Final Report

Texas Emission Reduction Plan Assessment in the Houston-Galveston-Brazoria Region

Prepared for

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EXECUTIVE SUMMARY

The Houston Galveston (HGA) ozone non-attainment area is classified as a severe ozone non-attainment area under the Federal Clean Air Act Amendment of 1990 (CAA), and therefore is required to attain the 1-hour ozone standard of 0.12 ppm by November 15, 2007. The HGA area, defined by Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties, has been working to develop a demonstration of attainment in accordance with the CAA. The CAA not only designated HGA as a severe ozone non-attainment area, but it also required the state of Texas to submit a State Implementation Plan (SIP) describing the actions to be taken to meet the 1-hour ozone standard by November 15, 2007.

On September 26, 2001, The Texas Commission on Environmental Quality (TCEQ) published a SIP revision that was applicable to the HGA. Provisions in that HGA revision were to require Texas to perform a mid-course review by May 1, 2004, and to include recalculations and a submittal of a revised motor vehicle emission budget (MVEB) using the latest planning assumptions and the MOBILE6 emission factor model for on-road vehicles. As part of that SIP revision, TCEQ called for emission reductions from two voluntary programs, the Texas Emissions Reduction Plan (TERP) and the Voluntary Mobile Emission Reduction Programs (VMEP).

The 77th Texas Legislature established the TERP in 2001, through enactment of Senate Bill (SB) 5. The TERP includes a number of voluntary financial incentive programs, as well as other assistance programs, to help improve the air quality in Texas. The primary purpose of the TERP program is to reduce NOx emissions through voluntary incentive programs, mainly from heavy-duty on and off-road vehicles and equipment in the HGA and the Dallas/Fort Worth (DFW) ozone nonattainment areas. The emission reductions from the TERP are intended to replace reductions that would have been achieved through two mandatory measures that SB5 directed the TCEQ to remove from the SIP for the DFW and HGA ozone nonattainment areas. The two mandatory measures that were removed from the SIP were the Construction Equipment Restriction and the Accelerated Purchased of Tier 2/3 Diesel Equipment, in which the NOx reduction expected from these measures totaled 18.9 tons per day (tpd) for the HGA area. In addition, the TERP incentives are also intended to achieve 14 to 20 tpd of NOx reduction, out of 56 tpd of remaining NOx reduction gap in the SIP for the HGA area. Thus, the TERP is intended to reduce NOx emissions by 32.9 to 38.9 tons per day in the HGA area. The funding for the TERP is estimated to be about $130 million each year until fiscal year 2008.

The VMEP is funded by the Federal Congestion Mitigation and Air Quality (CMAQ) program, and is administrated by the Houston-Galveston Area Council (H-GAC). One of the primary programs under the VMEP is the Clean Cities/Clean Vehicles Program, which provides funding to government and private entities to assist in their efforts to introduce low emission (clean) vehicles in their on-road fleets. Other VMEP programs that are applicable or relevant to the SIP include commute reduction, increased vanpools, and increased transit utilization. The major restrictions of this program are that it funds only emission reduction projects for on-road vehicles, and it will not fund emission reduction projects related to clean fuels. The VMEP was intended to reduce NOx emissions in the HGA by 23 tpd. The annual funding for the VMEP is estimated to be about $50 million each year.

In addition to the current SIP and the mid-course review, the transition from the 1-hour average to the 8-hour average ozone and to the $PM_{2.5}$ standard could affect administration of the SIP, as well as the goals for these emission reduction programs. Technologies designed for the TERP and VMEP should therefore not create potential problems later on (i.e., technologies that reduce NOx emissions but have the potential of increasing PM emissions).

Concerning the feasibility of achieving the NOx emission reductions in the HGA with available funding, projects and NOx reduction technologies, as well as the need for the mid-course review, Houston Advanced Research Center (HARC) retained ENVIRON International (ENVIRON) to carry out a project to quantify the types and numbers of actions that will be necessary to achieve the required levels of NOx reductions from the TERP in the HGA.

The objectives of the project were to review and revise the emission inventories for on-road and off-road mobile sources in the HGA nonattainment area for the mid-course review, to assess the TCEQ's TERP and H-GAC's VMEP, and to recommend actions that will be necessary to achieve the NOx reductions from the TERP. This Executive Summary presents some key discussions and conclusions of the project.

Emission Inventories - In order to achieve these objectives, ENVIRON first assessed the existing the emission inventories for on-road and off-road mobile sources in the HGA, and revised these emission inventories for the mid-course review, as well as for the TERP and H-GAC program assessment. The emission inventory development and results for on-road vehicles and off-road diesel equipment in the HGA are discussed in Section 2.

For on-road heavy-duty diesel vehicles (HDDVs), ENVIRON corrected the MOBILE6-based emission inventory data provided by TCEQ to account for the use of Texas Low Emission Diesel (TxLED) and for humidity and temperature effects. Table ES-1 shows the comparison of the revised NOx emission estimate for HDDVs in the HGA, and that reported in the 2001 SIP.

Table ES-1. Comparison of CY 2007 NOx emission estimates for heavy-duty diesel vehicles in the HGA.

Description	NOx Emissions (tpd)
9/2001 SIP	65.5
Revised (MOBILE6, TxLED and humidity/temp. corrections)	103

As shown in Table ES-1, the revised NOx emission estimate for on-road HDDVs increased from 66 tpd to 103 tpd or by about 57%, as compared to that reported in the 2001 SIP. The reason for the dramatic increase in the HDDV emission estimates from that reported in the 2001 SIP is threefold. The estimated total daily vehicle miles traveled (VMT) has increased from 129 to 147 million miles per day, and the percentage of VMT from HDDVs has been revised upward from 5.9% to 7.3%. The effect of these two factors has increased the estimated VMT of HDDVs from 7.6 to 10.7 million miles per day from earlier modeling. Lastly, TCEQ has used the revised MOBILE6 model instead of MOBILE5b in the 2001 SIP; for 2007, MOBILE6 now estimates higher NOx emissions rates at about 9.3 g/mile compared to 7.9 g/mile in MOBILE5 to account for the higher real-world NOx emissions. About 75% or 76 tpd of the on-road HDDV NOx emissions is contributed by the largest truck class (heavy HDDVs or Class 8 tractors/trucks), which is estimated to be more than 33,000 of them operating in the HGA.

For the off-road equipment, ENVIRON generated the CY 2007 emission estimates in the HGA using the NONROAD2002 model with guidance from the TCEQ on the input files and assumptions used in generating the emissions estimates. The emission estimates were then corrected for the temperature and humidity effects. The NOx emission estimates for the non-road diesel equipment are presented in Table ES-2.

Table ES-2. 2007 NOx emission estimates from off-road diesel equipment in the HGA[1].

Equipment Category	NOx Emissions Average Summer Day (tons per day)
Agricultural	2.3
Commercial	3.6
Commercial Marine (Harbor craft and push boats)	14.9
Construction and mining	32.8
Industrial	4.1
Lawn and garden	1.7
Locomotive	12.1
Logging	0.2
Oil Field	6.6
Railroad maintenance	0.1
Recreational marine	0.1
Recreational equipment	0.0
Total	**78.5**

[1] The non-road emission inventory presented in this report reflects the best estimates of the HGA's emissions available from TCEQ as of February 2004. TCEQ was still revising and reviewing these emissions estimates, while ENVIRON was drafting the report.

As shown in Table ES-2, the construction and mining equipment category contributes to more than 40% of the NOx emissions from the non-road diesel equipment in the HGA. Therefore, it is the single most important category for TERP emission projects. Among these diesel construction equipment types, rollers, surfacing equipment, bore/drill rigs, excavators, rubber tire loaders, tractors/loaders/backhoes and crawlers/tractors/dozers are the major construction equipment types in the HGA, with an estimated population to be about 19,000 units. These major construction equipment types contributes to more than 20 tpd of NOx emissions or about 70% of the total NOx emissions from the non-road construction equipment. Hence, these emission sources provide very viable options for reducing NOx emissions in the HGA due to their overall emission contribution and ample equipment availability.

Emission Control Strategies & Scenarios - ENVIRON reviewed the current and near-term emission reduction technologies for on-road HDDVs and for non-road diesel equipment. The potential emission reduction per vehicle/equipment, cost, cost effectiveness and availability of several verified and near-term unverified technologies for on-road HDDVs and off-road equipment were assessed and documented in Section 3. ENVIRON also developed potential emission reduction strategy scenarios for reducing NOx emissions from on-road H-HDDVs and several major non-road construction equipment types (Section 7) based on these control technologies.

A summary of the general findings in terms of emission reduction technologies, potential emission reduction per vehicle/equipment and cost effectiveness for diesel engines with different model year and equipment types is presented in Table ES-3. As shown in this table, potential

emission reduction and cost-effectiveness values vary substantially for different technologies. In general, it is more cost effective to apply emission reduction technologies to older, higher-emitting vehicles and equipment with higher usage.

Table ES-3. Summary of the cost-effectiveness and potential emission reduction values for some verified and near term, unverified emission reduction technologies.

Project and Equipment Type	Potential Emission Reduction per Unit (tpy)	Lifetime Cost Effectiveness[1] ($/ton of NOx reduced)	One-Year Cost Effectiveness[2] ($/ton of NOx reduced)
Emulsified Diesel Fuels			
On-road Vehicles	0.07 - 0.29	7,000 - 31,000	27,000 - 120,000
Off-road Equipment	0.05 - 0.40	11,000 - 31,000	40,000 - 120,000
Engine/Vehicle\Equipment Replacement			
On-road Vehicles	0.17 – 1.25	6,000 – 40,000	36,000 – 240,000
Off-road Equipment	0.05 – 1.65	6,000 – 42,000	38,000 – 260,000
Natural Gas/Dual Fuel Technologies			
On-road Vehicles	0.04 – 1.27	3,000 – 100,000	23,000 – 900,000
Off-road Equipment	NA	NA	NA
Injection Timing Retard with DPF/ODC Retrofit Systems			
On-road Vehicles	0.09 – 0.40	6,000 – 25,000	50,000 – 210,000
Off-road Equipment	0.03 – 0.78	9,000 – 50,000	73,000 – 430,000
Lean NOx Catalyst Retrofit Systems			
On-road Vehicles	0.11 – 0.48	6,000 – 22,000	41,000 – 190,000
Off-road Equipment	0.04 – 1.24	5,000 – 31,000	46,000 – 270,000
Exhaust Gas Recirculation (EGR) with DPF System Retrofits			
On-road Vehicles	0.11 – 0.48	6,000 – 24,000	48,000 – 210,000
Off-road Equipment	0.03 – 0.93	8,000 – 48,000	70,000 – 410,000
Selective Catalyst Reduction System Retrofits			
On-road Vehicles	0.27 – 1.21	3,000 – 12,000	23,000 – 100,000
Off-road Equipment	0.08 – 2.33	4,000 – 23,000	34,000 – 190,000

[1] TERP calculates an annualized (over the project life) cost divided by annual emission reduction

[2] One-year cost effectiveness is defined as total project cost divided by annual emission reduction. This figure is useful for determining the amount of money needed to fund a given emission reduction goal.

There are infinite possible NOx emission reduction strategy scenarios that can be implemented in the TERP to potentially achieve the TERP NOx emission reduction goals in HGA by 2007 within the expected TERP fund for the HGA, estimated to be approximately $320 million.

As presented in Section 7, a potential strategy scenario for on-road HDDVs focuses on the Class 8 HDDV type (the largest truck class) as it contributes most of the HDDV NOx emissions in the HGA. This strategy scenario shows that it would reduce about 9.3 tpd of NOx emissions totally approximately $184 million, involving about 8,600 Class 8 HDDVs or about 28% of the total available fleet using various control technologies. This potential strategy scenario is conservative in a sense that it assumes a 10% vehicle penetration rate for all technologies that meet the $13,000 cost-effectiveness limit, instead of focusing on those most cost-effective technologies such as the EGR+DPF and SCR systems, or if the penetration rate is higher than 10% for each of the technologies reviewed.

Also presented in Section 7, a potential strategy scenario for major emission sources from the non-road construction equipment with verified and near-term, unverified technologies. This potential strategy scenario shows that it would reduce about 6.4 tpd of NOx emissions for about $150 million, involving 5,800 units of equipment or about 30% of the total available units for

these equipment types. Similar to that for the on-road HDDV, this strategy scenario is conservative in a sense that it assumes 10 to 20% equipment penetration rate for all technologies that meet the $13,000 cost-effectiveness limit, instead of focusing on those most cost-effective technologies such as the EGR+DPF and SCR systems or on higher penetration rates.

Carl Moyer and SECAT Programs - To draw from experiences for other TERP-like programs, ENVIRON reviewed and documented the development, implementation and evolution California's Carl Moyer Program and the Sacramento Emergency Clean Air Transportation (SECAT) program. ENVIRON reviewed and reported the administration, emission reduction impacts, the key strategies used to reduce emissions, early mistakes and adjustments made throughout the development and implementation of these programs. Section 4 discusses these programs in detail.

Carl Moyer Program - The Carl Moyer Program was created by the California Assembly Bill 1571, which grants the California Air Resources Board (CARB) and California Energy Commission (CEC) with the authority to implement the voluntary, incentive-based program to reduce emissions from heavy-duty vehicles and off-road equipment. Similar to the TERP, the Carl Moyer Program provides funds on an incentive-basis for the incremental cost of cleaner HD vehicle and equipment, with emphasis of reducing NOx emissions, for both on-road and non-road road mobile sources.

The Carl Moyer Program is funded by California's fiscal budget, with matching funds from local air districts. The California Governor and the Legislature have appropriated a total of $140 million over the last five fiscal years, starting FY 1998/1999. Local air districts have provided more than $40 million in matching funds, mostly collected through vehicle registration fee.

While the Carl Moyer Program is mainly administrated by CARB, Air Quality Districts in California are responsible to outreach, solicit, approve, and issue Carl Moyer grants locally according to its guidelines, as well as monitor the implementation of these eligible projects.

The Carl Moyer Program is considered one of the most cost-effective emission reduction programs in the U.S. with an average cost-effectiveness of $5,000 per ton of NOx reduced. Table ES-4 summarizes the number of participating districts, funding available, estimated NOx reductions and cost-effectiveness values by fiscal year for the Carl Moyer Program. Table ES-5 shows the project types for the first three fiscal years. As shown in Table ES-5, agricultural irrigation pump projects provided the highest NOx reduction with a second most effectiveness value of about $2,400 per ton of NOx reduced. The second most NOx reduction for the Carl Moyer Program was from marine vessels.

Table ES-4. Program summary by fiscal year of the Carl Moyer Program.

Fiscal Year	Number of Participating Districts	Carl Moyer Funding ($ millions)	Matching Funds from Districts ($ millions)	NOx Reduction (tpd)	Cost Effectiveness Limit	Actual Average Cost-Effectiveness of All Projects Statewide
1998/99	16	24.5	12.25	4	$12,000.00	$3,000
1999/00	20	19	9.31	7	$12,000.00	Below $5,000
2000/01	21	45	12.00	14	$13,000.00	$4,000
2001/02	NA	16	~8	16	$13,600.00	NA
2002/03	NA	19.68	~9.8	NA	$13,600.00	NA

Table ES-5. Project summary for the first three fiscal years of the Carl Moyer Program.

Source Category/ Equipment Type	NOx (tpy)	Cost-Effectiveness ($/ton)	Number of Engines		Total Funds	
			Alt Fuel	Diesel	Alt Fuel	Diesel
On-Road						
Heavy-Duty Line Haul	41	$2,570	-	32	-	$788,661
Refuse Haulers	432	$6,563	511	62	$16,023,480	$735,077
Urban Transit Buses	413	$4,715	850	-	$11,323,140	-
School Buses	4	$10,039	20	-	$374,542	-
Other	116	$5,756	327	106	$5,025,363	$1,862,823
Off-Road						
Farm Equipment	36	$4,179	-	52	-	$535,492
Construction	54	$3,627	-	42	-	$1,066,286
Other	52	$3,587	18	42	$194,545	$375,603
Locomotives	22	$1,160	2	-	$820,000	-
Marine Vessels	698	$3,044	-	182	-	$14,162,390
Agricultural Irrigation Pumps	1767	$2,353	23	1878	$362,563	$20,414,223
Forklifts (electric)	163	$5,057	209	-	$2,083,527	-
TOTAL	**3798**		**1960**	**2396**	**$36,207,160**	**$39,940,555**

Some of the notable changes in the Carl Moyer program included the increase in the cost-effectiveness value from $12,000 to $13,600 per ton of NOx reduced to account for inflation, the inclusion of the PM emission reduction, funding for auxiliary power units (APUs), revised emission factors based on EMFAC2000 and OFFROAD emission models, and funding for incremental fuel cost on a case-by-case basis.

The funding for the Carl Moyer Program has been over-subscribed since its implementation in 1998 due to strong district response to their calls for project applications. Some of the key strategies for the success of the Carl Moyer Program include the following:

- Smooth initial implementation of the program;
- Quick response from CARB to accelerate the second year funding schedule to meet demand;
- Participation and assistance from the local level (air districts) to solicit, evaluate and implement projects;
- Inter-agency collaborations (e.g. CARB, CEC, California Department of Transportation, port authorities, California Department of Commerce etc.);
- Participation of the NGOs and local businesses (construction, agricultural, goods transportation industries etc.);
- Effective outreach programs via workshops and public meetings;
- Complement by the statewide Diesel Risk Reduction Program via mandatory regulations.

SECAT Program - The SECAT Program was created by California Assembly Bill 2511 to assist the Greater Sacramento Area to meet the 2005 SIP by reducing 3 tons per day of NOx from HD diesel vehicles by 2005. Similar to the Carl Moyer Program, the SECAT Program is an incentive based voluntary program. However, the SECAT Program is dedicated to reducing NOx emissions from on-road HD vehicles only.

The AB 2511 set aside $50 million of the California's 2000/2001 fiscal budget for the SECAT Program. In addition, local political leaders approved an additional $20 million from the CMAQ funds for the program. To date, the SECAT Program has funded $25 million on projects. The $45 million budget left in the program remains un-funded by California due to the California budget crisis, and the program is stalled at the moment due to this budget crisis.

Since its implementation in December 2000, the grant solicitations for the SECAT program have been successful and the program was over-subscribed. The program has allocated $25 million or 34% of its funds and met its 2005 goal of 3 tpd. The $25 million yielded a total of 154 contracts and resulted in a reduction of 0.54 tons per day of NOx in the Sacramento area with an average lifetime cost-effectiveness value of $18,200 per ton of NOx reduced. Funded projects included 176 repowered tractors, 107 Liquefied Natural Gas (LNG) garbage trucks, 131 Compressed Natural Gas (CNG) transit buses, and 13 propane utility trucks, as well as two LNG and three CNG fueling stations. The City of Sacramento also received funding for incremental fuel cost.

The major key control strategy for the SECAT program was the diesel power retrofit. Fifty nine percent (59%) of the NO_x reduction achieved by the SECAT program was from repowering trucks with remanufactured lower emissions diesel engines. Prior to the stalling of the funding, the SECAT program funded 140 projects to repower a total of 176 vehicles, with an average cost-effectiveness of $10,300 per lifetime ton NO_x reduced, and one-year cost-effectiveness of $44,600 per ton of NOx reduced.

The repower strategy was successful in the SECAT program because repowering older engines with newer engines is a common industry practice that provides significant benefits to the owners through reduction in maintenance and fuel costs. The success of the diesel repower strategy in the SECAT program was due largely to the active role of engine distributors/dealerships in performing outreach to equipment owners, as well as in facilitating the application process. The outreach effort from engine distributors/dealerships was effective in terms of identifying older vehicles that would provide most emission reduction when repowered. In addition, the simple application and approval process in the SECAT program made it easy for fleet owners to submit grant applications. The other major key strategies to the success of the SECAT program are as follows:

- Formation of the technical and policy review groups;
- Development of the objective funding criteria based on technical supporting documentation and application assessment software;
- Effective outreach program/materials, including workshops, conferences, exhibits, public announcements, new releases, direct mail post cards, dealer flyers, vehicle decals, posters, truck stop pamphlets, brochures, promotional collateral, own SECAT website with emission calculator, marketing video, new coverage, radio campaign etc.;
- Air District's responsibilities and assistance - project solicitation, evaluation, implementation and tracking;
- MPO (i.e. Sacramento Area Council of Government or SACOG)'s responsibility and assistance;
- Cooperation from the federal, state & local governments, NGOs and local businesses and industries;
- Driven by the risk of losing highway funds – cooperation from SACOG and local construction and related businesses;

- Complement the statewide Carl Moyer Program and the Diesel Risk Reduction Program;
- Focused voluntary measure, targeting only on-road HD diesel trucks; and
- Strong cooperation with local truck/engine distributors/dealerships.

VMEP and TERP – In order to assess the TERP and VMEP, ENVIRON reviewed the emission reductions achieved to date of the TERP and VMEP's Clean Cities/Vehicles Program based on implemented or approved projects and program progress reports. Sections 5 and 6 discuss these programs, as well as present the results of the assessment for the programs.

VMEP – The EPA adopted a policy to allow credit in the SIP for voluntary mobile source reduction programs (VMEPs) in 1997. Currently EPA regulations have set a 3% limit on the amount of emission reduction allowed for VMEPs in a SIP. TCEQ estimated in the 2000 SIP that 3% of the HGA area's projected NOx emissions was 23 tons per day. H-GAC has taken the initiative to develop and implement VMEPs in the HGA area with a best faith effort to achieve the 23 tpd NOx emissions reduction goal. After reviewing and implementing the SIP plan, many options were determined not to be feasible because either the funding was not available, participation rates insufficient or projects were to be funded by the TERP. The NOx emission reduction from the revised VMEP measures is now estimated to be 7 tpd, which is 16 tpd short of the original SIP goal of 23 tpd.

One of the HGAC's VMEPs is the Clean Cities/Clean Vehicles Program, which provides funding to government and private entities to assist in their efforts to use low emission (clean) vehicles in their fleets. The NOx emission reduction goal for the Clean Cities/Clean Vehicles Program originally was 5.06 tpd, and now revised to 3.0 tpd.

As of February 2004, H-GAC has approved 23 HD clean vehicle projects with an estimated NOx emission reduction of 537.8 tons per year or 1.5 tpd for a total of approximately $24.3 million of the CMAQ funding. Table ES-6 shows a summary of the approved projects by technology types, which includes natural gas and propane alternative fuel vehicles, EGR+DPF and SCR retrofits, MY 2004 diesel vehicle replacement, repowering with MY 2004 cleaner engines and/or engine reflash, and hybrid-electrical buses involving over 1,000 HD vehicles.

As shown in Table ES-6, EGR+DPF and SCR retrofits are the most cost-effective strategies based on the project lifetime cost-effectiveness values to reduce NOx emissions from HD vehicles among these approved projects. Based on an average 1-year cost-effectiveness value of approximately $45,000 per ton of NOx reduction, H-GAC would need additional CMAQ funding of approximately $25 million to achieve the 3.0 tpd revised goal for HD vehicles in the VMEP program.

Table ES-6. Summary of approved projects for HD vehicles in the H-GAC's Clean Vehicles Program (as of February 2004).

Technology Used	# of Vehicles	VMEP Emission Reduction (tpy)	TERP Emission Credit (tpy)	Total Emission Reduction (tpy)	Total Project Cost ($)	Eligible CMAQ Funds ($)	One-Year Cost-Effectiveness ($/tpy NOx)	Project Lifetime Emission Reduction (tons)	Project Lifetime Cost-Effectiveness ($/ton)
SCR	12	5.5	0.0	5.5	$474,000	$355,500	$64,542	55	$7,566
EGR+DPF	656	351.5	118.6	470.1	$18,400,003	$ 11,174,008	$31,786	3,515	$8,306
Propane	15	0.4		0.4	$65,050	$62,700	$148,578	5	$12,882
Hybrid-Electric	4	6.7		6.7	$1,748,225	$1,200,624	$178,134	81	$17,896
CNG	63	47.7	7.6	55.3	$3,209,681	$2,349,668	$49,232	564	$18,593
Vehicle Replacement	98	52.9		52.9	$2,171,775	$1,469,194	$27,794	298	$9,218
Engine Repowering	310	73.0		73.0	$10,672,669	$7,681,173	$105,259	576	$15,744
Total	1,158	537.8	126.2	663.9	$36,741,403	$ 24,292,868	$45,174	5,095	$12,887

TERP - The TERP, which is funded through revenue from fees and surcharges, was established to reduce emissions in the nonattainment and near nonattainment areas of Texas through voluntary incentive programs. The main program funded by the TERP with applicability for heavy-duty diesel engines for on-road and non-road applications is the Emissions Reduction Incentive Grants Program, which provides monetary grants to offset the incremental costs associated with reducing NOx emissions from high emitting internal combustion engines.

Since the establishment of the TERP, TCEQ has completed two grant application and selection processes for funding for FY 2002 and FY 2003. For FY 2004, TCEQ has also completed September 2003 and January 2004 grant solicitations. The January 2004 solicitation closed on March 12, 2004. Unlike the prior solicitations, TCEQ has conducted workshops in various counties, including two workshops in the HGA, to discuss the TERP as well as to explain application procedures, cost-effectiveness and emission reduction calculations. When ENVIRON was performing the data analyses and drafting the report starting in early February, TCEQ had only published the awards of the FY 2002 and FY 2003 grant applications, while it was still finalizing the award decision on the September 2003 solicitation and the January 2004 solicitation closed on March 12, 2004. Therefore, the data analysis and assessment results for the TERP discussed in the draft report were based on the FY2002 and FY 2003 data. Since then, TCEQ has published the awards of the September 2003 solicitation, as well as the application received for the January 2004 solicitation.

The TERP approved a total of 61 projects in the HGA for a total funding of approximately $18.0 million for FY 2002 to FY 2003. The funded projects were far less than the projected available $75 million TERP fund for the HGA, assuming a 50% split of the FY 2002 and FY 2003 expected fund of about $150 million (i.e. $20 million for FY 2002 and $130 million for FY 2003) between the HGA and DFW area.

As shown in Table ES-7, the estimated NOx reduction for these projects was about 1.2 tpd for a total cost to TERP $18 million, with an average amortized cost-effectiveness value of $ 7,500 per ton of NOx reduced. This 1.2 tpd is only slightly over 3% of the 32.9 to 38.9 tpd NOx reduction goal for the TERP in the HGA. Most of the emission reduction (about 50%) was from

projects related to on-road heavy-duty diesel vehicles, while about 25% each of the emission reduction was from the non-road equipment and fuel related projects.

Table ES-7. Summary of the TERP approved projects for FY 2002 and FY 2003.

Project type	Number of Projects	Number of Activities	Total Grant Amount	Estimated NOx Reduction (tpy)	Estimated NOx Reduction (tpd)	Estimated NOx reduction (total tons)	Projected Project C-E ($/ton)	First-Year C-E ($/ton)
Onroad	8	301	$13,285,509	217	0.6	1626	$8,173	$61,323
Nonroad	38	120	$2,818,341	55	0.2	330	$8,534	$50,971
Fuel	15	N/A	$1,937,522	149	0.4	440	$4,403	$12,995
Total	61	421	$18,041,372	421	1.2	2,396	$7,530	$42,849

The technologies used in most of the on-road projects were retrofitting of EGR+DPF and Dual-Fuel LNG systems. Most of the technologies used in the non-road projects were new purchases of non-road construction equipment. For the fuel projects, most of the projects were the use of emulsified diesel fuel, TxLED or ULSD fuels. Other lesser-used technologies for the approved TERP projects to date included the SCR retrofit system and marine engine repowering.

While there was no official announcement regarding award for the September 2003 TERP grant solicitation, TCEQ indicated that it has approved about $19 million projects while waiting for approval for another $35 million projects. These potential approved projects from the 1st round of the FY 2004 solicitation would total approximately $54 million or about 40% of the expected $130 million. This potential fund would translate to about 3.5 tpd of NOx reduction in the HGA. As for the 2nd round of the FY 2004 solicitation, the number of grant applications was expected to increase substantially due mostly to the available of the formal TERP guidance documents, as well as workshops conducted by TCEQ to explain the application procedures, cost-effectiveness and emission reduction calculations for the TERP.

Based on the $18 million to reduce 1.2 tpd of NOx based on the FY 2002/2003 data, it would require an additional $500 to $600 million to achieve the 32.9 to 38.9 tpd of NOx reduction in the HGA alone. Assuming that the TERP receives $130 million starting FY 2003 through FY2008, the total expected TERP fund would be about $800 million, including $20.5 million received for FY 2002. If 40% of this TERP fund ($320 million) were allocated to the HGA, the TERP would not be able to achieve the 32.9 to 38.9 tpd of NOx reduction. However, this $320 million would provide a projected NOx reduction of 20.5 tpd, which would be sufficient to fulfill the 18.9 tpd NOx reduction in the HGA expected from the two mandatory measures of Construction Equipment Restriction and the Accelerated Purchased of Tier 2/3 Diesel Equipment that were removed from the SIP. However, a quick review on the award and projects received data in the September 2003 and January 2004 solicitations indicates that the required funding to achieve the NOx reduction goal is substantially lower than the $500 to $600 million estimated based only on FY2002/2003 data.

The challenge is to increase the activities/project participation with more outreach programs, focusing on reducing emissions from major NOx sources such as the H-HDDVs on the on-road category, and the construction equipment on the non-road equipment category. In addition, many of the cost-effective approved projects involved the use of unverified technologies, such as the EGR+DPF and SCR retrofit systems. Therefore, it is essential that the TERP continue

funding these cost-effective projects while making sure that technology vendors for these systems are pursuing verification of their products with EPA or CARB.

List of Recommended Actions - Based on the review of the Carl Moyer and SECAT programs, and assessments of control strategies and the TERP and VMEP programs, the following actions are recommended to achieve the NOx emission reduction goals for the TERP and VMEP in the HGA.

1. **Change emission standards for on-road HD CI engines in TERP Guidelines**

   The TERP guidelines use incorrect emission standards for MY 1989 and earlier engines. The guidelines should use a NOx emission standard of 10.7 g/bhp-hr for model years 1989 and earlier HD engines, instead of 10.0 g/bhp-hr for MY 1987 and 6.0 g/bhr-hr for MY 1988-1989 engines; while adopted for the MY 1988 and later engines, the 6.0 g/bhp-hr NOx emission standard was postponed by EPA until MY 1990 engines. These changes provide additional 7% NOx reduction for 1987 and earlier baseline engines, and more than 40% more NOx reduction for 1988 to 1989 baseline engines, which are found in an estimated 1,500 HD diesel vehicles in the HGA. In addition, TERP should consider using MOBILE6-based emission factors, instead of certification level-based, to calculate the emission reduction and cost effectiveness because it would be consistent with the SIP emission inventory calculation.

2. **Provide funding to fuel projects through the year of 2007 in order to be eligible for the SIP emission reduction**

   In order to claim the SIP emission reduction in the year 2007, one of the criteria for the SIP emission reduction is "Permanent." If TERP funded, for instance clean fuels, projects with a project life of only 1 to 1.5 years prior to the year of 2006, the emission reductions from these projects would not be considered "Permanent" in the year of 2007 and therefore not creditable under the SIP. The TERP has funded some emulsified diesel fuel projects for only 1 to 1.5 years due to "funding restrictions."

3. **Focus on projects related to on-road Class 8 HDDVs**

   There are about 33,000 on-road Class 8 HDDVs in the HGA that contribute to about 76 tpd or 75% of the NOx emission inventory from HDDVs in the HGA. Since it can not fund non-road projects nor the cost of clean fuels because of the limitations on the use of CMAQ funds, the H-GAC Clean Cities/Clean Vehicles program under the VMEP should be focusing on funding projects related to emission reductions from Class 8 HDDVs. TERP can assist by funding clean fuels, such as alternative fuels (i.e. natural gas), TxLED or ULSD fuels, or provide matching funds for the Federal CMAQ dollars.

   The TERP should also actively pursue projects related to emission reduction from on-road Class 8 HDDVs as there are abundant of available vehicles. Using the TERP's cost-effectiveness limit of $13,000 per ton of NOx reduced, a potential strategy scenario shows that 9.3 tpd of NOx reduction could be achieved for a cost of about $184 million with a 10% penetration rate for different model years and various control strategies. Total number of vehicles involved in the potential strategy scenario would be about 8,600 or only about 28% of the total available fleet. The potential emission reduction would be higher if the TERP's

baseline emission levels (i.e. emission standards) for the 1989 and earlier CI engines have been corrected as discussed earlier.

4. Focus on projects related to non-road construction equipment

Construction equipment contributes to about 33 tpd or more than 40% of the NOx emission inventory from the non-road diesel equipment in the HGA. Major contributors include excavators, crawler tractors/dozers, rubber tire loaders, rollers, surfacing equipment, and bore/drill rigs, with an estimated population of about 16,000 units in the HGA, contributing nearly 20 tpd of NOx. The TERP should actively pursue projects related to emission reduction from these non-road sources, as there are abundant of available equipment.

Using the TERP's cost-effectiveness limit of $13,000 per ton of NOx reduced, a potential strategy scenario shows that 6.4 tpd of NOx reduction could be achieved for a cost of about $150 million with 10 to 20% penetration rates for different vehicle technologies (i.e. Tier 0, 1 or 2 baseline engines), horsepower ranges and equipment types with various control strategies. Total number of equipment involved in the potential strategy scenario would be about 1,760 or 52%, 2,970 units or 40%, and 1,010 units or 17% of the equipment with Tier 0, Tier 1 and Tier 2 baseline engines, respectively.

5. Increase the cost-effectiveness limit

The Carl Moyer program increased the $13,000 to $13,600 per ton of NOx reduced for FY 2002/2003 and later, to reflect inflation. Like the Carl Moyer Program, the TERP should increase the cost-effectiveness limit from $13,000 to $13,600 per ton of NOx reduced to reflect the increase in the cost of living. Increasing the cost-effectiveness limit would increase eligible projects.

6. Increase program staff members, especially at the local levels

At least 21 air districts in California are applying for funding from the Carl Moyer program with an average annual funding of $25 million for the past 5 years. Each district at least has one staff member involved in the Carl Moyer program, with some bigger districts (i.e. South Coast, Bay Area, Sacramento Management Air Districts etc.) having more than 2 or 3 staff members. In addition, CARB has several staff members administrating the Carl Moyer program.

In contrast, the TERP with an projected $130 million annual funding consists of one section manager, one program coordinator, one technical staff, four grant managers, and a administrator for a total of 8 staff members. The potential understaffed in the TERP could be one of the reasons the TERP was under-subscribed and requires longer time for project reviewing and approving. The TERP should consider adding more staff members or outside assistance in the program, especially on-site staff members or outside assistance at the *local levels* (at least in the HGA and DFW area) to interact with the local MPO, industry, NGO etc. Adding staff members would increase program outreach (e.g. via workshops, conferences etc.), outside accessibility, and speed up review of grant applications.

7. Funding Allocations

While there are no official percentages on the TERP funding allocation to the HGA and DFW area, as well as other areas, the TERP is intended to reduce NOx emissions by 32.9 to 38.9 tpd, and 16.2 tpd through voluntary incentive programs in the HGA and DFW area, respectively. Therefore, the funding allocation should be proportional to the emission reduction goals in these areas or about 70% for HGA and 30% for DFW area.

8. Work with engine distributors and other technology vendors and EPA/CARB to encourage and accelerate verification process

The H-GAC's Clean Vehicles program and the TERP have funded significant numbers of projects that use unverified technologies, namely EGR+DPF retrofit and SCR systems. While they are unverified yet, these retrofit technologies are essential for the success of the TERP due to the higher potential NOx emission reductions from the use of these technologies, as well as limited available NOx reduction technologies.

In addition to the Dual-Fuel NG retrofit system, there are only two NOx technologies have been verified by CARB or EPA, and they are PuriNOx emulsified diesel fuel and Cleaire's Flash & Match system. One EGR+DPF vendor (STT EMTEC) indicated that applications have been filed with the CARB and EPA. One SCR vendor (Extengine) indicated that an application has been filed with the CARB.

In addition to these technologies, the TERP should fund demonstration projects for other promising near term NOx reduction technologies through its New Technology Research and Development Program (NTRDP), and/or laboratories (e.g. SwRI, University of Houston etc.) so that it would further validate these technologies as well as generate additional or initial field data to start the EPA and/or CARB verification process.

9. Other recommended actions

The TERP program staff should:

- Work closely with government (federal/state/local) fleets to encourage participation
- Actively promote the TERP to and through local engine distributors
- Encourage cross inter-agency collaboration
- Encourage MPO & NGO collaboration
- Consider incentive-based government contracts with industry
- Develop and implement effective program, emission benefit, funding tracking software/programs
- Conduct effective program outreach to promote the TERP, including workshops, conferences, exhibits, public announcements, new releases, marketing materials (direct mail post cards, dealer flyer, vehicle decals, posters etc.), truck stop pamphlets, brochures, promotional collateral, TERP website, marketing video, and Radio campaign (Appendix E includes some examples of program outreach materials).