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June 27, 2007

By Telecopy and E-mail

Shelby Tucker
San Diego Association of Governments
401 B Street, Suite 800
San Diego, CA 92101

RE: Comments on the Notice of Preparation for Draft Environmental Impact Report For the 2007 Regional Transportation Plan (SCH Number 2007051145)

Dear Ms. Tucker:

The Attorney General submits these comments to the San Diego Association of Governments ("SANDAG") on the Notice of Preparation for the Draft Environmental Impact Report for the 2007 Regional Transportation Plan ("Transportation Plan"). The Notice indicates that SANDAG will prepare a draft Environmental Impact Report ("EIR") for the Transportation Plan and is seeking comments regarding environmental issues to address in the EIR.

Under the California Environmental Quality Act, Public Resources Code § 21000, et seq. ("CEQA"), SANDAG has an obligation to consider global warming impacts in the draft EIR. The projects authorized in the Transportation Plan will result in significant increases in emissions of greenhouse gases ("GHG") that cause global warming, and any increase in such emissions will make it more difficult for the state to meet the greenhouse gas reduction requirements of Assembly Bill 32. Accordingly, the draft EIR should evaluate the global warming impacts of the projects and priorities adopted in the Transportation Plan and discuss feasible alternatives and mitigation measures to avoid or reduce those impacts.

We commend SANDAG for the efforts it has already undertaken to reduce GHG emissions by adopting the Regional Energy Strategy (2003), which is currently being updated, and the Regional Comprehensive Plan for the San Diego Area (July 2004). We encourage SANDAG to continue those efforts in the proposed Transportation Plan and EIR.

Global Warming in California

The Intergovernmental Panel on Climate Change of the United Nations recently published its finding that overwhelming evidence establishes that global warming is occurring and is caused

by human activity.^{1/} With respect to impacts in the state, the California Climate Change Center reports that temperatures are expected to rise 4.7 to 10.5 °F by the end of the century.^{2/} These increases would have serious consequences, including substantial loss of snowpack, an increase of as much as 55% in the risk of large wildfires, reductions in the quality and quantity of agricultural products, exacerbation of California's air quality problems, and adverse impacts on human health from increased heat stress and heat related deaths, and increases in asthma, respiratory and other health problems.^{3/} According to NASA's James Hansen, proceeding at the greenhouse gas emissions rate of the past decade will result in "disastrous effects, including increasingly rapid sea level rise, increased frequency of droughts and floods, and increased stress on wildlife and plants due to rapidly shifting climate zones."^{4/} And, the experts tell us, we have less than a decade to take decisive action.^{5/} If we continue our business-as-usual emissions trajectory, dangerous climate change will become unavoidable.

In 2002, 493 million metric tons of carbon dioxide-equivalent greenhouse gases were emitted in California.^{6/} Of those emissions, 82% were emissions of carbon dioxide from fossil fuel combustion.^{7/} Fossil fuel consumption in the transportation sector was the single largest source of California's GHG emissions in 2002. According to a California Energy Commission report, transportation accounted for 41.2% of GHG emissions in the state.^{8/}

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1. "Climate Change 2007: The Physical Science Basis, Summary For Policymakers" (Fourth Assessment Report of the IPCC, February 2007).
 2. Amy Lynd Luers, Daniel R. Cayan et. al, *Our Changing Climate: Assessing the Risks to California* (July 2006) at p. 2. The report was prepared by the Climate Change Center at the direction of CalEPA pursuant to its authority under Executive Order S-3-5.
 3. *Id.* at pp. 2, 10; Executive Order S-3-05.
 4. <http://www.giss.nasa.gov/research/news/20070530/>; see also Hansen et al., *Dangerous human-Made Interference with Climate* (2007) 7 Atmos. Chem. Phys. 2287-2312 http://pubs.giss.nasa.gov/docs/2007/2007_Hansen_etal_1.pdf
 5. *Id.* For further discussion of dangerous climate change, see IPCC 4th, WG III, Ch. 1 at pp. 6-7 http://www.mnp.nl/ipcc/pages_media/FAR4docs/chapters/CH1_Introduction.pdf
 6. "Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update." (California Energy Commission, June 2005).
 7. Gerry Bemis and Jennifer Allen, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update* (June 2005) at p.5.
 8. *Id.* at pp. 6-7.

California's Actions to Address Global Warming

On June 1, 2005, Governor Schwarzenegger issued Executive Order S-3-05, which recognized California's vulnerability to global warming and the need for implementation of mitigation measures to limit the impacts to the state. To counteract the warming trend, the Governor set GHG emission reduction targets for California: by 2010, reduce GHG emissions to 2000 levels; by 2020, reduce emissions to 1990 levels; by 2050, reduce emissions to 80 percent below 1990 levels.

Assembly Bill 32, the California Global Warming Solutions Act of 2006, codified at Health and Safety Code Section 38500, et seq. ("AB 32"), was signed into law by the Governor on September 27, 2006. The bill demonstrates that the Legislature recognizes the serious threats that global warming poses to California.^{9/} To combat these threats, AB 32 requires reduction of the state's GHG emissions to 1990 levels by 2020.^{10/} This emissions cap is equal to a 25% reduction from current levels.^{11/} The bill directs that by June 30, 2007, the California Air Resources Board ("CARB") shall publish a list of discrete early action GHG emission reduction measures that will be implemented by 2010.^{12/} CARB must then adopt comprehensive regulations that will go into effect in 2012 to require the actions necessary to achieve the GHG emissions cap by 2020.^{13/} The legislation also encourages entities to voluntarily reduce GHG emissions prior to 2012 by offering credits for early voluntary reductions.^{14/}

California Environmental Quality Act

CEQA and its implementing regulations require that an EIR address the cumulative environmental impacts of a project when its incremental effect is cumulatively considerable. "[C]umulatively considerable' means that the incremental effects of an individual project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects."^{15/} Global warming is a

9. Health & Safety Code § 38501.

10. Health & Safety Code § 38550.

11. 9/27/2006 Press Release from the Office of the Governor, available at <http://gov.ca.gov/index.php?/print-version/press-release/4111>.

12. Health & Safety Code § 38560.5.

13. Health & Safety Code § 38562.

14. Health & Safety Code §§ 38562(b)(3), 38563.

15. Public Resources Code § 21083(b); Cal.Code Regs., tit. 14, § 15065; and Cal. Code Regs., tit. 14, § 15130, subd. (a).

quintessentially cumulative impact, caused by the added effects of countless individual projects at the local, regional, state, national and international level.

As the Court of Appeal concluded in *Kings County Farm Bureau v. City of Hanford* (1990) 221 Cal.App.3d 692, 720 [internal quotation omitted]:

"[o]ne of the most important environmental lessons evident from past experience is that environmental damage often occurs incrementally from a variety of small sources. These sources appear insignificant, assuming threatening dimensions only when considered in light of the other sources with which they interact. Perhaps the best example is air pollution, where thousands of relatively small sources of pollution cause a serious environmental health problem. CEQA has responded to this problem of incremental environmental degradation by requiring analysis of cumulative impacts."

As part of the analysis carried out in an EIR, the agency must identify mitigation measures and examine alternatives to the proposed project that would reduce its cumulative environmental impact.^{16/} CEQA mandates that agencies should not approve projects with significant environmental effects if there are feasible alternatives or mitigation measures that can substantially lessen or avoid those effects.^{17/} CEQA requires that "[e]ach public agency shall mitigate or avoid the significant effects on the environment of projects that it carries out or approves whenever it is feasible to do so."^{18/}

The Transportation Plan

The Transportation Plan will include policies and goals to guide transportation decisions and will include a list of transportation projects intended to meet travel demand through the year 2030. Transportation projects must be contained in, or consistent with, the Transportation Plan to qualify for federal or state funding. It is estimated that SANDAG's Transportation Plan will authorize \$40 billion worth of transportation projects.

The Transportation Plan is required to provide for consideration of projects and strategies that will, among other things: "protect and enhance the environment"; "promote energy conservation"; and "improve the quality of life." (23 U.S.C.A. § 134(h)). The Transportation Plan also "shall include a discussion of types of potential environmental mitigation activities and potential areas to carry out these activities, including activities that may have the greatest potential to restore and maintain the environmental functions affected by the plan." (23 U.S.C.A.

16. Public Resources Code § 21002.1(a); Cal. Code Regs., tit. 14, § 15130, subd. (b)(5).

17. Public Resources Code §§ 21002, 21081; see also, *Mountain Lion Foundation v. Fish and Game Commission*, 16 Cal.4th 105, 134 (1997).

18. Public Resources Code § 21002.1(b).

§ 134(i)(2)(B)(i)). Based on these provisions and the facts about causes and impacts of global warming discussed above, the Transportation Plan should include projects to reduce global warming impacts on the environment, and also discuss mitigation activities to avoid or reduce global warming impacts of the projects and priorities identified in the Transportation Plan.

The Draft EIR Should Consider Global Warming Impacts, Mitigation Measures and Alternatives

The Governor's Executive Order and AB 32 inform agencies' obligations under CEQA. The existence of global warming is indisputable; it is causing significant environmental impacts in California and will cause future catastrophic impacts if emissions levels are not substantially reduced; and many incrementally small but cumulatively significant sources of emissions are being approved and permitted every day. The global warming impact of \$40 billion worth of transportation projects that will be authorized in the SANDAG's Transportation Plan must be considered significant, even just based on the GHG emissions from the huge magnitude of construction (from use of off-road construction vehicles and building materials such as asphalt and concrete). In addition, the road improvement and construction projects authorized in the Transportation Plan will result in a significant increase in the capacity of roads in the area to accommodate vehicle travel, and this additional vehicle travel will result in a large increase in GHG emissions. The draft EIR should use the best available data and modeling tools to estimate the GHG emissions of the projects included in the Transportation Plan.^{19/}

Although the comprehensive regulations implementing AB 32 will not be in place until 2012, the projects included in the Transportation Plan will contribute cumulatively to the GHG load. Once permitted, these projects will continue to have environmental implications far beyond 2012. Accordingly, SANDAG has a current obligation under CEQA to analyze potential global warming impacts and evaluate alternatives and mitigation measures that would avoid or reduce any unavoidable adverse global warming impacts from the actions included in the Transportation Plan. These measures will help California meet its statutory requirements for GHG reductions.

We are pleased to see the "Energy White Paper For the 2007 Regional Transportation Plan", posted on SANDAG's website, that indicates that SANDAG intends to address "GHG emission impacts" and "reductions from various travel choices and from smart growth efforts" in the EIR for the Transportation Plan. The White Paper also recommends that the EIR "identify an action plan and possible funding sources to further address climate change effects of transportation activities." We encourage SANDAG to include such an action plan as part of its obligation under CEQA to evaluate, and where feasible adopt, mitigation measures and alternatives to reduce GHG emissions. SANDAG should also evaluate measures that can be implemented to mitigate for the GHG emissions that cannot be avoided, such as contributing funds for an urban

19. A chart of available modeling tools prepared by the California Air Resources Board is attached.

tree planting program.^{20/}

The Climate Action Team Report to Governor Schwarzenegger and the Legislature (CalEPA March 2006) has identified strategies for reducing transportation-related GHG emissions. The Report recommends two broad strategies relevant to regional transportation planning that could achieve significant GHG emission reductions -- Measures to Improve Transportation Energy Efficiency and Smart Land Use and Intelligent Transportation. (Report at p.57.) Measures to Improve Transportation Energy Efficiency includes: "Incorporating energy efficiency and climate change emissions reduction measures into the policy framework governing land use and transportation, including framework for developing energy element in state transportation and regional planning documents." (*Id.* at p.58.) Smart land use strategies generally "encourage jobs/housing proximity, promote transit oriented development, and encourage high-density residential/commercial development along transit corridors." (*Ibid.*) Intelligent Transportation Systems is "the application of advanced technology systems and management strategies to improve operational efficiency of transportation systems and movement of people, goods and services." (*Ibid.*) These strategies for reducing GHG emissions should be addressed in the draft EIR and, where appropriate, included in the Transportation Plan.

The "Climate Action Program at Caltrans" also includes many of the same strategies.^{21/} It also identifies the need to "[m]ainstream energy efficiency and GHG emissions reductions measures into land use and transportation decisions."^{22/}

There undoubtedly are numerous specific alternatives and mitigation measures to reduce GHG emissions that SANDAG could identify and evaluate in the draft EIR and include in the Transportation Plan. It is beyond the scope of this letter to attempt to identify fully the relevant mitigation measures and alternatives, but they may include the following: infrastructure for the "California Hydrogen Highway Network" such as private vehicle and fleet hydrogen refueling stations; construction of electric vehicle charging facilities; electrification at truck stops; measures to reduce idling time; transit vouchers; parking fees; education regarding trip linking; projects to facilitate and increase use of carpooling, vanpooling, and ridesharing; measures to increase use of public transit; increased public transit routes and times of operation; other transportation demand management measures; a requirement that off-road diesel-powered vehicles and equipment (unless it is new) use retrofit emission control devices, such as diesel

20. One of the simplest and cheapest ways to achieve significant energy savings (and accordingly reduction in GHG emissions) is planting trees to shade buildings and air conditioners. See, "Tomorrow's Energy Today for Cities and Counties: Cooling Our Cities" (U.S. Department of Energy, November 1993) (www.p2pays.org/ref/11/1-984.pdf).

21. Climate Action Program at Caltrans (California Department of Transportation, Business, Transportation, and Housing Agency, December 2006).

22. *Id.*, p. 6, Table 1.

oxidation catalysts and diesel particulate filters;^{23/} a requirement to use the most energy-efficient building materials and lighting technology, including alternative formulations of cement^{24/} and asphalt,^{25/} that have substantially lower GHG emissions, if they are available; planting trees to mitigate GHG emissions; increased funding for purchase of alternative fuel buses; safe streets to school projects; bike path construction/improvement and bike storage facilities; and adoption of funding priorities that target spending toward population and employment centers and withhold infrastructure funding from greenfield development at the urban edge. A more comprehensive list of transportation emission reduction strategies identified by the Federal Highway Administration is attached to this letter. SANDAG's draft EIR should evaluate these strategies as potential measures to reduce transportation-related GHG emissions.

Global warming presents California with one of its greatest challenges. SANDAG has the opportunity to continue addressing global warming in a constructive manner while educating the public and decision-makers. We urge SANDAG to meet the challenge with this Transportation Plan and environmental impact report.

Thank you for considering these comments.

Sincerely,


SANDRA GOLDBERG
Deputy Attorney General

For EDMUND G. BROWN JR.
Attorney General

23. See, www.arb.ca.gov/diesel/verdev/verdev.htm and www.epa.gov/ispd/pdf/emission_0307.pdf This requirement was applied to construction at LAX and O'Hare International Airports. See, www.oharemodernization.org (Sustainable Design Manual, §8.5) and www.laxmasterplan.org/cb_CBA_Exhibits.cfm. (Section X. F.) These devices also reduce public exposure to a known carcinogen and toxic air contaminant, diesel particulate exhaust. See "Digging Up Trouble: Health Risks of Construction Pollution in California" (Union of Concerned Scientists, November 2006).

24. Cement manufacture ranks ninth among the sources of U.S. GHG emissions. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2000 (Washington, D.C., April 2002, ES-4, 1-13 and 1-14). Alternative formulations may be available to reduce GHG emissions. Climate Action Report, p. 54.

25. "Warm-mix" asphalt technology that significantly reduces GHG emissions is currently being evaluated and may prove to be a feasible alternative road paving material. See, "Warm-Mix Asphalt (WMA) Potentially Can Provide Important Benefits for Paving Contractors, Reduce Fuel Costs and Diminish Green-House Gases" in [Construction Equipment](http://www.constructionequipment.com/article/CA6421459.html), March 1, 2007 (www.constructionequipment.com/article/CA6421459.html).

Modeling Tools to Estimate Climate Change Emissions Impacts of Projects/Plans

Tool	Availability	Scope Local/Regional	Scope Transp/Buildings	Data Input Requirements	Data Output
URBEMIS	<ul style="list-style-type: none"> Download Public domain (free) 	<ul style="list-style-type: none"> Local project level 	<ul style="list-style-type: none"> Transportation Some building (area source) outputs Construction 	<ul style="list-style-type: none"> Land use information Construction, area source, and transportation assumptions 	<ul style="list-style-type: none"> VMT per day (convert to CO2 and methane) Mitigation impacts
Clean Air and Climate Protection (CACP) Software	<ul style="list-style-type: none"> Download Available to public agencies (free) 	<ul style="list-style-type: none"> Local project level 	<ul style="list-style-type: none"> Buildings Communities Governments 	<ul style="list-style-type: none"> Energy usage Waste generation and disposal Transportation usage 	<ul style="list-style-type: none"> eCO2 (tons per year)
Sustainable Communities Model (SCM)	<ul style="list-style-type: none"> Custom model 	<ul style="list-style-type: none"> Regional, scalable 	<ul style="list-style-type: none"> Transportation Master planned communities 	<ul style="list-style-type: none"> Location and site specific information Transportation assumptions On-site energy usage 	<ul style="list-style-type: none"> eCO2 (tons per year)
I-PLACE³S	<ul style="list-style-type: none"> Web-based Small access fee Full model now available in eight CA counties 	<ul style="list-style-type: none"> Regional, scalable to site level 	<ul style="list-style-type: none"> Transportation Buildings Infrastructure (wastewater, street lights, etc.) 	<ul style="list-style-type: none"> Parcel level land use data (can work with less data) Project-level data for alternative comparisons 	<ul style="list-style-type: none"> CO2 (any quantity over any time) Provides for immediate comparison of alternatives
EMFAC	<ul style="list-style-type: none"> Download Public domain (free) 	<ul style="list-style-type: none"> Statewide Regional (air basin level) 	<ul style="list-style-type: none"> Transportation emission factors 	<ul style="list-style-type: none"> Used with travel demand and other models to calculate CO2 impacts of projects. 	<ul style="list-style-type: none"> CO2 and methane (grams per mile) emission factors
Climate Action Registry Reporting On-Line Tool (CARROT)	<ul style="list-style-type: none"> Web-based Available to Registry members 	<ul style="list-style-type: none"> Regional, scalable to entity and facility level 	<ul style="list-style-type: none"> General Specific protocols for some sectors 	<ul style="list-style-type: none"> Uses inputs such as fuel and electricity use, VMT to estimate emissions of each GHG 	<ul style="list-style-type: none"> Each GHG and eCO2 (tons per year)

VMT = Vehicle miles traveled.

Criteria pollutants = Nitrogen oxides (NO_x), reactive organic gases (ROG), carbon dioxide (CO), sulfur dioxide (SO₂), particulate matter (PM)

eCO₂ = Carbon dioxide equivalent emissions

Note: This is not meant to be a definitive list of modeling tools to estimate climate change emissions impacts. Other tools may be available.

Descriptions of Modeling Tools

URBEMIS. The Urban Emissions Model (URBEMIS) is currently being used extensively during the CEQA process by local air districts and consultants to determine criteria pollutant impacts of local projects. URBEMIS uses the ITE Trip Generation Rate Manual and the Air Resources Board's (ARB) motor vehicle emissions model (EMFAC) for transportation calculations. Area source outputs include natural gas use, landscaping equipment, and fireplaces. It also estimates construction impacts and impacts of mitigation options. An updated version with CO2 outputs may be available soon. In the interim, CO2 factors (pounds per mile) provided by ARB could be used to convert VMT per day into CO2 per day. Web site: <http://www.urbemis.com>.

Clean Air and Climate Protection (CACP) Software. This tool is available to state and local governments and members of ICLEI, NACAA, NASEO and NARUC to determine greenhouse gas and criteria pollutant emissions from government operations and communities as a whole. The user must input aggregate information about energy (usage), waste (quantity and type generated, disposal method, and methane recovery rate) and transportation (VMT) for community analyses. More detailed, site-specific information is necessary to calculate emissions from governmental operations. CACP uses emission factors from EPA, DOE, and DOT to translate the energy, waste and transportation inputs into greenhouse gas (in carbon dioxide equivalents) and criteria air pollutant emissions. If associated energy, waste and transportation reduction are provided, the model can also calculate emission reductions and money saved from policy alternatives. Web site: <http://cacpsoftware.org>.

Sustainable Communities Model (SCM). This model quantifies total eCO2 emissions allowing communities the ability to optimize planning decisions that result in the greatest environmental benefit for the least cost. SCM has been used by a number of master planned communities, but it could also be used for neighborhoods and smaller developments. Total eCO2 emissions are based on emissions from energy usage, water consumption and transportation. SCM uses published data sets for data input such as ARB's EMFAC for transportation calculations. The model provides a comparison of various scenarios to provide environmental performance, economic performance, and cost benefit analysis. Web site: http://www.ctg-net.com/energetics/News/News_SCM.html

I-PLACE³S is an internet-accessed land use and transportation model designed specifically for regional and local governments to help understand how their growth and development decisions can contribute to improved sustainability. It estimates CO2, criteria pollutant and energy impacts on a neighborhood or regional level for existing, long-term baseline and alternative land use plans. I-PLACE³S is currently being used in San Diego, San Luis Obispo, and the six-county Sacramento region to assist both the public participation process and technical analyses efforts for regional planning. The data input requirements are extensive and require a fiscal commitment from local government. The benefits include a tool that can provide immediate outputs to compare various alternatives during public meetings, as well as provide access for local development project CEQA analyses. Possible future modifications could include a stand-alone tool that would allow project-level analyses of land uses (buildings) without extensive regional data input requirements. Web site: <http://www.energy.ca.gov/places/> ; <http://places.energy.ca.gov/places>

EMFAC. The Air Resources Board's Emission FACTors (EMFAC) model is used to calculate emission rates from all motor vehicles (passenger cars to heavy-duty trucks) in California. The model includes emission factors for CO2, methane, and criteria pollutants. The emission factors are combined with data on vehicle activity (miles traveled and average speeds) to assess emission impacts. California local governments use EMFAC in concert with their travel demand models to assess impacts of transportation plans. The URBEMIS model described above uses EMFAC to calculate the transportation emission impacts of local projects. Web site: <http://www.arb.ca.gov/msei/onroad/onroad.htm>

Climate Action Registry Reporting On-Line Tool (CARROT). The California Climate Action Registry uses the Climate Action Registry Reporting On-Line Tool (CARROT) for registry members to report their greenhouse gas emissions. It calculates GHG emissions from energy, fuel use, and travel estimates made by the user. While use of the tool is only available to members, the Registry makes its protocols available to the public. The general reporting protocol is available at <http://www.climateregistry.org/docs/PROTOCOLS/GRP%20V2.1.pdf>. Specific reporting protocols are also available for reporting by the cement, forestry, and power/utility sectors and are being developed for additional sectors. Website: <http://www.climateregistry.org/CARROT/>



Multi-Pollutant Emissions Benefits of Transportation Strategies

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Appendix A: List of Transportation Strategies

This appendix includes a list of transportation emission reduction strategies that is intended to be comprehensive of the full range of strategies that would be examined by transportation agencies as part of transportation conformity analyses or other emissions analyses. Although this list is intended to be comprehensive, it is not exhaustive of all potential strategies. Two primary criteria were applied for inclusion of strategies:

1. The strategy can be implemented by policy makers at a state or local level (i.e., it does not require a change in federal law or federal action) - Many strategies in the list below can be funded or implemented directly by transportation agencies (e.g., transit programs, traffic flow improvements). However, we did not limit the list only to those that would be implemented directly by transportation agencies. Some strategies are typically funded by state air agencies (e.g., inspection and maintenance programs, vehicle buy-back programs) or require implementation by local governments (e.g., land use policies, parking policies).
2. The strategy is generally considered at least marginally useful as an emission reduction strategy -Some strategies have limited documentation of effectiveness, and may not generate significant emission reductions on their own; however, all strategies included are generally considered to be supportive of other strategies and contributing to emissions reductions.

The strategies are grouped into four broad categories:

1. **Transportation demand management (TDM) strategies** - these strategies generally focus on reducing the amount of vehicle travel;
2. **Transportation system management (TSM) / driver behavior-oriented strategies** - these strategies generally focus on improving the operating characteristics of vehicles, affecting speeds, traffic flow, idling, etc.;
3. **Vehicle, fuels, and technology strategies** - these strategies generally focus on reducing vehicle emission rates; and
4. **Non-road transportation strategies** - these strategies address railroads, marine vessels, airport ground support equipment, and other non-road engines.

Some individual strategies fall into more than one of these categories (e.g., high-occupancy vehicle lanes can be considered both a TDM and TSM strategy since they encourage ridesharing, and also may help to improve traffic flow) but are only listed once in order to avoid duplication.

Within these four broad categories, the strategies have been sub-categorized so that those with similar goals or targets are grouped together (e.g., transit strategies are grouped together, as are bicycle and pedestrian strategies). Often, strategies within a sub-category are implemented together and are analyzed as a package. In total, this memo identifies 137 different strategies in 29 sub-categories. For many of the strategies, examples of specific implementation approaches are provided. Although each of these examples is sometimes listed as a separate strategy in other resource documents, the examples for a given strategy generally serve the same purpose and would typically use the same general methodology for emissions analysis.

Each of the strategies focuses on policy or programmatic approaches that could be implemented by the public sector. Following the strategies, a table identifies specific technologies that can be applied as emission reduction measures.

Transportation Demand Management Strategies

Transportation demand management (TDM) strategies focus on changing travel behavior - trip rates, trip length, travel mode, time-of-day, etc. Most TDM projects/programs reduce emissions by reducing trips and/or vehicle miles traveled (VMT) by personal motor vehicles, or by shifting trips from peak periods to less congested periods. These strategies are listed below.

1. Shared Ride Programs/Projects

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Strategy	Examples
Park-and-Ride facilities	<ul style="list-style-type: none"> • New park-and-ride facility • Add parking to existing facilities
High-Occupancy Vehicle (HOV) lanes	<ul style="list-style-type: none"> • Separate roadway for exclusive HOV use • Barrier separated lanes within freeway right-of-way • Concurrent flow lane • Contra-flow lane • HOV on arterial streets • Bypass lanes for HOVs at metered freeway entrance ramps
Regional rideshare outreach/matching	<ul style="list-style-type: none"> • Implement regional rideshare matching programs • Upgrade ridematching software (for full regional address recognition, corridor searching, etc.)
Regional rideshare incentives	<ul style="list-style-type: none"> • Carpool incentives (e.g., free gas card, drawings) • Vanpool incentives (e.g., subsidized vanpools)
Dynamic rideshare programs	<ul style="list-style-type: none"> • Real-time rideshare matching
Encourage shared ride taxis	
Regional vanpool network	
Short-distance vanpools	<ul style="list-style-type: none"> • Vanshare program providing access from transit to workplaces

2. Bicycle and Pedestrian Programs/Projects

Strategy	Examples
New bicycle paths, lanes, routes, or safety enhancements	<ul style="list-style-type: none"> • Bicycle paths/lanes • On-street bicycle routes • Multi-use trails • Rails-to-trails conversions • Bicycle safety enhancements (lighting, grades, markings, etc.)
Bicycle parking	<ul style="list-style-type: none"> • Bicycle racks • Bicycle lockers • Attended bicycle parking • Ordinances requiring bicycle parking
Bikes on transit programs	<ul style="list-style-type: none"> • Bicycles on buses • Bicycles on rail
Bicycle information	<ul style="list-style-type: none"> • Informational signage (e.g., Share the Road signs, designated bicycle routes) • Bicycle maps/plans • Bicycle educational information, including bicycle safety information • Bicycle coordinators • Bicycle awareness/safety events
Bicycle share programs	<ul style="list-style-type: none"> • Public use bicycles • Bike stations providing maintenance facilities
Financial incentives to own bicycles	<ul style="list-style-type: none"> • Free bikes program • Cash rebates for bicycle purchases
Pedestrian connections/sidewalks	<ul style="list-style-type: none"> • New sidewalks • Sidewalk improvements (curb ramps, sidewalk gap closure, etc.) • Pedestrian bridges/tunnels

	<ul style="list-style-type: none"> • Mid-block pedestrian connections
Enhancing the pedestrian environment	<ul style="list-style-type: none"> • Wider sidewalks • Tree plantings • Crosswalk light fixtures • Street lights • Sidewalk furniture (benches, etc.) • Pedestrian safety modifications (count down pedestrian signals)

3. Transit

Strategy	Examples
New transit routes/services	<ul style="list-style-type: none"> • New bus routes • New rail lines • Demand response shuttle • Circulator buses • Express bus service
More frequent service	<ul style="list-style-type: none"> • Additional buses in service on existing routes (to reduce headways)
Longer service hours	<ul style="list-style-type: none"> • Expansion beyond peak periods • Late night hours
More capacity on services	<ul style="list-style-type: none"> • Larger buses • Additional railcars on trains • Redesign of seating/standing
Faster travel times/improved system performance	<ul style="list-style-type: none"> • Busways/bus rapid transit (BRT) • Improved bus/rail integration • Transit signal prioritization • Improved connections/reduced transfer times • Transit centers • Change routing
Passenger amenities	<ul style="list-style-type: none"> • Bus shelters • Benches/seating at bus stops • Improved maintenance of buses/trains and stops/stations
Improved transit access	<ul style="list-style-type: none"> • Increased parking at transit stations • Shuttle and feeder bus services • Improved pedestrian/bicycle access and bicycle parking
Transit information	<ul style="list-style-type: none"> • Signage/maps/schedules at bus/train stops • Signage/maps/schedules at major activity centers (e.g., malls, sports venues, etc.) • Terminal displays/kiosks with real-time passenger information • Transit information kiosks (e.g., in suburban employment sites, downtown, tourist sites) • Web page with transit planning capabilities • Inclusion of transit information in 511 and other travel planning services • Real-time text messaging/on-line information on bus schedules
Transit marketing and promotions	<ul style="list-style-type: none"> • Transit promotional campaign • Branding of services / routes
Reduced fares/free services	<ul style="list-style-type: none"> • Lower transit fares • Fare free zones

	<ul style="list-style-type: none"> • Free transit services
Fare structure/convenience improvements	<ul style="list-style-type: none"> • Fare structure simplifications • Elimination of fares for transfers • SmartCards • Automated fareboxes
Transit pass programs	<ul style="list-style-type: none"> • Monthly passes • Annual passes • Ecopasses/universal passes • Multimodal/Smart passes (for transit, parking, carshare) • Off-peak pass (low cost pass for unlimited use in off-peak hours)
"Try it" transit pass give-aways	<ul style="list-style-type: none"> • Promotional transit pass give aways • First month free program for new services

4. Parking Management

Strategy	Examples
Parking pricing / fees	<ul style="list-style-type: none"> • Increase public parking fees • Increase taxes on parking providers • Impose or increase fees/surcharges on SOVs • Free or reduced priced parking for carpools/vanpools
Parking supply limits	<ul style="list-style-type: none"> • Parking maximums for new development • Regional parking caps • Create parking/traffic-free zones • Peak-hour parking bans • Curb-parking restrictions
Preferential parking for carpools/vanpools	<ul style="list-style-type: none"> • Premium parking spots for carpools/vanpools • Guaranteed parking for carpools/vanpools
Parking cash out program	

5. Pricing

Strategy	Examples
Road pricing	<ul style="list-style-type: none"> • New tolls • Increase tolls on roads • Increase bridge tolls • High Occupancy Toll (HOT) lanes
Cordon pricing	<ul style="list-style-type: none"> • Charge vehicles for entering high-use area, such as CBD
Variable priced tolls	<ul style="list-style-type: none"> • Peak period surcharge • Prices vary based on traffic levels
Variable parking fees	
Pay-As-You-Drive Vehicle Insurance	<ul style="list-style-type: none"> • Incentives for per-mile vehicle insurance • Pilot programs for per-mile vehicle insurance
VMT-based registration fees	
Increase in gas tax	
Employee tax credits	<ul style="list-style-type: none"> • Tax credit for using transit, HOV, or bicycling

6. Employer-based TDM Programs

Note: A wide range of different employer-based demand management options are available, including: transit passes, vanpool subsidies, rideshare matching, bicycle lockers/showers, telecommuting programs, flexible work hours, compressed work schedules, etc. These programs typically are not promoted individually but as packages of strategies, and would be analyzed as a comprehensive program. As a result, the list below focuses on government policies or programs, not individual TDM program elements. The analysis of these strategies requires an assessment of levels of participation in different types of TDM activities.

Strategy	Examples
Employer marketing and support	<ul style="list-style-type: none"> ● Outreach to employers/information programs to encourage commute options ● Recognition/awards programs
Telecommuting support/incentives	<ul style="list-style-type: none"> ● Support in establishing telecommuting programs ● Telecommuting financial incentives
Telework centers	<ul style="list-style-type: none"> ● Remote/satellite offices close to residential areas ● Telework centers in communities
On-going incentives for employer-based transit/vanpool/carpool programs	<ul style="list-style-type: none"> ● Subsidized transit passes ● Subsidized vanpools ● Tax credit for employers that offer TDM programs, employer transportation coordinators, etc.
Start up incentives for employer-based transit/vanpool/carpool programs	<ul style="list-style-type: none"> ● Short-term (start-up) financial incentives for implementing transit pass program ● Short-term (start-up) financial incentives for implementing vanpool/carpooling program
Implement programs at government worksites	<ul style="list-style-type: none"> ● Flexible work hours programs ● Compressed work scheduled programs ● Telecommuting ● Promote ridesharing, transit, bicycling, walking
Mandatory commute trip reduction programs	<ul style="list-style-type: none"> ● Mandatory programs for employers of certain size ● Mandatory program for employers in certain locations/business districts
Regional guaranteed ride home program	<ul style="list-style-type: none"> ● Guaranteed ride home program ● Emergency ride home program
Support proximate commuting	<ul style="list-style-type: none"> ● Reassigning employees so they can work at a location closest to home

7. Non-employer-based TDM Programs

Strategy	Examples
School-based programs	<ul style="list-style-type: none"> ● School pools ● Safe Routes to Schools programs ● "Walking bus" programs
Campus programs	<ul style="list-style-type: none"> ● University parking pricing / TDM programs
Community-based programs	<ul style="list-style-type: none"> ● Community association/residential building based TDM programs
Development-based programs	<ul style="list-style-type: none"> ● Require new developments to meet trip reduction targets, implement TDM programs
Airport-based programs	<ul style="list-style-type: none"> ● Airport parking / TDM programs
Tourism promotions	<ul style="list-style-type: none"> ● Hotel partnerships to promote transit use, walking/bicycling ● Tourism site partnerships to promote transit use,

	ridesharing, walking, bicycling
Special events-based programs	<ul style="list-style-type: none"> ● Stadium events management ● Festivals and other events management ● Combined event ticket/transit pass

8. Outreach/Marketing/Education

Strategy	Examples
Regional TDM program outreach	<ul style="list-style-type: none"> ● Media campaigns/Public service announcements ● Voluntary "No Drive," "Share a Ride" Days
Episodic (Spare the Air / Ozone Action Days) programs	<ul style="list-style-type: none"> ● Media campaigns ● Ozone Action Coordinators ● Free/reduced price transit on Ozone Action Days ● Special incentives on Spare the Air Days ● Voluntary business closures / business practices
Educational curriculum	<ul style="list-style-type: none"> ● Incorporate air quality awareness into public school curriculum ● Incorporate information about transit, ridesharing into public school curriculum
Transportation management organizations	<ul style="list-style-type: none"> ● Regional Commute Management Organizations ● Local Transportation Management Associations

9. Integrated Land Use-Transportation Planning

Note: A wide range of different land use policy mechanisms are available, including: zoning requirements, impact fees, developer incentives, regional growth boundaries, etc. These policies typically would not be analyzed individually but as a package of strategies that affects land use patterns, and hence, travel and emissions. As a result, these strategies are not listed individually. Sometimes, strategies are identified based on the focus of the efforts: transit-oriented development, mixed-use activity centers, pedestrian-oriented design, etc. Five strategies are listed below that are organized around different types of programmatic approaches.

Strategy	Examples
Transit-oriented development (TOD) programs	<ul style="list-style-type: none"> ● Joint-development programs
Programs/requirements/incentives to encourage better regional land use/transportation coordination	<ul style="list-style-type: none"> ● Developer incentives (e.g., density bonuses for development near transit/urban core, reduced impact fees in TOD) ● Impact fees ● Zoning requirements ● Regional growth boundaries ● Concurrency requirements (adequate public facilities ordinances) ● Accessibility contracts (e.g., preferred access to road system for land use projects that reduce trips)
Programs/requirements/incentives to improve community design	<ul style="list-style-type: none"> ● Design standards (requirements for amenities, layout to street, etc.) ● Incentives for developers to incorporate public spaces and other amenities into new developments
Neighborhood schools	<ul style="list-style-type: none"> ● Locate schools in communities, with access via walking and bicycling
Incentives to live near work/transit/downtown	<ul style="list-style-type: none"> ● Location Efficient Mortgage ● Energy Efficient Mortgage

- Tax credits for redeveloping in blighted neighborhoods
- Tax credits for living downtown

10. Vehicle Use Restrictions

Strategy	Examples
Auto-free zones	<ul style="list-style-type: none"> • Pedestrian malls • Transit malls • Car bans in CBD
Limit access to HOVs only	<ul style="list-style-type: none"> • Require 2+ vehicle occupancy to enter designated congested activity centers/parking facilities during peak periods
No Drive Days	

11. Other Options to Reduce Auto Ownership / Avoid Vehicle Trips

Strategy	Examples
Carsharing programs	<ul style="list-style-type: none"> • Car-sharing programs • Station cars • Incentives for use of carsharing programs
Using technology to avoid vehicle trips	<ul style="list-style-type: none"> • E-government initiatives • Use teleconferences/web conferences

Transportation System Management / Vehicle Driver Behavior-Oriented Strategies

Transportation system management (TSM) strategies focus on changing the operation of the transportation system, typically with a primary focus on improving traffic flow and reducing traveler delay. TSM programs can reduce emissions by changing vehicle speeds, reducing rapid vehicle accelerations and decelerations, and reducing vehicle idling. Many of these strategies are under the umbrella of Intelligent Transportation Systems (ITS). In addition, some strategies focus directly on encouraging changes in driving behavior through educational information, incentives, or restrictions on driving speeds, operating patterns, and idling. These strategies are listed below.

12. Traffic Signal Synchronization

Strategy	Examples
Signal retiming	
Advanced traffic signal controls	<ul style="list-style-type: none"> • Adjust traffic control/signals based on traffic levels

13. Roadway / Intersection Improvements

Strategy	Examples
One-way streets	<ul style="list-style-type: none"> • Convert two-way streets to one-way to improve operations
Turn restrictions	<ul style="list-style-type: none"> • Restrict left turns on two-way streets
Turning lanes	<ul style="list-style-type: none"> • Separate turning vehicles from through traffic to avoid unnecessary backups
Roundabouts	<ul style="list-style-type: none"> • Implement traffic circles to improve traffic

	movement
Limit on-street parking	<ul style="list-style-type: none"> Remove or limit on-street parking during peak hours Enforce on-street parking limits
Intersection improvements	<ul style="list-style-type: none"> Construct interchanges instead of signalized intersections Develop tunnels/overpasses Grade separations at railroad/transit crossings
Bus pullouts	<ul style="list-style-type: none"> Bus pullouts in curbs Queue jumper lanes for passenger loading/unloading

14. Incident Management / Operations

Strategy	Examples
Incident management programs	<ul style="list-style-type: none"> Intersection/corridor monitoring and response Call number to report incidents Roadside assistance vehicles Motorist aid call boxes Rerouting traffic at incidents Active/dynamic traffic management systems (e.g., manage speeds; routes)
Ramp metering	
Encourage use of underutilized capacity	<ul style="list-style-type: none"> Route marking directing traffic to underutilized capacity Reversible traffic lanes
Allow use of road shoulders during peak periods/to get around incidents	

15. Traveler Information Systems

Strategy	Examples
Real-time traveler information systems	<ul style="list-style-type: none"> Variable message signs (directing traffic from incidents) Variable message signs and information including comparative travel times Real-time information services (including integrated, multi-modal information) Web site with real-time traffic information, speed information Toll-free phone number (511)
Real-time parking information	<ul style="list-style-type: none"> Availability updates (to reduce unnecessary searching for parking) Automated reservations and payment

16. Speed Control

Strategy	Examples
Lower speed limits	<ul style="list-style-type: none"> 55 mph highways
Increased speed enforcement	<ul style="list-style-type: none"> Photo speed enforcement Increased police enforcement

	<ul style="list-style-type: none"> Enforcement against aggressive driving (to reduce crashes/incidents, which cause delay)
Driver training/education	<ul style="list-style-type: none"> Information about saving fuel with less vehicle stops/starts

17. Access Management

Strategy	Examples
Access management	<ul style="list-style-type: none"> Limit development of access points to arterials/highways Parallel access roads

18. Shifting/Separating Freight Movements

Strategy	Examples
Shifting freight movement to off-peak periods	<ul style="list-style-type: none"> PierPASS program
Truck-only lanes/routes	<ul style="list-style-type: none"> Truck-only lanes Truck-only roads/routes
Truck restrictions	<ul style="list-style-type: none"> Road restrictions on trucks Restrictions during peak hours
Consolidated freight/package delivery	<ul style="list-style-type: none"> Consolidation at peripheral CBD locations or neighborhood locations
Rail shuttles	<ul style="list-style-type: none"> Containers brought to inland distribution center
Container matching services	<ul style="list-style-type: none"> Transport of empty containers minimized

19. Anti-Idling

Strategy	Examples
Anti-idling restrictions	<ul style="list-style-type: none"> School bus anti-idling restrictions Truck anti-idling restrictions Personal vehicle anti-idling restrictions (in specific zones, near schools, etc.)
Anti-idling information campaigns	<ul style="list-style-type: none"> Idling reminder hang-tags for trucks and commercial fleets Remote idling reminders (On-Star-type service) Inclusion of information in drivers education and at auto dealerships
Restrictions on drive-through services	
Freight facility improvements	<ul style="list-style-type: none"> Expansion/improvement of port terminals, intermodal facilities, etc. to reduce queuing and idling

Vehicle, Fuels, and Technology Strategies

Vehicle, fuel, and technology projects and programs are designed to change the emission rates of vehicles either by changing the fuel being used, the type of vehicle or emissions control technology, or a combination of both. Some programs also focus on eliminating gross polluters, or vehicles whose emissions controls have failed, or on controlling specific types of emissions (e.g., road dust). These strategies are listed below.

20. Accelerated Vehicle Retirement/Fleet Renewal/Replacement

Strategy	Examples
Vehicle buy-back programs	<ul style="list-style-type: none"> • Vehicle scrapping program
Fleet renewal / clean vehicle programs	<ul style="list-style-type: none"> • School bus replacements • Transit bus purchases/replacements • New purchases/replacements of heavy-duty trucks for solid waste trucks, etc. • New purchases/replacements of light-duty vehicles (e.g., government fleets) • Repowering / replacing existing older diesel engine with a newer, cleaner engine.

21. Heavy-Duty Diesel Vehicle Repowering/Retrofits*

Note: There are a range of technologies that can be used to retrofit heavy duty diesel vehicles, including particulate filters, oxidation catalysts, flow through filters, crankcase filters, NOX reducing catalysts, exhaust gas recirculation (EGR), and selective catalytic reduction. Each of these technologies has a different effect on pollutants of concern, and can be examined as an emissions reduction measure independently. Strategies listed below are those that are policy/program options available to state/local governments.

Strategy	Examples
Mandatory fleet retrofits	
Government contracting requirements	
Voluntary programs with funding	<ul style="list-style-type: none"> • Carl Moyer, TERP-type programs

* See section "Samples of Technology Samples/Options" for a more detailed list of technology options

22. Idle Reduction Technologies

Strategy	Examples
Truck stop electrification	
Purchase of auxiliary power units	<ul style="list-style-type: none"> • APUs • Electronically-driven auxiliary systems

23. Purchases of Advanced Technology and Alternative Fuel Vehicles

Strategy	Examples
Cleaner diesel fuels	<ul style="list-style-type: none"> • Emulsified diesel • Oxygenated diesel • Biodiesel • Fuel borne catalyst
Purchases of alternative fuel vehicles (buses, other heavy-duty vehicles, light-duty vehicles)	<ul style="list-style-type: none"> • LNG vehicles • CNG vehicles • Ethanol / methanol • LPG vehicles • Electric vehicles

24. Programs to Encourage Purchases of Advanced Technology/Alternative Fuel Vehicles

Strategy	Examples
General tax / financial incentives	<ul style="list-style-type: none"> • Tax credits for purchase of low emissions vehicles • Tax credits for purchase of alternative fuel vehicle • Feebates • Vehicle emissions fees
Specific target market programs with funding	<ul style="list-style-type: none"> • CNG taxicab program
HOV lane use allowed for advanced technology/ alternative fuel vehicles	
Preferential/free parking for advanced technology/ alternative fuel vehicles	
Government contracting requirements	<ul style="list-style-type: none"> • Contracts requiring alternative fuel/low emissions vehicles

25. Inspection and Maintenance

Strategy	Examples
Basic I&M	
Enhanced I&M and on-board diagnostics	
Remote Sensing	<ul style="list-style-type: none"> • Roadside pullovers
Smoking vehicle programs	<ul style="list-style-type: none"> • Toll-free number for reporting high polluting vehicles
Heavy-duty vehicle inspections	

26. Road Dust Reduction Strategies

Strategy	Examples
Mitigation for unpaved roads	<ul style="list-style-type: none"> • Apply water • Apply wet gravel • Apply chemical/organic dust suppressant • Use vegetative matter to reduce blowing dust
Road paving	<ul style="list-style-type: none"> • Pave previously unpaved roads • Pave road shoulders
Street sweeping	<ul style="list-style-type: none"> • Regular street sweeping on paved roads • Sweeping to remove sand and other de-icing/de-skid materials on paved roads
Transportation construction site mitigation efforts	<ul style="list-style-type: none"> • Require water or chemical stabilizers to be applied • Require wind barriers

Non-Road Strategies

Non-road vehicles and equipment include railroads, marine vessels, airport ground support equipment, lawn and garden equipment, construction and agricultural equipment, and other mobile equipment. There are a wide range of technologies and operational strategies available to address these sources. The list of strategies below focuses on policies and programs. Following this strategy list is an appendix that includes more detail on the specific types of modifications that can be made to equipment.

27. Encourage Replacement/Repowering/Retrofits*

Strategy	Examples
Mandatory fleet retrofits	<ul style="list-style-type: none"> Only CA requirements can be adopted
Scrappage programs	<ul style="list-style-type: none"> Equipment buy-back programs Replacement of gasoline lawnmowers with electric Replace older yard tractors with newer, lower emission ones
Government contracting requirements regarding vehicle/equipment technologies	
Voluntary repower / retrofit programs, with funding*	<ul style="list-style-type: none"> Carl Moyer, TERP-type programs

* See section "Samples of Technology Samples/Options" for a more detailed list of technology options

28. Encourage / Implement Use of Alternative Fuels

Strategy	Examples
Encourage use of on-road fuels by non-road diesel vehicles	<ul style="list-style-type: none"> Use of ultra low-sulfur on-road diesel
Purchase alternative fuel vehicles / equipment	<ul style="list-style-type: none"> Purchase CNG street sweepers
Incentives for purchase of alternative fuel vehicles / equipment	
Rail electrification	<ul style="list-style-type: none"> Commuter rail electrification

29. Encourage / Implement Operational Improvements and Anti-Idling Technologies

Strategy	Examples
Rail infrastructure improvements	<ul style="list-style-type: none"> Track geometry improvements Use of concrete ties/heavier rails
Rail operational strategies/practices	<ul style="list-style-type: none"> Switcher yard locomotives (anti-idling) Idle reductions using APUs Idle reductions using automatic shut-down
Marine vessel equipment modifications	<ul style="list-style-type: none"> Hull design/larger vessels Increased atomization Reduction of dead volume/Reduced sack volume
Marine vessel fleet operational strategies/practices	<ul style="list-style-type: none"> Speed reductions Vessel route modifications Programmable logic controllers Hull cleaning Cold ironing (anti-idling technologies while in port) Shoreside power
Airport operational strategies	<ul style="list-style-type: none"> Idling reduction policy Full electrification of gates / ground electrification / HVAC systems at gates Improved airport configuration and expanded

	capacity (to reduce idling)
Government contracting requirements limiting idling	<ul style="list-style-type: none"> Contracting requirements limiting idling during construction/maintenance activities

Samples of Technology Approaches/Options

Approach	Options
Heavy-duty diesel engine retrofits (trucks, locomotives, marine vessels, other)	<ul style="list-style-type: none"> Particulate filters Flow through filters Diesel oxidation catalysts Crank case filters NOX reducing catalysts Exhaust gas recirculation (EGR) Selective catalytic reduction
Locomotive engine modifications	<ul style="list-style-type: none"> Low heat rejection Bottoming cycles Improved engine lubricants Use of hybrid switcher locomotives Scrapage/fleet renewal
Railroad equipment modifications	<ul style="list-style-type: none"> Tare weight reduction, higher capacity cars Use of low-friction bearings Use of improved suspensions Use of hopper car covers Use of steerable rail car trucks Energy-minimizing train control Improved drive-train lubricants
Railroad alternative fuels	<ul style="list-style-type: none"> Use of natural gas Use of cellulosic ethanol
Marine vessel engine modifications	<ul style="list-style-type: none"> Cooled exhaust gas recirculation Charge air cooling Turbocharging Electric propulsion Podded propulsion Pre-injection Modified valve timing Lower compression ratio Detail design of combustion space Water injection in cylinder Variable exhaust back pressure More uniform injection Insulating combustion space Shutting off cylinder at low load Delay injector timing; injector upgrade Exhaust gas recirculation system or engine cycle modification Install an inlet air humidification system Modify cylinder heads for direct water injection
Marine vessel alternative fuels	<ul style="list-style-type: none"> Fuel homogenization Fuel/water emulsion Humid air motor technology Use of off-road diesel instead of residual fuel Use of ULSD Uses of LNG Use of Fischer-Tropsch diesel Use of Biodiesel Use of ethanol-blended diesel Use of low sulfur marine diesel fuel (SECA)

	<ul style="list-style-type: none"> ● Control fuel oil quality
<p>Airport ground support equipment engine modifications/ alternative fuels</p>	<ul style="list-style-type: none"> ● Replace GSE with LPG/CNG equipment ● Replace 2-stroke engines with 4-stroke gasoline equipment ● Use of hybrid or electric ground support vehicles ● Replace mobile GSE with fixed, electrically hardwired "at gate" equipment ● Use of alternative fuels in ground support vehicles (e.g., ultra low sulfur diesel)

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