California Environmental Protection Agency
AIR RESOURCES BOARD

Technical Support Document

Evaluation of Selected Projects Funded by Motor Vehicle Registration Fees

Prepared to Supplement the Proposed 1995 Report
to the Legislature on the Motor Vehicle Registration Fee Program

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EVALUATION OF SELECTED PROJECTS FUNDED BY MOTOR VEHICLE REGISTRATION FEES

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INTRODUCTION

This report contains evaluations of selected projects funded in part, or entirely, with motor vehicle registration fees during the first three years of the program. ARB staff reviewed the use of motor vehicle registration fees as part of the development of the Air Resources Board's (ARB) 1995 report to the California Legislature. The analyses evaluate representative uses of the motor vehicle registration fees to date and contributed to development of criteria for future use of the funds. Determining the relative cost-effectiveness of the projects was the primary focus of the evaluations.

The projects were analyzed using the data available; however, ARB staff had to make critical assumptions at times to fill in data gaps. The methodology used to calculate the emission reductions and costs is consistent with approaches used in other district and ARB programs. More detailed analyses are always possible, but also unlikely to produce substantially different results.

PROJECT SELECTION

ARB staff selected a range of typical projects with the goal of trying to identify both optimal and less well designed projects within project categories. This was done in an effort to determine the range of effectiveness both within and between project categories.

Two to four projects from the most common project categories were selected from various areas around the state. This included projects funded by air districts and local agencies, including a congestion management agency (CMA), as well as the South Coast Mobile Source Air Pollution Reduction Review Committee (MSRC). The limiting factor in selecting projects was the availability of sufficient information to complete the evaluation. Most projects selected were initiated in 1992-93 since the results are not in on most projects funded in late 1993 and 1994.

There has been no standard requirement for reporting results of projects up to this point; this makes it impossible to thoroughly evaluate every type of project funded. Nonetheless, the categories of projects covered in this report are comprehensive enough to provide a good overview of the projects funded primarily in the first two years of the program.

Most of the projects funded between 1992 and 1994 fit into one of the following categories:

Alternative Fuel Vehicles (conversions and purchases)
Electric Vehicles (conversions and purchases)
Vehicle Scrappage
Traffic Signal Timing
Shuttle Services
Employer Trip Reductions
Telecommunications
Bicycle Use and Infrastructure
Public Education
Smoking Vehicle Abatement
Air Quality Elements/Land Use Design

COST-EFFECTIVENESS METHODOLOGY

It is difficult to evaluate and compare projects as diverse as those funded with motor vehicle fees. This report attempts to present information to compare long term projects to short term projects; technology-based projects to service-based projects; and projects with ongoing benefits to those without. To do this, several pieces of information are provided: (1) an analysis period or "useful life" that best fits the individual characteristics of the project, (2) the total emission reductions over the useful life of the project; and (3) a cost-effectiveness ratio that compares total costs over the life of the project to the total emission reductions from the project.

There are two important differences associated with the work done for this report when compared to other efforts. First, staff has gone to considerable effort to capture both capital and operational costs and emission reductions directly associated with the project. Second, for the most part, the numbers in this report reflect actual monitored results, costs and cost savings. Where there were direct savings such as cost savings from lower fuel use, the savings were subtracted from the costs. Motor vehicle registration fees are used in conjunction with other funding. The costs in the cost-effectiveness ratios provided in this report do not represent motor vehicle registration fees alone, but rather of all costs incurred by the project.)

The evaluation included reactive organic gases (ROG), nitrogen dioxide (NOx), fine particulates (PM10), and carbon monoxide (CO). Cost-effectiveness ratios were developed for ozone precursors (ROG and NOx), and for ozone precursors plus PM10. Carbon monoxide was evaluated separately because there are few areas in the state where CO remains a problem pollutant.

Staff followed three guidance documents to establish the methodology: (1) Mobile Source Emission Reduction Credits Guidelines, Air Resources

Board, February 1994 (referenced as MSERCs Guidelines); (2) Cost-Effectiveness, District Options for Satisfying the Requirements of the California Clean Air Act, Air Resources Board, September 1990; and (3) Emission Reduction Calculation Methodologies, for Congestion Mitigation and Air Quality Improvement (CMAQ) Program Projects, California Department of Transportation and California Air Resources Board, October 1994 (Referenced as CMAQ Guidelines).

There are many approaches to determining the appropriate benefits and costs to include in a cost-effectiveness evaluation, especially for complex transportation demand management projects. In the end, staff identified only those costs and emissions benefits that could be directly attributed to the project.

The following are some points to clarify the general evaluation methodology used in this report.

Analysis Period: The useful life of a project is reasonably easy to identify for technology-based, capital investments such as the purchase of a CNG fueled bus. It is less obvious when the project involves providing a service for a limited period of time, when future funding is uncertain, and when services are intermingled with capital investments. ARB staff had to carefully consider the appropriate analysis period for each project. Each project summary includes an explanation for the length of the analysis period chosen.

Net Present Value of Costs: The net present value (NPV) method for evaluating costs calculates the lifetime costs of buying and operating equipment, expressed in current dollars. A 3% annual rate of inflation and a 10% annual discount rate were used in the analyses as described in the MSERCs Guidelines. The discount rate corresponds to the percentage return on investments that one would receive had the money been invested elsewhere or to the cost associated with raising capital. These discounted annual costs are added to the first year capital cost to give the total project cost.

Technology-Based Projects: Technology-based projects include alternative fuel vehicle conversions or purchases, electric vehicles, scrappage programs, and traffic signal timing. These were evaluated according to the MSERCs Guidelines. Costs included capital investments, maintenance, fuel savings, etc. Staff used emission factors from both the MSERCs Guidelines and the CMAQ Guidelines.

Trip Reduction Projects: The trip reduction projects include shuttle services, employer trip reduction programs, telecommuting and televideo programs, bicycle projects, and land use development requirements. Costs for these projects included capital costs for equipment, operating costs (e.g. phone bills and staff salaries), and savings or income to the project (e.g. as shuttle service fares or elimination of employer-paid travel expenses). Some projects, such as televideo interviewing, had additional benefits in terms of improved employee

efficiency and cost savings that go beyond the scope of this evaluation. Staff noted some of these benefits in the project descriptions.

Emission Factors: The emission factors for the trip reduction projects were based on statewide averages, but were also custom designed to match the vehicle mix, cold start proportions, and level of congestion that best reflected the specific project. Emission factors were developed for each year from 1992 to 2020 so that trip reductions for any given year could be multiplied by that year's emission factor. For the technology projects, emission factors were based on the MSERC and CMAQ Guidelines.

In some cases, it was necessary to calculate emission disbenefits such as new emissions from shuttle vans or bus services that replaced passenger vehicles trips. Emission disbenefits were subtracted from the emission reductions associated with passenger vehicle trip reductions.

Public Education: Public education projects that enhance awareness of the motor vehicle contribution to air pollution can lead to behavior changes that reduce emissions. However, it is difficult to calculate direct emission reductions from these programs. For this reason, the three education projects selected were evaluated using the following criteria:

- Was there a clear message, consistent with the district's attainment plan, delivered to a targeted audience?
- Did the message target specific behavioral changes to reduce emissions, and did that message reach its audience?
- Did the project have an evaluation component analyzing if and how well the message was received?
- Based on the evaluation component, did the targeted audiences' attitude and/or behavior change as a result of hearing the message? Did a behavioral change assist in or directly cause emissions reductions?

Smoking Vehicle Projects: Smoking vehicle projects were evaluated similarly to the public education projects because the emission reductions of these programs are also difficult to quantify with certainty. Smoking vehicle projects target gross emitters and increase public awareness of pollution caused by vehicles. Three smoking vehicle projects were evaluated.

Project Summaries: The summary for each project provides a project description, emission reductions, useful life, detailed cost

information, assumptions made, and formulas used to determine cost-effectiveness. There is also a summary chart for each category to enable comparison of similar projects.

The quantified results have been rounded to the nearest dollar in the case of the cost per pound of pollutant, to the nearest hundred in the case of pounds of emissions reduced, and to the nearest thousand in the case of total costs, trips reduced and VMT reduced. The calculations upon which the results are based are included without rounding to show the calculation procedure. However, the results should not be considered to meet that level of precision.

SUMMARY OF FINDINGS BY CATEGORY

The emission reductions, costs, and the cost-effectiveness of each project are shown in Table 1 (page 7). The table shows the length of the projects--1 year to 20 years. It also shows the varied magnitude of emissions reduced and/or VMT reduced (from less than 1,000 lbs to nearly 600,000 lbs (300 tons) and from 160,000 reduced VMT to over 100 million VMT reduced).

For stationary and mobile sources, cost-effectiveness has generally been under $10,000 per ton of pollutant reduced. Some district stationary measures have been as high as $20,000 per ton. A recent report, Emission Reduction Offsets Transaction Cost Summary Report for 1994 (Air Resources Board, May 1995), states that as much as $37,000 per ton was paid for NOx offsets in 1994.

Table 1 shows that many of the projects evaluated are under $10,000 per ton, although some are more costly. All but 6 of the 20 projects evaluated in this report fall within an acceptable cost-effectiveness range when the benefits of ROG, NOx, and PM10 are combined. Half of the projects reduced emissions for less than $10,000 per ton.

All categories had one or more projects with favorable cost-effectiveness ratios (some categories also had projects with unfavorable ratios). In some cases, it was the poor design of a project that resulted in worse cost-effectiveness. As shown below, there was substantial variability in cost-effectiveness for individual projects within a category.

	Cost-Effectiveness	
	<$10/lb*	**>$10/lb***
Alternative Vehicles (CNG)	$ 4/lb	$ 18/lb
Electric Vehicles	3/lb	62/lb
Vehicle Scrappage	2/lb	3/lb (both below $10)
Signal Timing	2/lb	8/lb (both below $10)

Shuttle Services	4/lb	450/lb
Employer Trip Reductions	3/lb	4/lb (both below $10)
Telecommunications	-8/lb	30/lb
Bicycles	5/lb	10/lb (both below $10)

*** $20,000/ton = $10/lb**

These variations are explained by the individual characteristics of each project. For example, the Santa Barbara Clean Air Express is a subscription commute bus service fueled by CNG that operates at capacity with a round trip of 160 miles. From an air quality viewpoint, this kind of service is significantly more beneficial than one like the Monterey WAVE summer tourist shuttle (a diesel bus) which operates at a lower efficiency and over a route of only 4 miles.

The following paragraphs discuss the projects by category, including variations in the cost-effectiveness ratio based on ROG+NOx+PM10 and the similarities and differences in the projects that may account for these variations. For more details on any one project, see the project summaries at the end of this section.

Alternative Fuel Vehicles (Conversions and Purchases)

Three projects were evaluated under this category: one CNG conversion and two CNG bus fleet purchases. The CNG vehicle conversion (South Coast UPS delivery trucks from diesel to CNG showed a favorable cost-effectiveness of $4/lb. The purchase of CNG buses for Sacramento Regional Transit and for San Diego Metropolitan Transit Development Board had cost-effectiveness ratios of $10/lb and $18/lb, respectively. The San Diego project, the more recent one, was somewhat less favorable because the costs of CNG buses increased significantly since the purchase of the Sacramento buses and, also, the San Diego buses had a higher emissions certification level than did the Sacramento buses.

Electric Vehicles (Purchase and Conversion)

There were two projects evaluated in this category. The Santa Barbara electric bus purchases showed a favorable cost-effectiveness ratio of $3/lb. These electric vehicle were research proto-types. The costs are higher when research and monitoring are included in the evaluation.

The electric vehicle conversion by the City of Visalia had a cost-effectiveness of $62/lb. This was the conversion of a light-duty gasoline pickup truck to electric. The project was considered a demonstration project.

Vehicle Scrappage

The two projects evaluated were the South Coast's UNOCAL and the

San Joaquin Valley's KAR project. Both projects had favorable cost-effectiveness ratios of $3/lb and $2/lb, respectively. The projects are very similar.

Traffic Signal Timing

Two signal timing projects were evaluated: a 26-intersection project in Fremont and a smaller 11 signal project in Porterville. The cost-effectiveness varied between $2/lb and $8/lb. Costs for traffic signal coordination vary widely depending on the size of the project, amount of traffic, roadway type, and the amount of equipment already in place. Costs and procedures to maintain optimal coordination also vary widely. See project summaries for more details on the projects.

Shuttle Services

Three types of shuttle services were evaluated: Santa Clara Employee Transit Shuttle, Monterey WAVE Tourist Shuttle, and Santa Barbara Long Range Commuter Express Bus Service. The cost-effectiveness ratios were $162/lb, $450/lb, and $4/lb, respectively.

The Monterey tourist shuttle, a diesel bus, operates at a lower efficiency and over a route of only four miles and only during the summer. Fares are low ($0.50 per day) to encourage tourist use.

The Santa Clara employee shuttle provides service to transit links. The service, by gasoline fueled vans, is co-funded by employers, the Santa Clara County Transit District, and motor vehicle fees. It is a relatively new service and ridership is expected to increase as the service becomes more established. The effects of long term increased transit ridership is not part of this analysis.

The Santa Barbara project is a long distance, subscription commute bus service fueled by CNG, that operates at full capacity with a round trip of 160 miles. Riders pay $90 - $100/month for the service.

The first two projects had a low cost-effectiveness. Both could have been improved somewhat if cleaner vehicles were used as shuttles.

Employer Trip Reductions

The projects include South Placer Computer Ridesharing, San Bernardino County Trip Reduction Program, and Sonoma County Trip Reduction Program. Cost-effectiveness ratios are $3/lb, $4/lb, and $3/lb, respectively.

The South Placer computer ridesharing project incurred one-time, up-front costs for the computer and had relatively low operational costs. This was a new service. Publicity campaigns and word-of-mouth may increase the number of matches made over time. The project proponent is the South Placer County Transportation Management Association (TMA), an indication of local business support.

The San Bernardino project has been in operation for some time. The project includes transit passes, promotional items, and other trip reduction program expenses. It serves roughly 6,000 county employees.

The Sonoma County project included transit passes, training, survey processing, plus bike racks at two locations. The program served roughly 1,343 employees.

Telecommunications

Projects include San Bernardino Probation Video Interviews, Los Angeles County Justice Video Interview System, and College of the Desert Administration Video System. The cost-effectiveness ratios for each project, respectively, are: $-8/lb, $30/lb, and $27/lb. The savings in these projects were savings from previous reimbursable employee travel expenses that were no longer necessary after the implementation of the video systems. In the case of San Bernardino, these savings were actually greater than the costs of the project.

The wide range in cost-effectiveness is attributed to the significant differences in the three programs. In the San Bernardino and Los Angeles County projects, probation officers, attorneys, and other employees who previously traveled to the many detention centers in Southern California to meet with inmates were given access to televideo interviewing.

In the San Bernardino project, all on-site interviewing of inmates was shifted to interviewing via televideo except in special cases. Thus, over 90% of possible interviews were conducted via video. The costs of this project were low because their video system was a lower cost, analog (freeze-frame) type which was a lower quality video than used in Los Angeles. Benefits were high because San Bernardino employees had formerly visited one inmate at a time so that every video interview replaced a long trip to the detention center. In addition, a second phase in the project resulted in many of the probation officers telecommuting from home for two days per week.

The Los Angeles Justice project implemented a higher quality, digital (full-motion) video system using six phone lines compared to San Bernardino's two phone lines. The costs for equipment and installation were higher. Benefits were less because the L.A. employees had formerly visited two or more inmates per trip and a smaller percentage of employees used the video system than in San Bernardino.

The College of the Desert project is different from the other two projects. Previously, a large number of administrative staff and faculty traveled between facilities for daily meetings. Televideo conferencing was implemented and many long daily trips were reduced. The cost-effectiveness was less favorable than for San Bernardino because costs for equipment, installation, and initial staff training were considerably higher. Fewer trips were reduced because the employees had been carpooling to their daily meetings prior to using the video system.

Bicycles

The two projects evaluated were the Pacific Grove Bicycle Path and the Monterey Bay Aquarium Employee Bike Loan Program. The cost-effectiveness ratios were $10/lb and $5/lb, respectively.

The Pacific Grove bicycle project included the construction of three miles of bike path along the scenic Asilomar/Pebble Beach area. The path carries both commute bikers and tourists. The project is cost effective because it will continue to provide emission reductions over a long period of time (analysis period is 20 years).

The Monterey Aquarium bike project is a bike loaner program for employees. The Aquarium purchased 30 bicycles, provided necessary amenities like storage, etc., and loaned to employees who agreed to bike no less than 3 times per week. Bikes were also used by employees to run errands.

Air Quality Elements/Land Use Design

Several projects related to land use design, such as air quality elements and specific plans emphasizing transit-pedestrian access, were funded using the motor vehicle fees. These could have favorable cost-effectiveness in the long term if they result in locational and design changes that can be made without significant added cost. However, because these efforts will affect future development projects, there is little data on results or tracking of the associated costs. Emission reductions and cost-effectiveness are difficult to estimate so projects in this category are not included here.

TABLE 1:

SUMMARY OF SELECTED PROJECTS

Category	Project	Analysis Period	VMT Reductions	Trip Reductions	Emission Reductions (ROG+NOx+PM10)	Costs (Net Present Value)	Cost-Effectiveness
Alt. Fuel Vehicle Conversions	UPS Delivery Trucks (Diesel to CNG)	15 years	--	--	199,500 lbs	$736,000	$4 / lb
Alt. Fuel Vehicle Purchase	Sacto. CNG Transit Buses	12 years	--	--	345,300 lbs	$3,489,000	$10 / lb
Alt. Fuel Vehicle Purchase	San Diego CNG Transit Buses	12 years	--	--	274,200 lbs	$4,875,000	$18 / lb
Electric Vehicle Purchase	Santa Barbara Transit Buses	18 years	--	--	44,600 lbs	$152,000	$3 / lb
Electric Vehicle Conversion	Visalia LD Truck Conversion (Gas to Electric)	7 years	--	--	300 lbs	$16,000	$62 / lb
Vehicle Scrappage	San Joaquin KAR Project	3 years	--	--	596,200 lbs	$1,090,000	$2 / lb
Vehicle Scrappage	South Coast UNOCAL	3 years	--	--	135,200 lbs	$399,000	$3 / lb
Traffic Signal Timing	Traffic Signal Coordination - Fremont	12 years	--	--	178,200 lbs	$403,000	$2 / lb
Traffic Signal Timing	Traffic Signal Coordination - Porterville	12 years	--	--	26,300 lbs	$213,000	$8 / lb
Shuttle Services	Santa Clara Employee Transit Shuttle	1 year	619,000	38,000	3,600 lbs	$587,000	$162 / lb
Shuttle Services	Monterey WAVE Tourist Shuttle	8 years	480,000	240,000	1,700 lbs	$761,000	$450 / lb
Shuttle Services	Santa Barbara Commuter Express	15 years	100,799,000	--	592,900 lbs	$2,115,000	$4 / lb
Employer Trip Reductions	South Placer Computer Rideshare	5 years	5,511,000	273,000	46,100 lbs	$125,000	$3 / lb
Employer Trip Reductions	San Bernardino Trip Reduction Program	1 year	4,797,000	240,000	45,000 lbs	$199,000	$4 / lb
Employer Trip Reductions	Sonoma Trip Reduction Program	1 year	851,000	84,000	8,800 lbs	$22,000	$3 / lb
Telecommunications	San Bernardino Probation Video Project	5 years	1,770,000	68,000	14,600 lbs	$113,000	- $8 / lb
Telecommunications	LA Co. Justice Video Interview System	5 years	1,066,000	26,000	8,700 lbs	$264,000	$30 / lb
Telecommunications	College of the Desert Admin. Video System	5 years	1,250,000	20,000	9,900 lbs	$269,000	$27 / lb
Bicycle Use / Infrastructure	Monterey Bay Aquarium Bike Loan Program	10 years	159,000	88,000	2,600 lbs	$14,000	$5 / lb
Bicycle Use / Infrastructure	Pacific Grove Bicycle Path	20 years	2,116,000	1,175,000	29,100 lbs	$297,000	$10 / lb

PROJECT EVALUATIONS

TABLE 2:

ALTERNATIVE FUEL VEHICLE CONVERSION AND PURCHASE PROJECTS EVALUATION SUMMARY

	South Coast UPS Delivery Trucks	Sacramento CNG Transit Buses	San Diego CNG Transit Buses
Motor Vehicle Fees Funding	$230,000	$1,000,000	$1,865,000
Matching Federal Funds	–	–	$20,450,000
Cost-Effectiveness Information			
ROG Emission Reductions	26,600 lbs.	0	0
NOx Emission Reductions	159,600 lbs.	345,300 lbs.	274,200 lbs.
PM10 Emission Reductions	13,300 lbs.	0	0
CO Emission Reductions	106,400 lbs.	0	0
VMT Reductions	0	0	0
Trip Reductions	0	0	0
Useful Life of Project	15 years	12 years	12 years
Capital Costs (NPV)	$915,000	$3,595,000	$3,946,000
Operating Costs (NPV)	$ - (179,000)	$ - (106,000)	$929,000
Cost-Effectiveness for ROG+NOx	$4 / lb.	$10 / lb.	$18 / lb.
Cost-Effectiveness for ROG+NOx+PM10	$4 / lb.	$10 / lb.	$18 / lb.
Cost-Effectiveness for CO	$7 / lb.	–	–

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Alternative Fuel Vehicle Conversions

2. **Name of Project:** United Parcel Service (UPS) Delivery Trucks (Diesel to CNG)

3. **Air District or Local Agency:** South Coast MSRC

4. **Implementing Agency or Organization:** Clean Air Partners & UPS

5. **Project Description:**

Fifty diesel delivery vans, averaging four years of age, were retrofitted to operate on CNG. The natural gas retrofit system being used was tested at levels below the proposed heavy-duty, low-emission emissions standards, and well below the level at which the replaced diesel engine was certified. The engine has been certified by ARB as a dedicated conversion (Exec. Order No. B-40). The project also involved the enhancement of a refueling site to be used by the UPS vans. (Project Date: 1993)

6. **Documentation of Cost-Effectiveness Analysis:**

An analysis period of 15 years was chosen based on useful remaining life of the delivery trucks.

Costs (15 yrs)(NPV)	
Total Cost of Project	**$ 735,847**
Vehicle Regis. Funding	**230,000**
Capital Costs	**915,000**
Operating Costs	**-(179,153)**

Capital Costs
Conversions cost $619,000 plus $300,000 for upgrade of fuel facility.

Operating Costs
There was a fuel savings. The diesel van driven 14,000 miles, getting about six miles a gallon, required 2,333 gallons a year. At about $1.01 per gallon, the cost of fuel would be $2,356 per year. On CNG, the mileage is about 5.51 miles/therm. A CNG van would require about 2,541 therms a year, at a cost of about $.77 per therm, for an annual fuel cost of $1,956 a year. This savings amounts to $400 per year per van, or $20,000 for 50 vans.

Emissions Benefit Calculations

Data Provided: Diesel engines were retrofitted to operate on CNG. The diesel engines tested at a NOx standard of 4.8 g/bhp-hr. During certification procedures, the CNG vans performed at a NOx level of 1.75 g/bhp-hr. However, for calculation purposes, emission levels of 5.0 and 2.0, respectively, were assumed, because these emissions levels account for engine deterioration. UPS vans are guaranteed to operate for 20 years. These are heavy-duty vehicles, which have a long lifetime. Vans retro fitted were on average about four years old.

Assumptions: All vans are driven 14,000 miles/year. Remaining life for vans was 15 years. (Note: This project involved removing the diesel engines, replacing them with General Motors 4.3l V6s, which in turn have been retrofitted with CNG conversion. This kind of combination retrofit and repower is a deviation from the retrofits covered in MSERC Guidelines. Staff has made the following estimates but there is no assurance that the low-emission performance will continue over the life of the vehicles.)

ROG
The CNG engines are certified at a level of 0.4 g/bhp-hr, while the diesel engines are certified at a level of 0.9 g/bhp-hr.
50(.9-.4 g/bhp.hr)(2.3 bhp.hr/mile)(14,000 miles/yr)(15 yrs)/454 g/lb. =26,600 pounds

NOx
50(5.0-2.0 g/bhp.hr)(2.3 bhp.hr/mile)(14,000 miles/yr)(15 yrs)/454 g/lb. =159,600 pounds

PM10
Heavy-duty vehicles averaging four years in age would have had to meet a standard of 0.25 g/bhp-hr. PM10 from CNG vehicles is negligible.
50(0.25 g/bhp.hr)(2.3 bhp.hr/mile)(14,000 miles/yr)(15 yrs)/ /454 g/lb. = 13,300 pounds

CO
During certification the diesel engines tested at an average CO level of 4.0 g/bhp-hr. During certification procedures, the CNG engines tested at a CO level of 2.0 g/bhp-hr.
50(4.0-2.0 g/bhp.hr)(2.3 bhp.hr/mile)(14,000 miles/yr)(15 yrs)/454 g/lb. = 106,400 pounds

Emissions Benefits (15 yrs)	
ROG	26,000 lbs
NOx	159,600 lbs
PM10	13,300 lbs
CO	106,400 lbs

Cost-Effectiveness	
ROG+NOx	$ 4/lb
ROG+NOx+PM10	4/lb
CO	7/lb

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Alternative Fuel Vehicle Purchase

2. **Name of Project:** Sacramento Regional Transit

3. **Air District or Local Agency:** Sacramento Metro AQMD

4. **Implementing Agency or Organization:** Sacramento Regional Transit

5. **Project Description:**

Ninety-five city transit buses, fueled with compressed natural gas (CNG), were purchased to replace an equal number of older diesel-fueled buses. Resources were supplied by a variety of contributors, including Pacific Gas & Electric, the federal government, Sacramento Transit District and others. One million dollars was supplied from vehicle registration funding. In addition to 95 buses, a CNG fueling station was added.
(Project Date: 1992)

6. **Documentation of Cost-Effectiveness Analysis:**

An analysis period of 12 years was used, based on an estimated 12-year bus life.

Costs (12 yrs)(NPV)	
Total Cost of Project	**$3,488,696**
Vehicle Regis. Funding	**1,000,000**
Capital Costs	**3,595,000**
Operating Costs	**-(106,304)**

Capital Costs
Total capital costs are the difference between the cost of 95 CNG buses (plus one CNG fueling station) and 95 diesel buses.
CNG: ($260,000 per bus)*(95 buses)+($270,000 CNG fueling station) = $24,970,000
Diesel: ($225,000 per bus)*(95 buses) = $21,375,000
Difference: ($24,970,000)-($21,375,000) = $3,595,000

Operating Costs
Total operating costs are the difference between the operating costs of 95 CNG buses and 95 diesel buses.
CNG assumptions: Fuel cost ($0.33/therm)/(1.9 miles/therm) = $0.17/mile; 40,000 miles per bus per year; $2,000 CNG station maintenance costs per bus per year.
Diesel assumptions: Fuel cost ($0.75/gallon)/(3.3 miles/gallon) = $0.23/mile; 40,000 miles per bus per year; $0 CNG station maintenance costs per bus per year.

Annual Savings is $13,636.
(660,000-863,636+190,000)

Emissions Benefit Calculations

NOx
The emissions benefit is the difference between the emissions from 95 CNG buses and 95 diesel buses over the estimated 12-year, 500,000-mile life of the buses. (Note: Bus emission factors are from the CMAQ guidance.)

CNG: (13.2 grams/mi)*(500,000 miles)*(95 buses)/(454 grams/lb) = 1,381,057 lbs

Diesel: (16.5 grams/mi)*(500,000 miles)*(95 buses)/(454 grams/lb) = 1,726,322 lbs

Difference: (1,726,322 lbs)-(1,381,057 lbs) = 345,265 lbs

ROG, PM10, CO
Levels from current diesel/trap engines are already quite low. This means that any ROG, PM10 and CO emission reductions from alternative fuel engines will be small. Uncertainties associated with the lifetime levels of ROG, PM, and CO emissions from alternative fueled buses are substantial due to the lack of in-use data. Therefore, no emission benefits are taken for pollutants other than NOx. (MSERC Guidelines).

Emissions Benefits (12 yrs)

ROG	0
NOx	345,265 lbs
PM10	0
CO	0

Cost-Effectiveness

ROG+NOx	$10/lb
ROG+NOx+PM10	10/lb
CO	N/A

NOTE: Some of the buses replaced were sold to a state agency to use as shuttle buses between state office buildings and employee parking lots. Thus, the buses continued to emit pollution in this air basin.

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Alternative Fuel Vehicle Purchase

2. **Name of Project:** San Diego Regional Transit

3. **Air District or Local Agency:** San Diego County APCD

4. **Implementing Agency or Organization:** Metropolitan Transit Development Board

5. **Project Description:**

Eighty-three city transit buses, fueled with compressed natural gas (CNG), were purchased to replace an equal number of older diesel-fueled buses. Resources were supplied by a variety of contributors, including vehicle registration funding. (Project Date: 1993)

6. **Documentation of Cost-Effectiveness Analysis:**

An analysis period of 12 years was used based on an estimated 12-year bus life. (Note: This project leveraged $20,450,053 of federal funding)

Costs (12 yrs)(NPV)	
Total Cost of Project	**$4,875,189**
Vehicle Regis. Funding	**1,865,422**
Capital Costs	**3,946,401**
Operating Costs	**928,788**

Capital Costs
Total capital costs are the difference between the cost of 83 CNG buses and 83 diesel buses. (Note: No costs were required to install a CNG fueling station because the local natural gas supply company had provided one with the cost rolled into the cost of natural gas.)
CNG: ($287,547 per bus)*(83 buses) = $23,866,401
Diesel: ($240,000 per bus)*(83 buses) = $19,920,000
Difference: ($23,866,401)-($19,920,000) = $3,946,401

Operating Costs
Total operating costs are the difference between the fuel costs of 83 CNG buses and 83 diesel buses. (Note: $0.50/therm is used because the project had the cost of the fueling station rolled into the cost of the natural gas.)
CNG assumptions: Fuel cost ($0.50/therm)/(1.9 miles/therm) = $0.26 per mile; 40,000 miles per bus per year.
Diesel assumptions: Fuel cost ($0.75 gallon)/(3.3 miles/gallon) = $0.23 per mile; 40,000 miles per bus per year.
Annual increase in costs of CNG over diesel is $119,139.

Emissions Benefit Calculations

NOx

The emissions benefit is the difference between the emissions from 83 CNG buses and 83 diesel buses over the estimated 12-year, 500,000-mile life of the buses. (Note: Bus emission factors are from the CMAQ guidance.)

CNG: (13.2 grams/mi)*(500,000 miles)*(83 buses)/(454 grams/lb) = 1,234,031 lbs

Diesel: (16.5 grams/mi)*(500,000 miles)*(83 buses)/(454 grams/lb) = 1,508,260 lbs

Difference: (1,508,260 lbs)-(1,234,031) = 274,229 lbs

ROG, PM10, CO

Levels from current diesel/trap engines are already quite low. This means that any ROG, PM10 and CO emission reduction benefit from alternative fuel engines will be small. Uncertainties associated with the lifetime levels of ROG, PM and CO emissions from alternative fueled buses are substantial due to the lack of in-use data. Therefore, no emission benefits are taken for pollutants other than NOx. (MSERC Guidelines.)

Emissions Benefits (12 yrs)	
ROG	0
NOx	274,229 lbs
PM10	0
CO	0

Cost-Effectiveness	
ROG+NOx	$18/lb
ROG+NOx+PM10	18/lb
CO	N/A

TABLE 3:

ELECTRIC VEHICLE / PURCHASE / RESEARCH / CONVERSION PROJECTS EVALUATION SUMMARY

	Santa Barbara Transit Buses	Visalia Truck Conversion	
Motor Vehicle Fees Funding	$220,000	$15,000	
Matching Federal Funds	$700,000	–	
Cost-Effectiveness Information			
ROG Emission Reductions	7,500 lbs.	100 lbs.	
NOx Emission Reductions	36,300 lbs.	200 lbs.	
PM10 Emission Reductions	800 lbs.	0 lbs.	
CO Emission Reductions	41,900 lbs.	1,500 lbs.	
VMT Reductions	0	0	
Trip Reductions	0	0	
Useful Life of Project	18 years	7 years	
Capital Costs (NPV) (excludes research)	$100,000	$15,000	
Operating Costs (NPV)	$52,000	$1,000.00	
Cost-Effectiveness for ROG+NOx	$3 / lb.	$62 / lb.	
Cost-Effectiveness for ROG+NOx+PM10	$3 / lb.	$62 / lb.	
Cost-Effectiveness for CO	$4 / lb.	$10 / lb.	

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Electric Vehicle Purchase/Research

2. **Name of Project:** Santa Barbara Electric Transit Buses

3. **Air District or Local Agency:** Santa Barbara County APCD

4. **Implementing Agency or Organization:** S.B. Metro. Transit District

5. **Project Description:**
One new 22-foot electric transit bus and one new 35-foot electric transit bus were to be developed and manufactured. One of the buses was completed and has been operated by the Santa Barbara Metropolitan Transit District for one and one half years; the other is still being constructed. Other involved parties include APS Systems (an electric bus manufacturer), Cal-Start, and Southern Cal. Edison. The bus in operation replaced a diesel bus in service; the bus being manufactured will also replace a bus in service. The bus in operation has been using nickel-cadmium batteries. The one being constructed will be constructed of aluminum composites. (Project Date: 1993)

This is mainly a research project. Research money was used to develop new proto-type buses to out-perform current electric buses by having 50% more range, the ability to operate on routes that require higher average speeds, and the ability to stay in service for 8 hours at a time.

6. **Documentation of Cost-Effectiveness Analysis:**

An analysis period of 18 years was chosen based on the life of an electric bus. The project that is evaluated is defined to be the purchase of electric buses instead of diesel buses. The research aspects of the project are not evaluated for cost-effectiveness.

Costs (18 yrs) (NPV)		Research Costs
Total Cost of Project	**$152,477**	**$580,000**
Vehicle Regis. Funding		**220,000**
Capital Costs	**100,000**	
Operating Costs	**52,477**	

Capital Costs
Capital costs are a $100,000 price differential between electric buses and diesel buses (2)*($225,000-175,000). (Source: A-Z Bus Sales, Colton, CA and Electric Transit Vehicle Institute.) (Note: One of the electric buses is smaller than standard size. This accounts for an average cost of $225,000 for electric and $175,000 for diesel counterpart.)

Although this project includes substantial funding for research, the research aspect of the project is not evaluated for cost-effectiveness. Research costs include $500,000 for engineering development and $80,000 for research monitoring.

Operating Costs
The differential in recharging vs. refueling cost is about 20%. A 30-foot electric bus has a per mile electricity cost of 16.2 cents compared to a 13.1 cents per mile diesel fuel cost. The additional annual cost for recharging vs. refueling one bus = (3.1 cents/mile)(500,000 miles)/18 years = $861

The maintenance cost for diesel buses, including parts & labor, is 48.7 cents/mile. For electric buses, the maintenance cost, including battery replacement, is 54.5 cents/mile. The differential for the maintenance = 5.8 cents/mile. The additional annual cost for maintaining an electric bus (including battery replacement) = 5.8 cents/mile (500,000 miles)/18 years = $1,611. Total annual operating cost = $861 + $1,611 = $2,472 per bus. (Source: Four-Year Report on Battery-Electric Transit Vehicle Operation at the Santa Barbara Metropolitan Transit Distict, U.S. Department of Transportation and Federal Transit Administration, May 1995.)

Emissions Benefit Calculations
Emission benefits equal the emissions from two new diesel buses minus emissions from two new electric buses.

Data Provided: Estimated life of an electric bus is 18 years. (MSERC Guidelines). Diesel bus emissions for ROG are about 3.4 g/mile, NOx emissions are 16.5 g/mile, PM10 emissions are 0.37 g/mile, and CO emissions are 19 g/mile. (Source: CMAQ Guidelines).

Assumptions: Each bus will be driven 500,000 miles over the 18-year analysis period. Electric bus emissions (power plant emissions) related to this project are negligible.

Emissions Benefits (18 years)

ROG	**7,489 lbs**
NOx	**36,344 lbs**
PM10	**815 lbs**
CO	**41,850 lbs**

Cost-Effectiveness (Does not include research costs)

ROG+NOx	**$ 3/lb**
ROG+NOx+PM10	**3/lb**
CO	**4/lb**

Note: This project leveraged $700,000 of federal money. Federal funds cover the base costs of the buses plus a portion of research costs. Vehicle registration funds also support both project costs & a portion of research.

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Electric Vehicles

2. **Name of Project:** Visalia Electrification of Light-Duty Truck

3. **Air District or Local Agency:** San Joaquin Valley Unified APCD

4. **Implementing Agency or Organization:** City of Visalia

5. **Project Description:**

   The City of Visalia received $15,000 to convert one light-duty pickup truck to electric for daily use (park clean-ups) within the city. A 1987 pick-up truck was converted to electric in March 1994. The vehicle operates on about a dozen lead-acid batteries. The vehicle is driven about 30 miles a day, or 11,000 miles a year. The vehicle did need to be repaired after the converter got wet. The purpose of the project is to learn more about EVs, as well as to reduce emissions in the near-term. (Project Date: 1992)

6. **Documentation of Cost-Effectiveness Analysis:**

   Analysis period is seven years, based on estimated remaining useful life of vehicle.

Costs (7 years)(NPV)	
Total Cost of Project	**$ 15,696**
Vehicle Regis. Funding	**15,000**
Capital Costs	**15,000**
Operating Costs	**696**

   Capital Costs
   The conversion of the truck to electric was $15,000.

   Operating Costs
   Battery cost is estimated at about 10 cents/mile.
   Recharging cost, assuming 8.5 cents/kw-hr and 0.3 kw-hr/mile, is about 2.5 cents/mile.
   Maintenance of EVs is about 2 cents/mile.
   Total = 14.5 cents/mile

   For the gasoline vehicle getting 15 miles/gallon at $1.25/gallon, the refueling cost is 8.3 cents/mile.
   The maintenance cost of a gasoline vehicle is about 5 cents/mile.
   Total = 13.3 cents/mile.

   Differential between EV and gasoline vehicle = 1.2 cents/mile
   Annual net operating cost = (11,000 miles)(1.2 cents/mile) =$132.

Emission Benefits Calculations

Data provided: Emissions, based on the MSERC guidelines (page 66), are 0.5 g/mile of ROG, 1.0 g/mile of NOx, 9.0 g/mile for CO. No credit is allowed from PM10. EV emissions are negligible for this analysis. The truck is driven 30 miles a day, or roughly 11,000 miles a year. (Source: City of Visalia)

Assumptions: The expected remaining life of the EV truck is 7 years.

ROG
(11,000)(.5)(7)/454 = 85 lbs
NOx
(11,000)(1)(7)/454 = 170 lbs
CO
(11,000)(9)(7)/454 = 1,526 lbs

Emissions Benefits (7 years)	
ROG	85 lbs
NOx	170 lbs
PM10	0 lbs
CO	1,526 lbs

Cost-Effectiveness	
ROG+NOx	$ 62/lb
ROG+NOx+PM10	62/lb
CO	10/lb

TABLE 4:

VEHICLE SCRAPPAGE PROJECTS EVALUATION SUMMARY

	San Joaquin KAR Project	South Coast UNOCAL	
Motor Vehicle Fees Funding	$945,000	$342,000	
Matching Federal Funds	–	–	
Cost-Effectiveness Information			
ROG Emission Reductions	459,900 lbs.	93,300 lbs.	
NOx Emission Reductions	136,300 lbs.	41,900 lbs.	
PM10 Emission Reductions	0	0	
CO Emission Reductions	2,169,400 lbs.	526,600 lbs.	
VMT Reductions	0	0	
Trip Reductions	0	0	
Useful Life of Project	3 years	3 years	
Capital Costs (NPV)	0	0	
Operating Costs (NPV)	$1,090,000	$399,000	
Cost-Effectiveness for ROG+NOx	$2 / lb.	$3 / lb.	
Cost-Effectiveness for ROG+NOx+PM10	$2 / lb.	$3 / lb.	
Cost-Effectiveness for CO	$1 / lb.	$1 / lb.	

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Vehicle Scrappage

2. **Name of Project:** KAR

3. **Air District or Local Agency:** San Joaquin Valley Unified APCD

4. **Implementing Agency or Organization:** Project Clean Air

5. **Project Description:**

Project Clean Air's KAR Model SJV-1500 project removed 1,500 pre-1975 automobiles from operation in San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare, and Kern counties. Owners of the removed vehicles were paid $500. The number of vehicles purchased in each county was proportional to the number of vehicles registered. Retired vehicles had all fluids removed and either recycled or disposed of according to applicable rules and regulations. They were then crushed, shredded, and recycled where possible. Qualifying vehicles had to be street-legal, registered in the San Joaquin Valley for a minimum of one year, and driven to the retirement site. (Project Date: 1992)

6. **Documentation of Cost-Effectiveness Analysis:**

An analysis period of 3 years was used based on a maximum emission reduction credit lifetime of 3 years recommended by MSERC Guidelines, ARB, February 1994.

Costs (3 yrs)(NPV)	
Total Cost of Project	**$1,089,723**
Vehicle Regis. Funding	**945,123**
Capital Costs	**0**
Operating Costs	**1,089,723**

Operating Costs
Payment of $500 for 1,500 vehicles ($750,000); set up and operation of eight scrappage sites, and all other costs associated with the project ($349,723). (Source: Project Clean Air)

Emissions Benefit Calculations

The emissions benefit is the difference between the emissions from 1,500 retired vehicles and the emissions from an average replacement vehicle. Methodology used is that specified in MSERC Guidelines, ARB, February 1994. There are no PM10 reductions from accelerated retirement. The following is an example of ROG emissions reduction calculations for one year.

ROG
- Pre-1972 vehicles retired: 675
- 1972-74 vehicles retired: 825

(Note: 55% of the 1,500 retired vehicles were between the model years of 1971 and 1974. Guidelines provide emissions factors for vehicles in two categories that apply to this project. Pre-1972 vehicles make up one category and 1972-74 make up another. Since the number of 1971 vehicles was unknown, they were calculated as part of the 1972-74 category.)

Retired vehicles:
Pre-1972: (675 vehicles)*(4,900 miles driven)*(12.4 gm/mi)/(454 gm/lb) = 90,337 lbs
1972-74: (825 vehicles)*(5,300 miles driven)*(9.7 gm/mi)/(454 gm/lb) = 93,421 lbs
Total: (90,337 lbs)+(93,421 lbs) = 183,758 lbs

Replacement vehicles:
Pre-1972: (675 vehicles)*(4,900 miles driven)*(1.8 gm/mi)/(454 gm/lb) = 13,113 lbs
1972-74: (825 vehicles)*(5,300 miles driven)*(1.8 gm/mi)/(454 gm/lb) = 17,336 lbs
Total: (13,113 lbs)+(17,336 lbs) = 30,449 lbs

Difference: (183,758 lbs)-(30,448 lbs) = 153,309 lbs

Emissions Benefits (3 yrs)

ROG	**459,927 lbs**
NOx	**136,318 lbs**
PM10	**0**
CO	**2,169,431 lbs**

Cost-Effectiveness

ROG+NOx	**$2/lb**
ROG+NOx+PM10	**2/lb**
CO	**1/lb**

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Vehicle Scrappage

2. **Name of Project:** UNOCAL SCRAP Program

3. **Air District or Local Agency:** South Coast MSRC

4. **Implementing Agency or Organization:** UNOCAL

5. **Project Description:**

UNOCAL's second SCRAP program removed 502, 1971-79 model year vehicles from operation in the greater Los Angeles area. Owners of the removed vehicles were paid $700. Retired vehicles had all fluids removed and either recycled or disposed, according to applicable rules and regulations. They were then crushed, shredded, and recycled where possible. Qualifying vehicles had to be street-legal, registered in Los Angeles County for a minimum of one year and driven to the retirement site. (Project Date: 1992.)

6. **Documentation of Cost-Effectiveness Analysis:**

An analysis period is three years corresponding to life of emissions reduction credits per MSERC Guidelines, ARB, February 1994.

Costs (3 yrs)(NPV)	
Total Cost of Project	$398,763
Vehicle Regis. Funding	341,979
Capital Costs	0
Operating Costs	398,979

Operating Costs
Payment of $700 for 502 vehicles ($351,400). (Note: $60,000 vehicle payment costs were not submitted for reimbursement, as agreed upon in the contract, so the cost of the contract was $341,979). Set up and operation of one scrappage site, and all other costs associated with the project ($47,363). (Source: UNOCAL.)

Emissions Benefit Calculations

The emissions benefit is the difference between the emissions from 502 retired vehicles, and the emissions from 502 average replacement vehicles. Methodology used is that specified in MSERC Guidelines, ARB, February 1994. PM10 reductions from accelerated retirement are negligible and therefore not included. The following is an example of ROG emissions reduction calculations for one year.

ROG
- 1972-74 vehicles retired: 248
- 1975-81 vehicles retired: 254

Retired vehicles:
1972-74: (248 vehicles)*(5,300 miles driven)*(9.7 g/mi)/(454 g/lb.)= 28,083 lbs.
1975-81: (254 vehicles)*(6,400 miles driven)*(3.9 g/mi)/(454 g/lb.)= 13,964 lbs.
Total: (28,083 lbs.)+(13,964 lbs.) = 42,047 lbs.

Replacement vehicles:
1972-74: (248 vehicles)*(5,300 miles driven)*(1.8 g/mi)/(454 g/lb) = 5,211 lbs.
1975-81: (254 vehicles)*(6,400 miles driven)*(1.6 g/mi)/(454 g/lb) = 5,728 lbs.
Total: (5,211 lbs.)+(5,728 lbs.) = 10,939 lbs.

Difference: (42,047 lbs.)-(10,939 lbs.) = 31,108 lbs.

Emissions Benefits (3 yrs)

ROG	**93,324 lbs**
NOx	**41,918 lbs**
PM10	**0**
CO	**526,575 lbs**

Cost-Effectiveness

ROG+NOx	**$3/lb**
ROG+NOx+PM10	**3/lb**
CO	**1/lb**

TABLE 5:

TRAFFIC SIGNAL TIMING PROJECTS EVALUATION SUMMARY

	Fremont	Porterville	
Motor Vehicle Fees Funding	$90,000	$88,000	
Matching Federal Funds	–	–	
Cost-Effectiveness Information			
ROG Emission Reductions	143,400 lbs.	30,700 lbs.	
NOx Emission Reductions	34.800 lbs.	- 4,400 lbs.	
PM10 Emission Reductions	0	0	
CO Emission Reductions	1,038,700 lbs.	210,700 lbs.	
VMT Reductions	0	0	
Trip Reductions	0	0	
Useful Life of Project	12 years	12 years	
Capital Costs (NPV)	$160,000	$110,000	
Operating Costs (NPV)	$243,000	$103,000	
Cost-Effectiveness for ROG+NOx	$2 / lb.	$8 / lb.	
Cost-Effectiveness for ROG+NOx+PM10	$2 / lb.	$8 / lb.	
Cost-Effectiveness for CO	< $1 / lb.	$1 / lb.	

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Traffic Signal Timing

2. **Name of Project:** Traffic Signal Coordination - Fremont

3. **Air District or Local Agency:** Bay Area AQMD

4. **Implementing Agency or Organization:** City of Fremont

5. **Project Description:**

The City's master traffic signal controller was replaced with a new controller with expanded capacity. This allowed 26 more intersections to be coordinated. The project costs included engineering fees, purchase and installation. Previous studies have indicated that signal coordination will provide a savings in fuel, a savings in time due to reduced delays and reduced vehicle emissions. (Project Date: 1992.)

6. **Documentation of Cost-Effectiveness Analysis:**

Analysis period is 12 years based on CMAQ Guidelines which state that signalization projects have useful life of 5-20 years.

Costs (12 yrs.)(NPV)	
Total Cost of Project	**$ 403,230.**
Vehicle Regis. Funding	**90,000**
Capital Costs	**160,000**
Operating Costs	**243,230**

Capital Costs
Develop, implement, and fine-tune signal coordination plans was $28,600. The cost to purchase and install the signal controllers was $131,400.

Operating Costs
Costs and procedures to maintain optimal coordination vary widely. Ideally, signal timing coordination should be maintained on an ongoing basis to keep up with the changes in traffic flow. The cost of updating and maintaining the coordinated timing plans on an ongoing basis can total up to $100 per intersection per month.

Assumption: Operating costs to maintain current level of service is $31,200 per year ((100)(12)(26)).

Emissions Benefit Calculations

Emissions benefits are the result of the emission changes associated with the changes in vehicle speeds. There are no emission changes due

to reductions in trips or VMT because vehicle travel is assumed to remain constant.

Assumption: Speeds will be maintained over the 12 years because analysis includes operation costs to maintain optimal use of equipment.

Data provided by the City of Fremont: The 26 intersections are on four roads. The Average Daily Traffic (ADT), project length, and "before and after project" speeds as measured by the City are given below. Emission Factors are taken from CMAQ Guidelines.

Name of Road	ADT (vehicles)	Project Length	B/A Speeds
Blacow Rd.	21,876	3.54 miles	25/30 mph
Grimmer Blvd.	20,062	1.0	30/35
Warm Springs Blvd.	26,480	2.0	30/35
Fremont Blvd.	20,225	1.53	25/30

Emission changes = (ADT)*(length)*(Emission Factor before - Emission Factor after)*(365 days/year)(12 years)/(454 grams/lb)

Example, using Blacow Blvd.
ROG: (21,876)*(3.54)*(0.56-0.47)*(365)(12)/(454) = 67,241 lbs

Emissions Benefits (12 years)	
ROG	143,423 lbs
NOx	34,781 lbs
PM10	0 lbs
CO	1,038,742 lbs

Cost-Effectiveness	
ROG+NOx	$2/lb
ROG+NOx+PM10	2/lb
CO	<1/lb

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Traffic Signal Timing

2. **Name of Project:** Traffic Signal Coordination - Porterville

3. **Air District or Local Agency:** San Joaquin Valley Unified APCD

4. **Implementing Agency or Organization:** City of Porterville

5. **Project Description:**

Eleven traffic signals on Olive Avenue in the downtown area of Porterville were coordinated. New controllers were purchased for each intersection. The signals were not directly connected, but utilized WWV, a universal time source coordination mechanism that can connect to the new controllers. Previous studies have indicated that signal coordination will provide a savings in fuel, a savings in time due to reduced delays and reduced vehicle emissions. (Project Date: 1992.)

6. **Documentation of Cost-Effectiveness Analysis:**

Analysis period is 12 years based on CMAQ Guidelines.

Costs (12 yrs.)(NPV)	
Total Cost of Project	**$212,905**
Vehicle Regis. Funding	**88,000**
Capital Costs	**110,000**
Operating Costs	**102,905**

Capital Costs
Develop, implement, and fine-tune signal coordination plans was $35,000. The cost to purchase and install the signal controllers was, $75,000.

Operating Costs
Costs and procedures to maintain optimal coordination vary widely. Ideally, signal timing coordination should be maintained on an ongoing basis to keep up with the changes in traffic flow. The cost of updating and maintaining the coordinated timing plans on an ongoing basis can total up to $100 per intersection per month.

Assumption: Operating costs to maintain current level of service is $13,200 per year ((100)(11)(12)).

Emissions Benefit Calculations

Emissions benefits are the result of the emission changes associated with the changes in vehicle speeds. There are no emission changes due

to reductions in trips or VMT because vehicle travel is assumed to remain constant.

Assumption: Speeds will be maintained over the 12 years because analysis includes operation costs to maintain optimal use of equipment.

Data provided by the City of Porterville: ADT (Average Daily Traffic) = 13,000 vehicles, project length = 3.5 miles, speeds before and after project are 30 and 35 mph, respectively, as measured by the City. Emission factors are based on CMAQ Guidelines.

Emission changes = (ADT)*(length)*(Emission Factor before - Emission Factor after)*(365 days/year)(12)/(454 grams/lb.)

ROG: (13,000)*(3.5)*(0.47-0.40)*(365)(12)/(454) = 30,728 lbs

Emissions Benefits (12 years)	
ROG	30,728 lbs
NOx	-4,390 lbs
PM10	0 lbs
CO	210,703 lbs

Cost-Effectiveness	
ROG+NOx	$8/lb
ROG+NOx+PM10	8/lb
CO	1/lb

TABLE 6:

SHUTTLE SERVICES
PROJECTS EVALUATION SUMMARY

	Santa Clara Employee Transit Shuttle	Monterey WAVE Tourist Shuttle	Santa Barbara Commuter Express
Motor Vehicle Fees Funding	$280,000	$190,000	$190,000
Matching Federal Funds	–	$309,000	$617,000
Cost-Effectiveness Information			
ROG Emission Reductions	1,200 lbs.	2,800 lbs.	105,100 lbs.
NOx Emission Reductions	800 lbs.	- 2,400 lbs.	71, 500 lbs.
PM10 Emission Reductions	1,700 lbs.	1,300 lbs.	416,400 lbs.
CO Emission Reductions	10,700 lbs.	31,600 lbs.	863,200 lbs.
VMT Reductions	619,000 miles	480,000 miles	100,799,000 miles
Trip Reductions	38,000 trips	240,000 trips	0
Useful Life of Project	1 year	8 years	15 years
Capital Costs (NPV)	0	$70,000	$1,250,000
Operating Costs (NPV)	$587,000	$691,000	$865,000
Cost-Effectiveness for ROG+NOx	$298 / lb.	$1,850 / lb.	$12 / lb.
Cost-Effectiveness for ROG+NOx+PM10	$162 / lb.	$450 / lb.	$4 / lb.
Cost-Effectiveness for CO	$55 / lb.	$24 / lb.	$2 / lb.

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Shuttle

2. **Name of Project:** Santa Clara County Employee Transit Shuttle

3. **Air District or Local Agency:** Bay Area AQMD

4. **Implementing Agency or Organization:** Santa Clara County Transit District

5. **Project Description:**

This shuttle project provided free shuttles between Santa Clara Light Rail Transit (LRT) stations and major employment sites. The shuttles have been operated by private firms (operating seven routes), that are paid a contracted hourly rate. Funds were provided by Santa Clara County Transit District, large local employers and vehicle registration funds. Most of the shuttle routes started in 1993 and early 1994, and are therefore relatively new. Ridership has increased on each route as service has become more established. (Project Date: 1993.)

6. **Documentation of Cost-Effectiveness Analysis:**

Analysis period is one year (1994) because there are no capital investments. The project is totally dependent on operating costs. This project, however, can be an ongoing project that continues to support light rail.

Costs (1 yr)(NPV)	
Total Cost of Project	**$587,283**
Vehicle Regis. Funding	**279,550**
Capital Costs	**0**
Operating Costs	**587,283**

Operating Costs
Contracted services with private shuttle firms.

Trip & VMT Reductions (1 yr.)	
Trip Reductions	**38,031 trips**
VMT Reductions	**618,578 miles**

Trip Reduction Analysis
Data provided: Shuttle ridership (both directions) was 176,233; 26% of shuttle riders previously drove to work; 83% of shuttle riders do not drive alone to station. (Source: Santa Clara County Transit District, and shuttle rider surveys.)

Total trips reduced = (176,233)*(0.26)*(0.83)
= 38,031 trips reduced

VMT Reduction Analysis

Data provided: Average one-way commute trip distance = 13.5 miles. (Source: shuttle rider survey.)

Total VMT reduced = (shuttle/LRT trips)*(% new riders)*(average commute trip length)
= (176,233)*(0.26)*(13.5 miles)
= 618,578 miles

Emissions Benefits (1 yr.)

ROG	**1,189 lbs**
NOx	**784 lbs**
PM10	**1,660 lbs**
CO	**10,728 lbs**

Emission benefits are the benefits from vehicle trips and VMT reduced minus the disbenefits of the shuttles.

Data provided: Shuttles drove 230,110 miles in 1994. There were eight routes. Average days in operation for each route was 202 days. (Source: Santa Clara Co Transit District.)

Assumptions: 3232 cold starts from the shuttles.
(8)(2)(202)=3232

Cost-Effectiveness

ROG+NOx	**$298/lb**
ROG+NOx+PM10	**162/lb**
CO	**55/lb**

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Shuttle

2. **Name of Project:** Monterey WAVE Summer Tourist Shuttle

3. **Air District or Local Agency:** Monterey Bay Unified APCD

4. **Implementing Agency or Organization:** Monterey/Salinas Transit District

5. **Project Description:**

Thirty-five transit buses provide summer-season shuttle service between highly visited points of interest (such as Monterey Aquarium and Fisherman's Wharf.) The shuttle service was used mainly by visitors, with a single, all-day price of $0.50. The buses were specially painted with wave graphics, and have announcement systems for highlighting points of interest. Local businesses and the city helped fund the WAVE shuttles. The buses were used in the off season in the regular transit fleet. The shuttle service is still in operation. (Project Date: 1992.)

6. **Documentation of Cost-Effectiveness Analysis:**

Analysis period of eight years was chosen for this project because shuttle services are given a useful life of eight years per CMAQ Guidance. (Note: This project leveraged $308,500 of federal CMAQ funding.)

Costs (8 yr)(NPV)	
Total Cost of Project	**$ 761,235**
Vehicle Regis. Funding	**190,000**
Capital Costs	**70,429**
Operating Costs	**690,806**

Capital Costs
Estimated purchase cost per service mile. Estimated purchase cost: $225,000. Service miles: Average service miles for shuttle route use: 19,720 (average of two years of service, 1992-93). Annual service miles of bus: 42,000 mi./yr. (Source: Monterey/Salinas Transit District)

Pro-rate cost of bus = (cost of bus)*(shuttle miles / actual miles)/(life of bus)*(analysis period)
= ($225,000)*(19,720/42,000)/(12)*(8)
= $70,429

Operating Costs
Operating costs include driver salaries, bus maintenance and cost of fuel. All costs were proportioned according to bus service

miles for this project. There are revenues of $0.50 per person per day that are deducted from operating costs.

Trip & VMT Reductions (eight years)

Trip Reductions	**240,184**
VMT Reductions	**480,368**

Trip Reduction Analysis

Data provided: Boardings in 1992 were 83,909 and in 1993 were 42,187. There are 2.1 boardings per person. (Source: Monterey Transit District).

Assumptions: Assume AVR is 2.0 for vehicle tourist travel.
Total trips reduced = (Av. Boardings)/2.1/2.0*2 trips per person
= (63048)/2.1/2.0*2
= 30,023 trips/year

VMT Reduction Analysis

Data provided: Length of route is four miles round trip or two miles one direction.

Total VMT reduced = (trips reduced)*(average trip length)
= 30,023*2
= 60,046 miles/year

(Note: Staff used actual trips and mileage for first two years and averages for remaining six years of the analysis period.)

Emissions Benefits (1 yr)

ROG	**2800 lbs**
NOx	**-2389 lbs**
PM10	**1282 lbs**
CO	**31568 lbs**

Emission reductions reflect the difference in vehicle emissions replaced and bus emissions.

ROG: 3,984 - 1,184
NOx: 2,195 - 4,584
PM10: 2,053 - 771
CO: 38,168 - 6,600

Cost-Effectiveness

ROG+NOx	**$1,850/lb**
ROG+NOx+PM10	**450/lb**
CO	**24/lb**

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Shuttle

2. **Name of Project:** Santa Barbara Clean Air (Commuter) Express

3. **Air District or Local Agency:** Santa Barbara County APCD

4. **Implementing Agency or Organization:** Santa Barbara County APCD

5. **Project Description:**

A subscription commute bus service was operated using five full-sized (40-passenger) compressed natural gas (CNG) buses. The buses provided service into Santa Barbara from Ventura, Santa Maria and Lompoc. All five buses ran at full capacity. A local tour bus company operated the buses. The contract covered driver salaries and bus maintenance. The fuel was purchased from the transit district directly by Santa Barbara County APCD. This project proved successful enough in its first two years of operation (1992 & 1993) that Congestion Mitigation & Air Quality (CMAQ) funds ($308,500 per year) were obtained for 1994 and 1995 to extend the commute service. (Project Date: 1992.)

6. **Documentation of Cost-Effectiveness Analysis:**

A 15-year analysis period was used based on an estimated 15-year life of an intercity (freeway) bus. (Note: Matching federal funds were $617,000.)

Costs (15 yrs)(NPV)		(no bus costs)
Total Cost of Project	**$2,115,308**	**$865,308**
Vehicle Regis. Funding	**190,000**	**190,000**
Capital Costs	**1,250,000**	**0**
Operating Costs	**865,308**	**865,308**

Capital Costs
Cost of five CNG buses at $250,000 each. (Note: The CNG buses were donated for this commute service at the end of a local demonstration project. However, for purposes of this analysis, two cost-effectiveness calculations were done, one with no capital costs for buses, and one including the cost of the buses, since most similar projects would involve actual bus purchases.)

Operating Costs
Total operating costs included fuel costs, driver salaries, bus maintenance etc., minus fare revenues, over 15 years (in net present value). The costs for 1992-93 were averaged to provide estimated costs for on-going years. Bus operated 252 days per year. (Source: Santa Barbara APCD.)

Fuel costs: ($25/day/bus)*(252 days/yr) = $6,300/yr/bus
Other Operating costs: ($225/day/bus)*(252 days/yr) = $56,700/yr/bus
Fares: ($90/mo)*(36 riders/mo)(12 mos) + ($100/mo)*(4 riders/mo)*(12 mos) = $43,680/yr/bus
Cost per year: ($6,300 fuel)+($56,700 operating)-($43,680 fares) = $19,320/yr/bus
($19,320/yr/bus)*(5 buses) = $96,600/yr

Trip & VMT Reductions (15 yrs)

VMT Reductions	100,799,370

Note: No trip reductions were estimated since, on average, the number of trips generated before and after the bus service started is the same. Before, 83% drove to work or drove to meet carpool. After, 80% drove to catch bus. (Source: Santa Barbara APCD.)

VMT Reduction Analysis
Data provided: Average round trip commute = 160 miles. Passengers per bus per day = 40 days of operation per year = 252. AVO before bus service = 1.2. Number of commuter buses = 5. (Source: Santa Barbara APCD.)

Assumptions: 15-year life of buses. Because the commute buses are used exclusively on highway routes, it is assumed they will have a longer life than the average urban transit bus (12 years.)

Total VMT reduced = (average round trip length)*(passengers per bus)/(AVO before bus service)*(days of operation per year)*(number of buses)*(life of buses)
= (160)*(40)/(1.2)*(252)*(5)*(15)
= 100,799,370 miles

Emissions Benefits (15 yrs)

ROG	**105,076 lbs**
NOx	**71,462 lbs**
PM10	**416,408 lbs**
CO	**863,233 lbs**

Emissions Benefit Calculations
Emissions benefits = the emissions benefits of the VMT reduction minus the emissions disbenefit of the bus emissions. (Note: Santa Barbara County APCD provided conversion factors from U.S. EPA to convert ARB's urban transit bus emission factors to intercity (freeway) CNG bus emission factors.) Bus factors are based on CMAQ Guidelines.

Bus emissions per year = (mileage per year for five buses)*(urban transit bus emission factor)*(freeway bus conversion factor)/(454 grams/lb)

ROG: (201,600)*(3.4)*(0.7)/(454) = 1056.9 lbs./yr.
NOx: (201,600)*(13.2)*(0.8)/(454) = 4689.2 lbs./yr.
CO: (201,600)*(19.0)*(0.8)/(454) = 6749.6 lbs./yr.
PM10: (201,600)*(2.22)*(0.97)/(454) = 956.2 lbs./yr.
(Note: PM10 factor is 0.37 gr./mi. exhaust plus 1.85 gr./mi.road dust. (0.37)(0.80)+1.85 = (0.97)((2.22))

Cost-Effectiveness		(w/o bus costs)
ROG+NOx	$12/lb	$5/lb
ROG+NOx+PM10	4/lb	1/lb
CO	2/lb	1/lb

TABLE 7:

EMPLOYER TRIP REDUCTION PROJECTS EVALUATION SUMMARY

	San Bernardino Co.Trip Reduction	Sonoma Co. Trip Reduction	South Placer Co. Ridematching
Motor Vehicle Fees Funding	$189,000	$22,000	$30,000
Matching Federal Funds	–	–	–
Cost-Effectiveness Information			
ROG Emission Reductions	12,900 lbs.	2,900 lbs.	11,800 lbs.
NOx Emission Reductions	11,500 lbs.	2,300 lbs.	10,800 lbs.
PM10 Emission Reductions	20,500 lbs.	3,600 lbs.	23,600 lbs.
CO Emission Reductions	117,300 lbs.	26,100 lbs.	103,700 lbs.
VMT Reductions	4,797,000 miles	851,000 miles	5,511,000 miles
Trip Reductions	240,000 trips	84,000 trips	273,000 trips
Useful Life of Project	1 year	1 year	5 years
Capital Costs (NPV)	$0	$2,000	$30,000
Operating Costs (NPV)	$199,000	$20,000	$95,000
Cost-Effectiveness for ROG+NOx	$8 / lb.	$4 / lb.	$6 / lb.
Cost-Effectiveness for ROG+NOx+PM10	$4 / lb.	$3 / lb.	$3 / lb.
Cost-Effectiveness for CO	$2 / lb.	$1 / lb.	$1 / lb.

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Employer Trip Reductions

2. **Name of Project:** South Placer County TMA Ridematching Computer

3. **Air District or Local Agency:** Placer County APCD

4. **Implementing Agency or Organization:** South Placer County TMA

5. **Project Description:**

An automated ridematching system was implemented by the South Placer County Transportation Management Association (TMA). Vehicle registration fees were used to purchase a computer and software. Other project components included promotional materials and salary and benefits for a program operator. (Project Date: 1993)

6. **Documentation of Cost-Effectiveness Analysis:**

An analysis period of 5 years was chosen because of a projected life of the ridematching computer of 5 years.

Costs (5 yrs)(NPV)	
Total Cost of Project	**$124,687**
Vehicle Regis. Funding	**30,000**
Capital Costs	**30,000**
Operating Costs	**94,687**

Capital Costs
Computer and software.

Operating Costs
Salary and benefits for a part time program operator, one-time expenditure for promotional materials, and phone costs.

Trip & VMT Reductions (5 yrs)	
Trip Reductions	273,375
VMT Reductions	5,511,240

Trip Reduction Analysis
Data provided: 128 placements into carpools were made between 3/93 and 3/95 using ridematching computer. (Source: South Placer County TMA)

Assumptions: The project maintains just over 129 carpools from 1995 on. Number of baseline carpools are sustained despite turnover and also increase by 1% each year after 1994 because of expected growth in work trip travel due to population growth of working age individuals (6% per year). (Source: "Projected Total

Population of California Counties," California Department of Finance, May 1993.) (Note: Staff reviewed trends for Sacramento Rideshare as an indicator of growth rate for the South Placer program. Growth was unpredictable from one year to the next.)

Because there were fewer placements during the first two start-up years, the number of placements over the analysis period averages to 109.35 per year. Two trips per day, 250 days per year, over five years. (Note: trips were distributed over appropriate years for purpose of determining emission reductions.)

Total trips reduced = (placements)*250*2*5
= (109.35)*250*2*5
= 273,375 trips reduced

VMT Reduction Analysis
Data provided: Average commute trip length (one way) is 20.16 miles. (Source: Placer County Transportation Planning Authority)

Total VMT reduced = (Trips reduced)*(Average commute trip length)
= (273,375)*(20.16 miles)
= 5,511,240 miles

Emissions Benefits (1 yr)	
ROG	11,750 lbs
NOx	10,820 lbs
PM10	23,550 lbs
CO	103,718 lbs

Cost-Effectiveness	
ROG+NOx	$6/lb
ROG+NOx+PM10	3/lb
CO	1/lb

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Employer Trip Reductions

2. **Name of Project:** San Bernardino County Trip Reduction Program

3. **Air District or Local Agency:** San Bernardino County

4. **Implementing Agency or Organization:** San Bernardino County

5. **Project Description:**

The Commuter Services Division of Human Resources/County Administrative Office (CAO) of San Bernardino County coordinates the County's compliance with the South Coast AQMD's Rule 1501. AB 2766 funds are used for operating expenses such as staff, supplies, communications (including promotional items, e.g. flyers), subscription to Commuter Transportation Services (CTS), and complimentary Omnitrans bus fares. (Project Date: 1993)

6. **Documentation of Cost-Effectiveness Analysis:**

An Analysis period of one year was chosen because project life is dependent on provision of operating funds. Costs and benefits associated with ongoing operation are expected to be roughly similar to the year analyzed.

Costs (1 yr)(NPV)	
Total Cost of Project	**$198,807**
Vehicle Regis. Funding	**189,040**
Capital Costs	**0**
Operating Costs	**198,807**

Operating Costs
Staff salaries and benefits, communications (telephones, etc.), services (temporary employees, bus passes, subscription to CTS, etc.) and supplies. (Source: Human Resources CAO budget sheet.)

Trip & VMT Reductions (1 yr)	
Trip Reductions	**239,854 trips**
VMT Reductions	**4,797,080 miles**

Trip Reduction Analysis
Data provided: Baseline AVR (1989) = 1.10; (VERi = 0.91); AVR for 1991/92 = 1.17; AVR for 1992/93 = 1.19; (VERf = 0.84), 32,947 round trips per week (Source: employee travel surveys)

Assumptions: 2 trips/day per employee, 52 weeks per year (Note: non-work days like vacation, sick leave, etc. are already

deducted from round trips per week). Without the program, AVR would return to AVR baseline of 1.10.

Total trips reduced = (Round Trips)*(VERi - VERf)*2*52
= (32,947)*(0.91 - 0.84)*2*52
= 239,854 trips reduced

Where: AVR = average vehicle ridership
VERi = initial vehicle to employee ratio
VERf = final vehicle to employee ratio

VMT Reduction Analysis

Data provided: Average one-way commute trip distance = 20 miles (Source: San Bernardino County average commute length, State of the Commute, Commuter Transportation Services, Inc., 1993)

Total VMT reduced = (Trips reduced)*(Average commute trip length)
= (239,854)*(20 miles)
= 4,797,080 miles

Emissions Benefits (1 yr)

ROG	12,944 lbs
NOx	11,517 lbs
PM10	20,499 lbs
CO	117,275 lbs

Cost-Effectiveness

ROG+NOx	$ 8/lb
ROG+NOx+PM10	4/lb
CO	2/lb

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Employer Trip Reductions

2. **Name of Project:** Sonoma County Trip Reduction Program

3. **Air District or Local Agency:** Sonoma County CMA

4. **Implementing Agency or Organization:** Sonoma County Transportation Authority

5. **Project Description:**

Funds were used to provide Employee Transportation Coordinator training, survey processing, bike rack installation at two locations, and subsidized transit passes to comply with the Sonoma County Trip Reduction Ordinanace (1993). (Project Date: 1993)

6. **Documentation of Cost-Effectiveness Analysis:**

An analysis period of one year was used (1993) because the trip reduction program was discontinued. However, 20 years worth of benefits are assumed for the capital investment (bike racks).

Costs (1 yr)(NPV)	
Total Cost of Project	**$22,088**
Vehicle Regis. funding	**22,088**
Capital Costs	**1,671**
Operating Costs	**20,417**

Capital Costs
Bike racks installed at two locations.

Operating Costs
Transportation survey processing ($1,750), bus pass subsidies ($15,709), staff ($2,957).

Trip & VMT Reductions*	
Trip Reductions	**83,745 trips**
VMT Reductions	**850,981 miles**

*1 year for trip reduction program; 20 years for bike rack benefits.

Trip Reduction Analysis
Data provided: (a) Number of employees = 1,343*, VERi for 1992 = .95; VERf for 1993 = .84; and (b) bicycling increased 5%, from 180 to 190 bicycle trips per week. (Source: employee travel surveys)
*Backcast calculation used because number of employees grew.

Assumptions: (a) 2 trips/day per employee, 250 work days per year; (b) 52 weeks per year; Remaining life of bike racks - 19 years (20-year life minus one year of existing life).

(a) Trips reduced =(Employees)*(VERi - VERf)*2*250
=(1,343)*(0.95 - 0.84)*2*250
= 73,865

(b) Trips reduced =(bike trips increased)*(52 wks)*(19 yrs)
=(10)*(52)*(19)
= 9,880

Total trips reduced = (a) + (b)
= 73,865 + 9,880
= 83,745 trips reduced

Where: VERi = initial vehicle to employee ratio
VERf = final vehicle to employee ratio

VMT Reduction Analysis

Data provided: (a) Average trip length, 11.28 miles (Source: Sonoma County Transportation Authority); (b) Average bike trip length, 1.8 miles (Source: National Personal Travel Survey).

(a) VMT reduced (Trips reduced)*(Average commute trip length)
(73,865)*(11.28)
= 833,197

(b) VMT reduced (Trips reduced-Bikers)*(Ave. bike trip length)
= 17,784

Total VMT reduced = (a) + (b)
= 833,197 + 17,784
= 850,981 miles reduced

Emissions Benefits (1 yr)

ROG	**2,857 lbs**
NOx	**2.272 lbs**
PM10	**3,636 lbs**
CO	**26,078 lbs**

Cost-Effectiveness

ROG+NOx	**$ 4/lb**
ROG+NOx+PM10	**3/lb**
CO	**1/lb**

TABLE 8:

TELECOMMUNICATION PROJECTS EVALUATION SUMMARY

	San Bernardino Probation Project	L.A. Co. Justice Interview System	College of the Desert Admin. Video System
Motor Vehicle Fees Funding	$80,000	$168,000	$128,000
Matching Federal Funds	–	–	–
Cost-Effectiveness Information			
ROG Emission Reductions	3,600 lbs.	2,200 lbs.	2,200 lbs.
NOx Emission Reductions	3,400 lbs.	2,000 lbs.	2,300 lbs.
PM10 Emission Reductions	7,600 lbs.	4.600 lbs.	5.300 lbs.
CO Emission Reductions	31,800 lbs.	18,800 lbs.	19,400 lbs.
VMT Reductions	1,770,000 miles	1,066,000 miles	1,250,000 miles
Trip Reductions	68,000 trips	26,000 trips	20,000 trips
Useful Life of Project	5 years	5 years	
Capital Costs (NPV)	$91,000	$261,000	$304,000
Operating Costs (NPV)	- ($204,000)	$3,000	- $35,000
Cost-Effectiveness for ROG+NOx	- $16 / lb.	$63 / lb.	$59 / lb.
Cost-Effectiveness for ROG+NOx+PM10	- $8 / lb.	$30 / lb.	$27 / lb.
Cost-Effectiveness for CO	- $4 / lb.	$14 / lb.	$14 / lb.

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Telecommunications

2. **Name of Project:** San Bernardino County Probation Videophone Project

3. **Air District or Local Agency:** South Coast MSRC

4. **Implementing Agency or Organization:** San Bernardino County Probation Department

5. **Project Description:**

A telecommuting and videophone interviewing project was implemented by the San Bernardino Probation Department to help them comply with South Coast AQMD's Regulation XV. Probation managers and staff were allowed to buy home computers at lower cost and at lower interest rates. Videophone equipment was installed at the branch probation offices and two detention centers. Telecommuting saved employee commute trips. Videophone interviewing of inmates saved trips to and from branch probation offices and detention centers. Reimburseable travel expense cost savings from the videophone interviewing over a five-year period will equal more than the cost of the project. (Project Date: 1993)

6. **Documentation of Cost-Effectiveness Analysis:**

Analysis period of five years was used based on an estimated five-year life of the videophone and telecommute equipment.

Costs (5 yrs)(NPV)	
Total Cost of Project	**$ -113,053**
Vehicle Regis. Funding	**80,000**
Capital Costs	**91,000**
Operating Costs	**-(204,053)**

Capital Costs
Videophone equipment ($80,000). Videophone and telecommuting start-up costs ($11,000).

Operating Costs
Operating costs include cost of phone bill for tele-interviews minus savings from previous reimburseable travel expenses. First year phone costs were $1,925. Second year phone costs were $12,325. (Video interviews went from 2,134 per year to 5,000.) This cost was assumed for years 3-5. First year travel expenses for mileage saved was $30,554. Second year travel expense savings was $71,000. This savings is assumed for years 3-5. (Assume $0.25/mi. same as quoted for L.A. Co. travel reimbursement. In fact, San Bernardino Co. Probation Department

has labor-negotiated rate of $0.32/mi. Staff chose to use $0.25 rate consistent with the other program.)

Trip & VMT Reductions (1 yr)

Trip Reductions	68,268 trips
VMT Reductions	1,770,216 miles

Trip Reduction Analysis

Data provided: 2,134 videophone interviews were conducted the first year and 5,000 during the second year. Also, 30 probation officers telecommuted an average 2 days per week, 50 weeks per year, starting the second year of the project. (Source: San Bernardino Co. Probation Department).

Assumptions: Two trips reduced per videophone interview. Two trips reduced each telecommute day.

Example: Trips reduced (year 2) = (5,000)(2 trips) + (30)(2 days/wk)(50 wks)(2 trips)

VMT Reduction Analysis

Data provided: Average trip length, probation office to detention center = 28.64 miles. Average commute trip length = 21 miles. (Source: San Bernardino Co. Probation Dept.)

Emissions Benefits (5 yrs)

ROG	3,616 lbs
NOx	3,444 lbs
PM10	7,564 lbs
CO	31,752 lbs

Cost-Effectiveness

ROG+NOx	$ -16/lb
ROG+NOx+PM10	-8/lb
CO	-4/lb

Note: This project was unusual in that the projected cost savings were significantly greater than the cost of the project. When the project was screened by the MSRC, the savings from reimbursable travel expenses were not considered.)

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Telecommunications

2. **Name of Project:** Los Angeles County Justice Video Interview System

3. **Air District or Local Agency:** South Coast MSRC

4. **Implementing Agency or Organization:** Los Angeles County Public Defender/Probation

5. **Project Description:**

Nine video-conference units were purchased with vehicle registration funds for distance interviewing of Los Angeles County jail inmates by personnel from the public defender's, probation's, and sheriff's offices. Equipment purchased includes seven "ruggedized" tele-stations for inmate use, with bulletproof glass and metal enclosures as well as a scanner and 486 computer. The air quality benefits of the project resulted from decreased vehicle trips. (Project Date: 1993)

6. **Documentation of Cost-Effectiveness Analysis:**

Analysis period of five years was used based on an estimated five-year life of the teleconferencing equipment.

Costs (5 yrs)(NPV)	
Total Cost of Project	**$ 263,604**
Vehicle Regis. Funding	**168,000**
Capital Costs	**260,602**
Operating Costs	**3,002**

Capital Costs
"Ruggedized" teleconferencing stations ($168,000), additional teleconferencing equipment ($20,000), and installation ($72,602).

Operating Costs
Costs include phone bill for televideo conference calls of $54,000 per year (Source: L.A. Co. Justice Dept.) minus savings from reduced travel expenses. Travel expenses were $53,250 per year based on mileage reduced. ($0.25/mi x 213,200 miles reduced per year. Source of rate is L.A. Co. Justice Dept.) This results in annual operating costs of $750.

Trip & VMT Reductions (5 yrs)	
Trip Reductions	26,000 trips
VMT Reductions	1,066,000 miles

Trip Reduction Analysis
Data provided: 5,200 teleconference inmate interviews per year. (Source: L.A. County Public Defender)

Assumptions: Two in-person inmate interviews are conducted for every roundtrip to the jail, so one roundtrip trip is saved for every two teleconference interviews conducted. Roundtrip = 2 trips.

Total trips reduced = (teleconference inmate interviews)/(2 interviews per roundtrip)*(2 trips reduced)*(5 years)
= (5,200)/(2)*(2)*(5)
= 26,000 trips reduced

VMT Reduction Analysis
Data provided: Average trip length = 41 miles (from Los Angeles *Civic Center to Peter Pitchess Honor Ranch Jail). (Source: L.A. County Public Defender)*

Total VMT reduced = (trips reduced)*(average trip length)
= (26,000)*(41)
= 1,066,000 miles

Emissions Benefits (5 yrs)

ROG	**2,189 lbs**
NOx	**1,996 lbs**
PM10	**4,555 lbs**
CO	**18,801 lbs**

Congestion-Related Emission Reductions:
Assumptions: Half of the VMT reduced would have occurred during congested travel. Additional emission reductions resulting from reducing congested travel in L.A. Co. is 0.09 g/mi for ROG+NOx and 0.87 g/mi for CO. (Source: EMFAC7F1.1, Air Resources Board estimate based on the difference in emissions between peak period travel and 24-hour travel in Los Angeles County.)

Cost-Effectiveness

ROG+NOx	**$ 63/lb**
ROG+NOx+PM10	**30/lb**
CO	**14/lb**

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Telecommunications

2. **Name of Project:** College of the Desert Video-Administrative System

3. **Air District or Local Agency:** South Coast MSRC

4. **Implementing Agency or Organization:** Desert Community College District

5. **Project Description:**

Portable video-conferencing equipment was installed in board conference rooms at the two campuses of the College of the Desert, located in Joshua Tree and Palm Desert. Vehicle trips between the campuses have been eliminated (a 62-mile trip). The equipment is used for daily administrative meetings attended by 14-18 persons and for monthly board meetings. Teleconference calls and meetings made to other sites with similar equipment also save trips. The success of the technology has sparked interest in other trip-saving and educational uses, such as video-monitored courses and distance learning presentations from other state campuses. (Project Date: 1993)

6. **Documentation of Cost-Effectiveness Analysis:**

Analysis period of five years was used based on an estimated five-year life of the teleconferencing equipment.

Costs (5 yrs)(NPV)	
Total Cost of Project	**$ 268,777**
Vehicle Regis. Funding	**128,000**
Capital Costs	**304,000**
Operating Costs	**-(35,223)**

Capital Costs
Teleconferencing equipment ($128,000 vehicle registration funding), and in-kind support for initial installation and testing ($276,000).

Operating Costs
Operation costs are the cost of phone for video conferencing minus savings from previous reimbursable travel expenses. Cost of phone is assumed to be $1,200. per year based on roughly 1,000 hours per year connect time. (Source: College of the Desert. Assume cost of teleconferencing is $0.02 per minute.) Previous reimburseable travel expenses were $10,000 per year. (Source: College of the Desert budget). Total operating costs of project equal a savings of $8,800 per year. (Note: There was excess capacity on the T-1 leased line between campuses so no other costs were incurred for adding teleconferencing.)

Trip & VMT Reductions (5 yrs)

Trip Reductions	**20,000 trips**
VMT reductions	**1,250,000 miles**

Trip Reduction Analysis

Data provided: 4,000 trips saved per year (Source: College of the Desert). (Note: This is a conservative estimate since other applications of the equipment, such as distance-learning classes, is reducing additional trips.)

Assumptions: 5-year equipment life.

Total trips reduced = (trips saved)*(5 years)
= (4,000)*(5)
= 20,000 trips reduced

VMT Reduction Analysis

Data provided: Average trip length = 62.5 miles (Source: College of the Desert).

Total VMT reduced = (trips reduced)*(average trip length)
= (20,000)*(62.5 miles)
= 1,250,000 miles

Emissions Benefits (5 yrs)

ROG	**2,241 lbs**
NOx	**2,335 lbs**
PM10	**5,341 lbs**
CO	**19,414 lbs**

Cost-Effectiveness

ROG+NOx	**$59/lb**
ROG+NOx+PM10	**27/lb**
CO	**14/lb**

TABLE 9:

BICYCLES
PROJECTS EVALUATION SUMMARY

	Monterey Aquarium Bike Loan	Pacific Grove Bike Trail	
Motor Vehicle Fees Funding	$5,000	$10,000	
Matching Federal Funds	–	–	
Cost-Effectiveness Information			
ROG Emission Reductions	1,200 lbs.	12,400 lbs.	
NOx Emission Reductions	700 lbs.	7,700 lbs.	
PM10 Emission Reductions	700 lbs.	9,000 lbs.	
CO Emission Reductions	12,000 lbs.	122,500 lbs.	
VMT Reductions	159,000 miles	2,116,000 miles	
Trip Reductions	88,000 trips	1,175,000 trips	
Useful Life of Project	10 years	20 years	
Capital Costs (NPV)	$13,000	$225,000	
Operating Costs (NPV)	$2,000	$72,000	
Cost-Effectiveness for ROG+NOx	$7 / lb.	$15 / lb.	
Cost-Effectiveness for ROG+NOx+PM10	$5 / lb.	$10 / lb.	
Cost-Effectiveness for CO	$1 / lb.	$2 / lb.	

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Bicycle Use and Infrastructure

2. **Name of Project:** Monterey Bay Aquarium Bicycle Loan Program

3. **Air District or Local Agency:** Monterey Bay Unified APCD

4. **Implementing Agency or Organization:** Monterey Bay Aquarium

5. **Project Description:**

   The Aquarium purchased 30 bicycles for their employees to use to get to work. Employees were required to bike to work three times per week in order to receive a bike. Employees were also required to maintain the bike. Five bikes were put in storage for future riders. Three bikes were used by staff to run errands during the day. The Aquarium also installed two new bike racks and one inside bike garage in support of the program. (Project Date: 1993)

6. **Documentation of Cost-Effectiveness Analysis:**

   An analysis period of 10 years based on the reasonable life for bicycles.

Costs (10 yrs)(NPV)	
Total Cost of Project	**$ 14,143**
Vehicle Regis. Funding	**5,200**
Capital Costs	**12,510**
Operating Costs	**1,633**

Capital Costs
30 bicycles ($275 each), 2 heavy duty bike racks ($800 each), 1 indoor bike garage ($1,000), 12 bike helmets ($25 each), 10 bike locks ($16 each), 10 bike covers ($10 each), 2 storage boxes ($250 each).

Operating Costs
Administration costs were $15 per participant (22) for first year. There was roughly 20% turnover which equals ongoing administration costs of $60 per year. (Source: Monterey Bay Aquarium staff)

Trip & VMT Reductions (10 yrs)	
Trip Reductions	**88,460**
VMT Reductions	**159,230**

Trip Reduction Analysis
Data provided: Employees are required to ride the bike at least 3 times per week to work in order to receive the bike loaner.

Assumptions: That the investment in bike parking facilities, covers, lockers, etc., support biking in bad weather. Therefore, assume that employees who took a loaner, biked to work on average, 4 times per week. Assume 4.2% of bikers may have walked or taken transit to work before biking. (Source: 1991 Statewide Travel Survey, AMBAG Commuter Travel Mode Split.)

Employee bike work trips: (22)(4)(2)(50) = 8800
Vehicle trips replaced: 8,800 - .042*8,800 = 8,430 trips/year

Errand bike trips: (4)(2)(52) = 416
Total vehicle trips replaced: 8,430 + 416 = 8,846 trips/year

VMT Reduction Analysis
Assumptions: Average bike trip is 1.8 miles (Source: National Personal Travel Survey.)

VMT reduced = 8,846*1.8 = 15,923 miles/year.

Emissions Benefits (10 yrs)

ROG	1,235 lbs
NOx	691 lbs
PM10	680 lbs
CO	12,048 lbs

Cost-Effectiveness

ROG+NOx	$ 7/lb
ROG+NOx+PM10	5/lb
CO	1/lb

PROJECT COST-EFFECTIVENESS EVALUATION

1. **Category:** Bicycle Use and Infrastructure

2. **Name of Project:** Pacific Grove Bicycle Path

3. **Air District or Local Agency:** Monterey Bay Unified APCD

4. **Implementing Agency or Organization:** Public Works

5. **Project Description:**

   A bicycle trail was added to the scenic Ocean/Sunset Avenue drive along the Monterey Bay/Pacific Ocean near the Asilomar/Pebble Beach area to promote tourist viewing by walking and bicycling rather than by automobile. The path carries both commute bikers and tourists. (Project Date: 1992)

6. **Documentation of Cost-Effectiveness Analysis:**

   An analysis period is 20 years based on useful life of Class I Bike Trail.

Costs (20 yrs)(NPV)	
Total Cost of Project	**$ 297,108**
Vehicle Regis. Funding	**10,000**
Capital Costs	**225,000**
Operating Costs	**72,108**

Capital Costs
Construction, design, and overhead of the bike path.

Operating Costs
Maintenance costs are between $2,000 and $2,500 per mile per year ($2,300*3 miles = $6,900 per year) for street sweeping, striping, and pot hole repairs. (Source: Santa Cruz Co. Public Works)

Trip & VMT Reductions (20 yrs)	
Trip Reductions	**1,175,300**
VMT Reductions	**2,115,540**

Trip Reduction Analysis
Data provided: Bike trips are 161 round trips per day for 365 days based on actual count of bike traffic. (Source: Monterey Bay Unified APCD).

Assumptions: Half of bike trips replace auto trips. (There is limited information on the portion of bike trips that replace vehicle trips. Based on the known uses of the bike path, it is

likely that half or more of the bike trips do replace commute or tourist vehicle trips. Other bike trips are recreational.

Total trips reduced = (161)(2)(365)(0.5)
= 58,765 trips per year

VMT Reduction Analysis
Assumption: Average bike trip is 1.8 miles (Source: National Personal Transportation Survey, 1990.)

Total VMT reduced = (1.8)(58,765)
= 105,777 miles per year

Emissions Benefits (20 yrs)	
ROG	12,422 lbs
NOx	7,687 lbs
PM10	9,040 lbs
CO	122,451 lbs

Cost-Effectiveness	
ROG+NOx	$ 15/lb
ROG+NOx+PM10	10/lb
CO	2/lb

PUBLIC EDUCATION PROJECTS

Project Evaluation

1. **Category:** Public Education

2. **Name of Project:** The Partners for Clean Air Summer Smog Season Public Education Campaign

3. **Air district or local agency:** Sacramento Metropolitan AQMD

4. **Implementing agency or organization:** Sacramento Metropolitan AQMD

5. **Project description:**

The district conducted a comprehensive summer smog season public education campaign to create awareness of Sacramento's serious ozone problem. Major campaign elements included:
- broadcast and print advertising of Sacramento's air quality problems and solutions;
- creation of special promotions;
- printed materials distributed to specific business and general public target audiences;
- operation of a public education display booth at a variety of community events;
- creation of a working group to coordinate campaign themes and messages with transit, ridesharing and health-related agencies for maximum message efficiency.

Cost of project: $196,500 (1994 Smog Season)
Vehicle registration funds: $196,500

6. **Project evaluation:**

- Clear message / audience targeted / consistent with attainment plan? Yes. In a region where the ozone federal classification is Severe-15, the message was that Sacramento has an ozone pollution problem, cars are the major contributor, and drivers can help by reducing vehicle trips on smoggy days.

- Did the message get to the target audience? Yes. Used mixed media and repeated the message in an ongoing campaign.

- Target specific behavior change? Yes, the campaign urged drivers to reduce vehicle trips on smoggy days.

- Work with the community? Yes. Worked with community groups, local media, and businesses to leverage funds and increase campaign audience.

- Evaluation component? Yes. Residents were surveyed as to their awareness about air pollution problems, their awareness of the

specific messages of the public information campaign as well as their own driving behavior to reduce polluting trips.

- Message well-received? Yes. The surveys indicated that people heard the message and better understand the need for individual behavior change to help solve Sacramento's air pollution problem.

- Behavior change result? Surveys asked the question, "Considering all of the trips you make, including things like walking to the store and shopping with someone else when each of you could otherwise drive alone . . . In all, how many round trips per month do you use transportation other than your car when you could use your car if you wanted to?" The response to this question indicated a 9% increase in driver use of alternatives once or twice a week.

- Emissions reductions.

  - Can an assumption be reached that the project assisted in or caused actions or behavior changes that reduced emissions? Yes.

  - Are there quantifiable emissions reductions based on data obtained? No. It can be assumed the public education assisted in, but did not cause emissions reductions directly.

NOTE: This public education effort is going into its sixth year. It is part of an ongoing public education effort of the Sacramento County AQMD as well as a public education effort of the "Cleaner Air Partnership", a joint project of the American Lung Association of Sacramento-Emigrant Trails and the Sacramento Metropolitan Chamber of Commerce. The Cleaner Air Partnership's Public Education Plan on Air Quality and Transportation was first adopted in 1989 and recently updated in 1994. An annual public opinion and driver behavior survey is a key component of the joint Partnership - AQMD effort.

The following letter puts forth a methodology proposed by the Cleaner Air Partnership of Sacramento for assessing the cost-effectiveness of their Summer SMOG Season Campaign. The Air Resources Board will be considering methodologies to evaluate public education programs. Your comments on this approach or on the evaluation of public education programs in general, are appreciated.

May 8, 1995

Anne Geraghty
Manager Transportation Strategies Group
California Air Resources Board
2020 L Street
Sacramento, Ca. 95814

Re: Criteria for Use of Motor Vehicle Registration Fees

Dear Anne:

Thank you for the opportunity to comment on criteria for use of motor vehicle registration fees at your April 19 workshop. This letter adds an important quantitative assessment of some emissions reductions achieved by the Sacramento Metropolitan Air Quality Management District public education program last year. Please add this assessment to your record.

The SACOG Instructions to Applicants for Phase III ISTEA applications provide average auto emissions factors for various time periods to facilitate calculation of emissions benefits of proposed CMAQ projects. This letter uses the average emission factors for 1995-1999, thus understating the reductions achieved per trip for the 1989 to 1994 period because average emissions were higher per vehicle in the earlier period. However, this letter focuses only on 1994 emission reductions, and does not attempt to quantify emission reductions achieved during each year of the program. We would need your help in establishing emission factors for the period in order to do that.

The Cleaner Air Partnership's annual Air Quality and Transportation Public Opinion Survey has documented some long term trends in vehicle trip reduction. It has also documented driver participation in reducing vehicle trips during smoggy days. This database provides the basis for calculating emission benefits from the District's summer smog season campaign to reduce vehicle trips. (We will be sending you a copy of the final 1994 report.) For purposes of these calculations, we are assuming that the number of drivers in

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Sacramento County is about 600,000. The DMV reports 786,523 registered autos, trucks and motorcycles in this county.

1. Documenting emissions reductions associated with increased driver use of alternative modes as a result of the Summer Smog Season Campaign.

Since 1989, the Cleaner Air Partnership has monitored driver use of alternative modes of transportation by a number of measures. The single most useful measure is response to the question "Considering all of the trips you make, including things like walking to the store and shopping with someone else when each of you could otherwise drive alone . . . In all, how many round trips per month do you use transportation other than your car when you could use your car if you wanted to?"

Comparing responses to this question between 1989 and 1994 shows that the percentage of drivers who *never* use an alternate mode instead of driving has declined and the percentage who use an alternate mode *one to two times a week* has increased, while other categories have stayed about the same ("less than once a week" and "more than twice a week.") The increase in driver use of alternatives once or twice a week was remarkably uniform throughout the county, with an 11.5 percent increase in the City of Sacramento, an 8 percent increase in the rest of the County, and an overall increase of 9 percent.

The reduction in ozone precursors due to this program in 1994 can be estimated as follows.

1. Each of these drivers reduced an average of 1.5 round trips or 3 one-way trips per week in 1994 compared to 1989.

2. The emissions reduced from each one-way trip were an estimated 5.11 grams of ozone precursors.

3. The number of such drivers can be estimated as 9 percent of all drivers in the County, or approximately 9 percent of 600,000, or 56,000.

4. The total annual number of trips can be estimated as 156 (@ 3 trips per week) times 56,000 drivers, or 8,736,000.

5. The total emission reductions of ozone precursors can be estimated as 8,736,000 times 5.11 grams per trip, or 44,640,960 grams of pollutants. That equates to 49 tons per year.

6. The grams per day reduction during the smoggy season can be estimated at 122,304 grams per day (270 pounds per day).

2. Documenting emission reductions associated with driver participation in smoggy day trip reduction.

In the 1994 Cleaner Air Partnership Public Opinion Survey, 60 percent of all drivers said they were aware that people were being asked last summer to avoid driving whenever possible on smoggy days, and 40 percent specifically recalled a television commercial with the message that the Air Quality Management District "is asking you not to drive because the air quality is forecast to be unhealthy." Drivers were asked whether they reduced vehicle trips on smoggy days as requested by the Air District in the summer of 1994. Driver responses indicated that 23 percent of all drivers did reduce trips on those days. On average, drivers eliminated 1.8 round trips of vehicle use on each day forecasted to have unhealthy air quality. The district issued an alert on 10 days asking driver cooperation.

Smoggy day emission reductions in 1994 can be estimated as:

23 percent of all drivers, or approximately 138,000
times 3.6 one-way trips which is 496,800 trips
@ 5.11 grams per trip, which is 2,538,648 grams or
2.8 tons of ozone precursors per smoggy day.

Summary

These significant emission reductions are important for a number of reasons:

- they are not duplicative of any other program;

• they represent the changes in transportation habits by drivers that many believe are too difficult or costly to achieve;

• they hold substantial promise for future payoff from episodic and seasonal programs that offer incentives and program support to drivers to make targeted shifts in their transportation habits;

• once a driver uses an alternative to driving and develops a workable alternative, that driver is more likely to use the alternative in the future for personal as well as clean air reasons.

The Sacramento Metropolitan Air Quality Management District's public education program has been locally funded (with DMV and other funds), and strongly supported by the community, in a variety of ways. The Cleaner Air Partnership, a joint project of the American Lung Association of Sacramento-Emigrant Trails and the Sacramento Metropolitan Chamber of Commerce, developed the Public Education Plan upon which it is based, to emphasize both partnership with the community and the focus on those periods when meteorological conditions are adverse for ozone formation. The data indicate that our strategy is working.

Sincerely,

Judith Lamare, Ph.D.
Project Manager

Project Evaluation

1. **Category:** Public Education

2. **Name of Project:** Local Government Commission -- Workshop on land Use Designs to Reduce Vehicle Travel

3. **Air district or local agency:** South Coast (MSRC)

4. **Implementing agency or organization:** Local Government Commission

5. **Project description:**

The Local Government Commission developed and conducted seven one-day workshops for local government officials and the public in the South Coast Air Basin with the purpose of stimulating voluntary local government implementation of land use strategies to reduce vehicle travel. The workshops addressed the air quality benefits of pedestrian and transit oriented land use designs, described existing projects, and provided possible implementation strategies.

Cost of project:	$35,000	(October '93 - June '94)
Vehicle registration funds:	$30,000	

6. **Project evaluation:**

- Clear message / audience targeted / consistent with attainment plan? Yes. The message was that there are benefits associated with pedestrian and transit-oriented land use planning strategies. The audience was local government officials. The project is consistent with the district's attainment plan since each local jurisdiction in the South Coast region has the authority to delegate and substitute land use planning for indirect source measures in the current air quality management plan.

- Did the message reach the audience? Yes. 654 individuals attended the workshops, of which 81 were elected mayors, city council members or county supervisors. This was a significant turnout of elected officals given the competition for their time.

- Did the message target specific behavior change? Yes. The conferences focused on how to implement proposed strategies by presenting successful example projects in detail, visually as well as with supporting written material, and, in some cases, including implementing ordinances.

- Work with the community? Yes (limited to key players in land use policy).

- Evaluation component? Yes. Follow-up phone survey.

- Message well-received? Yes. Reaction to workshops was positive and commitment to promote pedestrian and transit-oriented land use planning was evident by both elected officials and staff (based on evaluation survey).

- Behavior change result? It's too early to tell. Land use policy changes occur over a long time frame.

- Emissions reductions.

  - Can an assumption be reached that the project assisted in or caused actions or behavior changes that reduced emissions? Too soon to tell--but the potential impact is significant if local jurisdictions implement pedestrian and transit-oriented land use design.
  - Are there quantifiable emissions reductions based on data obtained? No.

NOTE: The Local Government Commission has received AB 2766 funding for three follow-up projects: a land use planning conference, a livable communities assessment, and a five-community, long-term land use planning project.

Project Evaluation

1. **Category:** Public Education

2. **Name of Project:** C.A.R.E. Curriculum Project

3. **Air district or local agency:** South Coast MSRC

4. **Implementing agency or organization:** Southern California Environmental Education & Leadership Foundation

5. **Project description:**

The Conserve, Avoid, Reduce, Encourage (CARE) educational curriculum was developed to expose elementary students to the benefits and rewards of alternative transportation methods, and to encourage and promote family behavior change that will reduce air pollution emissions. The curriculum was developed during the 1993-94 school year and then piloted in a sixth grade elementary school class. Other components included curriculum revisions, program exposure and curriculum guide dissemination to other school districts.

The key component to the program was the air pollution reduction segment. It consisted of (1) having the students keep travel records of their family for a week, (2) learning about the causes of air pollution and alternative modes of travel that could be used to reduce air pollution, and (3) encouraging the students to use the alternate forms of transportation during another full test week that again included keeping travel records.

The thirty-student class averaged more than 50 grams of air pollution reduction per student during the test week (a 17.2% reduction).

Cost of project:	$92,430	('93-94 School Year)
Vehicle registration funding:	$56,380	

6. **Project Evaluation:**

- Clear message / audience targeted / consistent with attainment plan? Yes. The message consists of general air pollution education, awareness of alternative modes of travel and their potential for pollution reduction. The target audience is students and their families. The project is to reduce trips by reaching all drivers, not just employees, during peak hours.

- Did the message get to the target audience? Pilot study class: Yes. Students in region: No. This project was funded without a second phase which would distribute the curriculum to school districts and training instructors if the curriculum proved successful.

- Target specific behavior change? Yes. The project targeted behavior change, and monitored the change through the students' family travel logs.

- Work with the community? Only to a limited degree since the project was limited to curriculum development and pilot testing.

- Evaluation component? Yes. Travel logs monitored actual behavior change during the week of the program. The project also educated young people to be sensitive to the impacts of their travel behavior and to minimize their travel as much as possible.

- Message well-received? Yes. Feedback from teachers, parents and students was very positive. Parents were very cooperative in assisting the children with their project.

- Behavior change result? Yes. Students and parents used alternative forms of transportation during the test week.

- Emissions reductions.

  - Can an assumption be reached that the project assisted in or caused actions or behavior changes that reduced emissions? Yes.

  - Are there quantifiable emissions reductions based on data obtained? Yes. But only for a one-class pilot test. A class of 30 students reduced emissions by three pounds in one week (an average of 50 grams per student).

SMOKING VEHICLE ABATEMENT

Project Evaluation

1. **Category:** Smoking Vehicle Abatement

2. **Name of Project:** CUT-SMOG Program

3. **Air district or local agency:** South Coast AQMD

4. **Implementing agency or organization:** South Coast AQMD

5. **Project description:**

   The district advertises and administers a 1-800 complaint line for reporting smoking vehicles. Letters are sent to owners of the reported vehicles requesting that they be repaired. Postage-paid responses are included with each letter for reporting whether the vehicle has been repaired.

   Cost of project: $307,000 (1994)
   Vehicle registration funds: $307,000

6. **Project evaluation:**

   - Clear message / audience targeted / consistent with attainment plan? Yes. The message is clear: cars are a major cause of air pollution, smoking vehicles cause much more pollution than the average car, and we can all take part in reducing air pollution. There are two targeted audiences: the general public and owners of smoking vehicles.

   - Did the message get to the target audience? Yes. An ongoing mixed media campaign included radio and movie theater public service announcements, billboards, bumper stickers, brochures, and telephone book ads.

   - Target specific behavior change? Yes. Reporting and repairing smoking vehicles.

   - Evaluation component? Yes. Postage-paid response letters.

   - Message well-received? Yes.

   - Behavior change result? Yes. Thousands of people made complaint calls, and many smoking vehicle owners responded that they had repaired their vehicles.

   - Emissions reductions.

- Can an assumption be reached that the project assisted in or caused actions or behavior changes that reduced emissions? Yes.

- Are there quantifiable emissions reductions based on data obtained? The district does not attempt to quantify the reductions but has tracked the number of responses received and actions taken.

Complaints (1994)	131,000	$ 2.34 / complaint
Letters sent	71,762	4.27 / letter sent
Responses returned	21,114	
Indicated vehicle repaired	7,591	40.44 / indicated repair

Project Evaluation

1. **Category:** Smoking Vehicle Abatement

2. **Name of Project:** 1-800-EXHAUST

3. **Air district or local agency:** Bay Area AQMD

4. **Implementing agency or organization:** Bay Area AQMD

5. **Project description:**

The district advertises and administers a 1-800 complaint line for reporting smoking vehicles. Letters are sent to owners of the reported vehicles requesting that they be repaired. Postage-paid responses are included with each letter for reporting whether the vehicle has been repaired.

Cost of project:	$290,000	(1994)
Vehicle registration funds:	$290,000	

6. **Project Evaluation:**

- Clear message / audience targeted / consistent with attainment plan? Yes. The message is clear: cars are a major cause of air pollution, smoking vehicles cause much more pollution than the average car, and we can all take part in reducing air pollution. There are two targeted audiences: the general public and owners of smoking vehicles.

- Did the message get to the target audience? Yes. An ongoing mixed media campaign that includes radio, cable TV, newspaper, billboards, posters, and brochures. Letters go directly to smoking vehicle owners.

- Target specific behavior change? Yes. Reporting and repairing smoking vehicles.

- Evaluation component? Yes. Postage-paid response letters. (Minor weakness of response letter: district staff assumed that much of the repair work done was likely to be expensive [i.e. engine rebuilds or machine shop work on cylinder heads]. However, there were no boxes to check on the response letter for that type of repair. The vehicle owner had to indicate a major repair under "other.")

- Message well-received? Yes.

- Behavior change result? Yes. Thousands of people made complaint calls, and many smoking vehicle owners responded that they had repaired their vehicles.

- Emissions reductions.

  - Can an assumption be reached that the project assisted in or caused actions or behavior changes that reduced emissions? Yes.

  - Are there quantifiable emissions reductions based on data obtained? The district included a small quantifiable emissions reduction in their 1991 and 1994 air quality plans (0.08 tons/day ROG).

Complaints (1994)	64,032	$ 4.52 / complaint
Letters sent	38,946	7.45 / letter sent
Responses returned	12,152	
Indicated vehicle repaired	2,934	98.84 / indicated repair

Project Evaluation

1. **Category:** Smoking Vehicle Abatement

2. **Name of Project:** Smoking Vehicle Program (1-800-5599-AIR)

3. **Air district or local agency:** San Joaquin Valley Unified APCD

4. **Implementing agency or organization:** San Joaquin Valley Unified APCD

5. **Project description:**

   The district advertises and administers a 1-800 complaint line for reporting smoking vehicles. Letters are sent to owners of the reported vehicles requesting that they be repaired. Postage-paid responses are included with each letter for reporting whether the vehicle has been repaired.

   Cost of project: $70,000 (1994)
   Vehicle registration funds: $70,000

6. **Project Evaluation:**

   - Clear message / audience targeted / consistent with attainment plan? Yes. The message is clear: cars are a major cause of air pollution, smoking vehicles cause much more pollution than the average car, and we can all take part in reducing air pollution. There are two targeted audiences: the general public and owners of smoking vehicles.

   - Did the message get to the target audience? Yes. An ongoing mixed media campaign that includes radio and television spots, billboards, bumper stickers, and other printed advertising material.

   - Target specific behavior change? Yes. Reporting and repairing smoking vehicles.

   - Evaluation component? Yes. Postage-paid response letters.

   - Message well-received? Yes.

   - Behavior change result? Yes. Thousands of people made complaint calls, and many smoking vehicle owners responded that they had repaired their vehicles.

   - Emissions reductions.

     - Can an assumption be reached that the project assisted in or caused actions or behavior changes that reduced emissions? Yes.

- Are there quantifiable emissions reductions based on data obtained? The district included a small quantifiable emissions reduction in their attainment plan (0.03 tons/day ROG and NOx). The basic assumptions were that smoking vehicles are two times more polluting than the average vehicle and a repair reduces the emissions to average.

Complaints (1994)	8,476	$ 8.25 / complaint
Letters sent	4,541	15.42 / letter sent
Responses returned	1,256	
Indicated vehicle repaired	652	107.36 / indicated repair

APPENDIX A: EMISSION FACTORS

Emission Factors 1992 - 2020

Average Light Duty Fleet with Cold Starts

Methodology: Multiply miles traveled for each year by the VMT factor to get emissions in grams
Multiply number of trips by the trips factor (trip ends) for each year.
Add VMT emissions to trip end emissions.

	1992	1993	1994	1995
ROG				
VMT (g/mi)	0.92	0.86	0.81	0.76
trips (g/trip)	7.63	7.30	6.93	6.54
NOx				
vmt	1.00	0.94	0.88	0.83
trips	3.14	3.00	2.88	2.78
CO				
vmt	8.27	7.72	7.18	6.64
trips	70.54	67.58	63.40	58.74

	1996	1997	1998	1999	2000
ROG					
VMT (g/mi)	0.58	0.55	0.51	0.47	0.44
trips (g/trip)	5.7	5.39	5.04	4.65	4.23
NOx					
vmt	0.71	0.67	0.64	0.6	0.57
trips	2.28	2.23	2.17	2.09	2
CO					
vmt	4.56	4.19	3.86	3.56	3.29
trips	62.47	58.18	53.76	49.19	44.53

	2001	2002	2003	2004	2005
ROG					
VMT (g/mi)	0.41	0.37	0.34	0.31	0.28
trips (g/trip)	3.82	3.43	3.07	2.74	2.46
NOx					
vmt	0.53	0.5	0.47	0.44	0.41
trips	1.89	1.8	1.71	1.62	1.54
CO					
vmt	3.07	2.87	2.69	2.54	2.41
trips	40.05	35.96	32.24	28.94	26.08

Emission Factors - Continued

Average Light Duty Fleet with Cold Starts

	2006	2007	2008	2009	2010
ROG					
VMT (g/mi)	0.26	0.23	0.21	0.19	0.18
trips (g/trip)	2.21	1.99	1.79	1.63	1.50
NOx					
vmt	0.39	0.37	0.35	0.33	0.32
trips	1.47	1.4	1.34	1.29	1.25
CO					
vmt	2.31	2.21	2.13	2.07	2.01
trips	23.64	21.57	20.63	18.47	17.27

	2011	2012	2013	2014	2015
ROG					
VMT (g/mi)	0.17	0.16	0.16	0.15	0.14
trips (g/trip)	1.45	1.40	1.34	1.29	1.24
NOx					
vmt	0.31	0.31	0.30	0.30	0.29
trips	1.23	1.22	1.20	1.19	1.17
CO					
vmt	1.98	1.95	1.93	1.90	1.87
trips	16.77	16.27	15.76	15.26	14.76

	2016	2017	2018	2019	2020
ROG					
VMT (g/mi)	0.13	0.13	0.12	0.12	0.11
trips (g/trip)	1.19	1.13	1.08	1.02	0.97
NOx					
vmt	0.28	0.28	0.27	0.27	0.26
trips	1.15	1.13	1.12	1.10	1.08
CO					
vmt	1.84	1.81	1.79	1.76	1.73
trips	14.26	13.75	13.25	12.74	12.24

Source: EMFAC7F1.1/B7F. Includes annual average statewide emissions for light duty cars and trucks plus motorcycles.

VMT factor equals running exhaust plus running losses divided by daily VMT.

Trips factor equals (cold starts divided by cold trips) plus (hot soaks divided by daily trips).

Emission Factors 1992 - 2020

Average Van/Shuttle Fleet

Methodology: Multiply miles traveled for each year by the VMT factor to get emissions in grams.
Multiply number of trips by the trips factor (trip ends) for each year.
Add VMT emissions to trip end emissions.

	1992	1993	1994	1995
ROG				
VMT (g/mi)	1.06	0.98	0.9	0.83
trips (g/trip)	6.18	5.83	5.48	5.16
NOx				
vmt	1.37	1.3	1.25	1.2
trips	3.3	3.2	3.12	3.07
CO				
vmt	9.3	8.56	7.88	7.25
trips	57.63	55.16	52.25	49.1

	1996	1997	1998	1999	2000
ROG					
VMT (g/mi)	0.61	0.57	0.53	0.49	0.46
trips (g/trip)	4.58	4.34	4.1	3.83	3.53
NOx					
vmt	1.03	0.99	0.97	0.95	0.92
trips	2.57	2.59	2.6	2.59	2.56
CO					
vmt	4.78	4.39	4.09	3.83	3.58
trips	51.77	49.02	46.5	44.03	41.5

	2001	2002	2003	2004	2005
ROG					
VMT (g/mi)	0.43	0.4	0.37	0.34	0.31
trips (g/trip)	3.23	2.94	2.66	2.42	2.19
NOx					
vmt	0.9	0.88	0.86	0.84	0.81
trips	2.52	2.47	2.41	2.35	2.29
CO					
vmt	3.38	3.19	3.03	2.89	2.78
trips	38.93	36.48	34.06	31.89	30.02

Emission Factors - Continued

Average Van/Shuttle Fleet

	2006	2007	2008	2009	2010
ROG					
VMT (g/mi)	0.29	0.26	0.24	0.22	0.2
trips (g/trip)	2	1.82	1.67	1.55	1.44
NOx					
vmt	0.79	0.76	0.74	0.72	0.71
trips	2.22	2.16	2.11	2.07	2.03
CO					
vmt	2.7	2.63	2.59	2.56	2.54
trips	12.72	27.15	26.14	25.38	24.75

	2011	2012	2013	2014	2015
ROG					
VMT (g/mi)	0.19	0.18	0.18	0.17	0.16
trips (g/trip)	1.41	1.38	1.34	1.31	1.28
NOx					
vmt	0.70	0.70	0.69	0.69	0.68
trips	2.02	2.00	1.99	1.97	1.96
CO					
vmt	2.52	2.51	2.49	2.48	2.46
trips	24.51	24.27	24.04	23.80	23.56

	2016	2017	2018	2019	2020
ROG					
VMT (g/mi)	0.15	0.14	0.14	0.13	0.12
trips (g/trip)	1.25	1.21	1.18	1.14	1.11
NOx					
vmt	0.67	0.67	0.66	0.66	0.65
trips	1.95	1.93	1.92	1.90	1.89
CO					
vmt	2.44	2.42	2.41	2.39	2.37
trips	23.32	23.09	22.85	22.62	22.38

Source: EMFAC7F1.1/B7F. Includes annual average statewide emissions for light and medium duty trucks.
VMT factor equals running exhaust plus running losses divided by daily VMT.
Trips factor equals (cold and hot starts plus hot soaks) divided by daily trips.

Emission Factors for Fine Particulates

Fine particulates (PM10) are defined as particulate matter (PM) less than 10 microns in size. These smaller particles are particularly harmful to health. This report uses the following emission factors for fine particulates:

Light and Medium Duty Vehicles	**1.94 grams/mile**
CNG & Diesel Buses	**2.22 grams/mile**

These factors include emissions from motor vehicle exhaust, tire wear, and entrained road dust.

Light & Medium Duty Vehicles Factor

Based on statewide average annual fleet, particulate emissions (PM) for tire wear are roughly .19 grams/mile of which 40% is fine particulates or .076 grams/mile. Exhaust emissions are roughly .017 grams/mile of which more than 99% are PM10 or .0166 grams/mile. The combined PM10 factor for tire wear and exhaust is roughly .09 grams/mile.

Entrained road dust is an important part of PM10 emissions from motor vehicle travel. This report uses 4.01 grams/mile as a "conservative" factor for urban area PM emissions. The factor is based on a distribution of travel on freeways, major streets, collector streets, and local streets. Of this, 46% is PM10 or roughly 1.85 grams/mile.

The total PM10 factor used in this report for light and medium duty vehicle travel is 1.94 grams/mile. (.09 + 1.85). *(Note: Recently, ARB staff developed an updated urban PM10 factor for entrained road dust that is somewhat more representative of urban areas throughout the state. This factor is 2.29 grams/mile. The total PM10 factor is 2.38 grams/mile. (2.29 + .09).)*

Buses Factor

There is no distinquishable difference between compressed natural gas (CNG) and diesel buses with respect to PM10 emissions. Exhaust emissions for PM are roughly .4 grams/mile of which 96% is PM10 or .37 grams/mile. For this report, the entrained road dust PM10 factor was assumed to be the same for buses as for light and medium duty vehicles or 1.85 grams/mile. The total PM10 factor is 2.22 grams/mile. *(Note: Using the revised information from the previous note, ARB's updated PM10 factor for buses is 2.66 grams/mile. (.37 + 2.29).)*

Sources: EMFAC7F1.1/Burden 7F; Certifications Tests; and Methods for Assessing Area Source Emissions in California (Air Resources Board, 1991).

Bus Emission Factors

Source: Emission Reduction Calculation Methodologies for Congestion Mitigation and Air Quality Improvement (CMAQ) Program Projects, California Department of Transportation and California Air Resources Board, October 1994.

VMT Factors in grams/mile

Pollutant	Year	Diesel Fuel	Alternate Fuel (Methanol, CNG,LNG)
HC	1973-83	4.5	
	1984+	3.4	
CO	1973-83	18.0	
	1984+	19.0	
NOx	Pre-1984	31.0	
	1984-90	16.5	
	1991-95	16.5	13.2
PM	Pre-1984	2.5	
	1984-90	2.5	
	1991-93	0.39	
	1994-95	0.27	

Source: EMFAC7F1.1, Certification Tests

APPENDIX B: NET PRESENT VALUE OF PROJECT COSTS

Net Present Value of Project Costs

The total project costs used in the cost-effectiveness ratios for each project evaluation are expressed as Net Present Value (NPV). Simply stated, NPV is the lifetime costs of buying and operating equipment expressed in current dollars. Total project costs include immediate capital outlay plus the NPV of future payments (negative values) and income (positive values). NPV is derived using both an inflation rate and a discount rate.

The first step is to inflate current estimates of future costs (or payments and income) using an infation rate. In this report the inflation rate is 3% per year. The formula used to inflate current estimates of future costs is:

$$\textbf{Future \$ Cost}_i = \textbf{Today's \$ Cost}_i * (1 + \textbf{Infation Rate})^i$$

Where:

Future $ Cost$_i$ = Costs in future year "i" in terms of future dollars.

Today's $ Cost$_i$ = Costs in future year "i" in terms of today's dollars.

For example, suppose the expected total costs of a project include an initial capital outly of $10,000 plus annual costs (in terms of current dollars) for the three years that follow: $3000, $4200, and $6800. Using a 3% inflation rate, then:

Costs in the current year = $10,000

Costs in the first future year = $3,000 X 1.03 = $3,090

Costs in the second future year = $4,200 X $(1.03)^2$ = $4,456

Costs in the third future year = $6,800 X $(1.03)^3$ = $7,431

The next step is to determine the NPV of the future costs using a discount rate. The formula for NPV is:

$$\textbf{NPV} = \sum_{i=1}^{n} \frac{\textbf{cost}_i}{(1 + \textbf{discount rate})^i}$$

Where:

i = some future year

n = the life of the project

In this report the discount rate is 10%. To finish the example, determine the NPV of the series $3090, $4456, $7431 and add the NPV of the series to the

initial investment of $10,000 which is already expressed in terms of current dollars. The EXCEL software program calculates NPV for a series of payments. The syntax in EXCEL is NPV (rate, cost 1, cost 2, . . .). NPV for the series in this example is determined by NPV (10%, 3090, 4456, 7431). The NPV for the series is $12,074. Thus:

Total project costs (NPV) = $10,000 + $12,074 = $22,074

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