing programs. The Paris "Velib" program, perhaps the world's largest, has 1,400 automated bike stations with more than 20,000 bikes for rent. It is designed mainly for commuters, not tourists. The system averages 120,000 trips per day. Riders pay a small subscription fee (€1 per day, €5/week or €29/year). A subscriber has 30 minutes to reach his/her destination before any charge is made. For this reason, 96 percent of rides are less than 30 minutes. Stations are open 24/7. The bike program is operated by the city but financed by a large outdoor advertising company, as a part of a larger public advertising deal. Users need a credit or debit card to sign up for the program and to rent the bikes, they are charged €150 if a rented bike is not returned. [MTC GHG, p. 41]; Paris "Velib" System: http://en.wikipedia.org/wiki/Velib Long Beach, San Francisco, Palo Alto, and Oakland have limited bicycle rental operations at high-density transit and bike station facilities.

World City Bike: http://citybike.newmobility.org

MTC. 2009. *Transportation, Land Use and Greenhouse Gases: A Bay Area Resource Guide*

Metropolitan Transportation Commission, September 2009. Download from http://www.mtc.ca.gov/planning/climate/

Civic/Campus Bike Sharing – Links: [From MTC 2010]

Arcata Library Bike Program

Red Bike Program (Fresno State University)

Green Bike Program (Cal Poly Pomona)

Triton Bikes (UC San Diego

Zot Wheels (UC Irvine)

RESOURCES

Energy Aware chapter

Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware

T.2.1. Transportation Demand Management Programs
L.1.1 Smart Growth Development
L.3.1 Complete Streets and Street Design
L.4.2 Bicycle Parking and Facilities

Other resources

California Air Resources Board research on SB 375 implementation: http://arb.ca.gov/cc/sb375/policies/policies.htm

Victoria Transportation Policy Institute – TDM Encyclopedia (updated regularly) -- http://www.vtpi.org/tdm/tdm25.htm

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Garrard, J., Rose, G. & Lo, S. K. (2008). Promoting transportation cycling for women: The role of bicycle infrastructure. *Preventive Medicine 46*(1), 55-59.

Dill, J., & Carr, T. (2003) Bicycle commuting and facilities in major U.S. cities: If you build them, commuters will use them. *Transportation Research Record,* 1828, 116-123.

Moudon, A. V., Lee, C., Cheadle, A. D., Collier, C. W., Johnson, D., Schmid, T. L. & Weather, R. D. (2005). Cycling and the built environment, a US perspective. *Transportation Research Part D-Transport and Environment, 10*(3), 245-261.

Wardman, M., Tight, M., & Page, M. (2007). Factors influencing the propensity to cycle to work. *Transportation Research Part A: Policy and Practice, 41*(4), 339-350.

Pedestrian Facilities and Traffic Calming

SUMMARY

The ideal environment for pedestrians is one in which destinations are accessible within a short walking distance; adequate infrastructure is available; and the area is pleasant, safe, and secure. Unfortunately, many development patterns maximize convenience for the automobile driver, not the pedestrian. Long, winding subdivision streets often eliminate direct routes to destinations for pedestrians and encourage automobile travel at the expense of other modes. A suburban pedestrian often must travel a route five times longer than the direct distance.[1]

While paths are often provided for recreational walking, these routes generally do not link residential areas with common destinations. Pedestrian facilities (sidewalks, paths, crosswalks, etc.) must be provided and amenities (benches, landscaping, fountains, etc.) can further increase the attractiveness of walking relative to other modes.

In addition to convenience, safety and security are also a concern for pedestrians. Collisions with pedestrians account for about one out of every 10 fatalities in motor vehicle accidents in the United States.[2] Traffic calming measures such as narrowing streets, increasing curb radii, and installing mini-circles, speed humps and raised intersections, can slow vehicle traffic and signal to drivers that pedestrians are present. If implemented correctly, traffic calming measures will only modestly reduce the convenience of driving while offering pedestrians a safer, more attractive route to their destinations.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Combined Pedestrian	74	171	227	$205	$178	$186
Moving Cooler medians	45	59	83	$205	$163	$116

Combined Pedestrian: Audits and retrofits for pedestrian accessibility, more extensive pedestrian accesibility, and more extensive traffic calming.

Modeling Assumptions: *Moving Cooler* page B-24
Cost Assumptions: *Moving Cooler* page C-18

Other Findings

Link to *Energy Aware Planning Guide*

Cost and Effectiveness

Transportation consultants Fehr and Peers completed a comparative evaluation of specific traffic calming measures, in terms of speed, volume, and collision rates before and after intervention. They found statistical evidence that traffic calming measures in aggregate reduced collisions by at least 21%. http://www.trafficcalming.org/effectiveness.html (Note the environmental context, and existing conditions vary widely, so results may reflect the existing volume of traffic in location where measure is placed rather than intrinsic effectiveness).

MTC ranks pedestrian improvements (Strategy 15) to be Low in Impact, but Medium in Cost Effectiveness, based on a 2005 evaluation of Marin County's Safe Routes to Schools program. The program reduced CO2 by 1060 tons for the year, at a costs of $215,000 for education and enforcements and $165,330 in annualized capital costs for 4 major projects to improve bike/walk access to schools. MTC 2009, p. 45.

Equity and Co-benefits

"Smart growth" urban form factors (transit accessibility, residential density, and street connectivity) tend to increase per capita walking activity and reduce per capita motor vehicle fuel consumption, providing both health and environmental benefits. [Frank et al 2010]

Building multi-use trails can lead to short- and long-term increases in walking and cycling, especially on urban-area trails and trails that connect population centers with desirable destinations, such as downtowns. With few exceptions living near trails or having trails in one's neighborhood has been associated with people being 50 percent more likely to meet physical activity guidelines and 73 percent to 80 percent more likely to bicycle. Furthermore, trails have been shown to be particularly beneficial in promoting physical activity among women and people in lower-income areas. Active Living Research. Research Brief Summer 2009. Active Transportation: Making the Link from Transportation to Physical Activity and Obesity http://www.activelivingresearch.org/files/ALR_Brief_ActiveTransportation.pdf

The financial gain of the health benefits related to trail use outweighed the cost of building and operating the trails. For example, in Lincoln, Neb., every $1 invested in trails was estimated to save $2.94 in direct medical costs from a societal perspective. Wang G, Macera C, Scudder-Soucie B, et al. "A Cost–Benefit Analysis of Physical Activity Using Bike / Pedestrian Trails." Health Promotion Practice, 6(2): 174–179, April 2005. Also in: Active Living Research. Research Brief Summer 2009. Active Transportation: Making the Link from Transportation to Physical Activity and Obesity
http://www.activelivingresearch.org/files/ALR_Brief_ActiveTransportation.pdf

One study of changes in travel behavior and changes in the built environment found a significant association between neighborhood design and travel behavior, even after accounting for the different attitudes of residents in suburban and traditional neighborhoods. [Handy et al, 2005] These findings are reiterated in a more recent meta-analyses. [Handy and Boarchert, 2010 Draft – report to Caltrans, not yet published].

Some research finds that slower and less trafficked urban streets and access to non-street door-to-door pathways are associated with greater sociability among neighbors. [Leyden 2003]

Bicycle and pedestrian strategies can improve mobility by providing people with

increased travel options, at a lower cost. Such strategies should increase safety for non-motorized travelers, many of whom are lower income. Non-motorized improvements will provide increased opportunities for, and will encourage, recreational activity as well as non-motorized transportation, thereby increasing physical activity and improving public health. The evidence from many studies on walking and bicycling demonstrate that regular participation in these activities provides a health benefit for people of all ages, genders, and races. *Moving Cooler* - Appendix E-27

Positive equity impacts for non-motorized transport include improved mobility and access, and decreased cost of travel for low-income groups and inner-area groups. The gains may not apply equally to all within low-income and inner-area groups; those with disabilities or the infirm may not be able to take advantage of non motorized strategies as easily. *Moving Cooler* - Appendix E-31

Multiple studies show that the quality of local walking environments varies significantly across urban neighborhoods, with major social and public costs related to traffic safety and public health. A 2009 meta-analysis of literature finds that while "land use diversity, street design, and pedestrian amenities are increasingly identified by health researchers as correlated with obesity levels, particularly among children and low-income/disadvantaged populations[, there] also appear to be statistically significant differences in the quality of the environment in poor and non-poor neighborhoods. [Lovasi, 2009] A field study in New York City found that commercial streets in poor census tracts had statistically significantly fewer street trees, landmarked buildings, clean streets, sidewalk cafes, and higher rates of felony complaints, narcotics arrests, and vehicular/pedestrian crashes than did a matched sample in non-poor census tracts. Observers also counted fewer numbers of pedestrians and greater incidence of violent or antagonistic street behavior on blocks in poor versus non-poor tract. (Neckerman, et al, 2008)

An earlier meta-analysis by Rinquist 2005 found "ubiquitous evidence of environmental inequities based upon race," but concluded that "existing research does not support the contention that similar inequities exist with respect to economic class."

A number of researchers find disparities in the perception of barriers, risk, and other elements that influence walking behaviors by race, age, and gender. [Yan et al, 2010]

POLICY CONTEXT

Existing regulations/policies

Caltrans regulates state highways; and sets standards for streets, roads, pedestrian and bicycle paths. Caltrans Deputy Directive 64 makes addressing the needs of bicyclists, pedestrians and transit users an implicit objective of all planning.

California passed the first Safe Routes to School legislation in the country, AB 1475, in 1999. In 2007, AB 57 extended the program indefinitely with funding provided from the State Highway Account. Section 2333.5 of the Streets and Highways Code calls Caltrans to make competitive grants available to local governmental agencies. http://www.dot.ca.gov/hq/LocalPrograms/saferoutes/sr2s.htm

Implementation level

City and county

Population density required

Urban, suburban, and rural

Implementation Details

A number of cities use a 2- or 3-tiered approach to residential traffic calming. Year 1 includes low-cost measures using existing regulatory and voluntary measures (newsletters, radar trailer, pavement markings, and police enforcement) before considering higher cost infrastructure measures (curb extensions, speed humps, and traffic circles.

Specific and Emergent Programs

A. Active Transportation

This is a growing public advocacy movement that has brought professional planners, public health advocates, and bike/ped advocates and parents of school age children. This convergence of interests is resulting in local transportation plans that emphasize investment in pedestrian and bicycling infrastructure and to some extent public safety elements of public transit systems. Typically it combines elements of Safe Routes to Transit and Safe Routes to Schools programs.

http://www.activelivingresearch.org/files/ALR_Brief_ActiveTransportation.pdf

Alameda County Transit Agency's Active Transportation Campaign
http://www.actia2022.com/pdfs/Alameda%20County_2010%20Campaign_Case%20Statement_ver06-30-08_RTC.pdf

B. Safe Routes to Transit

Based on findings from a UK survey in 2002, Loukaitou-Sideris (2009) concluded "an extra 10.5% of journeys would be generated if the public felt more secure when traveling, particularly when waiting at stations."

In the Bay Area, the $22.5 million Safe Routes to Transit (SR2T) Program received Bay Area voter approval in March 2004 through Regional Measure 2, the $1 bridge toll increase for transit. Of the SR2T funds, $2.5 million are allocated directly to City CarShare projects (with $750,000 already encumbered) and the remaining $20 million will be allocated on a competitive grant basis.

C. Safe Routes to Schools and Walking School Buses

California ranks last in U.S. for percentage of students using school buses — 16 percent vs. the national average of 59 percent. Driving children to school (or high school students driving themselves) has become a significant issue for local congestion, student health, air pollution and greenhouse gas emissions. School trips constitute at least 10 percent of the morning peak trips in Bay Area region, and are higher in predominantly residential cities. (MTC 2009. *Transportation, Land Use, and GHG, p. 56.)* The rapid reduction in the number of children walking to school over the last 20 years is closely associated with rising obesity and related health factors for children. Safe Routes to Schools and Walking School Bus are related responses to these issues, as are other school-based programs to reduce school-based car trips.

Between 1996 and 2002, 154,878 Toronto students participated in Greenest City's Active & Safe Routes to School (ASRTS) program. Students, in over 160 schools collectively walked 317,980 kilometres and avoided the release of 46 tonnes of GHG emissions. A further savings of 89.1 tonnes of eCO2 was avoided through the No Idling at School project. An evaluation of four programs, Walking Schoolbus, Walking Wednesdays, Anti-Idling, and Walk to School Day, found the the Walking School bus (a scheduled and supervised pedestrian pick up and return system for elementary school children) generated the greatest impact: 422 families at 44 schools reduced VMT by 51,242 miles and reduced GHG by 15.68 tonnes. Source: Green Communites Active and Safe Routes to School Toronto Evaluation http://www.toolsofchange.com/en/case-studies/detail/97/

Marin County Congestion Management Agency found that 20 to 30% of morning traffic is attributed to parents driving their children to school. This has caused increased traffic congestion around schools, prompting even more parents to drive their kids. http://www.tam.ca.gov/index.aspx?page=94

The Marin County Bicycle Coalition provides training and technical assistance to communities to develop Safe Routes to Schools programs. http://saferoutestoschools.org/index.shtml

National Center for Safe Routes to School: http://www.saferoutesinfo.org/

Caltrans Safe Routes to Schools programs:
http://www.dot.ca.gov/hq/LocalPrograms/saferoute.htm

Model Policy Language

CAPCOA 2009. Model Policy Language (see detailed subcategories)

LU-3.2 Transit-Oriented Development
LU-4.1 Pedestrian oriented Character
LU-4.2 Pedestrian Access (includes Safe Siting of Schools)
TR-1.2.8 Safe Access along Major Streets
TR-1.1 Transportation Planning

TR-1.6 Transportation Impact Fees
TR-4.1 Development Standards for Bicycles and Pedestrians
TR-4.2 Bicycle and Pedestrian Trails
TR-4.4 Bicycle and Pedestrian Project Funding

CAPCOA 2008. Mitigation Measures

MM T-4-Proximity to Bike Path/Bike Lanes
MM T-5-Pedestrian Network
MM T-6-Pedestrian Barriers Minimized
MM T-8-Traffic Calming
MM T-12-Pedestrian Pathway Through Parking
MM D-2-Orientation to Existing/Planned Transit Bikeway or Pedestrian Corridor
MM D-5-Street Grid

Model ordinances

San Francisco has an integrated set of policies for improving bicycling, transit, walking conditions on all city streets (San Francisco Municipal Transportation Authority Livable Streets), as well as safe routes to schools programs. San Francisco Municipal Transportation Authority Livable Streets

Marin County has a detailed set of ordinances related to pedestrian, bicycle, and transit oriented design, policies, and procedures, as well as congestion management and parking management measures. http://www.tam.ca.gov/Search2.aspx?request=pedestrian+ordinance&maxFiles=25

Livermore - http://www.ci.livermore.ca.us/eng/speed.html

San Ramon - http://www.ci.san-ramon.ca.us/transp/calming.htm

Citrus Heights - http://www.ci.citrus-heights.ca.us/docs/934482872004ntmp.pdf - 2001

Case studies

A survey of parents at 10 schools that had completed projects under California's SR2S funding program founds that children who traveled past completed SR2S projects were more likely to show increases in walking or bicycle travel than were children who would not pass by projects (15% vs 4%). Long-term behavior shifts were not consistently maintained, however, possibly due to a number of locally specific reasons. http://uctc.net/research/papers/776.pdf

Transportation Authority of Marin has an extensive set of pedestrian and traffic calming programs and projects: http://www.tam.ca.gov/index.aspx?page=5

Data on 30 San Francisco Bay Area projects funded by a 1% sales tax measure for regional Safe Routes to Transit. - http://transformca.org/sr2t/sr2t-funded-projects

Resources

The National Bicycling and Walking Study 15-Year Status Report. This report is the third status update to the National Bicycling and Walking Study, originally published in 1994 as an assessment of bicycling and walking as transportation modes in the United States. Following the 5-year status report (1999) and 10-year status report (2004), the 15-year update measures the progress made toward the original goals of lowering the number of fatalities while increasing the percentage of trips made by bicycling and walking. Injury and fatality statistics are presented to measure this progress, as well as results from surveys related to travel habits. The 15-year report, unlike its two predecessors, examines a range of efforts to increase bicycling and walking in the United States. Programs at the Federal, State, and local levels are included, as well as case studies on best practices. Finally, the report makes recommendations for research, policy, and other measures that can be taken to meet the goals of the original study. http://www.walkinginfo.org/15_year_report/

The Nonmotorized Transportation Pilot Program was established in the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act, and managed by the Federal Highway Administration. The program provides $25 million to each of four communities (Columbia, MO; Marin County, CA; Minneapolis Area, MN; and Sheboygan County, WI) to demonstrate how improved walking and bicycling networks can increase rates of walking and bicycling. An Interim Report on the program was submitted to Congress in January 2008; a Final Report will likely be submitted in 2011. The Final Report will include information concerning changes in: 1) vehicle and transit use; 2) rates of walking and bicycling; and 3) health and environmental measures. http://www.fhwa.dot.gov/environment/bikeped/ntpp.htm

Ewing, R.and Brown, S. *U.S. Traffic Calming Manual*, Published by APA Planners Press and American Society of Civil Engineers, 2009. http://www.planning.org/apastore/Search/Default.aspx?p=3945

Leydon, K. 2003. Social Capital and the Built Environment: The Importance of Walkable Neighborhoods. American Journal of Public Health. September 2003, Vol 93, No. 9 . 1546-1551 http://ajph.aphapublications.org/cgi/content/full/93/9/1546

Municipal Research and Services Center of Washington, has an extensive resource site on traffic calming. http://www.mrsc.org/Subjects/Transpo/traffic/calming.aspx

The California Center for Physical Activity invites communities throughout the state to apply to host a Walkable Community Workshop or a Safe Routes to Schools workshop, led by its team of walkability experts.
http://www.caphysicalactivity.org/wcw.html
http://www.caphysicalactivity.org/safe_routes.html

RESOURCES

Energy Aware Chapter

Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware

L.1.2 Land Use Diversity
L.1.3 Transit-Oriented Development
L.1.4 Design Sites for Pedestrians and Transit Access
L.3.1 Complete Streets and Street Design
L.3.2 Street Trees
L.4.1 Bikeways

Other resources

California Air Resources Board research on SB 375 implementation:
http://arb.ca.gov/cc/sb375/policies/policies.htm

VTPI TDM Encyclopedia Entries
Traffic calming: http://www.vtpi.org/tdm/tdm4.htm
Nonmotorized improvements: http://www.vtpi.org/tdm/tdm25.htm
Nonmotorized encouragement: http://www.vtpi.org/tdm/tdm3.htm
Car free planning: http://www.vtpi.org/tdm/tdm6.htm
Community Liveability: http://www.vtpi.org/tdm/tdm97.htm
Street Reclaiming: http://www.vtpi.org/tdm/tdm30.htm

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American Academy of Pediatrics, **Committee on Environmental Health.** 2009. *The Built Environment: Designing Communities to Promote Physical Activity in Children*. PEDIATRICS Vol. 123 No. 6 June 2009, pp. 1591-1598. Policy Statement of AAP, accessed at http://aappolicy.aappublications.org/cgi/content/full/pediatrics;123/6/1591#SEC1

Boarnet, M.et al. 2005. Evaluation of the California Safe Routes

to School Legislation: Urban Form Changes and Children's Active Transportation to School. American Journal of Preventive Medicine. 2005;28(2S2):134 –140)

Bunn F, Collier T, Ker K, Roberts I, Wentz R. Traffic calming for the prevention of road traffic injuries: systematic review and meta-analysis. *Inj Prev.* 2003;9 (3):200 –204[Abstract/Free Full Text]

Duncan, M. J., Spence, J. C. and Mummery, W. K. (2005). Perceived environment and physical activity: A meta-analysis of selected environmental characteristics. *International Journal of Behavioral Nutrition and Physical Activity*, *2*(9)

Ewing R, Schmid T, Killingsworth R, Zlot A, Raudenbush S. Relationship between urban sprawl and physical activity, obesity, and morbidity. *Am J Health Promot.* 2003;18 (1):47 –57[Web of Science][Medline]

Fehr and Peers Research Bibliograpy - http://www.trafficcalming.org/references.html

Frank LD, Schmid TL, Sallis JF, Chapman J, Saelens BE. Linking objectively measured physical activity with objectively measured urban form. *Am J Prev Med.* 2005;28 (2 suppl 2):117 –125[CrossRef][Web of Science][Medline]

Handy, S. Cao, X. and Mokhtarian, S. 2005. Correlation or causality between the built environment and travel behavior? Evidence from Northern California.

Lovasi, G. et al. 2009. Built Environments and Obesity in Disadvantaged Populations Epidemiologic Reviews. Johns Hopkins Bloomberg School of Public Health 2009.

Neckerman, K. M. ,et al. 2008. Disparities in Urban Neighborhood Conditions: Evidence from GIS Measures and Field Observation in New York City. Accessed at *Journal of Public Health Policy* (2009) 30, S264–S285. doi:10.1057/jphp.2008.47 http://www.palgrave-journals.com/jphp/journal/v30/nS1/full/jphp200847a.html#aff1

Rinquist, Evan J. 2005. "Assessing evidence of environmental Inequities: A Meta-Analysis." Journal of Policy Analysis and Management 24(2): 223-47.

Transportation Research Part D: Transport and Environment Volume 10, Issue 6, November 2005, Pages 427-444

Williams C. *The Built Environment and Physical Activity: What Is the Relationship?* Princeton, NJ; Robert Wood Johnson Foundation; 2007. Research synthesis report No. 11

Yan, AF, Voorhees, C., Clifton, K. 2010. "Do you see what I see?" – Correlates of multidimensional measures of neighborhood types and perceived physical activity–related neighborhood barriers and facilitators for urban youth" [Preventive Medicine 50 (2010) S18-S23]

CHAPTER 3: Website Briefings of Transportation Measures in *Energy Aware Planning Guide*

Transit Fare Measures and Discounts

SUMMARY

By encouraging residents and workers to use mass transit instead of driving, local governments can help reduce the energy use and greenhouse gas emissions associated with transportation, as well as the maintenance and construction costs of road upkeep and widening. One method of encouraging use of mass transit is to reduce its cost, since the comparative cost of travel is a key component of a traveler's transportation mode choice.[1] However, measures to reduce fares will be most effective in conjunction with service improvements, because travelers are most responsive to the travel time and reliability of services they use.

Transit incentives may include permanent cash fare reductions as well as targeted bulk pass discounts through employers and residential organizations. Local or regional transportation demand management (TDM) programs can also be a means for distributing fare discounts. Establishing a tiered price structure whereby off-peak fares are lower than peak-hour fares can encourage off-peak travel while maintaining significant farebox revenues during peak hours.

The most challenging element of fare reduction measures is assuring that they do not unduly impact the finances of transit agencies. Transit agencies throughout the United States rely on funding subsidies and must make up any shortfall in fares. Some fare measures may attract sufficient new ridership that they pay for themselves, but often this is not the case. In other cases, such as employee pass programs, it may be possible to structure a bulk payment that compensates for lost fare revenue. Some transit agencies have surplus capacity (i.e., empty seats), particularly during midday periods that can be used at relatively low cost.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Transit Fare Measures	19	34	78	$3	$1	$1
Moving Cooler medians	45	59	83	$205	$163	$116

Fares decreased by 25% in large regions by 2015, by 33% in large and medium regions by 2015, and by 50% in all regions by 2010.

Modeling Assumptions: *Moving Cooler* page B-31
Cost Assumptions: *Moving Cooler* page C-26

Other Findings

Various factors affect price sensitivities including type of user and trip, geographic conditions and time period. Transit dependent people are generally less price sensitive and discretionary riders more price sensitive.

As per capita wealth, drivers, vehicles and transport options increase, transit elasticities are likely to increase. Commonly used transit elasticity values are based on studies performed 10-30 years ago, when real incomes where lower and a greater portion of the population was transit dependent. These studies primarily reflect short-term impacts. The resulting elasticity values are probably lower than what would accurately predict medium and long-term changes under current conditions in most North American urban areas.

Free transit on six Spare the Air days in 2006 increased transit ridership by 15 percent and two free days in 2007 increased transit ridership by 22 percent in the SF Bay Area. [MTC 2009. Bay Area Transportation Greenhouse Gas Strategies Page 84]

An eight-week 2006 pilot project with 4,800 households in Alameda, CA used phone calls and personal visits to provide customized trip planning information and incentives. The project produced a 14 percent decrease in drive-alone trips and a 34 percent increase in transit use. [MTC, 2009] p. 85]

Equity and Co-benefits

Public Transportation Improvement Strategies – Because low-income groups utilize public transportation more than average, fare reductions will greatly benefit low-income and inner-area groups. Public transportation improvements can thus remedy part of any mobility loss due to pricing measures. [*Moving Cooler* page E-31 andE-55]

Some researchers argue that a reliable car may be of greater economic value than subsidies or free fares for very low-income households or long-term unemployed. A reliably working car allows access to jobs not well-served by transit, and greater control over their schedules, thus reducing absenteeism and tardiness.
http://www.brookings.edu/papers/2005/12poverty_waller.aspx

Fare discounts that require large-up-front cash or credit card payments may not be feasible for very low-income persons with daily or weekly incomes. A "frequent rider" discount may be a more equitable method of reducing fares, should the technology become available. [Dahlgren, J & Morris, B, PATH 2005]

POLICY CONTEXT

Existing regulations/policies

Federal tax law allows employers to provide tax-free transit benefits to employees: Federal Commuter Choice Benefits Package (Transportation Efficiency Act-21)

There may be some communities that have explored the use of linkage or impact fees to support local transit. Typically local government action has been to require or encourage employers over a certain size to form transportation demand management agencies and subsidize transit fares for specific categories of riders such as employees of a specific company, or a students by a college, or in the case of K-12 students, by their local cities or counties.

Implementation level

City, county, or regional

Population density required

Urban, suburban or rural

CAPCOA model policies recommend considering feasibility of free fares for areas with 15 dwelling units per acre or more.

Implementation Details

Link to *Energy Aware Planning Guide*

Model policy language

CAPCOA 2009.

TR-1.2.6 Free Transit Feasibility.
TR-5.2.2 Transit Discounts to Events
TR-1.4.1 Regional Pass System

Model ordinances

Transit fares are operational or programmatic measures, not regulatory measures. One exception might be cities requirement that developers or employers over a certain scale, be required to provide transit passes to employers and residents.

Case studies

Downtown Seattle and Portland have free transit zones downtown. Seattle's program operates from 6am to 7pm daily. Seattle - http://www.seattlepi.com/transportation/408953_Metro4.html?source=rss.

Portland - http://trimet.org/fares/freerailzone.htm

In past years BART and regional bus riders could ride freeon the first four weekday "Spare the Air" days, when ozone levels are forecast to be high. The program, managed by the Bay Area Air Quality Management District and the Metropolitan Transportation Commission, in partnership with BART and 32 other transit agencies throughout the Bay Area, was funded by federal Congestion Mitigation and Air Quality Improvement (CMAQ) and Transportation Fund for Clean Air (TFCA)/Air District funds.
http://www.bart.gov/news/articles/2007/newsf20070530.aspx

Free transit on six Spare the Air days in 2006 increased transit ridership by 15 percent and two free days in 2007 increased transit ridership by 22 percent.
http://www.mtc.ca.gov/planning/climate/Resource_Guide_9-30-09.pdf, p 85

BART conducted a "Kids Ride Free Day" on December 22, 2007, sponsored by Kaiser Permanente, aimed at promoting healthy lifestyles and encouraging families to use BART for holiday shopping. A Nestle-sponsored "Kids Ride Free Day" in 2008 allowed two kids to ride free on BART along with one paying adult, with the purpose of increasing familiarity and use of BART. http://www.mtc.ca.gov/planning/climate/Resource_Guide_9-30-09.pdf, p. 85

RESOURCES

Related Energy Aware Strategies

T.1.2 Increased Transit Service and Improved Travel TimeT.2.1 Transportation Demand Management Programs
T.2.2 Transportation Management Associations

Other resources

Litman, T. 2010. Socially Optimal Transport Prices and Markets *Principles, Strategies and Impacts. Victoria Transport Policy Institute*
21 May 201http://www.vtpi.org/sotpm.pdf

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Katzev, R. *Effects of Deferred Payment and Fare Manipulations on Urban Bus Ridership. No date given.* http://www.publicpolicyresearch.net/transportation.html accessed June 1, 2010.

Taylor, B, et al. 2009. *Thinking Outside the Bus: Understanding User Perceptions of Waiting and Transferringin Order to Increase Transit Use*. UCB-ITS-PRR-2009-8. California PATH Research Report .

MTC . 2009. Bay Area Transportation Greenhouse Gas Strategies . pp. 84-86.

Increased Transit Service and Improved Travel Time

SUMMARY

Increasing service frequency, reducing travel time, improving reliability, and modifying schedules to match service with demand are some of the most common ways to boost transit service effectiveness. While new routes are required in some instances, more often better service on existing routes will be more effective in attracting passengers. These enhancements improve the experience of passengers and make using transit more desirable when compared to solo driving.

In addition to increased frequency, lowering wait times and transfers and providing customers with real-time information are service improvements that can help increase transit ridership and reduce energy consumption. Scheduling affects the waiting time customers encounter and perceive when making a transit trip. Positive benefits to passengers may include reducing wait time at the start of a trip, or during transfers if required. Scheduling changes and providing real-time information on transit arrivals can also improve passenger comprehension and allow for easier planning, which has the effect of reducing perceived wait times.

Improving transit service and travel time includes transit system design, route planning, scheduling, roadway design, and transit information. All of these elements can affect the speed, reliability, and ease of use of a transit system.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Increased transit service	45	72	168	$1,167	$1,425	$1,451
Expanded urban public transit	144	281	575	$1,771	$1,790	$2,082
***Moving Cooler* medians**	45	59	83	$205	$163	$116

Increased Level of Service and Improved Travel Times: Increase transit level of service by 1.5, 2, and 4 times current revenue mile growth rate, and improve travel speeds by 10%, 15%, and 30%.

Expanded urban public transit: Assumes expansion to increase annual ridership by 3.0, 3.5, and 4.7 percent by 2010.

Modeling Assumptions: *Moving Cooler* page B-32
Cost Assumptions: *Moving Cooler* page C-27

Other Findings

A Cambridge Systematics report for APTA, "*Public Transportation and the Economy*" (2000, and 2009 Update), found returns on investment of 3 to 1 or more for public transportation capital improvements. The average returns for the largest urban areas are 6 to 1. [*Moving Cooler* page E-53]

Litman (2010) documented significantly higher increases in ridership in cities that made higher than average levels of transit investments among US cities since 1980. These cities invested an average of $268 per capita in additional subsidies and $104 in additional fares annually per capita, and obtaining vehicle, parking and road cost savings averaging $1,040 per capita. Cities achieving high quality public transit, have on average 33% lower transit operating costs per passenger- mile (42¢ versus 63¢) and 58% higher transit service cost recovery (38% versus 24%).

TranSystem (2005) and Stanley and Hyman (2005) identify various factors and strategies that tend to increase transit ridership in an area, including improved service, reduced fares, Marketing and more integrated planning. Increased transit service and comfort, and reducing transit fares tends to increase transit ridership. The elasticity of transit use with respect to transit service frequency averages 0.5, meaning that each 1.0% increase in service (measured by transit vehicle mileage or operating hours) increases average ridership by 0.5% (Pratt, 1999). The elasticity of transit use to service expansion (e.g. routes into new parts of a community already served by transit) is typically in the range of 0.6 to 1.0, meaning that each 1.0% of additional service increases ridership by 0.6-1.0%. New bus service in a community typically achieves 3 to 5 annual rides per capita, with 0.8 to 1.2 passengers per bus-mile.[As cited in TDM Encyclopedia, http://www.vtpi.org/tdm/tdm47.htm]

Equity Impacts and Co-Benefits

Depending on levels of deployment, equity impacts range from modest, moderate, or strong positive equity impacts on low-income and inner area groups; including increased access to jobs, health care, education, and retail.

Bus service improvements in low-income and minority areas will have greater equity benefits than high cost light rail services designed to attract more affluent auto-drivers.

A major co-benefit of improving transit is the ability to reduce the relative degree of disadvantage to non-drivers.

The equity benefits of transit improvements will depend, to some extent, on the type of service provided, and the neighborhoods and employment opportunities served. For example, bus commuters tend to be lower income than light- and heavy-rail commuters, who similarly have lower incomes than commuter-rail users. Service improvements in low income and minority neighborhoods will have greater equity benefits than improvements serving wealthier areas. However, suburban transit service can be important for providing “reverse- commute” options for car-less central city residents to suburban jobs. The numerical equity analysis in Section 3.2 illustrates that public transportation services may be relatively more used by lower-income groups than by all groups, and thus the benefits of public transportation investments may occur with higher proportionality towards lower-income groups. This is of course dependent on the specific services and investments. [MC E-27]

[Assuming fares do not increase,] fare measures, level of service improvements, and expanded route miles will all greatly benefit low-income and inner-area groups by decreasing monetary travel costs on existing routes (e.g., decreased fares), decreasing travel times, and expanding the destinations that can be reached via transit. These equity benefits are not experienced for intercity public transportation, however. The *Moving Cooler* strategy emphasizes intercity rail, which is not disproportionately used by low-income groups. High-speed rail travel in particular will likely not benefit low-income travelers due to the cost of service. *Moving Cooler* E-31]

Several surveys of California transit system passengers indicate that perception of safety is important to both transit agencies and riders. However, they differ in how safety is defined and prioritized. [Taylor et al 2008; Dahlgren and Morris 2005] and in the size of the area that needs to be secure. Loukaitou-Sideris, 2009];

Public perception of transit affects ridership. Reducing fear about transit related crime could increase transit ridership. Using findings from a UK survey in 2002, Loukaitou-Sideris (2009) concludes “an extra 10.5% of journeys would be generated if the public felt more secure when traveling, particularly when waiting at stations." Loukaitou-Sideris also found that the majority of car owners who responded to a Los Angeles inner-city survey would use public buses if they perceived them as clean and safe.

Simple secure, well-lit bus stops are greatly valued by existing bus riders. Adding destination information at local bus stops may also increase ridership according to two user surveys, perhaps as much as 30% of current riders might take more trips if they had additional information to know what was within walking distance. [Louverakis-Sideris 2008; Dahlgren).

Two studies found that almost half of bus riders surveyed have trouble identifying bus times using tables in the conventional bus maps and schedules, although most could identify origin and destination points on a map and identify nearby bus stops. [cited in Nelson/Nygaard 2010]

In a 2008 survey, 42 transit agencies reported lack of operating funds as the largest obstacle to improving transit on state highways – which are typically important commercial corridors. The next largest category included infrastructure challenges - un-transit-friendly streets lacking pedestrian ways and suitable bus stop locations, to low-density suburban development that makes it cost prohibitive to serve with high- quality transit, and land use/planning laws that fail to promote transit first. Finally, agencies cited difficulties with Caltrans permitting process including sighting and installations of bus stop signs, shelters and other amenities; and one stated that procedures for installing bus stops, or adjusting locations that have changed and become more financially burdensome. [Caltrans, 2008]

POLICY CONTEXT

Existing regulations/policy

Caltrans has changed its performance measures to give transit equal status with other modes of travel on arterials and corridors under its jurisdiction. Caltrans Deputy Directive 64 makes addressing the needs of bicyclists, pedestrians and transit users an implicit objective of all planning.

Implementation Level

City, county, regional

Population Density Required

Urban and suburban

Implementation details

Improving safety concerns about transit stops, their surroundings, and routes to transit can increase ridership, as does attention to accurate, timely, and intelligible information about schedules, buses, routes, and surrounding destinations.

Model Policy Language

CAPCOA 2009 Model Policies:

TR-1.2 System Interconnectivity
TR.1.2.1 Multi-Modal Transportation Centers
TR-1.2.2 Provide More Transit Options
TR-1.2.3 Extend Transit Service & Hours
TR-1.2.3A Focus Transit Resources
TR-1.2.4 Coordinate across Services Lines
TR-1.2.5 Support "transit cars" (Station Cars/Carsharing)
TR-1.2.7 Transit Preference Measures
TR-1.2.8 Safe Access along Major Streets
TR.1.3 Transit System Infrastructure

TR-1.3.1 Efficient, Convenient Bus Stops
TR-1.3.2 Bus Stop Signage & Access
TR-1.3.3 Safe, Clean Lighted Bus Stops
TR-1.3.4 Transit Station Locations
TR-1.4 Customer Service for Transit
TR-1.4.1 Develop Regional Pass System
TR-1.4.2 Implement Smart Bus Technology
TR-1.4.3 Online Trip Planning
TR-1.5 Transit Funding
TR-1.5.1 Funding Preference for Transit
TR-1.5.2 Evaluate Feasible Alternatives (for transit funding preference)
TR-1.6 Transportation Impact Fees

CAPCOA 2008 recommends transit mitigation measures to offset environmental impacts of development projects which do not meet SB375 requirements for CEQA exemption.

Model Ordinances

None identified

Case Studies

Case Studies compiled in July 2009 in partnership with the California Air Resources Board. Additional climate change information is available at
http://www.ca-ilg.org/ClimateTransportationStories
http://www.ca-ilg.org/transportation
http://www.ca-ilg.org/node/1234

Kings (County) Area Rural Transit system – provides 230 vanpools and 23 rural bus routes to reach seniors, and low-income residents and provide access to medical services, schools, and daycare. The vanpool service has been tailored to agricultural workers, prison guards, school teachers, students, and state workers. Fares fully covered operating, though not start-up costs. In 2007 the vanpools eliminated 373,500 vehicle trips, and 176 tons of emissions. [EDF 2009]

La Mirada (Los Angeles County), Population: 50,447 - La Mirada's Transit service provides a flexible route Dial-a-Ride program, offering "curb-to-curb" service within the city. Passengers share rides in the city's fleet of small buses. The service is available to all residents and visitors. Passengers may call when they are ready to be picked up, schedule pick-up in advance, or subscribe to regular service. Reservations are based on time and space availability. The service also connects riders with adjacent transit agencies. http://www.ca-ilg.org/ClimateTransportationStories

The Travel Choice program run by a Bay Area advocacy nonprofit, Transform, sends trained educators to specific neighborhoods to talk one-on-one with residents about transit, walk, and bike options convenient to them. The 8-week pilot with 4800 households in 2006, showed a 14% reduction in drive alone trips and a 34% increase in transit use, after education intervention alone. This included personalized travel plan designed and delivered (by bicycle with a "gift bag") after the interview. Follow-up phone calls completed the personal process. [MTC, 2010] p. 85

Smart Trip - Portland Oregon, "routinely sees 9 to 13 percent reduction in drive-alone trips among participants and costs only about $10 per person. as cited in Environmental Defense Fund. 2009. Tailored Mass Transit - Mass Transit for California's 21st Century. http://www.edf.org/documents/10700_EDF_Tailored_Mass_Transit.pdf

Other resources

EDF. 2009. Tailored Mass Transit. Environmental Defense Fund, www.edf.org

RESOURCES

Energy Aware

T.1.1 Transit Fare Reductions
T.2.1. Transportation Demand Management Programs
See also T 4.3 Pedestrian Facilities and Traffic Calming for Safe Routes to Transit

REFERENCES

California Air Resources Board research on SB 375 implementation:

http://arb.ca.gov/cc/sb375/policies/policies.htm

Vancouver Transportation Policy Institute:

Bus Rapid Transit - ***http://www.vtpi.org/tdm/tdm120.htm***

Improving Personal Security For Walking, Cycling, Transit and Urban Infill

Transit Improvements http://www.vtpi.org/tdm/tdm47.htm

See also: Transportation Affordability - http://www.vtpi.org/tdm/tdm106.htm

Caltrans In Transition : Survey for Barriers to Implementing Transit Session CalACT Conference November 2008

http://www.dot.ca.gov/hq/MassTrans/Docs-Pdfs/survey_resultsfrom_CalAct.pdf - accessed 2010-03-29

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Litman, T. 2010. *Raise My Taxes, Please!* Victoria Transport Policy Institute. Victoria, BC.

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Loukaitou-Sideris, Anastasia. 2009. *How to Ease Women's Fear of Transportation Environments: Case Studies and Best Practices*. Mineta Transportation Institute, San Jose, CA.

Nelson/Nygaard Consultants. October 2009. *Northern California Google Transit Feasibility Study.* Shasta County Regional Transportation Planning Agency,

Litmann, T. 2010. Congestion Relief II, Re-evaluating the role of public transit. Victoria Public Transportation Institute. http://www.vtpi.org/cong_reliefII.pdf

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Signal priority for transit and bus rapid transit

SUMMARY

Transit signal priority gives transit vehicles extra green time at traffic signals to reduce the time they spend waiting at intersections. Transit signal priority can be used to make transit more reliable, faster and cost effective. In addition, it has little impact of general traffic flow and is an inexpensive way of making transit more competitive with personal automobiles.

Transit signal priority is a primary feature included in a bus rapid transit system. Bus rapid transit refers to a variety of public transportation systems that use buses to provide faster, more efficient service than a typical bus route. Bus rapid transit is considered a more affordable alternative to rail for improving transit service quality and attracting travelers who would otherwise drive on congested corridors. Routes can follow a variety of roadway types, including mixed traffic, dedicated lanes on surface streets and completely separated busways.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Increased transit service	45	72	168	$1,167	$1,425	$1,451
Expanded urban public transit	144	281	575	$1,771	$1,790	$2,082
Moving Cooler medians	45	59	83	$205	$163	$116

Increased Level of Service and Improved Travel Times: Increase transit level of service by 1.5, 2, and 4 times current revenue mile growth rate, and improve travel speeds by 10%, 15%, and 30%.

Urban Transit Expansion: Increase services proportional to 3.00%, 3.53%, and 4.67% per year ridership growth by 2010.

Modeling Assumptions: *Moving Cooler* page B-32 to B-35
Cost Assumptions: *Moving Cooler* page C-24 to C-29

Other Findings

Transit Signal Priority: A Planning and Implementation Handbook (USDOT):[17]

In Tacoma, Washington the combination of transit signal priority and signal optimization reduce transit signal delay by about 40% in two corridors. The TriMet in Portland, Oregon was able to avoid adding one more bus by using transit signal priority and experienced a 10% improvement in travel time and up to a 19% reduction in travel time variability. Due to increased reliability, TriMet has been able to reduce a scheduled recovery time. In Chicago PACE buses realized an average of 15% reduction (3 minutes) in running time. Actual running time reductions varied from 7 to 20% depending on the time of day. With the implementation of TSP and through more efficient run cutting, PACE was able to realize savings of one weekday bus while maintaining the same frequency of service. Los Angeles experienced up to 25% reduction in bus travel times with TSP.

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17 USDOT (2005) Transit Signal Priority: A Planning and Implementation Handbook. Prepared by: H. R. Smith, B. Hemily and M. Ivanovic, G. Fleming Inc.

A review of bus rapid transit systems around the world characterizes their infrastructure and operational features.[18] Based on the review features, the research recommends three sets of features that correspond to three phases of deployment in U.S. cities, depending on the project budget, time frame, users and traffic and corridor characteristics.

A single BRT vehicle may replace as many as 50 automobiles along a corridor, thus reducing total emissions (GTZ 2006). Environmentally-friendly vehicles are often highlighted as a branding feature of BRT systems. This is particularly important to the U.S. cities that seek federal funding (from FTA) to start BRT services. Galicia, L.D. Cheu, R. and Machemel, R. 2009. Bus Rapid Transit Features and Deployment Phases for U.S. Cities. Journal of Public Transportation, Vol. 12, No. 2, 2009

An analysis, based on traffic flow theory, provides approximate results on when transit signal priority, bus lanes with intermittent priority, and dedicated bus lanes should be utilized.[19] Bus lanes with intermittent priority involve variable message signs which indicate that non-bus traffic must leave the lane over a specific roadway segment. Pure transit signal priority is found to be most useful for cases of high traffic demand, dedicated bus lanes are most useful for low traffic demand, and bus lanes with intermittent priority are most useful for intermediate traffic demand. These results indicate that the optimal utilization of a bus lane may be induced by shifting its usage based on traffic congestion levels. These ideas have been further investigated in conjunction with Intelligent Transportation Systems technology.[20] The implementation of these ideas is occurring in Amman, Jordan presently.[21]

Equity and Co-benefits

Transit expansion has equity impacts on low-income and inner area groups – increased access to jobs, health care, education, and retail.

Increased Level of Service and Improved Travel Times have positive equity impacts on low-income and inner area groups – increased access to jobs, health care, education, and retail.

It has been uniformly reported that the impact to the non-priority street flow was extremely small or imperceptible. Signal synchronization is also not greatly disrupted, since transit signal priority only steals a small number of seconds from the non-priority street green.[22] Therefore benefits accrue to riders of transit with signal timing, while there are minimal negative impacts to other roadway users.

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18 Galicia, L. D., R. L. Cheu and R. Machemehl (2009) Bus Rapid Transit Features and Deployment Phases for U.S. Cities. Journal of Public Transportation, 12, 23-38.

19 Eichler, M., C. Daganzo (2006) Bus lanes with intermittent priority: Strategy formulae and an evaluation. Transportation Research Part B, 40, 731-744.

20 Todd, M., M. Barth, M. Eichler, C. Daganzo and S. Shaheen (2006) Enhanced Transit Strategies: Bus Lanes Intermittent Priority and ITS Technology Architectures for TOD Enhancement. California PATH Research Report UCB-ITS-PRR-2006-2.

21 Guler, I., M. Cassidy (2010) Deploying Underutilized Bus Lanes at Key Nodes in a Road Network. Working Paper UCB-ITS-VWP-2010-2 UC Berkeley Center for Future Urban Transport: A Volvo Center of Excellence.

22 USDOT (2005) Transit Signal Priority: A Planning and Implementation Handbook. Prepared by: H. R. Smith, B. Hemily and M. Ivanovic, G. Fleming Inc.

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

City

Population density required

Urban

Implementation Details

Link to *Energy Aware Planning Guide*

Model policy language

(p. 24 CAPCOA 2009): SB375 defines a new category of project, "Transit Priority Projects," and establishes a categorical exemption from review under CEQA for such projects, provided they meet additional specified criteria. Projects that meet the definition of the category, but not the additional criteria, are afforded other streamlining of CEQA requirements, but are not fully exempt. The definition of "Transit Priority Projects" is based on four factors:

1. The project is consistent with the SCS or APS, whichever has been determined by ARB to meet the assigned reduction targets
2. The project meets specified mixed-use criteria
3. The project has a minimum net density of at least 20 units per acre
4. The project is within a half mile of a major transit stop (existing or planned), or a "high quality"

A categorical exemption is provided for TPPs that conform to all criteria on a specified list, as well as at least one additional criterion from a list of options. The TPP must meet all of the following criteria:

1. The project is no larger than 8 acres and not more than 200 units;
2. The project can be served by existing utilities and has paid all applicable in-lieu and development fees;
3. The project does not have a significant effect on historical or environmental resources (e.g. natural habitat)

The project has remediated any environmental hazards to applicable standards and is not subject to significant and defined catastrophic risks

1. The project is not located on developed open space
2. The buildings in the project are 15 percent more energy efficient than required by California law and the project is designed to achieve 25 percent less water usage than the average household use in the region
3. The project does not result in the net loss of affordable housing units in the area
4. The project does not include any single-story building larger than 75,000 square feet
5. The project incorporates mitigation measures from previous environmental impact reports
6. The project does not conflict with nearby industrial uses. To meet the categorical exemption, the TPP must also conform to at least one of the following:
7. At least 20 percent of the housing units will be sold to families of moderate income, or not less than 10 percent of the housing will be rented to families of low income, or not less than 5 percent of the housing will be rented to families of very low income and the developer commits to the continued availability of the non-market units (55 years for rental units, 30 years for ownership units); or

8. The developer pays in-lieu fees equivalent to costs of meeting the first requirement; or
9. The project provides public open space equal to or greater than five acres per 1,000 residents.

TPPs that do not meet the criteria for a full categorical exemption from CEQA can qualify for streamlining under a Sustainable Communities Environmental Assessment or by implementing

approved Traffic Mitigation Measures. A TPP may be reviewed under a Sustainable Communities Environmental Assessment (SCEA) if the project incorporates all feasible mitigation measures, performance standards, or criteria from an applicable prior environmental impact report. The SCEA is similar to an EIR, but it does not have to address potential growth-inducing impacts, any project-specific cumulative impacts on climate change from the use of light duty vehicles, or any other cumulative effects of the project that have been addressed and mitigated in prior environmental documents. In addition to this streamlining, the bill provides that a legal challenge of the SCEA is to be reviewed under a standard of "substantial evidence" rather than under the "fair argument" standard that is generally applied to EIRs. The bill also authorizes cities and counties to adopt specific Traffic Mitigation Measures (TMMs) to apply specifically to TPPs. The TMMs include such measures as requirements for the installation of traffic control improvements, street or road improvements, transit passes for future residents, or other measures that will avoid or mitigate the traffic impacts of transit priority projects. Any TPP that implements the approved TMMs is not required to identify or implement any additional measures to mitigate traffic impacts under CEQA.

(p. 82 CAPCOA 2009): 1.2.8 Provide safe and convenient access for pedestrians and bicyclists to, across, and along major transit priority streets

Model ordinances

None identified

Case studies

A list of many agencies in the U.S. and Canada that have implemented transit signal priority is available in Chapter 10 of Transit Signal Priority: A Planning and Implementation Handbook.[23] The list includes San Francisco MUNI, Sacramento Regional Transit District, Santa Clara Valley Transportation Authority, Alameda-Contra-Costa Transit District, City of Glendale, and Los Angeles County Metropolitan Transportation Authority. Detailed case studies are available for multiple implementations including those by AC Transit in Oakland (http://www.actransit.org/planning_focus/brt/) and MTA in Los Angeles.

Los Angeles Orange Line/San Fernando Valley – this bus runs on a dedicated service lane built on a former rail right-of-way. At peak hours it arrives every 6 minutes; 10 minutes at off-peak hours. Seventy nine percent of riders use a 14 mile bikeway and 8 mile pedway to get to their transit stop. Transit stations are carefully designed and include art, real-time information displays, bike storage, shade, and convenient parking.
http://en.wikipedia.org/wiki/Orange_Line_%28Los_Angeles_Metro%29

A list of bus rapid transit systems around the world is available.[24] Particularly successful examples include those in Brisbane, Australia, Curitiba, Brazil, and Bogota Colombia. Examples in California that have been implemented or are currently being planned are in

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23 USDOT (2005) Transit Signal Priority: A Planning and Implementation Handbook. Prepared by: H. R. Smith, B. Hemily and M. Ivanovic, G. Fleming Inc.

24 Wikipedia, List of Bus Rapid Transit Systems:
http://en.wikipedia.org/wiki/List_of_bus_rapid_transit_systems

Oakland, San Francisco, Santa Rosa, San Jose, Stockton and Los Angeles.[25] Numerous other bus rapid transit systems can be found across the United States as well.

RESLOURCES

Energy Aware chapter

T.3.1.7 Traffic Signal Timing

Cross-references to other measures in Energy Aware

T.1.2 Increased Transit Service and Improved Travel Time
L.1.4 Design Sites for Pedestrians and Transit Access
L.3.1 Complete Streets and Street Design

Other resources

The USDOT provides a guidance document on the characteristics of bus rapid transit for decision-making.[26] These characteristics include those related to the running way, stations, operations, intelligent transportation systems, system capacity and safety.

The Transit Cooperative Research Program Report 118, sponsored by the Federal Transit Administration, provides a practitioner's guide to bus rapid transit.[27]

Victoria Transport Policy Institute, Strategies to Improve Transit and Ridesharing Speed and Convenience: http://www.vtpi.org/tdm/tdm19.htm

Victoria Transport Policy Institute, Bus Rapid Transit: http://www.vtpi.org/tdm/tdm120.htm

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25 Wikipedia, List of Bus Rapid Transit Systems in North America: http://en.wikipedia.org/wiki/List_of_bus_rapid_transit_systems_in_North_America

26 USDOT (2009) Characteristics of Bus Rapid Transit for Decision-Making.

27 Transportation Research Board (2007) Bus Rapid Transit Practitioner's Guide. Transportation Cooperative Research Program Report 188.

Transit Information

SUMMARY

Information on transit arrival times can greatly improve user experience, through a decrease in the time spent waiting for vehicles. This in turn can enhance the competitiveness of transit versus the personal automobile. Real-time transit information can be provided on updating signage at stops or stations, internet browsers, and to personal communication devices such as smart phones, through applications and websites. Information on transit vehicle location is typically collected via GPS. Transit information also includes route planning tools for internet browsers and smart phones.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler does not estimate the effectiveness or cost for this particular measure.

Other Findings

Redwood Transit Authority increased ridership 40% year-over-year following a number of improvements and enhancements including launching and promoting Google Transit, introducing a university bus pass program, new websites (with trip planner) and increasing frequency of service over a period of 2 months. (cited in Nelson/Nygaard 2010, p. 74]

Equity and Co-benefits

Real-time transit information for riders greatly reduces the perception of an acceptable wait time (even when buses are delayed) and levels of anxiety among passengers. Taylor, B, et al. 2009. Thinking Outside the Bus: Understanding User Perceptions of Waiting and Transferringin Order to Increase Transit Use. UCB-ITS-PRR-2009-8. California PATH Research Report .

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

City

Population density required

Urban

Implementation Details

Link to *Energy Aware Planning Guide*

Model policy language

None identified

Model ordinances

None identified

Case studies

Nextbus.com provides real-time transit information on many transit systems across the United States.[28] These include California systems such as AC Transit, San Francisco MUNI, Ventura

28 Nextbus: http://www.nextbus.com/predictor/agencySelector.jsp#California-Northern Accessed 6/22/2010.

Intercity, Glendale Bee and Camarillo Area. The information is based on GPS location information for a vehicle and its estimated arrival time to each stop.

Such information can be augmented to provide routing information. The real-time information from Nextbus has been integrated into the iphone application called BayTripper[29], which provides real-time routing and transfer information for MUNI, BART and Caltrain in the Bay Area.

Other systems, such as 511.org in the Bay Area, and googlemaps, provide routing information based on listed schedules.

RESOURCES

Energy Aware chapter

Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware

T.1.2. Increased Transit Service and Improved Travel Time

29 BayTripper: http://www.baytripper.org/ Accessed 6/22/2010.

Transportation Demand Management Programs

SUMMARY

Transportation Demand Management (TDM) can be defined as a set of strategies that strive to either reduce or reallocate automobile travel to achieve benefits such as reduced roadway congestion, reduced environmental impacts, and reduced travel costs. In contrast to conventional policies that focus primarily on roadway expansion to ease vehicle congestion, TDM strategies achieve transportation benefits by shifting travelers to the most efficient and lowest-cost means of travel for a particular trip.

Implementing a municipal TDM program to encourage city and county employees to switch from driving alone to walking, bicycling, transit, ridesharing and telecommuting can save energy, reduce greenhouse gas emissions, and provide a model for other local employers to do the same. Municipalities can also develop programs targeted at businesses, workers, and residents to encourage businesses to implement trip reduction measures at their worksites, and to provide workers and residents with the information and incentives they need to travel by alternative modes. TDM is often focused on work-related travel, but can be applied to other travel purposes as well, such as school trips. TDM strategies include guaranteed ride home programs, ridesharing, carsharing, telework, and alternative work schedules.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler estimates the combined effectiveness and cost of Transportation Demand Management Programs, Transportation Management Associations, Ridesharing and Guaranteed Ride Home Programs, Telework, and Alternative Work Schedules in their category Employer-Based Commute Strategies.

Moving Cooler measure	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
	Expanded Current Practice	Aggressive Deploy-ment	Maximum Deploy-ment	Expanded Current Practice	Aggressive Deploy-ment	Maximum Deploy-ment
Employer-Based Commute Strategies	252	486	1,165	$421	$249	$116
Moving Cooler medians	45	59	83	$205	$163	$116

Modeling Assumptions: *Moving Cooler* page B-53
Cost Assumptions: *Moving Cooler* page C-35

Other Findings

The FHWA has produced a report analyzing TDM in several European countries, and how those experiences could be adopted in US cities.
http://international.fhwa.dot.gov/traveldemand/index.cfm

Equity and Externalities/Co-benefits

Employer commute strategies in general would have positive equity impacts on low income groups, by increasing access to jobs (through shared ride or shuttle options). However, charging for employer parking would represent a negative equity impact for low-income groups, who would be less able to afford the fees. They also would be less likely to benefit from telework strategies, which often are not readily applied to lower income positions. For more detail refer to Appendix E-27.

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

City, county or region

Population density required

Urban or suburban

Implementation Details

Link to *Energy Aware Planning Guide*

Model policy language

Bay Area (www.arb.ca.gov/DRDB/BA/CURHTML/R13-1.HTM) requires all public and private employers with 100 or more employees at a work site to establish employee trip reduction targets for various locations and years, and identify various strategies to help achieve these targets.

Marin County (www.co.marin.ca.us/bos/code/cty-code/ch15-06.html).

Model ordinances

TR-3.2 Employer-based Trip Reduction: The City/County will support voluntary, employer-based trip reduction programs
TR-3.2.1 Provide assistance to regional and local ridesharing organizations
TR-3.2.2 Advocate for legislation to maintain and expand incentives for employer ridesharing programs.
TR-3.2.3 Require the development of Transportation Management Associations for large employers and commercial/industrial complexes.
TR-3.2.4 Provide public recognition of effective programs through awards, top ten lists, and other mechanisms
TR-3.3 Ride Home Programs: The City/County will implement a city/countywide "guaranteed ride home" program for those who commute by public transit, ride-sharing, or other modes of transportation, and encourage employers to subscribe to or support the program.
TR-3.4 Local Area Shuttles: The City/County will encourage and utilize shuttles to serve neighborhoods, employment centers and major destinations.
TR-3.4.1 The City/County will create a free or low-cost local area shuttle system that includes a fixed route to popular tourist destinations or shopping and business centers;
TR-3.4.2 The City/County will work with existing shuttle service providers to coordinate their services.
MO-3.1 Trip Reduction Program: The City/County will implement a program to reduce vehicle trips by employees, including:
MO-3.1.1 Providing incentives and infrastructure for vanpooling and carpooling, such as pool vehicles, preferred parking, and a website or bulletin board to facilitate ride-sharing;
MO-3.1.2 Providing subsidized passes for mass transit;
MO-3.1.3 Offering compressed work hours, off-peak work hours, and telecommuting, where appropriate;
MO-3.1.4 Offer a guaranteed ride home for employees who use alternative modes of transportation to commute.
MO-3.3 Municipal Parking Management: The City/County will implement a Parking Management Program to discourage private vehicle use, including:
MO-3.3.1 Encouraging carpools and vanpools with preferential parking and a reduced parking fee;

Case studies

None identified

RESOURCES

Energy Aware chapte Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware

L.2.1 Parking Pricing
L.2.2 Parking Supply Management
L.4.2 Bicycle Parking and Facilities
T.2.3 Guaranteed Ride Home Programs
T.2.4 Ridesharing
T.2.6 Telework
T.2.7 Alternative Work Schedules

Other resources

California Air Resources Board research on SB 375 implementation:
http://arb.ca.gov/cc/sb375/policies/policies.htm

Victoria Transportation Policy Institute:
Alternative work schedules: http://www.vtpi.org/tdm/tdm15.htm
Guaranteed ride home: http://www.vtpi.org/tdm/tdm18.htm
Ridesharing: http://www.vtpi.org/tdm/tdm34.htm
Commuter financial incentives: http://www.vtpi.org/tdm/tdm8.htm

Carsharing

SUMMARY

Carsharing refers to a short-term automobile rental service designed to serve as a substitute to private vehicle ownership. As opposed to traditional car rental services, carsharing makes occasional hourly vehicle use convenient and affordable, and provides an incentive to minimize driving by charging higher variable rates and very low fixed rates. Carsharing for many subscribers makes it feasible to own one car instead of two, or no car at all, while conveniently and more affordably meeting travel needs. Employer-run carsharing programs, similar to guaranteed ride home programs, provide commuters with "mobility insurance" – the knowledge that they may take transit or carpool to work without being stranded in the event of an emergency.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler measure	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
	Expanded Current Practice	Aggressive Deploy-ment	Maximum Deploy-ment	Expanded Current Practice	Aggressive Deploy-ment	Maximum Deploy-ment
Carsharing	37	77	163	$4	$4	$2
Moving Cooler medians	45	59	83	$205	$163	$116

Programs in all regions by 2010, one car per 2,000 inhabitants in 10 years, and one car per 1,000 inhabitants in 10 years.

Modeling Assumptions: *Moving Cooler* page B-51 to B-52
Cost Assumptions: *Moving Cooler* page C-35 to C-37

Other Findings

A review of the growth of worldwide carsharing has been conducted.[30] Recently, several transnational car-sharing companies have emerged, such as Zipcar in the United States and Canada, Greenwheels in Germany and Netherlands, CambioCar in Germany and Belgium, and CityCarClub in Sweden and Finland. New entrants are likely in Ireland, Israel, Portugal, and New Zealand. Car-sharing is expected to emerge in developing countries in Asia and Africa as well.

Another recent study has been conducted of the growth of carsharing in North America. 50 car-sharing operations have been deployed with 33 still operating.[31] Non-profit organizations have undergone dramatic growth; however for-profit operators still account for the majority of fleets deployed. Traditional rental car companies have begun to launch car-sharing, and the merger between Flexcar and Zipcar created the world's largest multi-national car-sharing operator.

A review of North American carshare parking policies, found that 17 out of over 57 local jurisdictions with carsharing have a combination of formal or informal policies, pilot projects, and proposed legislation focused on car-sharing parking. Eight public transit operators provide carsharing parking at their facilities. The San Francisco Bay Area study reveals the importance

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30 S. Shaheen, A. Cohen. (2008) Worldwide Carsharing Growth: An International Comparison. Institute of Transportation Studies, UC Davis.

31 S. Shaheen, M. Chung. (2009) North American Carsharing: A Ten-Year Retrospective. Transportation Research Record, 2010 pp. 35-44.

of resident support and features some of the policy approaches taken by public entities to allocate on-street, off-street, and transit-based car-sharing parking.[32]

Equity and Co-benefits

Positive equity impacts on low-income and inner area groups; increased access to jobs, health care, education, and retail.

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

City or county level.

Population density required

Urban.

Implementation Detail

Link to *Energy Aware Planning Guide*

Model policy language

(CAPCOA 2009, p.81): TR-1.2 System Interconnectivity: The City/County will create an interconnected transportation system that allows a shift in travel from private passenger vehicles to alternative modes, including public transit, ride sharing, car-sharing, bicycling and walking.

Model ordinances

None identified

Case studies

Energy Aware describes case studies for Berkeley, San Diego, and Seattle.

RESOURCES

Energy Aware chapter

L.1.5. Transportation Demand Management Programs

Cross-references to other measures in Energy Aware

L.1.1 Smart Growth Development
L.1.2 Land Use Diversity
L.1.3 Transit-Oriented Development
L.1.4 Design Sites for Pedestrian and Transit Access
L.2.2 Parking Supply Management
T.1.3 Park-and-Ride Lots
T.2.1 Transportation Demand Management Programs
T.2.4 Ridesharing

Other resources

Victoria Transport Policy Institute, Carsharing: http://www.vtpi.org/tdm/tdm7.htm

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32 S. Shaheen, A. Cohen. and E. Martin (2010) Carsharing Parking Policy: A Review of North American Practice and San Francisco Bay Area Case Study. Transportation Research Record.

Telework

SUMMARY

Telework substitutes telecommunications such as telephone, fax, e mail, and videoconferencing for vehicle trips, which can save vehicle miles traveled (VMT) and increase productivity. Many work-related trips can be replaced with telecommunication, and some workers are able to eliminate their commute entirely by working at home. Although managers may be reluctant to allow employees to work outside the office, telework can often add more specificity, structure and discipline to the manager-employee relationship by requiring employees and managers to set specific goals and objectives. Worker productivity has been shown to increase measurably in several studies.

Cities and counties can construct regional telework centers that encourage employers to allow more employees to perform their work closer to home.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler estimates the combined effectiveness and cost of Transportation Demand Management Programs, Transportation Management Associations, Ridesharing and Guaranteed Ride Home Programs, Telework, and Alternative Work Schedules in their category Employer-Based Commute Strategies.

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Employer-Based Commute Strategies	252	486	1,165	$421	$249	$116
Moving Cooler medians	45	59	83	$205	$163	$116

Modeling Assumptions: *Moving Cooler* page B-53
Cost Assumptions: *Moving Cooler* page C-35

Other Findings

Telework becomes a more attractive option the farther away a commuter lives; this means VMT reductions can be significant. For example, if 10 percent of vehicle trips are reduced via a telework program, VMT may drop 15 percent if the trips eliminated are longer distance commutes.[33]

The likelihood of employees to adopt telework depends on several factors, including job type, telecommunications service quality, employer support, individual preferences, and available incentives and promotions.[34]

A 2000 study estimated that 6.1 percent of California workers telecommute an average of 1.2 days per week, which eliminates 1.1 percent of total statewide VMT.[35]

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33 VTPI. 2008. "Telework: Using Telecommunications to Substitute for Physical Travel." TDM Encyclopedia. Victoria, BC: Victoria Transport Policy Institute. http://www.vtpi.org/tdm/tdm43.htm.

34 Kwan, Mei-Po and Marting Dijst. 2007. "Interaction Between Information and Communications Technologies and Human Activity Travel Behavior." Transportation Research Record A, 41(2). pp. 121-204.

Kitou and Horvath (2003) model the emissions resulting from telework and suggest that telecommuting may reduce CO_2 related to work-trips but these gains may be offset from increased home office energy use and/or commercial energy use at the business office.[36]

The California telecommuting pilot program measured productivity increases of 10 to 30 percent, and a 1997 survey of Fortune 1000 telemanagers reveled that 58 percent saw productivity increases as a result of telework programs.[37]

A 1996 survey of 400 teleworkers indicated that each daily telecommute results in a VMT reduction of 30 miles, and that if 10 percent of the workforce were to telecommute on any given day, total VMT for that day would decline by four percent.[38]

A study of neighborhood telework centers in the Seattle area found they may have the potential to reduce VMT considerably, but may provide smaller emissions reductions due to heavy emissions produced in "cold starts."[39] For example, a two-mile round trip emits only about 65 percent fewer grams of pollutants than a 20-mile round trip, even though it is 90 percent shorter. About 80 percent of the emissions in the two-mile trip come from starting and turning off the engine.[40]

An analysis of the California state telecommuting pilot project found that vehicle emissions for telecommuters dropped 63 to 73 percent on telecommuting days. TOG emissions were reduced 64%, CO reduced 63%, and NOx reduced 73%.[41]

A study of the State of California's telecommuting pilot program in the early 1990s found that participating employees reduced work trips by over 40 percent (approximately 366 miles each month). Using these data, each telecommuter saves about 230 gallons of gasoline per year if the telecommuter normally drives alone to work.[42] When all trips are included, telecommuters also reduced trips per day by about 20 percent. Evaluation of the costs and benefits of the State of California telecommuting pilot project with over 200 telecomuters found that the program broke even within three years (after startup costs) and that direct benefits outweighed costs by a five to one margin. Direct costs included training (about $300 per telecommuter-supervisor pair), phone costs (estimated at $30 per month per telecommuter), computers and maintenance and administration. Few employees needed extra phone lines or computers. Direct benefits included increased employee effectiveness (seven to 10 percent increase), decreased sick leave (10 to 20 percent fewer days), decreased turnover, reduced parking requirements and office

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35 Mokhtarian, Patricia. 2000. "A Synthetic Approach to Estimating the Impacts of Telecommuting on Travel." Urban Studies. Davis, CA: U.C. Davis Institute of Transportation Studies.

36 Kitou, E. and Horvath, A. Energy-related emissions from telework. Environmental Science & Technology.(37) 16: pp. 3467-3475. (2003).

37 Langhoff , June. 1999. "A Telemanager's Index: The Defi nitive Roundup of Telecommuting Statistics." Home Office Commuting.

38 Nilles, Jack. 1996. "What Does Telework Really Do to Us?" World Transport Policy and Practice, 2(1-2). pp. 15-23.

39 Henderson, Dennis and Patricia Mokhtarian. 1996. "Impacts of Center-Based Telecommuting on Travel and Emissions: Analysis of the Puget Sound Demonstration Project." Transportation Research D, 1(1). pp. 29-45.

40 Estimate for total organic gases, using emission factors in Appendix, assuming 30 mph.

41 Sampath, Saxena and Patricia Mokhtarian. 1991. "The Effectiveness of Telecommuting as a Transportation Control Measure." Davis, CA: U.C. Davis Institute of Transportation Studies.

42 Assuming 19 miles per gallon.

space savings. Nearly 20 percent of the telecommuters stated that telecommuting had been a moderate to decisive factor in their decision to remain in their job.[43]

Equity and Co-benefits

Telework is less likely to be applied to lower-income positions.

Modest positive equity impacts on low-income and inner area groups – increased access to jobs under expanded current practice scenario to strong positive equity impacts in an aggressive implementation.

If unoccupied or underoccupied desks, workstations and equipment are consolidated as a result of increased telework, employers can save on both equipment and maintenance costs and may save in commercial lease expenses by downsizing office spaces.[44]

POLICY CONTEXT

Existing regulations/policies

Funding may be available through the Congestion Mitigation and Air Quality Improvement (CMAQ) Program process and other sources.

The State of California Department of Personnel Administration offers a Telework Policy for state civil service employees. Individual telework plans are submitted to an employee's immediate supervisor and division chief with specific guidelines agreed to by all parties. Available on-line at http://www.dgs.ca.gov/Telework/TeleworkPolicy.htm.

The Telework Toolkit, created by the Kitsap Regional Coordinating Council and funded by the Washington State Department of Transportation, provides employers and employees with telework options, resources, and technology possibilities, as well as case studies, guidance, and sample telework agreements. Available at http://www.teleworktoolkit.com.

Implementation level

City or county

Population density required

Urban or suburban

Implementation Details

1. Establish home-based telecommuting for local government employees.
2. Review zoning code to eliminate restrictions on home-based telework.
3. Develop guidelines for use of conference calling vs. travel.
4. Assess need for telework centers.
5. Promote establishment of telecenters.
6. Share space with other local governments.
7. Organize forums and workshops for local employers to explain benefits of telework.
8. Make sure employers subject to trip reduction ordinance receive credit for telecommuting employees.

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43 Kitamura, Ryuichi, Ram M. Pendyala, and Konstadinos Goulias. 1990. "Telecommunicating and Travel Demand: An Impact Assessment for State of California Telecommute Pilot Project Participants." Davis, CA: Institute of Transportation Studies, University of California at Davis; and JALA Associates, Inc. 1990. The California Telecommuting Pilot Project Final Report. Sacramento: State of California Department of General Services. p. 52.

44 Langhoff , June. 1999. "A Telemanager's Index: The Defi nitive Roundup of Telecommuting Statistics." Home Office Commuting.

Model policy language
None identified

Model ordinances
None identified

Case studies
Ridelink, a transportation assistance program offered by the San Diego Association of Governments (SANDAG), offers a variety of services to employers interested in implementing telework programs. Ridelink provides one-on-one consultant services with telework experts, presentations on telework benefits, and assistance with design and implementation of programs, development of policies and agreements, program evaluation strategies, and training sessions. More information at http://ridelink.org.

The City and County of San Francisco launched a pilot telework program between 2004 and 2005 with support from private sector partners SBC Communications and Sun Microsystems. The city implemented new technology developed by Sun Microsystems to maintain security and operability in participants' home offices. In addition, SBC Communications assisted the city in installing DSL upgrades in some participants' homes. A program evaluation concluded the initiative was successful in boosting productivity and reducing vehicle miles traveled. It has since been expanded.[45]
http://www.sfenvironment.org/downloads/library/telecommutepolicy.pdf

The State of Arizona has been an early adopter of telework programs, starting with a pilot program in 1989. The Telework Arizona website provides resources on how the policy was implemented, administrative issues, and other issues such as perceptions of telework and managerial concerns.
http://www.teleworkarizona.com/mainfiles/coordinator/coverview.htm.

Other resources
The Telework Coalition is a Washington, D.C.-based organization that provides an information clearinghouse for the promotion of telework in the United States. More in formation available on-line at http://www.telcoa.org.

The State of Minnesota sponsors a Twin Cities metro area telework program called eWorkPlace. eWorkPlace provides free consultant services to support telework best practices, guides, policies, case studies business reports, and white papers. These tools are only available for registered Twin Cities employers. http://www.eworkplace-mn.com/AbouteWorkPlace/tabid/223/Default.aspx.

RESOURCES

Energy Aware chapter
T.2.6 Telework

Cross-references to other measures in Energy Aware
T.1.1 Transportation Demand Management Programs
T.1.2 Transportation Management Associations
T.2.7 Alternative Work Schedules

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45 Ware, James. 2005. A Telework Pilot for the City and County of San Francisco: A Case Study. Berkeley: Work Design Collaborative.

Other resources
Victoria Transportation Policy Institute: http://www.vtpi.org/tdm/tdm43.htm

Traffic Signal Timing

SUMMARY

Vehicles are most efficient when traveling at steady speeds. Stop-and-go driving and idling resulting from poorly timed traffic signals wastes fuel and increases greenhouse gas emissions. Optimizing the timing of existing signals and installing advanced control equipment can significantly reduce traffic congestion (and by association the need to widen roads), fuel use, and vehicle emissions.

An Active Traffic Management System can improve these benefits by changing signal timing in real time, responding to fluctuations in traffic demand throughout the day. These systems are dependent upon a reliable communications infrastructure, and cannot be deployed without an adequate Traffic Management Center (TMC) that can run the required software.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler estimates the effect of traffic signal timing in three distinct measures: Active Traffic Management, Integrated Corridor Management, and Arterial Signal Control Management.

	Effectiveness (mmt GHG reduced)			**Cost-effectiveness ($/ton GHG reduced)**		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Active Traffic Management	NA	46	80	NA	$235	$324
Integrated Corridor Management	NA	46	80	NA	$235	$325
Arterial Signal Control Management	3	18	37	$833	$339	$457
Moving Cooler medians	45	59	83	$205	$163	$116

Modeling Assumptions: *Moving Cooler* page B-63
Cost Assumptions: *Moving Cooler* page C-43

Other Findings

ATCS collects and analyzes extensive detector data to determine real-time traffic demand, control cycle lengths, and phase splits. A 2001 study indicated that the ATCS reduced travel time by 12.7 percent, decreased average stops by 31.0 percent, and reduced average delay by 21.4 percent in affected corridors[46]

Cities participating in California's Fuel Efficient Traffic Signal Management (FETSIM) Program reduced fuel consumption by an average of 7.8 percent, reduced travel time by 7.4 to 11.4 percent, decreased delay by 16.5 to 24.9 percent, and reduced stops by 17.0 to 27.0 percent.[47]

In a 2001 study, the City of Los Angeles Department of Transportation estimated that its Adaptive Traffic Control System (ATCS), which automatically adjusts signal timing at 375

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46 Banerjee, Frances T. 2001. Preliminary Evaluation Study of Adaptive Traffic Control System (ATCS). Los Angeles: City of Los Angeles Department of Transportation

47 Skabardonis, Alexander. 2001. ITS Benefits: The Case of Traffic Signal Control Systems. Presented at the 80th Annual Transportation Research Board meeting. Washington: Transportation Research Board

intersections, reduced travel time by 12.7 percent, decreased average stops by 31 percent, and reduced average delay by 21.4 percent.[48]

Based on work done for the Federal Highway Administration, for every hour of vehicle delay reduced, 0.62 gallons of fuel are saved by autos and 1.93 gallons are saved by large trucks.[49]

Institute of Transportation Engineers estimates that comprehensive retiming of traffic signals can reduce fuel consumption by six to nine percent.[50]

Portland, Oregon estimated that approximately 50 metric tons of CO2 were saved each year per traffic signal retimed in the city.[51]

ITE has estimated that the benefits of retiming traffic signals outweigh the costs by over 40 to 1.[52]

The Blackstone and Herndon arterial avenues are now synchronized with models indicating travel time reductions of up to 18 percent, fuel savings of 1.35 million gallons annually, and emission reductions of 300 Metric Tons (MT) of Carbon Monoxide, 60 MT of NOx, and 75 MT of volatile organic compounds.[53]

Salt Lake City's ATMS resulted in significant delay reductions, a 36 percent decrease in peak hour delay on freeways as a result of eight-second freeway ramp meters. The overall annual benefits of the system were estimated at $179 million yielding a benefit-to-cost ratio of 16.7.[54]

SCOOT can reduce traffic delay by an average of 20% in urban areas[55]

Equity and Co-benefits

Improving Signal Timing has fairly universal benefits. All drivers receive the same reductions in travel time, although drivers who drive in the peak times make notice greater reductions in delay simply they because they had the greatest delay to begin with. Improving signal timing also benefits transit, and primarily bus service by improving flow and reducing travel times (*Moving Cooler* Appendix E).

The California Air Resources Board estimates that a traffic signal coordination program that increases average corridor speed from 28 mph to 33 mph on a corridor that handles 38,400 vehicle trips per day can be expected to reduce volatile organic compounds (VOCs) by 1,057 pounds per year and nitrogen oxide (NOx) by 793 pounds per year.

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48 Banerjee, Frances T. 2001

49 Science Applications International Corporation. 1993. Speed Determination Models for the Highway Performance Monitoring System. Washington: Federal Highway Administration

50 Kittelson & Associates. 2008. Traffic Signal Timing Manual. Washington: Federal Highway Administration

51 Peters, J.; R. McCourt and R. Hurtado. 2009. "Reducing Carbon Emissions and Congestion by Coordinating Traffic Signals." ITE Journal. April 2009

52 Peters, J.; R. McCourt and R. Hurtado. 2009. "Reducing Carbon Emissions and Congestion by Coordinating Traffic Signals." ITE Journal. April 2009

53 City of Fresno. 2008. Intelligent Transportation Systems: Advanced Transportation Management Systems & Strategy Plan. Fresno: Public Works Department, City of Fresno

54 Perrin, Joseph, Rodrigo Disegni, and Bhargava Rama. 2004. Advanced Transportation Management System Elemental Cost Benefit Assessment. Salt Lake City: Utah Department of Transportation

55 http://www.scoot-utc.com/

POLICY CONTEXT

Existing regulations/policies

San Francisco Bay Area (MTC), Program for Arterial System Synchronization (PASS)

The purpose of the Program for Arterial System Synchronization (PASS) is to provide technical and financial assistance to Bay Area agencies to help improve the safe and efficient operation of certain traffic signal systems and corridors

MTC Regional Signal Timing Program (RSTP)

Under the RSTP, MTC provides local jurisdictions with traffic engineering assistance and expertise in retiming and coordinating their traffic signals, including implementing transit signal priority. Technical assistance is provided for the analysis of existing conditions, including collecting new traffic counts and performing travel time and delay studies; development of recommended timing plans; implementation and fine-tuning of approved timing plans; and evaluation of the benefits of the project.
http://www.mtc.ca.gov/services/arterial_operations/current.htm

Implementation level

Region, county, or city

Population density required

Urban

Implementation Details

Traffic Signal Timing can be implemented in many different ways, and can also be implemented to different extents depending on the goals of the program and the funding available.

Equipment

Regions that do not already have actuated signals (currently running "pre-timed" operations) may choose to install detection at intersections.

Regions that already have detection may choose to upgrade the detection equipment (from inductive loop detectors to video detection), or upgrade the control system.

Improving Signal Timing Plans

This could range from simply choosing several intersections and re-timing operations to better suit current demand, to selecting entire corridors and timing signals for coordination.

This implementation typically requires very little capital investment, and may even be done by a traffic engineer on staff at the municipality. For smaller agencies, this task is usually contracted out to a consulting firm.

Develop/Form a Traffic Management Center

Many of the denser regions throughout California have their own Traffic Management Centers (TMC's) which are connected to most or all of the intersections in their jurisdiction through a central communications infrastructure.

From these TMC's, traffic engineers can identify and correct problems in real time, and manage signal timing on a more finite level. For example, the TMC in Anaheim CA schedules additional personnel on the nights where there will be special events at Angel Stadium or the Honda Center. From the TMC, traffic engineers can coordinate with Law Enforcement to change signal timing and coordination to deal with the additional demand on an event-to-event basis.

Adaptive Control Systems

Perhaps the most advanced of current traffic signal timing programs, adaptive control systems change the signal timing at intersections in real-time.

ACS uses software with demand-responsive algorithms to alter signal timing and coordination continuously throughout the day based on inputs/measurements from detectors in the field.

Since these programs are so advanced, implementation necessitates a TMC, a reliable and meticulously maintained communications infrastructure, and a certain level of technology at intersections.

For all of these reasons, this is one of the most effective but also one of the most costly implementations of improved signal timing currently available.

This specific system primarily benefits large, dense urban areas where there are many closely spaced intersections and high levels of congestion already exist (like Los Angeles for example).

Model policy language

TR-2.2 Arterial Traffic Management: The City/County will modify arterial roadways to allow more efficient bus operation, including bus lanes and signal priority/ preemption where necessary. CAPCOA, page 83.

TR-2.3 Signal Synchronization: Expand signal timing programs where emissions reduction benefits can be demonstrated, including maintenance; coordinate with other jurisdictions to optimize transit operations while maintaining a free flow of traffic. CAPCOA, page 83.

Model ordinances

None identified

Case studies

LADOT Adaptive Traffic Control System (ATCS)

http://www.signalsystems.org.vt.edu/documents/Jan2001AnnualMeeting/HangHu-LAATCS_TRB2001.pdf

http://ladot.lacity.org/pdf/PDF114.pdf

City of Fresno/Fresno County ATMS Implementation

The Advanced Traffic Management System (ATMS) connected the city's new Traffic Operations Center to a fiber optic network, connecting key arterial roads and expressways for an efficient citywide traffic coordination system

Salt Lake City CommuterLink Advanced Transportation Management System (ATMS)

600 intersections in the Salt Lake Valley.

The capital cost of the ATMS was approximately $106 million.

Annual maintenance cost was $377,800 and annual operational cost was $2.3 million

The annual capital cost was estimated at $8 million, for an annual total of $10.7 million in relative annual costs

SCOOT

SCOOT (Split Cycle Offset Optimisation Technique) is a tool for managing and controlling traffic signals in urban areas. It is an adaptive system that responds automatically to fluctuations in traffic flow through the use of on-street detectors embedded in the road. http://www.scoot-utc.com/

RESOURCES

Energy Aware chapter

T.3.1. Traffic Signal Timing

Cross-references to other measures in Energy Aware

L.3.1 Complete Streets and Street Design
T.1.2 Increase Transit Service and Improved Travel Time

CHAPTER 4:
Website Briefings of Community Energy Measures in *Energy Aware Planning Guide*

Municipal Fleet Efficiency

SUMMARY

Local governments in California own and operate hundreds of thousands of vehicles. By increasing the fuel efficiency of individual vehicles, operating them more efficiently and improving overall fleet management, cities and counties can save significant amounts of energy and money while helping to address the risks associated with air pollution and climate change.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler does not estimate benefits from government vehicle procurement or maintenance policies.

Other Findings

None identified

Equity and Co-benefits

None identified

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

City. Any sized government can adopt procurement policies for fuel efficient vehicles.

Population density required

Rural. Government vehicle procurement policies can be adopted in counties of any size population density.

Implementation Details

Link to *Energy Aware Planning Guide*

Model policy language

Link to *Energy Aware Planning Guide*

Model ordinances

TR-6.1.3 Encourage transportation fleet standards to achieve the lowest emissions possible, using a mix of alternate fuels, PZEV or better fleet mixes. CAPCOA page 88

Case studies

Link to *Energy Aware Planning Guide*

RESOURCES

Energy Aware chapter

Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware
NA

Install vehicle refueling infrastructure

SUMMARY

In order for consumers to widely embrace alternative fueled vehicles, an extensive network of refueling stations is necessary. However, fuel providers are reluctant to build refueling stations until market penetration of alternative fueled vehicles reaches a critical mass. Governments can alleviate this situation by constructing refueling infrastructure prior to the wide adoption of alternative fueled vehicles, as well as purchasing and using these vehicles in their fleets.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler does not estimate benefits from government installation of vehicle refueling infrastructure.

Other Findings

CARB Low-Carbon Fuel Standard has emission factors.

Equity and Co-benefits

None identified

POLICY CONTEXT

Existing regulations/policies

CARB's Low Carbon Fuel Standard requires that the carbon content in transportation fuels be reduced by 10 percent by 2020. Carbon content is to be determined based on the full fuel cycle, including any carbon associated with changes in land use to grow the feedstock for the fuel. CARB has developed a computer model to estimate the carbon content of different fuels. http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

The Bay Area Air Quality Management District provides funding for the deployment and expansion of access to alternative fueling/charging stations in the Bay Area. Funding is available for: new construction, upgrades, improvements that expand access to alternative fuel infrastructure; upgrade of existing private alternative fuel infrastructure to make it accessible for public use; and up to 50% of the total project cost not to exceed $200,000 per project sponsor. http://www.baaqmd.gov/Divisions/Strategic-Incentives/Alternative-Fuel-Infrastructure.aspx

Implementation level

City, county or regional. Any sized government can install refueling infrastructure for alternative fuels.

Population density required

Rural, suburban, or urban. Refueling infrastructure will be necessary in counties of any size population density; it will be especially important to construct stations in rural areas far from other refueling stations.

Implementation Details

Link to *Energy Aware Planning Guide*

Model policy language

None identified

Model ordinances

TR-6.1.1 Develop the necessary infrastructure to encourage the use of zero-emission vehicles and clean alternative fuels, such as development of electric vehicle charging facilities and conveniently located alternative fueling stations. CAPCOA page 88

TR-6.1.2 Encourage new construction to include vehicle access to properly wired outdoor receptacles to accommodate ZEV and/or plug in electric hybrids (PHEV). CAPCOA page 88

Case studies

None identified

RESOURCES

Energy Aware chapter

Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware

NA

Eco-driving, tire inflation, and vehicle maintenance for consumers

SUMMARY

Programs can be implemented that train drivers in techniques that can reduce gas consumption, such as avoiding rapid acceleration and braking, reducing speeds, changing gears properly, using cruise control, and turning the engine off rather than idling when stopped. These programs would also provide training on proper vehicle maintenance: responding to the vehicle's check engine light, properly inflating tires, purchasing replacement tires with lower rolling resistance, using lower viscosity motor oil, etc. Programs could also include funding for public awareness campaigns and new driver education. Such eco-driving training programs have been in place since the late 1990s in the Netherlands and Sweden.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Eco-driving programs for consumers	727	1,170	1,815	$0	$0	$0
Moving Cooler medians	45	59	83	$205	$163	$116

Assumes 5%, 8%, and 20% adoption by drivers nationally. No costs were associated with this measure.

Modeling Assumptions: *Moving Cooler* page B-61
Cost Assumptions: *Moving Cooler* page C-43

Other Findings

U.S. EPA estimates that eco-driving can improve fuel economy by up to 33%. (EcoDriver's Manual**:** A Guide to Increasing Your Mileage and Reducing Your Carbon Footprint.)

The EU Commission's European Climate Change Programme estimated in 2001 that adoption of eco-driving across the then 15 EU countries had the potential to remove 50 million tons of CO2 per year from their total road traffic emissions.

In 2006 the eco-driving program in the Netherlands reduced road traffic CO_2 emissions by 0.3 to 0.6 million tons. The goal of the program is an annual reduction of 1.5 million tons of CO_2 by 2010. At that reduction level it is estimated that the program will cost less than 10 euros per ton CO_2 reduction.
http://www.oecdobserver.org/news/fullstory.php/aid/2596/Ecodriving:_More_than_a_drop_i n_the_ocean_.htm.

The implementation of eco-driving in the Netherlands involved a television and radio campaign to help disseminate the principles of eco-driving. Overall 67 percent of the population knows about eco-driving, and it is estimated that 35 percent actively uses the techniques. Demonstration of eco-driving skills was included as part of the driving license exam in 2008. ("Evaluation and monitoring as an instrument for policy-decision-making" by Henk Wardenaar, Ministry of Transport, Public Works and Water Management, Netherlands.)

Eco-driving in Sweden also started in the late 1990s; an association of fuel-efficiency "coaches" was established by 2005. In 2006 the government began phasing in eco-driving requirements for driver licensing programs for the taxi drivers (April 2007) and the driver education course for a private passenger car license (December 2007). By 2008 eco-driving requirements will be launched at all levels. ("Great savings every kilometre" by Gugge Häglund and Anna Gudmundsson of the Swedish Road Administration.)

Equity and Co-benefits

None identified

POLICY CONTEXT

Existing regulations/policies

The California Air Resources Board recently adopted a program that would require all vehicle service stations to perform a check of the tire air pressure, and inflate each tire that is under-inflated, every time a vehicle is brought in for service. The regulation was disapproved by ARB's Office of Administrative Law in March 2010; ARB staff has until July 2010 to resubmit a package. http://www.arb.ca.gov/cc/tire-pressure/tire-pressure.htm

AB 844 required the California Energy Commission to adopt a fuel efficient tire program that will provide consumers information on the rolling resistance and likely fuel economy benefits of replacement tires for light-duty vehicles.
http://www.energy.ca.gov/transportation/tire_efficiency/index.html

The California Bureau of Automotive Repair has run the Smog Check program in California since 1984. The program requirements have evolved over the years, with the latest proposal to replace tailpipe emission testing of 1996 and newer vehicles with a scan of the vehicle's on-board diagnostic computer. The program ensures that vehicles, and in particular their emission control systems, are performing properly; a malfunctioning vehicle can be the result of incomplete fuel combustion. http://www.autorepair.ca.gov/

Implementation level

City, county or regional. Any sized government can adopt an eco-driving program.

Population density required

Rural, suburban, or urban. Eco-driving will reduce energy use regardless of population density.

Implementation Details

None identified

Model policy language

None identified

Model ordinances

None identified

Case studies

None identified

Other resources

The Alliance of Automobile Manufacturers has established a website that provides state and local governments steps they can take to encourage eco-driving.
http://www.ecodrivingusa.com/#/state-and-local-action/ The website also provides an ecodriving calculator, tips, and educational tools for consumers.
http://www.ecodrivingusa.com/

A consortium of several European countries has established a similar website.
http://www.ecodrive.org/

RESOURCES

Energy Aware chapter

Link to *Energy Aware Planning Guide*

Cross-references to other measures in Energy Aware

NA

Cool Streets

SUMMARY

Pavement and its management by transportation agencies can contribute greatly to energy consumption and emissions. Pavement materials that create a smoother driving surface can reduce tire rolling resistance, thereby reducing vehicle fuel use. The use of more reflective and more porous paving materials, the shading of paved surfaces, and landscaping strategies around roadways can reduce the urban heat island effect. Paving (and repaving) roadways also generates emissions from several processes; these processes can be altered to reduce the emissions associated with them.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler does not estimate the effectiveness or cost for this particular measure.

Other Findings

A study of radiative forcing indicates that there is potential to offset global GHG emissions significantly through the use of cool pavements, due to the potential to increase the surface albedo. This should offset the growth in global GHG emissions for around 5 years and it is thought that this can save about $500billion.[56]

A life-cycle assessment of the global warming potential of pavements indicates that pavements can have a significant impact of energy consumption and GHG emissions, from a variety of sources, with tire rolling resistance, radiative forcing, and materials transportation the greatest contributors to greenhouse gas emissions in the pavement supply chain.[57]

Equity and Co-benefits

Cool pavements are also likely to contribute to the reduction of smog, reduced household electricity consumption, and improved visibility at night and in wet weather.[58] Choice of paving materials can also reduce tire wear and efficiency, and noise levels.

Nonroof Surfaces (shading and high albedo materials > 29 SR) = <1% emission reductions ("Low" = < 1%) CAPCOA, 2008. Table 16 - MM E8, p. B24).

Parking Area Tree Cover - CAPCOA 2008. Table 16, p. B-10): "Annual net CO2 reduction of 3.1 kg/m2 canopy cover (Moderate impacts). Costs estimated at $19/tree plus maintenance.

Historically traffic engineers have pursued a 'no trees' policy because of assumptions about visibility and the reality of fatalities resulting from crashes into trees. The presence or absence of street trees had a statistically significant and stronger effect on perception of safety than the surrounding land use urban or suburban in a driving simulation experiment. For the low-density suburban landscape, the presence of trees significantly dropped the cruising speed of drivers by an average of 3.02 miles per hour). Faster drivers and slower drivers both drove slower with the presence of trees. [Naderi et al, 2008]

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56 Akbari, H., S. Menon and A. Rosenfeld (2009) Global cooling: increasing world-wide urban albedos to offset CO2. Climate Change, 94, 275-286.

57 Santero, N. and A. Horvath (2009) Global warming potential of pavements. Environmental Research Letters, 4.

58 Akbari, H., M. Pomerantz and H. Taha (2001) Cool Surfaces and Shade Trees to Reduce Energy Use and Improve Air Quality in Urban Areas. Solar Energy, 70, 295-310.

Studies of low-income urban neighborhoods typically find fewer trees, minimal open space or green space and a higher proportion of hardscape surfaces than higher income areas. These conditions amplify heat island effects. "Cool street" designs can significantly improve the walking environment and air quality, and reduce public health impacts such as asthma attacks and early death known to be generated by high heat and smog alert days.

POLICY CONTEXT

Existing regulations/policies

The U.S. EPA provides information and guidance on pavements and the heat island effect.[59]

The Houston Advanced Research Center has conducted much investigation into methods for reducing urban heat islands and has developed a guidance document which includes Cool Paving.[60]

Caltrans adopted a goal to reduce the amount of cement used in pavements and bridges by up to 50 percent, by using fly ash, slag, limestone, and other substitutes. Caltrans estimates this policy will reduce GHG emissions by 4.2 MMT by 2020 statewide. The agency is also investigating the use of materials designed to last 100 years.
http://www.dot.ca.gov/docs/ClimateReport.pdf;
http://www.dot.ca.gov/hq/esc/Translab/ClimateActionTeam/limestone-in-cement.html

Implementation level

This policy likely to be implemented by at the state or regional level.

Population density required

The policy can be utilized for any population density level; however it will be most useful in denser areas, where heat islands tend to be more severe.

Implementation Details

Model policy language

Examples from CAPCOA, 2009.

LU-6.1 Hardscape Heat Gain: The City/County will reduce heat gain from pavement and other hardscaping, including
6.1.1 Reduce street rights-of-way and pavement widths to pre-World War II widths (typically 22 to 34 feet for local streets, and 30 to 35 feet for collector streets, curb to curb), unless landscape medians or parkway strips are allowed in the center of roadways
6.1.2 Reinstate the use of parkway strips to allow shading of streets by trees
6.1.5 Install cool roofs, green roofs, and use cool paving for pathways, parking, and other roadway surfaces
6.1.5 Install cool roofs, green roofs, and use cool paving for pathways, parking, and other roadway surfaces
6.1.7 Remove obstacles to xeriscaping, edible landscaping and low-water landscaping
6.1.6 Establish standards that provide for pervious pavement options;

See also:
EE- 3.1.1 50% Paved Surface Shading;

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59 U.S. EPA. Heat Island Effect, Cool Pavements: http://www.epa.gov/hiri/mitigation/pavements.htm. Accessed on 6/16/2010.

60 Houston Advanced Research Center (2004) Cool Houston! A Plan for Cooling the Region: http://files.harc.edu/Projects/CoolHouston/CoolHoustonPlan.pdf. Accessed 6/16/2010.

EE - 3.1.2 Heat Island Mitigation

Model ordinances

EPA maintains a website of model ordinances and case studies for cool streets: http://yosemite.epa.gov/gw/statepolicyactions.nsf/HIRIMitigation?OpenView&count=500&type=Cool%20Pavements

And street trees: http://yosemite.epa.gov/gw/statepolicyactions.nsf/HIRIMitigation?OpenView&count=500&type=Trees%20and%20Vegetation

City of Fresno Parking Lot Shading Standards. http://www.fresno.gov/NR/rdonlyres/7FDD2107-E556-4B87-8CDC-3D106C5DB37E/0/ParkingLotShadingStandards.pdf

Since 1983, Sacramento's zoning code has required that enough trees be planted to shade 50 percent of new or significantly altered parking lots after 15 years of tree growth. Sacramento's Parking Lot Tree Shading Design and Maintenance Guidelines: http://www.cityofsacramento.org/planning/long-range.

Case studies

California Center for Sustainable Energy's Cool Communities Shade Tree (CCST) Program has had direct energy benefits. The program provided 17,398 shade trees since 2006, which will result in an electric demand reduction of 2,958 kW and a total energy savings of 2.7 million kWh per year on average over the next 20 years. Since its inception in 2002, CCST has provided hands-on education and more than 35,000 trees to thousands of residents in San Diego County. http://energycenter.org.

Since 1990, the Sacramento Municipal Utility District (SMUD), in collaboration with the Sacramento Tree Foundation, has planted more than 450,000 trees in the Sacramento area and provided technical assistance at no cost. SMUD'sTree Benefits Estimator website can assess the amount of energy savings and pollution removed when mature trees are planted in urban and suburban settings. http://www.smud.org/en/residential/trees/Pages/index.aspx.

A study of the potential for increasing the albedo in Sacramento indicates that modifications to commercial roofs, roads, parking lots and sidewalks can increase the city's albedo by 16%.[61]

Sacramento Cool Communities Permeable Parking Lot Demonstration Pervious Concrete Pavements- describes results from a pervious concrete parking lot installed in 2001 to enhance stormwater management and to reduce the urban heat-island effect. This parking lot is one of the first in the state to use this type of paving.

Other resources

U.S. EPA Urban Heat Island Web Site. Ongoing research and case studies on cool pavement and shading research and best practices. http://www.epa.gov/hiri/mitigation/

A new initiative, Cool California Communities, will provide technical assistance for building and public works professionals on the needs, benefits and options for cool community practices, such as the selection of cool paving materials. The initiative is funded by CEC and CARB, and managed by Lawrence Berkeley National Laboratory.

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61 Akbari, H., L.S. Rose and H. Taha (2001) Analyzing the land cover of an urban environment using high-resolution orthophotos. Solar Energy, 70, 295-310.

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

L.3.2 Street Trees
B.1.7 Shade Trees
C.1.3 Cool Communities

CHAPTER 5: Website Briefings of Additional Transportation Measures not included in *Energy Aware Planning Guide*

Intercity Passenger Rail

SUMMARY

Intercity passenger rail (conventional and high-speed) can have lower greenhouse-gas emissions per passenger-mile than other modes of travel (light-duty vehicle, bus, or airplane). However, these benefits are only achieved with high ridership levels, and passenger rail systems can be quite expensive. Intercity rail systems must be carefully integrated with existing metropolitan transportation systems to ensure that ridership and in turn environmental benefits occur.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Intercity Passenger Rail	46	47	50	$420	$757	$1,522
Intercity High-Speed Passenger Rail	73	97	143	$1,364	$1,115	$1,008
Moving Cooler medians	45	59	83	$205	$163	$116

Increase funding over baseline by for the next 20 years. High-speed rail should be implemented in some percentage of corridors over the next 20 years.

Modeling Assumptions: *Moving Cooler* page B-36 to B-38
Cost Assumptions: *Moving Cooler* page C-30 to C-32

Other Findings

The results of a life-cycle assessment of high speed rail, conventional rail, automobile travel, and air travel, in California[62] indicate that high-speed rail can cause less emissions per passenger-mile traveled if ridership is sufficiently high. However, the results also indicate the potential for high-speed rail to have higher emissions for multiple pollutants. In particular, SO_2 emissions per passenger-mile traveled for high-speed rail can be much higher than those for other modes. The study assumes a maximum ridership for high-speed rail of 1200 passengers per train and a minimum of 120. The ridership range for personal automobile travel is from 1 to 5 passengers per car.

Equity and Co-benefits

No significant equity impacts.

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62 Chester, M. and A. Horvath (2010) Life-cycle assessment of high-speed rail: the case of California. Environmental Research Letters, 5.

POLICY CONTEXT

Existing regulations/policies

The California High-Speed Rail Authority provides information about proposed construction plans for the State.[63] News and facts, funding information, and potentials route are provided.

The Safe, Reliable High-Speed Passenger Train Bond Act for the 21st Century was approved by California voters in 2008. A high-speed rail (HSR) system is part of the statewide strategy to provide more mobility choice and reduce GHG emissions. This measure supports implementation of plans to construct and operate an HSR system between northern and southern California. As planned, the HSR is a 700-mile-long rail system capable of speeds in excess of 200 miles per hour on dedicated, fully-grade separated tracks with state-of-the-art safety, signaling and automated rail control systems. The system would serve the major metropolitan centers of California in 2030 and is projected to displace between 86 and 117 million riders from other travel modes in 2030.

Implementation level

Intercity rail has to be implemented on a regional level or statewide.

Population density required

Stations need to be located in central suburban or urban locations, with access to other local transport.

Implementation Details

None identified

Model policy language

CAPCOA Model Policies for GHG in General Plans p.B-6: The Safe, Reliable High-Speed Passenger Train Bond Act for the 21st Century was approved by California voters in 2008. A high-speed rail (HSR) system is part of the statewide strategy to provide more mobility choice and reduce GHG emissions. This measure supports implementation of plans to construct and operate an HSR system between northern and southern California. As planned, the HSR is a 700-mile-long rail system capable of speeds in excess of 200 miles per hour on dedicated, fully-grade separated tracks with state-of-the-art safety, signaling and automated rail control systems. The system would serve the major metropolitan centers of California in 2030 and is projected to displace between 86 and 117 million riders from other travel modes in 2030.

CAPCOA Model Policies for GHG in General Plans p.76: Amending the Development Code to encourage mixed-use development within one-half mile of intermodal hubs and future rail stations; to offer flexible standards for affordable housing; and to establish minimum residential densities and non-residential FAR.

Model ordinances

None identified

Case studies

A review of 166 high-speed rail projects across the world has been conducted.[64] The study focuses on costs and three major types are identified. These are planning and land use costs,

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63 California High-Speed Rail Authority: http://www.cahighspeedrail.ca.gov/

64 Campos, J., de Rus, G (2009) Some stylized facts about high-speed rail: A review of HSR experiences around the world. Transport Policy, 16, 19-28.

infrastructure building costs, and superstructure costs. It was found that these costs greatly varied, depending on the existing infrastructure prior to the introduction of high-speed rail.

A case study of high speed rail in Taiwan indicates that ridership has not met expectations due to some decline in the national economy, the large number of stops made between the main stations leading to longer travel times, and poor metropolitan transportation accessibility between stations, and origins and destinations. This highlights the need for the development of metropolitan transit networks to make intercity rail in California successful.

Another case study of high speed rail investigates its implications at multiple levels in Europe. One of the levels, is the local level, for which the authors empirically argue that high speed rail "becomes a planning tool to strengthen the national and regional roles of big intermediate cities, and is not just an opportunity to carry out local urban regeneration."[65] Another important conclusion is the role of large intermediate cities, such as those in along the planned high-speed rail route in the California's Central Valley. Such cities can utilize high speed rail by attracting intermetropolitan gatherings, mid-level businesses, congresses, scientific meetings, and international seminars and exhibitions.

RESOURCES

Energy Aware chapter

Cross-references to other measures in Energy Aware

Relates closely to land-use and transit measures.

65 Urena, J. M., P. Menerault and M. Garmendia (2009) The high-speed rali challenge for big intermediate cities: A national, regional and local perspective. Cities, 26, 266-279.

High Occupancy Vehicle (HOV) lanes

SUMMARY

High Occupancy Vehicle (HOV) lanes are off limits to single occupant vehicles during peak periods, and serve as an incentive to carpool or vanpool to and from work. HOV lanes are intended to carry more people per lane than adjacent freeway lanes in the peak hour, if not the entire peak period.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler estimates assume conversion of existing lanes to HOV lanes; the high cost is the installation of moveable barriers. Adding a lane with permanent barriers increases costs by several orders of magnitude, according to *Moving Cooler*. However, barriers are not necessary; in California there are both continuous and limited access HOV lanes.[66]

According to *Moving Cooler*, HOV lanes are quite expensive. Expanding HOV lanes to 24 hours has a small effect on emission reductions, but at little cost.

	Effectiveness (mmt GHG reduced)			**Cost-effectiveness ($/ton GHG reduced)**		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
HOV Lanes	48	64	141	$3,579	$3,623	$4,036
HOV Lanes (24-hours)	1	1	2	$50	$50	$25
Moving Cooler medians	45	59	83	$205	$163	$116

Initiate HOV expansion in all urban regions over a 10-, 8-, and 4-year period.

Modeling Assumptions: *Moving Cooler* page B-47
Cost Assumptions: *Moving Cooler* page C-33

Other Findings

Kwon & Varaiya[67] had a fairly negative view of HOV lanes:

(1) HOV lanes are under-utilized: 81% of HOV detectors measure flows below 1400 vehicles per hour per lane (vphpl) during the PM peak hour.
(2) Many HOV lanes experience degraded operations: 18% of all HOV miles during the AM peak hour and 32% during the PM peak hour have speeds below 45 mph for more than 10% of weekdays.
(3) HOV lanes suffer a 20% capacity penalty, achieving a maximum flow of 1600 vphpl at 45 mph vs. maximum flow above 2000 vphpl at 60 mph in general purpose (GP) lanes.
(4) HOV lanes offer small travel time savings. The mean savings over a random 10-mile route on an HOV lane vs. the adjacent GP lane is 1.7 min and the median is 0.7 min; however, HOV travel times are more reliable.
(5) Travel time savings do not provide a statistically significant carpooling incentive.

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66 Boriboonsomin, K. and Barth, M. Impacts of freeway high-occupancy vehicle lane configuration on vehicle emissions. Transportation Research Part D 13 (2008) 112-125.

67 Kwon, J. and Varaiya, P. Effectiveness of California's High Occupancy Vehicle (HOV) system. Transportation Research Part C 16 (2008) 98–115

(6) A system with one HOV lane and three GP lanes carries the same number of persons per hour as a system with four GP lanes.
(7) HOV lanes reduce overall congestion slightly only when the general purpose lanes are allowed to become congested.

Daganzo & Cassidy[68] provide a more positive alternative view of HOV laves, which has become more generally accepted by researchers:
The HOV lanes at all the sites we have analyzed, which are quite typical, add less than 2% to vehicle delay and reduce people delay by more than 10%. These estimates assume no increase in car-pooling (i.e. all HOV traffic comes from existing traffic in general purpose lanes, rather than induced demand). "Simulations have shown that some deployment strategies actually increase total bottleneck flow by exploiting the smoothing effect. However, bottleneck capacity is not the only freeway performance metric that can be affected by an H-lane. If a freeway's ability to store vehicles is reduced by converting a G-lane into an H-lane, freeway queues can grow physically longer and block more ramps, even if the bottleneck capacity is maintained. The added blockages could reduce the freeway's outflow via off-ramps and its inflow via on-ramps.[69]" (Daganzo 1a)

During the a.m. peak hour, State Route 91 carries 3,000 occupants into downtown Los Angeles in only 1,300 vehicles.[70]

Boriboonsomin & Barth[71] study the effect of HOV lanes on emissions. They find that HOV lanes decrease emissions, as long as the HOV lane is not underutilized in congested conditions. They use multiple scenarios for Southern California highways.

Boriboonsomin & Barth[72] estimate the influence of HOV lanes on emissions in California using a traffic simulation and modal emissions model. They conclude that *limited access* lanes, with a barrier between the HOV lane and other lanes, cause more emissions than *continuous* access lanes. The reason for this is that *limited access* induces more acceleration and deceleration movements and higher maximum speeds once vehicles are in the HOV lane.

Equity and Co-benefits

Modest negative equity impacts on low-income groups – reduced access to jobs, health care, education, and retail.

HOV Lanes are found in *Moving Cooler* to have "no significant equity impacts" for any of the three implementation levels.

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68 Daganzo, C. and Cassidy, M. Effects of high occupancy vehicle lanes on freeway congestion. Transportation Research Part B 42 (2008) 861–872

69 Daganzo, C. and Cassidy, M. Effects of high occupancy vehicle lanes on freeway congestion. Transportation Research Part B 42 (2008) 861–872

70 Turnbull, Katherine F., et al. 2006. "Traveler Response to Transportation System Changes, Chapter 2—HOV Facilities," Transit Cooperative Research Program (TCRP) Report 95. Washington: Federal Transit Administration. p. 6

71 Boriboonsomin, K. and Barth, M. Evaluating Air Quality Benefits of Freeway High-Occupancy Vehicle Lanes in Southern California. Transportation Research Record 2011 (2007) 137-147.

72 Boriboonsomin, K. and Barth, M. Impacts of freeway high-occupancy vehicle lane configuration on vehicle emissions. Transportation Research Part D 13 (2008) 112-125.

Mannering, Koehne and Kim[73] conduct an assessment of public opinion of lane conversion from general-purpose to HOV:

Their survey research indicates that the percentage of people opposed to HOV lanes has dropped in recent decades. Lane conversion resistance appears to be higher amongst those under 21 years of age, higher-income households, individuals who change their departure times after the introduction of HOV lanes, and single-occupancy vehicle drivers. In summary, the researcher conclude that the I-90 lane conversion in Seattle is a public opinion success.

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

State agency implementation (Caltrans), but encouraged to do so by local agencies.

Population density required

Urban, suburban

Implementation Details

None identified

Model policy language

TR-2.4 HOV Lanes: The City/County will encourage the construction of high- occupancy vehicle (HOV) lanes or similar mechanisms whenever necessary to relieve congestion and reduce emissions.

Model ordinances

None identified

Case studies

Many states have HOV lanes.

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

T.2.4 Ridesharing (to take advantage of HOV lanes)

Other resources

Victoria Transport Policy Institute, HOV Priority: http://www.vtpi.org/tdm/tdm19.htm

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73 Mannering, F., Koehne, J. and Kim, S-G. Statistical Assessment of Public Opinion Toward Conversion of General-Purpose Lanes to High-Occupancy Vehicle Lanes. Transportation Research Record 1485 (1995) 168-176.

Speed Limit Reductions

SUMMARY

Reduction of speed limits on highways, and increased enforcement, can result in large reductions in fuel consumption and greenhouse gas emissions, at minimal cost. However, reduced driving speeds will necessarily result in longer driving times, which may prove politically unpopular. Speed limits and enforcement are generally handled at the state level.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Intercity Tolls	1,236	2,320	2,428	$3	$3	$3
Moving Cooler medians	45	59	83	$205	$163	$116

National speed limit of 60 mph by 2020, 55 mph by 2020, and 55 mph by 2015.

Modeling Assumptions: *Moving Cooler* page B-59
Cost Assumptions: *Moving Cooler* page C-41

Other Findings

Equity and Co-benefits

Reducing travel speeds will increase travel times for highway travel.

Reduced speeds on highways will likely result in fewer serious crashes, thereby reducing fatalities and serious injuries. A recent study found that the increase in speed limits resulted in 3.2% more fatalities on all road types between 1995 and 2005, with the highest increases on rural interstates (9.1%) and urban intetstates (4.0%).
http://ajph.aphapublications.org/cgi/reprint/AJPH.2008.153726v1.pdf

POLICY CONTEXT

Existing regulations/policies

Congress adopted the National Maximum Speed Law in 1973, which set a national maximum speed limit of 55 miles per hour. The laws was enacted in response to the national oil crisis. The law was repealed in 1995, with the federal government ceding control over speed limits back to the states.

Implementation level

Regional or state.

Population density required

Any

Implementation Details

None identified

Model policy language

None identified

Model ordinances
None identified

Case studies
None identified

RESOURCES

Energy Aware chapter
NA

Cross-references to other measures in Energy Aware
NA

Other resources
Victoria Transport Policy Institute, Speed Reductions: http://www.vtpi.org/tdm/tdm105.htm

Bottleneck Relief/Capacity Expansion

SUMMARY

On much of the urban highway system, there are specific points that are notorious for causing congestion on a daily basis. These locations, referred to as bottlenecks, can be a single interchange (usually freeway-to-freeway), a series of closely spaced interchanges, or locations where lanes merge. How bad congestion becomes at a bottleneck is related to the physical design of the roadway. Some bottlenecks were originally constructed many years ago using designs that were appropriate when there were built, but are now considered antiquated. Others have been built to extremely high design specifications and are simply overwhelmed by traffic.[74]"

Evaluations of bottleneck relief and capacity expansion projects suggest that they provide no net energy benefits, or even negative benefits. This is primarily due to the dynamic nature of traffic flow and route choice. If drivers know that a certain route is always congested, they may find new ways to get around that bottleneck. However, if that section is later improved or expanded, and it becomes uncongested for a period of time, those drivers who previously took longer or less convenient routes to save travel time will switch back. After the system returns to an equilibrium state, most often the section that was expanded will be carrying more vehicles per hour, but congestion in terms of total delay either stays the same or worsens, because now more vehicles are experiencing an incremental amount of delay.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler estimates that bottleneck relief and capacity expansion will increase GHG emissions, at a negative cost-effectiveness, because they will induce additional traffic.

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Bottleneck Relief	-3	-5	-11	NA	NA	NA
Capacity Expansion	-4	-7	-15	NA	NA	NA
Moving Cooler medians	45	59	83	$205	$163	$116

Bottleneck Relief: Assumes improving 25 percent of top 200 bottlenecks to LOS E by 2030; 50 percent to LOS E by 2030; 100 percent to LOS D by 20020.

Capacity Expansion: Assumes completion of 25, 50, and 100 percent of economically justified investments.

Modeling Assumptions: *Moving Cooler* page B-68
Cost Assumptions: *Moving Cooler* page C-45

Other Findings

Texas Transportation Institute, US 75 Southbound Improvements: An annual benefit of over $500,000 in delay savings was calculated based on morning peak period traffic alone, compared to an implementation cost of less than $20,000. (more information under "Case Studies")

74 FHWA. Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation. Updated September 2008. http://www.ops.fhwa.dot.gov/congestion_report/chapter3.htm

Equity and Co-benefits

These strategies have strong positive equity impacts. Improved highway transportation is an important source of mobility for low-income persons. Despite their proportionately larger transit ridership than other socioeconomic groups, nationally low-income groups still rely primarily on highways for their mobility. Improved mobility gives these groups better access to jobs, healthcare, and retail.

Limited or negative environmental co-benefits.

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

State agency implementation for highways (Caltrans), but encouraged to do so by local agencies.

Population density required

Moderate to High Density (depends on congestion, not necessarily population density)

Implementation Details

Infrastructure investments can be made in the nation's existing highway bottlenecks, which can be identified using the FHWA's Highway Performance Monitoring System (HPMS) data. Reports are also regularly published by the FHWA identifying the nation's worst bottlenecks. Specific changes that need to be made must be identified on a case-by-case basis, but the most common and simplest solution is to add an additional lane. However adding a lane to certain section of highway to deal with a bottleneck may create a new bottleneck where that additional lane terminates further down the road. Horizontal curves may also cause freeway bottlenecks, in which case it may be possible to realign the road or additional sight distance might be cleared. Capacity may also be improved by simply maintaing the existing infrastructure: roads can be repaved, pot holes can be filled in, shoulders can be cleared, or an HOV lane could be designated[75].

Model policy language

None identified

Model ordinances

None identified

Case studies

Caltrans: Interstate 5 Major Improvement Project[76]

Caltrans, in collaboration with the Federal Highway Administration (FHWA), the I-5 Consortium Cities Joint Powers Authority (JPA), Orange County Transportation Authority, Federal Transit Administration and the Los Angeles County Metropolitan Transportation Authority (LACMTA), has completed a Major Investment Study (MIS) to develop

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75 Cassidy, M. et al. The Smoothing Effect of Carpool Lanes on Freeway Bottlenecks. http://www.dot.ca.gov/research/whats_new/utc_conference_2008/Carpool%20Lanes.pdf

76 This project has not yet been completed, but is a major project specific to the State of California, and shows examples of implementation details and environmental documentation.

improvements for I-5 that would improve mobility and achieve acceptable levels of traffic operation. http://www.dot.ca.gov/dist07/travel/projects/I-5/

US 75 Southbound, Dallas, TX

An example is a recent effort in the Dallas district to improve merging/weaving at the entrance to southbound US 75 (North Central Expressway) from the recently constructed President George Bush Turnpike. The problem was at its worst during the morning peak period. A restriping improvement was implemented recently, and TTI was asked to evaluate the benefits. Before and after data established that each vehicle using the ramp connection averaged one minute in travel time savings, with a peak savings of over three minutes. At the same time, mainlane traffic maintained or enjoyed a slight increase in speed; volumes increased on both facilities. An annual benefit of over $500,000 in delay savings was calculated based on morning peak period traffic alone, compared to an implementation cost of less than $20,000.

In general, benefit-to-cost ratios for these projects are typically high, averaging around 20:1, with a range from 5:1 to 200:1, for a ten-year life. Costs are low, sometimes only for restriping, and there are thousands of freeway users who benefit from quicker and more reliable travel time. Further, in some cases, reductions in crash rates have been noted over time, adding to the benefit.
http://tti.tamu.edu/publications/researcher/newsletter.htm?vol=38&issue=2&article=7

Evaluation of Highway Bottlenecks

The presence of infrequent incidents can, under some scenarios, cause large percentage increases in vehicle delay.

Although incidents can be the cause of 50% or more of total delay, the effect of eliminating incidents may be similar to that of increasing lane capacity by just a few percent.

Reduction in vehicle delay may be a misleading measure of the benefit from new highway investments; improvements will surely reduce average delay but also enables more people to travel in peak periods.

The biggest benefit of highway investments may be that more people have the mobility to travel during peak periods.

Hall, Randolph W., & Kamoun, Mahdi. (1991). Evaluation Of Highway Bottlenecks. UC Berkeley: California Partners for Advanced Transit and Highways (PATH). Retrieved from: http://escholarship.org/uc/item/0r7960zv

Understanding and Mitigating Capacity Reductions at Freeway Bottlenecks

Two freeway bottlenecks were investigated in an effort to understand traffic conditions leading to capacity losses: one is caused by a horizontal curve, the other by a reduction in travel lanes. These bottlenecks are shown to exhibit breakdowns after queues form immediately upstream. The vehicle congestion that occurs near these bottlenecks are good proxies for the mechanisms that trigger breakdowns. Controlling the congestion (how?) indicates that these losses (?) can be recovered, postponed or even avoided entirely.

Chung, Koohong. (2005). Understanding and Mitigating Capacity Reduction at Freeway Bottlenecks. UC Berkeley: Institute of Transportation Studies. Retrieved from: http://escholarship.org/uc/item/84n3350n

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware
NA

Incentives for vehicle buyback/early retirement

SUMMARY

Incentives can be provided to encourage households to retire their vehicles before they would otherwise. Retired vehicles are physically destroyed, and presumably replaced with a newer vehicle with higher fuel economy. Several jurisdictions have been running early vehicle retirement, or "buyback", programs for years, including the California Bureau of Automotive Repair and the Bay Area and South Coast Air Quality Management Districts. The National Highway Traffic Safety Administration (NHTSA) ran a national program, the Consumer Assistance to Recycle and Save (CARS) program, in the summer of 2009.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler does not estimate benefits from incentives to promote early vehicle retirement.

Other Findings

A study of two programs in California found that while these programs likely reduce emissions of criteria pollutants, as well as greenhouse gasses, the reductions are likely not as large as estimated by the California Air Resources Board. The CARB method makes several assumptions about participating vehicles, including the mileage, life expectancy, and emissions of the scrapped vehicle, and whether and how the miles driven by the scrapped vehicle were replaced. Changes to these assumptions can have a large impact on the estimated effectiveness of the program. Jennifer Dill, Transportation Research Part D, Volume 9, Issue 2, March 2004, Pages 87-106

Equity and Co-benefits

None identified

POLICY CONTEXT

Existing regulations/policies

The California Bureau of Automotive Repair runs a voluntary accelerated vehicle retirement (VAVR) program as part of its Consumer Assistance Program. Only vehicles that fail their biennial Smog Check vehicle emission inspection qualify for the program. BAR pays $1,000 per eligible vehicle.
http://www.bar.ca.gov/80_BARResources/01_CAP&GoldShield/Factsheets/Website%20CAP%20FAQs.pdf

The California Air Resources Board provides regulations and guidelines for implementing VAVR programs in California. http://www.arb.ca.gov/msprog/avrp/avrp.htm VAVR programs can be funded through CARB's Carl Moyer Program

Several air districts in California operate regional VAVR programs, including the Bay Area and South Coast Air Quality Management Districts. Only vehicles have passed their previous Smog Check inspection are eligible for these programs.
http://www.arb.ca.gov/msprog/avrp/avrpeo.htm,
http://www.oldcarbuyback.com/index.php

The Bay Area AQMD recently announced that it would suspend its program at the end of 2010, in response to expansion of the BAR's CAP program.
http://www.baaqmd.gov/Divisions/Strategic-Incentives/Vehicle-Buy-Back-Program.aspx

Implementation level

City, county or regional.

Population density required
Rural, suburban, or urban.

Implementation Details
None identified

Model policy language
None identified

Model ordinances
CARB VAVR http://www.arb.ca.gov/msprog/avrp/avrp.htm

Case studies
NHTSA's CARS program, commonly referred to as "Cash-for-Clunkers", was instituted to revive vehicle sales in the vehicle manufacturing industry, as well as to reduce gasoline consumption, by prematurely retiring older vehicles with relatively low fuel economy. CARS provided a credit of $3,500 to $4,500 toward the purchase or lease of a new vehicle, provided the replacement vehicle had a higher rated fuel economy than the retired vehicle. The higher credit was for replacement cars that had at least 10 mpg, or a replacement truck that had at least 5 mpg, higher rated fuel economy than the retired vehicle. The CARS program resulted in the early retirement of nearly 680,000 vehicles nationwide, with an average increase in rated fuel economy of 9 miles per gallon.

RESOURCES

Energy Aware chapter
NA

Cross-references to other measures in Energy Aware
NA

CHAPTER 6: Website Briefings of Freight Measures not included in *Energy Aware Planning Guide*

Optimizing Freight Truck Loads

SUMMARY

Appropriate control of truck weights can contribute to reducing emissions, since fewer total truck trips can be made. This can be accomplished through permitting, weigh station enhancements, and load factor controls.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler estimates effectiveness and cost from three separate measures, shipping container permits, longer combination vehicles (LCVs), and weigh-in motion (WIM) screening.

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Shipping Container Permits	8	8	9	$6	$6	$6
LCV Permits	8	12	15	$6	$4	$3
WIM Screening	1	1	1	$50	$50	$100
Moving Cooler medians	45	59	83	$205	$163	$116

Shipping Container Permits: In all states, allow indivisible load permits for trucks carrying shipping containers for distances up to 250 miles by 2025, 2020, and 2015.

LCV Permits: In all states, allow divisible load permits for LCVs up to some weight exceeding 105,000 lbs by 2025, up to 129,000 lbs by 2020, and up to 129,000 lbs by 2010.

WIM Screening: Implement by 2025 and 2020 at all 24-hour truck weigh stations, and by 2015 at all truck weigh stations.

Modeling Assumptions: *Moving Cooler* page B-72 to B-73.
Cost Assumptions: *Moving Cooler* page C-48 to C-51.

Other Findings

Although increasing truck weights should generally reduce vehicle energy consumption and GHG emissions, there is potential for unintended impacts to occur.[77] For example, pavement supply-chain emissions can increase due to increased resurfacing overlays. This is also well known to potentially increase pavement maintenance costs. However, the increase in axles per truck can reduce the effect.

Equity and Co-benefits

Truck load changes have no significant equity impacts.

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77 N. Sathaye, A. Horvath and S. Madanat, 2010. Unintended impacts of increased truck loads on pavement supply-chain emissions. Transportation Research A, 44(1), 1-15.

Freight diesel exhaust emissions have significant health impacts on communities near California ports and other truck corridors; these communities tend to have a high proportion of low-income households.[78]

POLICY CONTEXT

Existing regulations/policies

CalTrans has information on Oversize/Overweight permits (http://www.dot.ca.gov/hq/traffops/permits/) and Legal Truck Size & Weight Exemptions (http://www.dot.ca.gov/hq/traffops/trucks/#2).[79] Such policies can be utilized to reduce tailpipe emissions factors, by reducing the number of trips needed to transport freight.

Implementation level

This is likely to implemented by larger cities, counties or at the regional level.

Population density required

Urban, suburban, or rural

Implementation Details

None identified

Model policy language

None identified

Model ordinances

None identified

Case studies

None identified

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

L.1.1 Smart Growth Development
L.1.2 Land Use Diversity
L.1.3 Transit-Oriented Development
L.1.4 Design Sites for Pedestrian and Transit Access
L.1.5. Transportation Demand Management Programs

Other resources

Victoria Transport Policy Institute, Freight Transport Management: http://www.vtpi.org/tdm/tdm16.htm

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78 Houston, D., M. Krudysz and A. Winer, 2008. Diesel Truck Traffic in Low-Income and Minority Communities Adjacent to Ports: Environmental Justice Implications of Near-Roadway Land Use Conflicts. Transportation Research Record, 2067. 38-46.

79 CalTrans Office of Truck Services. http://www.dot.ca.gov/hq/traffops/trucks/#2.

Truck-Only Toll Lanes

SUMMARY

Truck-only toll lanes can eliminate the effects of passenger traffic congestion on freight movement and the influence of trucks on passenger traffic. In addition, they can be used in conjunction with congestion-pricing tolls to encourage off-peak freight operation and further reduce congestion.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler measure	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
	Expanded Current Practice	Aggressive Deploy-ment	Maximum Deploy-ment	Expanded Current Practice	Aggressive Deploy-ment	Maximum Deploy-ment
Truck-Only Toll Lanes	24	59	107	$713	$724	$669
Moving Cooler medians	45	59	83	$205	$163	$116

New facilities should cover 10, 25, and 40 percent of large urban area interstate VMT.

Modeling Assumptions: *Moving Cooler* page B-76 to B-77
Cost Assumptions: *Moving Cooler* page C-54

Other Findings

Potential air quality impacts have been analyzed of developing a truck-only facility on the I-170 freeway leading to and from the ports of Los Angeles and Long Beach.[80] Results in this case indicate that a truck-only lane may not reduce aggregate traffic emissions; however restricting trucks to the rightmost lane is likely to have emissions benefits.

Another paper discusses issues based on Southern California experiences such as tradeoffs between limiting access to improve operational costs and limiting capital costs, need to generate demand, time-of-day distribution of truck traffic and its relationship to potentially benefit truck mobility, and the need for improved analytical tools.[81] Preliminary analysis for SR-60 between Los Angeles and the Inland Empire, and I-710 to the ports of Los Angeles and Long Beach are described. Results indicate that the benefits of truck lanes are highly context-dependent and that they are most likely to be beneficial in corridors with concentrated origin-destination locations. This is especially true if existing facilities are congested throughout the day.

Equity and Co-benefits

Freight diesel exhaust emissions have significant health impacts on communities near California ports and other truck corridors; these communities tend to have a high proportion of low-income households.[82] Reduced truck congestion can reduce emissions of criteria pollutants, thereby minimizing public health impacts on these affected communities.

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80 Park, M., Y. Chung, A. Regan. 2004. Environmental Impacts of Truck-Only Lanes on Urban Freeway: An Integrated Microscopic Approach. UC Irvine Institute of Transportation Studies. UCI-ITS-LI-04-4.

81 Fischer, M., D. Ahanotu and J. Waliszewski. 2003. Planning Truck-Only Lanes: Emerging Lessons from the Southern California Experience. Transportation Research Record, 1833. 73-78.

82 Houston, D., M. Krudysz and A. Winer, 2008. Diesel Truck Traffic in Low-Income and Minority Communities Adjacent to Ports: Environmental Justice Implications of Near-Roadway Land Use Conflicts. Transportation Research Record, 2067. 38-46.

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

This policy likely to be implemented by a regional or state agency.

Population density required

The policy is likely to be considered in denser areas on heavily trafficked corridors.

Implementation Details

None identified

Model policy language

None identified

Model ordinances

None identified

Case studies

Caltrans provides information on current truck-only lanes and others under consideration.[83]
California has two truck-only toll lanes under consideration:

1. Northbound and southbound I-5 in Los Angeles County at the State Route 14 split
2. Southbound I-5 in Kern County at the State Route 99 junction near the Grapevine

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

NA

Other resources

Victoria Transport Policy Institute, Freight Transport Management:
http://www.vtpi.org/tdm/tdm16.htm

83 CalTrans Truck-Only Lanes. http://www.dot.ca.gov/hq/traffops/trucks/ops-guide/truck-lanes.htm.

Improved Truck Efficiency

SUMMARY

Technologies can be added to heavy-duty trucks to reduce the energy consumption per vehicle mile traveled. Similarly, improved vehicle operation and maintenance, such as eco-driving training, proper tire inflation, regular engine maintenance, and regular cab and trailer cleaning, can also reduce energy consumption per vehicle mile traveled.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler does not estimate the effectiveness or costs of this measure

Other Findings

One study compares the effect of several techniques (improved aerodynamics, wide-base tires, proper tire inflation, tare weight reduction, low-friction lubricants, reduced engine idling, speed reduction, driver training and monitoring programs) on improving heavy-duty truck efficiency.[84] Results indicate that improved trailer aerodynamics, wide-base tires, low-friction engine lubricants and a reduction in maximum driving speed can cause very large reductions in fuel use and emissions from trucks.

A study of various equipment for reducing fuel consumption associated with aerodynamic drag has been conducted[85]. The study analyzes the benefits of adding cab fairing, trailer-front fairings, tractor skirts, trailer skirts, base flaps and a gap splitter. Results indicate that the addition of cab fairings and trailer-front fairings make the largest improvements. Cab fairings are estimated to make a 3.4 - 6.5% reduction in fuel consumption for 40,000kg trucks and 4.7 – 8.8% for 20,000kg trucks. Trailer-front fairings are estimated to make a 2.7 - 3.8% reduction in fuel consumption for 40,000kg trucks and 3.6 – 5.2% for 20,000kg trucks.

Equity and Co-benefits

Freight diesel exhaust emissions have significant health impacts on communities near California ports and other truck corridors; these communities tend to have a high proportion of low-income households.[86] Improved truck efficiency can reduce emissions of criteria pollutants, thereby minimizing public health impacts on these affected communities.

POLICY CONTEXT

Existing regulations/policies

Under Proposition 1B, the California Goods Movement Emissions Reduction Program provides $1 billion to reduce air pollution and emissions along California's trade corridors. Local agencies apply to ARB for funding, then those agencies offer financial incentives to owners of equipment used in freight movement to upgrade to cleaner technologies. Projects funded under

84 J. Ang-Olson and W. Schroeer, 2002. Energy Efficiency Strategies for Freight Trucking: Potential Impacts of Fuel Use and Greenhouse Gas Emissions. Transportation Research Record, 1815. 11-18.
85 Mohamed-Kassim, Zulfaa, A Filippone, 2010. Fuel savings on a heavy vehicle via aerodynamic drag reduction. Transportation Research Part D. 15(5) 275-284.

86 Houston, D., M. Krudysz and A. Winer, 2008. Diesel Truck Traffic in Low-Income and Minority Communities Adjacent to Ports: Environmental Justice Implications of Near-Roadway Land Use Conflicts. Transportation Research Record, 2067. 38-46.

this Program must achieve early or extra emission reductions not otherwise required by law or regulation.[87]

The U.S. EPA SmartWay Partnership can provide assistance towards the reduction of emissions from the freight transportation sector. An innovative financing program is aimed at helping small trucking firms reduce their fuel costs and their carbon footprint (http://www.epa.gov/smartway/transport/index.htm).[88] In addition, SmartWay provides information on fuel efficient tractors and trailers, along with the opportunity to label the exterior of such vehicles with the SmartWay brand.

Implementation level

Requires regulation and/or incentives at the state level.

Population density required

Applies to all heavy-duty trucks, regardless of whether they are driven in rural or urban areas.

Implementation Details

State government can require retrofit of technologies to improve truck efficiency, as well as driver training and vehicle maintenance programs.

Model policy language

None identified

Model ordinances

None identified

Case studies

None identified

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

NA

Other resources

Victoria Transport Policy Institute, Freight Transport Management: http://www.vtpi.org/tdm/tdm16.htm

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87 Goods Movement Emission Reduction Program: http://www.arb.ca.gov/bonds/gmbond/gmbond.htm. Accessed on 6/14/2010.

88 U.S. EPA, SmartWay Transport: http://www.epa.gov/smartway/transport/index.htm. Accessed on 6/14/2010.

Alternative Fuels for Freight

SUMMARY

There are several alternative fuels that can be utilized to reduce emissions from the freight transportation sector. These include emulsified diesel, biodiesel, natural gas, propane and ethanol. In addition, electric and hybrid vehicles are being used for metropolitan freight movement.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler does not estimate effectiveness or cost of this measure.

Other Findings

California Air Resources Board provides lookup tables with information about life-cycle greenhouse gas emissions per energy consumed for various transportation fuels.[89] One can see that emissions for each fuel vary greatly depending on life-cycle conditions. Fuels in the analysis include gasoline, ethanol from corn, ethanol of sugarcane, compressed natural gas, liquefied natural gas, electricity, hydrogen, diesel, biodiesel, renewable diesel, compressed natural gas and liquefied natural gas. In addition, the estimated emissions account for various source locations and methods for production and transportation.

A study in Canada compares emissions associated with diesel, biodiesel, compressed natural gas, hythane, liquefied natural gas and with different advanced aftertreatment technologies. Results indicate that natural gas can reduce CO_2-equivalent GHG emissions by 10-20% compared to diesel.[90]

Another study compares the GHG emissions from diesel and liquefied natural gas for European heavy-duty vehicles.[91] Results indicate that liquefied natural gas can reduce GHG emissions by 10% compared to diesel.

A study in Madrid, Spain compares GHG emissions from diesel, biodiesel and natural gas refuse trucks.[92]

Equity and Co-benefits

Freight diesel exhaust emissions have significant health impacts on communities near California ports and other truck corridors; these communities tend to have a high proportion of low-income households.[93] To the extent that alternative fuels reduce criteria pollutant emissions from trucks, they can minimize public health impacts on these affected communities.

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89 California Air Resources Board, Alternative Fuels Program: http://www.arb.ca.gov/fuels/altfuels/altfuels.htm Accessed on 6/16/2010.

90 Graham, L., G. Rideout, D. Rosenblatt and J. Hendren (2008) Greenhouse gas emissions from heavy-duty vehicles. Atmospheric Environment, 42, 4665-4681.

91 Arteconi, A., C. Brandoni, D. Evangelista and F. Polonara (2010) Life-cycle greenhouse gas analysis of LNG as a heavy vehicle fuel in Europe. Applied Energy, 87, 2005-2013.

92 Lopez, J., A. Gomez, F. Aparicio and F. J. Sanchez (2009) Comparison of GHG emissions from diesel, biodiesel and natural gas refuse trucks of the City of Madrid. Applied Energy, 86, 610-615.

93 Houston, D., M. Krudysz and A. Winer, 2008. Diesel Truck Traffic in Low-Income and Minority Communities Adjacent to Ports: Environmental Justice Implications of Near-Roadway Land Use Conflicts. Transportation Research Record, 2067. 38-46.

POLICY CONTEXT

Existing regulations/policies

California Air Resources Board has initiated the Hybrid Truck and Bus Voucher Incentive Project.[94] Vouchers of $10,000 to $45,000 are now available at www.californiahvip.org for the purchase of each eligible new hybrid electric truck or bus.

The California Energy Commission is investigating hybrid electric medium- and heavy-duty vehicles, but is not proposing incentives for the purchase of these vehicles at this time. The Energy Commission will focus on providing financial support (~$10 million) for pre-production research, development and demonstration projects.

Implementation level

This policy can be implemented at any level of government.

Population density required

The policy can be used with any density, with the caveat that pure electric vehicles will need to be on routes which are within their battery charge capacity.

Implementation Details

None identified

Model policy language

Cal/EPA has a draft fuels guidance document.[95]

Model ordinances

None identified

Case studies

Biodiesel emissions are used in waste collection trucks in Berkeley and other California cities.[96]

FedEx has begun using electric delivery vehicles in Southern California.[97]

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

NA

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94 California Air Resources Board Hybrid Truck and Bus Voucher Incentive Project: http://www.arb.ca.gov/msprog/aqip/hvip.htm; http://www.californiahvip.org/.

95 Draft for Comment, Cal/EPA Fuels Guidance Document http://www.calepa.ca.gov/biofuels/Guidance.pdf

96 Hendricks, Tyche (2001 Trucks from Ecology Center run on waste oil from restaurants. SF Chronicle. http://www.mindfully.org/Energy/Ecology-Center-Biodiesel.htm

97 MarketWatch Navistar Officially Unveils eStar(TM), Its First Purpose-Built All-Electric Commercial Truck. http://www.marketwatch.com/story/navistar-officially-unveils-estartm-its-first-purpose-built-all-electric-commercial-truck-2010-05-13?reflink=MW_news_stmp, Accessed on 5/20/2010.

Other resources

Victoria Transport Policy Institute, Freight Transport Management: http://www.vtpi.org/tdm/tdm16.htm

Technologies for Reduced Idling

SUMMARY

Truck drivers frequently spend the night in their cabs, with heating/cooling systems and appliances powered by a generator driven by the engine under idle. These appliances can be powered by smaller, diesel auxiliary power units, or even electricity, rather than letting the engine idle for extended periods of time, which wastes fuel and produces emissions. Such a system typically utilizes auxiliary power units in sleeper cabs, as well as electrical connections at freight villages just outside of urban areas and truck stops along the highway.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

Moving Cooler measure	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
	Expanded Current Practice	Aggressive Deploy-ment	Maximum Deploy-ment	Expanded Current Practice	Aggressive Deploy-ment	Maximum Deploy-ment
Truck Stop Electrificiation	11	25	46	$55	$52	$48
Truck Auxiliary Power Units	133	148	162	$2	$2	$2
Moving Cooler medians	45	59	83	$205	$163	$116

Truck stop electrification: Allow truck drivers to plug in to local power at 1,500, 3,000, and 5,000 (out of 5,000) truck stops nationwide.

Truck Auxiliary Power Units: Require installation in all sleeper cabs by 2025, 2020, and 2015..

Modeling Assumptions: *Moving Cooler* page B-74 to B-76
Cost Assumptions: *Moving Cooler* page C-52 to C-54

Other Findings

One study analyzes technology options to reduce the fuel consumption of idling trucks: direct-fired heater, APU, thermal storage, direct heat with thermal storage cooling, and truck stop electrification.[98] Direct fired heaters are small and lightweight; however they do not provide cooling and may be unreliable when not equipped with automatic engine starting. APUs can be used at any stop for heating, cooling, and auxiliaries; however they are heavy. Thermal storage is comfortable for drivers, but cannot heat engines and requires much space. Direct heat with thermal cooling can be used at any stop for heating and cooling, but requires battery power. Truck stop electrification is useful for all vehicle energy needs, but limits the choice of overnight locations and requires truck stop infrastructure.

Equity and Co-benefits

Freight diesel exhaust emissions associated with engine idling have significant health impacts on communities near California ports and other truck corridors; these communities tend to have a high proportion of low-income households.[99] Reduced truck idling can reduce emissions of criteria pollutants, thereby minimizing public health impacts in these affected communities.

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98 F. Stodolsky, L. Gaines and A. Vyas, 2000. Analysis of Technology Options to Reduce the Fuel Consumption of Idling Trucks. Center for Transportation Research, Argonne National Laboratory, U.S. Department of Energy.

99 Houston, D., M. Krudysz and A. Winer, 2008. Diesel Truck Traffic in Low-Income and Minority Communities Adjacent to Ports: Environmental Justice Implications of Near-Roadway Land Use Conflicts. Transportation Research Record, 2067. 38-46.

POLICY CONTEXT

Existing regulations/policies

California Air Resources has a Heavy-Duty Vehicle Idling Emissions Reduction Program (http://www.arb.ca.gov/msprog/truck-idling/truck-idling.htm).[100] The regulation consist of new engine and in-use truck requirements and emission performance requirements for technologies used as alternatives to idling the truck's main engine.

A 400-pound weight exemption was signed into law in 2005 as part of the Energy Policy Act of 2005 (http://www.dot.ca.gov/hq/traffops/trucks/exemptions/apu.html).[101] However, California does not currently allow for this exemption in the state.

Implementation level

Freight villages and truck stop electrification can be implemented by large cities, counties or metropolitan areas.

Population density required

Development of new freight villages will occur on the outskirts of urban areas, whereas truck stop electrification occurs along freeways, likely in rural areas.

Implementation Details

None identified

Model policy language

None identified

Model ordinances

None identified

Case studies

None identified

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

NA

Other resources

Victoria Transport Policy Institute, Freight Transport Management: http://www.vtpi.org/tdm/tdm16.htm

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100 California Air Resources Board, Heavy Duty Vehicle Idling Emission Reduction Program: http://www.arb.ca.gov/msprog/truck-idling/truck-idling.htm

101 CalTrans: Auxiliary Power Units. http://www.dot.ca.gov/hq/traffops/trucks/exemptions/apu.html

Operational Improvements for Reducing Truck Idling

SUMMARY

Operational improvements such appointment systems at ports and weigh station bypass mechanisms can be introduced to reduce truck idling.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Weigh Station Bypass	1	1	2	$50	$50	$50
Moving Cooler medians	45	59	83	$205	$163	$116

Weigh Station Bypass: Implement at all 24-hour truck weigh stations.

Modeling Assumptions: *Moving Cooler* page B-74.
Cost Assumptions: *Moving Cooler* page C-51.

Other Findings

AB2650 and appointment systems at the Ports of Los Angeles and Long Beach are thought to have been ineffective, since the majority of terminals did not view appointments as an effective operational strategy and little effort was devoted to offering priority to those with appointments.[102]

Equity and Co-benefits

Freight diesel exhaust emissions have significant health impacts on communities near California ports and other truck corridors; these communities tend to have a high proportion of low-income households.[103]

POLICY CONTEXT

Existing regulations/policies

AB2650 encourages ports to implement appointment systems to reduce truck idling[104]: http://info.sen.ca.gov/pub/01-02/bill/asm/ab_2601-2650/ab_2650_cfa_20020822_091111_sen_floor.html

The appointment system sets a time at which trucks should arrive for pick-ups and deliveries at the ports, with the aim of reducing vehicle delay and idling.

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102 Giuliano, G. and T. O'Brien (2007) Reducing port-related truck emissions: The terminal gate appointment system at the Ports of Los Angeles and Long Beach. Transportation Research Part D, 12, 460-473.

103 Houston, D., M. Krudysz and A. Winer, 2008. Diesel Truck Traffic in Low-Income and Minority Communities Adjacent to Ports: Environmental Justice Implications of Near-Roadway Land Use Conflicts. Transportation Research Record, 2067. 38-46.

104 Giuliano, G. and T. O'Brien (2007) Reducing port-related truck emissions: The terminal gate appointment system at the Ports of Los Angeles and Long Beach. Transportation Research Part D, 12, 460-473.

CalTrans PrePass Weigh Station bypass is an automated system, allowing for heavy vehicles that are registered in the program to legally bypass open weigh stations.[105]

Implementation level
These policies are likely to be implemented by a regional authority.

Population density required
Any

Implementation Details
None identified

Model policy language
None identified

Model ordinances
None identified

Case studies
None identified

RESOURCES

Victoria Transport Policy Institute, Freight Transport Management:
http://www.vtpi.org/tdm/tdm16.htm

105 CalTrans PrePass Weigh Station Bypass.
http://www.dot.ca.gov/hq/traffops/trucks/bypass/index.html.

CHAPTER 7: Website Briefings of Intelligent Transportation System (ITS) Measures not included in *Energy Aware Planning Guide*

Ramp Metering

SUMMARY

Ramp meters are used to increase delay at certain freeway entrances, in order to regulate the flow of traffic on to the highways at or near bottlenecks. By diverting traffic away from key areas, congestion on the highway is reduced which in turn reduces the delay to vehicles already on the highway. To do this, however, delay is diverted from the highway to the ramps and in some cases to the arterials leading to the ramps.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Ramp Metering	27	78	83	$48	$40	$90
Moving Cooler medians	45	59	83	$205	$163	$116

Assumes electronic roadway monitoring in large urban areas where volume/capacity ratio exceeds 1.05, 1.0, and 0.9 by 2030, with new and expanded Traffic Management Centers (TMC).

Modeling Assumptions: *Moving Cooler* page B-14
Cost Assumptions: *Moving Cooler* page C-10

Other Findings

None identified

Equity and Co-benefits

Ramp metering, which decreases travel time delays for one group of users (those starting farthest from the ramp metering zone) while increasing delays for the other users. The most significant empirical studies of ramp metering's real efficiency and equity effects were conducted when the metropolitan area's meters were turned off for eight weeks in the Twin Cities during fall of 2000.

The authors found that, for instance, on Route 169 (a suburb-to-suburb limited access highway connecting the North and South legs of the region's beltway) with ramp metering, the average travel speed (taking ramp delay into account) of the highway increases from 37 km/h to 62 km/h; travel delay per mile decreases from 136 seconds to 112.5 seconds, and the average travel time for one trip decreased from 610 seconds to 330 seconds. The shortest trips actually are hurt in mobility terms by ramp metering, while the longest trips, benefit the most. As is expected, metering redistributes delay.

POLICY CONTEXT

Existing regulations/policies

Caltrans Ramp Metering Design Manual
http://www.dot.ca.gov/hq/traffops/systemops/ramp_meter/RMDM.pdf

Implementation level

State or regional

Population density required

Suburban

Implementation Details

Can be implemented using preset or actuated meters. Ramp meters are usually set to operate only during peak hours. Ramp metering is one of several ITS technologies designed to manage traffic flow The goal of ramp metering is to safely space vehicles merging onto a highway while minimizing speed disruptions to existing flows. Considerations include[106]:
1) Public misunderstanding and system dislikes.
2) Overflow of cars onto surface streets while waiting to enter ramps
3) Driver use of arterial streets to avoid ramp meters.

The most significant benefit of ramp metering is passenger time savings. (Shaheen and Lipman)

Model policy language

None identified

Model ordinances

None identified

Case studies

Minnesota DOT Ramp Metering Study: A bill passed in the Year 2000 session by the Minnesota Legislature required Minnesota DOT to study the effectiveness of ramp meters in the Twin Cities Region by shutting off the nearly 430 meters for eight weeks to test their effectiveness. The resulting study23 showed that without ramp a meter there was a 9 % decrease in traffic volumes on the freeways, coupled with a 22 % increase in freeway travel times. The reliability of freeway travel time was also found to decline by 91 percent without ramp meters. Cambridge Systematics (2001), "MnDOT Ramp Metering Study Final Report," http://www.dot.state.mn.us/rampmeterstudy

Kang, S and D. Gillen. Assessing the Benefits and Costs of Intelligent Transportation Systems Ramp Meters. UCB-ITS-PRR-99-19. Richmond, California. California Partners for Advanced Transit and Highways (PATH), University of California, Berkeley, (1999).

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

T.3.1 – Traffic Signal Timing (TMC's)

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[106] Shaheen, S., Lipman, T. Reducing Greenhouse Emissions and Fuel Consumption – Sustainable Approaches for Surface Transportation. IATSS Research Vol 31 No. 1 2007.

Traveler Information & Variable Message Signs

SUMMARY[107]

Traveler information technologies such as traffic surveillance and transit management systems support the collection, processing, and dissemination of real time information about travel modes and conditions. The objective is to provide the traveling public with information regarding available modes, optimal routes, and costs in real time, either pre-trip or en-route via in-vehicle information and Variable Message Signs (VMS) along roadsides or at transit stations. Effective traveler information requires the accurate collection and dissemination of real-time travel information to transportation managers and the public to aid them in making informed decisions about travel time, mode, and route. A wide array of ITS technologies assist with traveler information including in-vehicle guidance, web sites, mobile phones, PDAs, and VMS to distribute user information.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Traveler Information	4	30	31	$500	$163	$381
Variable Message Signs	2	2	3	$400	$1,000	$1,600
Moving Cooler medians	45	59	83	$205	$163	$116

Assumes implemented using electronic roadway monitoring where volume to capacity exceeds 1.05, 1.0, and 0.9 by 2030, 2025, and 2020, respectively.

Modeling Assumptions: *Moving Cooler* page B-63
Cost Assumptions: *Moving Cooler* page C-43

Other Findings

Orlando TravTek Project[108]*:* To determine the usefulness of advanced in-vehicle navigation and information systems for drivers, Orlando launched the TravTek (Traveler Technology) project in 1992. The test involved approximately 100 vehicles, mostly rental cars, equipped with electronic guidance systems. Some 4,000 drivers, the vast majority tourists, participated in the trial. During the yearlong trial period, the system was commended for its extreme ease of use. Most test subjects were able to fully operate the system after just a brief orientation. Compared to control tests in which drivers used standard printed road maps to find their way, TravTek was shown to reduce travel time by 19%, and also to reduce the number of accidents involving tourists.

Equity and Co-benefits

No significant equity impacts

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107 Shaheen, S. and Lipman, T. Reducing Greenhouse Emissions and Fuel Consumption – Sustainable Approaches for Surface Transportation. IATSS Research Vol 31 No 1, 2007

108 CalCCIT. ITS Decision – A Gatewat to Understanding and Applying Intelligent Transportation Systems. Services and Technologies. http://www.calccit.org/itsdecision/serv_and_tech/Traveler_information/Trav_services/trav_services_report.html

POLICY CONTEXT

Existing regulations/policies

On March 8, 1999, The U.S. Department of Transportation (USDOT) petitioned the Federal Communications Commission (FCC) to designate a nationwide three-digit telephone number for traveler information. This petition was formally supported by 17 State DOTs, 32 transit operators, and 23 Metropolitan Planning Organizations and local agencies. On July 21, 2000 the Federal Communications Commission designated "511" as the single traffic information telephone number to be made available to states and local jurisdictions across the country.

The FCC ruling leaves nearly all implementation issues and schedules to state and local agencies and telecommunications carriers. There are no Federal requirements and no mandated way to pay for 511; however, USDOT and FCC expect to see some type of nationwide deployment.

Implementation level

City/County/State

Population density required

Urban, suburban, and rural

Implementation Details

USDOT and FCC established 511 as a national phone number reserved for traffic information. Since then, 511 has evolved from a simple telephone service to include regional websites with travel information and route planning services. Some implementations also offer mobile services which will send emails or text messages to mobile phones providing travel time information and/or incident alerts. Smart-phone applications have also been developed both by 511 services (like MTC) and by independent companies like NAVTEQ[109] to provide real time route-based traffic information on the go. In order to disseminate information to travelers on the go without the use of a cell phone, many implementations use VMS's to display information at the roadside or on freeway overpasses, and some areas also have dedicated radio frequencies to distribute traffic information and alerts.

Other implementations include in-vehicle GPS based traffic information, and in-vehicle services like GM OnStar. However these services are paid for by individual users, and are not necessarily available to everyone.

Model policy language

None identified

Model ordinances

None identified

Case studies

While 511 is not yet deployed nationwide, commuters have expressed an interest in the service. According to an ITS America Survey, 25% of respondents said they would be most likely to use 511 daily or weekly; 29% said they would use it a few times a month; and 45% said they would use it a few times a year. Overall, those making five or more long distance trips a year were most likely to use 511 (63%); 39% of commercial vehicle operators reported they would be extremely likely to use 511.

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109 http://www.traffic.com/

SANDAG 511: 511 is a free phone and Web service that consolidates the San Diego region's transportation information into a one-stop resource. 511 provides up-to-the minute information on traffic conditions, incidents and driving times, schedule, route and fare information for San Diego public transportation services, carpool and vanpool referrals, bicycling information and more. 511 is available 24 hours a day, 7 days a week. However, some operators may have limited hours. http://www.511sd.com/

SF Bay 511 (MTC): SF Bay 51 provides users with real time travel information available by calling 511, visiting the website, or downloading a smart-phone application for mobile services. Information available includes traffic, transit, bicycling, and ridesharing.
http://www.511.org/about-511.asp

CommuteView/CommuteCall – Iteris Inc.: CommuteView features real-time traffic conditions via browser or e-mail on your desktop/laptop computers, cell phones, pagers, or wireless PDAs.

Highly personalized ramp-to-ramp travel route
Travel time and incident notifications based on your route
Look up incidents and areas of congestion on your route
Compare multiple route travel times right on your phone
Schedule notifications to be sent to you before your trip
http://www.commuteview.net/CommuteView/MainDesktop.aspx

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

NA

Road Weather Management

SUMMARY[110]

Three types of road weather management strategies may be employed in response to environmental threats: advisory, control, and treatment strategies. Advisory strategies provide information on prevailing and predicted conditions to both transportation managers and motorists. Control strategies alter the state of roadway devices to permit or restrict traffic flow and regulate roadway capacity. Treatment strategies supply resources to roadways to minimize or eliminate weather impacts. Many treatment strategies involve coordination of traffic, maintenance, and emergency management agencies. These mitigation strategies are employed in response to various weather threats including fog, high winds, snow, rain, ice, flooding, tornadoes, hurricanes, and avalanches.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Road Weather Management	1	1	2	$2,000	$4,900	$5,900
Moving Cooler medians	45	59	83	$205	$163	$116

Assumes fully deployed on all freeways by 2030, 2025, and 2020.

Modeling Assumptions: *Moving Cooler* page B-63
Cost Assumptions: *Moving Cooler* page C-43

Other Findings

This measure is mostly focused on improving safety; few studies have been done to estimate results in terms of energy or environmental impacts.

Equity and Co-benefits

None identified

POLICY CONTEXT

Existing regulations/policies

The Clarus Initiative is a joint effort of the U.S. DOT ITS Joint Program Office and the FHWA Road Weather Management Program. It is a multi-year effort to develop and demonstrate an integrated surface transportation weather observation data management system, and to establish a partnership to create a Nationwide Surface Transportation Weather Observing and Forecasting System.

The Clarus System is designed to enable various public agencies to more accurately assess weather and pavement conditions as well as their impacts on operations. Such knowledge is critical for planning, conducting, and evaluating the effectiveness of activities such as winter road maintenance, weather-responsive traffic management, traveler information dissemination, safety management, transit vehicle dispatching, and flood control.

110 Shaheen, S. and Lipman, T. Reducing Greenhouse Emissions and Fuel Consumption – Sustainable Approaches for Surface Transportation. IATSS Research Vol 31 No 1, 2007

Implementation level
City/County/State

Population density required
Any

Implementation Details
Surveillance, Monitoring and Prediction

http://www.fhwa.dot.gov/weather/mitigating_impacts/surveillance.htm

Environmental Sensor Stations (ESS) and Road Weather Information Systems (RWIS) can be used to measure atmospheric, pavement, and water level conditions, and communicate that information to TMC's and/or travelers through communications infrastructure and VMS's. Mobile sensors, which are typically mounted on vehicles can also be used to measure conditions, and allow more freedom and range than the ESS and RWIS that measure only at fixed locations.

Information Dissemination

http://www.fhwa.dot.gov/weather/mitigating_impacts/infodissem.htm

"Transportation managers and information service providers disseminate road weather information to travelers in order to influence their decisions, such as mode, route selection, departure time, vehicle type and equipment (e.g., tire chains), driving behavior (e.g., decrease speed, increase following distance) and trip deferral. Managers utilize various technologies to furnish road weather advisories to travelers. Strategies include activation of flashing beacons atop static signs, posting warnings on Dynamic Message Signs (DMS), and broadcasting messages via Highway Advisory Radio (HAR)."

Decision Support, Control and Treatment

http://www.fhwa.dot.gov/weather/mitigating_impacts/decision.htm

"By integrating environmental data with other data (e.g., traffic flow data, resource data, population data, topographic data) transportation managers can assess weather impacts on roadways to support their operational decisions. Some Traffic Management Centers (TMCs) utilize Advanced Traffic Management Systems (ATMS) that integrate environmental data with traffic monitoring and control software."

"Treatment strategies supply resources to roads to minimize or eliminate weather impacts. The most common treatment strategies are application of sand, salt, and anti-icing chemicals to pavements to improve traction and prevent ice bonding. Maintenance vehicles are equipped with plow blades, chemical storage tanks, spray nozzles, and material spreaders to clear roads of snow and ice."

Model policy language
None identified

Model ordinances
Transportation Management Center (TMC) Weather Integration Self-Evaluation and Planning Guide Tool:

The TMC Weather Integration Self-Evaluation and Planning Guide consists of a manual document and an electronic tool that transportation agencies can use to identify their weather integration needs and develop a plan for meeting those needs.

Available for download from the FHWA:
http://www.fhwa.dot.gov/weather/tmctool/registration.htm

Case studies

FHWA's "Best Practices for Road Weather Management," contains details from 30 different case studies. http://www.fhwa.dot.gov/weather/best_practices/CaseStudiesFINALv2-RPT.pdf

Caltrans' District 10 Motorist Warning System[111] collects traffic and weather data from 36 vehicle detection sites and nine Environmental Sensor Stations (ESS) deployed along the freeways near Stockton in the San Joaquin Valley. Detection sites are comprised of paired inductive loop detectors and Caltrans Type 170 controllers, which run software with speed measurement algorithms. Each ESS includes a rain gauge, a forward-scatter visibility sensor, wind speed and direction sensors, a relative humidity sensor, a thermometer, a barometer, and a remote processing unit. Traffic and environmental data are transmitted from the field to a networked computer system in the Stockton Traffic Management Center (TMC) via dedicated, leased telephone lines. The central computer system automatically displays advisories on nine roadside Dynamic Message Signs (DMS).
www.path.berkeley.edu/path/publications/pdf/PRR/99/PRR-99-28.pdf

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

T.3.1 – Traffic Signal Timing (ATMS)

111 FHWA. Best Practices for Road Weather Management, Version 2.0. May 2003.
http://www.fhwa.dot.gov/weather/best_practices/CaseStudiesFINALv2-RPT.pdf

Vehicle-Infrastructure Integration (VII)

SUMMARY[112]

IntelliDrive (previously known as Vehicle Infrastructure Integration or VII) is research sponsored by the US Department of Transportation, that combines leading edge technologies including advanced wireless communications, on-board computer processing, advanced vehicle-sensors, GPS navigation, smart infrastructure, and others to provide the capability for vehicles to identify threats and hazards on the roadway and communicate this information over wireless networks to give drivers alerts and warnings.

At IntelliDrive's core is a networked environment supporting very high-speed transactions among vehicles (vehicle-to-vehicle), and between vehicles and infrastructure components (vehicle-to-infrastructure) or hand held devices (vehicle-to-devices) to enable numerous safety and mobility applications.

IntelliDrive offers the opportunity to know much more about traffic and roadway conditions than ever before. It may be possible for IntelliDrive vehicles to anonymously send information that includes travel time and environmental conditions, making it possible one day to know traffic conditions along every major street in urban areas as well as along every interstate highway across the nation. This information could lead to improved traffic signal control, ubiquitous traveler information, better transportation plans, and reduced cost for existing transportation data collection methods, among other benefits.
http://www.intellidriveusa.org/

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Vehicle Infrastructure Integration	65	16	8	$655	$2,663	$5,325
Moving Cooler medians	45	59	83	$205	$163	$116

Assumes 50 percent of light-duty vehicles equipped by 2025 and 100 percent by 2040; 50 percent by 2020, 100 percent by 2030; 50 percent by 2015, 100 percent by 2020.

Modeling Assumptions: *Moving Cooler* page B-63
Cost Assumptions: *Moving Cooler* page C-43

Other Findings

None identified

Equity and Co-benefits

No significant equity impacts. _Privacy is a major concern, especially when using wireless communications infrastructure.

112 FHWA. Real-Time Traveler Information Program – Intellidrive. Overview. http://ops.fhwa.dot.gov/travelinfo/infostructure/aboutinfo.htm

POLICY CONTEXT

Existing regulations/policies

Research is being supported by the USDOT through the FHWA, but this measure is still primarily in the research phase.

Implementation level

Regional or state level

Population density required

Can be implemented at any density

Implementation Details

Vehicle Infrastructure Integration systems rely on several different types of communication, depending upon the implementation. Vehicles will require on-board units to communicate with other vehicles and with roadside devices ("infrastructure"). Some applications of VII are imagined to use cellular phones or other handheld devices for the on-board unit instead of integrating technology into the actual vehicles. Beyond the on-board device, roadside units are needed to communicate with a central control office such as a Traffic Management Center (TMC), or to relay information to other vehicles further down the road. For a VII system that is intended to simply relay traffic conditions to a TMC (used for traveler information, changing signal timing, etc.), not every vehicle necessarily needs to communicate with infrastructure; for example, 1 in 10 vehicles may be enough to warn of an accident on the road, slow traffic ahead, or other adverse conditions. The ultimate goal of the most advanced implementation is to include some technology in the vehicles in order to improve safety and efficiency "automatically." For example, speed limits could be enforced automatically, brakes could be applied to avoid rear-end or intersection collisions, and route information could be used to predictively change signal timings or routes.

Model policy language

None identified

Model ordinances

None identified

Case studies

<u>California VII Testbed</u>

The Vehicle Infrastructure Integration (VII) California Testbed is a joint Metropolitan Transportation Commission (MTC), Caltrans, Daimler-Chrysler and Volkswagen/Audi activity. In the end multiple partners are envisioned as co-developers and, ultimately, "owners" of the system. As documented in the VII California Concept of Operations, the overall goals of the VII California program are to:

Better manage the safety and productivity of the surface transportation system;
Benefit from the synergy of public sector, auto industry, and other private sector innovations; and
Build upon California's already considerable existing infrastructure investments
http://www.viicalifornia.org/publications/vii_demonstration_evaluation.pdf

<u>Washington State Transportation Commission OmniAir VII</u>

Vehicle-to-vehicle and vehicle to-infrastructure communication delivering:

Increased safety through collision avoidance and accident prevention

Traffic management through applications including signal optimization and in-vehicle signage
Commercial benefit through payment applications related to tolling, parking and mobility
http://wstc.wa.gov/AgendasMinutes/agendas/2009/Jan13/Jan13_BP2_OverviewVehicleInfrastructureInteg.pdf

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

Traveler Information

CHAPTER 8: Website Briefings of Pricing Measures not included in *Energy Aware Planning Guide*

Cordon Pricing

SUMMARY

Cordon pricing is a form of congestion pricing where motorists who pay the fee gain access to an entire central business district or other major employment or retail area, rather than a dedicated freeway lane. Motorists who pass through a "cordon" area are charged a fee; the fee, which can vary by day of week or time of day, is enforced by a network of license plate cameras throughout the cordoned area. Cordon pricing is intended to reduce peak period personal automobile usage in congested areas, while generating revenue to be used for other transportation improvements. A more extreme version of cordon pricing is absolute restrictions on what vehicles can enter a central business district, which is known as rationing.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Cordon Pricing	66	76	92	$367	$475	$427
Moving Cooler medians	45	59	83	$205	$163	$116

Implement area pricing in large central business districts.

Modeling Assumptions: *Moving Cooler* page B-13 to B-14
Cost Assumptions: *Moving Cooler* page C-8

Other Findings

Cordon pricing in London indicates that there has been 19.5% reduction in GHG emissions.[113] The London congestion charging scheme began in 2003, charging vehicles for entering central London between the hours of 7:00am and 6:30pm. The effect of the scheme has been a reduction in vehicle miles traveled by about 15% and an increase in the average speed by about 2.4 miles per hour. The violation rate is estimated to be around 5%.[114]

Equity and Co-benefits

Modest negative equity impacts on low-income groups – reduced access to jobs, health care, education, and retail.

There is much debate surrounding the equity effects of transportation pricing and specifically cordon pricing.[115] For instance, in Singapore buses became more crowded and experienced

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113 Beevers, S. and D. Carslaw (2005) The impacts of congestion charging on vehicle emissions in London. Atmospheric Environment, 39, 1-5.
114 Congressional Budget Office, Evaluating Congestion Pricing: http://www.cbo.gov/ftpdocs/97xx/doc9750/Chapter2.6.1.shtml

115 Levinson, D. (2010) Equity Effects of Road Pricing: A Review. Transport Reviews, 30, 33-57.

longer travel times; however this can be mitigated by investment in grade-separate alternative modes like light rail and bus rapid transit. In London, on the other hand it was argued that cordon pricing would have progressive impacts on all travelers, since bus users would benefit from faster speeds and pricing revenues. However the impact on low-income car owners was still thought to be progressive. In addition there are potentially inequitable effects on those residents who live or work very close to the cordon, since they may have to pay a fee for traveling very little within the cordon area.

Recent analysis combines new methodologies for analyzing the physics of traffic flow with pricing, showing that traditional economics cannot be used to analyze cordon pricing. However alternative methods, based on the physics of traffic, do exist. These methods indicate that cordon pricing can be Pareto-efficient (i.e. makes everybody better-off).[116]

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

City

Population density required

Urban

Implementation Details

Cordon charging schemes vary based on characteristics such as fee structure, time of day, vehicle type and penalties for violators. Fees can be either be flat rate throughout the charging period or vary over the course of the day, with the highest fees typically occurring during the commute hours. Various vehicle types can be considered for inclusion and different fee scales, such as motorcycles, commercial vehicles and taxis. Penalties care typically fines, which increase with time since the violation. In addition, the cordon can be monitored using various methods, such as cameras or electronic tracking devices.

Model policy language

None identified

Model ordinances

None identified

Case studies

Several examples of cordon pricing schemes exist around the world. These include implementations in Milan, Italy; Bergen, Norway; Stockholm, Sweden; London, UK; and Singapore. Implementations have also been considered in New York and San Francisco.[117]

In London the charge for most vehicles is £8 between 7am and 6pm from Monday to Friday.[118] Exemptions are made for certain vehicle types, such as a discount for residents living within the

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116 Geroliminis, N., D. Levinson (2009) Cordon Pricing Consistent with the Physics of Overcrowding. Transportation and Traffic Theory, Edited by W.H.K. Lam, S.C. Wong and H.K. Lo.

117 Wikipedia, Road Pricing applications: http://en.wikipedia.org/wiki/Road_pricing

118 Wikipedia, London congestion charge: http://en.wikipedia.org/wiki/London_congestion_charge

charging zone, taxis, mototcycles and emergency vehicles. Failure to pay results in a fine of £120.

Another study has modeled the effects of road pricing in Singapore.[119] The Electronic Road Pricing scheme in Singapore has charges which vary based on time and location throughout the day.[120] The highest charges occur during the peak commute hours. If a driver fails to have sufficient value of his/her cash card, a fine is posted. If this is note payed within two weeks, a $70 is issued, which can rise to a fine of $1000 within 30 30 days or 1 month jail time.

Significant debate surrounded a pricing proposal in New York City in 2008.[121] [122] Although the proposal had many supporters, opposition cited problems. At the cordon, it was thought that drivers would park just outside the charge zone. There were questions about privacy rights, since vehicle tracking cameras would be installed. In addition, arguments were made that middle- and lower-class residents would be the citizens that would be the most financially affected.

An entire journal issue in Transportation Research Part A has been devoted to analyzing a trial cordon pricing in Stockholm, Sweden.[123] The Stockholm congestion tax varies over the course of the day, with peak prices occurring between 7:30am-8:30pm and 4:00pm-5:30pm.[124] Exempt vehicles include those that are equipped for propulsion with electricity, or a fuel gas which is predominantly made up of alcohol.

Road space rationing has been implemented in several cities around the world, including Athens, Greece; Santiago, Chile; Mexico City; Sao Paulo, Brazil; Bogota, Colombia; La Paz, Bolivia; San Jose, Costa Rica; Honduras; and Quito, Ecaudor. Rationing is typically determined by vehicle license plate, which indicates what days vehicles can enter a city.[125]

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

NA

Other resources

California Air Resources Board research on SB 375 implementation:
http://www.arb.ca.gov/cc/sb375/policies/pricing/roadpricing.pdf
http://www.arb.ca.gov/cc/sb375/policies/pricing/roadpricingbkgd.pdf

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119 Olszewski, P. and L. Xie (2005) Modeling the effects of road pricing on traffic in Singapore. Transportation Research Part A, 39, 755-772.
120 Wikipedia, Electronic Road Pricing (Singapore): http://en.wikipedia.org/wiki/Electronic_Road_Pricing_%28Singapore%29

121 Wikipedia, New York congestion pricing: http://en.wikipedia.org/wiki/New_York_congestion_pricing

122 Schaller, B. (2010) New York City's congestion pricing experience and implications for road pricing acceptance in the United States. Transport Policy, 17, 266-273.

123 Eliasson, J. and L. Hultkrantz and L. Rosqvist (2009) Stockholm Congestion Charging Trial. Transportation Research Part A, 43, 237-310.

124 Wikipedia, Stockholm congestion tax: http://en.wikipedia.org/wiki/Stockholm_congestion_tax

125 Wikipedia, Road space rationing: http://en.wikipedia.org/wiki/Road_space_rationing

High Occupancy Toll (HOT) Lanes/Congestion Pricing

SUMMARY

High Occupancy Toll (HOT) lanes are tolled lanes that operate alongside existing highway lanes to provide users with a faster and more reliable travel option. Buses, carpools, motorcycles and emergency vehicles may have free access to HOT lanes. Drivers with fewer than the required number of occupants can choose to pay to access the lanes.

Tolls for the HOT lanes may change according to traffic conditions to regulate demand for the lanes and keep them congestion free, eveen during peak hours. When traffic increases, tolls increase; when traffic decreases, tolls decline. HOT lanes with variable charges are also referred to as congestion pricing.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Congestion Pricing	510	1021	1241	$459	$342	$306
Moving Cooler medians	45	59	83	$205	$163	$116

Include all large regions at $0.49 per mile peak price, all large and medium regions at $0.65 per mile peak price, and all regions at $0.65 per mile peak price.

Modeling Assumptions: *Moving Cooler* page B-14
Cost Assumptions: *Moving Cooler* page C-9

Other Findings

Equity and Co-benefits

Negative equity impacts on low income groups, including reduced access to jobs, healthcare, education and retail.

Looking at the equity concerns associated with proposed HOT lane projects, which have been derided as "Lexus Lanes," Weinstein and Sciara (2006) notes that equity may arise as an issue at any stage of project development, and is not something can simply be addressed beforehand, but instead continuous monitoring of the equity implications projects is required both before and after opening. Planners would be wise to engage the issue proactively. HOT lanes are generally coupled with parallel free lanes, where the free lanes may be left for equity reasons (Verhoef et al., 1996).

A study of SR 91 by Sullivan (2000) found lower-income drivers approved of the lanes almost as much as wealthier drivers, though wealthier drivers did make more use of the facility.

Examining the I-15 HOT lanes in San Diego, Supernak et al. (2002) states "Equity issues did not emerge despite the fact that FasTrak users came from the highest-income groups." Users perceived the system as fair, as it was seen that travel-time benefits went to those who paid.

Smirti et al. (2007) summarizes literature and interviews a number of players for various congestion charging proposals in California. There was consensus that to achieve political acceptability, excess revenues should remain within the project corridor, and especially be allocated for transit.

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

This is likely to implemented by larger cities, counties or at the regional level.

Population density required

Urban or suburban

Implementation Details

None identified

Model policy language

None identified

Model ordinances

None identified

Case studies

The two longest-running HOT lane systems are in California, although several other states are considering HOT lanes

SR-91 Express Lanes: "The 91 Express Lanes is a four-lane, 10-mile toll road built in the median of California's Riverside Freeway (State Route 91) between the Orange/Riverside County line and the Costa Mesa Freeway (State Route 55). The state-of-the-art facility boasts several firsts — the first privately financed toll road in the U.S. in more that 50 years, the world's first fully-automated toll facility, and the first application of value (i.e. congestion) pricing in America. http://www.91expresslanes.com/learnabout/snapshot.asp

I-15 HOT Lanes: "San Diego's "FasTrak" pricing program was implemented in April 1999. Under this program, customers in single-occupant vehicles pay a toll each time they use the Interstate 15 HOV lanes. The unique feature of this pilot project is that tolls vary dynamically with the level of congestion on the HOV lanes. Fees can vary in 25-cent increments as often as every six minutes to help maintain free-flow traffic conditions on the HOV lanes. Motorists are informed of the toll rate changes through variable message signs located in advance of the entry points. The normal toll varies between $0.50 and $4.00. During very congested periods, the toll can be as high as $8.00. Toll revenues are supporting express bus service in the corridor, in addition to all operational costs of the HOT lanes, including police enforcement." http://knowledge.fhwa.dot.gov/cops/hcx.nsf/docs/28F4A458AC0B537B85256DBF006155E1?opendocument&Group=Value%20Pricing&tab=REFERENCE

Virginia Capital Highway HOT Lanes: "VDOT and Fluor-Transurban are working in partnership to deliver the most significant package of improvements to the Capital Beltway in a generation - providing congestion relief and new travel choices to one of Virginia's busiest roadways." http://www.virginiahotlanes.com/

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

NA

Other resources

California Air Resources Board research on SB 375 implementation:
http://www.arb.ca.gov/cc/sb375/policies/pricing/roadpricing.pdf
http://www.arb.ca.gov/cc/sb375/policies/pricing/roadpricingbkgd.pdf

Victoria Transport Policy Institute, Road Pricing: http://www.vtpi.org/tdm/tdm35.htm
Victoria Transport Policy Institute, Congestion Pricing: http://www.vtpi.org/tdm/tdm35.htm

Intercity Tolls

SUMMARY

Tolls can be introduced on highways and freeways between cities. Such tolls would influence passenger traffic, and greatly affect the trucking industry, for which much travel occurs in rural areas between cities. Similar toll systems already exist for vehicles in general and more so for trucks in particular in many parts of the U.S.

Distance-based tolls are thought to be particularly beneficial in an era when vehicles are becoming more fuel efficient, since they maintain agency revenues, even as vehicles become more fuel efficient and fuel tax revenues decrease.[126] Intercity tolls are similar to a vehicle miles traveled fee, but would only apply to travel over interstate highways.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Intercity Tolls	31	54	105	$1084	$828	$557
Moving Cooler medians	45	59	83	$205	$163	$116

Toll all intercity interstate highways at a minimum of $0.02 per mile by 2020, $0.03 per mile by 2015, and $0.05 per mile by 2010.

Modeling Assumptions: *Moving Cooler* page B-14
Cost Assumptions: *Moving Cooler* page C-10 to C-11

Other Findings

None identified

Equity and Co-benefits

Negative impacts on low-income groups-reduced access to jobs, health care, education, and retail.

POLICY CONTEXT

Existing regulations/policies

The passage of AB680 in 1989 in California prompted the construction of intercity toll roads in California.

Implementation level

Regional or state.

Population density required

Any

Implementation Details

None identified

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126 Forkenbrock, D. (2005) Implementing a Mileage-Based Road User Charge. Public Works Management Policy, 10, 87-100.

Model policy language
None identified

Model ordinances
None identified

Case studies
Currently there is a toll road in Orange County on SR-91 and in San Diego County on SR-125.[127]

Sweden is in the process of developing a road user charging system for trucks.[128] Germany[129] and Switzerland[130] have successfully implemented truck tolling systems.

RESOURCES

Energy Aware chapter
NA

Cross-references to other measures in Energy Aware
NA

Other resources
California Air Resources Board research on SB 375 implementation:
http://www.arb.ca.gov/cc/sb375/policies/pricing/roadpricing.pdf
http://www.arb.ca.gov/cc/sb375/policies/pricing/roadpricingbkgd.pdf

Victoria Transport Policy Institute:
Distance-Based Pricing: http://www.vtpi.org/tdm/tdm10.htm
Road Pricing: http://www.vtpi.org/tdm/tdm35.htm

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127 California Department of Transportation, Toll Road Fact Sheet:
http://www.dot.ca.gov/hq/paffairs/about/toll/status.htm Accessed 8/23/2010.

128 arena: http://www.arena-ruc.com/eng/?info=about Accessed 8/23/2010.

129 Federal Ministry of Transport, Building and Urban Development, HGV Toll
http://www.bmvbs.de/en/Transport/Roads-,2075/HGV-toll.htm Accessed 8/23/2010.

130 Swiss Federal Customs Administration: http://www.ezv.admin.ch/index.html?lang=en Accessed 8/23/2010

Pay-as-you-Drive Insurance

SUMMARY

Pay-as-You-Drive, or mileage-based, insurance is a method to transfer much of the fixed cost of operating a vehicle into a variable cost. When consumers face a higher variable cost of driving they have an incentive to reduce the miles they drive. PAYD can take the form of a surcharge on gasoline purchases, or can be based on self-reported or actual miles driven. PAYD insurance programs have been proposed in California and other states and countries. Insurance companies in the US have recently offered mileage-based insurance premiums. In theory mandatory PAYD insurance would in aggregate cost the same as the current insurance system, but costs and savings would be reallocated from drivers who drive fewer than average miles per year to those who drive more.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Pay-as-you-Drive insurance	789	1,677	2,233	$210	$99	$74
Moving Cooler medians	45	59	83	$205	$163	$116

Assumes all states allow voluntary mileage-based insurance, with the installation of transmitters to allow remote reading of vehicle odometers.

Modeling Assumptions: *Moving Cooler* page B-14
Cost Assumptions: *Moving Cooler* page C-10

Other Findings

A thorough discussion of the benefits of PAYD and how such a program could be implemented can be found here: www.islandnet.com/~litman/dbvi.pdf

A discussion paper estimates that a national PAYD program would reduce driving by about 8 percent, carbon dioxide emissions by about 2 percent, and oil consumption by about 4 percent. A $1-per-gallon increase in the price of gasoline would be necessary to achieve the same reductions. The paper estimates that almost two-thirds of households would pay less for auto insurance because of fewer crashes due to reduced driving, with each of those households saving an average of $270 per car. The authors note that there are several barriers to widespread adoption of PAYD, including the cost to monitor miles traveled and some state insurance regulations. Jason E. **Bordoff** and Pascal J. Noel (2008), *Pay-As-You-Drive Auto Insurance: A Simple Way to Reduce Driving-Related Harms and Increase Equity*, The Brookings Institution (www.brookings.edu); at www.brookings.edu/papers/2008/07_payd_bordoffnoel.aspx.

Equity and Co-benefits

An analysis of PAYD in California found that a statewide program would benefit low-income drivers in particular, with households making less than $47,500 (in 2001) saving money on average. Aa majority of households are better off in higher income groups. Most California households of each ethnicity would save money with such a program. Finally, a similar portion (62 to 64 percent) of rural and urban households would save money under a statewide PAYD program. Jason E. **Bordoff** and Pascal J. Noel (2008b), *The Impact of Pay-As-You-Drive Auto*

Insurance in California, The Brookings Institution (www.brookings.edu); at www.brookings.edu/papers/2008/07_payd_california_bordoffnoel.aspx.

POLICY CONTEXT

Existing regulations/policies

The California Department of Insurance recently required that insurance companies offer a form of PAYD or mileage-based insurance to California drivers. Premiums will be based on traditional rating factors, such as driving record and years of experience, as well as the number of miles driven over the policy period. Whether mileage will be self-reported by the insured, or based on odometer inspection by the insurer or a third party, has not been determined. http://www.insurance.ca.gov/0400-news/0100-press-releases/0080-2009/release135-2009.cfm

As of August 2010, two insurance companies, State Farm and the Automobile Club of Southern California, have applied for rate plans for PAYD insurance in the state. http://www.insurance.ca.gov/0400-news/0100-press-releases/2010/release092-10.cfm

Implementation level

Regional. A compulsory PAYD insurance system would have to be implemented at the state level. However, government fleets and private vehicle owners could voluntarily purchase mileage-based insurance from insurance providers.

Population density required

Urban, suburban, or rural. A statewide PAYD system would apply to all vehicles statewide, while fleets or private vehicles could voluntarily purchase mileage-based insurance regardless of where they are driven.

Implementation Details

None identified

Model policy language

None identified

Model ordinances

Texas House Bill 45, passed in 2001, allows insurers to offer per-mile pricing for vehicle insurance. The bill requires insurance companies to track and report the claim losses and premium revenues for mileage-based versus time-based premiums. www.capitol.state.tx.us

Case studies

Various organizations in Texas are working together on a *Cents Per Mile For Car Insurance* campaign (www.centspermilenow.org) to promote Pay-As-You-Drive vehicle insurance in response to the 2001 legislation.

The Progressive insurance company offers *MyRate* policies which provide discounts based on when, how much and how a vehicle is driven. Cars that are driven less often, in less risky ways and at less risky times of day can receive large discounts. Participating motorists receive a device which they plug into their vehicle's On-Board Diagnostic computer (OBDII) port; the device records how far, how fast and when the vehicle is driven, and transmits the data to a central receiving station. This information is used to calculate discounts the customer may receive when they renew their policy. www.progressive.com/MyRate/myrate-default.aspx

MileMeter is a private insurance company which began selling insurance policies by the mile in Texas in 2008. All policies, which are purchased over the internet, are valid for a certain number of miles or a six-month period. Motorists report their odometer reading when they purchase or renew a policy. To insure accuracy, this information is cross-referenced with any odometer readings from vehicle emission inspection programs and registration databases. www.milemeter.com

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

NA

Other resources

Victoria Transportation Policy Institute: http://www.vtpi.org/tdm/tdm79.htm

Vehicle miles traveled fees

SUMMARY

The federal Highway Trust Fund, used to finance road maintenance and improvements, as well as public transit, is supported by a national tax on purchases of gasoline (18.4 cents per gallon) and diesel (24.2 cents per gallon). There is concern that as the on-road vehicle fleet becomes more efficient, through higher fuel economy standards, replacement of light trucks with cars, and greater use of alternative fuels, there will be fewer gasoline tax revenues to support the Fund, and investment in transportation systems will suffer. In addition, only gasoline vehicles contribute to the Fund; other fuels such as ethanol, methanol, natural gas, biofuels, and electricity are not taxed. A more equitable system would charge all road users based on the miles driven, regardless of the fuel used. Mileage-based fees would also provide a stronger incentive to reduce miles traveled, rather than just reducing GHG emissions per mile driven.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
VMT fee	280	840	3,361	$593	$198	$49
Moving Cooler medians	45	59	83	$205	$163	$116

Introduce a $0.01, $0.03, and $0.12 per mile fee; costs include the installation of transmitters to allow remote reading of vehicle odometers.

Modeling Assumptions: *Moving Cooler* page B-14
Cost Assumptions: *Moving Cooler* page C-10

Other Findings

The Transportation Research Board (TRB) published a special report on the fuel tax and alternatives for Transportation Funding, which analyzed alternatives to the gasoline tax to raise revenue for transportation projects. http://www.trb.org/publications/sr/sr285.pdf

TRB sponsored a follow-up study which looked at different strategies to shift from a gas tax to a mileage-based fee to fund transportation projects.
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w143.pdf

In 2006 the Oregon Department of Transportation began a Road User Fee Pilot Program to assess the efficacy of charging a VMT fee. Under the program 260 vehicles were instrumented with equipment that transmitted the number of miles the vehicle had been driven to "smart" gas pumps each time the vehicle was refueled. The participants were charged a fee of 1.2 cents per mile driven rather than the 24 cent per gallon state gas tax. An evaluation of the pilot program indicated that the mileage fees are a feasible alternative to the gas tax to provide funding for road maintenance and improvements. The evaluation indicated that the prototype technology used in the pilot program needed to be improved before it could be used in a statewide program, however. http://www.oregon.gov/ODOT/HWY/RUFPP/mileage.shtml

The University of Iowa has begun a similar project, the Road User Study, using 1,200 vehicles in six cities. In this program drivers pay the existing gasoline tax when they refuel, but are sent simulated bills based on their vehicle's mileage each month, to assess their acceptance of a mileage-based fee as a substitute for the state gas tax. http://www.roaduserstudy.org/

A recent survey of 1500 California adults found that only 28% would support replacing the 18 cents per gallon gasoline tax with a mileage based fee of 1 cent per mile driven. The mileage fee would be paid at the time of refueling. A variant of the hypothetical mileage fee, under which vehicles with higher emissions would pay a higher rate, and vehicles with lower emissions a lower rate, per mile was much more popular, with 50% of those surveyed in support. Green transportation taxes and fees: A survey of public preferences in California, Transportation Research Part D: Transport and Environment, Volume 15, Issue 4, June 2010, Pages 189-196, Asha Weinstein Agrawal, Jennifer Dill, Hilary Nixon. http://tinyurl.com/27j9yqk

Equity and Co-benefits

Rural drivers would pay more than urban drivers.

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

Statewide

Population density required

Urban, suburban, or rural. VMT fees would apply to all vehicles statewide, regardless of where they are driven.

Implementation Details

None identified

Model policy language

None identified

Model ordinances

None identified

Case studies

None identified

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

NA

Other resources

California Air Resources Board research on SB 375 implementation:
http://www.arb.ca.gov/cc/sb375/policies/pricing/roadpricing.pdf
http://www.arb.ca.gov/cc/sb375/policies/pricing/roadpricingbkgd.pdf

Victoria Transportation Policy Institute: http://www.vtpi.org/tdm/tdm10.htm

Carbon pricing

SUMMARY

Carbon pricing would increase fuel taxes to a point that the tax rate covers all, or a larger portion, of the estimated monetized cost of environmental damage caused by the release of carbon emissions. The federal Highway Trust Fund, used to finance road maintenance and improvements, as well as public transit, is supported by a national tax on purchases of gasoline (18.4 cents per gallon) and diesel (24.2 cents per gallon). States, regions, and counties charge additional taxes on fuel purchases. Fuel taxes are one of the most effective measures to reduce vehicle travel and fuel consumption, because they produce immediate results and cover the entire vehicle fleet. Drawbacks of fuel taxes are political opposition, and how to spend the revenue generated by the taxes.

KEY NUMBERS

Effectiveness and Cost-Effectiveness

	Effectiveness (mmt GHG reduced)			Cost-effectiveness ($/ton GHG reduced)		
***Moving Cooler* measure**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**	**Expanded Current Practice**	**Aggressive Deploy-ment**	**Maximum Deploy-ment**
Carbon pricing (fuel economy impact)	1,181	3,343	10,442	$0	$0	$0
Carbon pricing (VMT impact)	350	1,067	4,744	$0	$0	$0
Moving Cooler medians	45	59	83	$205	$163	$116

Introduce a gasoline tax equivalent to a $0.01, $0.03, and $0.12 per mile fee. No costs were associated with this measure.

Modeling Assumptions: *Moving Cooler* page B-14
Cost Assumptions: *Moving Cooler* page C-10

Other Findings

A study by the U.S. Congressional Budget Office indicates that increased fuel prices in recent years have reduced fuel consumption slightly. Results indicate that a 10% increase in the retail price of gasoline would reduce consumption by only 0.6% in the short run, but by 4% in the long run. Prices have caused drivers to reduce speed, make fewer trips, and purchase smaller, more efficient vehicles.[131]

A study by the National Bureau of Economic Research indicates that short-run price elasticities have declined in recent decades.[132]

Another study indicates a reduction in the rebound effect in recent years. In other words, the impact of increased fuel efficiency on increasing fuel consumption has been lessened.[133]

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131 Effect of Gasoline Prices on Driving Behavior and Vehicle Markets. U.S. Congressional Budget Office, 2008. http://www.cbo.gov/ftpdocs/88xx/doc8893/01-14-GasolinePrices.pdf.

132 Jonathan E. Hughes, Christopher R. Knittel and Daniel Sperling (2006), Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand, National Bureau of Economic Research, Working Paper No. 12530 (http://papers.nber.org/papers/W12530)

However, results indicate that the rebound effect increases for higher fuel prices and decreases for higher incomes.

Research indicates that fuel taxes in Europe have contributed greatly to reducing environmental impacts from the transportation sector. Results show that long-term policies that increase fuel price by a factor of three cause half the carbon emissions that would otherwise occur. This is in contrast to the comparatively low taxes in the U.S. where emissions have increased greatly.[134]

Equity and Co-benefits

Fuel taxes are generally thought to be regressive, since lower income groups are likely to spend a greater proportion of their income on transportation fuels than those with higher incomes. However, some analyses show that taxes on transportation fuels are not as regressive as they may seem.

This occurs for two reasons. The first is that the fraction of people with lower incomes is comprised of a large fraction of young and elderly people. However, these people are also likely to have higher incomes during the middle period of their lives. When equity is considered based on a person's lifetime expected earnings, fuel taxes are seen as less regressive.[135]

The second reason is that fuel taxes influence the price of all goods transported, not just the price of individual transportation. For example, the fuel price of diesel is accounted for in the price of trucked goods. After accounting for these indirect effects, fuel taxes are less regressive than when only accounting for the effects associated with direct fuel consumption.[136]

POLICY CONTEXT

Existing regulations/policies

None identified

Implementation level

Statewide

Population density required

Urban, suburban, or rural. Carbon pricing would apply to all vehicles statewide, regardless of where they are driven.

Implementation Details

None identified

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133 Kenneth A. Small and Kurt Van Dender (2007), "Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect," Energy Journal, Vol. 28, No. 1, pp. 25-51; at www.econ.uci.edu/docs/2005-06/Small-03.pdf

134 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

135 Poterba, J. (1991) "Is the Gasoline Tax Regressive?" Tax Policy and the Economy, Vol. 5. pp.145-164.

136 Casler, S., A. Rafiqui (1993) "Evaluating Fuel Tax Equity: Direct and Indirect Distributional Effects." National Tax Journal, Vol. 46. pp. 197-205.

Model policy language

CAPCOA Model Policies for GHG in General Plans p.87: Use existing revenues, such as state gas tax subventions, sales tax funds, and general fund monies for projects to enhance bicycle use and walking for transportation.

Model ordinances

None identified

Case studies

None identified

RESOURCES

Energy Aware chapter

NA

Cross-references to other measures in Energy Aware

NA

Other resources

Victoria Transportation Policy Institute, Fuel Taxes: http://www.vtpi.org/tdm/tdm17.htm; Victoria Transportation Policy Institute, Carbon Taxes: http://www.vtpi.org/tdm/tdm130.htm

The optimal gas tax for California has been estimated to be about three times its current value. This accounts for externalities such as traffic congestion, oil security, accidents, local air pollution and climate change.[137]

137 Lin, C., L. Prince (2009) "The optimal gas tax for California." Energy Policy, Vol. 37. pp. 5173-5183.

CHAPTER 9:
Additional Pages on the Website

Tools for Additional Information

On the website there is a Tools page that provides information on additional resources for cities and counties. Many of the references listed are also cited and linked on the briefing pages for specific measures. Below is the information presented on the Tools page.

Moving Cooler

This report published by the Urban Land Institute examines the national carbon reduction potential in the transportation sector.

California Energy Commission, Public Interest Energy Research Program, Transportation Energy Research

This project will identify the magnitude of impacts resulting from integrated land use and transportation strategies under short-term and longer-term conditions likely to shape California growth, and will present alternatives for integrating improved land use and modal shift components into the CEC's transportation/fuel demand models. The project will analyze the carbon reduction potential from transportation and land-use measures in the four largest metro areas in California. [PDF]

California Air Pollution Control Officers Association

The California Air Pollution Control Officers Association has published several reports intended to assist city and county governments in reducing carbon, as well as criteria pollutant, emissions.

California Air Research Board, SB 375 Research

ARB staff are working with researchers at the University of California at Irvine and Davis to identify the impacts on vehicle use and greenhouse gas emissions of key transportation and land use policies based on the scientific literature. This research is the first step in a long-term process to help strengthen the technical underpinnings of SB 375 and to identify important data gaps and research needs. The research results may be used to help inform development of and potential improvements to the models and tools used by MPOs and others for SB 375 implementation. The results of the draft U.C. research are presented in two papers for each of 10 policies, five transportation-related and five land-use related.

ICLEI—Local Governments for Sustainability

ICLEI provides resources, including software and tools, to assist local governments in reducing carbon emissions.

Vision California

As part of the Vision California project, Calthorpe Associates has developed a *Rapid Fire* spreadsheet tool that allows regional MPOs to evaluate the costs and impacts of statewide or regional scenarios regarding land use development and vehicle miles traveled, light-duty vehicle fuel economy, and gasoline prices in future years. Using the Rapid Fire tool, Calthorpe estimates that, under a Growing Smart scenario, California households could each save $6,400 per year, while reducing statewide miles driven by 3.7 trillion miles and saving 140 billion gallons of gas by 2050, and saving cities and counties $4.3 billion in annual infrastructure costs. Vision California also has developed a map-based model called *Urban Footprint*, a GIS-based tool that allows visualization of changing land-use under different development scenarios.

Vision California is a partnership of the California High-Speed Rail Authority and the Strategic Growth Council.

- Vision California
- Vision California report [PDF]
- Rapid Fire technical summary [PDF]
- For a copy of the *Rapid Fire White Paper and Technical Guide* contact Calthorpe Associates at VisionCalifornia@calthorpe.com.

Victoria Transportation Policy Institute, TDM Encyclopedia

VTPI has assembled and summarized a wealth of research on various measures to reduce emissions from the transportation sector in its Transportation Demand Management (TDM) Encyclopedia. The Encyclopedia is a comprehensive source of information about innovative management solutions to transportation problems. It provides detailed information on dozens of demand management strategies, plus general information on TDM planning and evaluation techniques.

Electronic Version of the *Energy Aware Planning Guide*

The website also includes a link to an electronic version of the *Energy Aware Planning Guide*, written in html. The top page of the electronic version replicates the table of contents from the Guide, with each section linked to an electronic version of that section in the Guide. The entire Guide is included on the website, including the Introduction, Create an Energy Action Plan, Meeting California's Climate Change Challenge, and Fully Integrated Planning sections; the Building, Water Use, and Community Energy Strategies; and Appendices A and B. All documents that are referenced in the *Energy Aware Planning Guide* or the transportation website have been downloaded and linked to the html version of the *Guide* and the website, so that links will not be broken as outside sources change their websites.