APPENDIX C
EVALUATION OF MOBILE SOURCE CONTROL STRATEGIES FOR THE HOUSTON-GALVESTON-BRAZORIA STATE IMPLEMENTATION PLAN (DRAFTED BY ENVIRON FOR THE HOUSTON-GALVESTON AREA COUNCIL)

Draft Final Report

EVALUATION OF MOBILE SOURCE CONTROL STRATEGIES FOR THE HOUSTON-GALVESTON-BRAZORIA STATE IMPLEMENTATION PLAN

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1. BACKGROUND AND PURPOSE OF STUDY

This report documents a study performed by ENVIRON International Corporation on behalf of the Houston-Galveston Area Council (H-GAC). The study was conducted in support of development of an Ozone Attainment Plan. ENVIRON International Corporation, in collaboration with subcontractors and Earth Matters and ESTC, provided assistance in identifying, evaluating, and documenting emission control measures in an attempt to determine a set of strategies that would achieve more than 50 percent reduction in nitrogen oxides (NOx) in the Houston-Galveston-Brazoria (HGB) nonattainment area. The bulk of the work was performed in the first three months of 2006, and involved the selection, evaluation, presentation and documentation of numerous individual control measures. Much of the information compiled in this final report has been previously provided to the H-GAC over the course of the early portions of the study as draft results. Much of this information was also made publicly available through extensive public hearings and workshops, and the H-GAC internet site. That information was used extensively, along with other work carried out by H-GAC themselves, and input from the public outreach efforts, to form the basis of the State Implementation Plan (SIP) revision developed by the Texas Commission on Environmental Quality (TCEQ).

BACKGROUND

The study was initiated by a request and support from the Texas Commission on Environmental Quality (TCEQ) to the H-GAC to provide assistance in developing an approvable control strategy for the Houston-Galveston-Brazoria area to attain the ozone standard. The study was initiated to assist in the State Implementation Plan (SIP) to demonstrate attainment for the ozone standard now based on an 8-hour averaging standard. TCEQ requested that an evaluation of control strategies be conducted in order to understand the potential benefit of strategies that could be implemented as rules or voluntary initiatives. The Houston-Galveston-Brazoria ozone nonattainment area consists of the counties of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller.

PURPOSE OF STUDY

This study is a part of the overall process to develop the 8-Hour Ozone SIP. The primary objective of the study was to identify and evaluate feasible control measures to reduce NOx emissions. A secondary objective was to assist H-GAC in ensuring that area stakeholders and local officials were involved in the process of identifying the measures and in commenting on their feasibility. These efforts were intended to "feed in" to: the general SIP process, which included emission inventory development and photochemical modeling by the TCEQ; ongoing and new processes initiated by H-GAC to identify potential new control measures; and H-GAC efforts to solicit stakeholder input into these potential measures, as well as to continue to keep local legislators and planners in the eight-county nonattainment area informed about the on-going SIP process.

Key tasks of the ENVIRON study included:

1) Review existing emission inventory and previously evaluated control measures

2) Assist H-GAC in identifying potential new measures
3) Refine list of potential new measures
4) Quantify effects of measures (emissions, costs, feasibility)
5) Coordinate with TCEQ on understanding the measure analyses in order that they could be placed into emission projections
6) Document control measure effects and present findings to technical, policy and steering committees
7) Develop control strategies and submit documentation to TCEQ

Although H-GAC is the regional transportation planning agency, the study was not limited to transportation sources. Instead, the purpose was to explore all possible on-road and off-road mobile source measures, including sources such as lawnmowers or construction equipment.

ORGANIZATION OF REPORT

The remainder of this report is organized as follows:

Section 2, Control Measure Identification, documents the process used to select individual control measures to analyze.

Section 3, Methodology for Analysis of Control Measures, briefly describes the data sources, assumptions and techniques used in the analysis.

Section 4, Summary of Results presents an overview of the results, with measure results for each measure displayed in both tabular and graphic format. These measures include those measures evaluated in detailed with other master list measures not evaluated provided in Appendix A.

Section 5, Detailed Results, documents each individual measure by describing the measure, detailing the specific analysis approach, and listing results for emission reductions, costs, cost effectiveness and a description of feasibility and public acceptance.

Appendix A, Control Measures not selected for further evaluation.

2. CONTROL MEASURE IDENTIFICATION

Initial identification of potential control measures was accomplished through a process initiated for the Dallas – Fort Worth area by the North Central Texas Council of Governments (NCTCOG) and refined for the HGB area in this analysis. NCTCOG conducted an extensive process including facilitating a series of stakeholder meetings and operating a continuing online solicitation over several years through 2005 to elicit and describe a wide range of control measure strategies. ENVIRON with H-GAC used the NCTCOG master control measure list as a starting point from which to identify measures for the HGB nonattainment area Ozone SIP strategies development. Additional measures for the HGB area were solicited by local stakeholders to ensure that all potential emission control measures could be identified.

Grouping and Refining Initial List

Several hundred potential on-road mobile source measures and just less than one hundred off-road mobile source measures were suggested in the master list. Because the NCTCOG process was all encompassing, many measures were suggested more than once, although in different ways. In addition, many measures that would alone have minimal effect on emissions were easily recognized as being naturally a part of larger measures and others were not well described. So many of the measures were either combined into a larger measure or were defined in a manner that could be considered an emission reduction measure.

The measures were grouped into categories so that like measures could be more easily compared with one another. The general categories included such diverse groupings as clean vehicle programs, pricing measures for on-road mobile sources; and incentive programs, public fleet measures, locomotive, and marine for off-road mobile sources. A full list of the master list measures includes measures outlined in Tables 2-1 and 2-2 and those that were not evaluated in detail in Appendix A. For each individual measure, ENVIRON qualitatively evaluated the measures to determine those measures which were the most feasible and had the highest potential for emission reductions. For those measures considered more feasible and effective, ENVIRON conducted a more detailed evaluation.

Evaluating Feasibility and Potential for Emission Reductions

Control measures were ranked primarily on the following four criteria:

1. Feasibility of implementation
2. Public acceptability
3. Emission reduction potential
4. Cost effectiveness

As noted, the initial ranking was qualitative, as it was not feasible to model each of the individual control measures suggested. The qualitative rankings in the master list were used to identify the most feasible and effective measures which to include in a more detailed analysis of measures referred to as the "Short List" provided here. The primary goal of identifying short list measures was to better evaluate those measures with the highest feasible potential emissions reduction.

Measures Selected for Additional Analysis

After the master list and qualitative rankings were reviewed and discussed at a series of meetings, 35 on-road and 13 off-road measures were selected for additional analysis. Table 2-1 and Table 2-2 list the individual measures that were selected for additional evaluation. Appendix A provides the measures from the master list that were not selected for additional study.

Table 2-1. Short list of individual on-road measures selected for additional evaluation.

Number	Strategy	Added Description
Bicycle and Pedestrian		
17	Bicycle and pedestrian action groups	A specified percentage of employees can request facilities as a group and pledge to commute by bicycle. This measure would likely only affect a small proportion of employees living relatively close to where they work (such as 5 miles).
Clean Vehicle Programs		
51	Clean Freight (EPA Smartway Program)	This measure will be analyzed as part of the EPA's Smartway program for improving energy and emission performance of freight movement.
54, 59	Public and private sector clean fuel fleets (Clean Cities/Clean Vehicles)	This measure is the currently operating (Low) H-GAC Clean Cities/Clean Vehicles Program and continuing high levels of program funding and improved efficiency (High).
71	Electric Vehicles	Voluntary introduction of zero emitting vehicles.
Freeway Incident / Roadway Construction Management		
99, 100, 101	Area-wide "Steer It/Clear It" program, augment with more enforced mandatory quick removal of disabled vehicles during peak periods with an expanded Safe Clear area and additional freeway patrol	Program for immediate removal of disabled vehicles from the roadway in event of a stall or non-serious accident. Lack of data on incident-related congestion and emissions may necessitate a qualitative evaluation although it is clear that it is resulting in congestion reductions. Operation of additional lane miles of new roving tow truck patrols to clear incidents and reduce delay on freeways during peak periods.
Fuel Standards		
115	Cleaner diesel fuel	Cetane additives or ultra reformulated diesel fuels (High) for emission reductions beyond TxLED.
Goods Movement		
144	Divert trucks from nonattainment areas	Encourage through-traffic trucks to travel around rather than through nonattainment areas.
150, 157, 161	Single Occupant Vehicles (SOV) peak pricing to managed lanes and transit stations.	Additions to Commute Solutions – existing programs that are already doing this will be evaluated as part of the rationale for assuming increased effectiveness of the Commute Solutions program. Increase occupancy to three or more per vehicle to HOV and transit stations.

Table 2-1. (Cont.) Short list of individual on-road measures selected for additional evaluation.

Number	Strategy	Added Description
High-Emitting Vehicle Detection and Programs		
172	Scrappage/buy-back plan	Expanding the Low Income Repair Assistance Program (LIRAP). Heavy-duty vehicle scrappage addressed under Measure 54.
Parking Management		
227, 229, 241	Preferential parking for High Occupancy Vehicle (HOV) lane users and ride sharers; Free spaces, reserved spaces, Commuter parking pricing, Create retail parking spaces for especially for hybrid/alternative fuel vehicles (like handicapped or expectant mother spaces)	Extend programs to hybrids and other clean vehicles.
248, 249, 470	Eliminate employee parking subsidies. Include employee parking cash-out programs, subsidies for not driving to work	Employer pays a monthly stipend to employees who do not drive; employees who drive receive no corresponding benefit.
Pricing Measures		
275	Congestion pricing for major activity centers	Charge vehicles to enter high-activity centers (retail/business districts, etc.) in cities, with higher prices charged during high-traffic hours.
277	Pay-As-You-Drive Insurance (per-mile)	Insurance prices vary by the driving amount. This provides a financial incentive to reduce driving.
295	Increase tolls during peak traffic periods	Congestion tolls are coming on-line but this measure is difficult to quantify.
Speed		
300, 304, 312	Reduced average speed	Lower average vehicle speeds for trucks-only (Low) and all (high) vehicles by added enforcement of current limits. This could also be seen as a safety measure, which reduces incident-related congestion and emissions.
Traffic Flow Improvements		
342, 350, 351, 352, 354, 355, 360	Traffic signalization improvements, intersection improvements, Reversible traffic lanes	This measure is still under review to ensure that credit is not taken for measures in baseline transportation modeling, as traffic flow improvements are a key and ongoing portion of H-GAC activities. However, in the 2005 conformity assessment though there could be emission reductions achieved through these programs.
Transit		
371	Reduce transit fares	Increased transit ridership program.
376, 403, 407, 484	Personalized rapid transit, subscription bus service, Business First enhanced buses, personalized transit planning	Targeted transit services to appeal to potential users who need convenience-based incentives to use transit. Perhaps TREK and other TMAs could assist in providing internet and personalized planning so users know better what connectors there are between Metro and vanpools, subscription buses, etc.
424	Provide an off-peak unlimited-ride daily pass	Increase transit ridership included in other measure evaluations.
426, 441	Universal card	Combine TREK and Metro transit services; already implemented.

Table 2-1. (Cont.) Short list of individual on-road measures selected for additional evaluation.

Number	Strategy	Added Description
Travel Demand Management - Business Operations		
453	Mandated peak spreading	Could evaluate as a mandatory staggered work hour program for area employers. EPA acceptability unclear.
459, 435	Mandatory or voluntary compressed work week	Reduction in vehicle commutes.
461, 503, 504	Internet ridematching services, incentives, rewards for ridesharing	Real-time ridematching offered via a Website, by an employer, or by a third party (sponsored by city or transportation authority). NuRide has been running just such a pilot program with H-GAC.
462, 463, 496	Mandate or encourage vanpooling, purchase vans for vanpooling	Already encouraged with possible expansion of the program.
471, 470, 249	Employer tax credit or deduction	Institute a tax credit or deduction for employees that regularly use a non-single occupancy vehicle mode for commuting and/or for employers, based on number of employees that commute using non-SOV.
487	Telecommuting incentives or mandates, additional video conferencing between worksites	Currently part of the Commute Solution program. Assume a percentage of area employees to telecommute once per week to reduce employee commutes and other similar travel.
Travel Demand Management - Regional Applications		
499, 500, 501	Pooled ownership of hybrid and non-hybrid vehicles	Shared vehicles among a group of owners
Vehicle Emission Standards		
551	California LEV	Introduction of California Low Emitting Vehicle Program in Texas.
553	Adopt California standards for vehicle emission rates	Public and publicly-contracted fleet rules adopted by California for certain air quality management districts.
Vehicle Idling		
576	Limitations on idling of heavy-duty vehicles.	Add alternate power sources at truck stops or other sites or other implementation strategies to eliminate extended idle. May require additional power sources for local major events.
Vehicle Inspection and Maintenance		
601, 604	If the largest city in a county takes part in a testing program, the entire county must opt-in.	Modeled as an expanded Inspection and Maintenance (I/M) program to Chambers, Liberty, and Waller counties where I/M does not currently occur.

Table 2-2. Short list of individual off-road measures selected for additional evaluation.

Number	Control Strategy	Short List Description and Groupings
3	Aircraft emission standards	This measure investigated the aircraft rules and engine certifications to determine if a quantifiable emission reduction could be determined. Implementation policy options were not identified other than per aircraft emission reductions by type.
9	Ordering lowest emission engines	
28	Enhanced Texas Emission Reduction Program (TERP)	This measure reviewed the TERP, Carl Moyer, and other programs to identify technologies, cost effectiveness (both in terms of amortized $/ton and capital cost $/ton/year) to determine the total budgets required to meet air quality goals.
31	Accelerated equipment turnover; Tier 2 or Tier 3 nonroad engines	
46	Water injection for diesel engines	
47	Alternative fuel heavy-duty equipment	
48	Lean NOx catalyst	
49	Early introduction of low-NOx engines	
50	Selective catalytic reduction (SCR)	
35	Conditions of approval for new construction	This initiative uses the TxDOT incentive program as a basis for estimating the potential emission reduction from extending similar incentives to municipal and other contracting mechanisms.
37	Control clauses for construction contracts	
38	Contract bidding; Give preference to companies that use environmentally-friendly equipment - Backend incentive upon completion of the contract	
39	Government construction incentives	
41	Develop air quality best management practices (BMPs); Use BMPs to manage emissions from construction sites, construction vehicles & wind-blown dust and clean equipment	
42	Limitations on idling of heavy-duty construction equipment	The potential emission reduction from reduce idling initiatives for nonroad equipment.
55	Reformulated fuels for off-road vehicles	Existing clean diesel options beyond TxLED.
72	Use of auxiliary power units (APUs) for locomotives operating; Controls for locomotives are pre-empted by Federal law, but voluntary controls might have some success	Hybrid-electric locomotives available. This technology is also funded under the TERP program.
79	Limitations on idling of locomotives	This measure investigated the potential emission reduction from reduced idling or idling limits of all locomotives. This measure is included in the current SIP under a voluntary commitment and some TERP projects also reduce emissions with this technology.
73	Accelerated purchase of Tier II locomotive engines	This measure investigated the potential emission reduction from a more rapid fleet turnover to Tier II engines than is currently assumed.

Number	Control Strategy	Short List Description and Groupings
75	Efficiency improvements on In-Use Class 1 Rail Equipment (R11); grade separations, double tracking, other efficiency improvements	This measure investigated the potential improvements in air quality resulting from efficiency improvements from double-tracking, rail straightening, grade separations projects, and other similar improvements in rail operations.
87	ARB Portable engine registration and rulemaking	This measure investigated the California portable engine rule to determine if this measure can be adapted to the air quality goals of the HGB area.
88	California Auxiliary Engine Rule	This measure reviewed the emission reduction potential of the California rule mandating either low sulfur fuel or shoreside power for auxiliary engines on large ocean-going vessels.
89	California Cargo Handling Equipment Rule	This measure reviewed the emission reduction potential of the California rule mandating cleaner engines used in equipment at intermodal marine and rail facilities.
90	Use of TxLED in Marine and Locomotive Sources	Expanded use of TxLED beyond the mandated uses.

3. METHODOLOGY FOR ANALYSIS OF CONTROL MEASURES

As noted in Section 2, over 50 different measures were evaluated, covering on-road and off-road mobile sources and requiring numerous analysis techniques and projections. This section briefly summarizes the approaches and assumptions used in the analysis of these measures. Section 5 provides detailed, measure-by-measure descriptions and results, and includes descriptions of the specific approaches used for each individual measure.

KEY DATA AND ASSUMPTIONS

A number of "background" estimates and assumptions were used which are relevant to document. These include vehicle miles traveled, projected activity levels, control measures incorporated in the baseline inventory, non-road inventory and activity, and other estimates provided in background documentation or developed from previous SIP emission inventory improvement efforts that inform the understanding of the 2009 activity and emissions.

Baseline Emissions

The projected on-road and off-road NOx inventory in the 2009 attainment year, according to TCEQ projections, will be about 152 and 90 tons per day. The baseline emissions inventory were adjusted for ambient conditions accounting for elevated humidity and temperature experienced during the modeled ozone episode. This baseline emissions inventory includes expected emission reductions from the TERP program of about 39 tpd of which about 3 tpd are from on-road emission reduction projects with the remainder from off-road sources. The on-road emissions inventory also includes adjustments of 3.6 tpd from emission reductions from the voluntary mobile source emission reduction program (VMEP), and about 3.4 tpd of voluntary off-road emission reductions.

A detailed breakdown of the activity and emissions inventory is described here for the two major categories of mobile sources.

On-road Vehicle Activity and Baseline Emissions Inventory

Estimates used to develop the emission inventories are varied, but the most important for on-road mobile sources are vehicle miles of travel (VMT). For transportation control measures and engine emission reductions, these variables are used directly in many calculations.

TCEQ and H-GAC used a study made by the Texas Transportation Institute which provided VMT and emission projections for these evaluations. These are shown in Table 3-1. TCEQ will adjust the emissions from the TTI study for the ozone model attainment evaluations including ambient humidity, temperature adjustments, and expected baseline control strategies from the TERP and VMEP programs prior to input into the ozone model.

Table 3-1. Baseline 8-county HGB on-road weekday daily vehicle activity and emissions prior to adjustments for ambient conditions and known emission control programs.

Vehicle Type	Vehicle Type Description	VMT	VOC (lbs/day)	NOx (lbs/day)
LDGV	Light-duty gasoline passenger car	88,469,793	96,345	84,474
LDGT1	Light-duty gasoline truck 1	8,396,334	9,190	7,596
LDGT2	Light-duty gasoline truck 2	27,951,516	32,413	37,007
LDGT3	Light-duty gasoline truck 3	7,152,769	4,841	6,764
LDGT4	Light-duty gasoline truck 4	3,289,307	2,455	4,528
HDGV2b	Heavy-duty gasoline vehicle Class 2b	1,214,688	1,957	6,991
HDGV3	Heavy-duty gasoline vehicle Class 3	457,542	594	2,960
HDGV4	Heavy-duty gasoline vehicle Class 4	204,384	274	1,232
HDGV5	Heavy-duty gasoline vehicle Class 5	76,644	193	547
HDGV6	Heavy-duty gasoline vehicle Class 6	213,672	503	1,696
HDGV7	Heavy-duty gasoline vehicle Class 7	74,323	204	795
HDGV8a	Heavy-duty gasoline vehicle Class 8a	71,999	232	837
HDGV8b	Heavy-duty gasoline vehicle Class 8b	9,287	23	123
LDDV	Light-duty diesel passenger	81,081	37	86
LDDT12	Light-duty diesel truck 1 and 2	1,339	8	8
HDDV2b	Heavy-duty diesel vehicle Class 2b	1,809,165	483	7,821
HDDV3	Heavy-duty diesel vehicle Class 3	713,553	247	4,271
HDDV4	Heavy-duty diesel vehicle Class 4	427,007	179	3,134
HDDV5	Heavy-duty diesel vehicle Class 5	280,926	131	2,160
HDDV6	Heavy-duty diesel vehicle Class 6	910,201	589	10,092
HDDV7	Heavy-duty diesel vehicle Class 7	511,286	421	7,370
HDDV8a	Heavy-duty diesel vehicle Class 8a	966,386	926	21,684
HDDV8b	Heavy-duty diesel vehicle Class 8b	5,335,816	4,712	106,312
MC	Motorcycles	149,477	881	348
HDGB	Heavy-duty gasoline bus	36,270	229	638
HDDBT	Heavy-duty diesel bus transit	170,305	107	5,095
HDDBS	Heavy-duty diesel bus school	319,927	401	6,935
LDDT34	Light-duty diesel truck 3 and 4	181,901	82	165
TOTALS		149,476,894	158,657	331,667

Off-Road Activity and Emissions Inventory

While final documentation is still being drafted for the 2009 emission inventory, off-road activity in the HGB area was derived from a series of special studies or default estimates provided by EPA's NONROAD model. The special studies include off-road source categories of commercial marine, locomotive, aircraft, construction and mining equipment, and airport ground service equipment. Table 3-2 describes the emissions from off-road sources prior to ambient adjustments and TERP and VMEP emission reduction projects. The TERP emission reductions would primarily affect the construction and mining and locomotive emissions inventory, while the VMEP projects affect the locomotive and commercial marine emissions.

Table 3-2. HGB off-road baseline emission inventory prior to adjustments for ambient conditions and known emission control programs.

Equipment	**VOC (tpd)**	**NOx (tpd)**
Agricultural	0.3	2.6
Aircraft	1.8	6.3
Airport Ground Support	0.6	1.7
Commercial	5.6	6.3
Construction and Mining	4.2	30.4
Industrial	3.3	14.8
Lawn and Garden	11.6	2.7
Locomotive	0.9	21.1
Logging	0.1	0.2
Marine Vessels, Commercial	0.2	43.5
Pleasure Craft	19.4	3.2
Railway Maintenance	<0.1	0.1
Recreational	8.2	0.3
Grand Total	**56.2**	**133.7**

4. SUMMARY OF RESULTS

This section summarizes the results of the study for all measures. Table 4-1 lists each on-road measure that was analyzed, and Table 4-2 lists each off-road measure analyzed. The emission reduction potentials provided in these tables include measures that affect the same emission sources. Therefore, summing the emission reduction potentials within these tables will either double count or otherwise overestimate the emission reduction potential. Likewise, the emission reduction potential depends upon the penetration rate for the targeted emission source in the implementation plan.

Table 4-1. Summary of results for all evaluated control measures.

Number	Strategy	Added Description	VOC Low	VOC High	NOx Low	NOx High
54, 59	Public and private sector clean fuel fleets (Clean Cities/Clean Vehicles)	This measure is the currently operating (Low) H-GAC Clean Cities/Clean Vehicles Program and continuing high levels of program funding and improved efficiency (High).	0.1	0.5	0	9
115	Cleaner diesel fuel	Cetane additives at 10% penetration rate (Low) or 100% penetration ultra reformulated diesel fuels (High) for emission reductions beyond TxLED.	0	0	0.1	10
277	Pay-As-You-Drive Insurance (per-mile)	Insurance prices vary by the driving amount. This provides a financial incentive to reduce driving.	4	4	4.4	4.4
144	Divert trucks from nonattainment areas	Encourage through-traffic trucks to travel around rather than through nonattainment areas.	0	0.2	0.6	4
300, 304, 312	Reduced average speed	Lower average vehicle speeds for trucks-only (Low) and all (high) vehicles by added enforcement of current limits. This could also be seen as a safety measure, which reduces incident-related congestion and emissions.	0	0	0.3	0.8
551	California LEV	Introduction of California Low Emitting Vehicle Program in Texas.	0.2	5.8	0.1	2.4
459, 435	Compressed work week	Reduction in vehicle commutes.	2.4	2.4	2.3	2.3
553	Adopt California standards for vehicle emission rates	Public and publicly-contracted fleet rules adopted by California for certain air quality management districts.	0	0	0	1.5
487	Telecommuting incentives or mandates, additional video conferencing between worksites	Currently part of the Commute Solution program. Assume a percentage of area employees to telecommute once per week to reduce employee commutes and other similar travel.	1.4[1]	1.4[1]	1.4[1]	1.4[1]
576	Limitations on idling of heavy-duty vehicles.	Add alternate power sources at truck stops or other sites or other implementation strategies to eliminate extended idle. May require additional power sources for local major events.	0	0	0	1.0
601, 604	If the largest city in a county takes part in a testing program, the entire county must opt-in.	Modeled as an expanded Inspection and Maintenance (I/M) program to Chambers, Liberty, and Waller counties where I/M does not currently occur.	0.72	0.72	0.81	0.81
499, 500, 501	Pooled ownership of hybrid and non-hybrid vehicles	Shared vehicles among a group of owners	0.55	0.55	0.53	0.53
51	Clean Freight (EPA Smartway Program)	This measure will be analyzed as part of the EPA's Smartway program for improving energy and emission performance of	0	0	0.4	0.4

Number	Strategy	Added Description	VOC Low	VOC High	NOx Low	NOx High
		freight movement.				
462, 463, 496	Mandate or encourage vanpooling, purchase vans for vanpooling	Already encouraged with possible expansion of the program.	0.2	0.41[1]	0.2	0.39[1]
172	Scrappage/buy-back plan	Expanding the Low Income Repair Assistance Program (LIRAP). Heavy-duty vehicle scrappage addressed under Measure 54.	0	0.04[2]	0	0.38[2]
461, 503, 504	Internet ridematching services, incentives, rewards for ridesharing	Real-time ridematching offered via a Website, by an employer, or by a third party (sponsored by city or transportation authority). NuRide has been running just such a pilot program with H-GAC.	0.28	0.28	0.27	0.27
376, 403, 407, 484	Personalized rapid transit, subscription bus service, Business First enhanced buses, personalized transit planning	Targeted transit services to appeal to potential users who need convenience-based incentives to use transit. Perhaps TREK and other TMAs could assist in providing internet and personalized planning so users know better what connectors there are between Metro and vanpools, subscription buses, etc.	0.37	0.37	0.21	0.21
150, 157, 161	Single Occupant Vehicles (SOV) peak pricing to managed lanes and transit stations.	Additions to Commute Solutions – existing programs that are already doing this will be evaluated as part of the rationale for assuming increased effectiveness of the Commute Solutions program. Increase occupancy to three or more per vehicle to HOV and transit stations.	0.14	0.14	0.14	0.14
71	Electric Vehicles	Voluntary introduction of zero emitting vehicles.	0.24	0.24	0.13	0.13
227, 229, 241	Preferential parking for High Occupancy Vehicle (HOV) lane users and ride sharers; Free spaces, reserved spaces, Commuter parking pricing, Create retail parking spaces for especially for hybrid/alternative fuel vehicles (like handicapped or expectant mother spaces)	Extend programs to hybrids and other clean vehicles.	0.11	0.11	0.11	0.11
371	Reduce transit fares	Increased transit ridership program.	0.09	0.09	0.08	0.08
248, 249, 470	Eliminate employee parking subsidies. Include employee parking cash-out programs, subsidies for not driving to work	Employer pays a monthly stipend to employees who do not drive; employees who drive receive no corresponding benefit.	0.04	0.04	0.04	0.04

Number	Strategy	Added Description	VOC Low	VOC High	NOx Low	NOx High
17	Bicycle and pedestrian action groups	A specified percentage of employees can request facilities as a group and pledge to commute by bicycle. This measure would likely only affect a small proportion of employees living relatively close to where they work (such as 5 miles).	<0.01	<0.01	<0.01	<0.01
99, 100, 101	Area-wide "Steer It/Clear It" program, augment with more enforced mandatory quick removal of disabled vehicles during peak periods with an expanded Safe Clear area and additional freeway patrol	Program for immediate removal of disabled vehicles from the roadway in event of a stall or non-serious accident. Lack of data on incident-related congestion and emissions may necessitate a qualitative evaluation although it is clear that it is resulting in congestion reductions. Operation of additional lane miles of new roving tow truck patrols to clear incidents and reduce delay on freeways during peak periods.	<0.01	<0.01	<0.01	<0.01
275	Congestion pricing for major activity centers	Charge vehicles to enter high-activity centers (retail/business districts, etc.) in cities, with higher prices charged during high-traffic hours.	<0.01	<0.01	<0.01	<0.01
295	Increase tolls during peak traffic periods	Congestion tolls are coming on-line but this measure is difficult to quantify.	<0.01	<0.01	<0.01	<0.01
342, 350, 351, 352, 354, 355, 360	Traffic signalization improvements, intersection improvements, Reversible traffic lanes	This measure is still under review to ensure that credit is not taken for measures in baseline transportation modeling, as traffic flow improvements are a key and ongoing portion of H-GAC activities. However, in the 2005 conformity assessment though there could be emission reductions achieved through these programs.	<0.01	<0.01	<0.01	<0.01
424	Provide an off-peak unlimited-ride daily pass	Increase transit ridership included in other measure evaluations.	<0.01	<0.01	<0.01	<0.01
426, 441	Universal card	Combine TREK and Metro transit services; already implemented.	<0.01	<0.01	<0.01	<0.01
453	Mandated peak spreading	Could evaluate as a mandatory staggered work hour program for area employers. EPA acceptability unclear.	<0.01	<0.01	<0.01	<0.01
471, 470, 249	Employer tax credit or deduction	Institute a tax credit or deduction for employees that regularly use a non-single occupancy vehicle mode for commuting and/or for employers, based on number of employees that commute using non-SOV.	<0.01	<0.01	<0.01	<0.01

[1] – The baseline emission inventory already includes an assumption that 0.3 tpd will be reduced through these measures limiting the additional emission reduction potential.
[2] – The baseline emission inventory already includes an assumption that 0.1 tpd will be reduced through this measure.

Table 4-2. Off-road measures sorted from highest potential emission reduction.

Number	Control Strategy	Short List Description and Groupings	NOx Low	NOx High
28	Enhanced Texas Emission Reduction Program (TERP)	This measure investigated extending and expanding the TERP beyond the approximately 39 tpd already credited in the baseline emissions inventory.	0	15
88	California Auxiliary Engine Rule	This measure consisted of applying the expected emission reductions from the California rule mandating either low sulfur fuel or shoreside power for auxiliary engines on large ocean-going vessels in HGB.	1.1	14.8
73	Accelerated purchase of Tier II locomotive engines	This measure investigated the potential emission reduction from the exclusive use of Tier II locomotives.	2.9[1,2]	6.3[1,2]
55	Reformulated fuels for off-road vehicles	Existing clean diesel options beyond TxLED.	0.1	8.2
79	Limitations on idling of locomotives	This measure investigated the potential emission reduction from reduced idling of all or part of the locomotive fleets. This measure is included in the current SIP under a voluntary commitment.	0.0[2]	1[2]
3	Aircraft emission standards	This measure reviewed aircraft emission rates to quantify an emission reduction from preferred use of lower emitting aircraft.	1	1.9
72	Use of auxiliary power units (APUs) for locomotives operating; Controls for locomotives are pre-empted by Federal law, but voluntary controls might have some success	Hybrid-electric locomotives using ultraclean engines. The measure is part of many TERP emission reduction projects in HGB and elsewhere in Texas.	0.8[1]	1.8[1]
75	Efficiency improvements on In-Use Class 1 Rail Equipment (R11); grade separations, double tracking, other efficiency improvements	This measure investigates the potential improvements in air quality resulting from efficiency improvements from double-tracking, rail straightening, grade separations projects, and other similar improvements in rail operations.	0.5	1.8
90	Expanded use of TxLED	The use of TxLED would be expanded to sources not currently mandated to use TxLED including commercial marine and locomotive sources.	0	1.3
37, 38, 39, and 41	Government construction incentives	This initiative uses the TxDOT incentive program as a basis for estimating the potential emission reduction from extending similar incentives to municipal and other contracting mechanisms.	1	1
42	Limitations on idling of heavy-duty construction equipment	This will investigate the potential emission reduction from reduce idling.	0.4	1
87	California portable engine registration and rulemaking	This measure investigated the potential from adopting the California portable engines rule.	0.7	1
89	California cargo handling equipment rule	This measure investigated the potential emission reductions if California rule mandating cleaner engines used in equipment at intermodal marine and rail facilities was implemented in HGB.	0.4	0.5

[1] – These emission reduction potentials account for the introduction of ultraclean Green Goat engines accounting for about 26% of all switching engines in HGB from the TERP program.
[2] – These emission reduction potentials account for the idle emission reductions implemented under the VMEP program.

5. DETAILED RESULTS

This section of the report presents the detailed analysis and results for each control measure evaluated in this study. The results presented here become the central documentation for subsequent inclusion in future ozone attainment plans.

The description of a measure may indicate a mandate or requirement, even though the actual implementation may be voluntary or through an incentive. The use of the word 'mandate' or 'requirement' is to indicate a higher penetration rate of the measure into the fleet of vehicles or activity targeted.

Control Measure: EPA SmartWay Single-Wide Tires and Aerodynamics, Measure 51
Category: On-road
Author: John Grant, ENVIRON

DESCRIPTION

This measure would encourage or require the purchase of single-wide tires and aerodynamic options for new trucks that operate within the HGB area, a Clean Freight Strategies of the EPA SmartWay Transport Partnership[1,2].

Implementation Feasibility

The purchase of single-wide tires on a new truck could save $1,000 per truck initially[1]. Difference in operations due to the usage of single-wide tires could make changes in maintenance necessary, forcing fleets to alter retread methods and monitor tire air pressure more closely. In addition, shift in wheel bearing load position could stress and prematurely shorten the life of certain wheel ends, leading to increased maintenance costs. Wide based tires are not currently stocked widely in repair facilities, so additional waiting time could be incurred during tire repair.

Aerodynamic options can be included on new trucks at additional costs. It is expected that initial costs can be partially/fully recovered as a result of decreased fuel consumption. Aerodynamic options including skirt and gap farings and boat tails were evaluated as part of this measure. Skirt farings are attached to the trailer, while gap farings are installed between the trailer and tractor to decrease wind resistance. Boat tails are installed on the back of the trailer to reduce turbulence.

Public Acceptance

This measure would require changes in heavy-duty truck maintenance. It would not be feasible to implement this measure on all trucks that travel through the HGB, however, it could be implemented for trucks based within the HGB.

ANALYSIS

This measure was analyzed by comparing the expected fleet turnover with the exclusive use of single-wide tires and aerodynamic options on 50% of all new Class 8b heavy-duty trucks within the HGB.

Though more testing is needed, initial results (EPA, 2005) suggest that NOx reduction could be achieved through the implementation of single-wide based tires and aerodynamic operations compared to truck operations without these technologies. Emission reductions for a truck outfitted with single-wide based tires and aerodynamic options for a suburban test cycle and 65

[1] http://www.epa.gov/smartway/documents/supersingles.pdf
[2] http://www.epa.gov/smartway/documents/aerodynamics.pdf

mph highway test cycle indicated a NOx emission reduction of 45% and about 25%, respectively. It was suggested that these are preliminary results and that the NOx emission reduction may have been artifact as a result of the engines used in the testing of this technology.

The measure was assumed to apply to Class 8b heavy-duty trucks that are locally based. Locally based trucks were assumed to account for 50% of all new Class 8 heavy-duty trucks in the HGB.

Emissions Affected

The emissions affected include, Class 8b heavy-duty diesel trucks (53 tpd) (TTI, 2005).

Emissions Benefit

Estimated potential emission reductions from this measure are projected at 0.45 tpd NO_x based on Mobile6 analysis of emissions from Class 8b heavy-duty diesel trucks and EPA 2005 projected emission reductions as the result of single-wide tire use. Some of the emissions benefit is artifact as it is expected that some truck fleets already use single-wide tires and/or aerodynamic options.

Cost and Cost-effectiveness

Skirt and gap farings can be added to a heavy-duty truck at a cost of $2400[3]. Boat tail cost was estimated at $2000 based on engineering judgment for an estimated total initial cost of $4400.

Total cost for single-wide tires is not expected to include any overhead costs as single-wide-based tires are generally less expensive to include on new trucks compared to regular dual tires[1]. Additionally, significant increases in truck and road maintenance are not expected as a result of the use of single-wide-based tires.

Based on a annual mileage accumulation of 50,000 miles for Class 8b heavy-duty trucks, and HGB Class 8b heavy-duty truck VMT, it was found that at a 50% penetration, this measure would affect 4,351 Class 8 HDTs. Assuming a life of 8 years and a prime rate of 3% for aerodynamic options, the annualized capital cost was estimated at $627 per vehicle. Based on cost and emission reduction estimates, the cost effectiveness of this measure is estimated at $17,000 per ton.

[3] http://www.epa.gov/smartway/calculator/loancalc.htm

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
51	EPA SmartWay Single-Wide Tires and Aerodynamics	Add single-wide based tires and aerodynamics to 50% of Class 8b HDT	On-road – Class 8b Heavy-Duty Diesel	53.2	0.1%	0.4	$17,000

REFERENCES

EPA (2005), "Effect of Single-Wide Tires and Trailer Aerodynamics on Fuel Economy and NOx Emissions of Class 8 Line-Haul Tractors-Trailers", United States Environmental Protection Agency, 2005.

EPA (2004), "A Glance at Clean Freight Strategies: Wide-based Tires", EPA 420-F-04-004, United States Environmental Protection Agency, February 2004.

TTI (2005), "2002, 2009, and 2012 Emissions Inventories for the Houston/Galveston Eight-Hour Nonattainment Counties", Texas Transportation Institute, August 2005.

Control Measure: Retrofit/Replacement of On-road Heavy-duty Vehicles, Measures 54 and 59
Category: On-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This measure seeks to reduce on-road vehicle emissions by rapid turnover to newer lower emitting engines, retrofit of existing engines with approved devices, or new lower emission technologies. These programs have been mandated or voluntarily implemented with incentive funding from State (e.g. TERP) or Federal (Congestion Mitigation and Air Quality, CMAQ).

Implementation Feasibility

Programs of this type have been successfully established in Houston, Los Angeles, and Sacramento. The program implementation relies on a partnership between the transportation planning organization, H-GAC, and TxDOT and FHWA to properly distribute CMAQ dollars. H-GAC has dedicated staff time to administer the program addressing funding, prepare contracts, conduct verification, reporting, and other functions with this program.

Public Acceptance

The program has been successful in Houston and has gained participation with each funding cycle. The similar TERP program has also demonstrated high participation and has lowered the cost per emission reduction during the 2005 fiscal year from previous years.

ANALYSIS

The analysis of the cost and effectiveness of these programs relies primarily on the TERP and Houston area programs. Other programs such as the California Carl Moyer program demonstrate similar costs and effectiveness, but rely on evaluations specific to California. The Houston area H-GAC Clean Cities/Clean Vehicles program conducted a review of cost and effectiveness of their CMAQ program and determined that the most cost effective use of these funds for emission reductions would be to target heavy-duty vehicles. Other competing uses of CMAQ dollars, such as vanpool and other commute reduction programs were not excluded, but more emphasis was directed toward heavy-duty vehicles for this reason.

Through 2005, the H-GAC Clean Cities/Clean Vehicles program had committed funding to nearly 100 projects, most of which involved many vehicles in a fleet under a single project. The projects include alternative fueled vehicles, hybrid-electric drive trains, and clean diesel engines. These projects produced NOx, PM, and some VOC emission reductions. Projects funded in the Houston area through 2005 represent approximately 900 tons per year NOx emission reduction with total CMAQ funding of $50,000,000 (equivalent to about $56,000/ton). Annual NOx emission reductions reported for the HGB and DFW areas combined by the TERP program were reported to be 2,021 tons per year with a total funding level of $60,000,000 (equivalent to

$30,000/ton). Thus, the TERP program has begun to produce emission reductions with lower cost effectiveness.

Emissions Affected

This measure would affect about 90 tpd 2009 on-road heavy-duty emissions in the eight-county HGB ozone nonattainment area. This measure includes heavy-duty diesel, heavy-duty gasoline, and buses.

Emissions Benefit

Benefits from the Clean Cities/Clean Vehicles program primarily impact non-holiday weekday travel, as there is considerably less heavy-duty vehicle activity on weekends and holidays. An approximate value of 290 - 295 average weekdays of emissions per year has been used by TCEQ for modeling purposes. Based on an average capital cost of $30,000 - $56,000 to reduce emissions by one ton per year, the cost to gain 1 ton per day reduction would be approximately $9,000,000 - $16,000,000. Based on a $20,000,000 annual program budget over four years (2006 – 2009), a NOx emissions reduction benefit in excess of 5 tons per day and up to 9 tons per day could be achieved in addition to the 3 tpd NOx reduction achieved to date under a similar program. The lower bound is the progress to date of this program, though some projects in place will have expired by 2009.

However, TCEQ already credits 3 tpd of emission reductions from this measure in its baseline emission inventory. Therefore the emissions reductions from this program shown in the table below reflect emission reductions in addition to those already achieved.

Cost and Cost-effectiveness

$20,000,000 a year for 2006-2009 based on discussion above and therefore $80,000,000 would need to be committed over the next 4 years. Amortizing the initial capital cost ($30,000 - $56,000 initial cost to achieve one ton of emission reductions per year) over the life of the project leads to a TERP comparable cost effectiveness of no more than $10,000 per ton per year.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effective-ness ($/ton)
					%	Tpd	
54, 59	Clean Fleet Vehicle Procurement Policy/Clean Fleet Program	Maintain a fleet program that addresses clean vehicle acquisitions of public and private fleets.	On-road Heavy-duty Vehicles	90	0 – 10%	0 – 9	$5,000 - $10,000

REFERENCES

H-GAC, "Clean Cities and Clean Vehicles," http://www.houston-cleancities.org/

Sacramento COG, "SECAT program," http://www.4secat.com/

Control Measure: Electric Vehicles, Measure 71
Category: On-road
Author: John Grant, ENVIRON

DESCRIPTION

The electric vehicle control measure consists of the voluntary inclusion of a greater percentage of zero emission vehicles (ZEVs) into the HGB fleet. This measure evaluates the scenario in which 10% of all new LDGVs from 2007-2009 are fuel cell or other ZEVs.

Implementation Feasibility

There are two main ZEV types in development: electric vehicles and hydrogen fuel cell vehicles (FCVs). Electric vehicles have been developed, but are generally only applicable for limited range applications. Fuel cell vehicles are currently a developing technology considered to be a possible alternative to gasoline/diesel vehicles in the future. The U.S. Department of Energy, Energy Efficiency and Renewable Energy Hydrogen, Fuel Cells & Infrastructure Technologies Program has specific goals for fuel cell vehicle technology development including validating a FCV with a range of 250+ miles at a cost of $3.00 / gge (gasoline gallon equivalent) by 2009. FCVs require a various alternative fuel stock and a fuel delivery system to supply the fuel stock. Demonstration projects have established the functionality of FCVs, however, high production costs and lack of infrastructure for fuel delivery have precluded these vehicles from becoming more widely used.

Public Acceptance

This measure would represent a significant change in the 2007 to 2009 model year LDGV fleet makeup compared to expected makeup. Technology needed to adopt this measure may not be cost-effective and could potentially be burdensome to vehicle manufacturers and consumers. The program could target specific niches to partially or fully achieve the goal and achieve favorable acceptance. Options include targeting public or private sector fleets, or enacting within city demonstration programs for the implementation of ZEV technology and the placement of needed infrastructure.

ANALYSIS

This measure was analyzed by comparing the expected fleet turnover with the same turnover, assuming 10% of 2007 to 2009 MY LDGVs as fuel cell ZEVs. ZEVs were assumed to produce no emissions, i.e. emissions associated with fuel (hydrogen) and electricity production were not included in this analysis.

A standard MOBILE6 run for Harris County shows that, 2007 to 2009 MY LDGVs comprise 4.9% and 3.2% of all LDGV VOC and NOx emissions, respectively. Based on the onroad emission inventory for 8 counties in the HGB nonattainment area (TTI, 2005) that indicated that

LDGVs were responsible for 48.2 tpd VOC and 42.2 tpd NOx emissions, the estimated contribution of emissions from 2007 to 2009 MY vehicles is 1.34 tpd NOx and 2.38 tpd VOC.

Assuming that ZEVs comprise 10% of the LDGV fleet for 2007 to 2009 MY vehicles, the emissions reduction from this measure is estimated at 0.24 tpd VOC and 0.13 tpd NOx.

Emissions Affected

The emissions affected include onroad LDGV emissions (48.2 tpd VOC and 42.2 tpd NOx) (TTI, 2005).

Emissions Benefit

Estimated emission reductions from this measure are 0.24 VOC and 0.13 tpd NO_x.

Cost and Cost-effectiveness

Based on the 2009 onroad HGB emissions inventory, the total number of vehicles that would be replaced with ZEVs is 69,000 assuming a fleet penetration of 10% and an average annual LDGV mileage accumulation of 10,482 miles per year. The average added cost of a fuel cell vehicle was optimistically estimated at $10,000 per vehicle (CEC, 2001) (methanol fuel cell vehicle). Based on this average added cost, and the total number of vehicles to be replaced, an average annual cost of $98.0 million was estimated for vehicle costs.

The cost of methanol fueling stations was estimated at $60,000 per station (cost to convert gasoline station to 100% methanol station) (CEC, 2001). Assuming that 10 stations would be needed for refueling, an average annual cost of $85,000 was estimated.

Based on the annual cost of fuel cell ZEVs and fuel stations, the total annual cost of $98.1 million is estimated for this measure. The cost effectiveness is estimated at $1.1 million per ton VOC and $2.0 million per ton NOx.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
71	Electric Vehicles	10% of 2007-2009 fleet as ZEV	Onroad - LDGV	48.2 VOC, 42.2 NOx	0.4% VOC, 0.3% NOx	0.24 VOC, 0.13 NOx,	$1.1 million VOC, $2.0 million NOx

REFERENCES

CEC (2001), "Projected Automotive Fuel Cell Use in California", California Energy Commission.P600-01-022F, October 2001.

TTI (2005), "2002, 2009, and 2012 Emissions Inventories for the Houston/Galveston Eight-Hour Nonattainment Counties", Texas Transportation Institute, August 2005.

Control Measure: Cleaner Diesel Fuel, Measure # 115
Category: On-road
Author: John Grant, ENVIRON

DESCRIPTION

The cleaner diesel control measure would consist of a change in diesel fuel from Texas Low Emission Diesel fuel (TxLED) to either cetane additive enhanced (CAE) or Fischer-Tropsch (FT) diesel fuel. It is anticipated that, due to the nature of CAE and FT diesel technology, this program may not be a mandatory change to CAE or FT diesel, but may more likely be for a localized or demonstration project on specific Class 8b Heavy Duty Truck (HDT) fleets.

TxLED fuel contains less than 10 percent by volume of aromatic hydrocarbons and has a cetane number of 48 or greater. CAE diesel would consist of diesel to which additives were supplemented, producing a cetane number increase of 5 points with no changes in other parameters from TxLED fuel. FT diesel fuel would consist of typical FT fuel with a cetane number of 74 and an aromatic content of 0.1 percent (Clark et. al., 1999).

Implementation Feasibility

Large-scale production of Fischer-Tropsch fuels are currently being researched by several oil companies (EPA, 2002), however, production is currently scarce and costly. Cetane additives are available for implementation; however, distribution issues would make it difficult to make the use of cetane enhancers mandatory over the entire HGB. Therefore, this measure was evaluated as a targeted measure, consisting of replacing TxLED fuel in 10% of the heavy-duty truck fleet with either FT or CAE fuel.

Public Acceptance

This measure would require changes in diesel production associated with each technology. Increased costs associated with this production could potentially be burdensome for diesel manufactures that would need to change their operations to conform to new standards, as well as for diesel consumers due to increased diesel costs. It is expected that grant funding could ease this burden.

ANALYSIS

This measure was analyzed by comparing the emissions associated with current TxLED fuel for heavy-duty vehicles (including buses) with FT and CAE diesel fuel. Emission reductions of 12% (Clark et. al. 1999) and 1.3% (EPA, 2003) were estimated for FT, and CAE fuel, respectively. Based on the onroad emission inventory for 8 counties in the HGB nonattainment area (TTI, 2005) that indicated that heavy-duty diesel vehicle (Class 8b only) emissions were responsible for 53.2 tpd of NOx emissions, a reduction of 0.64 tpd and 0.07 tpd is estimated for the implementation of FT and CAE fuel in 10% of the heavy-duty fleet, respectively.

Emissions Affected

The emissions affected could include all diesel engines (87 tpd, prior to adjustments for ambient conditions and other emission reduction measures) or to the entire or portions (estimated here at 10%) of fleets of larger Class 8b heavy-duty trucks (53.2 tpd) (TTI, 2005).

Emissions Benefit

Estimated emission reductions from this measure are 0.07 - 0.64 tpd NO_x for the fleets representing 10% of Class 8b, or 1.1 – 10 tpd if applied across all diesel operating in the area.

Cost and Cost-effectiveness

Estimates from vendors indicate that cetane increases of 5 points would cost approximately $0.08 per gallon.

The cost of Fischer-Tropsch fuels ranges from $0.10 (cost to produce) up to $0.25 per gallon (to deliver under current market conditions) more than California Diesel (CEC, 2003)[4]. The cost of these fuels however has been decreasing due to advance in the technology and economies of scale if demand increases as it is beginning to in California where it is increasingly sold as a neat fuel or a blend stock to produce California reformulated diesel fuel.

Based on VMT traveled per day by Class 8b HDT (from onroad emission inventory for 8 counties in the HGB nonattainment area), an estimate of total diesel fuel cost was made, assuming a diesel cost of $2.13/gallon and a fleet average of 5.35 miles/gallon ($2.1 million/day). This fuel cost was compared to the fuel cost for scenarios in which CAE or FT fuel was used in 10% of all vehicle miles traveled, which produced added costs of $8,000/day and $25,000/day respectively. The cost effectiveness was then estimated as the ratio of added fuel cost to emission reductions, $118,000/ton and $39,000/ton for CAE and FT fuel respectively.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
115	Cleaner Diesel Fuel	Cetane Additive Enhanced or Fischer Tropsch Diesel Fuel	Onroad – Class 8B HDT	5.32 87.4	1.3% - 12%	0.07-0.64 1.1 – 10	$39,000 - $118,000

REFERENCES

CEC (2003), "Reducing California's Petroleum Dependence", A Joint Report of the California Energy Commission and California Air Resources Control Board, P600-03-005F, August 2003.

Clark, et. al. (1999), Clark, Nigel, Mridul Gautam, Donald Lydons, Chris Atkinson, Wenwei Xie, 1999, "On-Road Use of Fischer-Tropsch Diesel Blends", SAE Technical Paper Series, 1999-01-2251, Washington D.C., April 1999.

EPA. 2002, "Fact sheet: Clean Alternative Fuels: Fischer-Tropsch", EPA420-F-00-036, http://www.epa.gov/otaq/consumer/fuels/altfuels/420f00036.pdf

EPA (2003), "The Effect of Cetane Number Increase Due to Additives on NOx Emissions from Heavy-Duty Highway Engines, Final Technical Report", EPA420-R-03-002, February 2003.

TTI (2005), "2002, 2009, and 2012 Emissions Inventories for the Houston/Galveston Eight-Hour Nonattainment Counties", Texas Transportation Institute, August 2005.

Control Measure: Divert or Route Trucks Around Nonattainment Area, Measure 144
Category: On-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This strategy would attempt to reroute through truck traffic without business around the local roadways in the HGB area.

Implementation Feasibility

The implementation of this measure could be very difficult. Incentives to use likely longer routes would need to be identified or other means such as pricing measures.

Public Acceptance

The local traffic situation would improve as a result of less traffic though through trucks represent a small fraction of the overall vehicular traffic in the area.

ANALYSIS

The analysis of this measure used a gross estimate that 8.99% of trips in the HGB area originate and end outside of the area. This figure includes both light and heavy-duty vehicles and was applied equally between the two general types.

Emissions Affected

This measure would affect under 90 tpd 2009 on-road heavy-duty emissions in the eight-county HGB ozone nonattainment area. This measure includes heavy-duty diesel freight vehicles and may only affect the larger Class 8 heavy-duty trucks, which are responsible for about 60 tpd of the <90 tpd heavy-duty vehicle total.

Emissions Benefit

The emission benefit was estimated by using a penetration rate (fraction of vehicle rerouted) of 10 – 50% of the through vehicles. Because the implementation of this strategy is undefined, it was difficult to determine how and therefore how much of the through traffic would be diverted.

Cost and Cost-effectiveness

The cost for encouraging rerouting is unknown.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
144	Divert Through Truck Traffic	Around non-attainment area	On-road Heavy-duty Vehicles	5.5 – 7.5	10 – 50%	0.6 – 4	Unknown

REFERENCES

H-GAC (2006), personal communication

Control Measure: HOV Lanes (Combines aspects of Measures 150,157 and 161)
Category: On-Road
Author: Barbara Joy, Earth Matters Inc.

DESCRIPTION

High occupancy vehicle lanes have been a key strategy for congestion relief and emission reductions in the Houston region for many years. HOV lanes allow carpools and transit vehicles to use special lanes during peak traffic periods. The overall effect can be a significant incentive to utilize higher occupancy vehicles, which reduced travel and associated emissions in an area.

The current HOV system in the Houston region consists of the following facilities:

1. Katy Freeway (IH 10W)
2. North Freeway (IH 45N)
3. Gulf Freeway (IH 45S)
4. Northwest Freeway (US 290)
5. Southwest Freeway (US 59S)
6. Eastex Freeway (US 59N)

Utilization, according to the last report available (September 2005) is 122,596 passenger trips/day. The lanes operate for long periods; the am period generally runs from 5 am – 11 am and the pm period from 2 pm to 8 pm (12 hours a day). The lanes are for vehicles with 2 or more passengers most of the time; they are reserved for vehicles with 3 or more passengers about two hours a day.

Potential of this Measure

The extensive coverage and utilization of HOV lanes throughout the region may limit increases in the effectiveness of HOV measures. Use is already restricted to 3+ vehicles for portions of the day and efforts are always ongoing to improve HOV access to transit stations and park and ride lots. This measure is evaluated in a semi-quantitative manner here. In separate evaluations of improved Commute Solutions programs, this measure is considered as part of the encouragement and rationale for additional benefits from Commute Solutions. The benefits *cannot* be double-counted; emission benefits from increased ridesharing, vanpooling and transit use are going to be the same reductions counted as additional use of HOV lanes.

METHODOLOGY AND EMISSIONS ANALYSIS

The 1995 utilization report notes there were 122,596 people per day using the HOV lanes. The average trip distance in the area is about 15 miles (20 miles for work trips and less for non-work). The average vehicle occupancy for carpools has not been estimated for the Houston region but a default used in methodologies such as the California Air Resource's Board *Methods to Find the Cost Effectiveness of Funding Air Quality Projects* is 2.5. In terms of accounting for the individuals driving a carpool (who cannot be counted as reductions), this means that about 40% of the people using the HOV lanes cannot be counted as reducing VMT.

As noted above, this measure has been significantly implemented already. Because additional emission reductions are expected to be limited, the measure is evaluated in a semi-quantitative manner, with an arbitrary assumption about potential growth. In short, it is assumed that growth in HOV use between 2005 and 2009 is 20 percent, or roughly 4% per year (this may be too optimistic and more could create so much utilization that any speed increase in using the lanes would be offset by too much utilization). Therefore by 2009 there are 147,115 people per day using the lanes. Adjusting for VMT by the drivers, it is expected that 88,269 people/day will be reducing their driving to use the HOV lanes, with the remaining 58,846 people doing the driving for the carpools. At an average vehicle trip of 15 miles this could reduce VMT by up to 1,324,035 miles per day. Since EPA only allows *additional* benefits to be counted toward emissions credit, it must be assumed that only 20% of this benefit could be counted as a *new* benefit. Based on this, 264,807 miles per day are reduced.

The emissions analysis uses the following key variables:

- ✓ Total light duty vehicle VMT for average ozone day (episode day used in air quality modeling) is 135,673,516
- ✓ Average light duty vehicle composite emission factor for NOx for same day is 0.471 grams per mile
- ✓ Average light duty vehicle composite emission factor for VOC for same day is 0.489 grams per mile

There is no methodology in the MOSERs guide for this measure; however the following equation utilizes the basic process suggested by the MOSERs methodology, as follows:

Variables:	**EF_A:**	Speed-based composite emission implementation, VOC, or CO) grams/mile
	EF_B:	Speed-based running composite emission factor before implementation (NO_x VOC, or CO) (grams/mile)
	VMT_A:	**Change in** VMT as a result of growth in HOV lane use

It is assumed that emission factors and trip length before and after implementation are the same. Emissions changes from vehicle trips and associated start emissions are evaluated through the use of composite emission factors.

In this analysis **VMT_A** was derived above.

Equation:

Daily Emission Reduction =

$$C = VMT_A * EF_A =$$

264,807 * 0.471 gram/mile NOx/453.6 = 275 lb/day, and 0.14 tpd NOx

and

264,807 * 0.489 gram/mile VOC/453.6 = 285 lb/day, and 0.14 tpd VOC.

Cost Effectiveness

The facilities have already been constructed so no additional costs can be calculated. If data were available on construction costs they could be amortized through 2009 but this is not possible at this time. Therefore it is estimated that cost effectiveness will be <$4,000/ton.

COMMENTS

This evaluation is based on hypothetical assumptions and data for this program and may be considered for use in ozone plan after review of key assumptions. Key to this consideration is the nearly 100 percent overlap between this measure and any other measures that increases vehicle occupancy. Separate analyses for ridesharing, transit and vanpooling cannot simply be added to this benefit.

Also key is that the emission factors used in the analysis are emission factors with currently programmed federal and other control measures such as Tier 2 tailpipe standards. Other measures are being evaluated for the H-GAC region, such as California LEV (low emission vehicles), cleaner fleets and wider application of the Inspection and Maintenance program. If these or other similar programs were implemented, the emission factors used to evaluate programs affecting the amount of travel (such as this one) would be smaller – each mile driven would be at a lower emission rate and therefore each mile not driven would not reduce emissions as much as it would have without the additional measures.

SUMMARY OF RESULTS: NO_x

Measure ID	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
150,157, 161	HOV Lanes	20% increase in HOV lane use	On-Road	165.8 tpd	0.09	0.14	<$4,000

SUMMARY OF RESULTS: VOC

Measure ID	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
150, 157, 161	HOV Lanes	20% increase in HOV lane use	On-Road	79.3 tpd	0.18	0.14	<$4,000

Control Measure: Scrappage/Buy-Back Program, Measure 172
Category: On-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This strategy would build on and expand the Low Income Repair Assistance Program (LIRAP) to include greater and more emission effective vehicle buy-back and scrap those high emitters. H-GAC is administering LIRAP on behalf of Brazoria, Harris, Fort Bend, Galveston and Montgomery counties. For administering the program, H-GAC claims the emission reductions achieved through the scrapped portion of the LIRAP.

Implementation Feasibility

The LIRAP program was designed originally to improve the compliance with the inspection and maintenance Texas AirCheck program.

Public Acceptance

The LIRAP program has a social and air quality benefit to the program and so is a generally acceptable program to most stakeholders.

ANALYSIS

The majority (approximately 96%) of the funding is spent on repairing high emitting vehicles, and the emission reduction is counted in the low waiver rates (those vehicles that still do not pass the inspection even after every reasonable repair has been made) assumed in the MOBILE6 emissions modeling. The smaller numbers of vehicles that are scrapped have not been counted in the emissions modeling and therefore are available to use as a separate air quality strategy.

Emissions Affected

The overall light-duty emissions accounts for 70.5 tpd for a typical weekday, but this measure would affect the small fraction, 3%, of vehicles that are high emitters that would be waived through the I/M program. In addition, three counties do not have I/M programs, and so high emitter vehicles cannot be identified for removal.

Emissions Benefit

The emission reduction could be structured either that model years that fail the I/M test is replaced with the average levels or that high emitters above a certain cutpoint in emissions level be selected for replacement. In Table 1, an emission reduction potential is shown for the average emission reduction potential if an older vehicle is replaced with an average emitting vehicle in

2009. This estimate may underestimate the effectiveness of the measure because no additional selection for high emitters was used.

Table 1. Overall Annual Emission Reduction Estimate (tpy) per Vehicle for Older Model Years.

Vehicle Type	Emission Reduction Potential (tpy)		Model Year
	VOC	NOx	
LDGV	0.002	0.004 – 0.007	<2000
LDGT1	0.002	0.003 – 0.004	<2000
LDGT2	0.002	0.003 – 0.010	<2000
LDGT3	0.004	0.005 – 0.012	<2004
LDGT4	0.004	0.005 – 0.021	<2004
Average	**0.003**	**0.005 – 0.010**	

The total emission benefit would depend upon the number of vehicles that could be replaced under such a program. If 10% of the current LIRAP program cost were dedicated to high emitter replacement, between 40 and 400 high emitters could be retired per year. The range of the program effectiveness using 10% or 100% of current program cost would result in 0.2 to 4 tpy and 2 to 40 tpy NOx emission reduction and 0.1 to 12 tpy VOC reduction for each year the program existed, so over the 2007 – 2009 time frame, the benefits would be 3 times that estimated.

However, TCEQ already credits 0.1 tpd of emission reductions from this measure in its baseline emission inventory. Therefore the emissions reductions from this program were reduced by 0.1 tpd to account for that current expectation.

Cost and Cost-Effectiveness

The current LIRAP program spends, on average $550 - $750 per vehicle, for repair and replacement, but only 295 vehicles have been replaced in the first 2½ years of the program of the thousands taking advantage of the program. To generate significant emission reduction, many more vehicles would need to be replaced and the incentive may need to be greater so an upper end estimate was considered as $5,000, a typical retail price of an 8-year old vehicle. The cost of the entire LIRAP program is currently running about $2,000,000 a year for the HGB area.

The cost effectiveness of the LIRAP program, using the assumption of emission reduction cited above, would range from $17,000 to $340,000 per ton of NOx only and $13,000 to $200,000 per ton of VOC plus NOx. The high range of the cost effectiveness has used assumptions of full replacement cost and the low-end emission benefits resulting from scrappage of the average vehicle. A lower per vehicle cost and a more focused program targeting only high emitters would improve the cost effectiveness.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
172	Scrappage / buy-back program	High emitter vehicle scrappage	On-road Light-duty Vehicles	70.5	0.0 to 0.5%	0 to 0.38	$10,000 - $200,000

[1] – The emission reduction potential accounts for the emission reductions already credited in the baseline emission inventory.

REFERENCES

H-GAC (2005), Air Check Texas Program Statistics, April 2005.

Control Measure: Parking Surcharge and Preferential Parking (Combines aspects of Measures 227, 229, and 241)
Category: On-Road
Author: Eric Schreffler, ESTC

DESCRIPTION

Parking is generally free and abundant for most commuters. Among commuters who drive to work, only 5% pay the full cost of parking and another 9% pay a subsidized rate. Parking is not priced at 98% of U.S. work locations. (Litman, 2006).

In Houston, paid parking is only common in a very few locations, namely Central Houston and a few large employment centers, like the Texas Medical Center. Commuters are most likely to pay all or part of the cost of parking in the Houston CBD. According to parking inventories from 2005, there are almost 75,000 structured parking spaces in downtown Houston and another 27,000 spaces in surface lots. In 2003, the average daily price of parking in downtown Houston was $8.00, with monthly-unreserved spaces averaging $165.00 and reserved spaces averaging $245.00 per month.

There are also 2,300 metered spaces downtown, which may be replaced by 750 multiple-space metering machines which would allow for cell phone or pre-paid card payment and better tracking of utilization (according to a *Houston Chronicle* article dated 3/5/06). This new technology also allows for variable pricing by time of day and demand.

Changing the price of parking can affect mode choice and reduce VMT by shifting commute and other trips to alternative modes. A 2001 parking management plan prepared for Central Houston, Inc, called for "a comprehensive city-sponsored and promoted program to promote alternative means of transportation to the central business district." (Moore and Assoc. 2001) According to the online TDM encyclopedia, Vaca and Kuzmyak (2005) found that the price elasticity of vehicle travel with respect to parking pricing ranges from –0.1 to –0.3 (meaning that a 10% increase in parking price would typically be expected to reduce vehicle trips by 1% - 3%, depending on the location, availability of transit and HOV options, demographics, etc. An elasticity of –0.2 will be applied to the Houston CBD given the income levels, location, and availability of HOV lanes and commuter transit services.

ANALYSIS

At this time, the best data on parking charges, employment, and parking availability is from Central Houston. Most employees working in downtown Houston pay for some or all of their parking. Parking fees are most feasible where an existing market and infrastructure exists, as in Central Houston. As such, parking pricing would take the form of a parking surcharge to existing fees. As of 2003, the average cost of unreserved and reserved parking in downtown Houston was $8.00 per day. A surcharge of 25% would increase this average fee to $10 per day. Increases in parking fees are known to shift some numbers of commuters to alternative modes, including carpooling. As such, preferential parking for carpools and vanpools is also recommended because some commuters would seek to share parking costs by sharing a ride. For this analysis, the commuters that might be subject to a parking surcharge and offered preferential parking are assumed to be located in Central Houston, where employees are most likely to pay some of all of their parking costs.

There are a total of 2,757,548 employees projected for the Houston-Galveston region in 2009. In 2004, there were 145,318 employees in Central Houston. With a growth rate of 3.0% (based on Central Houston, Inc. projections), this would equate to 168,463 employees. In order to convert employees to vehicles, with which to apply the price elasticity factor, it is assumed that each 100 employees generates 77 vehicle trips (based on an assume CBD commute mode split of 70% SOV, 15% HOV, 10% transit, and 5% bike/walk/telework/CWW/other). Thus, 168.463 employees are assumed to generate 129,717 round trip vehicle trips.

Emissions Analysis

The emissions analysis utilized the basic process suggested by the MOSERs methodology, as follows:

Variables:

Variables:	$\mathbf{EF}_{A}$:	Speed-based composite emission factor after implementation (NO_x, VOC, or CO) grams/mile)
	$\mathbf{EF}_{B}$:	Speed-based running composite emission factor before implementation (NO_x, VOCor CO) (grams/mile)
	$\mathbf{N}_{VA}$:	Number of vehicles after implementation
	$\mathbf{N}_{VB}$:	Number of vehicles before implementation
	$\mathbf{TEF}_{AUTO}$:	Auto trip-end emission factor (NO_x, VOC, or CO) (grams/trip)
	$\mathbf{TL}_{A}$:	Average auto trip length after implementation (miles)
	$\mathbf{TL}_{B}$:	Average auto trip length before implementation (miles)
	$\mathbf{VMT}_{A}$:	Vehicle trips after implementation
	$\mathbf{VMT}_{B}$:	**Change in** VMT as a result of implementation

It was assumed that emission factors and trip length before and after implementation are the same. Emissions changes from vehicle trips and associated start emissions are evaluated through the use of composite emission factors and the assumption that access to alternative modes is not through SOV use.

In this analysis $\mathbf{VMT}_{B}$ is derived by multiplying the number of employee vehicle trips by the elasticity associated with a 25% increase in average daily parking rates (from $8.00 to $10.00 per day) resulting in a switch to alternative modes that would result in vehicle trip reduction. It is assumed that preferential parking will be offered to carpools and vanpools as an incentive to increase these alternative modes. By multiplying the estimated number of vehicle trips (129,717) by a price elasticity of –0.5 (associated with a 25% increase in price, as opposed to 10%), the vehicle trip reduction is estimated to be 6,486 daily round trips. The VMT reduction associated with this trip reduction is derived by multiplying the average round trip work length

(40.0 miles) for an average of 4 out of 5 workdays per week (to account for holidays, vacations, and that few alternative mode users use alternative modes every day; this part of the calculation assures that the estimate is an average daily reduction.

Equation:

Daily Emission Reduction =

$$C = VMT_B * EF_A =$$

207,546 * 0.471 gram/mile NOx/454 = 215 lb/day, and 0.108 tpd NOx

and

207,546 * 0.489 gram/mile VOC/454 = 224 lb/day, and 0.112 tpd VOC.

Cost Effectiveness

No data on costs for Houston is available. However, the cost associated with a surcharge and preferential parking program will largely be program planning and enforcement. This annualized cost could be around $5,000 for planning and $25,000 for enforcement. Depending on program structure, cost per ton could be $267857 - $277,778. However, the surcharge, or a portion of it, could be used to defray program costs, especially enforcement.

COMMENTS

This evaluation is based on national elasticities and may be considered for use in ozone plan after review of key assumptions

SUMMARY OF RESULTS: NO_x

Measure ID	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
227, 229, 241	Parking surcharge and preferential parking	25% surcharge on parking in Central Houston and preferential parking for carpools and vanpools	On-Road	165.8 tpd	0.07%	0.11	$277,778/ton

SUMMARY OF RESULTS: VOC

Measure ID	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
227, 229, 241	Parking surcharge and preferential parking	25% surcharge on parking in Central Houston and preferential parking for carpools and vanpools	On-Road	79.3 tpd	0.14%	0.11	$267,857/ton

REFERENCES

Litman, 2006, "Parking Pricing – Direct Charges for Using Parking Facilities" in the Online TDM Encyclopedia, http://www.vtpi.org/tdm/tdm26.htm, updated February 2006.

Vaca and Kuzmyak, 2005. "Parking Pricing and Fees" Chapter 13, TCRP Report 95, Traveler Response to Transportation System Changes, Transit Cooperative Research Program, Transportation Research Board**.**

Walter Moore and Associates, Inc., Downtown Parking Management Program Planning – Houston Texas, prepared for Central Houston, Inc., January 23. 2001.

Control Measure: APU-Hybrid Locomotives, Measure 72
Category: Non-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This measure originally referenced auxiliary power units (APU), but now refers to smaller auxiliary engines used in combination with hybrid-electric systems to power switching engines.

Implementation Feasibility

Through TERP funding or other mechanisms, it might be possible to address the switching engine emissions without much trouble although large purchases may encounter scheduling delays. Also, some uses of switching engines such as those used to make short haul runs require more power for a longer period than Hybrid-Electric engines can provide.

Public Acceptance

Aside from the issue of who pays for the new engines, this measure would have a high acceptance. A careful review of the routes and operations able to use these lower powered engines would determine the total emission reductions available.

ANALYSIS

This measure was analyzed by comparing the expected fleet turnover with the exclusive use of hybrid switching engines.

Because use of the technology is not feasible with line-haul locomotives, the measure was considered to apply to just those engines locally based and considered for this evaluation to be the switching engines.

A recent study (ERG, 2005) of the locomotive emission inventory in Texas provided emission results for 8 counties HGB nonattainment area that indicated that switching engines were responsible for nearly 39% of the locomotive emissions; however fleet turnover to cleaner engines is expected to affect line-haul engines more than switching engines, so switching engines could be responsible for up to 46% of locomotive NOx emissions by 2009. Applying the 39 – 46% figures to TCEQ reported locomotive emissions inventory for 2009 (21.1 tpd) indicates that switching engine emissions could be responsible for 8.2 – 9.8 tpd of NOx emissions. EPA (1997) projected switching engine emissions reductions to be only 15% by 2009 through fleet turnover alone.

One example of a hybrid-electric switching locomotive is called the “Green Goat” manufactured by RailPower (2005) and funded as in TERP projects is purported to result in 80 –90% NOx emission reductions although this estimate did not specify from what base emissions level. The actual emission reduction will depend upon the engine used in the Green Goat and the specific design and operating cycles. The current year (2006) emission standard for off-road engines of the kind used in the Green Goat is less than 3.0 g/hp-hr for engines less than 750 hp this is reduced to 3 g/hp-hr as compared with the Tier II switching engine emissions of 7.3 g/hp-hr. In addition, a hybrid electric locomotive can reduce fuel consumption by operating the engine in its most efficient mode, eliminating idle, and recovering braking energy. Using the range in emission standards and reduced fuel consumption by 30 – 50% results in emission reductions of 50 – 80% from Tier II levels. Therefore, replacing the average switching engine with a hybrid-electric engine would result in the reported 80 – 92% reduction from precontrolled levels.

Hybrid-electric engines cannot, however, be used for all switching engine activity, especially the short haul activity that many switching engines perform. As a result, the penetration of the hybrid technology may be as low as 20% of all switching engine activity. Applying the 80 – 92% emission reduction to 20% of the 8.2 - 9.7 tpd switching engine emissions results in an estimated 1.3 – 1.8 tpd NOx reduction.

Emissions Affected

Switching engine emissions are estimated to be 8 tpd NO_x as explained above.

Emissions Benefit

1.3 – 1.8 tpd reduction (switching only). Some of this emissions benefit has already been captured in TERP projects.

Cost and Cost-effectiveness

Total cost is estimated to be $30,000,000 and upward based on the assumption that 20% of the 206 (in the year 2003) or more (for 2009) switching engines operating in the HGB area and the fact that past TERP funding has averaged $700,000 per GreenGoat locomotive. The cost to applied advance technology on all line-haul and switching engines is considerably more than the capital cost of the equipment owning to the ongoing cost of staff and operation time required to change out engines at points of entrance and exit from the HGB area, so only a fraction of the locally-based switching engines are considered as candidates for this technology.

The cost effectiveness in the TERP annual reports for this technology averages from $5,000 - $10,000 per ton.

COMMENTS

The switching engine activity and the fraction of that activity applicable to this technology deserves additional study. TERP projects include 80 clean switching engines of the 206 switching engines reported as locally based in HGB in 2003 (ERG, 2005) or 39% of the fleet in that year. These TERP projects were expected to result in 3.9 tpd NOx reductions. Therefore, further analysis is required to determine how many more switching engines can be feasibly replaced with this technology.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
72	Hybrid-electric locomotives	TERP funded Green Goat	Nonroad – switching locomotive	1.0 – 2.0 tpd[1]	80 – 90%	0.8 – 1.8	$5,000 - $10,000

[1] - 1.6 tpd is derived from 20% additional penetration of the 8 - 10 tpd switching engine emissions.

REFERENCES

Donnelly, Frank W., (RailPower Technologies Corp.), Cousineau, Raymond L., Horsley, R. Nigel M., "Hybrid Technology For The Rail Industry," RTD2004-66041, Proceedings of the 2004 ASME/IEEE Joint Rail Conference, April 6–8, 2004, Baltimore, Maryland USA.

ENVIRON (2004). "Texas Emission Reduction Plan Assessment in the Dallas Fort-Worth Area," Prepared for Houston Advanced Research Center4800 Research Forest Dr. The Woodlands, TX 77381, November 2004.

EPA (1997), "Locomotive Emission Standards," Regulatory Support Document, United States Environmental Protection Agency, Office of Mobile Sources, April 1997.

ERG (2005), "Texas Railroad Emission Inventory Model (TREIM) and Results," Prepared for Karla Smith-Hardison, (TCEQ) and David Hitchcock (HARC) by Richard Billings, Roger Chang, and Heather Perez, ERG, June 30, 2005.

Control Measure: Tier II-only Locomotives, Measure 73
Category: Non-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This measure would only allow Tier II locomotives to operate within the HGB area. This is similar to a measure employed in the South Coast of California where, by 2010, only locomotives meeting Tier II or better emissions will be allowed to operate within that area.

Implementation Feasibility

Several new depots for each entrance/exit into the HGB area would be required with Tier II engines available to change out for every train coming through the area. The capital cost of new engines, staff and operational time would preclude this option from being considered generally feasible for all engines. Through TERP funding or other mechanisms, however, it might be possible to address just the switching engine emissions, a significant portion of the projected emissions in the HGB area.

Public Acceptance

This measure conflicts with the current operations, especially of line-haul trains, which constitute a significant portion of the operations with the HGB area. A measure such as this for line-haul locomotives would be uniformly considered too burdensome by the railroads operating in the area. Through TERP funding or other mechanisms, however, it might be possible to address the switching engine emissions.

Other than affect freight movement cost, this measure would not affect the general public.

ANALYSIS

This measure was analyzed by comparing the expected fleet turnover with the exclusive use of Tier II engines.

A recent study (ERG, 2005) of the locomotive emission inventory in Texas provided 2003 emission results for 8 counties in the HGB nonattainment area which indicated that switching engines were responsible for 39% of the locomotive emissions; however fleet turnover to cleaner engines is expected to affect line-haul engines more than switching engines, so switching engines could be responsible for up to 46% of locomotive NOx emissions by 2009. Applying these figures to the TCEQ reported locomotive emissions inventory for 2009 (21.1 tpd), indicates that switching engine emissions could be responsible for 8.2 – 9.8 tpd of NOx emissions with line-haul responsible for 12.9 – 11.3 tpd of NOx emissions.

EPA projected average emission reductions from precontrolled levels to be 44% for Class I line-haul, 15% for Class I switching engines, and 3% for Class II/III engines by 2009. EPA estimated that the Tier II emission standards would reduce line-haul emissions by about 61% from precontrolled levels. Turning over the entire fleet to Tier II engines by 2009 would result in about a 30% reduction from Class I line-haul, 54% from Class I switching, and 60% from Class II/III levels expected in that year. The measure used in the South Coast of California was considered feasible because the traffic either originated or departed within the area. Some may consider the HGB area to be similar in structure due to the ports, yet this ignores through trains north-south and east-west. Because of the difficulty within the HGB area of addressing all trains that operate through the area, the measure could be applied to just those engines locally based and considered for purposes of this evaluation to be the switching engines.

A recent study (ERG, 2005) of the locomotive emission inventory in Texas provided emission results for 8 counties in the HGB nonattainment area that indicated that switching engines were responsible for nearly 40% of the locomotive emissions in 2003. Because the expected emission reductions from fleet turnover of primarily line-haul engines are expected to be more significant in the years between 2003 and 2009, the remaining older switching engine fleet would be expected to be responsible for nearly half of the locomotive emissions. Applying this figure to TCEQ reported locomotive emissions inventory for 2009 (26.8 tpd), indicates that switching engine emissions could be responsible for 9.8 tpd of the NOx emissions. Applying a 54% reduction to 9.8 tpd emissions results in a 5 tpd NOx reduction estimate.

Emissions Affected

The emissions affected include either all locomotives (21.1 tpd) or only switching engines (9.8 tpd), which is the most feasible and effective source category for this measure.

Emissions Benefit

Estimated emission reductions from this measure are 5.3 tpd NO_x (when applied to switching engines only) to 9.6 tpd (if applied to all engines). Some of this emissions benefit has already been captured in TERP projects where hybrid-electric engines (Measure 72) have been used in a significant portion of the fleet.

Cost and Cost-effectiveness

Total cost is estimated at $100,000,000 and upward based on the assumption that more than 250 switching engines operating within the HGB area of which of half will need to be replaced. The ERG (2005) report noted that over 206 switching engines were operating in 2003 and more with added growth through 2009. TERP funded 140 locomotive replacements (in all of Texas) and cost $100,000,000 through fiscal year 2005. The cost effectiveness was taken from TERP projects where replacement switching engines were the projects funded.

The cost for all engines (including line-haul) meeting the advanced emissions standard is considerably more than the capital cost of the equipment owning to the ongoing cost of staff and operation time required to change out engines at the entrance/exit of the area.

COMMENTS

The switching engine activity and the fraction of that engines that already comply with Tier II emissions standards needs to be identified. Both normal fleet turnover and TERP projects affect a large portion of the fleet, so the remaining emission reduction potential could be significantly less than show here. Therefore, further analysis is required to determine the fraction of switching or all engines that would be affected. TERP projects include 80 clean switching engines resulting in a projected emission reduction of 3.9 tpd or a portion of the expected benefit reported here.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
73	Tier II	Tier II Locomotives	Nonroad – locomotive	9.8 local 21.1 all	54 local 41 all	2.9 – 6.3[2]	$5,000[1] upward

[1] TERP switching engine project; with line-haul likely much higher costs affecting normal operations.
[2] Emission reduction potential subtracts for the fleet affected by TERP and VMEP projects

REFERENCES

EPA (1997), “Locomotive Emission Standards,” Regulatory Support Document, United States Environmental Protection Agency, Office of Mobile Sources, April 1997.

ERG (2005), “Texas Railroad Emission Inventory Model (TREIM) and Results,” Prepared for Karla Smith-Hardison, (TCEQ) and David Hitchcock (HARC) by Richard Billings, Roger Chang, and Heather Perez, ERG, June 30, 2005.

Control Measure: Rail Efficiency, Measure 75
Category: Non-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This measure investigates the improvement of rail efficiency through grade separation, double tracking, rail straightening, and other efficiency improvements.

Implementation Feasibility

The implementation would necessarily be an investigation of the rail network and operations to identify areas where rail efficiency could be improved.

Public Acceptance

Depending upon the cost of each project and whether that cost burden is acceptable to all parties, this measure could be a win-win for air quality, transportation planning, and the railroads.

ANALYSIS

Analysis was performed by comparing the current and expected revenue ton-mile with improvements due to track or operational improvements.

A recent study (ERG, 2005) of the locomotive emission inventory in Texas provided emission results for 8 counties in the HGB nonattainment area which indicated that switching engines were responsible for 39% of the locomotive emissions; however fleet turnover to cleaner engines is expected to affect line-haul engines more than switching engines, so switching engines could be responsible for up to 46% of locomotive NOx emissions by 2009. Applying these figures to the TCEQ reported locomotive emissions inventory for 2009 (21.1 tpd), indicates that switching engine emissions could be responsible for 8.2 – 9.8 tpd of NOx emissions with line-haul responsible for 12.9 – 11.4 tpd of NOx emissions.

The rail efficiency measures commonly used primarily affect the line-haul activity. Rail efficiency for the major railroads has been improving for the last 10 years or more. AAR (2005) provided historical efficiency (gallons per ton-mile) data for Burlington Northern (predating the merger with the Atchison Topeka and Santa Fe railroad) and Union Pacific (predating the merger with Southern Pacific and others). Estimated fuel efficiency trends for each company showed an increase in fuel efficiency 7 to 20% during this period. The national trend in freight ton-miles was combined with the individual company efficiency to estimate the fuel efficiency from 1990 through 2002 as shown in Figure 1. If the efficiency improvements can continue at the historic rate, then the projected emissions would be expected to improve beyond those projected from 2002 to 2009 in the TCEQ base case inventories by 4 to 12%, with the primary gains expected in the line-haul emissions.

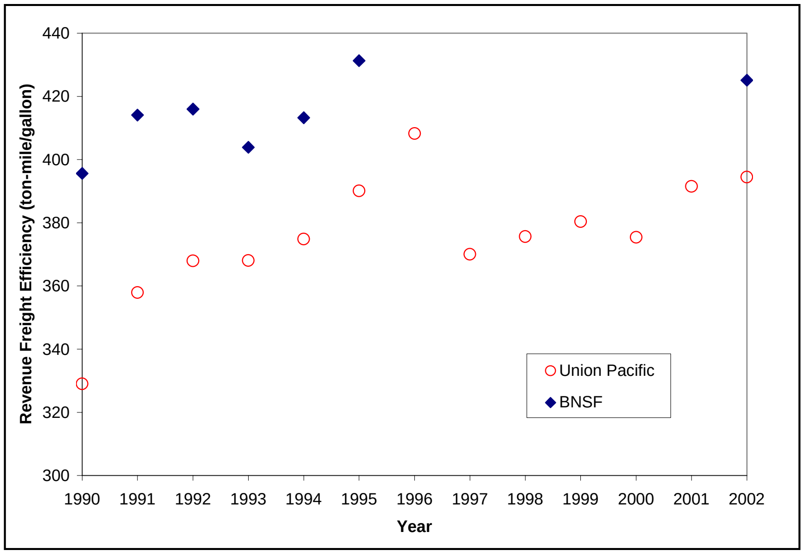

Figure 1. Union Pacific and BNSF rail efficiency trends.

BNSF submitted comments for the Houston-Galveston voluntary emission reduction plan that characterized their activities in improving rail efficiency. Their estimate of increased fuel efficiency mirror the trend presented by the above referenced AAR report, demonstrating improved efficiency of the system-wide fuel consumption:

> *"Other activities such a reducing train aerodynamic drag, using low torque bearings on rail cars, optimizing engineer operation of trains, and reducing friction between the rail and train wheels all increase fuel efficiency. BNSF has programs in all of these areas in order to realize as much fuel savings as possible.*
>
> *The above programs and operating trains with new locomotives has caused BNSF's annual fuel efficiency rating to increase. BNSF fuel efficiency is determined by taking the total gross ton miles (GTM) of freight moved divided by diesel fuel consumed yearly divided by the total gross ton miles. Table (1) shows the GTM/gallon number from 1995 to 2003."*

Table 1. *BNSF reported local efficiency.*

Year	***Fuel Efficiency (GTM/G)***
1995	*693.3*
1996	*699.4*
1997	*717.5*
1998	*736.8*
1999	*734.4*
2000	*747.2*
2001	*760.4*
2002	*760.3*

Besides the operational fuel efficiency measures outline by BNSF, rail infrastructure improvements could also result in fuel savings. From a study of freight efficiency, the fuel consumption from rail transport is calculated from train resistance and freight movements. "Train resistance usually is measured in pounds per ton of train weight and is a function of many factors including (but not limited to): (1) rolling resistance, (2) flange resistance, (3) journal (axle) resistance, (4) track resistance, (5) air resistance, (6) curve resistance, and (7) grade resistance." (Army Corps, 2000). Therefore, besides operational controls that each railroad can effect, proper transportation planning can assist railroads by working to reduce curve and grade resistance, and alternatively local planning could be used to provide sufficient right of ways to double track and grade separation projects that would both reduce braking and idling events.

Emissions Affected

Locomotive efficiency measures such as reduced congestion, or engine or rail car rolling efficiency methods would primarily affect line-haul emissions (11.4 tpd) rather than switching engine activity.

Emissions Benefit

0.8 – 3 tpd reduction (line-haul only).

Union Pacific and BNSF have voluntarily agreed to reduce emissions in the HGB area of which rail efficiency is one measure used to satisfy the agreement.

Cost and Cost-effectiveness

The cost and effectiveness of would need to be analyzed project by project.

COMMENTS

The potential for improving rail efficiency through specific projects may be difficult to demonstrate when included in the overall rail operations.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
75	Rail Efficiency	System efficiency improvement	Line-haul locomotives	11.4	4 – 16%	0.5 – 1.8	Unknown

[1] HGB voluntary measure.

REFERENCES

AAR (2005), Fuel consumption and revenue ton-mile data for Burlington Northern and Union Pacific railroads, personal communication with Clyde Crimmel, May 4, 2005.

Army Corps (2000), “Analysis of Energy, Emission, and Safety Effects of Proposed UMR-IW Projects,” http://www2.mvr.usace.army.mil/umr-iwwsns/documents/aug2000-entire%20report.pdf

BNSF (2004), “Houston/Galveston Ozone Nonattainment Area Statement of Principles Progress Report for The Burlington Northern and Santa Fe Railway Company,” Report to H-GAC and TCEQ of the Progress for the Houston-Galveston Area Memorandum of Understanding, March 11, 2004.

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Control Measure: Limitations on Idling Locomotives, Measure 79
Category: Non-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

Reduction of idling from all locomotives.

Implementation Feasibility

TERP funding or other funding mechanisms have and could expand installation of automatic start/stop devices on all locally based short haul and switching engines in the area. Emission reduction credits could account for national programs implemented by Union Pacific and BNSF to install automatic anti-idling equipment on line-haul engines in their general fleet.

Public Acceptance

Funding for this program could be implemented through voluntary grants. If the measure were implemented as a mandate, there may be some resistance from operators, especially since some engines have already been retrofitted with TERP funding.

ANALYSIS

Analysis of this measure was based on the use of EPA surveyed activity profiles combined with Texas survey results by locomotive type.

Based on the EPA (1997) evaluation of locomotives activity profiles, line-haul locomotives spend 38% of their time idling and switching locomotives spend 60% of the time at idle. Using the modal emission rates provided by EPA (1997) and depending upon the engine model, this idle time translates into 1 - 6% of line-haul and 5 – 27% of switching engine NOx emissions.

A recent study (ERG, 2005) of the locomotive emission inventory in Texas provided emission results for 8 counties in the HGB nonattainment area which indicated that switching engines were responsible for 39% of the locomotive emissions; however fleet turnover to cleaner engines is expected to affect line-haul engines more than switching engines, so switching engines could be responsible for up to 46% of locomotive NOx emissions by 2009. Applying these figures to the TCEQ reported locomotive emissions inventory for 2009 (21.1 tpd), indicates that switching engine emissions could be responsible for 8.2 – 9.8 tpd of NOx emissions with line-haul responsible for 12.9 – 11.3 tpd of NOx emissions.

NCTCOG received comments from area railroads that it is infeasible to eliminate *all* idling because the time required to restart engines would conflict with established safety procedures designed to maintain brake system air pressure and avoid collisions and would generally be impractical from an operational standpoint. Even if *all* idling were eliminated, 0.5 – 2.6 tpd of switching engine emissions would be eliminated and line-haul engine emissions would be reduced by just 0.1 - 0.7 tpd.

Technologies to reduce but not eliminate idling emissions are currently available. These include automatic start/stop equipment that can determine when it is safe to shut an engine off. This equipment is being rapidly deployed for fuel and maintenance savings through new purchases and use of TERP funding to retrofit older engines. Over half of the BNSF switching engines have been retrofitted with automatic devices to significantly reduce idling time. Other techniques include the use of smaller pony engines more efficiently operating at the lower loads used to maintain brake pressure and electric power while parked.

Emissions Affected

The affected emissions could include all locomotive activity (21.1 tpd) though approximately half of the switching engines were projected to have been retrofitted with automatic start/stop devices.

Emissions Benefit

Emission benefits are estimated to be between 0.4 and 2.0 tpd NOx.

Some of this emissions benefit has already been captured in TERP projects. Through the 2005 fiscal year, TERP funded 15 locomotives be retrofit for automatic idle shut-off and advance technology hybrid-electric switching engines (Measure 72) also reduce or eliminate extended idle.

Likewise, Union Pacific and BNSF have voluntarily agreed to reduce emissions in the HGB area of which reduced idle is one measure used to satisfy the agreement.

Cost and Cost-effectiveness

The cost of idle limiting devices is typically about $10,000 apiece. This would result in a total cost of $1,000,000 for 100 switching engines only (it is estimated that 50% of engines are already retrofitted and this would be the cost to retrofit the remaining switching engines).

The cost effectiveness of implementation for these devices was taken from the TERP program annual reports.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
79	Locomotive Idling Reductions	Install start/stop devices on locomotives	Nonroad – switching locomotive	21.1	2 – 12%[2]	0.0 –1.0	<$1,000[3]

[1] The reduction percentage is an average for line-haul and switching engines together.
[2] Emission reduction potential reduced 1 tpd from VMEP emission reduction that has already been credited in the baseline emissions inventory.
[3] TERP project.

REFERENCES

EPA (1997), "Locomotive Emission Standards," Regulatory Support Document, United States Environmental Protection Agency, Office of Mobile Sources, April 1997.

ERG (2005), "Texas Railroad Emission Inventory Model (TREIM) and Results," Prepared for Karla Smith-Hardison, (TCEQ) and David Hitchcock (HARC) by Richard Billings, Roger Chang, and Heather Perez, ERG, June 30, 2005.

Control Measure: Statewide Portable Equipment Registration Program, Measure 87
Category: Non-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This control measure is based on approaches to regulation of portable equipment that have been adopted in recent years by the California Air Resources Board (ARB). While the ARB has the authority to regular emissions from motor vehicles, the air pollution control and air quality management districts (districts) have been given the primary authority to regular air pollution from stationary sources. Portable equipment has historically been permitted as a stationary source under California district rules or regulations even though it shares attributes of both mobile and stationary sources. Since the 35 California districts treat portable equipment differently and have different permitting requirements and rate schedules, portable equipment owners must obtain permits, pay fees, and adhere to different permit requirements or regulations as they move between districts. Recognizing the need of a uniform and consistent statewide permitting program for portable engines/equipment, the California Legislature required ARB to adopt regulations that establish a uniform statewide program to register and regulate portable engines and associated equipment. This resulted in adoption by the ARB of the statewide Portable Equipment Registration Program (PERP) on March 27, 1997. Subsequent revisions to the Program were adopted on December 11, 1998 and became effective December 1, 1999, and the most recent changes were adopted on February 26, 2004 with an effective date of September 1, 2005.

In addition to the PERP, ARB has also adopted an air borne toxic control measure (ATCM) for portable diesel-fueled engines. The ATCM for Diesel Particulate Matter from Portable Engines regulation was adopted in February 2004 to reduce diesel particulate matter (DPM) emissions from portable diesel-fueled engines having a rated brake horsepower of 50 and greater.

These two regulations are summarized in the following sections[5].

Portable Equipment Registration Program (see (**http://www.arb.ca.gov/regact/portreg/portreg.htm**):

> The Portable Equipment Registration Program (PERP) in California establishes a uniform program to register and regulate portable engines and portable engine-driven equipment units. Once registered in the PERP, portable engines and equipment units can operate throughout the State of California without the need to get individual permits from local air districts as the California Legislature preempts the districts in California from permitting, registering, or regulating portable engines and portable equipment units registered with the ARB. However, local air districts are responsible for enforcement of portable engines or equipment registered under PERP. Also, portable engines and associated equipment that are not registered with ARB are subjected to district permitting requirements.
>
> Owners and operators of portable engines and portable equipment units that meet the definitions and requirements of PERP are eligible for registration. However, the

[5] These summaries of the Portable Equipment Registration Program and the ATCM for Portable Diesel-Fueled Engines Regulations are extracted from an ARB website (http://www.arb.ca.gov/diesel/portdiesel.htm).

registration is voluntary. The PERP defines a portable engine as any piston-driven internal combustion engine that can be moved from one location to another and does not remain at a single location for more than 12 consecutive months. According to the PERP regulation, portable engines include, but are not limited to, internal combustion engines used in the following:

- Cranes;
- Power generation;
- Pumps;
- Diesel pile-driving hammers;
- Ground support equipment at airports;
- Welding equipment;
- Service or work-over rigs;
- Well drilling;
- Dredges on boats or barges;
- Wood chippers;
- Compressors; and
- Tactical support equipment

As for portable equipment, the PERP defines a portable equipment unit as a portable piece of engine-driven equipment that is associated with, and driven solely by, a portable engine and emits pollutants over and above the emissions of the portable engine. According to PERP, portable equipment units include, but are not limited to, the following portable engine-associated units:

- Confined and unconfined abrasive blasting operations
- Portland concrete batch plants
- Sand and gravel screening, rock crushing and unheated pavement crushing and recycling operations
- Tub grinders and trommel screens

However, engines used to propel mobile equipment or a motor vehicle of any kind, engines/equipment units not meeting the definition of portable, dredging units owned by a single port authority or similar agency, and baseload generators, are not eligible for registration.

According to PERP, only engines certified to EPA/ARB off-road engine emission standards can be registered in the PERP by January 1, 2010. Portable engines can meet PERP eligibility requirements three ways:

1. <u>A "certified" engine</u>. A certified engine is one that has been tested by EPA or ARB and meets the federal off-road engine emission standards. Certified engines will have an emissions information label showing an "engine family name." This engine family name must be provided to ARB as part of the application.

2. <u>A "resident" engine</u>. A resident engine is one that was located and operated in California during the period of July 1, 2003 and July 1 2004. Applicants must provide documentation showing the engine met the residency requirements. The

engines have to be registered on or before December 31, 2005. These uncontrolled engines must be replaced with certified engines by January 2010.

3. A "controlled" engine. A controlled engine is one that meets the spark-ignition engine standards of the PERP regulation (1.5 g/bhp-hr or 80 ppmdv of NOx; 1.5 g/bhp-hr of 240 ppmdv of VOC; and 2.0 g/bhp-hr or 176 ppmdv of CO emissions), an engine retrofitted with a Clean Cam technology kit, or an engine that is equipped with a selective catalytic reduction system. Applicants must submit to ARB documentation showing the control efficiency and controlled emission factors for the technology employed.

In addition, registered portable engines shall not exceed emission limits of 550 lbs/day/engine of CO emissions, 150 lbs/day/engine of PM_{10} emissions, and 100 lbs/day/engine of NOx emissions (100 lbs/day/project of NOx emissions in the South Coast Air District.)

According to PERP, portable equipment units registered in PERP are required to comply with established Best Available Control Technology requirements. Additional registration requirements include a daily emission limit of 82 lbs/day/project of PM_{10} emissions, and an annual limit of 10 tons/yr for any criteria pollutant, and record keeping requirements.

As for the enforcement, the local air districts have primary enforcement responsibility, and the ARB or the districts may conduct inspections at any time to verify and ensure compliance with the PERP requirements. The basic fees to register a portable engine or equipment unit in PERP are $270 for a 3-year period, and $450 for a 5-year period.

ACTM for Diesel Particulate Matter from Portable Engines (http://www.arb.ca.gov/regact/porteng/porteng.htm):

In parallel to the PERP regulation and as part of the ARB Diesel Risk Reduction Plan, the ACTM for DPM from Portable Engines regulation was adopted by ARB in February 2004 to reduce DPM emissions from portable diesel-fueled engines. All portable diesel-fueled engines having a maximum rated horsepower of 50 bhp and greater are subjected to this regulation. The applicable portable engines include those engines registered in the PERP, district permitted engines, and engines that have historically been exempted from district permits. Engines used to proper mobile equipment or motor vehicles of any kind, alternative-fueled engines, dual-fuel engines, tactical support equipment, federal preempted engines, are not subjected to this regulation.

By 2010, the ARB's ACTM for DPM from Portable Engines regulation requires portable diesel-fueled engines to be certified to Tiers 1, 2 or 3 EPA/ARB offroad emission standards.

After 2010, the regulation requires owners of fleets of portable diesel-fueled engines to meet progressively more stringent fleet average PM emission limits in 2013, 2017, and 2020. By 2020, the ARB's ACTM for DPM from Portable Engines regulation would require portable diesel-fueled engines to be certified to the EPA/ARB Tier 4 emission standards or be equipped with a Level 3 PM control technology or a combination of verified control technologies that will achieve 85% or more PM reduction.

Implementation Feasibility

Adopting the California statute and administering the program through TCEQ or other agency staff will be necessary. The reporting requirements by the owner/operators of portable engines will be an additional consideration.

Public Acceptance

This would constitute additional requirements of portable engine owner/operators, which should be a consideration before adopting the California program.

ANALYSIS

ARB estimated that the replacement of uncertified engines with certified engines under the PERP would result in 1,900 tons per year of NOx emission reductions and 100 tons per year of diesel PM emission reductions for the State of California. ARB estimated that the total potential economic impact of the PERP was about $2.2 million over a 5-year period. Thus, this translates to cost effectiveness values of about $4,500 per ton of PM emissions reduced, $230 per ton of NOx emissions reduced, or about $220 per ton of PM+NOx emissions reduced. Scaled to the HGB area using a relative human population in the 8-county area to California State of 14.5%, the NOx emission reduction estimate for HGB is 276 tons per year (0.76 tpd). Because of the high intensity of industrial facilities in HGB, this measure may affect more engines and therefore be responsible for higher emissions reductions.

ARB estimated that the ATCM regulation will reduce PM and NOx emissions from portable diesel-fueled engines in California by about 52% and 51% in 2010, and 69% and 61% in 2015, and 95% and 66% in 2020, respectively. According to ARB, the overall cost effectiveness of the ACTM regulation was $16-$19 per pound ($32,000 to $38,000 per ton) of PM emissions reduced. If the compliance cost was split between PM and NOx+VOC emissions, the overall cost effectiveness of the ATCM regulation was estimated to be $8 to $10 per pound ($16,000 to $20,000 per ton) of PM emissions reduced and less than $2 per pound ($4,000 per ton) of NOx+VOC emissions reduced. Because this is primarily a diesel PM emission control requirement, the NOx emission reductions were not specified. However, the control requirement that accelerated turnover of engines will result in NOx as well as the mandated PM reductions. An estimate specific to Texas deserves additional study.

Emissions Affected

The affected emissions reductions could include a wide variety of equipment. While the total affected is provided as 72 tpd accounting for all equipment other than marine, locomotive, and aircraft, the actual equipment types affected (primarily pumps, generators, and compressors) will be a fraction of the nonroad total.

Emissions Benefit

Estimated emissions benefits of this measure are a 1 ton/day reduction in NO_x.

Cost and Cost-effectiveness

This measure description includes only the California cost effectiveness analysis, and cost should be investigated in more detail.

COMMENTS

Because this measure was instituted statewide in California, a significant analysis of this measure would be required to understand how Texas could implement such a measure, the cost, and other uncertainties that would affect stakeholders.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
87	California Portable Engine Rule	Registration and accelerated engine turnover	Nonroad engines	72	1-2%	1	$200 – 300[1]

[1] California ARB estimate.

REFERENCES

ARB rule and background documentation and staff evaluations found online at: (http://www.arb.ca.gov/diesel/portdiesel.htm)

Control Measure: California Auxiliary Engine on Ocean-Going Vessels, Measure 88
Category: Non-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This measure would reduce emissions by adopting the California Auxiliary Diesel Engines And Diesel-Electric Engines Operated On Ocean-Going Vessels rule. The measure seeks to reduce emissions from vessels near or at ports. The measure mandates low sulfur fuel use in auxiliary engines or as an alternative control method allows compliance if the vessel uses shoreside power instead of auxiliary engines when tied up at the dock. The primary justification for the rule stems from the reduction of particulate matter (PM) rather than other pollutants.

Implementation Feasibility

The implementation of the rule assumes that the primary method for complying with the rule will be to use the lower sulfur fuel resulting in marginal NOx reduction with the added expense of the fuel. An alternative compliance of using shoreside power while at dock results in greater NOx reduction than fuel substitution, but the greater reduction is not guaranteed under rule as adopted.

Implementing the low sulfur rule would require a substantially increase in the enforcement and oversight resources. While it may be easier to verify the shoreside power requirement, infrastructure and/or electric power subsidies or incentives may be required for vessel operators to chose this option.

Public Acceptance

For the general public the measure would likely be welcome even if the primary outcome was a reduction in PM and visible smoke. However, unless targeted more toward the greater emission reduction resulting from the shoreside power measure, this control strategy would have less impact on area-wide ozone formation.

Both the fuel option and the shoreside power option will have a financial impact on the owner/operators of the vessels and thus would affect the implementation of the control strategy.

ANALYSIS

Emissions Affected

According to the ERG/Starcrest (2000, 2003) reports for large ocean-going deep draft vessel, emissions in the Houston-Galveston-Brazoria area are shown in Table 1. The growth projections used by Starcrest to project from 1997 to 2007 were extended 2 years to estimate 2009 emissions.

Table 1. Large vessel emission estimates for all and for only auxiliary engines.

Source	VOC (tpd)	NOx (tpd)
All Ocean-Going Vessel 1997 (Starcrest 2000)	0.55	20.21
All Ocean-Going Vessel 2007 (Starcrest 2000)	0.73	26.83
All Ocean-Going Vessel projected to 2009	0.77	28.16
Auxiliary engine dwelling emissions 1997 (ERG/Starcrest 2003)	0.38	12.12
Auxiliary engines while in transit 1997 (ERG/Starcrest 2003)	---	1.86
Auxiliary engine dwelling emissions 2009 estimated	**0.53**	**16.46**
Auxiliary engines while in transit 2009 estimated	**---**	**2.53**

Emissions Benefit

This measure was analyzed in two ways: using low sulfur fuel for all auxiliary engines, and using shoreside power for all vessels. The low sulfur fuel option affects all auxiliary engine emissions either while transiting or dwelling within the area. The shoreside power option only affects the dwelling emissions while at dock. Some simplifying assumptions were used with each measure to demonstrate the potential emission reduction.

The low sulfur fuel option results in NOx emission reductions as shown in Table 2 for the primary engine type used as auxiliary engines. These emission reductions may result from lower fuel nitrogen (removed along with sulfur) or other fuel parameters. Nominally a 6% NOx reduction is reported when using a lower sulfur fuel. The PM reduction associated with low sulfur fuel is still the subject of research, but it is reported as substantial and could be more significant than shown in Table 2.

[One simplifying assumption was that all auxiliary engines would derive a 6% benefit for the use of low sulfur fuel even though ARB (2005) reported that the fraction of auxiliary engines using high sulfur fuel is about 75%. The California rule for low sulfur fuel extends out to 24 nautical miles (beyond but upwind of the HGB area), and includes all emissions from vessels using diesel-electric propulsion used primarily on cruise ships. So the simplifying assumption of 6% for all auxiliary engines seems reasonable.]

Table 2. Emission factors found in the IVL 2004 report for average 1999 conditions.

Engine Category	BSFC[1] [g/kW-hr]	HC [g/kW-hr]	CO [g/kW-hr]	NO_X [g/kW-hr]	PM [g/kW-hr]
Medium Speed – Residual Oil (2.4% sulfur)	215	0.2	1.1	14.0	0.5
Medium Speed – Gas Oil (0.6% sulfur)	205	0.2	1.1	13.2	0.2

[1] BSFC is brake specific fuel consumption in g/kW-hr and this estimate is uncertain for the two fuel types.

An alternative control strategy in the California auxiliary engine rule is the use of shoreside power. For the purpose of reducing ozone precursors in the HGB area, shoreside power would be a more effective strategy because a large fraction of all emissions could be reduced. Shoreside power (sometimes referred to as 'cold ironing') is a strategy where the vessel docks and switches their onboard electric load to the electric grid on shore. Typical the time to engage and disengage the shore power is ½ to 1 hour on each end of the dwelling period. Because dwelling times exceed 20 hours for almost all vessels, the shoreside power initiative was modeled to result in 90% control of the dwelling emissions.

[Simplifying assumptions in this analysis were to ignore the dwelling periods that could not feasibly employ shoreside power such as short-term stays where the ships make frequent shifts to other docks or periods of anchorage away from any dock. Most dwelling times exceed 20 hours and the changeover time is considered to occur within less than an hour, so a 90% reduction is considered a reasonable estimate. Also, no estimate was made for the emissions generated from the additional electric power demand to supply the vessel power.]

Cost and Cost-effectiveness

The fuel cost for high and low sulfur fuel were taken from http://www.bunkerworld.com/index_fs.html on March 1, 2006 and indicate that high sulfur fuel costs $323 per metric tonne and low sulfur fuel costs $546.50 per metric tonne. Using equivalent average fuel consumption for the two fuels and the NOx emissions in Table 2, the NOx (ignoring PM or SOx emission reductions) cost effectiveness of using low sulfur fuel is approximately $53,000 per ton of NOx reduced. This estimate does not account for the cost associated with retrofit of vessels that do not currently have alternative tanks onboard for low sulfur fuel.

The cost and cost effectiveness of shoreside power are relatively lower for vessels that make many calls, have high loads while at dock. ENVIRON (2004 and 2005) prepared two shoreside power feasibility studies including the cost of ship retrofit, landside power supply, electricity and other operating costs amortized over a project life of 20 years. These reports detailed cost effectiveness ranging from $9,000 per ton reduced of NOx only for a cohort of cruise ships calling at the same terminal to $500,000 per ton of NOx for an individual smaller OGV vessel calling once a year at a terminal built for that one visit. The upper end estimate would be an extraordinary situation, and for most vessels, the cost would be spread over several ships and many calls, so a more reasonable upper end estimate for cost effectiveness would be less than $100,000 per ton. It is clear from these analyses that the more vessels call at a terminal dramatically improve the cost effectiveness of the measure. While the capital cost of installing shoreside power capability on ships and at terminals is significant, the price of electricity is a critical cost component, which was recognized and recommendations were forwarded that it be subsidized for the Port of Los Angeles and Port of Seattle shoreside power projects.

COMMENTS

The use of shoreside power appears to be potentially a very significant emission control strategy. The simplifying assumptions made in this analysis may overstate the feasibility and potential emission reduction of this strategy because many vessels call too infrequently to justify retrofit costs. The implementation of this measure would need to carefully weigh the need for emission reductions with the incremental cost of including vessel that call infrequently or demand little power while at dock.

The California rule by itself may not reduce NOx emissions much as the mandated fuel switching results in a smaller incremental reduction in emissions at a relatively high cost. The California rule focused on PM reduction with the small NOx reduction a side benefit.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
88	California Auxiliary Engine Rule	Low sulfur fuel	Nonroad; Marine Auxiliary Engines	19 tpd for all auxiliary	6 %	1.1	$50,000 - $60,000
88	Alternative Control Measure	Shoreside power		17 tpd at dock	90%	14.8	$9,000 - $100,000

REFERENCES

ERG and Starcrest (2003), “Improvements to the Commercial Marine Vessel Emission Inventory in the Vicinity of Houston, Texas,” Prepared for the Houston Advanced Research Center (HARC), July 28, 2003.

Starcrest (2000), “Houston-Galveston Area Vessel Emissions Inventory,” Prepared for: Port of Houston Authority and the Texas Natural Resource Conservation Commission, November 2000.

IVL (2004) “Methodology for Calculating Emissions from Ships: 1 Update on Emission Factors,” Prepared for the Swedish Environmental Protection Agency by IVL Swedish Environmental Research Institute, February 2004.

ENVIRON (2004), “Cold Ironing Cost Effectiveness,” Prepared for Port of Long Beach, March 30, 2004.

ENVIRON (2005), “Shoreside Power Feasibility Study for Cruise Ships Berthed at Port of San Francisco,” Prepared for Port of San Francisco, September 13, 2005.

ARB (2005), “2005 Oceangoing Ship Survey Summary Of Results,” California Air Resources Board, September 2005.

Control Measure: California Cargo Handling Equipment Rule, Measure 89
Category: Non-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This measure would reduce emissions by adopting the California Cargo Handling Equipment rule. The measure seeks to reduce emissions from equipment used at ports and rail intermodal terminals. The definition of cargo handling equipment includes There are a number of types of cargo handling equipment including container handling equipment such as top picks and rubber tire gantry cranes and bulk handling equipment which includes tractors, sweepers, fork lifts, and excavators.

Implementation Feasibility

The implementation of the rule assumes that the primary method for complying with the rule will be to turn the fleet over to new equipment/engines meeting more stringent emission standards. However, compliance can be delayed by introducing emissions control devices.

Public Acceptance

The compliance of the rule can be costly because the value of the older equipment (that will no longer be permitted to be used) will be reduced and new equipment must be purchased. The report requirements will be another burden for the owner/operators.

Local communities near these facilities may welcome the introduction of this measure for their local exposure.

ANALYSIS

Analysis of this measure was based on estimates that California provided with the introduction of this rule. The introduction of the rule is expected to result in approximately 25% NOx reduction in 2010 and 50% in 2015. The emission reduction decreases after that as the fleet was expected to turnover regardless of this rulemaking.

Emissions Affected

An estimate of the population of the cargo handling equipment (cranes, top and side picks, and yard trucks) without a clear estimate of the use of other equipment such as excavators used with bulk materials loading. The range of affected emissions was estimated on the basis of the California emission estimates per piece of equipment for cranes, forklifts, top and side picks, and yard trucks. The Port of Houston TEU throughput was used as a ratio to the Port of Long Beach and Port of Oakland equipment population survey results to estimate the equipment population of Port of Houston

Table 1. Cargo handling equipment emission estimates for the Port of Houston.

Port	2005 TEU	2004 TEU	Population Cranes	Forklifts	Picks	Yard Trucks
Oakland	2,272,525		32	57	60	263
Long Beach	6,709,818		89	159	166	728
Houston (estimated)		1,440,478	20	35	37	161
ARB Emissions Level (tpd per piece)			0.006012	0.001164	0.006674	0.005613
Houston (1.3 tpd total)			0.12	0.04	0.25	0.91

This estimate does not include other ports, other equipment types, and rail intermodal facilities but could comprise the majority of the equipment affected by this rulemaking. It is also assumed that there will be some reduction (California estimated about 15% reduction from 2004 to 2009) in emissions (even accounting for growth in activity) from the fleet turnover to equipment meeting more stringent Federal emission standards. So overall this rule will likely affect emissions of 1.5 to 2 tpd.

Emissions Benefit

Using a 25% benefit in the 2009 – 2010 timeframe assumed by ARB, the expected emission reductions are estimated to be approximately 0.4 – 0.5 tons/day NO_x reductions.

Cost and Cost-effectiveness

California estimated that the NOx emission reduction cost effectiveness would be approximately $6,000 per ton in 2009 decreasing to $3,000 per ton in later years of the rule. This is comparable to the fleet modernization costs found in the TERP program, however a mandated rule may entail more costs than a voluntary rule because all equipment (even little used or smaller equipment) will be affected rather than those providing the greatest benefit.

COMMENTS

The primary purpose of the California rule addressing Cargo Handling Equipment was to reduce (diesel) particulate emissions. The NOx reduction is evident when the owner/operator chooses the option to turnover their fleets to those meeting more stringent emission standards of PM and NOx emissions. The rule however allows for owner/operators to retrofit their equipment for PM only. So while the rule will probably result in NOx emission reductions, there is no guarantee that it would.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
89	California Cargo Handling Equipment	Accelerated turnover or retrofits	Nonroad	<2 tpd	25%	0.4 - 0.5	$3,000 - $6,000

REFERENCES

ARB (2005), "Staff Report: Initial Statement Of Reasons For Proposed Rulemaking Regulation For Mobile Cargo Handling Equipment At Ports And Intermodal Rail Yards," State of California Air Resources Board, October 2005.

Control Measure: Expanded Use of TxLED, Measure 90
Category: Off-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This measure would expand the use of Texas Low Emission Diesel fuel (TxLED) to off-road sources not currently mandated to use TxLED. The source categories estimated here for such use includes harbor craft and other smaller marine vessels, and locomotives dedicated to the area.

Implementation Feasibility

For source categories that can move outside the nonattainment area, it can be difficult to demonstrate compliance for the use of TxLED. This may be one reason why marine and locomotive sources were excluded from TxLED use. However, it should be possible to demonstrate voluntary use of the lower emitting fuel though the penetration rate of the fuel's use in these sources could be limited.

Public Acceptance

The use of TxLED is typically considered to be an engineering/technical and a cost/availability issue. For the practical use of TxLED, careful consideration of lubricity and materials compatibility must be investigated, though the California experience has shown that many seemingly intractable problems can be overcome. The cost and availability of the fuel becomes an issue when assuring supply can meet demand preventing price spikes or insufficient fuel available.

ANALYSIS

The analysis of the benefits accounts for the potential emission reduction from the use of TxLED and therefore may overstate the penetration of the fuel into the source categories under consideration.

Emissions Affected

The emissions sources not currently required to use TxLED include harbor craft (listed in Table 1). The Bolivar ferries, operated by TxDOT, are required to use TxLED, but emission credit for its use is included in this evaluation because it is uncertain whether the emission reduction has been credited in the baseline emissions inventory.

Table 1. Harbor craft emissions.

Vessel	Emissions (tpd)
Assist Tugs	2.3
Ferries	1.2
Towboats	9.0
Dredges	0.6
Barge Pumps	1.3
Total	**14.4**

Emissions Benefit

The TxLED benefit is estimated to be 6.8% for engines without an active exhaust gas recirculation system (EGR) from EPA (2001). This benefit was applied (assuming EGR is not employed on any marine engines) to harbor craft emissions assuming half of the Towboat emissions derive from vessels that refuel outside of the HGB area.

ENVIRON estimated based on the EPA (1997) projected fleet turnover and TCEQ supplied 2009 emission inventory that the locally based switching (yard) locomotive engines comprised an estimated 46% of the 21.1 tpd locomotive NOx emissions, or 9.8 tpd.

Therefore, emission reductions with the use of TxLED would be 0.7 tpd of NOx reduction each for marine vessels and locomotives for a total of 1.3 tpd (accounting for rounding error).

Cost and Cost-effectiveness

The cost of TxLED or California diesel typically ranges from 5 to 10 cents more than other diesel fuels (comparing TxLED to nonTxLED areas with similar transportation costs http://www.fleetfueler.com/prices/truckstops.html), though CTR (2005) reported 44 cents per gallon differential between TxLED and conventional diesel. The typical specific fuel consumption for harbor craft and locomotive engines is 0.049 gallons per horsepower-hour and the NOx emission rate can range from about 7 (with controlled engines) to 14 g/hp-hr (for uncontrolled engines). Applying the cost per gallon, specific fuel consumption, emission rate, and 6.8% NOx reduction, the cost effectiveness for TxLED use ranges from $2,000 to $10,000 per ton reduced using the more realistic range of 5 to 10 cents a gallon differential.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
90	Expand TxLED	More use of TxLED	Local Off-road Diesel Engines	19.6	6.8%	1.3	$2,000 - $10,000

REFERENCES

Center For Transportation Research (2005), "Emulsified Diesel Emission Testing, Performance Evaluation and Operational Assessment; Project Extension to Examine an Ultra-Low Sulfur Diesel Fuel: TxLED By Ron Matthews, Rick Baker, Tim DeFries, DK Ezekoye, Matt Hall, Sandeep Kishan, Nick Lownes, Randy Machemehl, Jolanda Prozzi, and Harovel Wheat, Technical Report Number 0-4576-4Research Project 0-4576, July 2005. http://www.utexas.edu/research/ctr/pdf_reports/0_4576_4.pdf

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Control Measure: Parking Cash-Out (Combines aspects of Measures 248, 249, and 470)
Category: On-Road
Author: Eric Schreffler, ESTC and Barbara Joy, Earth Matters Inc

DESCRIPTION

Parking cash-out is a program where certain employers who provide subsidized parking for their employees can offer a cash allowance in lieu of a free or subsidized parking space. California enacted a parking cash-out law after studies showed cash allowances in lieu of parking encourage employees to find alternate means of commuting to work, such as public transit, carpooling, vanpooling, bicycling, or walking. Parking cash-out offers the opportunity to improve air quality and reduce traffic congestion by reducing vehicle trips and emissions. It can also reduce an employer's parking demand and reduce parking costs, which are estimated to be $432 annually per suburban parking space and $1,598 per urban space provided. (Thornton, 2005)

According to the online TDM encyclopedia (http://www.vtpi.org/tdm/tdm8.htm) Don Shoup (1997) found that total vehicle trips declined by 17% after Parking Cash Out was introduced at various urban and suburban worksites, as illustrated in Figure 1 (from the online encyclopedia). These automobile trip reductions tend to increase over time: one employer found that solo commuting continued to decline each year after Parking Cash Out was introduced, as more employees found opportunities to reduce their driving and take advantage of the benefit.

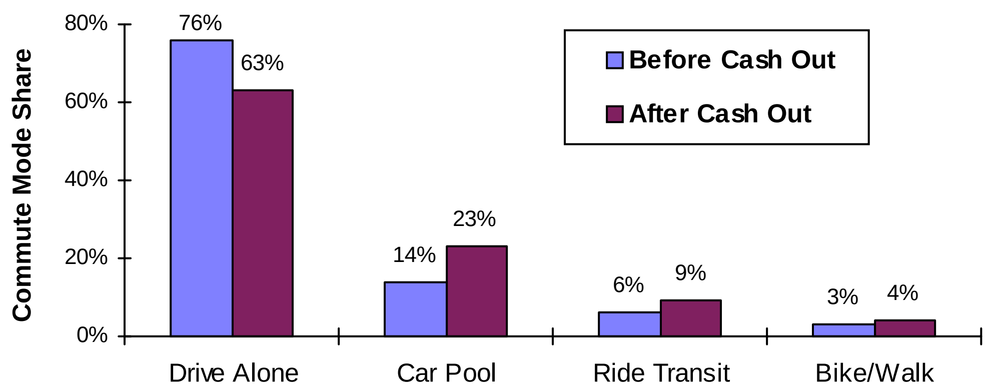

Figure 1. Cashing Out Impacts on Commute Mode (Shoup, 1997).

Parking Cash Out results in reduced automobile commuting and increases in carpooling, transit and non-motorized travel.

In a later report, (Shoup, 2001), Shoup notes that employer-paid parking is the most common tax-exempt fringe benefit offered to workers in the United States, and that 95 percent of American automobile commuters park free at work. He notes that case studies and statistical models suggest that, compared with driver-paid parking, employer-paid parking increases the number of cars driven to work by about 33 percent.

ANALYSIS

At this time there is little data upon which to support an analysis for the Houston-Galveston area. The number of employees who have free or subsidized parking at their worksites is unknown. However, employees who pay all or some of the cost of parking are generally located in Central Houston and the Texas Medical Center. In addition, the precise number of employers who require employees to pay or offer subsidized parking could be eligible for this program is unknown. Parking cash-out tends to work best where employers lease parking for their employees (creating the incentive to participate). For this analysis, the commuters that might be offered parking cash-out are assumed to be located in Central Houston or the Texas Medical Center. This analysis uses a hypothetical example in which 10 percent of downtown and medical center employees are offered a cash payment in lieu of free or heavily subsidized parking. It is also assumed that the results in California are applicable to Houston, since there are no other case studies available. Therefore it is suggested that this analysis not be used as a formal control measure until there is some basis upon which to support a projected emission reduction.

There are a total of 2,757,548 employees projected for the Houston-Galveston region in 2009. In 2004, there were 145,318 employees in Central Houston and 65,300 in the Texas Medical Center. With a growth rate of 3.0% (based on Central Houston, Inc. projections), this would equate to 244,164 employees. If ten percent, or 24,416 of them are provided with parking cash out payments and there is a 13 percent reduction in their drive-alone travel to work, the following emission reductions could be achieved.

Emissions Analysis

The emissions analysis utilized the basic process suggested by the MOSERs methodology, as follows:

Variables:

$\mathbf{EF}_{A}$:	Speed-based composite emission factor after implementation (NO_x, VOC, or CO) grams/mile)
$\mathbf{EF}_{B}$:	Speed-based running composite emission factor before implementation (NO_x, VOC, or CO) (grams/mile)
$\mathbf{N}_{VA}$:	Number of vehicles after implementation
$\mathbf{N}_{VB}$:	Number of vehicles before implementation
$\mathbf{TEF}_{AUTO}$:	Auto trip-end emission factor (NO_x, VOC, or CO) (grams/trip)
$\mathbf{TL}_{A}$:	Average auto trip length after implementation (miles)
$\mathbf{TL}_{B}$:	Average auto trip length before implementation (miles)
$\mathbf{VMT}_{A}$:	Vehicle trips after implementation
$\mathbf{VMT}_{B}$:	**Change in** VMT as a result of implementation

It was assumed that emission factors and trip length before and after implementation are the same. Emissions changes from vehicle trips and associated start emissions are evaluated through the use of composite emission factors and the assumption that access to alternative modes is not through SOV use.

In this analysis $\mathbf{VMT}_B$ is derived by multiplying the number of employees offered parking cash-out (24,416) by their average round trip work length (40.0 miles) and applying a 13 percent reduction for an average of 4 out of 7 days per week (to account for weekends, holidays, vacations, and that few alternative mode users use alternative modes every day; this part of the calculation assures that the estimate is an average daily reduction over any day of the week.

Equation:

Daily Emission Reduction =

$\mathbf{C = VMT_B * EF_A =}$

72,369 * 0.471 gram/mile NOx/454 = 75 lb/day, and 0.036 tpd NOx

and

72,369 * 0.489 gram/mile VOC/454 = 78 lb/day, and 0.039 tpd VOC.

Cost Effectiveness

No data on costs for Houston is available. However, given employer saving on reduced parking lease costs, the cost to employers could be neutral (i.e., cost of the cash out equal or even less than the parking lease cost savings. Depending on program structure, cost per ton could be as low as $0.

COMMENTS

This evaluation is based on hypothetical assumptions and data for this program and may be considered for use in ozone plan after review of key assumptions

SUMMARY OF RESULTS: NO_x

Measure ID	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
248, 249, 470	Parking Cash-Out	Cash-Out for 10% of Central Houston and TMC	On-Road	165.8 tpd	0.02	0.04	Parking cash-out costs equal to or less than employer

		employees					parking lease savings

SUMMARY OF RESULTS: VOC

Measure ID	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
248, 249, 470	Parking Cash-Out	Cash-Out for 10% of Central Houston and TMC employees	On-Road	79.3 tpd	0.05%	0.04	Parking cash-out costs equal to or less than employer parking lease savings

REFERENCES

Shoup, 2001. "Parking Cash Out (Chapters 1 and 22-28 from the manuscript of) The High Cost of Free Parking". Donald Shoup, Chair, Department of Urban Planning Director, Institute of Transportation Studies.

Shoup, 1997. Donald Shoup, "Evaluating the Effects of California's Parking Cash-out Law: Eight Case Studies," *Transport Policy*, Vol. 4, No. 4, 1997, pp. 201-216.

Thornton, 2005. "Beating the Parking Crunch: How to Reduce Traffic, Expand Parking Supply, Save Money and Improve Employer Commutes," *Facilities Management Journal*, May/June 2005, pp. 38-39.

Control Measure: Pay As You Drive Insurance Programs (Measure 277)
Category: On-Road
Author: Barbara Joy, Earth Matters Inc.

DESCRIPTION

Pay-As-You-Drive (PAYD) Vehicle Insurance (also called Distance-Based Vehicle Insurance and Mileage-Based Insurance) is a program whereby a vehicle's insurance premiums are based directly on how much it is driven during the policy term. Driving more causes higher charges and driving less causes lower charges. As noted by (Litman, 2005), this can be done by changing the unit of exposure (i.e., how premiums are calculated) from the vehicle-year or vehicle-mile. Existing rating factors are incorporated so higher-risk motorists pay more per unit than lower-risk drivers. For example, a $375 annual premium becomes 3¢ per mile, and a $1,250 annual premium becomes 10¢ per mile. An average U.S. motorist would pay about 6¢ per mile. Studies based on individual's response to changes in the price of auto use show that significant travel and associated emission reductions can be realized through these programs. Pay As You Drive (PAYD) programs are operating in Oregon, Britain, Holland, Australia, Israel and South Africa with pilot programs operating in other regions such as Dallas.

One major benefit of this and other pricing programs is that it affects all categories of travel. Most measures aimed at reducing travel and associated emissions focus on commute travel, which represents about 25 – 30 percent of total travel in a given region. This measure would affect both commute and non-commute travel.

In 2001 the Texas legislature passed House Bill 45 that allowed Texas insurance companies to offer mileage-based insurance. However this law had a sunset provision and expired in September 2005. Companies in Texas and in all other states can still voluntarily offer the cents-per-mile choice under existing insurance law.

Mileage-based vehicle insurance programs may also to achieve greater cost-balance on a per trip basis with other modes of travel. Traditional vehicle insurance premiums are established as an upfront, fixed cost. Whether the insured drives one mile or one thousand miles in any given month, he or she will pay the same amount of insurance. With a mileage-based insurance program, insured drivers will have a cost-based incentive to reduce unnecessary vehicular travel because their insurance cost will be lowered if they drive less. This will have the effect of reducing VMT, which in turn, yields positive air quality and safety benefits. This is likely to produce net positive equity benefits for low and moderate income individuals.

This analysis evaluates the potential effect of this program were it subscribed to by 50 percent of Houston area drivers. In addition, given that the program has not yet been implemented, the effect is also evaluated at 10 percent and 25 percent of drivers, in addition to presenting a potential maximum scenario in which 90% of drivers participate.

BACKGROUND FOR EMISSION REDUCTION BENEFITS

There have been a number of estimates of the potential benefits of mileage programs and similar programs involving changes in the price of driving. These estimates range from 1.8 to about a

20 percent reduction in driving per individual in the program. The sources of these estimates include:

1. Todd Littman's "*Distance-Based Vehicle Insurance Feasibility Costs and Benefits*", 2001, Victoria Transport Policy Institute;
2. Harvey and Deakin's 1997 Appendix to the report "*Technical Methods for Analyzing Pricing Measures to Reduce Transportation Emissions*" by EPA and FHWA; and
3. Baker and Barrett's "*The feasibility of Pay by the Mile Auto Insurance*", *1999* Economic Policy Institute.

Harvey and Deakin utilized a modified transportation model called the STEP model initially developed for the San Francisco Bay Area to evaluate a variety of pricing measures on driving behavior. The model was applied to four different areas in California, based on 1990 land use and price data. Table B-21 of their appendix[6] contains a list of cents per mile charges and associated percent travel reduction. For example these range from 2.3 to 19.7 percent changes in VMT for mileage fees ranging from one to ten cents for 1991 in Los Angeles.

These values were updated by Todd Littman (see http://www.vtpi.org/tdm/tdm79.htm, Table 1) to account for inflation between 1991 and 2001, as follows:

Table 1. Mileage Fees and Percent Travel Reduction.

Mileage Fee (cents)	Travel Reduction (percent)
1	1.8
2	3.5
3	5.1
4	6.7
5	8.2
6	9.7
7	11.2
8	12.5
9	13.8
10	15.2

While the values were originally developed for California using a transportation model, they may be applicable to other areas. The Appendix written by Deakin and Harvey does not contain details about assumptions regarding elasticities, the number of people subject to a given measure, base prices, base transportation network characteristics and other inputs necessary for replicating the analysis for another area such as Houston. The values are reportedly based on generalized elasticity coefficients that include combined values of travel time, vehicle costs, toll prices, fuel taxes, transit fares, and parking prices. Some researchers quoted by Littman in http://www.vtpi.org/tdm/tdm11.htm such as Lee (2000) estimated the elasticity of vehicle travel with respect to total price (including fuel, vehicle wear and mileage-related ownership costs, tolls, parking fees and travel time, which is equivalent to generalized costs) is –0.5 to –1.0 in the short run, and 1.0 to –2.0 over the long run. The project team found that the Harvey Deakin estimates were equivalent to a price elasticity of 0.4, which is slightly below the lower range noted above by Lee ("Demand Elasticities for Highway Travel," *HERS Technical Documents*,

[6] Greig Harvey and Elizabeth Deakin, "The STEP Analysis Package: Description and Application Examples," Appendix B, in Apogee Research, *Guidance on the Use of Market Mechanisms to Reduce Transportation Emissions*, USEPA (Washington DC; www.epa.gov/omswww/market.htm), April 1997

FHWA (www.fhwa.dot.gov), 2000). However it is in line with the average long term elasticity of demand with respect to gasoline price of 0.3.

ANALYSIS AND RESULTS

The methodology uses the cents per mile changes noted by Littman (2001) and quoted in Table 1 above.

Assumptions include the following:

- Emission factors for MOBILE6 for 2009 are used;
- Insurance prices observed in 2001 are applicable to 2009 on a cent per mile basis;
- Only light duty passenger vehicles are affected by the program – delivery vehicles, line haul trucks and the like are not;
- Daily light duty vehicle miles traveled in 2009 for the H-GAC nonattainment area are 135,673,516.
- NOx emission factor for light duty vehicles is 0.471 grams per mile;
- VOC emission factor for light duty vehicles is 0.489 grams per mile;
- VOC and NOx emissions include all categories of emissions, including start, tailpipe, evaporative, running loss, etc.

All results are expressed as tons per day reduction and percent of total on-road vehicle emissions reduced.

According to http://www.carinsurance.com/state/Texas-car-insurance.aspx, the average Texas vehicle insurance was $932 per year in 2003. No later data is available nor is there any reliable way to project future insurance costs so we evaluated the cents per mile for this annual auto insurance price. At the average driving rate of 12,000 miles per year[7], this cost is effectively 7.8 cents per mile. For the purpose of simplicity this value is rounded to 8 cents per mile.

In a PAYD program a non-driver who never drove would not pay anything for insurance. If a program were structured such that the average of 8 cents per mile was charged for driving through insurance prices, according to Table 1, this per mile charge would result in a 12.5 percent reduction in VMT for each participant. If 100 percent of drivers in the H-GAC nonattainment area were insured through a PAYD program structured to achieve an 8 cents per mile charge and all of them participated in the program, light duty driving in the region would drop by about 12.5 percent (out-of-area drivers such as tourists, delivery vehicles and emergency vehicles would presumably not change their behavior). This analysis assumes that changes in driving behavior would be limited to light duty vehicles only. This assumption is made because the majority of medium and heavy-duty travel is for business purposes and is more sensitive to demand than to a pricing incentive such as insurance.

[7] According to the 2001 National Personal Transportation Survey (http://nhts.ornl.gov/2001/html_files/trends_ver6.shtml) national average vehicle miles are 11,186 miles per year per vehicle. This value was calculated by dividing total household vehicle miles traveled by total household vehicles. Based on comments from reviewers of this report, who expected annual miles driven to be somewhat higher, a more typically used value of 12,000 miles is used in these calculations.

Of course, it is not reasonable to assume that 100 percent of insured would participate initially; therefore a range of participation is considered, as shown in Table 2, below. It should also be noted that estimates of light duty vehicle emissions in the Houston area assume that some driving and related emissions is by vehicles from out of the area.

Total light duty travel in 2009 is estimated by the H-GAC transportation model to be 135,673,516 for one of the August episode days.

Table 2. Estimated VMT, NOx and VOC Reductions Possible For A Range of Participation Rates Using a "Cent-per-Mile" charge approach (2009).

Participation (percent of drivers)	Daily VMT Reduction	NOx Reduction (tons per day)	VOC Reduction (tons per day)
10	1,695,919	0.88	0.9
25	4,239,797	2.2	2.3
50	8,479,595	4.4	4.6
90*	15,263,271	7.9	8.2

*90% is assumed to be the maximum with the other 10% being out-of-region vehicles and emergency vehicles that cannot change their driving behavior in response to insurance price.

As the results show, such a program can achieve significant benefits when implemented on a broad scale.

It is important to note that these results are based upon a transportation model developed for different areas of the United States with different circumstances, prices, population, land use, geographic characteristics and assumptions that may or may not apply in this case. However that model has been adapted for use in other areas of the country and has estimated similar results for these other areas.

Cost Effectiveness

PAYD insurance programs may actually produce a net savings in money, meaning they are exceptionally cost effective. No data on the cost of these programs was found, with the exception that the state of Oregon provides a $100 tax credit for each policy applying PAYD principles. However there is believed to be a significant cost savings with these programs because of reduced accident rate. According to a May, 2003 the Environmental Defense Fund letter to the Senate Environment and Public Works Committee regarding the reauthorization of ISTEA, recent research suggests that PAYD insurance is likely to save consumers money while cutting air pollution and traffic congestion by 10% or more and accidents by up to 15%. A recent study by the Federal Highway Administration showed that by converting fixed motorist costs of car insurance, taxes, and fees to variable costs that allow motorists to save money if they drive less, consumers would save billions of dollars a year and experience substantially less traffic delay.

In summary it is expected that cost effectiveness will be less than $4,000/ton, which is the highest ranking for cost effectiveness.

COMMENTS

This evaluation is based on a combination of hypothetical assumptions and data for this program and may be considered for use in ozone plan after review of key assumptions, expected emission reductions and potential implementation approaches. If amore refined analysis is conducted it may provide additional accuracy to evaluate the measure based on price elasticities and estimates of expected costs per mile for driving.

Also key is that the emission factors used in the analysis are emission factors with currently programmed federal and other control measures such as Tier 2 tailpipe standards. Other measures are being evaluated for the H-GAC region, such as California LEV (low emission vehicles), cleaner fleets and wider application of the Inspection and Maintenance program. If these or other similar programs were implemented, the emission factors used to evaluate programs affecting the amount of travel (such as this one) would be smaller – each mile driven would be at a lower emission rate and therefore each mile not driven would not reduce emissions as much as it would have without the additional measures.

SUMMARY OF RESULTS: NO_x

Measure ID	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
277	Pay-As-You-Drive (PAYD) Insurance	PAYD participation at 50 percent of LDV activity	On-Road	165.8 tpd	2.7	4.4	<$4,000

SUMMARY OF RESULTS: VOC

Measure ID	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
277	PAYD Insurance	PAYD participation at 50 percent of LDV activity	On-Road	79.3 tpd	5.8%	4.6	<$4,000

Control Measure: Reduced Average Speeds, Measures 300, 304 and 312
Category: On-road
Author: John Grant, ENVIRON

DESCRIPTION

This measure would seek to reduce average speeds by increase enforcement of current speed limits. However to determine the emission reduction potential, the average speed was reduced to no higher than 55 mph for all vehicles. For on-road vehicles, especially heavy-duty diesel trucks, emissions vary significantly as a function of vehicle speed. As shown in Table 1, MOBILE6 estimates that heavy-duty diesel trucks emit more NOx at higher speeds than they do at lower speeds. Light-duty vehicles follow the same trend as well, but to a lesser extent. For purposes of analysis, this measure was assumed to consist of setting an HGB area-wide average speed of no higher than 55 mph.

Table 1. NOx and VOC emission factors as predicted by MOBILE6.

	NOx				VOC			
SPEED (mph)	LDGV (g/mile)	LDGT34 (g/mile)	HDGV (g/mile)	HDDV (g/mile)	LDGV (g/mile)	LDGT34 (g/mile)	HDGV (g/mile)	HDDV (g/mile)
5	1.368	2.134	2.498	14.644	3.527	5.277	5.819	1.296
15	0.727	1.257	2.751	10.9	1.44	2.376	2.601	0.817
25	0.725	1.27	3.004	9.243	1.141	1.986	1.81	0.562
35	0.713	1.268	3.257	8.84	1.024	1.818	1.491	0.422
45	0.729	1.295	3.51	9.507	0.955	1.73	1.33	0.346
55	0.75	1.329	3.764	11.555	0.9	1.646	1.24	0.31
65	0.773	1.369	4.017	16.046	0.863	1.579	1.211	0.303
Reduction from 65 to 55	-3%	-2.9%	-6.3%	-28%	4.3%	4.2%	2.4%	2.3%

Implementation Feasibility

The measure could be feasible, as speed reduction measures are often implemented in metropolitan areas in the U.S. However, the effectiveness of the measure would depend on the level of program enforcement.

Public Acceptance

This measure would require slower travel speeds and longer trip times. However, public safety could be strengthened as a result of lower traveling speeds, possibly reducing accident frequency and/or severity.

ANALYSIS

This measure was analyzed by comparing the emissions associated with estimated average speeds by roadway and vehicle type and estimated speed distributions assuming a maximum area-wide average speed of no higher than 55 mph (i.e. reducing average speeds that exceeded

55 mph to 55mph). The EPA MOBILE6 model was run for Harris County at average freeway speeds from 55 mph to 65 mph. An emission reduction of 3.9 tpd NOx and an emissions increase of 0.1 tpd VOC were estimated based on the ratio of MOBILE6 emissions associated with an maximum average speed of 55 mph and average unmodified HGB speeds. A compliance rate of 50% was assumed.

Emissions Affected

The emissions affected include onroad emissions on toll roads and interstates (20 tpd VOC and 53 tpd NOx) (TTI, 2005).

Emissions Benefit

Estimated emission reductions for the area wide speed reduction measure are shown in Table 2. About 90% of the benefit is derived from heavy-duty vehicle speed reduction. The speed reduction was assumed to be 20% of the benefit of lower maximum speeds to no higher than 55 mph.

Table 2. NOx and VOC emission reductions.

Condition	VOC (tpd)	NOx (tpd)
Speed reduction for all vehicles in all 8 counties	<-0.1	0.8
Speed reduction for heavy-duty only in all 8 counties	0.0	0.7
Speed reduction for all vehicles in Harris County only	<-0.1	0.38
Speed reduction for heavy-duty only in Harris County only	0.0	0.34

Cost and Cost-effectiveness

The primary cost of this measure would be enforcement and signage. According to www.salary.com, the average salary for a highway patrol officer in the U.S. is about $41,000. Including fringe benefits, $100,000 annual cost was assumed for a highway patrol officer. If ten additional highway patrol officers were added to the HGB to more aggressively enforce the current speed limit, annual costs for would be $5,000,000.

Based on annual costs and emission reductions, a cost effectiveness of $3500 tons per day NOx is estimated for this measure. VOC emissions are estimated to increase, therefore, cost effectiveness was not estimated for VOC.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
300, 304, 312	Reduced Maximum Speeds	Lower maximum speeds by increased enforcement	On-road	20 VOC, 53 NOx	0% VOC, 1.5% NOx	0 VOC, 0.8 NOx	$3500 NOx

REFERENCES

TTI (2005), "2002, 2009, and 2012 Emissions Inventories for the Houston/Galveston Eight-Hour Nonattainment Counties", Texas Transportation Institute, August 2005.

Control Measure: Reduced Transit Fares, Measure 371
Category: On-Road
Author: Barbara Joy, Earth Matters, Inc.

DESCRIPTION

Transit fare decreases can increase transit ridership, and encourage some individuals who are currently driving their own vehicles to use transit for some travel. This switch reduces vehicle miles of travel and air pollution emission associated with this travel.

The transit system in the Houston area is run mostly by Metro; some service is provided by other agencies and often coordinated through the efforts of local transportation management associations. Metro provides local bus, express bus, Commuter bus, trolley services in the Texas Medical Center, and rail services for the Houston area. Statistics on the Metro system were provided by H-GAC for 2005 are as follows:

2005 daily average transit ridership (weekday)

Local bus	267,600
Express bus	21,550
Commuter bus	35,900
Rail	39,450
Total	**364,500**

The fare structure varies depending on the system, on the travel zone (there are 4), and whether the fare is paid per use, or as a daily, weekly (METRORail), monthly or annual pass. METRORail fares are $1 (daily pass is $2). Commuter route fares range from $.60 to $1.50 for zone 1; $1.10 - $2.50 for zone 2; $1.25 to $3.00 for zone 3; and $1.45 - $3.50 for zone 4. Transfers between systems (eg from express bus to rail) are allowed with a valid transfer (good for three hours). Annual passes range from $$459 for zone 1 to $990 for zone 4, bringing the cost of a round-trip ride (assuming riders use transit 260 days per year, which is all weekdays or a combination of weekdays and weekends), to between $1.76 (zone 1) and $3.80 (zone 4). This analysis utilizes a change in the daily fares for evaluation purposes. If the measure is deemed to merit additional review, a range of fare decreases based on the amount of ridersip from each zone and for each fare structure (percent using daily, monthly or annual passes) would be evaluated. For the purpose of determining whether this measure results in significant enough emission benefits at a reasonable cost, the use of daily fares is sufficient.

METHODOLOGY AND EMISSIONS ANALYSIS

Assessing the effect of reduced transit fares on travel can be accomplished using transit elasticities. Elasticities are an economic measure of the percentage change in use of a good or service given a percentage change in another variable such as price. A demand elasticity is expressed as the amount demand for a good will change given a percentage change in price. For example a demand elasticity of .5 tells us that a 10% change in price would lead to a 5% change in demand. Transit use can increase for changes in variables such as transit service and transit fares. Transit use is most elastic with respect to transit service and then transit fare. However, transit use alone is not necessarily a measure of a corresponding decrease in vehicle travel. For example, according to (Litman, 2005), transit use has a low-end short-term elasticity of .2 for transit use with respect to fare, and a low-end short-term elasticity of .03 of auto use with respect to fare. What this means is that a 50 percent decrease in transit fares would be expected to increase transit use by 10 percent but only a 1.5 percent decrease in auto use. This difference is due to the fact that the decreased transit fares will attract many non-vehicle owners and drivers while also convincing a few vehicle drivers to switch from their car to transit at least some of the time.

The emissions analysis uses the following key variables:

- ✓ The current transit use is 364,500 people per day.
- ✓ The current fare averages $2.62 per trip[8].
- ✓ The commuter route fares are lowered to $1.44 (the average annual fare for a person using service twice per day 260 days per year). Fares for other transit services such as METRORrail are decreased by the same percent.
- ✓ The percentage change in fare is 45 percent.
- ✓ The high range short-term elasticity of auto use with respect to transit fare is used. It is .1. If the program operates for three years before emission benefits are estimated, a longer range elasticity should be used. The long range elasticity of auto use with respect to transit fares ranges from .15 to .3.
- ✓ The average trip distance is 15 miles (work trips are 20 miles and non-work trips are generally around 10 miles)
- ✓ For this analysis,
- ✓ Average light duty vehicle composite emission factor for NOx for same day is 0.471 grams per mile
- ✓ Average light duty vehicle composite emission factor for VOC for same day is 0.489 grams per mile

The following utilizes the basic process suggested by the MOSERs methodology, as follows:

Variables:	**EF_A:**	Speed-based composite emission factor after implementation (NO_x, VOC, or CO) grams/mile)
	EF_B:	Speed-based running composite emission factor before implementation (NO_x, VOC, or CO) (grams/mile)
	VMT_A:	Average Daily Change in VMT as a result of decreased transit fares = Current daily transit ridership * average trip distance * % change in fare * elasticity of auto use with respect to transit fare = 364,500 * 15 * .45 * .1 = 164,025.

It is assumed that emission factors and trip length before and after implementation are the same. Emissions changes from vehicle trips and associated start emissions are evaluated through the use of composite emission factors.
In this analysis **VMT_A** was derived above.

[8] This is based on a simple average of standard commuter route fares for the 4 zones.

Equation:

Daily Emission Reduction =

$\mathbf{C = VMT_A * EF_A =}$

164,025 * 0.471 gram/mile NOx/453.6 = 170.3 lb/day, and 0.085 tpd NOx

and

164,025 * 0.489 gram/mile VOC/453.6 = 176.8 lb/day, and 0.09 tpd VOC.

Cost Effectiveness

If current ridership is 364,500, revenues from fares are approximately (using the assumptions above) are $954,990/day, or 348.5 million a year. With the new fares the ridership would increase by approximately 16,402 people per day, to a total daily ridership of 380,902. Fares at this ridership are $548,499 a day, or about 200 million per year. The phase 2 implementation plan calls for 2 billion over ten years, or roughly 200 million per year. Assuming that this funding is allocated to the new ridership in proportion to the increase over 2005 ridership, funding for this fare decrease (along with any needed change in transit service to accommodate the new ridership) would be 9 million/year.

Total annual costs are $209 million and total annual emission reductions of NOx are 31 tons per year cost effectiveness is 6.7 million dollars per ton.

COMMENTS

This evaluation is based on hypothetical assumptions and data for this program and may be considered for use in ozone plan after review of key assumptions.

Also key is that the emission factors used in the analysis are emission factors with currently programmed federal and other control measures such as Tier 2 tailpipe standards. Other measures are being evaluated for the H-GAC region, such as California LEV (low emission vehicles), cleaner fleets and wider application of the Inspection and Maintenance program. If these or other similar programs were implemented, the emission factors used to evaluate programs affecting the amount of travel (such as this one) would be smaller – each mile driven would be at a lower emission rate and therefore each mile not driven would not reduce emissions as much as it would have without the additional measures.

SUMMARY OF RESULTS: NO_x

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	

371	Decreased transit fares	45% decrease in transit fares	On-Road	165.8 tpd	0.05	0.08	>$14,000

SUMMARY OF RESULTS: VOC

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
371	Decreased transit fares	45% decrease in transit fares	On-Road	79.3 tpd	0.1	0.09	>$10,000

Control Measure: Personalized Transit, Measures 376,403,407,484, 426 and 441
Category: On-Road
Author: Barbara Joy, Earth Matters, Inc.

DESCRIPTION

Among the major obstacles to transit use are limitations in service between residential and employment areas. If transit service were designed specifically for certain residential areas to highly used but somewhat underserved employment areas, transit use could increase substantially. An example of such a service would be between the Katy area to downtown areas such as the Texas Medical Center.

There are number of potential services that could assist in transit use between such area, including personalized rapid transit, subscription bus service, business first buses, easier access between Metro and other services such as those provided by TREK (such as a universal card), and personalized transit planning. Because time spent in traffic, along with rising gas, maintenance and parking costs, can be so significantly offset by using an alternative mode such as transit there is likely some pent-up or latent demand for transit service that specifically serves individuals. For example, personalized transit planners, somewhat like personal shoppers, could assist individuals by showing them how to easily use transit from one point to another (such as home to work, work to lunch spots or meeting locations, and work to home). Such a service could even be provided online. In addition, some buses could be equipped with fold-down tables and wireless internet connections (for example through cell-phone companies) so that people could work while on the buses, and feeder shuttles could bring people from transit stops directly to work centers.

This measure evaluates the benefits of a hypothetical and ambitious program that provided these services. It is assumed that 100 new business buses (buses equipped with fold-down tray tables and wireless internet) seating 35 people each providing service directly from neighborhoods to specific work locations would operate four trips per morning and four per evening. Service would also be augmented by the addition of 100 shuttle buses to provide service between current Metro stops and (1) under-served residential areas too far from transit centers or park and ride lots to utilize them; and (2) employment areas in downtown Houston which currently do not have sufficient transit access. The shuttle buses are assumed to seat 15 people each and operate six trips each morning and six each evening. For the purpose of simplicity it is assumed that currently planned expansions to Metro service would accommodate the extra ridership created by the shuttle services. If this measure results in emission significant enough to merit further review, this assumption, along with the others would need to be refined.

METHODOLOGY AND EMISSIONS ANALYSIS

This analysis is based upon the hypothetical scenario described above and an assumption that after a year of marketing, the development of an easy-to-use internet personal planning site, and fine-tuning the routes that the vehicles will be 80% full on an average day.

The emissions analysis uses the following key variables:

- ✓ There are 100 buses seating 35 people operating four round trips (per person) per day; at 80% capacity this is equivalent to 11,200 people per work day;
- ✓ There are 100 shuttle buses seating 15 people operating 6 round trips (per person) per day; at 80% capacity this is equivalent to 7,200 people per work day.
- ✓ It is assumed that 100% of shuttle use is due to new transit users who did not previously use transit because it did not provide a viable way to their place of employment or their home.
- ✓ The average work trip distance is 40 miles round trip
- ✓ The business buses travel 40 miles for each round trip, or 160 miles each day per bus; new emissions due to these buses is therefore based upon an average weekday mileage of 16,000 miles.
- ✓ The shuttle buses are assumed to travel 10 miles per round trip, or 60 miles per day per shuttle; new emissions due to the shuttles is therefore based upon an average weekday shuttle mileage of 6,000 miles.
- ✓ Average light duty vehicle composite emission factor for NOx for same day is 0.471 grams per mile
- ✓ Average light duty vehicle composite emission factor for VOC for same day is 0.489 grams per mile.
- ✓ Average shuttle bus emissions are represented by the MOBILE6 category LDDT12 and are 2.68 grams per mile of NOx and 2.56 grams per mile of VOC.
- ✓ Average transit bus emissions are represented by the MOBILE6 HDDBS category and are 9.83 grams per mile NOx and .57 grams per mile VOC.

The following utilizes the basic process suggested by the MOSERs methodology, as follows:

Variables:

EF_A: Speed-based composite emission factor for passenger vehicles (NO_x, VOC, or CO) grams/mile)

EF_B: Speed-based running composite emission factor for transit vehicles (NO_x, VOC, or CO) (grams/mile)

VMT_A: Average Daily Change in passenger VMT as a result of increased transit service

VMT_B: Average Daily Change in transit vehicle VMT as a result of increased transit service

Emissions changes from vehicle trips and associated start emissions are evaluated through the use of composite emission factors.

In this analysis

VMT_A is 18,400 new transit users * 40 mile average round trip work distance = 736,000 miles per weekday.

VMT_B is SUM(VMT for business buses and VMT for shuttle buses) = 22,000 miles/day.

Equation:

Daily Emission Reduction from passenger vehicles =

C = VMT_A * EF_A =

736,000 * 0.471 gram/mile NOx/453.6 = 764.2 lb/day, and 0.4 tpd NOx

and

736,000 * 0.489 gram/mile VOC/453.6 = 793.4 lb/day, and 0.4 tpd VOC.

<u>Daily emission increase from increased transit vehicles</u>

= 16,000 * 9.83 gram/mile NOx = 347 lb/day and .17 tpd NOx;
16,000 * .569 gram/mile VOC = 20 lb/day and 0.01 tpd VOC

and 6,000 * 2.68 gram/mile NOx = 35 lb/day and 0.02 tpd NOx. Total NOx increase is 0.19 tpd NOx.

= 6,000 * 2.56 gram/mile VOC = 33.9 lb/day and 0.02 tpd VOC. Total VOC increase is 0.03 tpd.

The *net* emission decrease is 0.21 tpd NOx and 0.37 tpd VOC.

Cost Effectiveness

Costs of the program are estimated based upon hourly fees paid to transit vehicle leasing companies used in Houston such as AFC. Based on a conversation with Trek, these costs are $54.85/hour to cover the driver, the vehicle and other costs such as fuel and insurance. Both the business buses and the shuttles would operate from 4:30am to about 8 pm to provide the number of round trips described, or about 16 hours per day. At 260 weekdays per year the gross cost will be $45,635,200/year before marketing and administration. Because of the convenience of the business buses, it is assumed that each rider would pay a round-trip fare of $5 and that shuttle riders would pay a round-trip fare of $2. Therefore fare revenue would be $18,304,000. It is possible that additional revenue could be generated by selling ad space on the interior walls of the buses and shuttle vehicles. This is not currently done in the Houston area but is in many other urban areas and can be a significant source of revenue. For this analysis it is assumed that no advertising revenue would occur and that marketing/internet costs are insignificant compared with the operation of the vehicles. Therefore net costs are $27.3 million dollars per year.

Annual NOx benefits are 54.6 tons. Cost effectiveness is $500,000/ton.

COMMENTS

This evaluation is based on hypothetical assumptions and data for this program and may be considered for use in ozone plan after review of key assumptions.

Also key is that the emission factors used in the analysis are emission factors with currently programmed federal and other control measures such as Tier 2 tailpipe standards. Other measures are being evaluated for the H-GAC region, such as California LEV (low emission vehicles), cleaner fleets and wider application of the Inspection and Maintenance program. If these or other similar programs were implemented, the emission factors used to evaluate programs affecting the amount of travel (such as this one) would be smaller – each mile driven would be at a lower emission rate and therefore each mile not driven would not reduce emissions as much as it would have without the additional measures.

SUMMARY OF RESULTS: NO_x

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
376,403, 407,484	Personalized Transit	Business buses, shuttle services, personalized transit	On-Road	165.8 tpd	0.1	0.21	$500,000

SUMMARY OF RESULTS: VOC

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
376, 403, 407, 484	Personalized Transit	Business buses, shuttle services, personalized transit	On-Road	79.3 tpd	0.5	0.37	Not calculated for VOC.

Control Measure: Compressed Work Week, Measures 459 and 435
Category: On-Road
Author: Barbara Joy, Earth Matters, Inc.

DESCRIPTION

Compressed work weeks are among the most effective of transportation demand management measures. Many Houston area employers currently already have compressed work week programs. The way most programs work is that employees either have a 4/40 schedule or a 9/80 schedule. A 4/40 schedule means they work four ten-hour days per week and have one day off. A 9/80 schedule means the employees work 9 hours a day and take one day off every two weeks. Most programs operate on a 4/40 schedule.

Currently the H-GAC alternative work schedules program, which operates under the umbrella of the Commute Solutions program helps employers implement several measures including telecommuting, carpooling, vanpooling, alternative parking and compressed work weeks. A program specifically aimed at increasing the amount of compressed work weeks through a mandatory program is not currently in place but could be implemented as a part of the overall ozone attainment plan.

Approach and Associated Assumptions

The purpose of this analysis is based upon the need to determine what programs, if implemented in a highly ambitious manner, might yield sufficient emission reductions to be further considered for inclusion in the 8-hour ozone attainment plan. The analysis presented here explores the potential effects of a focused and mandatory compressed work week program targeting 20 percent of Houston area employees for a 4/40 program.

EMISSIONS ANALYSIS

There are a number of variables important for evaluating the emission benefits of this measure. These are as follows:

- ✓ Total employment projected by H-GAC for 2009 is 2,757,548. The above-cited figure of 20% would be 551,510 employees.
- ✓ The average round trip work distance for Houston area employees is 40 miles.
- ✓ Average light duty vehicle composite emission factor for NOx for same day is 0.471 grams per mile.
- ✓ Average light duty vehicle composite emission factor for VOC for same day is 0.489 grams per mile.

The emissions analysis utilized the basic process suggested by the MOSERs methodology, as follows:

Variables: **EF_A:** Speed-based composite emission factor after implementation (NO_x, VOC, or CO) grams/mile)

EF_B: Speed-based running composite emission factor before implementation (NO_x, VOC, or CO) (grams/mile)

VMT_B: **Change in** vehicle miles traveled as a result of implementation = number of compressed work week employees * round trip distance * 1/5 (one day every 5).

It was assumed that emission factors and trip length before and after implementation are the same. Emissions changes from vehicle trips and associated start emissions are evaluated through the use of composite emission factors.

Equation:

Daily Emission Reduction =

C = VMT_B * * EF_A =

4,412,080 * .471 gram/mile NOx/453.6 = 4,581 lb/day, and 2.3 tpd NOx

and

4,412,080 * 0.489 gram/mile NOx/453.6 = 4,756 lb/day, and 2.4 tpd VOC.

COMMENTS

This evaluation is based on hypothetical assumptions and data for this program and may be considered for use in ozone plan after review of key assumptions. The feasibility of achieving a 20% participation rate from all Houston area employees has not been studied. Cross effects of a 20% compressed work week share on alternative modes such as transit, vanpooling and ridesharing have not been evaluated. Therefore if all these programs were implemented, emission benefits could not simply be added up without some accounting for the relationships between the programs.

Also key is that the emission factors used in the analysis are emission factors with currently programmed federal and other control measures such as Tier 2 tailpipe standards. Other measures are being evaluated for the H-GAC region, such as California LEV (low emission vehicles), cleaner fleets and wider application of the Inspection and Maintenance program. If these or other similar programs were implemented, the emission factors used to evaluate programs affecting the amount of travel (such as this one) would be smaller – each mile driven would be at a lower emission rate and therefore each mile not driven would not reduce emissions as much as it would have without the additional measures.

Cost Effectiveness

Costs for this hypothetical program are not known. Costs to employers should be minimal and benefits in the form of decreased turnover, reduced parking demand, and possibly fewer sick days would be expected to offset costs. Current outreach/advertising and marketing costs for the Commute Solutions program are $2.5 million annually. It is assumed that all of this budget could be spent on marketing and outreach related to implementing this mandatory program, or that additional funds be made available so that this amount would be available on an annual basis.

Annual NOx emission benefits are daily benefits * 260 workdays per year, or 598 tons per year. This would result in an estimated cost effectiveness of $4,181 per ton.

COMMENTS

This evaluation is based on hypothetical assumptions and data for this program and may be considered for use in ozone plan after review of key assumptions.

Also key is that the emission factors used in the analysis are emission factors with currently programmed federal and other control measures such as Tier 2 tailpipe standards. Other measures are being evaluated for the H-GAC region, such as California LEV (low emission vehicles), cleaner fleets and wider application of the Inspection and Maintenance program. If these or other similar programs were implemented, the emission factors used to evaluate programs affecting the amount of travel (such as this one) would be smaller – each mile driven would be at a lower emission rate and therefore each mile not driven would not reduce emissions as much as it would have without the additional measures.

SUMMARY OF RESULTS: NO_x

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
435, 459	Compressed Work Week Mandate	20% of area employees on a 4/40 schedule	On-Road	165.8 tpd	1.4	2.3	$4,181

SUMMARY OF RESULTS: VOC

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
435, 459	Compressed work week Mandate	20% of area employees on a 4/40 schedule	On-Road	79.3 tpd	3.0	2.4	Not calculated for VOC

Control Measure: Internet Ridematching Services, Measures 461, 503, and 504
Category: On-Road
Author: Barbara Joy, Earth Matters, Inc.

DESCRIPTION

A new H-GAC ridesharing program was kicked off in August of 2005 which utilizes computer-based methods similar to other online travel programs such as Travelocity. The program is internet based and uses the consultant NuRide, Inc. (http://www.nuride.com), the nations first incentive-based rideshare network.

NuRide's innovative online program lets individuals use NuRides patent-pending technology to find the ideal partner with whom to share a single ride for work or pleasure. Subscribing to the philosophy that people sharing rides provide a valuable service to their community, NuRide offers its members rewards each time they use the ridesharing program. By accumulating "NuRide Miles," members earn enough points to acquire gift cards and gift certificates from a variety of corporate sponsors such as Old Navy, TGI Fridays, Macy's and many other familiar retailers and restaurants.

The new program provides incentives to ridesharers to carpool that are significant enough to have made the program grow to nearly 2,500 ridesharers after only three months of operation. The incentives mentioned above earn points at dozens of participating retailers. Points are only earned when, for each ridesharing day a ridesharer matches themselves with an online carpool and fills out a survey form (all ridesharers must fill out the survey or none will receive credit). Other incentives are the ease and convenience, as well as a "cool factor".

The program tracks miles in the carpools by all riders except the driver. In the first quarter of operation the program removed 459,386 miles from Houston roadways and it is highly likely the program will exceed its goal of removing two million miles for its first year. If two million miles a year are reduced, this is equivalent to 5,479 miles a day (because the program is used for work and non-work trips it is assumed to operate 365 days a year rather than only on weekdays). Actually the first quarter results are achieving an approximately 5,100 miles per day reduction which is already quite close to the annual goal.

Approach and Associated Assumptions

This analysis is based upon the hypothetical assumption that the NuRides program recruits 100,000 regular ridesharers who carpool an average of two round trips per week at an average trip distance of 15 miles.

The NuRides program directly tracks all the key variables for estimating the VMT reductions and emission benefits of a ridesharing program. These include

1. The number of ridesharers;
2. Miles of carpooling;
3. Miles driven by the carpool driver and
4. Frequency of ridesharing.

The program allows ridesharing for both work and non-word trips, which provides an increase in benefits over programs that simply affect work trips.

EMISSIONS ANALYSIS

The emissions analysis utilized the basic process suggested by the MOSERs methodology, as follows:

Variables:

EF_A:	Speed-based composite emission factor after implementation (NO_x, VOC) grams/mile)
EF_B:	Speed-based running composite emission factor before implementation (NO_x, VOC) (grams/mile)
TEF_{AUTO}:	Auto trip-end emission factor (NO_x, VOC) (grams/trip)
VT_B:	Number of new carpoolers.
AVR:	Average vehicle ridership in carpools
TL_B	Trip Length

It was assumed that emission factors and trip length before and after implementation are the same. Emissions changes from vehicle trips and associated start emissions are evaluated through the use of composite emission factors and the assumption that access to the carpool is not through SOV use.

Equation:

Daily Emission Reduction =

$C = VT_B * ((AVR-1)/AVR) * TL_B * 2 * Frequency * EF_A =$

100,000 * 0.6 * 15 * 2 * 2/7 * 0.471 gram/mile NOx/453.6 = 534 lb/day, and 0.27 tpd NOx

and

100,000 * 0.6 * 15 * 2 * 2/7 * 0.489 gram/mile VOC/453.6 = 554 lb/day, and 0.28 tpd VOC

Cost Effectiveness

The NuRides budget for 2005 – 2006 fiscal year was $400,000. Since the program includes many start-up costs, economies of scale are expected for future years so that a budget of 1.5 million is expected to be sufficient to achieve the 100,000 ridesharer goal that was evaluated above. Since the emission benefits were estimated for an average day (as opposed to an average weekday), the annual benefits are 98.55 tons and the cost effectiveness for NOx would be $15,220 per ton.

COMMENTS

This evaluation is based on hypothetical assumptions and data for this program and may be considered for use in ozone plan after review of key assumptions.

SUMMARY OF RESULTS: NO_x

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
461,503, 504	Internet ridemat-ching	100,000 twice per week carpoolers	On-Road	165.8 tpd	0.16	0.27	$15,220

SUMMARY OF RESULTS: VOC

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
461,503, 504	Internet ridemat-ching	100,000 twice per week carpoolers	On-Road	79.3 tpd	0.35	0.28	Not calculated for VOC

Control Measure: Vanpooling, Measures 462, 463, and 496
Category: On-Road
Author: Barbara Joy, Earth Matters, Inc.

DESCRIPTION

H-GAC's vanpooling program consists of ongoing efforts by METRO and a newer effort called "miniPOOL" to recruit vanpoolers. The program began operation in 1996 and is funded using Surface Transportation Program (STP) funds, METRO local funds and employer incentives, which provide reduced monthly costs to participating employees. As of December 2005 the vanpool program had 508 vans and 5,874 vanpoolers, with an average of 11.6 riders per van. The miniPOOL program vanpoolers average 67.7 miles per day (round trip). The METRO vanpoolers are believed to average more but no data was provided on their activity; therefore an average of 70 miles per round trip is assumed for all vanpooling trips.

The VMT reduction resulting from these vanpoolers is 411,180 miles per day, or 100.7 million miles per year, assuming a 260 day work year. As vanpools are driven 35,560 miles per day, or 9.2 million miles per year, the total VMT reduction is 91.5 million miles per year.

Approach and Associated Assumptions

The approach here is to assume the vanpooling program is made more aggressive through improved coordination and implementation of the program, additional funding and improved marketing and outreach. The goal of this program would be to increase the number of vanpoolers to 17,622 by 2009 (a factor of three). This would require 1,519 vans. The result would be a decrease of 1,233,540 miles per day before adjusting for the VMT from the vans, which would be approximately 106,330 miles per day. The net VMT decrease would be 1,127,210 miles per day.

EMISSIONS ANALYSIS

The emissions analysis utilized the basic process suggested by the MOSERs methodology, as follows:

Variables:

EF_A: Speed-based composite emission factor after implementation (NO_x, VOC, or CO) grams/mile)

EF_B: Speed-based running composite emission factor before implementation (NO_x, VOC, or CO) (grams/mile)

TEF_{AUTO}: Auto trip-end emission factor (NO_x, VOC, or CO) (grams/trip)

VMT_B: Net VMT Reduction from Vanpooling

It was assumed that emission factors and trip length before and after implementation are the same. Emissions changes from vehicle trips and associated start emissions are evaluated through the use of composite emission factors and the assumption that access to the vanpools is not through SOV use.

Equation:

Daily Emission Reduction =

C = VMT$_B$* * EF$_{A}$ =

1,127,210 * 0.471 gram/mile NOx/453.6 = 1,170 lb/day, and 0.59 tpd NOx

and

1,127,210 * 0.489 gram/mile NOx/453.6 = 1,215 lb/day, and 0.61 tpd VOC

However, TCEQ already credits 0.4 tpd of emission reductions from this measure in its baseline emission inventory. Therefore the emissions reductions from this program were reduced by 0.4 tpd to account for that current expectation.

Cost Effectiveness

The current cost of this program is $3.7 million per year. However with coordinated program management (for example marketing and management conducted by one entity instead of two) and application of revenue positive features such as limited in-van advertising, the cost could likely be kept to five million per year or less.

Based on a 260 day work year, annual benefits are 153 tons and the cost effectiveness would be $32,680/year for NOx

COMMENTS

This evaluation is based on hypothetical assumptions and data for this program and may be considered for use in ozone plan after review of key assumptions.

SUMMARY OF RESULTS: NO$_x$

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
462,463,496	Vanpooling	Triple 2005 vanpooling through increased vanpools and	Light-duty On-road	70.5 tpd	0.3	0.39[1]	$32,680

		encouragements					

SUMMARY OF RESULTS: VOC

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
462,463,496	Vanpooling	Triple 2005 vanpooling through increased vanpools and encouragements	On-Road	79.3 tpd	0.77	0.41[1]	Not calculated for VOC

[1] – The emission reductions were adjusted to account for the VMEP emission reductions credited in the baseline emission inventory.

Control Measure: Telecommuting Mandates, Measure 487
Category: On-Road
Author: Barbara Joy, Earth Matters, Inc.

DESCRIPTION

Telecommuting is among the more effective travel demand management programs as it completely eliminates a work trip for the days a person telecommutes. Telecommuting programs can operate through an employee working from home part-time, such as one day per week, or from a satellite work center closer to their residence. Obstacles to telecommuting are mostly related to uncertainty about the ability of an employee to work a full day without supervision; issues regarding provision of computer and phone equipment; and issues related to the provision of insurance while working at home. Additionally, some studies have shown a possible increase in the amount of non-work-related driving on telecommuting days (employees working from home have more time for errands, for example). Benefits can include a reduction in worker stress with resulting fewer sick days and increased productivity. The implicit trust required to allow an employee to work from home also lead to an increased sense of importance and "ownership" of their work, which also can increase productivity. In practice, most employees that work hard at the office will work just as hard at home.

This measure incorporates suggestions for telecommuting ranging from mandates to incentives to additional video conferencing between worksites. H-GAC has had a telecommuting program in operation for some years as part of the Commute Solutions and Best Workplaces programs. The program has operating as an incentive program and has been marketed through phone calls and face to face meetings with potential companies, along with advertising and other outreach by H-GAC and various consulting groups.

Approach and Associated Assumptions

Currently there are 1,115 telecommuters participating from 97 different area companies. The frequency varies enormously with some teleworking nearly full-time and others teleworking once or twice a month. The average frequency is assumed to be once per week. The average round trip distance is 52 miles, based on data on the teleworkers collected by the companies and by H-GAC.

As experience with the program has grown, so has the effectiveness of implementation methods. The purpose of this analysis is based upon the need to determine what programs, if implemented in a highly ambitious manner, might yield sufficient emission reductions to be further considered for inclusion in the 8-hour ozone attainment plan. In discussion with H-GAC and TCEQ it was agreed to explore an expanded telecommuting program in which 10 percent of Houston area employees participated once per week.

EMISSIONS ANALYSIS

There are a number of variables important for evaluating the emission benefits of this measure. These are as follows:

- ✓ Total employment projected by H-GAC for 2009 is 2,757,548. The above-cited figure of 10% would be 275,755 employees.
- ✓ As noted above, figures for Houston area telecommuters show average round trip distances as being 52 miles.
- ✓ Each telecommuter works from home once per week.
- ✓ Average light duty vehicle composite emission factor for NOx for same day is 0.471 grams per mile
- ✓ Average light duty vehicle composite emission factor for VOC for same day is 0.489 grams per mile

The emissions analysis utilized the basic process suggested by the MOSERs methodology, as follows:

Variables: **EF_A:** Speed-based composite emission factor after implementation (NO_x, VOC, or CO) grams/mile)

EF_B: Speed-based running composite emission factor before implementation (NO_x, VOC, or CO) (grams/mile)

VMT_B: Change in vehicle miles traveled as a result of implementation = number of telecommuters * round trip distance * 1/5 (one day every 5).

It was assumed that emission factors and trip length before and after implementation are the same. Emissions changes from vehicle trips and associated start emissions are evaluated through the use of composite emission factors.

Equation:

Daily Emission Reduction =

$C = VMT_B * * EF_{A\ =}$

2,867,852 * .471 gram/mile NOx/453.6 = 2,978 lb/day, and 1.5 tpd NOx

and

2,867,852 * 0.489 gram/mile NOx/453.6 = 3,092 lb/day, and 1.5 tpd VOC.

COMMENTS

This evaluation is based on hypothetical assumptions and data for this program and may be considered for use in ozone plan after review of key assumptions. The feasibility of achieving a 10% participation rate from all Houston area employees has not been studied. Cross effects of a 10% telecommuting share on alternative modes such as transit, vanpooling and ridesharing have not been evaluated. Therefore if all these programs were implemented, emission benefits could not simply be added up without some accounting for the relationships between the programs.

Also key is that the emission factors used in the analysis are emission factors with currently programmed federal and other control measures such as Tier 2 tailpipe standards. Other measures are being evaluated for the H-GAC region, such as California LEV (low emission vehicles), cleaner fleets and wider application of the Inspection and Maintenance program. If these or other similar programs were implemented, the emission factors used to evaluate programs affecting the amount of travel (such as this one) would be smaller – each mile driven would be at a lower emission rate and therefore each mile not driven would not reduce emissions as much as it would have without the additional measures.

Cost Effectiveness

The current program costs approximately $150,000 per year. The amount of a program that is in essence 100 times larger cannot reliably be estimated. Uncounted revenues from the program, such as resources not spent on sick days, lower employee turnover, reduced parking requirement and additional productivity from happier, less stressed employees cannot be estimated either. Most telecommuting experts agree that the net benefits offset the costs (such as computers, phone line installation, phone bills, furniture lease or purchase, etc) by a factor of three (see for example, JALA International at www.jala.com. Therefore it is assumed that all costs would be attributed to employer outreach and marketing by H-GAC and consultants. Current outreach/advertising and marketing costs for the Commute Solutions program are $2.5 million annually. It is assumed that an additional $2.5 million is allocated specifically to the telecommuting program evaluated here.

Annual NOx emission benefits are daily benefits * 260 workdays per year, or 390 tons per year. This would result in an estimated cost effectiveness of $6,410 per ton.

COMMENTS

This evaluation is based on hypothetical assumptions and data for this program and may be considered for use in ozone plan after review of key assumptions.

Also key is that the emission factors used in the analysis are emission factors with currently programmed federal and other control measures such as Tier 2 tailpipe standards. Other measures are being evaluated for the H-GAC region, such as California LEV (low emission vehicles), cleaner fleets and wider application of the Inspection and Maintenance program. If these or other similar programs were implemented, the emission factors used to evaluate programs affecting the amount of travel (such as this one) would be smaller – each mile driven would be at a lower emission rate and therefore each mile not driven would not reduce emissions as much as it would have without the additional measures.

SUMMARY OF RESULTS: NO_x

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
487	Tele-commuting Mandate	10% of area employees telecommute once/week	On-Road	165.8 tpd	0.9	1.4[1]	$6,410

SUMMARY OF RESULTS: VOC

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
487	Tele-commuting Mandate	10% of area employees telecommute once per week	On-Road	79.3 tpd	1.9	1.4[1]	Not calculated for VOC

[1] – The emission reductions were adjusted to account for the VMEP emission reductions credited in the baseline emission inventory.

Control Measure: Carsharing; Pooled Ownership of Hybrid and Non-hybrid Vehicles (Combines Measures 499, 500 and 501)
Category: On-Road
Author: Barbara Joy, Earth Matters, Inc.

DESCRIPTION

Carsharing is common in Europe, and is being developing in some North American cities. Carshare organizations typically charge $1-2 per vehicle-hour, plus 25-40¢ per mile. Some charge a refundable membership deposit of $300-500. These charges cover all vehicle operating expenses, including fuel and insurance. There are often special rates for extended trips and infrequent users. Carsharing is considered a cost effective alternative to owning a vehicle driven less than about 6,000 miles (10,000 kms) per year. There are typically 8-15 members per vehicle. Some small businesses use Carsharing (Reutter and Bohler, 2000).

Station cars are a type of Carsharing (*National Station Car Association*). Station cars are rented at transit stations for travel between terminals and local destinations. This supports transit use, particularly in suburban areas where destinations are too dispersed for convenient pedestrian access. Because they are intended for short trips, station cars can employ small, alternative fuel vehicles, such as battery powered electric cars.

ANALYSIS

Because carsharing variable costs are 2-10 times higher than for a personal automobile, users tend to minimize their driving. Overall travel reductions depend on what portion of carshare participants would otherwise own a personal automobile (they typically reduce their vehicle use by 50-80%)and which portion would otherwise not own an automobile (they typically increase their vehicle use by a small amount). Most studies suggest that carsharing typical results in a net reduction in per capita driving among participants that averages 40-60%, but this varies depending on the demographics of participants and the quality of travel choices in their community (Steininger, Vogl and Zettl, 1996).

In a study of the San Francisco *City CarShare* program, Cervero and Tsai (2003) find that when people join, nearly 30 percent reduce their household vehicle ownership and two-thirds stated they avoided purchasing another car, indicating that each Carshare vehicle substitutes for seven private cars, and that the average member drives 47% fewer annual miles after joining. However, since carsharing tends to attract motorists who already drive relatively low mileage, total travel reductions may be relatively small.

In a series of examples presented in the online TDM encyclopedia (www.vtpi.org), the number of vehicles by program ranges from 4 – 40. Unless a program was expanded to thousands of vehicles the effect would hardly be measurable. This analysis assumes a 10,000 car station fleet to provide a benchmark emission reduction easily adjusted to an actual planned program. Based on experience in other areas such as San Francisco, Toronto, Quebec, and Vancouver, it appears that an average of 8 – 15 members per vehicle is common.

Emissions Analysis

This analysis assumes 10,000 station cars used by 10 people per car. As it is known that station car users tend to drive less than average, it is assumed that these users previously drove 8,000 miles per year (an average of 21.9 miles per day). As noted above, carsharing has been found to reduce travel by about 47 percent in users. Therefore we would expect that these 100,000 drivers would now drive 11.6 miles per day on average, representing a reduction of 10.15 miles per day per user, or an average of 1,029,300 miles per day of VMT reduction.

The emissions analysis utilized the basic process suggested by the MOSERs methodology, as follows:

Variables: **EF_A:** Speed-based composite emission factor after implementation (NO_x, VOC, or CO) grams/mile)

EF_B: Speed-based running composite emission factor before implementation (NO_x, VOC, or CO) (grams/mile

TEF_{AUTO}: Auto trip-end emission factor (NO_x, VOC, or CO) (grams/trip)

VT_B: **Change in** VMT as a result of implementation

It was assumed that emission factors and trip length before and after implementation are the same. Emissions changes from vehicle trips and associated start emissions are evaluated through the use of composite emission factors and the assumption that access to transit is not through SOV use. Any inaccuracy in this assumption is offset by the larger assumption of frequency of transit use per week, another key unknown factor.

As noted earlier **VT_B** is the same as the reduction in VMT by carsharers.

Daily Emission Reduction =

$C = VT_B * EF_A =$

1,029,300 * 0.471 gram/mile VNOx/453.6 = 1,068 lb/day, and 0.53 tpd NOx

and

1,029,300 * 0.489 gram/mile VOC/453.6 = 1,110 lb/day, and 0.55 tpd VOC.

Cost Effectiveness

No data on costs for the Houston area is available. Depending on program structure, cost per ton could be as low as $0. It is expected that costs would be in the less-than-$14,000 range. If this measure is deemed appropriate for further review, a more detailed cost effectiveness estimate could be prepared.

COMMENTS

This analysis presents a hypothetical case in which 1,000 cars are provided. If the Houston area chooses to pursue such a measure this analysis will provide documentation on expected benefits and can easily be adjusted to an actual proposed program by proportionately raising or lowering the number of vehicles to be shared.

SUMMARY OF RESULTS: NO_x

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
499, 500, 501	Carsharing	10,000 shared cars	On-Road	165.8 tpd	0.3	0.53	<$14,000

SUMMARY OF RESULTS: VOC

Measure #	Name	Description	Affected Source	Affected Emissions	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
500, 505, 506, 507	Carsharing	10,000 shared cars	On-Road	79.3 tpd	0.7%	0.55	Not estimated for VOC

REFERENCES

Robert Cervero and Yu-Hsin Tsai, *San Francisco City CarShare: Travel-Demand Trends and Second-Year Impacts*, Institute of Urban and Regional Development, University of California at Berkeley, Working Paper 2003-05 (www-iurd.ced.berkeley.edu), August 2003.

K. Steininger, C. Vogl and R. Zettl, "Car Sharing Organizations," *Transport* Policy, Vol. 3, No. 4, 1996, pp. 177-185.

Control Measure: California LEVII Program, Measure 551
Category: On-road
Author: Lit-Mian Chan, ENVIRON

DESCRIPTION

This measure would require the adoption of the California Low Emission Vehicle II (LEV II) program. As compared to the EPA Tier 2 standards, studies have indicated that about 10% of VOC reduction, and 5% of NOx reduction could be achieved within 10 years, and about 20% of VOC reduction and 10% NOx reduction within 20 years. Most of the NOx emission reductions would result from the ZEV requirement of the CA LEV II program.

The EPA sets emission standards for new vehicles sold in the United States, but California has the authority to set its own vehicle standards. Other states may adopt either California or the federal standards. In the late 1990's, California established the LEV Program[9] that contained more stringent emission standards compared to the federal standards for LDVs, and several Northeast states adopted the California LEV program. California, subsequently in November 1998, adopted the second-generation of the LEV Program, so called LEVII program.[10] The California LEV II emission standards are shown in Table 1. The EPA, in December 1999, adopted the Tier 2 emission standards for LDVs, phasing in between 2004 and 2007 for light LDVs or LDTs, and 2008 to 2009 for heavy LDTs and medium-duty passenger vehicles (MDPVs). The EPA Tier 2 emission standards are shown in Table 2. The programs are similar in general, and while there is disagreement in the projected benefit of each, this work used analysis from other States to demonstrate the potential benefit of the California program compared with the Federal emission standards.

Implementation Feasibility

The implementation of the rule would require Texas to sell LEV II vehicles (instead of Federal Tier 2) including the California program provisions for sales of zero emissions vehicle (ZEV) category and partial ZEVs. While it is feasible, as was done in some Northeast states, it would require substantial effort to develop and implement such as a measure.

Public Acceptance

The compliance of the rule can be costly because of the need to introduce higher cost vehicles, including PZEV and ZEV requirements.

[9] http://www.arb.ca.gov/msprog/levprog/levprog.htm.
[10] http://www.arb.ca.gov/regact/levii/levii.htm

ANALYSIS

Analysis of this measure was based on past studies on the LEVII program. A number of emission benefit assessments of the LEVII program relative to the Tier 2 program have been conducted in several states (e.g. Northeast states and Texas[11,12]). While results from these studies showed that there would be substantial long-term emission benefits for the LEVII program, the NOx emission benefits for the LEVII program would be limited during the first few years after program implementation. Figure 1 shows the NESCAUM modeling of NOx emission benefits for the LEV II program implemented in 2009 in the Northeast states[13]. As shown in this figure, potential NOx emission benefits for the LEV II program range are about 2% in 2012, 5% in 2015, and 12% in 2020.

Table 1. California LEV II emission standards (http://www.dieselnet.com/).

California LEV II Emission Standards, Passenger Cars and LDVs < 8500 lbs, g/mi

Categor y	50,000 miles/5 years					120,000 miles/11 years				
	NMOG	CO	NOx	PM	HCHO	NMOG	CO	NOx	PM	HCHO
LEV	0.075	3.4	0.05	-	0.015	0.09	4.2	0.07	0.01	0.018
ULEV	0.04	1.7	0.05	-	0.008	0.055	2.1	0.07	0.01	0.011
SULEV	-	-	-	-	-	0.01	1	0.02	0.01	0.004

California LEV II Emission Standards, Medium Duty Vehicles, Durability 120,000 miles, g/mi

Weight (GVWR), lbs.	Categor y	NMOG	CO	NOx	PM	HCHO
8,500 - 10,000	LEV	0.195	6.4	0.2	0.12	0.032
	ULEV	0.143	6.4	0.2	0.06	0.016
	SULEV	0.1	3.2	0.1	0.06	0.008
10,001 - 14,000	LEV	0.23	7.3	0.4	0.12	0.04
	ULEV	0.167	7.3	0.4	0.06	0.021
	SULEV	0.117	3.7	0.2	0.06	0.01

[11] "Comparing the Emissions Reductions of the LEV II Program to the Tier 2 Program," White Paper prepared by NESCAUM, and Cambridge Systematics, Inc., October 2003.
[12] "Preliminary Assessment of LEV-II Program Benefits for Texas," H37 Final Report by ERG, and Cambridge Systematics, Inc. for Houston Advanced Research Center, December 31, 2004.
[13] Spreadsheet file provided by Coralie Cooper of NESCAUM.

Table 2. EPA Tier 2 emission standards (http://www.dieselnet.com/).

Tier 2 Emission Standards, FTP 75, g/mi

Bin#	50,000 miles					120,000 miles				
	NMOG	CO	NOx	PM	HCHO	NMOG	CO	NOx*	PM	HCHO
Temporary Bins										
MDPV[c]						0.28	7.3	0.9	0.12	0.032
10[a,b,d,f]	0.125 (0.160)	3.4 (4.4)	0.4	-	0.015 (0.018)	0.156 (0.230)	4.2 (6.4)	0.6	0.08	0.018 (0.027)
9[a,b,e]	0.075 (0.140)	3.4	0.2	-	0.015	0.090 (0.180)	4.2	0.3	0.06	0.018
Permanent Bins										
8[b]	0.100 (0.125)	3.4	0.14	-	0.015	0.125 (0.156)	4.2	0.2	0.02	0.018
7	0.075	3.4	0.11	-	0.015	0.09	4.2	0.15	0.02	0.018
6	0.075	3.4	0.08	-	0.015	0.09	4.2	0.1	0.01	0.018
5	0.075	3.4	0.05	-	0.015	0.09	4.2	0.07	0.01	0.018
4	-	-	-	-	-	0.07	2.1	0.04	0.01	0.011
3	-	-	-	-	-	0.055	2.1	0.03	0.01	0.011
2	-	-	-	-	-	0.01	2.1	0.02	0.01	0.004
1	-	-	-	-	-	0	0	0	0	0

* - average manufacturer fleet NOx standard is 0.07 g/mi

a - Bin deleted at end of 2006 model year (2008 for HLDTs)
b - The higher temporary NMOG, CO and HCHO values apply only to HLDTs and expire after 2008
c - An additional temporary bin restricted to MDPVs, expires after model year 2008
d - Optional temporary NMOG standard of 0.195 g/mi (50,000) and 0.280 g/mi (120,000) applies for qualifying LDT4s and MDPVs only
e - Optional temporary NMOG standard of 0.100 g/mi (50,000) and 0.130 g/mi (120,000) applies for qualifying LDT2s only
f - 50,000 mile standard optional for diesels certified to bin 10

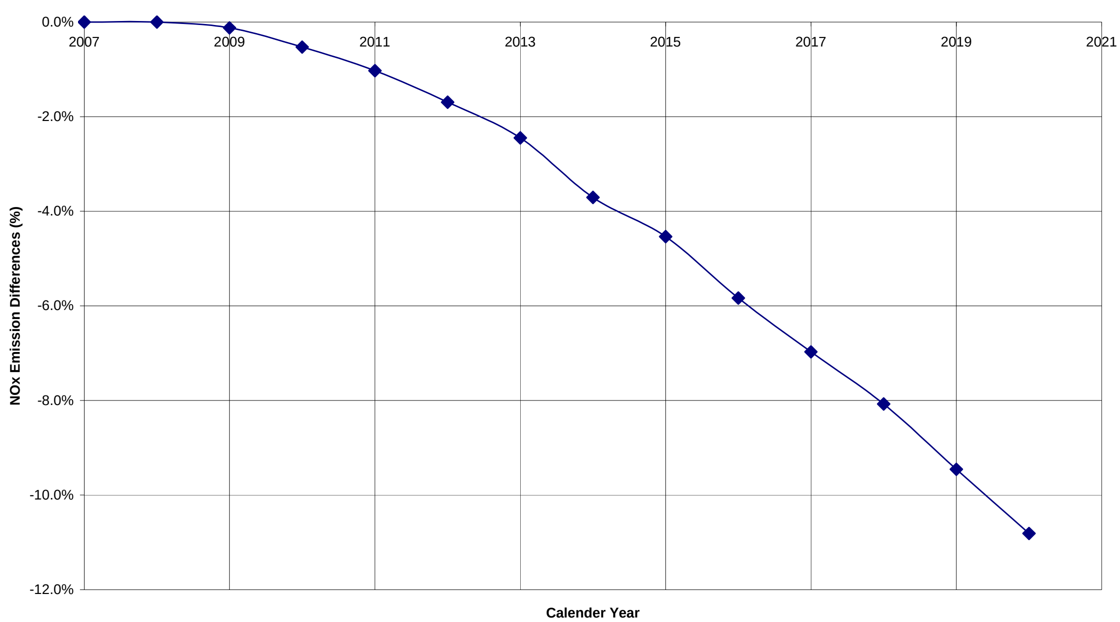

Figure 1: LEV II versus Tier 2 programs using EPA input assumptions for both programs implemented in 2009 in the Northeast States[14].

[14] Spreadsheet file provided by Coralie Cooper of NESCAUM.

Emissions Affected

The 2009 on-road emissions provided by TCEQ estimated that light duty vehicles contribute to about 70 tpd of NOx emissions in the HGB area.

Emissions Benefit

The LEVII emission benefit review study sponsored by HARC[3] estimated that adopting the LEVII program with the zero emission vehicles component would provide "upper bound" emission benefits of 2.4 tpd reduction in NOx and 5.8 tpd of VOC reduction in the Houston region in 2015. According to the HARC report, these estimates were based on the midpoint estimates of 3.1% NOx reduction and 7.4% VOC reduction reported in a LEVII study for the state of Connecticut.

Cost and Cost-effectiveness

CARB estimated cost-effectiveness values for the LEVII program to range from $1,600 to $3,000 per ton of NOx+ROG reduced, depending on vehicle classes[15].

COMMENTS

The approach is feasible and there would be some NOx and VOC emission benefits for this measure in 2009 though more emission reduction in future years, and other states have adopted the program.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
551	California LEVII	Accelerated turnover or ZEVs	On-road	70 tpd	0 - 3%	0 - 2.5	$1,600 - $3,000

REFERENCES

CARB LEV Program: http://www.arb.ca.gov/msprog/levprog/levprog.htm

CARB LEVII Program: http://www.arb.ca.gov/regact/levii/levii.htm

[15] http://www.arb.ca.gov/regact/levii/levii.htm (Staff Report: Initial Statement of Reasons for Rulemaking)

NESCAUM, 2003. “Comparing the Emissions Reductions of the LEV II Program to the Tier 2 Program,” White Paper prepared by NESCAUM, and Cambridge Systematics, Inc., October 2003. Spreadsheet file provided by Coralie Cooper of NESCAUM.

HARC, 2004. “Preliminary Assessment of LEV-II Program Benefits for Texas,” H37 Final Report by ERG, and Cambridge Systematics, Inc. for Houston Advanced Research Center, December 31, 2004.

Control Measure: California Air Toxic Control Measure Regulations Related Public Fleets or Public Contractor Fleets, Measure 553
Category: On-road
Author: Lit-Mian Chan, ENVIRON

DESCRIPTION

This measure would reduce emissions by adopting the Air Toxic Control Measures (ATCMs) adopted by California Air Resources Board for transit buses and refuse trucks for public agencies and utilities. While these ATCMs are focusing on reducing PM emissions, some NOx emission benefits could be achieved via fleet modernization resulting from cleaner vehicle or engine replacement.

On August 1998, CARB identified particulate emissions from diesel-fueled engines as toxic air contaminants. As a result, CARB established the California's Diesel Risk Reduction Program (DRRP) to reduce PM emissions from existing on-road and off-road diesel engines and vehicles in California. As part of the DRRP, CARB adopted, among others, the Fleet Rules for Transit Agencies in 2000 for urban buses, and in 2005 to include transit fleet vehicles, and airborne toxic control measures (ATCMs) for on-road HD diesel solid waste collection trucks in 2003. Other on-going related activities include ATCMs for public-owned and private-owned diesel vehicles.

Fleet Rule for Transit Agencies

The Fleet Rule for Transit Agencies for urban buses adopted in 2000 is designed to encourage the use of alternative-fuel buses, and includes multiple strategies to reduce emissions from existing diesel urban bus fleets[16]. Amended in October 2002 by CARB, the fleet rule requires public transit fleets that chose the "diesel path" to achieve and maintain a fleet average 4.8 g/bhp-hr NOx limit by October 2002, to use ultra low-sulfur (less than 15 ppm sulfur content) diesel fuel beginning July 2002, and a phased-in diesel PM reduction beginning 2004. For new transit agencies established after January 2005, a fleet average 4.0 g/bhp-hr NOx limit is applied. The phase-in PM reduction for the fleet rule is as follows:

Fuel Path	2004	2005	2007	2009
	Emission Reduction from 2002 PM Baseline (%)			
Diesel	40	60	85	85
Alternative Fuel	20	40	60	85

In addition to the fleet average limit, the fleet rule also includes a zero emission bus (ZEB) requirement that requires transit agencies with 200 or over urban buses to procedure a minimum of 15% ZEBs per year, starting in 2008 for transit agencies that chose diesel path, and 2010 for transit agencies that chose alternative fuel path.

Since this fleet rule was intended to mainly reduce PM emissions, most transit agencies can meet the 4.8 g/bhp-hr limit simply by retiring transit buses with pre-1989 HD diesel engines. CARB estimated that the rule would reduce NOx emissions by 5.4 tpd, and PM emissions by 0.04 tpd

[16] "Fleet Rule for Transit Agencies," Section 1956.2, Title 13, California Code of Regulations, October 2002.

statewide in 2010. The cost effectiveness value was estimated to be about $3,600 per ton of NOx reduced in 2010.

In the fleet rule, CARB also include a fleet average NOx limit for transit fleet vehicles (TFVs), which defined as on-road vehicles greater than 8,500 lbs GVWR powered by HD engine fueled by diesel or alternative fuel, owned or operated by a transit agency, and are not urban buses. These TFVs, such as charters or commuter buses, paratransit, intra-city and dial-a ride services buses, are generally smaller than a typical urban bus and use a medium HD engine. Beginning December 31, 2007, the fleet rule for TFVs requires that a transit agency to meet a fleet average 3.2 g/bhp-hr NOx limit, and this limit reduces to 2.4 g/bhp-hr in 2010.

Comparing to transit buses with a pre-1989 HD diesel engine certified to 10.7 g/bhp-hr NOx standard, the fleet average NOx limit would provide more than 50% reduction. As for transit buses with a pre-1991 HD diesel engine certified to 6.0 g/bhp-hr NOx standard, the fleet average NOx limit would provide more than 15% reduction. However, based on the NOx emissions and VMT data provided by TCEQ, the fleet average NOx emissions for transit buses in the HGB area in 2009 is estimated to be about 13.6 g/mile or about 3 g/bhp-hr, assuming a conversion factor of 4.68 bhp-hr/mile. Thus, the fleet average NOx limit of 4.8 or 4.0 g/bhp-hr would provide no benefit for the HGB in 2009. Though, the ZEB requirement would provide about 15% NOx emission reduction for larger fleet.

Fleet Rule for Solid Waste Collection Vehicles

Like other ATCMs, the ATCM for solid waste collection vehicles (SWCVs) mandates the reduction of diesel particulate matter emissions from 1960 to 2006 model year engines in on-road diesel-fueled heavy-duty residential and commercial SWCVs with a manufacturer's gross vehicle weight rating greater than 14,000 pounds.[17] The ATCM requires that each SWCV operator to use the best available control technology (BACT) to reduce PM emissions in his/her fleet as required by the following implementation schedule.

BACT options include an engine or power system certified to the optional 0.01 g/bhp-hr particulate emission standard; an engine or power system certified to the 0.1 g/bhp-hr particulate emission standard used in conjunction with the highest level diesel emission control strategy (DECS); an alternative fuel or heavy-duty pilot ignition engine; model year 2004 to 2006 alternative fuel engines must be certified to the optional, reduced emission standards, and the highest level verified DECS. Level 1 of CARB-verified DCES means the strategy reduces engine DPM emissions by between 25 and 49 percent, Level 2 means the strategy reduces engine DPM emissions by between 50 and 84 percent, and Level 3 means the strategy reduces engine DPM emissions by 85 percent or greater, or reduces engine emissions to less than or equal to 0.01 g/bhp-hr DPM.

[17] http://www.arb.ca.gov/regact/dieselswcv/dieselswcv.htm

Group	Engine Model Years	Percentage of Group to Use Best Available Control Technology	Compliance Deadline
1	1988 – 2002	10 25 50 100	December 31, 2004 December 31, 2005 December 31, 2006 December 31, 2007
2a[a]	1960 – 1987 (Total fleet ≥ 15 collection vehicles)	15 40 60 80 100	December 31, 2005 December 31, 2006 December 31, 2007 December 31, 2008 December 31, 2009
2b	1960 – 1987 (Total fleet < 15 collection vehicles)	25 50 75 100	December 31, 2007 December 31, 2008 December 31, 2009 December 31, 2010
3	2003 – 2006 (Includes dual-fuel and bi-fuel engines)	50 100	December 31, 2009 December 31, 2010

[a] Group 2a: An owner may not use Level 1 technology as best available control technology on Group 2a engines or collection vehicles.

While this ATCM focuses on reducing PM emissions, some BACT or DECS also reduce other pollutants, such as NOx emissions. CARB estimated that the ATCM would reduce DPM emissions by about 1 tpd in 2010 or 80% reduction from the baseline, and NOx emissions by 16 tpd or about 60% reduction from the baseline. The NOx emission reduction scenario used in the CARB analysis was based on the use of emulsified fuel, a level 2 DECS, as BACT for some of the SWCVs. The cost effectiveness values were estimated to be about $1,500 per ton of NOx reduced.

Implementation Feasibility

The implementation of the rule assumes that the primary method for complying with the rule will be to turn the fleet over to new vehicles meeting more stringent emission standards, or to retrofit existing vehicles with aftertreatment devices.

Public Acceptance

For the general public the measure would likely be welcome even if the primary outcome was a reduction in PM and visible smoke. This measure would generate good public appearance, as it would directly affect the local communities, in terms of running cleaner buses on city and local bus routes, and SWCVs around residential areas. However, unless more stringent average fleet NOx limit is used, this control strategy would have less impact on area-wide ozone formation.

In addition, the compliance of the rule can be costly because of the need of early retirement of older vehicles (i.e. buses or SWCVs) or retrofit control devices on these vehicles, and new vehicles must be purchased.

ANALYSIS

Analysis of this measure was based on requirements of these fleet rules. As discussed earlier, these rules are developed to reduce PM emissions. However, some NOx control may be achieved depending on the BACT or DECS chosen.

Emissions Affected

The 2009 on-road emissions provided by TCEQ estimated that transit buses contribute to about 2.5 tpd NOx emissions in the HGB area. As for the transit fleet vehicles, ENVIRON estimated that it would amount to about 0.2 tpd based on the ratio of the 2010 NOx emissions of transit buses and transit fleet vehicles in California. As for the SWCVs, ENVIRON estimated that it would amount to about 0.23 tpd based on the ratio of the 2010 NOx emissions of the HDDVs and SWCVs in California.

Emissions Benefit

If the measure would just adopt the California fleet rule for transit buses and TFVs, it would have no or limited NOx benefit. However, if the average NOx limit were to reduce from 4.8 g/bhp-hr to 2.4 g/bhp-hr (the emission standards for new MY 2004 to 2006 transit bus engines), there would be about 17% NOx reduction, or about 0.5 tpd, from these vehicles in 2009 the HGB area. If the average NOx limit were to reduce to 1.2 g/bhp-hr (the emission standards for new MY 2007 and later transit bus engines), there would be about 60% NOx reduction, or more than 1.5 tpd, from these vehicles in 2009. As for the SWCVs, potential of about 50% NOx reduction, or about 0.1 tpd in 2009, if natural gas or Dual-Fuel engines or diesel emulsified fuel were chosen as BACT or DECS.

Cost and Cost-effectiveness

California estimated that cost effectiveness values would range from $1,200 to $3,600 per ton of NOx reduced. This is comparable to the fleet modernization costs found in the TERP program, however a mandated rule may entail more costs than a voluntary rule because most vehicles will be affected rather than those providing the greatest benefit.

COMMENTS

The primary purpose of the California fleet rules was to reduce diesel particulate emissions. Some NOx emission benefits could be realized only if more stringent average fleet NOx limit were to be recommend for the rule for transit agencies, and alternative fuel or DECS that provides NOx reduction were chosen as BACT for the SWCV rule. Thus, while the rule will probably result in NOx emission reductions, there is no guarantee that it would.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
553	California Fleet Rules	Accelerated turnover or retrofits	On-road	<3 tpd	0 - 50%	0 - 1.5	$1,200 - $3,600

REFERENCES

ARB (1999), "Staff Report: Initial Statement of Reasons Proposed Regulation for a Public Transit Bus Fleet Rule and Emission Standards for New Urban Buses," State of California, Air Resources Board, December 10, 1999.

ARB (2003), "Staff Report: Technical Support Document for Proposed Control Measure for Diesel Particulate Matter from On-Road Heavy-Duty Diesel-Fueled Residential and Commercial Solid Waste Collection Vehicle Diesel Engines," State of California, Air Resources Board, June 6, 2003.

ARB (2005), "Staff Report: Initial Statement of Reasons for Proposed Modifications to the Fleet Rule for Transit Agencies and New Requirements for Transit Fleet Vehicles," State of California, Air Resources Board, January 7, 2005.

Control Measure: Limitations on Idling of Heavy-duty Vehicles, Measure 576
Category: On-road
Author: John Grant and Chris Lindhjem, ENVIRON

DESCRIPTION

This measure would reduce idling from Heavy Duty Trucks through the use of auxiliary power units (APUs), automatic engine idling systems, or truck stop electrification as described in EPA's SmartWay website description of the EPA Clean Freight Strategies for Idle Reduction (http://www.epa.gov/otaq/smartway/documents/apu.pdf). These measures have also been funded by TERP program.

Implementation Feasibility

Retrofits of truck stops or other places where extended vehicle idling occurs with systems to provide electric power to parked trucks, or the installation of APUs, the installation of automatic engine idle systems would be required. The capital cost of truck stop power systems, APU units, or automatic engine idle systems makes some sort of assistance program necessary. Additionally, the best technology or technologies to implement would need to be chosen based on a more in-depth feasibility and cost-effectiveness analysis. Likewise, a mechanism or company that can recover its costs would be needed to administer and maintain the equipment and provide truck operators field assistance.

Public Acceptance

This measure requires capital investment in truck stop power systems, APU units, and/or automatic engine idle systems. The capital costs of a measure such as this could be burdensome to the owners and operators of truck fleets or truck stops; however, potential fuel savings and TERP funding mechanisms could cause this measure to be feasible for adoption if the administrators can recover their cost for administration and maintenance.

The general public, especially those living or working near these trucks stops or other places with extended idling, would welcome the reduction in emissions, smell, and noise from idling trucks.

ANALYSIS

EPA estimates that the emissions from idling constitute no more than 3.4% of the truck emissions. EPA (2004) determined that vehicle idling is responsible for 3.4% of exhaust emissions, so a reduction of 50 to 100% in idling reductions would result in about 1.7 to 3.4% emissions reduction.

Emissions Affected

The emissions affected include Class 8a and 8b heavy-duty trucks (64 tpd).

Emissions Benefit

Estimated emission reductions from this measure are 1.1 to 2.2 tpd NO_x.

Some of this emissions benefit (estimated at more than 1 tpd) has been captured by a TERP project in Fiscal Year 2005, and other vehicles may already be equipped with anti-idling (such as autostop) technology.

Cost and Cost-effectiveness

The cost of an automatic shut-off system ranges from $1,325 to $2,500, while the cost of an auxiliary power unit ranges from $6,000 to $9,000 (http://www.epa.gov/smartway/idlingtechnologies.htm).

Total cost is estimated at $45,000,000 and upward based on a population of about 35,000 Class 8 heavy-duty trucks at the cost of $1,325 per unit.

IdleAire provides one of the truck stop electrification technologies, which provides a cooling or heating ventilation connection to the truck cab through the passenger side window. Based on a Tennessee EAP study, the initial capital cost of a truck stop parking space, for 100 HD diesel trucks, that is equipped with an IdleAire truck stop electrification system in Knox County, Tennessee, was about one million dollars (Tennessee, 2003). The estimated cost effectiveness value for that program was about $1,700 per ton of NOx emission reduced (Tennessee, 2003).

Devices that provided the creature comforts without the fuel consumption can create cost savings for the truck operators and so maintenance and other costs were not included in the cost of the program reported here. To the extent that the reduced idling devices reduce fuel costs more than maintenance costs, the overall cost effectiveness may be less.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
576	Idle Reduction	Class 8 HDT Idle Reduction	Onroad – Class 8 HDT	64	1.7 – 3.4%	0 – 1.0[1]	$1,700

[1] – Emission reduction from the TERP program already credited in the baseline emission inventory was subtracted from the emission reduction potential of this measure.

REFERENCES

EPA. 2004. “Guidance for Quantifying and Using Long Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity,” Office of Transportation and Air Quality,” EPA420-B-04-001, January 2004.

University of Tennessee, 2003. “Draft Report: Emission Inventories and Potential Emission Control Strategies For Ozone Earl Action Compact Areas in Tennessee.” Department of Civil and Environmental Engineering, April 13, 2003.

Control Measure: Expanded Inspection and Maintenance, Measure 601 and 604
Category: On-road
Author: John Grant, ENVIRON

DESCRIPTION

Implementing and/or expanding a vehicle inspection and maintenance (I/M) program can reduce emissions from in-use vehicles, especially from high emitters and/or vehicles with defective emission control systems. An I/M program can consist of a combination of exhaust and evaporative emission control system inspections[18].

Currently all but three of the HGB counties have adopted I/M programs. This measure assesses the scenario in which the three counties in the HGB that are currently without I/M program (Chambers, Liberty, and Waller) were to adopt an inspection and maintenance program similar to the program for Fort Bend and Montgomery counties. Inspection and maintenance programs for Fort Bend and Montgomery include both light-duty gasoline ASM and OBD programs and heavy-duty gasoline idle and evaporative programs that assess emissions from vehicles of specific model years.

Implementation Feasibility

The measure is feasible, as it has already been implemented in other counties in the HGB.

Public Acceptance

This measure would require owners of vehicles of specific model years to have their vehicles inspected, incurring an annual inspection cost and time, and repair cost if necessary.

ANALYSIS

This measure was analyzed by comparing HGB emissions with and without the expanded I/M program. Mobile6 was run for these three counties with and without I/M. The emission reductions resulting from the I/M program was then estimated based on the ratio of emission factors with and without I/M using MOBILE6 input files used to create the base emissions inventory. Emissions reductions of 0.72 tpd and 0.81 tpd were estimated for NOx and VOC respectively.

Emissions Affected

The emissions affected are from light-duty gasoline and heavy-duty gasoline vehicles from the three counties (Chambers, Liberty, and Wall) to which I/M would be expanded to (5.22 ton VOC and 5.60 ton NOx) (TTI, 2005).

[18] http://www.epa.gov/otaq/im.htm

Emissions Benefit

Estimated emission reductions from this measure are 0.72 tpd VOC and 0.81 tpd NO_x.

Cost and Cost-effectiveness

Existing I/M programs in other HGBs have a fee of $40 per vehicle, however, the repair costs are have not been estimated. A Tennessee study estimated that the average cost of the I/M Program per vehicle tested was about $58[19]. This cost estimate was used in the cost-effectiveness analysis of this measure.

The number of vehicles was estimated by dividing the light duty gasoline and heavy-duty gasoline vehicles by an assumed mileage accumulation per year (10,432 and 25,000 miles/year/vehicle, respectively). This allowed for the calculation of total cost per year, $14 million. The cost effectiveness of this measure was then estimated at $54,000 per ton of VOC and $48,000 per ton NOx.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
601, 604	Expanded Inspection and Maintenance	Expand I/M to Chambers, Wall, and Liberty Counties	Onroad – Class 8B HDT	5.22 VOC, 5.60 NOx	14% VOC, 14% NOx	0.72 VOC, 0.81 NOx	$54,000 VOC, 48,000 NOx

REFERENCES

TTI (2005), "2002, 2009, and 2012 Emissions Inventories for the Houston/Galveston Eight-Hour Nonattainment Counties", Texas Transportation Institute, August 2005.

[19] "Emission Inventories and Potential Emission Control Strategies for Ozone Early Action Compact Areas in Tennessee," Draft Report to Division of Transportation Planning, Tennessee Department of Transportation, and Division of Air Pollution Control, Tennessee Department of Environmental and Conservation, Department of Civic and Environmental Engineering, University of Tennessee, April 2003.

Control Measure: Aircraft Emissions Standards, Measures 3 and 9
Category: Non-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

Investigate the expected emission reductions from international rules and assess whether fleet selection can improve the emissions from aircraft. The fleet selection may be encouraged by structured gate fees or other means not determined by this review. The measure was evaluated to understand if airplanes had sufficiently different emissions rates that could affect an emission reduction by choosing lower emitting planes.

Implementation Feasibility

The implementation of this measure would be difficult though not impossible because of the reporting requirements of the different model of airplanes (sometimes by the same airplane maker). The challenge for this measure would be the already constrained airplane scheduling, so an additional requirement of airplane type may be difficult to incorporate.

Public Acceptance

Increase administration and reporting burdens would be the likely factors affecting the acceptance of such a measure.

ANALYSIS

The method used was to analyze the Federal Aeronautical Administration (FAA) Emissions and Dispersion Modeling System (EDMS) database of emission rates by airplane model. Using the EPA (1999) estimates of time in mode, the largest emissions modes for a landing and take-off (LTO) are the take-off and climb out modes. Figure 1 demonstrates the range in emissions of different airplane models where take-off and climb-out emission rates closely correlate.

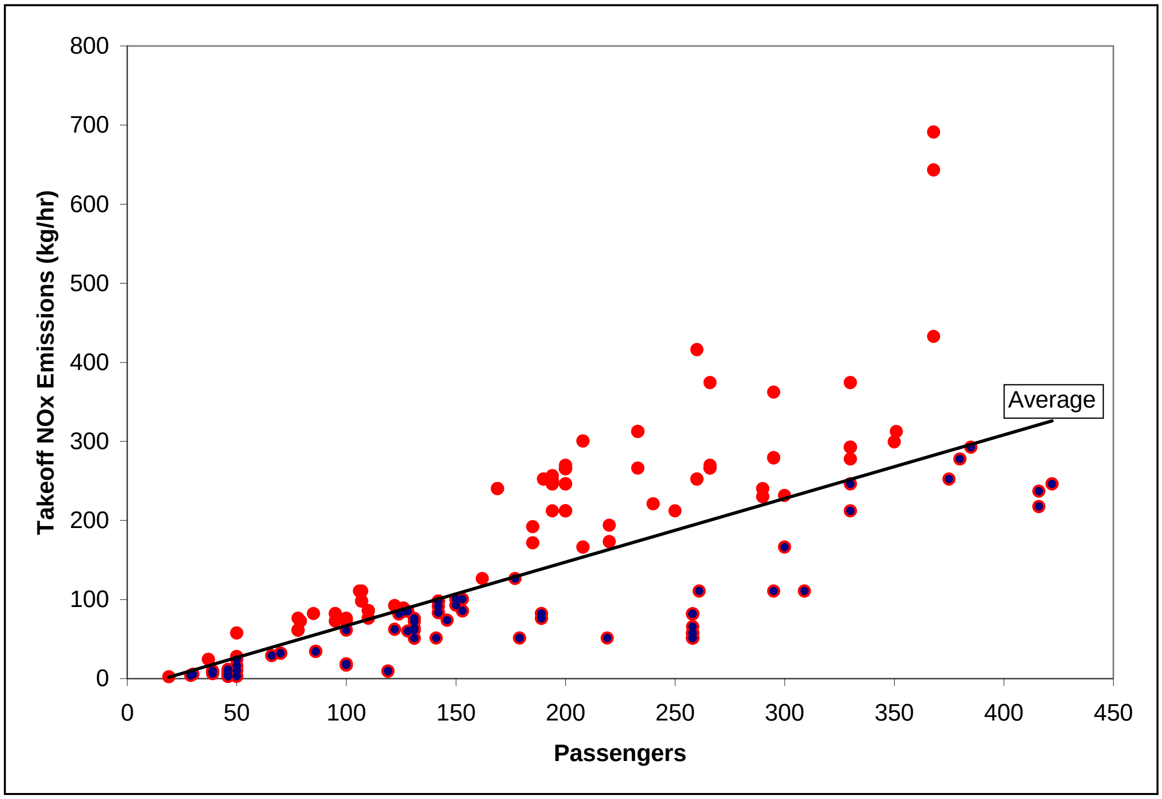

Figure 1. Take-off emissions by individual model of airplane.

To determine emission reductions which could potentially be achieved by encouraging the use of lower emitting models, the overall average emission rate and the average emission rate of those airplane models with emissions that are less than the overall average were determined for various size airplanes as measured by passenger capacity. Results are presented in Table 1. These results show that emission reductions of 15 – 30% could be achieved by selecting or encouraging use of airplane models with better than average emission rates.

Table 1. Take-off and climb-out emission rates (kg/hr).

Passenger Group	Average Emissions (all planes)	Average of Planes with Better Than Average Emissions	Emission Reduction
150 –189	126	89	30%
190 – 224	240	197	18%
225 – 274	275	235	14%
275 – 350	252	193	23%
>350	360	262	27%

This analysis did not account for actual LTO's by airplane models arriving in the HGB area. Instead, all models appearing in the EDMS database were equally weighted. Therefore, the emission reductions shown in Table 1 give an indication of the potential range of reduction potential that might be achieved; additional study will be needed to obtain emission reduction estimates specific to the HGB area.

Emissions Affected

A total of 6.34 tpd NO_x were estimated by TCEQ to be emitted from aircraft operating within the atmospheric mixing layer.

Emissions Benefit

A 1 – 2 tons/day reduction is estimated based on the 15 to 30% reduction of the total aircraft emissions.

Cost and Cost-effectiveness

A fee structure for implementing this measure could be designed to be revenue neutral. However, the administration costs of the program might need to be covered under an increase in the average fee. The cost to airlines for extra care in scheduling cleaner aircraft is unknown and will vary by airline.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
3, 9	Aircraft Emissions Standards	Encourage lower emitting aircraft	Nonroad Aircraft	6.34	15 – 30%	1 – 2	Unknown

REFERENCES

EPA (1999), "Evaluation of Air Pollutant Emissions from Subsonic Commercial Jet Aircraft," EPA420-R-99-013, April 1999, and the formal rulemaking http://www.epa.gov/fedrgstr/EPA-AIR/2003/September/Day-30/a24412.htm

FAA (2005), Emissions and Dispersion Modeling System (EDMS) version 4.3, release date 7/18/05, Office of Environment and Energy, FAA http://www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model/

International Civil Aviation Organization (ICAO) Aircraft Engine Emissions Databank http://www.caa.co.uk/default.aspx?categoryid=702&pagetype=90

Control Measure: Enhanced TERP Program, Measures 28, 31, and 45 - 50
Category: Non-road and On-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This measure is based on enhanced TERP funding and effectiveness. The current TERP program would be extended and perhaps expanded through 2009 or later.

Implementation Feasibility

The TERP in its current format is an acceptable and oft cited model program to most affected parties. Depending upon the progress of the TERP program funding effectiveness, however it may be necessary to generate additional funding. Any additional funding might be a concern for those entities affected by the revenue generation.

Public Acceptance

The current funding mechanism has been acceptable to nearly all parties, but an order of magnitude increase in funding would likely need a public process and tap new and as yet unidentified funding sources.

ANALYSIS

Annual results for the current TERP were reviewed in light of current cost and effectiveness. In addition, selected NONROAD model runs with altered phase-in files were performed to estimate emission reductions resulting from rapid fleet turnover.

Through fiscal year 2005, the TERP program had funded programs designed to generate nearly 27 tons per day of NOx emission reduction by 2007 in the Houston-Galveston-Brazoria and Dallas-Ft. Worth nonattainment areas combined. The program contracted to spend $230 million dollars through fiscal year 2005. Projects involving nonroad engines have generally been more cost effective than those involving on-road vehicles except in the program start year, and fiscal year 2005 funding cycles as shown in Table 1.

Table 1. TERP funding and progress through 2005 (not including 1 year clean fuel projects).

Fiscal Year	Onroad				Nonroad			
	Funding	NOx tpy	NOx tpd	$/tpy[1]	Funding	NOx tpy	NOx tpd	$/tpy[1]
FY 02	$8,798,467	282	1.1	$31,161	$3,072,131	49	0.2	$62,636
FY 03	$12,103,886	144	0.6	$84,009	$2,368,698	92	0.4	$25,677
FY 04	$7,985,527	142	0.6	$56,113	$59,825,298	1784	7.1	$33,529
FY 05	$34,413,413	1498	6.0	$22,968	$110,614,152	2660	10.6	$41,591
Subtotal	**$60,431,930**	**2067**	**8.3**	**$29,235**	**$167,260,888**	**4585**	**18.3**	**$36,479**

[1] 1-year cost effectiveness is total project dollars divided by the emission reductions in the design year only.

Based on these figures, we conclude that, to produce 1 ton per day of NOx reduction, \$7 - \$9 million of projects must be funded. Therefore the targeted emission reduction must be multiplied by \$7 - \$9 million to determine the required funding level to meet the air quality goal. Additional funding would be required to produce additional emission reductions, however it may be necessary to fund programs at a higher cost effective threshold than is currently applied. Current projects have generally been funded at an annualized (accounting for the time value of money) rate of less than \$7,000 per ton per year with a project life of 5 – 11 years as shown in Figure 1. TCEQ has instituted new guidance to improve the cost effectiveness of projects to be all less than \$7,000 per ton per year to improve the performance of the program, and this change has not decreased participation.

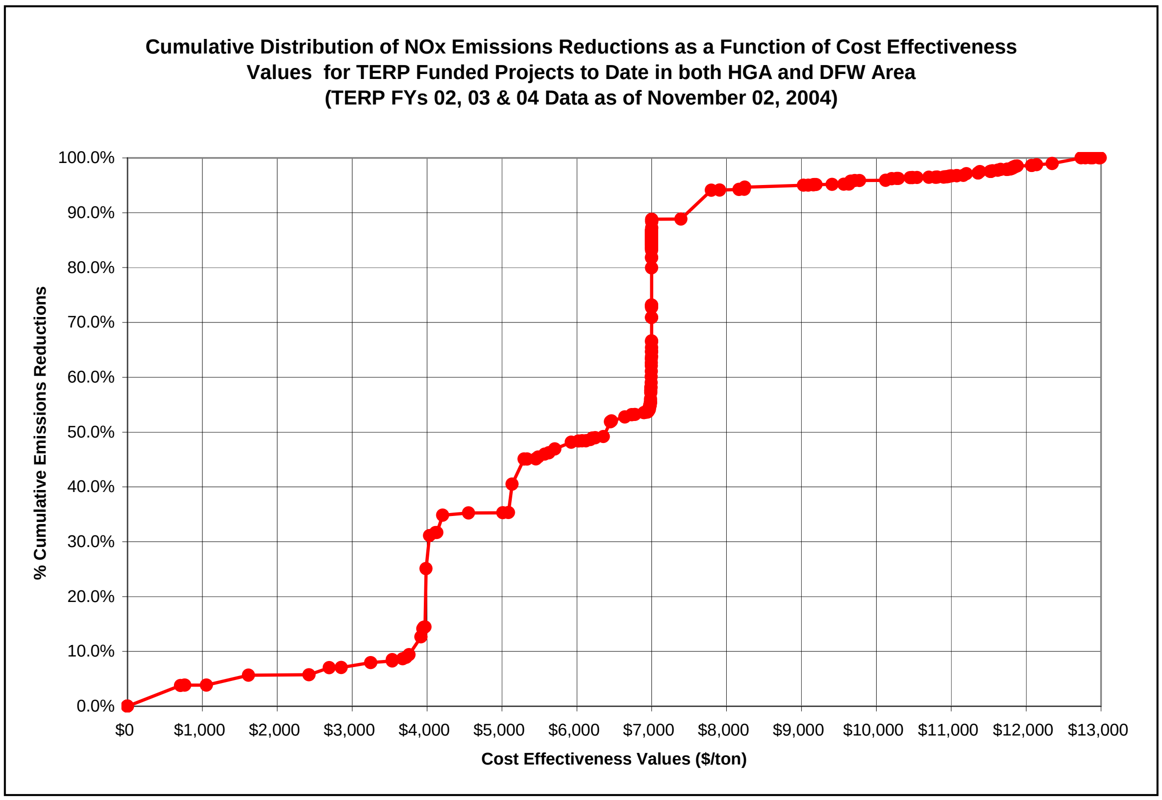

Figure 1. Cost-effectiveness (annualized over the life of the project) of TERP projects through 2004.

Although this cost effectiveness estimate does not provide a clear method to determine how much money must be spent, it does provide a means to determine which programs should be funded. We therefore used the one-year cost effectiveness to determine the funding level required to meet a specific emission reduction goal. TERP funding has been growing as the program has been implemented as shown in Table 1. As the funding levels increase, emission reductions would be expected to rise commensurately. Therefore, the program effectiveness in terms of expected emission reduction is dependent primarily on the available funding levels.

Table 2. TERP funding in HGB.

Year	Funding Level ($MM)	Emission Reduction (tpy)	Emission Reduction (tpd)	1-Year Cost Effectiveness
FY 2002	$3	40	0.2	$76,762
FY 2003	$13	155	0.6	$82,884
FY 2004	$45	1183	4.7	$37,694
FY 2005	$104	3234	12.9	$32,006
Total thru 2005	$164	4611	18.4	$35,556

TERP funding through 2005 has generated emission reduction in the HGB nonattainment area of between 17 and 20 tpd NOx reduction.[20] However, some projects with a limited life (most typically reported as 5 – 11 years) already funded under this program may be retired prior to the 2009 target year. Furthermore, it is uncertain how much of the TERP reductions have already been incorporated into the 2009 emission inventory. So the 20 tpd reduction already available with current funding or with future funding may overestimate the actual reductions which could be expected by 2009.

The TERP program however has been expected to distribute equivalent funding for 2006 and beyond. Through mid-year 2007 (the original sunset date of the TERP), funding of an additional $106 million was to be distributed in the HGB area as shown in Table 3. If the TERP were extended until 2010 with 50% of the funding used in the HGB area, the expected emission reduction at current cost effectiveness and the improved cost effective targets recently used by TCEQ, the range in emissions reductions would be 49 – 63 tpd for HGB TERP-funded projects. (see ENVIRON, 2004 and updated with recent TERP FY2005 figures for this work) through 2010. Through 2009, the emission reductions would range from 42 – 54 tpd.

Table 3. Expected revenue in $million (TCEQ Numbers: TERP Draft December 04 Biennial Report, 09/28/04).

Fiscal Year	TERP	HGB
FY 02/03	25.56	15.85
FY 2004	103.21	44.60
FY 2005	188.25	103.51
FY 2006	130.82	36.19
FY 2007-1st bid cycle	66.94	36.64
FY 2007-2nd bid cycle	66.94	33.47
FY 2008	135.13	67.57
FY 2009	135.13	67.57
FY 2010	135.13	67.57
Total	**987.11**	**472.97**

[20] Emission reductions will be primarily generated during nonholiday weekdays as most activity occurs during the week for on-road heavy-duty and nonroad engines. Therefore, an average of 290 days per year, which represents the mid-point between a full 365 day year and the 250 non-holiday weekdays in a year, represents one end of the range to convert tons/year to tons/day compared with the other end of the range, 250 days, as has been often reported.

Additional funding may come from additional sources to enhance the TERP program. These sources could include several discussed here and/or enhanced through other offroad programs such as the Portable Engine Registration Program that include registration fees. United States Environmental Protection Agency (EPA) (National Clean Diesel Campaign/Voluntary Diesel Retrofit Program) line item funding has been available to reduce emissions from diesel engines. The EPA has sponsored several initiatives with elements that could apply to an enhanced emission reduction program. The money available could be derived from a number of sources including grants or other direct or indirect funding opportunities.

Enforcement actions often result in fines or agreements to reduce emissions as a result of the actions or settlements. Supplemental Environmental Programs (SEP) are another source of funding for emission control projects. Violators of the Clean Air Act, as part of an agreement, fund mitigation programs as a portion of their violation penalties. The funding can be derived from State or Federal enforcement actions but is always special case funding and depends on availability.

The Congestion Mitigation and Air Quality (CMAQ) program has historically been exclusively restricted for use on highway projects (including car ferries as a special case). However, recent Congressional actions allow this money to be used for nonroad (offroad) construction engines. The CMAQ program is funded from the Federal highway motor fuel tax, but is administered by the individual state departments of transportation with the oversight of the Federal Highway Administration.

Emissions Affected

The emissions affected are those for nonroad sources other than aircraft (94 tpd) plus stationary internal combustion engines (0.4 tpd estimated from HGB inventory). Some TERP programs will affect on-road heavy-duty vehicles, which are projected to be 87 tpd for diesel vehicles (prior to adjustments for ambient humidity and temperature). Heavy-duty gasoline vehicles (7.9 tpd) are permitted to be included as TERP projects, but have yet to be part of any TERP projects.

Emissions Benefit

This measure is estimated to provide about 20 tons/day through 2005 and 42 – 54 tons/day with continuing funding levels or enhanced funding levels continued through 2009.

For the purposes of the modeling, TCEQ has assumed that about 39 tpd of NOx reductions will be realized by the TERP program in its current form. Therefore because the majority of the TERP are already accounted in the baseline emissions levels, an enhanced TERP program could realize an additional 15 tpd with the increased funding levels described in this analysis.

Cost and Cost-effectiveness

Up to $67 million per year ($240 million for 2006 – 2009).

The cost effectiveness has averaged about $5,000 per ton, though the cost effectiveness may need to rise as the more effective projects are funded first.

COMMENTS

The TERP program is the most acceptable emission reduction program to date based on participation and public comments.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
28	Enhanced TERP program	Continuing and increased TERP funded projects	Offroad (except aircraft and large CMV)	94 tpd offroad 87 tpd onroad	0 – 8%	0 – 15[1]	$5,000 – $10,000

[1] – TERP emission reductions of 39 tpd has already been credited in the baseline emissions inventory.

REFERENCES

ENVIRON (2004). "Texas Emission Reduction Plan Assessment in the Dallas Fort-Worth Area," Prepared for Houston Advanced Research Center, 4800 Research Forest Dr., The Woodlands, TX 77381, November 2004.

Control Measure: Construction and Other Publicly Funded Contracting Incentives, Measures 37, 38, 39, and 41
Category: Non-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

An incentive (pay for use) program for all publicly funded projects including captive state, county, or municipal fleets of off-road equipment.

Implementation Feasibility

An incentive program already exists for State funded highway projects through TxDOT. Similar incentives could be developed for fleets that bid on county and municipal projects. The implementation might also entail additional contract administration burdens or reduce the number of potential bidders on projects.

Consideration could be given to fleets, which have built-in turnover to newer equipment that may reduce the cost of the program. One implementation issue would be to avoid double counting between normal fleet turnover and TERP emission reductions, and emission reductions resulting from this measure.

Public Acceptance

However, the general public is unlikely to be affected by this strategy. The cost of incentives would need to be considered carefully.

ANALYSIS

Review of the TxDOT clean engine incentive program as a model for other programs.

TxDOT (2004) issued a contracting incentive to encourage the use of advanced emission controlled engines in equipment used for road construction projects. The incentive was described as shown in Table 1 with Table 2 describing the model year of equipment for each Tier. The incentive provided by TxDOT is significant especially because some of the benefit could be realized without a special purchase of new equipment or engines. But the incentive does not provide for the full cost of clean engine purchases because the present value of the benefit (<$30,000) usually exceeds the cost of a new engine.

Table 1. TxDOT clean engine incentive and calculated benefit.

Engine Tier	Monthly Incentive ($/hp)	Annualized Benefit for a 250hp Engine	Present Value of Incentive[1]
Tier 1	0.50	$1,500	$13,960
Tier 2	0.75	$2,250	$20,939
Tier 3	1.0	$3,000	$27,919

[1] Using 5% rate of return for 12 years.

Table 2. Emission standards for new compression-ignition engines in g/kW-hr (g/hp-hr).

Engine Power	Tier	Model Year	NMHC+ NO_X	CO	PM
KW<8 (hp<11)	Tier 1	2000	10.5 (7.8)	8.0 (6.0)	1.0 (0.75)
	Tier 2	2005	7.5 (5.6)	8.0 (6.0)	0.80 (0.60)
	Tier 3	2008	---	---	0.40 (0.30)
8≤kW<19 (11≤hp<25)	Tier 1	2000	9.5 (7.1)	6.6 (4.9)	0.80 (0.60)
	Tier 2	2005	7.5 (5.6)	6.6 (4.9)	0.80 (0.60)
	Tier 3	2008	---	---	0.40 (0.30)
19≤kW<37 (25≤hp<50)	Tier 1	1999	9.5 (7.1)	5.5 (4.1)	0.80 (0.60)
	Tier 2	2004	7.5 (5.6)	5.5 (4.1)	0.60 (0.45)
	Tier 3	2013	4.7 (3.5)	---	0.03 (0.02)
37≤kW<75 (50≤hp<100)	Tier 1	1998	9.25 (6.9) NO_X 1.3 (1.0) HC	None	None (smoke)
	Tier 2	2004	7.5 (5.6)	5.0 (3.7)	0.40 (0.30)
	Tier 3	2008	4.7 (3.5)	5.0 (3.7)	
75≤kW<130 (100≤hp<175)	Tier 1	1997	9.25 (6.9) NO_X 1.3 (1.0) HC	None	none (smoke)
	Tier 2	2003	6.6 (4.9)	5.0 (3.7)	0.30 (0.22)
	Tier 3	2007	4.0 (3.0)	5.0 (3.7)	
130≤kW<225 (175≤hp<300)	Tier 1	1996	9.25 (6.9) NO_X 1.3 (1.0) HC	8.5	0.54 (0.4)
	Tier 2	2003	6.6 (4.9)	3.5 (2.6)	0.20 (0.15)
	Tier 3	2006	4.0 (3.0)	3.5 (2.6)	
225≤kW<450 (300≤hp<600)	Tier 1	1996	9.25 (6.9) NO_X 1.3 (1.0) HC	8.5	0.54 (0.4)
	Tier 2	2001	6.4 (4.8)	3.5 (2.6)	0.20 (0.15)
	Tier 3	2006	4.0 (3.0)	3.5 (2.6)	
450≤kW≤560 (600≤hp≤750)	Tier 1	1996	9.25 (6.9) NO_X 1.3 (1.0) HC	8.5	0.54 (0.4)
	Tier 2	2002	6.4 (4.8)	3.5 (2.6)	0.20 (0.15)
	Tier 3	2006	4.0 (3.0)	3.5 (2.6)	
kW>560 (hp>750)	Tier 1	2000	9.25 (6.9) NO_X 1.3 (1.0) HC	8.5	0.54 (0.4)
	Tier 2	2006	6.4 (4.8)	3.5 (2.6)	0.20 (0.15)

According to Charles Brauer (2005), the TxDOT incentive program has resulted in only one contractor applying for repayment (of less than $1,000) under this specification through mid-2005. The documentation burden or the level of the incentive may be the reason for the low participation rate, and the incentive may not be sufficient.

Raising the level of the incentive may be required to affect emission reductions by encouraging greater use of equipment with advanced controls. The incentive may need to be raised four –fold to be equivalent to the TERP incentive as has been suggested to the City of Houston as shown in Table 3. As an example, the annualized benefit and present value for the incentive are shown in Table 1 to range from about $20,000 to $30,000 in present value when amortized over 12 years, a period typically far longer than remaining life of older equipment that could be replaced. However, the average incentive for a new engine according to the TERP funding for nonroad projects was $40,000. So the TxDOT incentive represents just over half the incentive of the TERP program and only if that piece of equipment is used exclusively on projects garnering the incentive. In addition, the TxDOT specification requires somewhat burdensome documentation, and there is no guarantee that the contractor can amortize equipment purchases over the 12-year period used in this example. A more realistic shorter amortization period of 5 years would reduce the present value of the incentive shown in Table 1 by half again making the incentive worth about 25% of a similar TERP grant. This latter conditional analysis was used to create the alternative incentive structure for contractors during a similar program review conducted by the City of Houston. (Pepple, 2006)

Table 3. Recommended clean engine incentive (Pepple, 2006).

Engine Tier	TxDOT Monthly Incentive ($/hp)	Recommended Monthly Incentive ($/hp)
Tier 1	0.50	2.50
Tier 2	0.75	3.50
Tier 3	1.0	4.50

Emissions Affected

The emissions affected include those associated with public fleets and publicly funded contracts. The estimates for construction equipment in the table above would be supplemented to include other types of equipment including forklifts, specialty vehicles, lawn and garden maintenance, and other nonconstruction equipment. It was estimated for DFW from files provided by TCEQ (2005, and ERG, 2005) that about 16% of construction equipment NOx emissions would be generated by public fleets and publicly funded contracts. Applying 16% to the HGB construction inventory of 30.4 tpd projected for 2009 yields about 5 tpd from public and publicly contracted construction equipment fleets.

Emissions Benefit

If all the incentive were used, this would represent about a 20% reduction from the baseline. The 20% figure was determined as a difference between the emissions expected using the typical model year distribution and if the latest model year was used for entire fleet. In 2009, many engines will have already turned over to the Tier 3 (or Tier 2 for some engine types), so the incentive would not affect an emission reduction for those engines. Therefore, for all public fleets and all publicly funded projects, the maximum benefit would be approximately 1 tpd.

Cost-effectiveness

Without TERP funding, $5,000,000 - $13,000,000 annually may be the cost to encourage cleaner fleets based on the range in cost effectiveness of the TERP program where one ton of annual off-road NOx emission reductions cost from $20,000 to $50,000 in capital funding. The cost effectiveness of this measure should be similar to the TERP though both TERP and this incentive could potentially co-fund the same emission reduction.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
37, 38, 39, 41	Emission Reduction Contract Incentives with Public Funding	Encourage lower emitting engines used on Publicly-funded projects	Nonroad Construction – Public Funded Projects	5	20	1	<$14,000

REFERENCES

Brauer, Charles, personal communication, TxDOT, October 14, 2005.

ERG (2005), “Ozone Science and Air Modeling Research Project H43T163: Diesel Construction Equipment Activity and Emissions Estimates for the Dallas/Ft. Worth Region,” Prepared for: The Houston Advanced Research Center, Prepared by: Eastern Research Group, Inc., August 31, 2005.

Pepple, K. (2006), “Clean Contracting Program for Houston-Galveston Area Local Governments,” DRAFT, November, 2005, transmitted through personal communication, January 2006.

TCEQ (2005), personal communication with Karla Hardison, October 14, 2005.

TxDOT (2004), Special Specification 5018, “Incentive for Using Non-Road Diesel Equipment Powered by EPA Tier 1, 2 or 3 Diesel Engines in Nonattainment and Affected Counties,” December 7, 2004.

TxDOT (2005), Dallas and Ft. Worth District contract letting, http://www.dot.state.tx.us/des/letperf2006/allareas.htm

Control Measure: Limitations on Idling of Heavy-duty Construction Equipment, Measure 42
Category: Non-road
Author: Chris Lindhjem, ENVIRON

DESCRIPTION

This measure would reduce extended idle from construction equipment. The measure may be implemented through operational controls or through engine retrofit.

Implementation Feasibility

Without installed devices, it might be difficult to demonstrate reduced extended idling of equipment.

Public Acceptance

The cost of installed devices may be prohibitive but automatic shut-off devices during warm weather may be cheaper or if a reasonable enforcement mechanism can be developed the cost could drop significantly.

ANALYSIS

Analysis of this measure is based on estimated time in idle and relative emissions rates while at idle. Base on the EPA test procedure for off-road engines, it is estimated that nonroad engines are at idle 15% of the time they are in operation. Using emission results for a Tier 1 engine (see EPA, NONROAD model documentation, 2005) as shown, for example, in Table 1, the idle emissions are responsible for 1.4% of all emissions. Not all engines operate with the same profile as the 8-mode testing cycle shown in Table 1. On the other hand, it is not possible to eliminate all engine idling as some of the idle time occurs in short duration intervals between non-idle modes that occur during normal operations.

Table 1. Mode weightings and emissions by mode for a sample engine.

Mode	Time Weighting	Speed	Torque	NOx (Tier 1 Engine) (g/hour)	Emissions Fraction
1	0.15	Rated	100%	1,626	24.9%
2	0.15	Rated	75	1,220	18.7%
3	0.15	Rated	50	784	12.0%
4	0.1	Rated	10	231	2.4%
5	0.1	Intermediate	100	1,740	17.8%
6	0.1	Intermediate	75	1,342	13.7%
7	0.1	Intermediate	50	898	9.2%
Idle	0.15	0	0	92	1.4%

Applying the idle emission reduction percentage, 1.4%, to all nonroad equipment, excluding locomotive and aircraft addressed under different measures, the expected emission reductions would total 1 tpd in emission reduction. Because not all idling can be addressed as noted above and not all engines may be cost effectively retrofitted with automatic engine shut-offs, a 50% effectiveness criteria was applied to determine a more reasonable, lower estimate of actual emission reduction.

Technology approaches for an automatic shut-off could be as simple as a timer on the ignition or more complex. For example, the Kim HotStart (2004) system uses engine and oil heaters combined with automatic engine shut off software to reduce idle time without a difficulty of restarting or detriment to the engine.

Emissions Affected

The range of affected emissions includes just construction and mining (30 tpd) or all nonroad equipment (72 tpd) aside from locomotive and aircraft.

Emissions Benefit

0.4 – 1 tons/day NO_x reductions are estimated if all equipment reduced idling by 50% or 100%.

Cost and Cost-effectiveness

The cost of devices that would provide engine-warming technology coupled with automatic idle reductions would be approximately $3,000 - 5,000 per unit. Given the climate and need mainly for warm weather emissions control, a more basic timing device (at an estimated 10% of the higher cost device) might be used to automatically shut off the engine when not in used.

About 90% of all nonroad emissions are derived from 25,000 pieces of higher power equipment and about 70% from 13,000 pieces of equipment based on certain power and application, so might cost upwards to $100,000,000. In addition, the fuel saving was an estimated 80 – 100 gallons per year per piece of equipment based on the idle mode reduction and so may pay for the cost of installing automatic shutoff devices.

Using the upper end of the price range at $4,000 per piece of equipment and 25,000 pieces of equipment, the cost amortized over a 10-year project life would be about $40,000 per ton. If a cheaper device can be used that costs $400 dollars and applied to the only the larger pieces of equipment, the cost effectiveness can be improved to about $4,000 per ton.

COMMENTS

This measure is often considered an operational control, however the use of automatic devices would be useful for demonstrating compliance. An in-depth analysis of the technology or cost was not performed due to time constraints but is recommended prior to moving forward with implementation.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	tpd	
42	Limitations on idling of heavy-duty construction equipment	Reduce Idling from construction and all nonroad engines	Nonroad	30 – 72[1]	1.4	0.4 – 1	$4,000 - $40,000

[1] Upper bound of range based on idle reduction from all nonroad equipment except marine, aircraft, and locomotive. Lower bound based on construction equipment only.

REFERENCES

EPA (2005), "Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling -- Compression-Ignition," NR-009c, EPA420-P-04-009, April 2004.

Kim HotStart, "Idle Reduction Technologies," April 14, 2004 Jason Barnes, http://www.epa.gov/region02/air/2004/hotstart04_14_04.pdf

Control Measure: Cleaner Diesel Fuel, Measure 55
Category: Off-road
Author: John Grant, ENVIRON

DESCRIPTION

The cleaner diesel control measure would consist of a change in diesel fuel from Texas Low Emission Diesel fuel (TxLED) to either cetane additive enhanced (CAE) or Fischer-Tropsch (FT) diesel fuel. It is anticipated that, due to the nature of CAE and FT diesel technology, this program may not be a mandatory change to CAE or FT diesel, but may more likely be for a localized or demonstration project on specific fleets of off-road equipment.

TxLED fuel contains less than 10 percent by volume of aromatic hydrocarbons and has a cetane number of 48 or greater. CAE diesel would consist of diesel to which additives were supplemented, producing a cetane number increase of 5 points with no changes in other parameters from TxLED fuel. FT diesel fuel would consist of typical FT fuel with a cetane number of 74 and an aromatic content of 0.1 percent (Clark et. al., 1999).

Implementation Feasibility

Large-scale production of Fischer-Tropsch fuels are currently being researched by several oil companies (EPA, 2002), however, production is currently scarce and costly. Cetane additives are available for implementation; however, distribution issues would make it difficult to make the use of cetane enhancers mandatory over the entire HGB. Therefore, this measure was evaluated as a targeted measure, consisting of replacing TxLED fuel in 10% of the off-road diesel engines with either FT or CAE fuel.

Public Acceptance

This measure would require changes in diesel production associated with each technology. Increased costs associated with this production could potentially be burdensome for diesel manufactures that would need to change their operations to conform to new standards, as well as for diesel consumers due to increased diesel costs. It is expected that grant funding could ease this burden.

ANALYSIS

This measure was analyzed by comparing the emissions associated with current TxLED fuel with FT and CAE diesel fuel. Emission reductions of 12% (Clark et.al. 1999) and 1.3% (EPA, 2003) were estimated for FT, and CAE fuel, respectively. Based on the onroad emission inventory for 8 counties in the HGB nonattainment area provided by TCEQ, relative fractions of emissions from diesel, gasoline, and other fueled engines indicated that approximated 68 tpd of NOx was derived from locally-based diesel fueled engines. At the lower bound, 10% of these were estimated to be fleet equipment for the implementation of FT and CAE fuel projects.

Emissions Affected

The emissions affected could include all local (subtracting commercial marine and line-haul locomotives) diesel engines (68 tpd, prior to adjustments for ambient conditions and other emission reduction measures) or to the entire or portions (estimated here at 10%) of fleets of off-road equipment (7 tpd).

Emissions Benefit

Estimated emission reductions from this measure are 0.1 – 0.82 tpd NO_x for the fleets representing 10% of all diesel off-road equipment, or 0.9 – 8.2 tpd NOx if applied across all diesel operating in the area.

Cost and Cost-effectiveness

Estimates from vendors indicate that cetane increases of 5 points would cost approximately $0.08 per gallon.

The cost of Fischer-Tropsch fuels ranges from $0.10 (cost to produce) up to $0.25 per gallon (to deliver under current market conditions) more than California Diesel (CEC, 2003). The cost of these fuels however has been decreasing due to advance in the technology and economies of scale if demand increases as it is beginning to in California where it is increasingly sold as a neat fuel or a blend stock to produce California reformulated diesel fuel.

The average emissions per gallon of fuel were based on the fuel consumption and NOx emissions from a typical NONROAD model run for the HGB counties. The fuel cost and emission reductions per gallon of fuel were used to estimate the cost effectiveness of the strategy. The cost effectiveness was then estimated as the ratio of added fuel cost to emission reductions, $64,000/ton and $21,000/ton for CAE and FT fuel respectively based on the assumptions of cost and effectiveness.

SUMMARY OF RESULTS

Measure #	Name	Description	Affected Sources	Affected Emissions (tpd)	Expected Emission Reduction		Est. Cost Effectiveness ($/ton)
					%	Tpd	
55	Cleaner Diesel Fuel	Cetane Additive Enhanced or Fischer Tropsch Diesel Fuel	Local Off-road Diesel Engines	6.8 68	1.3% - 12%	0.1 – 0.8 0.9 – 8.2	$21,000 - $64,000

REFERENCES

CEC (2003), "Reducing California's Petroleum Dependence", A Joint Report of the California Energy Commission and California Air Resources Control Board, P600-03-005F, August 2003.

Clark et. al. (1999), Clark, Nigel, Mridul Gautam, Donald Lydons, Chris Atkinson, Wenwei Xie, 1999, "On-Road Use of Fischer-Tropsch Diesel Blends", SAE Technical Paper Series, 1999-01-2251, Washington D.C., April 1999.

EPA, 2002, "Fact sheet: Clean Alternative Fuels: Fischer-Tropsch", EPA420-F-00-036, http://www.epa.gov/otaq/consumer/fuels/altfuels/420f00036.pdf

EPA (2003), "The Effect of Cetane Number Increase Due to Additives on NOx Emissions from Heavy-Duty Highway Engines, Final Technical Report", EPA420-R-03-002, February 2003.

TTI (2005), "2002, 2009, and 2012 Emissions Inventories for the Houston/Galveston Eight-Hour Nonattainment Counties", Texas Transportation Institute, August 2005.

Appendix A

Control Measures Not Evaluated

ID	STRATEGY	*Further Description*	EPA
Bicycle and Pedestrian			**PQSE**
1	Subsidized "Segway" vehicles or bicycles	*Provide subsidies for purchase of bicycles, "Segway" vehicles, or other ped-bike-related mobility aids.*	Y
2	Bicycle lane striping		N
3	Medians		N
4	Safer bike routes with better signs marking lanes and routes		N
5	Require inclusion of bicycle lanes on state or federally funded thoroughfare projects		Y
6	Create more dirt trials for multiple use activities (bicycles, motorcycles, horses, hiking)		N
7	Fully fund projects in bicycle plan		Y
8	Bicycle route signalization		N
9	Bicycle facility design guidelines and regulations		N
10	Expedite bicycle projects and programs from RTP		N
11	Bicycle lanes on every arterial and frontage road		Y
12	Bike-through service	*"Bike-through" (rather than drive-through) service at fast-food restaurants, other convenience services.*	N
13	Bicycle lane and path repaving		N
14	Bicycle lanes on freeways		N
15	Bicycle speed ramps for safety		N
16	Bicycle route lighting		N
18	Bicycle plans and maps		N
19	Bicycle coordinators		N
20	Increased bicycle and pedestrian outreach to immigrant communities		N
21	Media coverage and promotion of bicycle facilities		N
22	Bicycle education		N
23	Adopt public and private bicycle parking standards and ordinances		N
24	Region-wide mandatory bicycle racks at work sites		N
25	Address security concerns of pedestrians and cyclists		N
26	Showers and clothing lockers		N
27	Bicycle lockers, racks and other storage facilities		N
28	Cash rebates for bicycle purchases		N
29	Free bicycles		N
30	Biking and hiking patrols to ensure safety		N
31	Clear sight lines for bicycle safety		N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
32	Regional bicycle parking ordinance for all new construction and require bicycle transit centers for/at all employment centers with 100 or more employees. Also, bike lockers, clothing lockers, showers, dry cleaners, bike repair, bike rental.		Y
33	Integration of bicycle and pedestrian facilities with transit		N
34	Permit bicycles on rail transit		N
35	Bicycle racks on buses	*Install racks on buses to permit bikers to use buses for long portion of trip and use bike for access at both ends of trips.*	N
36	Street level shops		N
37	Give bicyclists and pedestrians the right-of-way		N
38	Provide funding so volunteers do not have to pay the cost of trail creation and maintenance		N
39	Cyclist and pedestrian sidewalk furniture		N
40	Pedestrian facilities and programs		N
41	Sidewalks and walkways		N
42	Crosswalks		N
43	Additional pedestrian access and circulation		N
44	Pedestrian signals		N
45	In-line skating commuter paths		N
46	Connected street system and pedestrian pass-throughs		N
47	Pedestrian design improvements	*Pedestrian design improvements to facilitate walking (e.g., benches, water fountains, lighting, emergency phone booths).*	N
48	Mid-block pedestrian connections	*Provide additional pedestrianways connecting through blocks where existing pedestrian routes are circuitous.*	N
49	Wide, unobstructed sidewalks on both sides of all arterials, major roads and other streets		N
50	Pedestrian facility design guidelines and regulations		N
Clean Vehicle Programs			
51	Clean Cities Technical Coalition		N
52	Incentive for Clean City Designation		N
53	Automobiles with 27 or greater miles per gallon average and an EPA score of 6 or greater eligible for property or sales tax reduction		N
55	Provide public recognition of fleets that have undertaken voluntary efforts to reduce emissions as an incentive to consider projects that benefit regional air quality and public health		N
56	Close loopholes in the Texas Clean Fleet Program making fewer exemptions for fleets		N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
57	Marketing campaign to develop and image that Low Emitting Vehicles (LEVs) are "cool"		N
58	Fleet review, procurement and operations policies		Y
59	Public agency clean fleet program	*Commitment by public agencies to purchase cleanest possible fleet vehicles*	Y
60	Natural gas fuel specifications	*Natural Gas Fuel Specification (NOx) MSC-07. Set an upper limit of the heating value of natural gas. Prevent emission increases from the combustion of natural gas with uncharacteristically high heating value (HHV) in stationary applications. The high heating value of such gas relative to natural gas with a lower heating value may result in increased combustion temperature and, possibly, higher NOx emissions. Natural gas produces/suppliers could achieve the objective of this control strategy by either not supplying hot gas to the District, or by removing higher hydrogen compounds or otherwise reducing the Btu value of the hot gas.*	N
61	Alternative Fuel pilot projects		Y
62	Require service stations with more than two gas or diesel pumps to offer at least one alternative fuel pump		N
63	Incentives to add alternative fuel vehicles to fleet		N
64	Ethanol (E85) refueling stations for public use		N
65	Require fleets who meet EPACT regulations with flexible fuel vehicles to make arrangements for the delivery of ethanol to Texas		N
66	Require alternative fuels for public fleets		Y
67	Require new truck stops to offer alternative fuels in addition to gas and diesel		N
68	Clean Vehicle Loaner Program		Y
69	Bill to allow more hybrid outlets (i.e. Ebay, Costco, local food co-ops, etc.)	*To boost sales and reduce the cost of hybrids and other lower-emission vehicles, a bill in the California Assembly proposes that automakers be allowed to sell them through alternative channels.*	N
70	Hybrid Vehicles		Y
72	Clean Vehicle Program to offer incentives to purchase Ultra Low Emitting Vehicle (ULEV) or equivalent vehicles		Y
73	Electric buses		Y
74	Fuel cell school buses		Y
75	Airports use Ultra Low Emitting Vehicle (ULEV) or electric vehicles instead of diesel for ground transportation		Y
76	Propane school buses (Dallas County Schools 800 buses)	*Received a National Partner Award from US Department of Energy for using 800 propane school buses and 1.5 million gallons of propane last year. Also recognized by the national Propane Education and Research Council.*	Y
77	Bus conversion to Liquid Natural Gas (LNG) or cleaner fuel		Y

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
78	Electric powered aircraft refueling		Y
79	Clean Vehicle Taxi Cab Program		Y
80	Lottery for purchasers or owners of qualifying low emission vehicles	*Use $5-$10 from each vehicle registration fee for lottery type award program. Monthly drawing with buyers of qualifying (lowest) LEVs during past year or registrants of qualifying LEVs eligible for prizes.*	Y
81	Market incentives for the manufacture and use of fuel cells		Y
82	Use solar cells to run A/C and other electrical equipment on DART buses		Y
Emission Credits / Offsets			
83	Mobile source emission reduction credits	*Provide opportunities to generate NOx, VOC, CO, PM, and SOx mobile source emission reduction credits (MSERC) that could be used as an alternative means of compliance with District regulations. These credits would be generated based on voluntary emission reductions created by the operation of low- or zero-emission on-road vehicles within the boundaries of the District that result in emission reductions beyond those required by local, state and federal regulations. For light, medium, and heavy-duty vehicles.*	N
Freeway Incident / Roadway Construction Management			
84	System/service operational improvements and changes	*Needs definition*	Y
85	Coordinate scheduling of arterial and highway maintenance to exclude ozone action days if the maintenance activities require lane reductions on heavily utilized arterials and highways		N
86	Minimize impact of construction on traveling public by having contractors pay when lanes are closed as an incentive to keep lanes open		N
87	Stage road construction and lane closures to reduce congestion	*Schedule road construction or other non-emergency lane closures for lower-traffic times of the year and time of day to minimize congestion. Also develop staging as to avoid creating additional congestion.*	N
88	Stricter requirements on construction sign advisory accuracy	*Ensure construction advisory signs are accurate. Numerous misleading signs cause drivers to ignore them and not merge ahead of time.*	N
89	Freeway diversion and advisory signing		N
90	Force traffic onto frontage roads during incidents		N
91	Use dynamic message signs to direct and smooth speeds during incidents or congestion		N
92	Off-road ticketing	*Ticket traffic violators for going "off-road" rather than in right lane or shoulder.*	Y
93	Allow use of shoulders to circumvent accidents		N
94	Integrated surveillance and control		N
95	Installation of glare screens to reduce rubber-necking delays on High Occupancy Vehicle lanes		N
96	Flashing signs noting "Emergency Vehicle Approaching"	*Flashing signs to allow drivers to merge before an emergency vehicle is directly behind them.*	Y

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
97	Congestion management field team to clear accidents	*Insufficient data to detemrine accident-related emissions and not in base-case inventory anyway*	N
98	Improved incident detection, response and management to minimize traffic delays		N
102	Locate hazardous freeway areas for possible improvements, i.e. sharp turns, clover leafs, et cetera		Y
103	Implement effective environmental driving		
Freeway System Infrastructure			
104	Limit road and highway improvements to those benefiting transit and high occupancy vehicle (HOV) lanes		N
105	Shift highway funds to transit		Y
106	General highway improvements		N
107	Additional lanes without new construction		Y
108	No new peripheral highways or loops	*Increase street capacity only within established urban areas (in nonattainment areas), rather than encouraging longer trips and sprawl development with new peripheral capacity*	N
Fuel Evaporative Emissions			ENVIRON
109	No morning fueling	*No vehicle refueling permitted from 7 a.m. to noon, or similar hours.*	Y
110	Sell cheap lottery tickets to people who buy gas in the afternoon as opposed to the morning during ozone season		Y
111	Ozone alerts to postpone morning gas activity; have incentives to promote industry support		Y
112	Gas cap legislation and program		Y
Fuel Standards			ENVIRON
113	Federal Ultra Lower Sulfur Diesel (ULSD)		N
114	California diesel fuel		N
116	Federal diesel fuel Advance Notice of Proposed Rulemaking (ANPRM)		N
117	Texas Low Emission Diesel (TxLED)		N
118	Outlaw diesel		N
119	Lower Reid Vapor Pressure clean gasoline	*Summer month Reid Vapor Pressure (RVP) of 7.8 pounds per square inch (psi), effective May 2000*	Y
120	Federal Phase II Reformulated Gasoline (RFG)	*California RFG with reduced (30 ppm to 20 ppm) sulfur - 12 counties*	N
121	Nitrogen Oxide reduction following removal of MTBE		N
Funding			
122	Streamline process for Safe, Accountable, Flexible and Efficient Transportation Equity Act (SAFETEA) and Congestion Mitigation and Air Quality (CMAQ) projects		Y
General Public Education and Outreach			
123	Educate public about fuel savings from properly inflated tires, regular tune-ups and driving speed		N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
124	Promotion of good driving habits and not using vehicle air conditioning before 10:00 a.m.		N
125	Celebrity volunteers for ozone alert announcements		N
126	Provide more information on what not to do on ozone days		N
127	Air quality information with driver training	*Include information on vehicle emissions and air pollution with new-driver and defensive-driving education.*	N
128	Air quality public outreach		N
129	Ozone awareness booths at events and festivals		N
130	Targeted Movie Theater Promotions	*In past years, radio has been the media of choice to air ozone public service announcements. The 2003 ozone season was the second summer the RAQC took a different approach and ran slides in movie theaters throughout the region. The slide listed three things "You Can Do" to reduce pollution*	N
Goods Movement			
131	On-street loading zones for commercial vehicles		N
132	Peak-hour on-street loading prohibition for commercial vehicles		N
133	Additional lanes		N
134	Sign placement for truck management		N
135	Scheduling of shipping and receiving		N
136	Freight and delivery consolidation		N
137	Reschedule truck travel		N
138	Route trucks to not be impacted by event traffic		N
139	Designated truck routes		Y
140	Reroute trucks on ozone days		N
141	Dedicated truck lanes		N
142	Reduce truck travel during peak periods		N
143	Establish curfews for heavy trucks to prohibit night-time high speed travel		N
145	Lane restrictions		N
High Occupancy Vehicle (HOV) Lanes/Managed Lanes			
147	Permit HOV lane use by qualifying low emission vehicles (LEV)		Y
148	Use of HOV lanes by trucks	*Allow commercial trucks to use HOV lanes during off-peak hours.*	N
149	Allow alternative fuel vehicles in HOV lanes		Y
151	More aggressive HOV enforcement	*Aggressive enforcement of HOV occupancy requirements to further benefit HOV facility users and encourage HOV use.*	Y
152	Automated enforcement of HOV occupancy requirements via cameras and related technology		N
153	Incentives for high HOV users - track and waive registration fees		Y
154	Convert free lanes to HOV		Y

ID	STRATEGY	*Further Description*	EPA
Bicycle and Pedestrian			**PQSE**
156	Limit use of selected freeway interchanges to HOVs all day	*Reduce freeway use by reducing number of interchanges available to single occupant vehicles. Will reduce congestion and promote use of HOVs. Would require several restricted interchanges to have effect.*	Y
158	Continue HOV to Denton		N
159	HOV service on all freeways with increased access (compared to barrier separated scheme)	*Two HOV lanes per direction with buffer rather than barrier separation*	N
160	Exclusive HOV ramp	*Separate entrance or exit ramp for HOVs or buses; could be grade separated or at grade depending on connections needed.*	Y
162	Managed HOV lane on tollway		Y
High-Emitting Vehicle Detection and Programs			ENVIRON
163	Focus on finding and penalizing extreme high emitters		Y
164	Emissions Smart Signs		N
165	Rewards for reporting smoking or high emitting vehicles		Y
166	Smoking vehicle hotline	*Public program to report smoking vehicles. Follow-up contact is made by letter to vehicle owner.*	Y
167	More enforcement of smoking vehicles; Peace officers	*Increase enforcement of smoking vehicles; institute a separate law-enforcement staff to monitor smoking or high-emitting vehicles.*	Y
168	Surveillance program (roadside on-board diagnostic read)		Y
169	Use vehicle model targeting to identify high-emitting vehicles	*Develop and implement targeting strategies (based upon vehicle model, production year or similar criteria) to identify likely high-emitters for emissions testing and repair.*	Y
170	Remote sensing and follow-up letters		N
171	Roadside pullovers (portable inspection and maintenance measures)		N
173	High-emitting vehicle repair assistance		N
174	Retrofit, replace or repower vehicles and engines		Y
175	Retrofit aircraft engines		N
176	Demolish impounded vehicles that are high-emitting		N
177	Recognized emission repair facility technician training		N
178	Allow cities to remove engines of high-emitting vehicles (pre-1980) that are abandoned and to be auctioned		N
179	Accelerated vehicle retirement program		N
180	Fuel additives		N
181	Dedicated funding for school bus replacement		N
182	Low income vehicle repair and replacement assistance program		N
183	Buy vehicles older than model year 1975 to retire from use		N
184	Aftermarket Technology and Fuel Additive Research Program		N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
185	Expanded repair and replacement assistance program (near-low income and non-low income)		N
186	Non-profit organization assistance program	*Investigate opportunities to partner with non-profit organizations to ensure high-emitting donation vehicles are not returned to the road and reused in an "as is" condition.*	N
187	Direct funding of alternative fuel conversions (target inspection and maintenance failures)		N
188	Enforce smoking vehicle reports and require repairs		N
189	Tax or license fee credit to scrap old vehicles, replace or retrofit engines	*Provide property or income tax credit or credit on next license fee for accelerated retirement of qualifying vehicle according to state or other definition.*	N
190	New vehicle discounts for old vehicle trade-ins		N
191	Low-interest financing for low income and/or old vehicle trade-ins		N
192	Transit passes/credit in exchange for old vehicle scrappage		N
193	Ban sale of high-emitting vehicles		N
194	Ban high-emitting vehicles in CBD		N
195	Deny registration to vehicles with repeated emission failures		N
196	Limit access for high-emitting vehicles to major urban arterials (such as heavy trucks) during peak hours		N
197	AFE/2000 Fuel Modifier		N
198	Retrofit with catalytic converters		N
199	Muffler for low-exhaust emission control retrofit system (EcoNOx)		N
200	Retrofit with particulate traps		N
Intelligent Transportation Systems (ITS)			
201	Communicate by radio best routes through area to avoid congestion		N
202	Information telephone hotline for traffic conditions		N
203	Text messaging/real-time on-line service for bus stop routes	*Persons can sign up for text message notifications on their cell phone or check real-time bus route information to find out if they have missed a bus.*	N
204	Provide transportation information kiosks in high activity areas in or near transit stations and stops		N
205	Provide real-time traffic information to trucking centers and rental car agencies		N
206	Post current facility speeds on internet		N
207	Provide transportation conditions internet site	*Provide hotlink to local transportation conditions website or provide internal webpage with transit, traffic, other conditions, schedules and directions to encourage use of modes other than driving alone.*	N
208	Encourage bicycle use by using ITS to increase safety in strategic bicycle/automobile conflict areas		N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
209	Dynamic message signs for control of truck movements		N
210	Dynamic message signs for freeway traffic control		N
211	Real-time display of estimated time of arrivals at bus stops	*Provide changeable message signing at bus stops noting ETA of the next buses arriving at the stop.*	N
212	Increase system surveillance		N
Ozone Action Day / Ozone Season			
213	Postpone external meetings until after 10:00 a.m. during ozone season		N
214	Limit left turns on selected thoroughfares during ozone season		N
215	Do not schedule off-site meetings on ozone action days		N
217	Incentives to shift production to low production		N
218	Delay high emissions producing activities on ozone action days; delay activities for non-ozone action days		N
219	Close government offices on ozone action days to serve as an example		N
220	Have varying levels of reduction on ozone actions days to accommodate vital activities		N
221	Voluntary business closures on ozone action days		N
Parking Management			
222	Employers charge for drive alone parking		Y
223	Revise or impose maximum parking requirements in zoning code		N
224	Allow reduction in minimum parking requirements per zoning code for traffic mitigation actions		N
225	Use zoning and parking regulations to limit capacity and control parking supply		N
226	Scare tactics combined with educational programs to explain parking options	*Use "scare tactics" advertising the scarcity of parking and the difficulty of single occupant vehicle travel for special events; promote transit, special shuttles or other high occupant vehicle travel modes as applicable. Provide information on alternative transportation to special events.*	N
228	Preferential parking for High Occupancy Vehicle (HOV) lane users and ride sharers; Rate reduction		N
230	Remote parking/meal packages with shuttle bus services	*Event/meal package at outlying location with shuttle service provided to and from event venue*	N
231	Free parking at park-and-ride facilities for High Occupancy Vehicle (HOV) lane and transit users	*Provide free parking at facilities served by transit; include costs elsewhere or subsidize. Include in weekly or monthly passes.*	N
232	Remote parking with shuttle service		N
233	Purchase parking lots and convert to other land use		N

ID	STRATEGY	*Further Description*	EPA
Bicycle and Pedestrian			**PQSE**
234	Promote joint use of theater, church, stadium and shopping center parking		N
235	Increase parking at transit centers or stops		N
236	Use direct ramps to connect park-and-ride lots with freeway system		N
237	Locate fringe parking and park-and-ride lots on approach routes and interchanges to central and other major business districts		N
238	Provide park-and-ride lots serving perimeter counties		N
239	Parking space locater	*Automated management/fee collection/information system/direction to available spaces in parking lots or garages.*	N
240	Provide parking at all major transit stations		N
242	Increased parking fees during peak commuter arrival hours	*Charge higher rates than normal daily rates for vehicles arriving during AM peak periods.*	N
243	Parking space tax or surcharge	*Institute a parking space tax or surcharge which is used to subsidize transit*	N
244	Area-wide tax for parking		N
246	Increase meter fees for on-street parking		N
247	Charge per parked car at events	*Charge those who rent space for each car that drives to (and parks at) the event; charge if alternate transportation is not provided to the event.*	N
250	Increase parking fees		N
251	Tax provision of free public sector free parking		N
252	Long vs. short term public sector parking pricing		N
253	Smart Cards pay as you go parking		N
254	On-street residential parking controls		N
255	Develop requirements for no or limited parking		N
256	Reduce legal on-street parking spaces in high congestion areas		N
257	Limit the number of parking spaces at commercial airlines to support mass transit		N
258	Removal of on-street parking for commercial and industrial developments	*Require design and implementation of off-street parking.*	N
259	Restrictions on on-street curbside parking		N
260	Increase enforcement of on-street parking, including towing		N
262	Limit peak period parking to vehicles with two or more occupants	*Use flextime, but permit only vehicles with two or more occupants to enter workplace parking facilities during peak periods.*	N
263	Limit construction of new parking supply in areas served by transit		N
264	Limit number of on-street and off-street parking spaces in designated areas for control of parking supply		N
265	Permit no additional parking supply in activity centers well served by transit	*Place cap or permit not additional parking (perhaps other than visitor parking) in downtowns or other activity centers that have good transit service from most parts of area.*	N
266	Limit residential parking in areas around transit centers; Limit parking to one vehicle per dwelling unit		N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
267	Close selected parking facilities until after AM peak period ends	*Open centrally-located parking facilities after 9:00 or 9:30 a.m. so commuter parking is not available and those short-term parking can use the most convenient parking available.*	N
268	On-street parking peak hour ban and enforcement		N
269	Reduce parking at stadiums		N
Pricing Measures			
270	Cheaper gasoline prices during evening hours		Y
271	Remove fuel subsidies		Y
272	Charge more for higher emission fuels		N
273	Accelerated depreciation allowance for employer provided vanpool and bicycle facilities		N
274	State and local exemptions for provision of vanpool benefits		N
276	Encourage having multiple cars	*Many people need larger vehicles for occasional household needs (ie. kids, pets), but could own a second, more fuel efficient car for regular commuting when cargo space is not needed.*	N
279	Progressive registration fees for vehicle emission standards (age)	*Progressively increase vehicle registration fees for higher emission rates vehicles still operating*	N
280	Discounted registration for lower-than-standard annual vehicle miles traveled		N
281	Progressive registration fees for number of vehicles per household or person	*Institute progressive vehicle registration fees (second, subsequent cars per household cost more to register).*	N
283	Vehicle miles traveled - based registration fees	*Base vehicle registration fees on VMT driven in previous year. e.g.: 25K VMT/year -- $700; 20K VMT/year -- $400; 15K VMT/year -- $200-300; etc.; 6K VMT/year -- base fee*	N
284	Tax incentive and subsidy programs - Insurance coverage		N
285	Tax increase for cars with and EPA score of four or less and all mobile equipment below a certain standard		N
286	Tax incentive and subsidy programs - Liability responsibility		N
287	Local or regional fuel taxes		Y
288	State and local exemptions for pooling or transit subsidies		N
289	Exemption of rideshare vehicles from "common carrier" tax status		N
290	Vehicle tax for two or more vehicles per household		N
291	Vehicle miles traveled - based taxes	*Charge a tax for VMT per year.*	Y
292	Tax credits for alternative fuel use		N
293	Exclude sales tax on hybrid and other clean vehicle purchase		N
294	Cold start tax	*Implement a tax based on the number of cold starts per vehicle per year.*	N
296	Peak period tolls to enter designated congested areas		N
297	Increase tolls during daytime traffic periods		N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
298	No tolls for buses and vanpools		N
299	For vehicle miles traveled charge, levy higher rate during daytime than at night		N
Speed			
302	Aggressive driving enforcement		N
305	Safety speed limits	*Establish lower speed limits in urban areas as a safety measure; will also lower emissions.*	N
308	Variable speed limit signs		N
309	Work-zone-type flashing speed limit lights	*Use flashing lights on drums alongside roadway to give impression of work zone or other special lower-speed zones in urban areas.*	N
310	Better law enforcement to regulate truck speeds to prevent accidents due to sharp turns on highway interchanges		N
Sustainable and Transit-Oriented Development			
313	Manage location of new growth to limit additional sprawl		N
314	Subsidized transit use for transit-oriented development residents		N
315	Development bonuses for pedestrian, bicycle or transit accommodations	*Density, height, or other bonuses for developments providing linkages, amenities, and/or priorities that encourage bicycle, pedestrian or transit usage for access and internal circulation.*	N
316	Incentives for infill and redevelopment		N
317	Location-efficient mortgage strategy	*Higher mortgage limits offered to buyers who purchase a home in densely populated, transit-served neighborhoods.*	N
318	Discounted service for residential developments	*Discounted transit service for residents of some neighborhoods/apartment complexes.*	N
319	Local medical facilities	*Increase the number of local "neighborhood" facilities for routine medical procedures*	N
320	Mixed use development ordinances and zones		N
321	Encourage or require complementary uses in close proximity in all developments or development areas	*Apply Planned Use Development (PUD) concept by area, requiring a mix of complementary uses in each square mile or other development area in accordance to a sub-area, locally developed plan.*	N
322	Require housing and complementary services on campuses		N
323	Comprehensive design guidelines for activity centers	*Comprehensive design guidelines for layout of schools, neighborhoods and other activity centers to maximize walkability and minimize the need for short-distance automobile trips.*	N
324	Locate personal business support centers at park-and-ride facilities (convenience businesses)		N
325	Center for Development Excellence		N
326	Co-locate event centers and major transit centers and stations	*Local event centers at sites of major transit centers to ensure high level of service.*	N
327	Daycare and other services	*Daycare, other convenience services at park-and-ride lots and transit stations.*	N
Traffic Flow Improvements			
328	Ban left turns		N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
329	Close selected ramps to limit freeway use to trips over a specified number of miles to reserve freeway use for longer grips and reduce congestion.		N
330	Enforcement and management - Mainline metering	*Freeway mainline metering involves controlling the amount of traffic entering a freeway segment to provide improved travel downstream of the control area. This can be accomplished in a variety of ways including specific geometric designs or lane use signals regulating when vehicles can proceed into the control section (similar to ramp meter signals). Although freeway mainline metering may result in congestion upstream of the control area, it allows for increased vehicle speeds downstream and, in certain situations, may provide an overall net reduction in travel time and an increase in downstream traffic volume.*	N
331	Low cost measures to reduce bottlenecks		N
332	Freeway bottleneck improvements (add lanes, construct shoulders, etc.)		N
333	Ramp metering		N
334	Driveway spacing		N
335	Driveway entrance design		N
336	Grade separation		N
337	Improve traffic operations at railroad crossings		N
338	Turn lane installation		N
339	Intersection and roadway widening		N
340	Intersection Improvements		N
341	Turning movement restrictions		N
343	Off-street loading areas for commercial vehicles		N
344	One-way streets		N
345	Prohibit truck use of right lanes for loading on bus and bike routes	*Remove conflicts in lane use by prohibiting curbside loading zones or loading and service parking along bus routes to remove lane blockages*	N
346	Automobile-free zones route diversion		N
347	Regional route marking systems to encourage underutilized capacity		N
348	Pedestrian mall route diversion		N
349	Traffic controls for route diversion		N
353	Remove unwanted/unnecessary stop signs and signals		N
356	Bus traffic signal pre-emption or priority		N
357	Light emitting diode (LED) traffic signal replacement		N
358	Two-phase signals		N
359	Improved traffic control devices		N
Traffic Management			
361	Traffic management at airports		N

ID	STRATEGY	*Further Description*	EPA
Bicycle and Pedestrian			**PQSE**
362	Require two or more occupants per vehicle to enter designated congested activity centers during AM and PM peak traffic periods		N
363	Require two or more occupants per vehicle to enter designated congested activity centers all day		N
364	Controls on existing drive-thru facilities		N
367	Controls on new drive-thru facilities		N
368	Promote route efficiency for delivery and garbage vehicles		N
369	Lane use restrictions		N
370	Protected motorcycle only lanes	*People prefer single occupancy vehicles (SOV) for the freedom. May switch to riding motorcycles if it is safer to ride on highways. Make protected lanes, like permanent HOV lanes, but for motorcycles only. This caters to the SOV desire, while still driving low emitting vehicles.*	N
Transit			
372	Provide transit/High Occupancy Vehicle (HOV) priority	*Provide transit/HOV priority at ramps, intersections and other congested areas using HOV lanes, queue jumpers, signal priority or preemptions. A second option: restriction of certain downtown streets to transit and HOV-only during peak periods.*	N
373	Improve transit stop attractiveness	*Provide landscaped and direct pedestrian connections to stops; shelters; information systems; seating; and security to increase attractiveness and convenience.*	N
374	Peak/off-peak transit fares		Y
375	Subsidize transit service	*Subsidize service providing access to or circulation within major activity areas to make it feasible for transit operators to provide shorter headways or extended routes and service hours.*	N
377	Transit schedule coordination		N
378	Regional transit center		N
379	Implement seamless public transit; connectivity		N
380	Design guidelines and regulations for transit		N
381	Transit service to park-and-ride		N
382	Passenger amenities		N
383	Transit operations monitoring		N
384	Improved transfers		N
385	Construct new/enlarged dedicated facilities on public property		N
386	Transit marketing and informational programs		N
387	More transit access near universities and airports		N
388	Streamline transit planning and funding	*Improve interfaces between transit providers within a region. Establish a single fare structure for all providers.*	N
389	Transit joint development activities		N
390	Coordinate regional transit systems		N
391	Fixed guideway transit		N

ID	STRATEGY	*Further Description*	EPA
Bicycle and Pedestrian			**PQSE**
392	Limit freeway use in transit corridors to vehicle with two or more occupants		N
393	Guaranteed ride home		N
394	Arterial - Concurrent flow		N
395	Arterial - Contra flow		N
396	Arterial - Reversible flow		N
397	Arterial - Median lane		N
398	Arterial bus street		N
399	Freeway - Barrier or buffer separated - Two way		N
400	Arterial bus tunnel		N
401	Entrance ramp priority		N
402	Exclusive bus lanes		N
404	Feeder bus service		N
405	Bus pullouts in curbs and queue jumper lanes for passenger loading and unloading		N
406	Circumferential and local bus service		N
408	Fixed route and express bus service		N
409	More street access to bus stops		N
410	Add bus stops at employer sites		N
411	Freeway - Contra flow		N
412	Freeway - Concurrent flow		N
413	Bus stop relocation		N
415	Bus route and schedule modification and operational improvements		N
416	Move trips out of peak hours (reduce congestion) - Reroute transit		N
417	Interconnected transfer centers several miles from downtown	*Locate a ring of transfer centers a mile or more outside downtown and provide easy transfers and frequent service connecting all transfer centers along the ring.*	N
418	Freeway - Exclusive (separated) right-of-way		N
419	Freeway - Barrier or buffer separated - One way		N
420	Direct service to major generators	*Provide bus service directly to the entrances of buildings that are major trip generators to increase convenience, especially for those set back from street behind major parking lot.*	N
421	Graduated transit pricing starting with highest in central business districts		N
422	Monthly transit pass programs	*Already have*	N
428	Simplified fare collection		N
429	Free transit on critical routes		N
430	Public transportation - Special fares		N
432	Public transportation - Special headways on regular routes		N
433	Accelerate rail expansion		N
434	Light Rail		N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
435	Make the Trinity Railway Express line to Dallas-Fort Worth International Airport a higher priority		N
436	Commuter Rail		N
437	High-speed rail		N
438	Free circulator service to major generators	*Free shuttle/transit service connecting remote areas with major activity generators.*	N
439	Internal circulators	*Shuttles (bus, taxi, moving sidewalk or other appropriate conveyance) connecting activity points within activity center to alleviate need to use personal vehicle for internal trips. Free service as a possible incentive.*	N
440	Midday shuttles		N
442	Establish special improvement district to fund local shuttles, shared fleets, etc.	*Establish district to pay all or most of cost of transportation system for midday travel in activity centers.*	N
443	Paratransit programs		N
444	Provide shuttle transit service to fringe parking facilities		Y
Travel Demand Management - Business Operations			
445	Reward Business efforts		N
446	Teleconferencing of meetings		Y
447	E-Commerce and E-government incentives and enhancement	*Promote e-commerce through economic incentives such as sales tax exemptions on retail purchases, reduced business taxes for those doing some or all business by internet.*	N
448	E-commerce deliveries	*Arrange for e-commerce deliveries to park-and-ride/transit centers for pickup by commuters; reduces delivery driving.*	N
449	Expand electronic transactions		N
450	Discount for paying bills by mail		N
451	More online business and purchasing		N
452	Waive sales taxes for internet purchases		N
453	Mandated peak spreading	*Require business hours to be staggered to spread peak traffic over a wider time period and reduce congestion.*	Y
454	Shift hours of business to later hours	*Delay opening times and extend hours to make more use of cooler, evening hours for retail, service, and other convenience businesses. Could also apply to other types of businesses that generate extensive emissions like construction, lawn mowing, urban trucks.*	N
455	Require or encourage delayed openings of some businesses until after 9:00 a.m.	*For areas with extensive congestion, prohibit peak period business openings or provide incentives for business openings outside peak traffic periods (e.g., 6:45 – 9:00 am).*	N
456	Late retail hours	*Retail businesses open from noon-9 p.m.; shifts trips out of peak ozone formation time.*	N
457	Link start times of interacting businesses	*If some businesses are shifted to non-traditional work hours (see above), link start times of businesses that interact with each other.*	N
458	Later business hours during ozone season	*During ozone season, move business hours later to move additional travel into evening hours when ozone will not be produced*	N
460	Subscription buses or buspooling		N
464	Staggered work days		N
465	Mandatory or voluntary flextime program (daily start and end time)		N
466	Increase incentives during ozone season		N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
467	Customize commute program by employer		N
468	Staggered lunch schedules	*To spread lunchtime traffic out and avoid a noontime "rush hour".*	N
469	Positive reinforcement for alternative travel	*Positive reinforcement in form of incentives or rewards for alternative travel arrangements, such as extra vacation or holidays, priority parking, additional transportation allowance, priority in work schedule selection or vacation time selection, preferential parking.*	N
472	Discounted or free lunches on ozone action days		N
473	Require same employer subsidy for employee parking and transit	*Require that employers equally subsidize employee commute trips by drive and transit modes*	N
474	Focused incentives to reduce personal trips	*Incentives, demographically-based, for reducing personal trips. Determine number of miles/trips per "average" person for a particular demographic and offer incentives for making fewer trips than that average.*	N
475	Incentives for Best Workplaces for Commutes Designation	*Already implementing in Houston*	N
476	Midday flexibility for trip chaining	*To encourage trip chaining of errands during off-peak hours, provide longer lunch breaks/midday time for personal business.*	N
477	Trade equivalent jobs to be closer to work	*For employees of the same company but at different worksites, identify opportunities to "trade jobs" or worksites to reduce commute distance.*	N
478	Safety regulations for vanpools, buspools and subscription buses		N
479	On-site transportation coordinator		N
480	In-building cafeterias at businesses		N
481	Food vendors at remote worksites		N
482	Business-based concierge services		N
483	Gym facilities in offices		N
485	On-site convenience services	*Employer-provided convenience services on-site such as dry cleaning, post office.*	N
486	Determine current and future availability of dsl/cable for residential use		N
487	Telecommuting incentives or mandates		N
488	Provide home computers and work stations		N
489	Remote or satellite offices close to residential areas		N
490	Full-time telecommuting with full tele/video conferencing and electronic support		N
491	Require that government employees use transit for home to work trips; expand transit; and encourage large businesses to promote transit use		N
492	Free or subsidized transit (bus, rail, party bus)	*Already doing in Houston*	N
493	Allow use of employer's fleet during business hours		N
494	Shared low emission vehicles at work sites		N
495	Limit workday outings in personal vehicles	*Limit workday outings in personal vehicles to once or twice a week*	N
Travel Demand Management - Regional Applications			
497	Shared ride taxis		N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
498	Slug (real-time ridesharers) waiting areas	*Waiting areas designated at park-and-ride facilities, HOV-lane entrances for "slugs" (real-time ridesharers) to wait for rides from drivers needing passengers.*	N
502	Regional pre-tax commute benefit policy		N
503	Rideshare matching, transit marketing and information programs		N
504	Rewards for reducing total vehicle miles traveled in a city or region		N
505	Employee surveys		N
506	Informational materials		N
507	Advocacy and educations		N
508	Ozone season transit incentive program	*Provides transit incentives to increase mass transit ridership during the ozone season.*	N
509	Improve picnic areas to promote eat-in		N
510	Church services on television	*Broadcast most denominations of church services on television to reduce number of Sunday morning trips.*	N
511	Transportation services coordinators		N
512	Traffic management education for activity center directors		N
513	Activity center transportation management	*Develop and implement activity center traffic, parking, and transit management plan to maximize efficiency and vehicle occupancy of trips to/from activity center.*	N
Travel Demand Management - Schools and Colleges			
514	School system change policy regarding bus operations		N
515	Provide school bus service within 1/2 mile of schools	*Most school districts currently provide busing service for students who live 2 or more miles from schools; reduce this required distance to ½ mile.*	N
516	Intramural and after school van service or pooling	*Carpool and/or vanpool service for school-age children participating in sports or other extracurricular activities; coordination by school, park district, or other entity.*	N
517	School bus stop locations	*Designate a few specific school bus stops rather than stopping the bus every block or half-block to pick up individual students; if possible, install bus bays so that children are picked up off the main road.*	N
518	Use "walking bus" program for younger children	*Organize neighborhood walking bus program for elementary and middle school students with parents escorting groups of children walking to/from school; reduce parking/waiting provisions at schools.*	N
519	Promote youth bus riders		N
520	On-campus housing	*Provide more on-campus housing at colleges/universities to make more housing pedestrian accessible to campus and reduce vehicle trips*	N
521	Satellite campuses		N
522	Increase distance learning programs	*Provide more community college and university programs on television and cease offering some courses in classrooms.*	N
523	Eliminate internal streets within campuses	*Eliminate internal streets and prohibit all but service vehicle traffic within college/university campuses.*	N
524	On-campus convenience retail		N
525	Restrict student drivers to high schools		N
526	Encourage community schools		N
527	Locate schools away from arterial streets to eliminate slow zones		N

ID	STRATEGY	*Further Description*	EPA
Bicycle and Pedestrian			**PQSE**
528	School districting to reduce distances		N
529	Adjust school hours so they do not coincide with peak traffic periods and ozone season		N
530	Adjust school year to not coincide with ozone season		N
531	Encourage more home schooling	*Reduce trips to/from school by having more students educated at home, either by parents or distance learning*	N
Travel Demand Management - Special Events			
532	Public/private coordination committees		N
533	Regional coordination of special events during ozone season		N
534	Coordination of service with event schedules		N
535	Television and newspaper communication		N
536	Radio communication		N
537	Dynamic message signs along approach routes		N
538	Education on travel options		N
539	Site plan review ordinances		N
540	Schedule all major events at night		N
541	Schedule supplemental events before and after main event(s)	*Schedule lesser events before and after main events to attract some of audience earlier and/or retain them later (e.g., tailgate parties, fireworks, after-game concerts) to spread event traffic peaks.*	N
542	Delayed start of Six Flags, Water Parks, Ranger Games		N
543	Alternative travel schedules		N
544	Coordinate traffic flow with special event needs	*Re-route, re-signal, or otherwise alter traffic flow to accommodate special event needs.*	N
545	Close streets for special events for use by bikes and pedestrians		N
546	Special routes for special events		N
547	Free transit during special events		N
548	Include transit service as part of facility rental	*Include the cost of providing transit service in the rental fee of an event facility; all renters must pay fee, which will be used to provide transportation to those attending the event.*	N
549	Ticket/transit packages	*Similar to parking/meal packages; offer transit/shuttle pass as an optional package with event ticket. Related: reduced ticket prices for transit users.*	N
550	Open high occupancy vehicle (HOV) lane facilities to peak direction traffic for special events		N
Vehicle Emission Standards			
552	California Heavy-Duty Diesel Vehicle Standards and Fleet Modernization for Mexican Trucks	*All Mexican trucks servicing ports or other facilities must comply with the On-Road Heavy-Duty Diesel Emission Standards applicable to the engine's model year at the time the engine was manufactured beginning in 2006.*	Y
554	National Low Emission Vehicle (LEV) or equivalent	*LEV requirements for mass transit, local government and private fleets.*	N
555	Encourage EPA to further tighten emission standards for trucks and sport utility vehicles	*Encourage EPA to tighten the emissions standards for light trucks and SUVs to bring them more in line with standards for other passenger vehicles.*	N
556	Tier 2 Vehicle Emission Standard		N
557	Light and Medium Duty Vehicle Emission Control 2	*ARB medium-duty vehicle standards*	Y
558	Sell only Low Emission Vehicles (LEV) in Texas		Y
Vehicle Engine Modifications			Environ
559	Catalytic converter replacement in light-duty vehicles		Y
560	Start or warm-up catalysts		N
561	Fuel injection systems - Multipoint		N
562	Fuel injection systems - Monolithic		N
563	Require block heaters for trucks.	*Require trucks to have/use block heaters to warm up cold engines.*	N
564	Intake manifold heaters		N
565	Engine software upgrade (HDV4) or Low NOx software upgrade	*Installation of low NOx software in heavy-duty diesel vehicles with 1993 - 1998 model year engines is required.*	N
566	Promote use of Pony engines		N

ID	STRATEGY	*Further Description*	EPA
Bicycle and Pedestrian			**PQSE**
567	Chip Reflash--regulation in heavy-duty diesel engines.	*Low NOx software upgrade is computer programming for electronic control modules in certain heavy-duty diesel engines that reduces excess emissions of oxides of nitrogen (NOx). ~~Owners of most 1993-1999 model year California registered heavy-duty diesel*	N
Vehicle Idling			Environ
568	Idling reminder hang-tags	*Hang-tags for trucks and other vehicles (particularly for commercial fleets) reminding drivers not to idle longer than 5 minutes.*	N
569	Remote idling reminders	*On-Star type service to remind drivers to turn off engine if idling continues past a set time limit.*	N
570	Post signs in garages to discourage idling	*Also expand in-house testing for gas and pollutant buildups*	N
571	Idling education at automobile dealerships	*Provide education about the disadvantages of extended idling to air quality to vehicle owners at auto dealerships (at point of purchase).*	N
572	Extended idling tax	*Implement an extended idling tax; tax begins to accrue after a set number minutes in idle.*	N
573	School bus idling Airborne Toxic Control Measure	*The California Air Resources Board (ARB) has approved an airborne toxic control measure (ATCM) that limits school bus idling and idling at or near schools to only when necessary for safety or operational concerns. The ATCM is effective as of July 16, 2003. The ARB is authorized by the California Health and Safety Code, Division 26 (Air Resources), to adopt regulations to protect public health and the environment through the reduction of toxic air contaminants (TACs) and other air pollutants with adverse health effects. The ATCM to limit idling is intended to reduce diesel exhaust particulate matter and other TACs and air pollutants from heavy-duty motor vehicle exhaust.*	N
574	Idle restrictions at airport curbsides		N
575	Discourage vehicles from idling during downtown events		N
577	Prohibit off-street idling in parking lots and other non-roadway areas		Y
578	Shorten truck stop stays		N
579	Reduce idling at drive-thrus; shut windows down		N
580	Turn off engines while stalled in traffic		N
581	Aircraft idling emission reductions through powered electric wheel motor		N
582	Idling emissions testing	*Test for emissions generated by idling for a set time versus emissions generated by warm starts.*	N
583	Reduce vehicle emissions in ambulance fleet by providing electrical power for air conditioning and heating while ambulances are in the station		N
584	Public parking facility electrification		N
585	Idling shut-off		N
586	Private parking facility electrification		N
Vehicle Inspection and Maintenance			Environ
587	Heavy-Duty Vehicle Border Inspection Program for AB 1009 (Pavley 2004)	*The Air Resources Board, in cooperation with the California Highway Patrol, shall develop regulations establishing inspection protocol for determining whether the engine of a heavy-duty vehicle met the federal emission standard applicable to the engine's model year at the time of manufacture, pursuant to AB 1009 (Pavley 2004)*	N
589	More frequent emissions tests for taxi cabs		N
590	Statewide emissions testing	*Require emissions testing on all vehicles in all areas of the state no just in selected nonattainment areas.*	N
591	Require certification to operate in a nonattainment county	*Extends I&M requirements to vehicles not registered in a nonattainment county. Non-resident vehicles must pass and hold certification for the area's I&M requirements in order to drive in that area.*	N

ID	STRATEGY	*Further Description*	EPA PQSE
Bicycle and Pedestrian			
592	Augment truck and bus highway inspections with community-based inspections (HDV8)	*HD vehicles are inspected to detect mal-maintenance and tampering and to measure smoke emissions in mixed-use communities.*	N
593	Out-of-region heavy-duty diesel vehicle emission inspections	*HDD trucks and buses traveling in California, including vehicles registered elsewhere, are tested for excessive smoke emissions.*	N
594	Addition of HDGV2B weight class vehicles to inspection and maintenance program		N
595	Modify basic vehicle inspection program to include up to 10,000 pound vehicles and tighten standards for 6,000-8,000 pound vehicles		N
596	Periodic smoke inspection (HDV7) Program (PSIP)	*Owners of California-based fleets with two or more vehicles are required to perform annual smoke opacity tests on their heavy-duty diesel-powered vehicles with a GVWR greater than 6,000 pounds.*	N
597	Check engine light test for post-1996 vehicles as part of annual inspection.	*This is to make sure the engine light is working properly.*	N
598	More frequent testing for vehicles that repeatedly fail inspection tests		N
599	Centralized IM-240 test with repairs done separately. Motorist's choice in surrounding counties.		N
600	Acceleration Simulation Mode (ASM) test		N
601	Extend or expand light-duty diesel engine inspection and maintenance program		N
602	Acceleration Simulation Mode (ASM) with VMAS volume sampler		N
603	California Motor Vehicle Service Information Program	*Senate Bill 1146 directs the Air Resources Board to develop regulations that require vehicle manufacturers to provide all emission-related service information to the service and aftermarket industries for 1996 and later models.*	N
605	Tie emissions tests to license plate renewal to promote properly running vehicles		N
606	On-Board Diagnostic (OBD-II) Test		N
607	Military ground equipment inspections		N
608	Put bar codes on inspection stickers for better tracking		N
609	New and in-use testing for trucks and buses	*On-board diagnostics for new truck and bus fleet vehicles and in-use testing for existing truck and bus fleet vehicles.*	N
610	Heavy-duty diesel vehicle inspection and maintenance program		N
611	IG420		N
612	RG240 equipment		N
613	Test on resale program		N
614	Set goals for employee vehicle maintenance	*Set a goal for a certain percentage of employees to maintain their personal vehicles at specified manufacturer intervals providing copies of receipts and other documentation for verification.*	N
615	Tire maintenance	*Distribute free tire pressure gauges to motorists at time of vehicle registration/renewal and subsidize maintenance and operation of service station air pumps so they are functioning properly and available free of charge*	N
616	Car care clinic	*Provide motorists with an opportunity to receive a free emissions test and learn how regular car maintenance can reduce driving costs and protect air quality.*	N
617	Promote vehicle tune-ups (spark plugs, oil, filter changes, tires)		N
618	Expand tune-up programs at the start of ozone season		N
619	Service contracts for emission-related repairs		N
620	Sliding scale fee for maintenance	*Cleaner cars will be charged less than dirtier cars for inspection and maintenance checks.*	Y
Vehicle Operations Management			
622	No vehicles in the central business district unless they are low emissions, alternative fuel or electric		N
624	Limit excessive automobile dealership vehicle starts	*Require car dealers to limit the starting of vehicles for sale on their lot(s) to once every two weeks. Presently, a number of new and used car dealers start their vehicles daily to avoid battery failure and assure smooth start-ups for customer test drives.*	N
625	Limit the number of drivers licenses in an area	*Enact more stringent requirements for driver's licenses that will limit the number of licenses issued in one area.*	N

ID	STRATEGY	*Further Description*	EPA
Bicycle and Pedestrian			**PQSE**
626	Limit number of vehicles owned in an area	*Control the total number of vehicles that can be bought and owned within a given region, through use of vehicle ownership certificates.*	N
627	Local/regional ban on high-emitting vehicles such as sport utility vehicles		N

Table A-2. Offroad control measures not evaluated.

Number	Control Strategy	EPA Allowable
1	Super 21 Aircraft fuel additive (ENTVA)	N
2	Aircraft vapor recovery	Y
3	Aircraft emission standards	Y
4	Optimum flap retraction	N
5	Reduced landing flap	N
6	Reduced thrust takeoffs	N
7	Minimization of reverse thrust	N
8	Aircraft towing	Y
10	Slot control	N
11	Communications, navigation, surveillance /air traffic management (CNS/ATM) free flight	N
12	Single-engine taxi for aircraft	Y
13	Use electric or cleaner technology auxiliary power units (APUs) for gate electrification	Y
14	New auxiliary power unit (APU) design	Y
15	Use electric or cleaner technology auxiliary power units (APUs) for preconditioned air	Y
16	De-icing operations	N
17	Reduce ground delays and gate holds	N
18	Ozone alert travel schedules	Y
19	Ground support equipment (GSE) engine/unit retirement	Y
20	Increased sharing of ground support equipment (GSE)	N
21	Require commercial airports to implement an alternative fuels plan governing tenants; Encourage electric ground support equipment and other alternative fuel vehicles	Y
22	Study air transport patterns in Texas	N
23	Restrictions on use of ground support equipment at certain times of day/week/season	N
24	Aircraft movement control	N
25	Changes in general conformity to make provisions more realistic; Allow equipment turnover to count	N
26	Modify regulations so credits can be generated for general conformity	N
27	Texas Emissions Reduction Program (TERP); incentives for replacement, repair and retrofit of engines	N
29	Market-based incentives to promote lower-emitting light-duty vehicles	Y
30	Replace gas golf carts with electric golf carts	Y
31	Accelerated equipment turnover; Tier 2 or Tier 3 nonroad engines	Y
32	Aftermarket Technology and Fuel Additive Research Program	N
33	Heavy-duty diesel ozone season operating restrictions	Y
34	Monitoring of newly manufactured engines	Y
36	Improve inventory of construction equipment; Log hours of actual equipment operation	N
37	Control clauses for construction contracts	Y
38	Contract bidding; Give preference to companies that use environmentally-friendly equipment	Y
39	Government construction incentives	Y
40	Require half-day construction schedules	Y
41	Develop air quality best management practices (BMPs); Use BMPs to manage emissions from construction sites, construction vehicles & wind-blown dust	Y
43	Share construction equipment resources across jurisdictions	N
44	Tags to identify equipment as having clean emissions or not	N
45	Water injection for diesel engines	Y
46	Alternative-fueled equipment for all equipment types	Y
47	Alternative fuel heavy-duty equipment	Y
48	Lean NOX catalyst	Y

Number	Control Strategy	EPA Allowable
49	Early introduction of low-NOX engines	Y
50	Selective catalytic reduction (SCR)	Y
51	Compression ignition standards for vehicles and equipment	N
52	Spark ignition standards for vehicles and equipment	N
53	Lower sulfur fuels	Y
54	Federal Ultra Low-Sulfur Diesel (ULSD)	Y
56	Change fuel chemistry (aircrafts)	N
57	Texas Low Emission Diesel (TxLED); already implemented and credited	N
58	Discourage using off-road vehicles during high ozone alert says; possible legislative action	Y
59	Developers should have to do an air quality impact study	N
60	Keep manufacturer warranties valid when performing equipment repairs and maintenance	N
61	Place work restrictions on the most polluting equipment. Allow low polluting equipment to work regular hours	Y
62	Educational materials for contractors; Encourage them to develop ideas	N
63	Lawnmower exchange; Trade in old gas powered equipment for discounts on zero emission models	Y
64	Lawnmower recycling programs (rebate program); replace gas mowers with electric	Y
65	Promote use of cleaner lawn and garden equipment such as lower-emission four-stroke and electric-powered equipment	Y
66	“Buy a Clunker” concept for small gas equipment	Y
67	Disincentives such as fines if caught mowing during Ozone Alerts	Y
68	Ban equipment such as two-stroke engines	Y
69	No-mowing days	Y
70	Grass cutting; Public works will delay cutting grass till 6 pm on ozone action days	Y
71	Landscape ordinance for nonresidential areas	Y
74	Electrification of rail switching yards http://www.trainweb.org/southwestshorts/txumartinlake.html	Y
76	Development of technologies that make shipping more efficient	N
77	Use liquefied natural gas (LNG) engines for locomotives	Y
78	Selective catalytic reduction (SCR) for locomotives	Y
80	North American Free Trade Agreement (NAFTA) trucks; If goods are being shipped past a certain point along the border states, move the goods to rail before it reaches the border	N
81	Better design of intermodal facilities to promote efficiency	N
82	Remote sensing of locomotives	Y
83	Use “clean trains” to ship goods into cities from surrounding break of bulk locations	Y
84	Recreational marine standards	N
85	Fuel alternatives for stationary equipment; Pumps, generators, et cetera	Y
86	DriveMax programmable computer installed on diesel engines for tub grinders at mulching operations	N