EXECUTIVE SUMMARY

These are the proposed guidelines for the establishment and implementation of an incentive program. The program is called the Carl Moyer Memorial Air Quality Standards Attainment Program (the Carl Moyer Program.) The purpose of the Carl Moyer Program is to reduce emissions by providing grants for the incremental cost of cleaner heavy-duty vehicles and equipment. The grants will be issued locally by air pollution control and air quality management districts that choose to administer a local program. Private companies or public agencies that operate heavy-duty engines in California may apply for grants.

The Carl Moyer Program is designed to substantially reduce emissions of oxides of nitrogen (NOx), a smog-forming pollutant. The program is also expected to reduce the fine particulate component of diesel exhaust, which contributes to particulate matter (PM) air pollution and is a toxic air contaminant.

There are two parts to these guidelines. Part I is an overview of the program, which was originally released December 30, 1998, and is re-published here. Part II contains the program requirements and project criteria. The program requirements describe what districts that administer a local program must do. The project criteria describe what types of projects qualify for funding.

The three major program requirements are: 1) the district must provide $1 in match funding for every $2 in Carl Moyer Program funding, 2) all projects approved for funding must follow these guidelines, and 3) all projects funded must be cost-effective (cost no more than $12,000 per ton of NOx reduced, based on Moyer program plus district matching funds).

These guidelines contain proposed project requirements for on-road vehicles, off-road equipment, marine vessels, locomotives, and stationary agricultural pumps. The guidelines also include a discussion of staff's strategy for the development of project requirements for forklifts and airport ground support equipment after the board hearing.

The projects must result in real, quantifiable emission reductions that are not required by any regulation or binding agreement. The project criteria call for projects that go beyond current requirements. The project criteria emphasize the use of certified technology where it is available, and the project criteria call for significant reductions in NOx – on the order of 30 percent.

Based on current district grant programs, likely projects under the Carl Moyer Program include: purchase of new CNG or LNG transit buses, purchase of new LNG line-haul trucks, purchase of electric equipment to replace equipment powered by internal combustion engines, repowering off-road equipment such as tractors, balers, and loaders with new diesel engines, and repowering tugboats with new diesel engines.

The Carl Moyer Program will result in real, cost-effective reductions in NOx and PM emissions that will help California meet its clean air commitments. Therefore, staff recommends that the Board approve these proposed guidelines for the Carl Moyer Program.

THE CARL MOYER PROGRAM GUIDELINES – PART II

PROGRAM REQUIREMENTS AND PROJECT CRITERIA

PART II

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CHAPTER I.

PROGRAM REQUIREMENTS

This chapter presents the requirements for districts that wish to administer the Carl Moyer Program locally and issue grants to project applicants. This chapter also lists milestones/due dates for districts implementing the program. The chapter concludes with staff's proposed allocation and disbursement of funding to the districts that apply for funding.

A. Introduction

The Carl Moyer Program will be implemented locally by air pollution control and air quality management districts that choose to participate. Districts must follow the program requirements in this chapter, and must fund projects that meet the criteria in subsequent chapters of these guidelines. The three major program requirements are: 1) the district must provide $1 in match funding for every $2 of Carl Moyer Program funding, 2) all projects approved for funding must follow the Carl Moyer Program Guidelines, and 3) all projects funded must meet the cost-effectiveness criterion.

With the exception of some funding designated for ARB administration, all Carl Moyer Program funds will be allocated to participating districts. Districts must apply for funding to administer the program locally. The application form is given in Appendix A.

B. Match Fund Requirements

State funding for this program is $25 million. Districts must provide $1 in match funding for every $2 of Carl Moyer Program funding. With the required district matching funds, the total program will be about $37 million. The district matching fund requirement is important because it provides a literal "buy-in" from the districts responsible for the selection, monitoring, and enforcement of the project. This requirement will help ensure that the most worthwhile projects are selected.

Many districts receive funds from a surcharge on motor vehicle registration fees (a.k.a. AB 2766, AB 434, and AB 4355 funds). Most districts will be using the funds from their motor vehicle fees as match funding for the Carl Moyer Program. In fact, several districts already have active programs to fund grants for lower-emission on-road and off-road motor vehicle projects with the motor vehicle fee money. The Carl Moyer Program funding will augment their programs.

There are some notable differences between district motor vehicle fee funding and the proposed Carl Moyer Program funding: motor vehicle fee funding can be used for refueling infrastructure – the Carl Moyer Program funding cannot. Motor vehicle fee funds cannot be used for marine, locomotive, stationary agricultural pump, or some off-road projects, while the Carl Moyer Program funds can. These differences made designing the proposed program more challenging. The program as proposed allows both sources of funding to be used despite the funding restrictions.

1. Infrastructure Funding

The staff is proposing that the Carl Moyer Program funds not be used for refueling infrastructure. Although the funds were allocated to the ARB with only broad directions for usage, the clear intent was that the funds be used for "hardware" and not infrastructure. However, some qualifying projects would not be practical unless funds were available for infrastructure. Therefore, staff proposes that district funding for infrastructure count toward the district's required match.

2. Match Funding On An Overall Program Basis

Motor vehicle fee funds must be used for projects that reduce emissions from motor vehicles. Table I-1, below, gives a partial list of motor vehicles and non-motor vehicles. Motor vehicle fee funds cannot be used for locomotives, marine vessels, or stationary agricultural pump engines.

Table I-1
Motor Vehicles vs. Non-Motor Vehicles

Motor Vehicles	Non-Motor Vehicles
Automobiles	Locomotives
Trucks	Aircraft
Buses	Lawn mowers (non-riding)
Vans	Leaf blowers
Road graders	Refrigeration units
Earth movers	Chain saws
Tractors	Auxiliary generators
Golf carts	Welding machines
Motorcycles	Pleasure craft
Self-propelled harvesters	Cranes
Forklifts	Marine vessels
Sweepers	Stationary agricultural engines
Motorized Bicycles	Bicycles

Carl Moyer Program funds, on the other hand, could be used for on-road vehicles, marine, locomotive, stationary agricultural pump, off-road, and other approved projects. Staff proposes to allow districts to meet their matching fund requirement on an overall program basis, rather than a project-by-project basis. This will allow districts to meet their matching fund requirement by funding motor vehicle projects, and allow districts to use Carl Moyer Program funds for other project categories. The result will be increased flexibility for districts to fund worthwhile clean air projects.

For example, suppose a district is allocated $300,000 in Carl Moyer Program funds. The district spends $150,000 of motor vehicle fee funds (and no Carl Moyer Program funds) for a qualified LNG truck project. The district has met their matching fund requirement, and can spend the $300,000 in Carl Moyer Program funds to repower tug boats (or any other qualifying projects).

3. Tracking Match Funds

If a district is only going to fund motor vehicle projects, the tracking is simple. For every project, the district would put up $1 in funding for every $2 of Carl Moyer Program funding (a project-by-project match). However, staff expects most districts will accept applications for projects in all categories included in the Carl Moyer Program. As shown in the example above, districts can fund non-motor vehicle projects even if the only matching funds they have available are motor vehicle fee funds. If that is the case, however, districts must meet the matching fund commitment before they fund a locomotive, marine vessel, or stationary agricultural pump project.

4. District In-kind Contributions

Districts can use up to 15 percent in-kind contributions (i.e., administrative costs) as matching funds.

5. Matching Funds From Other Sources

Staff proposes to allow port authorities to provide match funding for port projects. The original legislative language for the program (which was vetoed) would have allowed ports to administer programs at the ports for marine vessel projects. However, because the program must be implemented quickly, and because districts have experience implementing this type of program, staff is proposing that districts administer the program.

Staff believes it is important to have port authorities participate in the program. Port authorities could participate through projects involving their own equipment, or by soliciting port tenants to apply for project funding. To encourage port authority participation, staff is proposing that port authorities be allowed to put up match funding for port projects, in lieu of districts. Thus, funding provided by a port authority for a qualifying project, or for associated infrastructure, would count toward the district’s matching fund requirement.

Staff does not propose to let private companies provide match funding in lieu of the districts. Staff believes it is appropriate for districts to provide the required matching funds. The requirement that districts provide the matching funds will facilitate an equitable distribution of funds, in that it will prevent companies with "deep pockets" from tying up the majority of the funds. This requirement will also help ensure that districts carefully evaluate the projects they approve for funding.

C. Cost-Effectiveness

Carl Moyer Program funding plus district match funding can be used for the incremental cost of a project, up to $12,000 per ton of NOx reduced. Only Carl Moyer Program funding, funding under the district's budget authority, or funding provided by a port authority (to meet the matching fund commitment) is included in the cost-effectiveness calculation. Private funding is not included in the cost-effectiveness calculation. Thus, a project that costs more than $12,000 per ton of NOx reduced could be funded, but only if outside funding is used to "buy down" the incremental cost. Funding for infrastructure does not need to be included in the cost-effectiveness calculation. For more detail on what is included in the cost-effectiveness calculation, see the application form in Appendix A.

D. Project Selection

Districts may fund only those projects that comply with the Carl Moyer Program Guidelines, or those projects approved on a case-by-case basis by ARB's Executive Officer. Districts may select which of the qualifying projects to fund based on local priorities. To expedite program implementation, districts may elect to fund qualifying projects on a first come, first served basis. Districts may elect to fund a mix of vehicle, equipment, marine, and locomotive projects. When selecting among competing projects, districts are encouraged to give priority to projects that yield reductions in particulate matter (PM) emissions, as well as the required reductions in NOx emissions. Districts are also encouraged to give priority to the most cost-effective projects.

E. Projects Outside the Scope of the Carl Moyer Program

The Carl Moyer Program is not intended to fund engine research and development, certification testing, the incremental cost of fuels or fuel additives, operation and maintenance or other "life-cycle" costs, the cost of operational controls, or infrastructure.

F. Monitoring

Districts must monitor the projects they fund to ensure that the expected emission reductions occur. ARB expects that districts would include provisions in their contracts with project applicants requiring the repayment of funds in the event the applicant does not carry out the project as agreed.

G. Reporting

Districts will be required to submit an annual report on the projects funded under this program, so that ARB can track both the NOx and PM emission benefits of the program. In addition, ARB will track district progress in implementing the program.

By September 30, 1999, districts must submit a report on their implementation efforts. This implementation report will include 1) an overview of the application and allocation process; 2) draft project applications, mailout date(s), targeted types of recipients, the number of recipients of each type on the program mailing list (e.g., 23 trucking firms, 14 warehouse distribution centers, 27 farms; 3) names of staff responsible for program implementation; and 4) report on outreach activities (completed and planned).

Districts must report to the ARB by June 30, 2000, and again by July 31, 2001 on the Carl Moyer Program. The report must include: 1) a description of projects funded, 2) baseline and incremental project costs, 3) infrastructure funding for qualified vehicle or equipment projects, 4) total state funding obligated under contract, and 5) total district match funding obligated.

ARB has developed a program that is currently used by districts to report on motor vehicle registration fee projects. ARB will modify that program to include Carl Moyer Program projects as well.

H. Timetable with District Milestones

January 1999	Release of staff report with draft Carl Moyer Program Guidelines.
February 25, 1999	ARB hearing to consider approval of guidelines.
April 2, 1999	District/port authority applications to administer program due.
May 1999	ARB review of applications to administer program.
June 30, 1999	ARB award of grants.
September 30, 1999	District report on implementation efforts due.
June 30, 2000	District report on project status due. Districts must report funds that are obligated under contract. Funds that are not obligated may be reallocated to other districts.
June 15, 2001	Deadline for districts to have distributed program funds (purchase order issued).
July 31, 2001	Final district report on program due.

I. Funding Allocation

Table I-2, below, shows a tentative allocation of funds among nonattainment districts. This allocation is based on a 50/50 weighting of the district population and the benefits of SIP measure M4 in the district's attainment year. Several districts rely heavily on heavy-duty engine incentive funds to meet early attainment dates (as mentioned in Part I). The proposed allocation shown in Table I-2 also sets aside $1 million dollars of the funding for the remaining (attainment) districts.

Districts may request more than the funding shown. In fact, districts are encouraged to request the maximum funding for which they can commit the required match funds. ARB expects that the total funding requested will exceed the funding available, although it is possible that some districts may request less than their tentative allotment.

ARB will determine the final funding allocation among districts. All funds will be allocated. If any district requests less than their tentative allotment, the remaining funds will be allocated among the districts that requested more than their tentative allotment.

Table I-2
Funding Allocation

District	Tentative Funding Allocation
Antelope Valley	$300,000
Bay Area AQMD	$2,520,570
Mojave Desert AQMD	$843,220
Sacramento Metropolitan AQMD	$1,925,220
San Diego County APCD	$1,083,090
San Joaquin Valley Unified APCD	$4,397,230
Santa Barbara County APCD	$300,000
South Coast AQMD	$11,273,020
Ventura County APCD	$857,650
Other districts	$ 1,000,000 total
ARB 2% administration	$500,000
TOTAL	**$25,000,000**

J. Disbursement of Funds

ARB will determine the district grant award allocations in May 1999. ARB will issue checks to districts for the initial disbursements in June 1999. The initial disbursement will be 10 percent of the district's allocation, or $100,000 – whichever is greater.

The remaining funds will be disbursed on an as needed basis. When a district has contracts in place for the initial disbursement plus the required matching funds, the district may request a check from ARB for an additional 10 percent disbursement. ARB will disburse more than 10 percent of the allocation at a time if the district demonstrates the need based on additional contracts where project funding is imminent. Estimated turnaround time for issuance of checks is two to three weeks from the date ARB receives the request.

K. Reallocation of Funds

ARB encourages districts to implement the program quickly, and to have all the funds obligated via contract within one year. Districts must submit a report on project status by June 30, 2000. The report should list projects, state funds spent to date, additional funds obligated via contract, any contracts being negotiated, and remaining state funds that have not yet been obligated.

Any funds not obligated under contract after one year may be reallocated to other districts. Should ARB decide not to reallocate all remaining funds at that time, ARB reserves the right to require periodic progress reports, and to reallocate funding at any time after June 30, 2000, if funds are still not obligated under contract.

CHAPTER II.

ON-ROAD HEAVY-DUTY VEHICLES

This chapter presents the proposed project criteria for on-road heavy-duty vehicles under the Carl Moyer Program. It also contains a brief overview of the heavy-duty vehicle industry, NOx emission inventory, current emission standards, available control technology, potential projects eligible for funding, and emission reduction and cost-effectiveness calculation methodologies.

A. Introduction

Vehicles greater than 14,000 pounds gross vehicle weight rating (GVWR) are considered heavy-duty vehicles. Heavy-duty vehicles can be categorized as heavy heavy-duty (HHD) and medium heavy-duty (MHD) vehicles. Heavy heavy-duty vehicles are those greater than 33,000 pounds GVWR and are grouped under a “class 8” truck classification. Medium heavy-duty vehicles are those greater than 14,000 but less than or equal to 33,000 pounds GVWR and comprised of classes 4 through 7 trucks. The majority of all heavy-duty vehicles are powered by diesel engines.

The preference for diesel engines gives rise to an air quality challenge since emissions from diesel engines have not been able to be controlled to the same extent as gasoline vehicles, particularly light- and medium-duty vehicles. Furthermore, heavy-duty diesel vehicles involved in goods movement applications typically accrue higher annual mileage than other vehicles. Consequently, the share of emissions, particularly of NOx and PM, from heavy-duty diesel vehicles is disproportionately higher than their population would suggest. The Carl Moyer Program will provide financial incentives to assist in the purchase of cleaner heavy-duty vehicles, including urban buses, to achieve additional near-term emission reductions from these sources.

1. Emission Inventory

In California, on-road mobile sources account for about 50 percent of total NOx emissions. Even though heavy-duty diesel vehicles, including urban buses, account for less than two percent of all on-road vehicles, they emitted about 25 percent of the statewide NOx emissions and over 70 percent of the exhaust PM emissions from all on-road vehicles in 1998. Heavy-duty diesel vehicles emitted 424 tons per day (tpd) of NOx and 26 tpd of exhaust PM emissions statewide. In addition, vehicle miles traveled from heavy-duty vehicles are projected to increase by about 30 percent by 2010. Emissions from heavy-duty diesel vehicles have to be reduced further if air quality goals are to be achieved.

2. Emission Standards

Adopted emission standards have reduced NOx and PM emissions from heavy-duty vehicles substantially. Furthermore, NOx emissions from new heavy-duty vehicles will be cut in half starting in 2004 as a result of recently adopted regulations. Table II-1 lists the existing and future NOx and PM emission standards for heavy-duty engines.

Table II-1
Exhaust Emission Standards for Heavy-Duty Engines

Model Year	NOx and PM Emission Standards (g/bhp-hr)[a]			
	Heavy-Duty Vehicles		Urban Buses	
	NOx	PM	NOx	PM
1996 - 2003	--	--	4.0	0.05 [b]
1998 - 2003	4.0	0.10	--	--
2004 +	2.4 [c] or 2.5 [d]	0.10	2.4[c] or 2.5[d]	0.05[b]

[a] g/bhp-hr = grams per brake-horsepower-hour
[b] in-use standard of 0.07 g/bhp-hr
[c] NOx plus Non-Methane Hydrocarbons (NMHC)
[d] NOx plus NMHC with 0.5 g/bhp-hr NMHC cap

The Carl Moyer Program will provide incentives to obtain additional emission reductions immediately by encouraging the purchase and deployment of reduced-emission heavy-duty vehicles. Alternative fuel and advanced technology engines can provide significant emission reductions for on-road vehicles. There are several MHD and HHD reduced-emission engine technologies available in the California marketplace.

3. Control Technologies

This section discusses commercially-available reduced-emission engines for MHD and HHD vehicles. The engines discussed are considered suitable as new engine/vehicle purchase, or new engine purchases for vehicle repower opportunities. Also discussed briefly are emerging technologies that may be commercially available in two to three years. The information in this section is intended to provide information regarding reduced-emission engine technologies that can be purchased now, and technologies, which have potential to become commercially available in the near term. These technologies are most likely available for the Carl Moyer Program funding in the 1999 to 2000 timeframe. A program criterion for the Carl Moyer Program is that the engines be certified. Some engines discussed below have not been certified to the ARB's optional NOx emission credit standards. However, they are included in this discussion since they could potentially be certified to those standards during the time frame of the Carl Moyer Program.

a. Available Technologies

Diesel engines, due to their high efficiency and long life, dominate the MHD and HHD vehicle market. However, due to their lean-burn operation, they have had limitations in achieving significant NOx emission reductions. Currently, alternative fuel engines, especially compressed natural gas (CNG) and liquefied natural gas (LNG) engines have been able to achieve NOx emissions about half of a conventional diesel engine. In addition to CNG and LNG engines, dual-fuel engines are also available for heavy-duty truck applications. Alternative fuel engines, including LPG, are also available for medium heavy-duty truck application. Engine manufacturers have invested a considerable amount of resources in the research and development of reduced-emission diesel engines and progress is being made, especially with the integration of advanced electronics and greater use of exhaust gas recirculation. However, it is expected that within the time frame of the Carl Moyer Program, the only new vehicles that will be able to demonstrate the requisite emission reduction will be alternative fuel vehicles.

The variety of alternative fuel engines available, and the number sold, has increased significantly in the past five years. Currently, three different manufacturers offer nine different low-emission alternative fuel engines from 150 to 410 horsepower. The number and variety of engines continues to expand. Alternative fuel vehicles have made the most progress in the transit bus market. At this time, more than 20 percent of all bus sales in California are alternative fuel and several transit agencies have a policy of exclusively buying alternative fuel buses. These include Sacramento Metropolitan Regional Transit Authority, Los Angeles County Metropolitan Transportation Authority, and Sunline Transit. Current district incentive programs have been instrumental in maturing this market.

b. Emerging Technologies

Several low-emission technologies hold promise for the future, but are not yet commercially available. Some of these technologies include: aqueous fuel, ceramic coating, and high pressure direct injection natural gas. These technologies may be developed as engine retrofit or new engine technologies, but, at the present time, they are not certified for sale in California to reduced-emission levels. Some of these emerging/experimental technologies may not be able to be certified during the tenure of this program. These technologies would be ineligible to participate in the Carl Moyer Program since the ARB’s policy is to provide funding only for reduced-emission engines or technologies that have been certified. However, for very promising technologies that have sufficiently demonstrated their potential to reduce emissions, ARB could grant, on a case-by-case basis, an experimental permit for an engine with certain technology to operate in California. Experimental permits are typically granted for demonstrations involving one or two vehicles, and include very strict limitations. For example, the allowed time for operating a vehicle with an experimental-permitted engine is usually limited to one or two years, after which the engine has to be removed from service, unless an extension is requested and is justified. The ARB intends experimental permits to be a means to field test a technology in some limited situations and not to be a way to circumvent certification requirements.

Even though these emerging technologies may not be commercially available at the start of the Carl Moyer Program, an on-going incentive program would likely provide the impetus that could expedite the development of these technologies and encourage research and development into additional technologies. Promising longer-term technologies, such as fuel-cell or hybrid powerplants, could potentially qualify for partial funding under the program, if they comply with the program criteria and are certified for sale, or have been granted an experimental permit subject to the strict limitations discussed above. However, since these technologies are currently too expensive for a project to meet the cost-effectiveness criterion of $12,000 per ton of NOx emissions reduced, a cost buy-down would likely be needed.

B. Project Criteria

The proposed project criteria for on-road heavy-duty vehicles provide districts, fleet operators, and transit agencies with the minimum qualifications that must be met for a project to qualify for funding. The main criteria for selecting a project are the amount of emission reductions, cost-effectiveness, and ability for the project to be completed within the timeframe of the program. These criteria will also provide districts and program operators with calculations that must be used for determining emission reductions and cost effectiveness resulting from reduced-NOx on-road heavy-duty vehicle projects. Reduced-NOx on-road heavy-duty vehicle projects, which include new vehicle purchase, vehicle engine replacement (repower), and engine retrofit, will be considered and evaluated for incentive funding. In general, on-road heavy-duty vehicle projects qualifying for evaluation must meet the following criteria:

- Eligible projects must provide at least 30 percent NOx emission reduction (for new vehicle purchase or vehicle repower, projects) compared to baseline NOx emissions. For retrofit projects, the retrofit kit must be certified to reduce NOx emissions by at least 25 percent;

- NOx reductions obtained through this program must not be required by any existing regulations, memoranda of agreement/understanding, or other legally binding documents;

- Reduced-emission engines or retrofit kits must be certified for sale in California and must comply with durability and warranty requirements. Qualified engines could include new ARB-certified engines; ARB-certified aftermarket part engine/control devices; or engines with ARB-approved experimental permits;

- For urban transit buses and school buses --- new bus purchase must be for alternative fuel buses - repowering an existing bus with a new or rebuilt diesel engine is not eligible;

- Funded projects must operate for a minimum of 5 years and at least 75 percent of vehicle annual miles traveled must occur in California; and

- Projects must meet a cost-effectiveness criterion of $12,000 per ton of NOx reduced.

C. Potential Types of Projects

The primary focus of the Carl Moyer Program is to achieve emission reductions from heavy-duty vehicles operating in California as early and as cost-effectively as possible. The following project criteria are designed to ensure that the emission reductions expected through the deployment of low-emission engines or retrofit technologies under this program are real and quantifiable.

1. New Vehicles

New vehicle purchases of LNG and CNG trucks and buses are expected to be the most common type of project for on-road heavy-duty vehicles under this program. In order to be eligible to participate in this program, the new vehicle/engine has to be certified to one of the ARB's optional NOx emission credit standards, regardless of fuel type or engine design. The ARB NOx emissions credit standards start at 2.5 g/bhp-hr and decrease in 0.5 g/bhp-hr increments. Engines not certified to the ARB's NOx emission credit standards are not eligible to participate in the Carl Moyer Program even if the engines were certified at levels similar to, or could have been certified at, the credit levels. Table II-2 lists the current heavy-duty engines that have been certified to the ARB's optional NOx emission credit standards. Since new engines are certified throughout the year, districts are encouraged to contact ARB staff for the most current list of eligible engines.

Table II-2
Heavy-Duty Engines Certified to
ARB's Optional NOx Emission Credit Standards
(Emission Levels for NOx, PM, and NMHC are in g/bhp-hr)

MY	Manuf.	Service Type [a]	Fuel Type	Displ (ltr)	NOx	PM	NMHC	Cert. Std. NOx/PM	HP
1998	Cummins	MHD	L/CNG	5.9	1.8	0.02	0.1	2.5/0.10	150/195/230
1998	Cummins	MHD	LPG	5.9	2.3	0.01	0.8 [b]	2.5/0.10	195
1998	Cummins	UB	L/CNG	8.3	2.2	0.02	0.5	2.5/0.05	250/275
1998	Cummins	HHD	L/CNG	8.3	1.8	0.02	0.6	2.5/0.10	250/275
1998	Cummins	UB	L/CNG	10.0	1.4	0.02	0.03	2.0/0.05	280/300
1998	Cummins	HHD	L/CNG	10.0	1.6	0.02	0.1	2.0/0.10	280/300
1998	DDC	UB	CNG	8.5	2.2	0.01	0.6	2.5/0.05	275
1998	PSA[c]	HHD	Dual [d]	10.3	2.4	0.06	1.1	2.5/0.10	305/350
1998	PSA	HHD	Dual	12.0	2.4	0.10	0.5	2.5/0.10	370/410

[a] Service Type: MHD (Medium Heavy-Duty); HHD (Heavy Heavy-Duty); UB (Urban Bus)
[b] Total Hydrocarbons
[c] Power Systems Associates (using Caterpillar engines)
[d] Dual Fuel (CNG + Diesel; or LNG + Diesel)

As evident from Table II-2, only alternative fuel engines are currently certified to the ARB's optional NOx emission credit standard. The Carl Moyer Program is fuel neutral for all project categories, with the exception of urban transit and school buses. For urban transit and school buses, only new purchases of alternative fuel buses are eligible to be funded under the

Carl Moyer Program. This requirement is in keeping with the ARB policy (Resolution 98-49, adopted September 24, 1998) to support the immediate and continued effort to replace diesel school and urban transit buses with cleaner alternative fuel buses.

2. Repowers

Vehicle repower refers to replacing an older engine with a newer engine certified to lower emission standards. There may be limited opportunities to repower on-road vehicles with new engines. One area where this may be cost-effective to do is in replacing an old mechanical engine with a newer model year mechanical engine that is certified to a lower NOx emission standard. Mechanical engines are those engines having their injection timing mechanically controlled and are most common for pre-1991, and particularly for pre-1987, model year engines. Since certain mechanical engine families share similar engineering designs they could be replaced with another mechanical engine in some cases.

For the purpose of the Carl Moyer Program, eligible heavy-duty truck repowering projects are those that replace pre-1987 model year mechanical engines with emission-certified 1987 to 1990 model year mechanical engines. Additionally, projects that involve rebuilding pre-1987 mechanical engines to 1987-1990 mechanical engine configurations that are certified to a NOx emission standard of 6.0 g/bhp-hr would also be eligible. For urban and school buses, repowering projects are allowed for all model years but only for projects that replace the existing (diesel) engine in a bus with an alternative fuel engine. As discussed previously, this requirement is in keeping with the ARB policy to support the immediate and continued effort to replace diesel school and public transit buses with cleaner alternative fuel buses. The replacement alternative fuel engine must be certified for sale in California to a NOx emission standard that is at least 30 percent lower than the original engine NOx certification level for the engine being replaced.

3. Retrofits

Retrofit means making modifications to the engine and/or fuel system such that the retrofitted engine does not have the same specifications as the original engine. Retrofit projects are allowed for all engine model years. The most straightforward retrofit projects are those that could be done at the time of engine rebuild. This might entail upgrading certain engine and/or fuel system components to result in a lower emission configuration. For urban and school buses, only projects that convert the existing diesel engine in a bus to operate on alternative fuel would be eligible to participate in the program. To qualify for funding for these types of projects, the engine retrofit kit must be certified to reduce NOx emissions by at least 25 percent compared to the original engine certification level.

4. Sample Application

In order to qualify for incentive funds, districts will make applications available and solicit bids for reduced-emission projects from heavy-duty vehicle operators and transit agencies. A sample application form is included in Appendix B. The applicant must provide at least the following information, as listed in Table II-3.

Table II-3 Minimum Applicant Information	
1. Company Name	9. Estimated Annual Miles Traveled
2. Project Name	10. % Operated in California
3. District	11. Baseline NOx Emissions
4. Vehicle Type: local delivery, line haul carrier, urban bus, etc.	12. New Lower NOx Emissions
5. Vehicle GVWR	13. Before Capital Costs
6. Type of Engines	14. After Capital Costs
7. Type and Estimated Annual Amount of Fuel Used	15. Matching Funds
8. Project Life (min. 5 years)	16. Incentive Amount Requested

D. Emission Reduction and Cost-Effectiveness

1. Emission Reduction Calculation

In accessing compliance with cost-effectiveness criterion, the emission reduction benefit will be calculated for NOx emissions. The difference in the certified NOx emission levels between a conventional vehicle/engine and a reduced-emission vehicle/engine is multiplied by a conversion factor to convert emissions from g/bhp-hr to g/mile. The annual NOx emission reduction is then dependent on the estimated annual miles traveled. The conversion factors for converting from g/bhp-hr to g/mile are:

Heavy-duty line haul trucks: **2.6 bhp-hr/mile**
Urban buses: **4.3 bhp-hr/mile**

The above conversion factors were developed specifically for heavy-duty line haul trucks and urban buses based on their particular duty-cycles. The duty-cycles for other on-road heavy-duty vehicle applications can vary considerably and a different approach, based on fuel consumption, is used to determine emission rate. To determine an emission rate in terms of per-gallon of fuel used, an energy consumption factor is used to convert g/bhp-hr to g/gallon of fuel used. Heavy-duty diesel engines typically have a brake-specific energy consumption of 6,500 to 7,000 BTU per horsepower-hour on the certification cycle. With an energy density of about 18,000 BTU/lb for diesel fuel and a mass density of 7.0 lb/gallon, this converts to about 18.5 horsepower-hour per gallon of fuel consumed. This provides a direct conversion from annual fuel consumption to emissions even though there may be some variation because energy consumption is a function of the duty cycle. The conversion factor for heavy-duty vehicles, other than line haul trucks and urban buses, for converting from g/bhp-hr to g/gallon is:

Other heavy-duty vehicles: **18.5 bhp-hr/gallon of fuel used**

For new vehicle purchases, emission reductions are determined by subtracting the certified NOx emission level of the new heavy-duty vehicle meeting an optional NOx emission credit standard from the NOx emission level of a new vehicle meeting the current standard (baseline NOx emission level). Table II-4 lists the baseline NOx emission levels for new vehicle projects.

Table II-4
Baseline Emission Levels for New Heavy-Duty Vehicle Purchase Projects

Model Year	NOx Emission Standards (g/bhp-hr)	
	Class 8 Heavy-Duty Vehicles	Urban Buses and Other Heavy-duty Vehicles
1999 - 2002	6.0	4.0

As shown in Table II-4, the baseline NOx emission level for class-8 heavy-duty trucks is 6.0 g/bhp-hr. This NOx emission level is different from the current NOx emission standard of 4.0 g/bhp-hr for heavy-duty engines. The proposed baseline NOx emission level for class-8 heavy-duty truck engines is the NOx emission level for over-the-road operation of class 8 trucks according to the settlement agreement between the ARB and the diesel engine manufacturers regarding excess emissions from the use of alternative injection timing strategies. The baseline NOx emission rate of 6.0 g/bhp-hr is to be used for class-8 heavy-duty trucks only. Other heavy-duty vehicles, including urban buses, shall use a NOx emission baseline of 4.0 g/bhp-hr, as shown in Table II-4.

Emission reductions from an engine repower or retrofit project are determined by subtracting the certified NOx emission standard of the new engine, or of the retrofitted engine, from the certified NOx emission standard (baseline NOx emission level) of the engine being replaced. In situations where the model year of the vehicle chassis and the model year of the existing engine are different, the model year of the engine will be used to determine the baseline emission level for emission reduction calculations. Tables II-5 and II-6 list the baseline NOx emission levels for vehicle repower and engine retrofit projects, respectively. As discussed previously in section C.2., repower projects for heavy-duty trucks are allowed only for pre-1987 model year mechanical engines.

2. Cost-Effectiveness Calculation

For new heavy-duty vehicle purchase projects, only the incremental cost of purchasing a new vehicle that meets the optional NOx emission credit standard compared to a conventional vehicle that meets the existing NOx emission standard, will be funded through the Carl Moyer Program. For vehicle repower projects, the portion of the cost for a vehicle repower project to be funded through the Carl Moyer Program is the difference between the total cost of purchasing and installing the new, emission-certified engine and the total cost of rebuilding the existing engine. For engine retrofit projects, the full cost of the retrofit kit will be funded subject to the$12,000 per ton cost-effectiveness criterion. Costs which are not considered eligible for Carl Moyer funds include infrastructure and any differential fuel costs, maintenance costs, or other “life-cycle” costs.

Table II-5 Baseline NOx Emission Levels for Heavy-Duty Vehicle Repower Projects		
Vehicle Category	**Model Year**	**NOx Emission Levels (g/bhp-hr)**
Heavy-Duty Trucks	Pre-1987	10.0
Heavy-Duty Trucks	1987 – 1990	6.0
Urban/School Buses	Pre-1987	10.0
Urban/School Buses	1987 – 1990	6.0
Urban Buses	1991 – 1995	5.0
Urban Buses	1996 – 2002	4.0
School Buses [a]	1991 – 1997	5.0
School Buses [a]	1998 – 2002	4.0

[a] Class 8 School Buses use 6.0 g/bhp-hr for these model years.

Table II-6 Baseline NOx Emission Levels for Heavy-Duty Engine Retrofit Projects		
Vehicle Category	**Model Year**	**NOx Emission Levels (g/bhp-hr)**
Classes 4 - 8 Trucks	Pre-1987	10.0
Class-8 Heavy-Duty Trucks	1987 – 2002	6.0
Classes 4 – 7 Trucks	1987 - 1990	6.0
Classes 4 – 7 Trucks	1991 - 1997	5.0
Classes 4 – 7 Trucks	1998 - 2002	4.0
Urban/School Buses	Pre-1987	10.0
Urban/School Buses	1987 – 1990	6.0
Urban Buses	1991 – 1995	5.0
Urban Buses	1996 – 2002	4.0
School Buses [a]	1991 – 1997	5.0
School Buses [a]	1998 – 2002	4.0

[a] Class 8 School Buses use 6.0 g/bhp-hr for these model years.

Only the amount of money provided by the program and any local district matching fund is to be used in cost-effectiveness calculations. The one-time incentive grant amount is to be amortized over the expected project life (at least five years) and with a discount rate of five percent. The amortization formula (given below) yields a capital recovery factor, which, when multiplied by the initial capital cost, gives the annual cost of a project over its expected lifetime.

Capital Recovery Factor (CRF) = $[(1 + i)^n (i)] / [(1 + i)^n – 1]$

Where, i = discount rate (5 percent)
n = project life (at least five years)

The discount rate of five percent reflects the opportunity cost of public funds for the Carl Moyer Program. This is the level of earning that could be reasonably expected by investing state funds in various financial instruments, such as U.S. Treasury securities. Cost-effectiveness is determined by dividing the annualized cost by the annual NOx emission reductions. Example calculations for on-road vehicle projects are provided below.

3. Examples

For the purposes of explaining the emission reduction and the cost effectiveness calculations from a heavy-duty engine project, two examples are presented below.

Example 1 – Heavy-Duty Truck Purchase: A fleet operator proposes to purchase a new LNG heavy-duty truck instead of a new diesel truck. The costs of an LNG truck and a diesel truck are $110,000 and $80,000, respectively. The new truck will operate 100 percent of the time in California, for a project life of 10 years. The emission reduction and cost effectiveness for this project are calculated as follows:

<u>Emission Reduction Calculation</u>

Annual NOx Reductions (tons/year) =
[(Baseline NOx Emissions) - (Reduced NOx Emissions)] * (Conversion Factor) * (Annual Miles) * (% Operated in CA) * (ton / 907,200 grams)

Where,

Baseline NOx Emissions	= NOx emission rate from a new diesel engine (class 8 truck): 6.0 g/bhp-hr
Reduced NOx Emissions	= Certified NOx emission level from a new LNG engine: 2.0 g/bhp-hr
Conversion Factor	= 2.6 bhp-hr/mile
Annual Miles Traveled	= 70,000 miles
% Operated in CA	= 1.0 (i.e., 100%)
(ton/907,200 g)	Converts grams to tons

Hence, estimated annual NOx reductions are:

[((6.0 – 2.0) g/bhp-hr) * (2.6 bhp-hr/mile) * (70,000 miles/year) * (1)] * (ton / 907,200 g) = **0.80 tons/year**

<u>Cost and Cost-Effectiveness Calculations</u>

The annualized cost is based on the portion of incremental project costs funded by the Carl Moyer Program, any matching funds that were used to fund the project, the expected life of the project (10 years for heavy-duty trucks), and the interest rate (5 percent) used to amortize the project cost over the project life. The incremental capital cost to the fleet operator for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

Incremental Capital Cost	= \$110,000 - \$80,000 = \$ 30,000	
Maximum Amount Funded	= \$ 30,000	
Capital Recovery	**=** $[(1 + 0.05)^{10} (0.05)]/[(1 + 0.05)^{10} – 1] = 0.13$	
Annualized Cost	= (0.130)(\$ 30,000)	= \$ 3,900/year
Cost-Effectiveness	= (\$3,900/year)/(0.80 tons/year)	**= \$4,875/ton**

The cost effectiveness for the example is less than $12,000.00 per ton of NOx reduced. This project would qualify for the maximum amount of grant funds requested.

Example 2 – Urban Bus Purchase: A transit agency proposes to purchase a new CNG bus instead of a new diesel bus. The costs of a CNG bus and a diesel bus are $350,000 and $310,000, respectively. The new bus will operate 100 percent of the time in California.

Emission Reduction Calculation

Annual NOx Reductions (tons/year) =
[(Baseline NOx Emissions) - (Reduced NOx Emissions)] * (Conversion Factor) * (Annual Miles) * (% Operated in CA) * (ton / 907,200 grams)

Where,

Baseline NOx Emissions	= Certified NOx emission level from a new diesel engine: 4.0 g/bhp-hr
Reduced NOx Emissions	= Certified NOx emission level from a new CNG engine: 2.0 g/bhp-hr
Conversion Factor	= 4.3 bhp-hr/mile
Annual Miles Traveled	= 50,000 miles
% Operated in CA	= 1.0 (i.e., 100%)
(ton/907,200 g)	Converts grams to tons

Hence, estimated annual NOx reductions are:

[((4.0 – 2.0) g/bhp-hr) * (4.3 bhp-hr/mile) * (50,000 miles/year) * (1.0)] * (ton / 907,200 g) = **0.47 tons/year**

Cost and Cost-Effectiveness Calculations

The annualized cost is based on the portion of incremental project costs funded by the Carl Moyer Program, any matching funds that were used to fund the project, the expected life of the project (12 years for urban bus), and the interest rate (5 percent) used to amortize the project cost over the project life. For urban bus purchases, the Federal Transit Administration (FTA) pays approximately 80% of the cost of a new transit bus. The incremental capital cost to the transit agency for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

FTA Grant for purchase of new diesel bus	= (0.8)($310,000) = $248,000
Transit agency's cost for new diesel bus	= $310,000 - $248,000 = $62,000
FTA Grant for purchase of new CNG bus	= (0.8)($350,000) = $280,000
Transit agency's cost for new CNG bus	= $350,000 - $280,000 = $70,000
Incremental Capital Cost	= $70,000 - $62,000 = $8,000
Max. Amount Funded	= $8,000
Capital Recovery Factor	$= [(1 + 0.05)^{12} (0.05)]/[(1 + 0.05)^{12} - 1] = 0.113$
Annualized Cost	= (0.113)($8,000) = $904/year
Cost-Effectiveness	= ($904/year)/(0.47 tons/year) **= $1,923/ton**

The cost effectiveness for the example is less than $12,000.00 per ton of NOx reduced. This project would qualify for the maximum amount of grant funds requested.

E. Reporting and Monitoring

During the project life, a district has the authority to conduct periodic checks or solicit operating records from the applicant that has received Carl Moyer funds for new heavy-duty vehicle purchase, vehicle repowering, or engine retrofit projects. This is to ensure that the vehicle or engine is operated as stated in the program application. Fleet operators and transit agencies participating in the Carl Moyer Program are required to keep appropriate records during the life of the funded project. Records must contain, at a minimum, total miles traveled and California miles traveled, amount of fuel used, and maintenance and repair information. Records must be retained and updated throughout the project life and made available at the request of the district.

CHAPTER III.

OFF-ROAD EQUIPMENT

This chapter presents the proposed project criteria for off-road equipment projects under the Carl Moyer Program. It also contains a brief overview of the current emission standards, available control technology, potential incentive projects eligible for funding, and emission reduction calculation and cost-effectiveness calculation methodologies.

A. Introduction

Off-road engines are used in a wide array of applications, including, but not limited to, the following applications: agricultural tractors, backhoes, excavators, trenchers, motor graders, portable generators, excavators, compressors, and miscellaneous applications. Off-road equipment can be further split into two broad categories: less than 175 horsepower and equal to or greater than 175 horsepower. The ARB is preempted from regulating new farm and construction equipment less than 175 horsepower; the United States Environmental Protection Agency (U.S. EPA) has sole authority to control equipment in this category. ARB has the authority to regulate off-road equipment equal to or greater than 175 horsepower and non-preempted off-road equipment less than 175 horsepower.

Off-road equipment eligible for funding under the Carl Moyer Program includes equipment 50 horsepower or greater. Excluded from this discussion are engines that propel or are used on aircraft, locomotives, and marine vessels. Engines used in locomotive and marine vessel applications are discussed in Chapters IV and V, respectively, and aircraft engines are excluded from the Carl Moyer Program. Also excluded from this discussion are engines used in fork lifts and airport ground support equipment. These two off-road categories will be discussed separately in Chapter VII. This program does not apply to off-road engines that are regulated by the Mining Safety and Health Administration.

1. Emission Standards

Emissions from off-road equipment were uncontrolled prior to 1996. Estimates of NOx emission levels from uncontrolled off-road engines range from 8.3 g/bhp-hr to 18 g/bhp-hr. In January 1992, ARB adopted exhaust emission standards for off-road diesel cycle engines 175 horsepower and greater to be effective starting with the 1996 model year engines. Table III-1 lists ARB's existing and future NOx and PM emission standards for off-road diesel cycle engines.

Table III-1
ARB Exhaust Emission Standards for
Heavy-Duty Off-Road Engines

Rated Power (horsepower)	NOx and PM Emission Standards (g/bhp-hr) 1996		2000		2001	
	NOx	PM	NOx	PM	NOx	PM
175 ≤ hp ≤ 750	6.9	0.4	--	--	5.8	0.16
> 750 hp	--	--	6.9	0.4	--	--

The U.S. EPA has adopted virtually identical NOx emission standards for off-road diesel cycle engines at or above 50 horsepower. The U.S. EPA rule aligns with California's first tier regulations for engines 175 horsepower and greater and took effect in 1996. The U.S. EPA rule also took effect in 1997 for off-road diesel cycle engines at or above 100 horsepower but less than 175 horsepower and in 1998 for off-road diesel cycle engines at or above 50 horsepower but less than 100 horsepower. The combination of ARB and U.S. EPA emission standards means that all of today's new off-road diesel cycle engines 50 to 750 horsepower have to be certified to meet a NOx emission standard of 6.9 g/bhp-hr. Table III-2 lists U.S. EPA's existing and future NOx and PM emission standards for off-road diesel cycle engines.

Table III-2
U.S. EPA Exhaust Emission Standards for
Off-Road Diesel Engines

Rated Power (horsepower)	NOx and PM Emission Standards (g/bhp-hr) 1996		1997		1998		2000	
	NOx	PM	NOx	PM	NOx	PM	NOx	PM
50 ≤ hp < 100	--	--	--	--	6.9	--	--	--
100 ≤ hp < 175	--	--	6.9	--	--	--	--	--
175 ≤ hp < 750	6.9	0.4	--	--	--	--	--	--
≥ 750 hp	--	--	--	--	--	--	6.9	0.4

U.S. EPA, ARB, and off-road diesel engine manufacturers have signed a Statement of Principles (SOP) that sets forth comprehensive future emission standards for compression ignition (diesel) off-road engines. The SOP provides for new NOx, PM, and carbon monoxide (CO) emission standards for engines with different horsepower ratings to be effective in a tiered approach. The SOP's Tier 1 NOx emission levels for off-road diesel engines 50 horsepower and greater are the same as the ARB's NOx emission standards for off-road diesel cycle engines 175 horsepower or greater, as discussed previously. Starting with model year 2001 engines, the SOP provides for a combined NOx and non-methane hydrocarbon (NMHC) emission levels for off-road engines in this category ranging from 4.8 g/bhp-hr to 5.6 g/bhp-hr (NOx + NMHC). The Tier 2 NOx + NMHC emission levels for off-road diesel engines 50 horsepower and greater will be reduced further with the incorporation of the Tier 3 emission levels, ranging from 3.0 g/bhp-hr to 3.5 g/bhp-hr NOx + NMHC, starting in 2006. U.S. EPA has adopted regulations for off-road diesel equipment consistent with the emission levels contained in the SOP. The ARB intends to revise California's regulations for off-road equipment to harmonize with federal regulations.

The Carl Moyer Program is intended to provide additional emission reductions immediately by encouraging the purchase of eligible new off-road equipment, or emission-certified off-road engines to replace eligible uncontrolled engines. This program will also apply to projects that repower emission-certified equipment with engines certified to an optional NOx emission credit standard that is at least 30 percent lower than the existing NOx emission standard. Grants from the Carl Moyer Program can be used for the purchase of eligible retrofit kits that reduce NOx emissions from uncontrolled engines to the 6.9 g/bhp-hr NOx emission standard, or lower. Carl Moyer Program grants can also be used for the purchase of retrofit kits that reduce NOx emissions by at least 25 percent from eligible emission-certified engines.

2. Control Technologies

The purpose of this section is to discuss reduced-emission engines for off-road equipment that are commercially available. The engines discussed are considered suitable as new equipment purchase, or new engine purchases for repower opportunities. Emerging technologies that may be commercially available in two to three years are also discussed. There is no discussion of technologies considered to be in the experimental or pre-prototype category. This section is intended to provide information regarding reduced-emission engine technologies that can be purchased now, and technologies, which have potential to become commercially available in the very near term. These technologies, it is expected, are the most likely to be available for the Carl Moyer Program in the 1999 to 2000 timeframe.

a. Available Technologies

Emission-Certified Engines. Currently, off-road diesel cycle engines 50 horsepower to 750 horsepower have to comply with a NOx emission standard of 6.9 g/bhp-hr. Starting in model year 2000, off-road diesel cycle engines greater than 750 horsepower must also comply with a 6.9 g/bhp-hr NOx emission standard. The NOx emission standard for off-road diesel cycle engines 175 to 750 horsepower sold in California will be reduced to 5.8 g/bhp-hr for the model year 2001 engines. As discussed previously, these standards do not apply to engines used in aircraft, locomotive, or marine vessel applications.

A viable and cost-effective way to reduce emissions from pre-controlled equipment is to replace the engine in that equipment (i.e., repower) with an emission-certified engine instead of rebuilding the existing engine to its original uncontrolled specifications. Although this is commonly a diesel-to-diesel repower, significant NOx and PM benefits may be achievable due to the high emission levels of the uncontrolled engine being replaced. With the exception of off-road engines greater than 750 horsepower, emission-certified engines are commercially available for off-road engines 50 horsepower and greater that are covered under this program. Off-road equipment comes in a vast array of sizes, weights, and power requirements. Therefore, a particular engine may be suitable for one application but not another. Another option, which may be possible for some situations, is to replace an off-road engine with a new or rebuilt on-road engine certified to a NOx emission standard of 6.0 g/bhp-hr or lower. It may be possible, in some cases, to replace an older uncontrolled diesel engine with a newer emission-certified alternative fuel engine. Even though diesel-to-alternative fuel repower projects for off-road equipment are eligible for funding under the Carl Moyer Program, they are not expected to be as common as diesel-to-diesel repower projects.

Off-Road Engine Retrofit Technology. Retrofit technology options for off-road diesel engines to reduce NOx emissions from uncontrolled levels to the existing 6.9 g/bhp-hr NOx emission standard, or lower, are limited. Any retrofit technology must be certified for sale in California, must be able to reduce NOx emissions by at least 25 percent, and must comply with established durability and warranty requirements. It is possible that retrofit technologies that have been used to reduce NOx and PM emissions from on-road heavy-duty diesel engines could be used to control off-road engine emissions in some applications.

b. Emerging Technologies

Several reduced-emission technologies hold promise for the future, but are not yet commercially available. These technologies are being developed for on-road heavy-duty diesel engines, but they can be used in off-road diesel engine applications as well. Some of these technologies include: aqueous fuel, ceramic coating, and high pressure direct injection natural gas. These technologies may be developed as engine retrofit or new engine technologies, but at the present time, they are not certified for sale in California. Some of these emerging and/or experimental technologies may not be able to be certified during the tenure of this program. These technologies would be ineligible to participate in the Carl Moyer Program since the ARB's policy is to provide funding only for reduced-emission engines or technologies that have been certified. However, for very promising technologies that have sufficiently demonstrated their potential to reduce emissions, ARB could grant, on a case-by-case basis, an experimental permit for an engine with certain technology to operate in California. Experimental permits are allowed for only one or two engine demonstrations and are granted with very strict limitations. For example, the allowed time for operating equipment with an experimental-permitted engine is usually limited to one or two years, after which the engine has to be removed from service, unless an extension is requested and is justified. The ARB intends experimental permits to be a means to field test a technology in some limited situations and not to be a way to circumvent certification requirements.

B. Project Criteria

The proposed project criteria have been designed to provide districts and equipment operators with a list of minimum qualifications that must be met in order for an off-road equipment project to qualify for funding. The main criteria for selecting a project are: the amount of emission reductions, cost-effectiveness, and ability for the project to be completed within the timeframe of the program. The criteria also establish a method for calculating emission reductions and cost-effectiveness for reduced-NOx off-road equipment projects. Reduced-NOx off-road equipment projects that include equipment repowers or engine retrofits will be considered and evaluated for incentive funding. In general, off-road equipment projects qualifying for evaluation must meet the following criteria:

- For new equipment purchase, the new engine must be certified to an ARB optional NOx emission credit standard for off-road diesel equipment that is at least 30 percent lower than the existing NOx emission standard.

- For equipment repower projects: (i) the new engine must be certified to the NOx emission standard of 6.9 g/bhp-hr, or lower, if it is replacing an eligible uncontrolled engine, or (ii) the new engine must be certified to an optional NOx emission credit standard that is at least 30 percent lower than the existing NOx emission standard if it is replacing an eligible emission-certified engine;

- For engine retrofit projects: (i) the retrofit kit must be certified to reduce NOx emissions to 6.9 g/bhp-hr, or lower, if it is used to retrofit an eligible uncontrolled engine, or (ii) the retrofit kit must be certified to reduce NOx emissions by at least 25 percent if it is used to retrofit eligible emission-certified engines;

- Reduced-emission engines or retrofit kits must be certified for sale in California and must comply with durability and warranty requirements. Qualified engines could include new ARB-certified engines; ARB-certified aftermarket part engine/control devices; or engines with ARB-approved experimental permits;

- NOx reductions obtained through this program must not be required by any existing regulations, memoranda of understanding/agreement, or other legally binding documents;

- Funded projects must operate for a minimum of 5 years and at least 75 percent of equipment hours of operation must occur in California; and

- Projects must meet a cost-effectiveness criterion of $12,000 per ton of NOx reduced. For repower projects involving the replacement of an existing diesel engine with an eligible reduced-emission diesel engine, the project must also comply with the maximum cost allowed per repowering project for each horsepower category.

C. Potential Types of Projects

The primary focus of the Carl Moyer Program is to achieve emission reductions from off-road diesel engines and equipment operating in California as early and as cost-effectively as possible. The following project criteria are designed to ensure that the emission reductions expected through the deployment of reduced-emission engines or retrofit technologies under this program are real and quantifiable. A project must meet a cost-effectiveness criterion of $12,000 per ton of NOx reduced, and/or subject to a maximum dollar amount to be granted based on the horsepower ratings of the engine. The project must be operated for at least five years from the time it is first put into operation and at least 75 percent of the hours of operation must occur in California.

1. Purchase of New Emission-Certified Engines

New off-road engines 50 horsepower or greater are required to be certified to a NOx emission standard of 6.9 g/bhp-hr. In addition to the 6.9 g/bhp-hr NOx emission standard, the ARB has adopted optional NOx emission credit standards for off-road equipment that start at 5.0 g/bhp-hr and decrease in 0.5 g/bhp-hr increments. Starting in 2001, the NOx emission credit standards for off-road diesel equipment will start at 4.5 g/bhp-hr and also decrease in 0.5 g/bhp-hr increments. The Carl Moyer Program fund will be available for the incremental cost of buying new off-road equipment certified to an optional NOx emission credit standard compared to the cost of buying a new off-road equipment certified to the current NOx emission standard. Even though off-road engines certified to an optional NOx emission credit standard are not available now, they may become available during the life of the Carl Moyer Program. In some cases, it may be possible to specify that the new off-road equipment be equipped with a new on-road engine certified to an optional NOx emission credit standard instead of a new off-road equipment engine.

2. Repower with Emission-Certified Engines

Purchases of new emission-certified engines to replace uncontrolled engines in existing equipment are expected to be the most common type of project for off-road diesel equipment under this program. Eligible off-road equipment repower projects refers to replacing an older uncontrolled engine with a newer engine certified to either a current NOx emission standard of 6.9 g/bhp-hr or to an optional NOx emission credit standard for off-road diesel equipment.

Eligible off-road equipment repower projects also refers to replacing an emission-certified existing engine with a new engine that is certified to an optional NOx emission credit standard that is at least 30 percent lower than the NOx standard of the engine being replaced. Another option, which may be possible for some situations, is to repower off-road diesel equipment with a new or rebuilt on-road engine certified to NOx emission standard of 6.0 g/bhp-hr or lower. In addition, ARB could grant, on a case-by-case basis, an experimental permit for a particular engine with certain technology to operate in California.

Off-road equipment repower projects that replace an existing diesel engine with an eligible reduced-emission diesel engine (either off-road or on-road) are subject to a maximum grant amount awarded, based on the horsepower category of the engine. Table III-3 lists the maximum grant amount allowed for each horsepower category. Technology for diesel-to-diesel repowers is readily available and relatively inexpensive compared to alternative fuel technologies. In addition, with newer diesel engines, an equipment operator can expect more reliable operation and improved fuel economy compared to older diesel engines and less risks compared to alternative fuel engines. Because of these reasons, staff believes that the incentive amounts listed in Table III-3 are adequate to allow diesel-to-diesel repower participation in the Carl Moyer Program. Repowering projects that replace an existing diesel engine with a reduced-emission alternative fuel engine are not subject to the maximum cost limits as listed in Table III-3. However, diesel-to-alternative fuel repowering projects would still be subject to the cost-effectiveness criterion of $12,000 per ton of NOx emissions reduced, as well as other criteria presented in this guideline.

Table III-3 Maximum Grant Award for Diesel-to-Diesel Off-Road Equipment Repowering Projects	
Horsepower Category	**Maximum Incentive ($/repower)**
50 – 99	4,000
100 – 174	10,000
175 – 299	14,000
300 – 499	20,000
500+	25,000

3. Retrofits

Retrofit means making modifications to the engine and/or fuel system such that the retrofitted engine does not have the same specifications as the original engine. Retrofit projects may be applicable to certain off-road diesel engine families. The most straightforward retrofit projects are those that could be accomplished at the time of engine rebuild. This might entail upgrading certain engine and/or fuel system components to result in a lower emission configuration. It is possible that retrofit technologies that have been used to reduce NOx and PM emissions from on-road heavy-duty diesel engines could be used to control off-road engine emissions in some applications. To qualify for funding, the engine retrofit kit must be certified to reduce NOx emissions to 6.9 g/bhp-hr, or lower, if it is used to retrofit an eligible uncontrolled engine. The Carl Moyer Program grants will also apply to retrofit kits that reduce NOx emissions from emission-certified engines by at least 25 percent.

4. Sample Application

In order to qualify for incentive funds, districts will make applications available and solicit bids for reduced-emission projects from off-road diesel equipment operators. A sample application form is included in Appendix C. The applicant must provide at least the following information, as listed in Table III-4 below:

Table III-4 Minimum Applicant Information	
1. Company Name	9. Estimated Annual Hours of Operation
2. Project Name	10. % Operated in California
3. District	11. Baseline NOx Emissions
4. Equipment Type: agriculture harvester, bulldozer, grader, backhoe, etc.	12. New Reduced-NOx Emissions
5. Engine Horsepower	13. Cost of Baseline Engine
6. Type of Engines	14. Cost of Reduced-NOx Engine
7. Project Life (min. 5 years)	15. Matching Funds
8. Type and Estimated Annual Amount of Fuel Used	16. Incentive Amount Requested

D. Emission Reduction and Cost-Effectiveness

1. Emission Reduction Calculation

The emission reduction benefit will be calculated for NOx emissions only and can be determined using either: (a) the annual fuel consumption or (b) the annual hours of operation. If annual fuel consumption is used, the difference in the baseline NOx emission levels between the old engine and the certified NOx emission level from the new replacement engine is multiplied by an energy consumption factor to convert emissions from g/bhp-hr to g/gallon of fuel used. Annual NOx emission reductions are then determined by the estimated annual fuel consumption. To determine an emission rate in terms of fuel used, an energy consumption factor is used to convert g/bhp-hr to g/gallon of fuel used. Heavy-duty diesel engines typically have a brake-specific energy consumption of 6,500 to 7,000 BTU per horsepower-hour on the certification cycle. With an energy density of about 18,000 BTU/lb for diesel fuel and a mass density of 7.0 lb/gallon, this converts to about 18.5 horsepower-hour per gallon of fuel consumed. This provides a direct conversion from annual fuel consumption to emissions even though there may be some variation because energy consumption is a function of the duty cycle.

If hours of operation are used, annual NOx emission reductions are determined by multiplying the difference in the NOx emission levels by the rated horsepower of the engine, the load factor, and the hours the engine is expected to operate per year. The load factor is an indication of the amount of work done, on average, by an engine in a particular application, given as a fraction of the rated horsepower of that engine. The load factor is different for each application. If the actual load factor is known for an engine application, it should be used in calculating emission reductions. If the actual load factor is not known, the default values provided in Table III-5 should be used in emission reduction calculations. Another variable in determining emission reductions is the number of hours the equipment operates. If actual hours of equipment operation are not available, the default values given in Table III-5 should be used to calculate emission reductions. Table III-5 provides conservative default values for off-road equipment in agricultural and construction applications. For agricultural applications, the operating hours can range from 110 to 814 hours per year and the load factor can vary between 0.48 and 0.7. For construction applications, operating hours can range from 130 to 1836 hours per year and the load factor can vary from 0.43 to 0.78.

Table III-5
Default Operating Hours and Load Factors for Off-Road Agricultural and Construction Equipment

Engine Rated Horsepower	Agricultural Equipment		Construction Equipment	
	Operating Hours (hrs/yr)	Load Factor	Operating Hours (hrs/yr)	Load Factors
50+ hp	110	0.50	130	0.68

Emission reductions from an engine repower or retrofit project are determined by subtracting the certified NOx emission standard of the new engine from the baseline NOx emission level of the engine being replaced. Table III-6 lists the baseline NOx emission levels for engine repower and retrofit projects.

Table III-6
Baseline Emission Rates for
Uncontrolled Off-Road Engines

Rated Power (horsepower)	NOx Emission Rates (g/bhp-hr)
$50 \leq hp \leq 175$	13
> 175 hp	11

For an equipment repower or engine retrofit project that converts an emission-certified engine with an engine certified to an optional NOx emission credit standard, the emission reduction benefit is determined by subtracting the certified NOx emission standard of the new engine from the certified NOx emission standard of the engine being replaced. In situations where the model year of the off-road equipment and its existing engine that is to be replaced are not the same, the engine model year, and not the equipment's, will be used to determine the baseline emission level for emission reduction calculations.

2. Cost-Effectiveness Calculation

The portion of the cost for a repower project to be funded through the Carl Moyer Program is the difference between the total cost of purchasing and installing the new, emission-certified engine and the total cost of either rebuilding the existing engine or the cost of buying a "conventional" replacement engine.

Only the amount of money provided by the Carl Moyer program and any local district match funds can be used in the cost-effectiveness calculations. The one-time incentive grant amount is to be amortized over the expected project life (at least five years) with a discount rate of five percent. The amortization formula (given below) yields a capital recovery factor, when multiplied with the initial capital cost, gives the annual cost of a project over its expected lifetime.

Capital Recovery Factor (CRF) $= [(1 + i)^n (i)] / [(1 + i)^n - 1]$

Where, i = discount rate (5 percent)
n = project life (at least five years)

The discount rate of five percent reflects the opportunity cost of public funds for the Carl Moyer Program. This is the level of earning that could be reasonably expected by investing state funds in various financial instruments, such as U.S. Treasury securities. Cost-effectiveness is determined by dividing the annualized cost by the annual NOx emission reductions. Example calculations for off-road equipment projects are provided below.

3. Examples

For the purposes of explaining the emission reduction and the cost effectiveness calculations from a particular off-road equipment project, two examples are presented below. The first example describes the calculations based on fuel consumption, whereas, the second example describes the calculations based on hours of operation.

Example 1 – Calculations Based on Fuel Consumption

Agricultural Harvester Repower: An equipment owner applies for a Carl Moyer Program grant for the purchase of a new off-road diesel engine (170 hp, 6.9 g/bhp-hr NOx) to replace an uncontrolled diesel engine (1980, 13 g/bhp-hr NOx) used in a harvester. The installed cost of the new emission-certified diesel engine is $9,500, whereas, the cost to rebuild and install the old engine would be $6,900. The new engine will use 4,600 gallons of diesel fuel annually and will operate 100 percent of the time in California.

Emission Reduction Calculation

Annual NOx Reductions (tons/year) =
[(Baseline NOx) - (Reduced NOx)] * (Energy Cons. Factor) * (Annual Fuel Consumption) * (% Op. In Ca) * (ton / 907,200 grams)

Where,

Baseline NOx Emissions	= Emission level from an uncontrolled diesel engine: 13.0 g/bhp-hr
Reduced NOx Emissions	= Certified NOx emission level from a new diesel engine: 6.9 g/bhp-hr
Energy Consumption Factor	= 18.5 hp-hr/gal
Annual Fuel Consumed	= 4,600 gallons
% Operated in CA	= 1.0 (i.e., 100%)
(ton/907,200 g)	Converts grams to tons

Hence, estimated annual NOx reductions are:

[((13.0 – 6.9) g/bhp-hr) (18.5 hp-hr/gal) (4,600 gallons/year) (1.0)] * (ton/907,2000 g) = **0.57 tons/year**

Cost and Cost-Effectiveness Calculations

The annualized cost is based on the portion of incremental project costs funded by the Carl Moyer Program, the expected life of the project (5 years at a minimum), and the interest rate (5 percent) used to amortize the project cost over the project life. The incremental capital cost to the fleet operator for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

Incremental Capital Cost	= $9,500 - $6,900 = $2,600
Max. Incentive Amount for horsepower category	= $10,000 (Table III-3 --- 100-174 hp)
Max. Amount funded from Carl Moyer Program	= $2,600
Capital Recovery	= $[(1 + 0.05)^5 (0.05)]/[(1 + 0.05)^5 – 1] = 0.23$
Annualized cost	= (0.23)($2,600) = $600/year
Cost-Effectiveness	= ($600/year)/(0.57 tons/year) **= $1,054/ton**

The project meets the cost-effectiveness limit of $12,000/ton NOx reduced and is within the maximum incentive amount of $10,000 for a diesel repower of a 100-174 hp engine. This project would qualify to receive the entire incremental cost ($2,600).

Example 2 – Calculations Based on Hours of Operation

Construction Equipment Repower: An equipment owner applies for a Carl Moyer Program grant for the purchase of a new off-road diesel engine (180 hp, 6.9 g/bhp-hr NOx) to replace an uncontrolled diesel engine (11 g/bhp-hr NOx) used in a construction loader. The cost of the new emission-certified diesel engine is $13,400 whereas the cost to rebuild the old engine would be $8,000. Installation and re-engineering cost (to install the new engine into the existing equipment) is $3,000. The new engine will operate 700 hours annually and will operate 100 percent of the time in California.

Emission Reduction Calculation

Annual NOx Reductions (tons/year) =
[(Baseline NOx) - (Reduced NOx)] * (Horsepower Rating) * (Annual Operating Hours) * (Load Factor) * (% Op. in CA) * (ton / 907,200 grams)

Where,

Baseline NOx Emissions	= Emission level from an uncontrolled diesel engine: 11.0 g/bhp-hr
Reduced NOx Emissions	= Certified NOx emission level from a new diesel engine: 6.9 g/bhp-hr
Rated Horsepower	= 180 hp
Annual Operating Hours	= 700 hours
Load Factor	= 0.68
% Operated in CA	= 1.0 (i.e., 100%)
(ton/907,200 g)	Converts grams to tons

Hence, estimated annual NOx reductions are:

((11.0 – 6.9) g/bhp-hr) (180 hp) (700 hours/year) (0.68) (1.0) * (ton / 907,200 g) = **0.39 tons/year**

Cost and Cost-Effectiveness Calculations

The annualized cost is based on the portion of incremental project costs funded by the Carl Moyer Program, the expected life of the project (5 years at a minimum), and the interest rate (5 percent) used to amortize the project cost over the project life. The incremental capital cost to the equipment owner for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

Total installed cost of new engine	= $13,400 + $3,000 = $16,400
Incremental Capital Cost	= $16,400 - $8,000 = $8,400
Max. Incentive Amt. for HP Category	= $14,000 (Table IV-3 --- 175 - 299 hp)
Max. Amount Funded	= $8,400
Capital Recovery	= $[(1 + 0.05)^5 (0.05)]/[(1 + 0.05)^5 – 1] = 0.23$
Annualized cost	= (0.23)($8,400) = $ 1,940/year
Cost-Effectiveness	= ($1,940/year)/(0.39 tons/year) **= $4,970/ton**

The project meets the cost-effectiveness limit of $12,000/ton NOx reduced and is within the maximum incentive amount of $14,000 for a diesel repower of a 175 to 299 horsepower engine. This project would qualify to receive the entire incremental cost ($8,400).

E. Reporting and Monitoring

During the project life, a district has the authority to conduct periodic checks or solicit operating records from the applicant that has received Carl Moyer funds for new engine purchases or for equipment repowering or engine retrofit projects. This is to ensure that the equipment is operated as stated in the program application. Off-road diesel equipment operators participating in the Carl Moyer Program are required to keep appropriate records during the life of the project funded. Records must contain, at a minimum, total hours operated, amount of fuel used, and maintenance and repair information. Records must be retained and updated throughout the project life and made available at the request of the district.

CHAPTER IV.

LOCOMOTIVES

This chapter presents the proposed project criteria for locomotives under the Carl Moyer Program. It also contains a brief overview of the locomotive industry, emission inventory, current emission standards, available control technology, potential incentive projects eligible for funding, recommended emission reduction calculations, and estimated cost benefits.

A. Introduction

Over the years, the focus of reducing emissions has been from stationary sources and on-road vehicles (light-, medium-, and heavy-duty). Off-road sources, such as locomotives, also contribute to California's pollution problem and have not been regulated in California until recently, although locomotives have been subject to various locally enforced opacity limits. Federal law prohibits California from setting standards for new locomotives and new engines used in locomotives. Only the U.S. EPA has the authority to regulate emissions from locomotives, and has, in fact, adopted standards that phase-in beginning in 2000.

Participating railroads proposed to U.S. EPA, and ARB the establishment of a locomotive fleet average emissions program in the South Coast Nonattainment Area tied to promulgation of a U.S. EPA National Locomotive Rule. ARB, U.S. EPA and participating railroads committed to develop this program, known as the South Coast Locomotives Program, by signing a Statement of Principles (SOP) in May 1997. Following the signing of the SOP, the railroads, U.S. EPA, and ARB discussed improvements and refinements of this program. In July 1998, a second agreement was signed that affects the in-use locomotive fleet in the South Coast Nonattainment area. That agreement is a Memorandum of Understanding (MOU) signed by the ARB and participating railroads agreeing to a voluntary locomotive fleet average emissions program that will speed the introduction of new, lower-emitting engines in the South Coast Air Basin.

1. Emissions Inventory

The primary business of railroads is transportation of freight or passengers. Locomotives provide line-haul, local (short-line), switchyard, and passenger services. In California, line-haul transportation is the primary function of the Union Pacific Railroad Company, and the Burlington Northern and Sante Fe Railway Company. These companies transport goods between major urban centers, sometimes over 1,000 miles apart. Reliability is an important factor when transporting goods at large distances. Locomotive "down-times" could be very expensive and are the cause of a tremendous loss in revenue. Hence, line-hauls are well maintained, with remanufacture occurring every seven to eight years.

Locomotives are well maintained and typically have a long useful life. Line-hauls with engines over 3000 horsepower (hp) and no longer suitable for line-haul service are typically designated for other services out of California, or even out of the U.S. Line-hauls less than 3000 hp that are no longer suitable for line-haul services, are usually re-assigned to the short-line fleets, and subsequently to the switchyards. Short-lines have smaller engines than line hauls since these locomotives require less work, carry smaller loads, and travel shorter distances, generally under 200 miles. Short-lines consist of an older locomotive fleet, mostly predating the 1973 model year. Switch-yard locomotives are usually the oldest locomotives, and require the least amount of travel and work. Switchers typically distribute and re-arrange cars within the terminal and provide services within the state, usually remaining in the same geographical area.

There are approximately 20,000 locomotives in the U.S and about 1,200 (or six percent) are in California. Of these 1,200 locomotives, approximately 250 are used as locals, 200 are used in switchyards, 100 are passenger trains, and the remaining 650 are used as line-hauls.[1] Locomotives generated approximately 3 to 4 percent of the 1990 baseline NOx emissions in the South Coast Air Basin.[2] Table IV-1 lists baseline NOx emissions for 1990, 1996, and 2010. The baseline NOx emissions listed in Table IV-1 do not reflect U.S. EPA nationwide emission standards for new and remanufactured locomotives, or the MOU for the in-use locomotive fleet in the South Coast Nonattainment area.

Table IV-1
Baseline NOx Emissions [a]
(tons/day)

Area	1990	1996	2010
South Coast	30	28	26
Statewide	160	150	140

[a)] Emission estimates from the ARB's emission inventory.

2. Emission Standards

U.S. EPA adopted emission standards for locomotives nationwide in December 1997. The standards take effect in the year 2000. Federal standards apply to locomotives originally manufactured from 1973 and any time they are manufactured or remanufactured. Electric locomotives, historic steam-powered locomotives, and locomotives originally manufactured before 1973 are not regulated. Table IV-2 contains the federal exhaust emission standards for locomotives. Emission standards for short-line and line-hauls are both based on the line-haul duty cycle.

Table IV-2
Federal Exhaust Emission Standards for Locomotives
Beginning in 2000 for New Engines and at Time of Remanufacture

Duty-cycle	Gaseous and Particulate Emissions (g/bhp-hr)			
	HC	CO	NOx	PM
	Tier 0 (1973 – 2001 model years)			
Line-haul duty-cycle	1.00	5.0	9.5	0.60
Switch duty-cycle	2.10	8.0	14.0	0.72
	Tier 1 (2002 – 2004 model years)			
Line-haul duty-cycle	0.55	2.2	7.4	0.45
Switch duty-cycle	1.20	2.5	11.0	0.54
	Tier 2 (2005 and later model years)			
Line-haul duty- cycle	0.30	1.5	5.5	0.20
Switch duty-cycle	0.60	2.4	8.1	0.24

U.S. EPA, Final Emissions Standards for Locomotives, EPA420-F-97-048, December 1997

3. Control Technology

Although locomotives and their engines are expensive, they are designed to last a long time. Typical lifetimes are between 25 and 30 years. Over this life, they are overhauled several times and, perhaps, re-engined once. For the most part, locomotive engines are well maintained and the emissions associated with these engines typically remain the same over their lifetime.

The desire to improve fuel economy has influenced the development of more advanced locomotive technologies. Locomotive exhaust emission levels have generally been reduced with the development of new engine technologies. These technologies are somewhat similar to those for on-road heavy-duty vehicle control technology. Technologies include, but are not limited to, turbocharging and aftercooling for NOx control, and improved fuel injection and combustion chamber design for PM and HC control.

B. Project Criteria

The proposed project criteria for locomotives under the Carl Moyer Program have been designed to provide districts with a list of minimum qualifications that must be met by applicants in order for a reduced-NOx locomotive project to qualify for funding. These criteria will provide districts and program operators with calculations that must be used for determining emission reductions and cost effectiveness resulting from reduced-NOx locomotive projects. Reduced-NOx locomotive engine projects that include new, repowered, or retrofitted locomotive engines will be considered and closely evaluated as qualifying for incentive funding. For the most part the criteria for selecting a project will depend on the amount of emission reductions, cost effectiveness, and the potential for the project to materialize within a realistic timeframe. In general, locomotive projects that meet the following criteria would qualify for funding.

- Any emission reductions achieved through the application of Carl Moyer Program funds cannot be credited toward compliance with the 1998 MOU in the South Coast;

- NOx reductions for all other districts must beyond what is required by any federal or local regulations;

- Pre-1973 model year (MY) locomotives – must test to 30 percent below uncontrolled baseline NOx emissions;

- 1973 and later MY locomotives – must test to Tier 1 or Tier 2 federal locomotive NOx standards;

- Reduced emission levels must be maintained for a minimum of 5 years;

- Seventy-five percent of estimated annual ton-miles traveled must occur in California;

- Seventy-five percent of estimated annual fuel consumption must occur in California; and

- Cost effectiveness must be no more than $12,000/ton of NOx reduced.

C. Potential Types of Projects

Typical projects that would qualify for incentive funding under this program would include repowering a locomotive engine to a reduced-NOx configuration, use of a retrofit kit to lower engine NOx emissions, or the purchase of new, reduced-NOx engines. Repowering and retrofit projects are not limited, and could include use of control technologies that involve selective catalytic reduction (SCR), dual-fuel natural gas engine retrofits, or even turbocharging and aftercooling. There are also reduced-emission technologies (such as engine retrofit or new engine technologies) that hold promise for the future, but are not yet commercially available or certified for sale in California. ARB could approve test data for these technologies on a case by case basis. Beginning in the year 2000, when the federal standards go into effect, ARB could grant an experimental permit for a particular engine with certain technology to operate in California. However, all projects will be evaluated carefully to determine whether or not NOx reductions could indeed occur.

Reliability of a line-haul engine is extremely important. Since some of the control technologies are costly and have not been in wide use for locomotive engines, line-haul participation in the Carl Moyer Program is not expected until these technologies are proven effective and reliable on passenger, short-line, and switcher locomotive engines. Therefore, the ARB expects that reduced-NOx locomotive projects would be limited to passenger, short-line, or switchyard locomotives.

1. Repowers

Repowering could occur during engine remanufacture by exchanging a locomotive's old engine for a newer, lower-emission engine. According to these criteria the amount of funding granted and final project qualifications must be based on the amount of emissions reduced and a cost effectiveness of at most $12,000 per ton. There is no cap on the amount of funding received. However, in order to qualify for funding, locomotive engines must test to a reduced-

NOx emissions level. The reduced- NOx emission level must be maintained for a minimum of 5 years (project life).

Projects submitted for pre-1973 MY locomotives must show that engine NOx emissions will be reduced by a minimum of 30 percent below the uncontrolled baseline NOx emissions for pre-1973 MY, as listed in Table IV-3, below. Since there are no line haul locomotives in service in California with pre-1973 engines, these projects are likely to be for switchers. Projects submitted for 1973 and later MY locomotive engines must consist of engines tested to the federal Tier 1 or Tier 2 locomotive NOx standards as listed in Table IV-3, below. Engine tests must be conducted according to the Federal Test Procedures for locomotives. If additional funding is available beyond the calendar year 2001 to continue the Carl Moyer Program, criteria for project NOx limits will be modified to reflect the current federal standards.

Table IV-3
Baseline NOx Emission Factors and Maximum NOx Limits
(g/bhp-hr)

Engine Model Year	Source	Line-haul	Switcher
Pre-1973	Uncontrolled Baseline Emission Factor	16 [a, b]	16.9 [b]
1973 and later	Baseline Emission Factor	9.5	14.0
1973 and Later	NOx Limit – Federal Tier 1	7.4	11.0
	NOx Limit – Federal Tier 2	5.5	8.1

a. There are no line haul locomotives in service in California that are pre-1973, baseline emissions are listed for short-line locomotives only.
b. ARB emission rates are average estimates based on data provided by engine manufacturers.

2. Retrofits

Retrofit involves hardware modifications to the engine, so the engine has lower emissions. The conversion could occur by adding on control equipment to convert the engine to a reduced-NOx engine technology. This technology could include conversion to an alternative fuel locomotive engine. The amount of funding granted and the final project qualifications must be based on the amount of emissions reduced and a cost effectiveness of at most $12,000 per ton. Similar to repowers, in order to qualify for funding, locomotive engines must test to a reduced-NOx emissions level. As with repowers, the tested emission level must be maintained for a minimum of 5 years (project life).

The maximum allowable NOx levels for line-haul and switchers using retrofit kits will be the same as for repowers. Projects submitted for pre-1973 MY locomotives must show that engine NOx emissions will be reduced by a minimum of 30 percent below the uncontrolled baseline NOx emissions as listed in Table IV-3, above. Projects submitted for 1973 and later MY locomotive engines must consist of engines tested to the federal Tier 1 or Tier 2 locomotive NOx standards as listed in Table IV-3, above. Once again, if additional funding is available beyond the calendar year 2001 to continue the Carl Moyer Program, criteria for project NOx limits will be modified to reflect the current federal standards.

3. Sample Project Application Forms

In order to qualify for incentive funds, districts will make applications available and solicit bids for reduced-emission projects from railroads. A sample application has been provided in Appendix D. The applicant must provide at least the following information, as listed in Table IV-4 below:

Table IV-4
Minimum Applicant Information

1. Company name	9. Matching funds
2. Project name	10. Percent operated in district
3. District	11. Incentive amount requested
4. Type of locomotive	12. Annual fuel consumption or hours of operation along with a fuel consumption rate
5. Type of fuel used	13. Annual ton-miles
6. Type of engine	14. Project life (min. 5 years)
7. Capital cost of remanufacture w/out control upgrade	15. Baseline NOx emissions
8. Capital cost of remanufacture with control upgrade	16. New lower NOx emissions

D. Emission Reduction and Cost-Effectiveness

Control costs for locomotives differ greatly, depending on the particular scenarios and technology involved in any individual case. Preliminary cost evaluations of some reduced-NOx controls for locomotive engines indicate that the capital costs can be high (although less than purchasing a new engine), whereas some cost evaluations indicate that others could actually create a cost savings to locomotives. The amount of incentive funds granted would depend on the amount of emission reductions. Only the portion of the incremental cost that meets a cost effectiveness of at most $12,000/ton of NOx reduced will qualify for incentive funding.

1. Emission Reduction Calculation

Emission reductions for locomotives will be based on annual fuel consumption or hours of operation, and percent operated in California. When the applicant provides annual hours of operation, a fuel consumption rate must also be provided. Annual project emission reductions are calculated by multiplying the estimated annual fuel consumption by the energy consumption factor 20.8 bhp-hr/gal. The result is multiplied by the difference between the baseline NOx emission level and the controlled NOx emission level. It is also multiplied by the percent operated in California.[3] The result is in grams per year (g/year) and converted to tons/year by using a conversion factor. If annual hours of operation are provided, the annual fuel consumption is calculated by multiplying the fuel consumption rate by the annual hours of operation. The following formulas must be used when calculating project NOx reductions.

Annual NOx Reductions (tons/year) =
[(Ann. Fuel Cons.) * (Fuel Cons. Factor) * [(Baseline NOx Emissions) – (Reduced NOx Emissions)] * (% operated in CA)] * (ton / 907,200 grams)

Where,

Ann. Fuel Cons	= Estimated Annual Fuel consumption for the retrofitted engine(gal/year). If not known, provide annual hours of operation and a fuel consumption rate.
Fuel Cons. Factor	= Assumed Fuel Consumption Factor of 20.8 bhp-hr/gal
Baseline NOx Emissions	= NOx Emissions from the old engine in g/bhp-hr
Reduced NOx Emissions	= NOx Emissions from the new engine in g/bhp-hr
% operated in CA	**=** The percent of time operated in California
(ton/907,200 g)	Converts grams to tons

2. Cost Effectiveness Calculation

The cost benefits are based on the incremental capital cost, any matching funds that were used to fund the project, the expected life of the project, the interest rate (five percent), and estimated annual NOx reductions in a particular district. The discount rate of five percent reflects the opportunity cost of public funds for the Carl Moyer Program. This is the level of earning that could be reasonably expected by investing state funds and is based on the most recent published interest rates on U.S. Treasury securities.

Incremental costs are determined by considering the difference between the capital cost to remanufacture an engine to its original configuration (without improved control technology) and the capital cost to repower/retrofit the engine with new control technology. The incremental capital cost is annualized using a five percent interest rate. Incremental costs are divided by the annual NOx reductions in a district, and multiplied by a capital recovery factor. This calculation will result in annualized project cost benefits. Larger NOx reductions could result in better cost benefits, depending on the amount of project incremental cost. Cost benefits can be calculated using the following formulas:

Incremental Project Cost = (Aft. Proj. Cap. Cost) - (Bef. Proj. Cap. Cost)

Where, **Aft. Proj. Cap. Cost =** capital costs for reduced-NOx engine
Bef. Proj. Cap. Cost = capital costs for the rebuilt engine without the upgrade

Maximum Amount Funded = (Incremental Project Cost) - (Match Funds)

Where, **Match Funds =** Any matching funds

Capital Recovery Factor = $[(1 + i)^n (i)] / [(1 + i)^n – 1]$

Where, i = discount rate (5 percent)
n = project life (at least five years)

Annualized Cost = [(Maximum Amount) + (Match Funds)] * (Capital Recovery Factor)

Cost-Effectiveness = (Annualized Cost) / (Annual NOx Reductions)

Where, **Annual NOx Reductions =** Calculated NOx reductions (tons/year)

3. Examples

For the purposes of explaining the emission reduction and the cost effectiveness calculations from a locomotive engine project, two examples are presented below. The first example describes the calculations based on fuel consumption, whereas the second example provides an explanation for the calculations based on hours of operation.

Example 1 – Locomotive Engine Retrofit: Consider an operator faced with the opportunity to convert one locomotive engine, perhaps during the normal remanufacture period. In this case, the railroad applies for funding for a locomotive natural gas retrofit kit for a 1972 short-line engine. The retrofit kit reduces uncontrolled emissions by 30 percent. Since it is usually about seven years until the next remanufacture, the project life is seven years. The railroad company estimates the remanufacture of the engine without the retrofit kit to be about $890,000. The upgrade, however, is more expensive, and will cost a total of $920,000. The railroad also estimates that the annual fuel consumption for this engine in California would be approximately 60,000 gals. Emission reductions are calculated using the formula listed in section D1, above, as follows:

Ann. Fuel Cons	=	60,000 gals/year
Baseline NOx Emissions	=	16.0 g/bhp-hr (assumed uncontrolled emissions from Table IV-3 above)
Reduced NOx Emissions	=	11.2 g/bhp-hr (30 percent reduction from 16.0 g/bhp-hr)
Fuel Cons. Factor	=	20.8 bhp-hr/gal (default provided by U.S. EPA)
% operated in CA	=	1 (i.e. 100% is input as 1, 75% is 0.75, etc.)
(ton/907,200 grams)	=	converts grams to tons

Estimated annual NOx reductions are:

[(60,000gal/year) * [(16.0 - 11.2) g/bhp-hr * 20.8 bhp-hr/gal] * 1] * (ton / 907,200 g) = **6.6 tons/year**

Using the formulas in section D2, above, and the cost assumptions provided earlier in this section, the capital costs, the incremental costs and benefits can be calculated as follows:

Capital Costs for remanufacture without Upgrade	$ 890,000
Capital costs for remanufacture with retrofit kit	$ 920,000
Matching funds	$ 0

Incremental Project Cost = (890,000 - 920,000) = $30,000
Maximum Amount Funded = (30,000 – 0) = $30,000
Capital Recovery Factor = $[(1 + 0.05)^7 (0.05)]/[(1 + 0.05)^7 – 1] = 0.17$
Annualized Cost =[(30,000) + (0)] * (0.17) = $5,100/ year
Cost Effectiveness = (5,100 / year) / (6.6 tons/year)= **$773/ ton**

The cost effectiveness for the example is less than $12,000 per ton of NOx reduced. This project would qualify for the maximum amount of grant funds.

Example 2 – Locomotive Engine Replacement: Consider an operator faced with the opportunity to replace a short-line locomotive engine, perhaps during the normal remanufacture period. In this case, the railroad applies for funding for a short-line locomotive to replace a 1983 short-line engine (9.5 g/bhp-hr NOx) with a liquefied natural gas (LNG) engine (4.0 g/bhp-hr NOx). The railroad company estimates a project life of 20 years for the LNG engine. The railroad company also estimates the normal remanufacture costs for the engine to be about $890,000. The LNG upgrade, however, is more expensive, and will cost a total of $1.2 million. The railroad also estimates that the annual hours of operation for the new engine to be 1000 hours per year, with an average fuel consumption rate of 260 gallons per hour. Emission reductions are calculated using the formula listed in section D1, above, as follows:

Ann. Fuel Cons	=	(1000 hrs/yr) * (260 gals/yr) = 260,000 gals
Baseline NOx Emissions	=	9.5 g/bhp-hr
Reduced NOx Emissions	=	4.0 g/bhp-hr
Fuel Cons. Factor	=	20.8 bhp-hr/gal (default provided by U.S. EPA)
% operated in CA	**=**	1 (i.e. 100% is input as 1, 75% is 0.75, etc.)
(ton/907,200 grams)	**=**	converts grams to tons

Estimated annual NOx reductions are:

[(260,000gal/year) * [(9.5 – 4.0) g/bhp-hr * 20.8 bhp-hr/gal] * 1] * (ton / 907,200 g) = **32.8 tons/year**

Using the formulas in section D2, above, and the cost assumptions provided earlier in this section, the capital costs, the incremental costs and benefits can be calculated as follows:

Capital Costs for remanufacture without Upgrade	$ 890,000
Capital costs for LNG engine	$1,200,000
Matching funds	$ 0

Incremental Project Cost **=** (1,200,000 - 890,000) = $310,000
Maximum Amount Funded = (310,000 – 0) = $310,000
Capital Recovery Factor **=** $[(1 + 0.05)^{20} (0.05)]/[(1 + 0.05)^{20} – 1] = 0.08$
Annualized Cost =[(310,000) + (0)] * (0.08) = $24,875/ year
Cost Effectiveness = (24,875 / year) / (32.8 tons/year)= **$758/ ton**

The cost effectiveness for the example is less than $12,000 per ton of NOx reduced. This project would qualify for the maximum amount of grant funds ($310,000).

E. Reporting and Monitoring

During the project life, the district has the authority to conduct periodic checks or solicit operating records from the applicant that has received Moyer funds for each retrofitted/repowered locomotive engine. This is to ensure that the engine is operated as stated in the program application. Hence the applicant must maintain operating records and have them available to the district upon request. Records must contain, at minimum, locomotive identification numbers, retrofit hardware model and serial numbers, estimated annual fuel consumption in the California, hours of operation in California, hours in idle, and maintenance/repair dates (or any type of servicing information), and any emission testing results. Records must be retained and updated throughout the project life and made available for district inspection.

F. References

1. Controlling Locomotive Emission in California: Technology, Cost-Effectiveness, and Regulatory Strategy, Chris Weaver and Douglas McGregor, Engine, Fuel, and Emissions Engineering, Inc., March 1995.

2. Locomotive Emission Study California Air Resources Board, Booz, Allen, & Hamilton, January 1991.

3. Emission Factors for Locomotives, U.S. EPA, EPA420-F-97-051, December 1997.

CHAPTER V.

MARINE VESSELS

This chapter presents the proposed project criteria for marine vessels under the Carl Moyer Program. It also contains a brief overview of the marine vessel industry, NOx emission inventory based on emissions calculated for the South Coast Air Basin, current emission standards, available control technology, potential incentive projects eligible for funding, recommended emission reduction calculations, and estimated cost benefits.

A. Introduction

Marine vessel engines contribute to emissions of NOx, HC, CO, PM, and SOx. Marine vessel traffic consists of foreign and domestic (U.S. based) fleets. Emissions from marine vessel engines are generated in California during vessel travel through defined California coastal waters, vessel calls on California ports, as well as from other vessel activities in and near the ports such as fishing, tugboat operations and work boats. The coastal water boundary for California consists of a range from 27 miles off of the California coast at the narrowest, to 102 miles off the coast at the widest (Figure V-1 shows this boundary). There have been recent actions on both the international and national level to address the emissions from marine vessel engines. While some strategies being discussed for the South Coast Air Basin may generate emission reductions in the near-term, the full effects from the international and national emission control programs won’t be realized for many years since these regulations apply, with certain exceptions, to new engines.

The Carl Moyer Program presents a timely opportunity to realize emission reductions from marine vessels within the next 2-5 years. By providing marine vessel owners with incentive funds for voluntarily reducing NOx emissions from marine vessel engines before mandated regulatory controls are effective, this program has the potential to generate near-term emission reductions from the marine fleet. These emission reductions, in turn, will benefit the local air quality districts’ efforts to meet the health based air quality standards.

1. Emission Inventory

The marine vessel source category includes ocean-going vessels and harbor vessels exclusive of those used in recreational activities. Marine vessel fleets range in power, from approximately 500 to 67,000 horsepower. Marine vessels, for the most part, are propelled by diesel engines and to a smaller extent by steam turbines, or gas turbines. In 1993, approximately 95 percent of the vessels calling on the San Pedro Bay Ports were propelled by diesel engines, with the remaining 5 percent propelled by steam turbines. Typical lifetime for a marine vessel engine is approximately 30 years, with rebuilds occurring about every five years.

INSERT FIGURE V-1 HERE

The emission inventory for the South Coast Air Basin shows significant NOx emissions from ocean-going vessels, tug boats, harbor vessels, fishing vessels, U.S. Navy and coast Guard, and transiting vessels. In 1993 approximately 1,500 vessels made 5,500 calls on the San Pedro Bay Ports in the South Coast. Approximately 94 percent of the 1,500 vessels were foreign and six percent were U.S. vessels. Estimated emissions from these engines are calculated for both the main engines and the auxiliary power engines operating in either or all of the following modes:

- Cruising,
- Maneuvering, and
- Hotelling

Baseline NOx emissions for 1990 are estimated to be approximately 32 tons per day in the South Coast Air Basin (SCAB). In 2010, NOx emissions are expected to be approximately 52 tons per day in the SCAB which is approximately eight percent of total mobile source NOx emissions for that year. Table V-1 lists 1990, 1996, and 2010 estimated NOx emissions from marine vessel engines in the South Coast and statewide**.**

Table V-1
Baseline NOx Emissions
(tons/day)

Area	1990	1996	2010
South Coast	32	41	52
Statewide	58	66	79

Emission estimates from the ARB's emission inventory.

2. Emission Standards

At the international level, the International Maritime Organization (IMO) recently adopted Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). This protocol, which is expected to be signed by more than 15 countries representing over 50 percent of the commercial tonnage worldwide, will reduce NOx emissions from new engines installed on ships after January 1, 2000. At the national level, the U.S. EPA proposed regulations in December 1998 to limit the emissions from domestic vessels not subject to the IMO standards. U.S. EPA's proposed NOx standards include the IMO Standards as Tier 1 and two additional levels (Tier 2 and Tier 3) of standards that will go into effect in 2000, 2004 through 2006, and 2008 through 2010, respectively. In addition, the U.S. EPA has been exploring potential control options for reducing the emissions from marine vessels in the South Coast Air Basin to fulfill U.S. EPA's obligation for Measure 13 (M-13) in the 1994 Ozone State Implementation Plan. These discussions have focused on a wide variety of emission reduction strategies including operational controls in the basin such as voluntary speed reduction and moving of the shipping channels as well as port infrastructure improvements and strategies to retrofit engines on harbor vessels. Table V-2 lists the IMO standards for NOx emissions.

Table V-2 IMO NOx Standards Effective January 1, 2000		
Engine Speed, n	**NOx (g/kW-hr)**	**NOx (g/bhp-hr)**
N < 130	17	12.7
1 130 < n < 2000	$45 * n^{-0.2}$ = 17.0 at 130 rpm and 9.8 at 1999 rpm	= 12.7 at 130 rpm and 7.3 at 1999 rpm
n = 2000 +	9.8	7.3

Source: U.S. EPA, 40 CFR Part 89, Control of Emissions of Air Pollution from New CI Marine Engines at or above 37 Kilowatts, May 11, 1998.

MARPOL 73/78 prevents U.S. EPA from setting lower emission standards for engines on marine vessels traveling to or from foreign countries. U.S. EPA has the authority to propose marine vessel standards for domestic vessels that remain in national waters. As such, U.S. EPA proposed marine standards in May 1998 for domestic vessels not subject to IMO standards. The proposed federal marine standards mimic the IMO standards for engine speeds that are less than 2,000 rpm. For marine engine speeds that are greater than 2,000 rpm, however, U.S. EPA has proposed standards similar to U.S. EPA's current tiered emission standards for locomotive engines (9.5 g/bhp-hr).

3. Control Technology

Marine vessel engines in tugboats and fishing vessels are very similar to locomotive and heavy-duty truck-type engines. Marine vessel engines are costly and designed to last a long time. Typical lifetimes are about 30 years. Over this period, engines are overhauled at regular five-year intervals. Since they are often overhauled regularly, applying control technologies at the point of overhaul would be the least disruptive and least costly approach. The technology required to meet lower NOx emissions are somewhat similar to those for on-road heavy-duty vehicle and locomotive control technology. Technologies include exhaust aftertreatment, and advanced technologies that have been applied to on-road engines. Dual fuel natural gas retrofit kits are available that could lower NOx emissions from marine vessel engines (fishing boats) by about 30 to 40 percent. Selective catalytic reduction (SCR) which is used for land based applications, could also be used on vessels. There are about eight marine vessels operating with SCR.

B. Project Criteria

The proposed project criteria for marine vessels under the Carl Moyer Program are designed to provide districts with a method for evaluating reduced-NOx marine vessel projects that are submitted to them for receiving incentive funding. Reduced-NOx marine vessel engine projects that include new, repowered, or retrofitted engines will be considered and closely evaluated as qualifying for incentive funding. For the most part the criteria for selecting a project will depend on the amount of emission reductions, cost effectiveness, and the potential for the project to materialize within a realistic timeframe. These criteria will also provide districts and program operators with calculations that must be used for determining emission reductions and cost effectiveness resulting from reduced-NOx marine vessel projects. In general, marine vessel projects qualifying for evaluation would need to meet the following criteria:

- Thirty percent reduction in NOx emissions from uncontrolled baseline emissions, and beyond what is required by any, national or international regulations;

- Reduced emission levels that must be maintained for a minimum of 5 years; and

- Cost effectiveness no more than $12,000/ton of NOx reduced in California Coastal waters.

C. Potential Types of Projects

Typical projects that would qualify for incentive funding under the Carl Moyer Program for marine vessels would include the use of retrofit kits or repowers to lower NOx emissions, the purchase of new reduced-NOx marine engines, or the purchase of reduced-NOx portside equipment. Since many ocean-going vessels do not call on ports frequently during the year, controls may not be as cost effective for these vessels. For the most part, cost effective projects will be those that include controls incorporated on vessels that frequent the ports or remain in the harbor. These types of vessels include, but are not limited to, tugs, crew/supply boats, and fishing boats.

Projects consisting of new marine vessel engines that produce reduced-NOx emissions would also be considered for funding. However, incremental costs for new engines may be too high to qualify this type of project as cost effective.

Projects consisting of reduced-NOx portside equipment could also be considered for incentive funds. These types of projects would be less costly, compared to marine engine control. However, NOx emission reductions and cost effectiveness would depend on the amount of operation hours from these types of equipment. The types of equipment, as well as the extent of operation, could vary considerably in each port. Hence, these types of projects would need to be evaluated individually to determine the project eligibility.

1. Repowers & Retrofits:

Repowering could occur during engine rebuild by exchanging a marine vessel's old engine for a newer, lower-emission engine. Retrofit involves hardware modifications to the engine, so the modified engine emits lower emissions. The conversion could occur by adding on control equipment to convert the engine to a reduced-NOx engine technology. In both cases, funding eligibility will be evaluated based on the amount of emissions reduced and a maximum cost effectiveness of $12,000 per ton. Furthermore, the cleaner engine would need to test to an emission limit that is at least 30 percent lower then uncontrolled baseline NOx emissions. If a baseline emission limit is not provided by the applicant, an average baseline uncontrolled emission factor will be used when calculating emissions. These factors were provided to ARB by the South Coast Air Quality Management District and are listed in Tables V-3 through V-6. The emission level will have to be maintained for a minimum of 5 years (project life).

Table V-3
Marine Vessel Emission Factors for all Design Categories
(lbs/1000 gal)

Propulsion Type		Cruise		Maneuvering	
		Baseline NOx	30 Percent Reduction in NOx	Baseline NOx	30 Percent Reduction in NOx
Motorship	Slow Speed (2 Stroke)	616	431	616	431
	Medium Speed (4 Stroke)	403	282	403	282
Steamship		64	45	56	39

Table V-4
Marine Vessel Auxiliary Power Emission Factors for all Design Categories
(lbs/hour)

Vessel Type	Propulsion Type	Auxiliary Power	Baseline NOx	30 Percent Reduction in NOx
All	Motorship	Engines	22	15
		Boilers	4	3
	Steamship	Main Boilers	29	20

Table V-5
Harbor Vessel Emission Factors – Medium Speed Diesels
(lbs/1000 gal)

Vessel Type	Baseline NOx [a]	30 Percent Reduction in NOx
Tug/tow/push boats, passenger/excursion boats, lighter barges, work/supply/utility/cargo boats, fishing and U.S. Coast Guard vessels	270	189

a. Emission Inventory Procedural Manual, Volume III, Methods for Assessing Area Source Emissions, California Environmental Protection Agency, ARB, September 1995

Table V-6 U. S. Navy Ship Emission Factors (lbs/1000 gal)		
Vessel Type	**Baseline NOx**	**30 Percent Reduction in NOx**
Motorship	652	456
Steamship	64	45

2. Portside Equipment Repowers & Retrofits

Projects that consist of portside equipment engine repowers and retrofits could also qualify for incentive funds. Similar to marine vessel engine repowers and retrofits, these projects will be evaluated based on the amount of emissions reduced and a cost effectiveness of at most $12,000 per ton. However, the cleaner engine would need to reduce NOx emissions to levels as described in the off-road equipment section of the Carl Moyer Program. In addition, the new certified emission level will have to be maintained for a minimum of 5 years (project life).

3. Sample Project Application Forms

In order to qualify for incentive funds, districts will make applications available and solicit bids for reduced-emission projects from marine vessel owners. A sample application has been provided in Appendix E. The applicant must provide at least the following information, as listed in Table V-7 below:

Table V-7 Minimum Applicant Information	
1. Company Name	13. % Operated in California
2. Project Name	14. Type of fuel used
3. District	15. Type of Engines:
4. Vessel Type: auto carrier, bulk carrier, container Ship, general cargo, passenger ship, reefer, RORO, tanker, tug/tow/push boat, Work/supply/utility boats, fishing vessel, U.S Navy ship	16. Annual number of Port Calls in California
5. Propulsion Type: motorship, or steamship	17. Avg. time (hours) per port call in each service mode, and fuel consumption rate: a. Cruise b. P-zone Cruise c. Maneuvering d. Hotelling
6. Ship Service Speed	18. Average Nautical Miles per port call within California coastal water boundary
7. Ship Deadweight Tonnage (DWT)	
8. Avg. fuel consumption (gallons) per port call for Each service mode: a. Cruise b. P-zone Cruise c. Maneuvering d. Hotelling	19. Project Life (min. 5 years) 20. Avg. fuel consumption (gallons) per port call for Auxiliary Power: a. Boilers (motorship) b. Engines (motorship) c. Main boilers (steamship)

Table V-7, continued Minimum Applicant Information	
9. Capital cost of remanufacture w/out control	21. Annual number of Port Calls in a Port
10. Capital Cost of remanufacture with control	22. Baseline NOx Emissions
11. Matching Funds	23. New Lower NOx Emissions
12. Incentive Amount Requested	

D. Emission Reductions and Cost-Effectiveness

According to the criteria for marine vessels under the Carl Moyer Program, the amount of incentive funds granted would depend on the amount of emission reductions. Only projects that have a cost effectiveness of at most $12,000/ton of NOx reduced will qualify for incentive funding.

1. Emission Reduction Calculation

Emission reductions for marine vessel engines are based on annual fuel consumption, and percent operated in California coastal waters. The applicant must provide information pertaining to the amount of annual fuel consumed for the main engines, and the auxiliary power, depending on the vessel type. When calculating emission reductions, fuel consumption is multiplied by a specific NOx emission factor and then converted to tons per year. Emission factors for each engine are based on vessel type, propulsion type, and service mode. Average emission factors for uncontrolled baseline NOx emissions listed in Tables V-3 through V-6 above can be used where actual uncontrolled baseline emissions are not known.

Emission reductions for marine vessels could also be calculated based on hours of operation, as long as the applicant also provides the fuel consumption rate. When annual hours of operation are provided, the annual fuel consumption is estimated by multiplying the fuel consumption rate by the annual hours of operation. The estimated annual fuel consumption will then be used to determine NOx reductions. The following formulas must be used when calculating project NOx reductions.

Annual NOx Reductions (tons/year) =
**[(Ann. Fuel Cons.) * [(Baseline NOx Emissions) - (Reduced NOx Emissions)] *
(% operated in CA)] * (ton / 2,000 lbs)**

where,

Ann. Fuel Cons	=	Estimated Annual Fuel consumption for the retrofitted/repowered engine(gal/year)
Baseline NOx Emissions	=	NOx Emissions from the overhauled engine (without retrofit/repower)
Reduced NOx Emissions	=	NOx Emissions from the new engine
% operated in CA	**=**	The percent of time operated in California
(ton/2,000 lbs)		Converts lbs/year to tons/year

There is a degree of uncertainty regarding the amount of offshore emissions that actually reach the mainland. For this reason, the staff may recommend an emission discount to apply to offshore emissions. In late 1997, as part of the Southern California Ozone Study, the Tracer Dispersion Study was conducted to determine offshore emission impacts. The results of this study, which are expected later this year, may help staff in quantifying these impacts.

2. Cost-Effectiveness Calculation

Typical marine vessel engine control projects, although technologically feasible, also have higher initial capital cost. Control technologies for a particular vessel will be associated with a certain annual cost each year, but emission reductions will vary from year to year depending on the amount of calls in a port. Emission reductions might even be zero in some years, making some control options less cost effective. Each application will be carefully evaluated on a case by case basis.

The cost benefits are based on the incremental capital cost, any matching funds that were used to fund the project, the expected life of the project, the interest rate (five percent), and estimated annual NOx reductions. The discount rate of five percent reflects the opportunity cost of public funds for the Carl Moyer Program. This is the level of earning that could be reasonably expected by investing state funds and is based on the most recent interest rates published.

Incremental costs are determined by considering the difference between the capital cost for overhauling/rebuilding an engine to its original configuration (without improved control technology) and the capital cost to repower the engine or retrofit the engine with new control technology. Incremental costs are divided by the annual NOx reductions and multiplied by a capital recovery factor. This calculation will result in annualized project cost benefits. Cost benefits can be calculated using the following formulas:

Incremental Project Cost = (Aft. Proj. Cap. Cost) - (Bef. Proj. Cap. Cost)

Where, **Aft. Proj. Cap. Cost =** capital costs for reduced-NOx engine
Bef. Proj. Cap. Cost = capital costs for the rebuilt engine without the upgrade

Maximum Amount Funded = (Incremental Project Cost) - (Match Funds)

Where, **Match Funds =** Any matching funds

Capital Recovery Factor = $[(1 + i)^n (i)]/[(1 + i)^n - 1]$

Where, i = discount rate (5 percent)
n = project life (at least five years)

Annualized Cost = [(Maximum Amount) + (Match Funds)] * (Capital Recovery Factor)

Cost-Effectiveness = (Annualized Cost) / (Annual NOx Reductions)

Where, **Annual NOx Reductions =** Calculated NOx reductions (tons/year)

3. Examples

For the purposes of explaining the emission reduction and cost effectiveness calculations for a particular marine vessel project, one example is presented below. The example describes the calculations based on fuel consumption. If hours of operation and a fuel consumption rate are provided, the annual fuel consumption will be estimated and put into the calculation accordingly.

Example – Tugboat Engine Repower: Consider an owner faced with the opportunity to replace one tugboat engine perhaps during the normal engine overhaul period. In this case, the marine owner applies for funding to repower one 1,400 hp tugboat engine with a low emission diesel engine. The repowered engine reduces uncontrolled NOx emissions by 40 percent, with a project life of about 10 years. The marine vessel owner estimates that the capital cost for rebuilding a 1,400 hp marine vessel engine without the upgrades is about $100,000. The upgrade, however, is more expensive, with a quoted price of $250,000. The marine vessel owner also estimates that the annual fuel consumption for this tugboat in California would be approximately 700,000 gals. Emission reductions are calculated using formulas listed in section D1, above, as follows.

Ann. Fuel Cons	=	700,000 gals/year
Baseline NOx Emissions	=	270 lbs/1000 gals (baseline emission factor for tug boat engines provided in Table V-5 above)
Reduced NOx Emissions	=	162 lbs/1000 gals (40 percent reduction from 270 lbs/1000 gals)
% operated in CA	**=**	1 (i.e. 100% is input as 1, 75% is 0.75, etc.)
(ton / 2,000 lbs)		Converts lbs/year to tons/year

Estimated NOx reductions are:

(700,000 gals/year) * [(270 – 162)lbs/1000 gals] * (1) * (ton/2000 lbs) = **37.8 tons/year**

Using the formulas listed in section D2 above, and the cost assumptions provided earlier in this section, the capital costs, the incremental costs and benefits can be calculated as follows:

Capital Costs to rebuild a 1,400 hp marine vessel engine w/o upgrade	$100,000
Capital costs to repower a 1,400 hp marine vessel engine	$250,000
Matching funds	$ 0

Incremental Project Cost = (250,000 - 100,000) = $150,000
Maximum Amount Funded = (150,000 - 0) = $150,000
Capital Recovery Factor **=** $[(1 + 0.05)^{10} (0.05)]/[(1 + 0.05)^{10} - 1] = 0.13$
Annualized Cost =[(150,000) + (0)] * (0.13) = $19,500/ year
Cost Effectiveness = (19,500 / year) / (37.8 tons/year)= **$516/ ton**

The cost benefit for the example is less than $12,000 per ton of NOx reduced. This project would qualify for grant funds.

E. Reporting and Monitoring

During the project life, the district has the authority to conduct periodic checks or solicit operating records from the applicant that has received Moyer funds for each retrofitted or repowered marine engine. This is to ensure that the engine is operated as stated in the project application. Hence the applicant must maintain operating records and have them available to the district upon request. Records must contain, at minimum the following: marine vessel identification numbers; retrofit hardware model and serial numbers; nautical miles traveled in the district and California coastal waters; estimated fuel consumption in California coastal waters; estimated hours of operation in the California coastal waters; hours in idle; and maintenance and repair dates (or any servicing information). Records must be retained and updated throughout the project life and made available for district inspection.

F. References

1. Control of Emissions of Air Pollution from CI Marine Engines at or Above 37 Kilowatts, U.S. EPA, May 11, 1998.

2. Control of Ship Emission in the South Coast Air Basin, Port of Los Angeles and Port of Long Beach, August 1994.

3. Emissions by Category, 1990 through 2010, ARB, November 1998.

4. Emissions Inventory Procedural Manual, Volume III, Methods for Assessing Area Source Emissions, September 1995, ARB, September 1995.

5. Marine Vessel Emissions Inventory and Control Strategies, Acurex Environmental for South Coast Air Quality Management District, December 12, 1996.

6. Reducing Marine Vessel and Port Emissions in the South Coast, U. S. EPA, EPA420-F-96-011, July 1996.

7. The California State Implementation Plan for Ozone, Volume II: The air Resources Board’s Mobile Source and Consumer Products Elements, ARB, November 15, 1994.

CHAPTER VI.

STATIONARY AGRICULTURAL ENGINES

This chapter presents the proposed project criteria under the Carl Moyer Program for stationary agricultural engines. It also contains a brief overview of NOx emission inventory, current emission standards, available control technology, potential incentive projects eligible for funding, and emission reduction calculation and cost-effectiveness calculation methodologies.

A. Introduction

Stationary internal combustion engines used for agricultural purposes in California are primarily utilized to power irrigation water pumps. For the purposes of the Carl Moyer Program these engines could be considered part of the off-road equipment. However due to the operating characteristics specific to stationary agricultural engines, they are evaluated separately from the off-road equipment category, which generally covers mobile equipment such as agricultural tractors, backhoes, excavators, trenchers, and motor graders.

Off-road engines can be divided into two major categories: (1) engines less than (<) 175 brake horsepower (bhp) and (2) engines greater than or equal to (≥) 175 bhp. The federal Clean Air Act Amendments (CAAA) of 1990 gave the United States Environmental Protection Agency (U.S. EPA) exclusive authority to regulate new off-road engines. The amendments created a federal preemption that prevents states from adopting emissions standards or other requirements for off-road engines [CAA, section 209(e)]. However, Congress allowed California, upon receiving authorization from the U.S. EPA, to adopt standards and regulations for preempted engines, with the exception of new farm and construction engines <175 bhp. In other words, the ARB does not have authority to regulate off-road engines <175 bhp used in farm operations. Also, the California Health and Safety Code (HSC) section 42310(e) prohibits local air districts or the State from requiring a permit for farm equipment. Under the Carl Moyer Program, however, funding will be provided for voluntary reduction of NOx emissions from stationary agricultural pumps with engines 50 horsepower or greater. Section B of this chapter discusses specific criteria that must be met in order to qualify for funding from the Carl Moyer Program for this source category.

1. Emission Inventory

Agricultural irrigation pumps are powered electrically and with internal combustion engines. A 1995 report written by Sonoma Technology, Inc. for the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) indicates 90 percent of irrigation pumps in the San Joaquin Valley are electrically powered. The remaining 10 percent are engine-driven pumps fueled most commonly with diesel and, to a lesser degree, with natural gas or propane. Diesel is most commonly used due to its lower cost and the limitations posed by inaccessibility to natural gas lines in certain rural areas. In general, the lifetime for a stationary agricultural engine is about 30 to 40 years, with a typical overhaul happening at about 10-year intervals. Once an engine has exhausted its useful life, the most common engine replacement practice by farmers is to purchase a rebuilt engine rather than a new engine purchase.

Stationary agricultural engines can be considered a seasonal source of NOx emissions, although NOx emissions occur throughout the calendar year. Most NOx emissions occur throughout the spring and summer months during the primary crop growing period. In fact, seasonal NOx emissions from agricultural engines may be as high as 52 tons per day in the summer months throughout the San Joaquin Valley, according to a 1995 Sonoma Technology, Inc. report. According to the ARB's 1997 baseline NOx emission inventory for agricultural irrigation pumps powered by diesel engines, NOx emissions are 34 tons per day. ARB's estimated NOx emissions are based on data provided by San Joaquin Unified and Ventura County Air Pollution Control Districts. Future emissions are projected to remain the same through 2010.

2. Emission Standards

Historically, the districts have not regulated emissions from stationary agricultural engines. In fact, district prohibitory rules for stationary internal combustion engines specifically exempt agricultural engines from the requirements of the district rules. Therefore, stationary agricultural engine emissions are largely uncontrolled, except in cases where engines of 1996 model year and newer are in use. These engines are subject to ARB/U.S. EPA off-road diesel engine emission standards.

In January 1992, ARB adopted exhaust emission standards for 1996 and later model year off-road diesel cycle engines $\geq$175 bhp. The U.S. EPA has adopted virtually identical NOx emission standards for new off-road diesel cycle engines; however, the U.S. EPA standards apply to off-road engines $\geq$50 bhp. Table VI-1 lists both the ARB and U.S. EPA standards. As shown in Table VI-1, these standards vary depending on the model year and the engine size. The combination of ARB and U.S. EPA emission standards means that all of today's new off-road diesel cycle engines from 50 through 750 bhp have to be certified to meet a NOx emission standard of 6.9 g/bhp-hr.

ARB has also adopted optional NOx standards (emission reduction credit standards) for off-road diesel equipment. The optional NOx emission credit standards currently start at 5.0 g/bhp-hr and decrease in 0.5 g/bhp-hr increments. Beginning in 2001, the NOx emission credit standards for off-road diesel equipment will start at 4.5 g/bhp-hr and also decrease in

0.5 g/bhp-hr increments. Stationary agricultural engine projects eligible under the Carl Moyer Program must be certified to one of the emission reduction credit standards for 1996 and later model year engines. Certification must be conducted using the off-road test cycle.

Table VI-1
ARB and U.S. EPA Exhaust Emission Standards for New Off-Road Diesel Engines (g/bhp-hr)

Model Year	Agency	Horsepower	NOx (g/bhp-hr)	PM (g/bhp-hr)
1996 – 2000	ARB/EPA	175-750	6.9	0.4
1997	EPA	100-<175	6.9	-
1998	EPA	50-<100	6.9	-
2000+	ARB/EPA	750+	6.9	0.4
2001+	ARB	175-750	5.8	0.16

3. Control Strategies

The purpose of this section is to discuss commercially available control technologies for stationary agricultural engine projects. The reduced-emission engines discussed are considered suitable as new engine purchases for repower opportunities. This section also provides information regarding reduced-emission engine technologies that can be purchased now, and or have potential to become commercially available in the near term. These technologies are expected to be available for the Carl Moyer Program in the 1999-2000 time frame.

a. Emission-Certified Engines

New 1996 and later model year off-road diesel cycle engines from 50 through 750 bhp must comply with a NOx emission standard of 6.9 g/bhp-hr. Starting in model year 2000, off-road diesel cycle engines >750 bhp must also comply with a 6.9 g/bhp-hr NOx emission standard. The NOx emission standard for off-road diesel cycle engines with 175-750 bhp sold in California will be reduced to 5.8 g/bhp-hr for the model year 2001 engines.

A viable and cost-effective way to reduce emissions from uncontrolled engines is to replace the engine (i.e., repower) with an emission-certified engine instead of rebuilding the existing engine to its original uncontrolled specifications. With the exception of off-road engines >750 bhp, emission-certified engines are commercially available for off-road engines ≥50 bhp that are covered under this program. The appropriate engine size for an irrigation pump will depend on a number of factors such as water demand and the size of the irrigation pump.

b. Electric Motors

Another potentially cost-effective way to reduce emissions from uncontrolled engines is to replace the internal combustion engine with an electric motor instead of rebuilding the existing engine to its original uncontrolled specifications. Substituting an electric motor for an internal combustion engine on an agricultural irrigation pump significantly reduces emissions. Replacing an older electric motor for a newer electric motor on an agricultural irrigation pump does not reduce emissions. Irrigation pumps powered by electric motors are commercially available for various applications. In fact, 90 percent of current irrigation pumps are already powered by electric motors. Hence, the requirements for an electrification project to qualify for funding under the Carl Moyer Program are designed to target the replacement of the remaining 10 percent of internal combustion engines used in agricultural irrigation pumps. The viability of an electrification project will depend on a number of factors, including cost of electricity and proximity to an electric power grid.

c. Engine Retrofit Technology

Any retrofit technology must be certified by ARB before it can be sold in California, must be able to reduce NOx emissions by at least 25 percent, and must comply with established durability and warranty requirements. There are few retrofit technologies available for pre-1996 model year off-road diesel engines that would reduce NOx emissions from uncontrolled levels to the 6.9 g/bhp-hr NOx emission standard or lower. ARB recently pre-certified diesel engine retrofit kits for selected Detroit Diesel Corporation pre-1993 model year engines. The retrofit technology is certified to a NOx emission standard no greater than 5.8 g/bhp-hr. Currently, retrofit kits are available for a limited number of engine models, some of which may be engines in the size range typically used for agricultural irrigation pumps. It is also possible that retrofit technologies that have been used to reduce NOx and PM emissions from on-road heavy-duty diesel engines could be used to control off-road engine emissions in some applications.

B. Project Criteria

The intent of the Carl Moyer Program is to provide early emission reductions by encouraging the purchase of new emission-certified off-road engines. The proposed project criteria have been designed to provide districts and equipment operators with a list of minimum qualifications that must be met in order for a project to qualify for funding. The main criteria for selecting a project are: the amount of emission reductions, cost-effectiveness, and ability for the project to be completed within the timeframe of the program. The criteria also specify the method for calculating emission reductions and cost-effectiveness from reduced-NOx stationary agricultural engine projects. Reduced-NOx stationary agricultural engine projects that include engine repowers, engine replacements with electric motors, or engine retrofits will be considered and evaluated for incentive funding. In general, stationary agricultural engine projects qualifying for evaluation must meet, at minimum, the following proposed criteria:

- An engine must be 50 horsepower or greater which is equivalent to an electric motor 37 kilowatts or greater;

- An engine replacement must be with a new emission-certified engine instead of rebuilding the existing engine to its original uncontrolled specifications;

- Pre-1996 model year engines greater than 50 and through 750 horsepower must be certified at the 6.9 g/bhp-hr NOx emission standard;

- Pre-2000 model year engines greater than 750 horsepower must certify to a NOx level 30% below uncontrolled baseline emissions;

- Emission-certified engines of the model years 1996 and later, must be certified at one of the applicable NOx emission credit standards listed in Table VI-2;

Table VI-2
Project Eligibility Criteria
1996 and Later Model Year Engines

Engine Model Year	Engine Horsepower Rating (bhp)	Qualifying NOx Level (g/bhp-hr)
1996-2000	50-750	4.5
2000+	750+	4.5
2001+	50-750	4.0

- Electric motors must only replace internal combustion engines that are fueled with diesel, and the applicant must have documentation of payment to the local utility company for power installation;

- Reduced-emission engines or retrofit kits must be certified for sale in California and must comply with durability and warranty requirements. Qualified engines could include new ARB-certified engines or ARB-certified aftermarket part engine/control devices;

- NOx reductions obtained through this program must not be required by any existing regulations or any legally binding document (i.e. MOU, MOA, etc.);

- Funded projects must operate for a minimum of 5 years and the agricultural stationary engine must be registered with the district throughout the specified life of the project; and

- Projects must meet a cost-effectiveness criterion of $12,000 per ton of NOx reduced.

Priority should be given to proposed stationary agricultural engine projects which result in the greatest amount of emission reductions (e.g. engine replacements with electric motors, engine repowers with certified engines, followed by engine retrofits). This is in line with the intent of the Carl Moyer Program to provide early emission reductions, and in turn, produce the greatest air quality benefit.

C. Potential Types of Projects

The primary focus of this category of the Carl Moyer Program is to achieve emission reductions from stationary diesel agricultural engines operating in California as early and as cost-effectively as possible. The following project criteria are designed to ensure that the emission reductions expected through the deployment of electric motors, reduced-emission engines, or retrofit technologies under this program are real and quantifiable. All projects must meet a cost-effectiveness criterion of $12,000 per ton of NOx reduced. In addition, repower projects are also subject to a maximum dollar amount to be granted based on the horsepower rating of the engine. The project must be operated for at least five years from the time it is first put into operation.

1. Repower with Emission-Certified Engines or Replacement with Electric Motors

Purchases of new emission-certified diesel engines to repower uncontrolled diesel engines are expected to be the most common type of project for stationary agricultural engines under this program. These projects are currently being funded by several air districts. Replacement of uncontrolled engines with electric motors is not expected to be as frequent due to the higher capital costs associated with electrification projects.

Under the Carl Moyer Program, a stationary agricultural engine repower is replacing an existing uncontrolled engine with a new engine certified to a current NOx emission standard, or replacing an existing certified engine with a new engine certified to an optional ARB NOx emission credit standard for off-road diesel equipment. Another repower option would be the replacement of an existing engine with an electric motor. The certified NOx level that would qualify a stationary agricultural engine repower project for funding would depend on the engine model year and the engine size, as outlined in the criteria under section B and listed in Table VI-2.

Technology for "diesel-to-diesel" repowers is readily available, project applicants are familiar with these technologies, and these technologies are relatively inexpensive compared to alternative fuel technologies. Hence, off-road "diesel-to-diesel" engine repower projects are subject to a maximum grant amount award, based on the horsepower category of the engine. Staff believes that the incentive amounts listed in Table VI-3 are adequate to ensure participation in the Carl Moyer Program. Stationary agricultural engines are part of the off-road equipment category and are subject to the same limitations.

Table VI-3
Maximum Grant Award for Repowering Stationary Diesel Agricultural Engines

Horsepower Category	Maximum Incentive ($/repower)
50-99	4,000
100-174	10,000
175-299	14,000
300-499	20,000
≥ 500	25,000

2. Retrofits

Retrofit means making modifications to the engine and/or fuel system such that the retrofitted engine does not have the same specifications as the original engine. Retrofit projects may be applicable to certain off-road diesel engine families. The most straightforward retrofit projects are those that could be accomplished at the time of engine rebuild. This might entail upgrading certain engine and/or fuel system components to result in lower emission configuration. It is possible that emission control technologies that have been used to reduce NOx and PM emissions from on-road heavy-duty diesel engines could be used to control off-road engine emissions in some applications. To qualify for funding for this type of project, the engine retrofit kit for uncontrolled engines must be certified to 6.9 g/bhp-hr NOx emission standard, or less.

3. Sample Application

In order to qualify for incentive funds, districts will make applications available and solicit bids for reduced-emission projects from stationary agricultural engine operators. A sample application form is included in Appendix F. The applicant must provide at least the following information, as listed in Table VI-4 below:

Table VI-4
Minimum Application Information

1. Company name	9. Capital cost for rebuild without upgrade
2. Project name	10. Capital cost for repower/replacement with new Engine (reduced-NOx or electric motor)
3. Air district	11. Incentive amount requested
4. Equipment type: irrigation pump, etc.	12. Match funds
5. Engine horsepower rating	13. Project life (min. 5 years)
6. Type of engine (e.g., model and serial number)	14. Baseline NOx emissions
7. Type of fuel used	15. New reduced-NOx emissions
8. Estimated annual fuel usage or hours of operation and engine operating load	

D. Emission Reduction and Cost-Effectiveness

1. Emission Reduction Calculation

Qualification with the cost-effectiveness criteria will be based upon NOx emissions only. Calculations shall be done using either the fuel consumption method or hours of operation method described below, consistent with the type of records that will be maintained over the life of the project.

a. Fuel Consumption Method

To determine a NOx emission rate in terms of fuel consumed, an energy consumption factor must be used. A typical naturally aspirated diesel engine brake-specific energy consumption factor (BSFC) is 7,800 Btu per horsepower-hour on the certification cycle. With a diesel higher heating value (HHV) of 137,000 BTU/gallon, the energy consumption factor in horsepower-hour per gallon of fuel consumed is:

Energy consumption factor (bhp-hr/gallon) = HHV/BSFC
= 17.5

The difference in the baseline NOx emission levels between the existing engine and the replacement engine must be multiplied by the energy consumption factor to convert the g/bhp-hr emission factor to g/gallon of fuel used. Annual NOx emission reductions are then determined by multiplying the g/gallon emission factor by the estimated annual fuel consumption. This provides a direct conversion from annual fuel consumption to emissions even though there may be some variation because energy consumption is a function of the duty cycle.

For repower or retrofit projects involving uncontrolled engines, the emission reduction benefit must be determined by subtracting the certified NOx emission standard of the new engine from the uncontrolled baseline NOx emission rate of the existing engine. In absence of manufacturer “guaranteed” emission factors, Table VI-5 lists the default baseline NOx emission levels for pre-1996 model year diesel engine repower and retrofit projects to be used when determining the NOx emission difference between the existing engine and the replacement engine.

Table VI-5
Default Baseline Emission Factors
for Pre-1996 Stationary Diesel Agricultural Engines [a]

Engine Rated Power	NOx Emission Rate (g/bhp-hr)
50 through 175 bhp	13
>175 bhp	11

a. Emission factors are from the ARB off-road emission inventory.

For a certified (1996 and later model year) engine repower or retrofit project, the emission reduction benefit must be determined by subtracting the certified NOx emission credit standard of the new engine from the certified NOx emission standard of the engine being replaced.

For replacement of an engine with an electric motor, the emission reduction benefit must be determined by subtracting the equivalent NOx emission rate of the electric motor from the NOx emission standard of the engine being replaced. Equivalent emissions from an electric motor replacement of a fuel-fired engine can be determined by assessing the projected emissions increase from the fuel-fired power plant supplying the electricity for the electric motor. For the purposes of this program, potential increased emissions from power plants are considered to be insignificant and therefore equivalent NOx emissions for electric motors are considered to be negligible (i.e., 0.0 g/bhp-hr).

b. Hours of Operation Method

To determine an emission rate in terms of hours of operation, an engine load factor must be used. Internal combustion engines can be used in several operational modes. In many cases, they are used continuously under a constant power load, shutting down only when there is a breakdown, or when maintenance or repair is required. Other engines operate cyclically, changing power output on a regular, frequent schedule. Some engines may operate continuously, but for only part of the year. Generally, irrigation pump engines are not run at full load continuously during the irrigation season. Different farmers and farms will run engines at different loads. When designing an irrigation pump system, the load factor will be a function of the size of the irrigation pump, amount of water needed, and size of the available engine. To compensate for this load variation, a default load factor of 75 percent will be used in the absence of actual operating load data.

The difference in the baseline NOx emission levels between the existing engine and the replacement engine shall be multiplied by the engine-operating load, the engine rated brake horsepower, and the annual hours of operation to determine annual NOx emission reductions.

2. Cost-Effectiveness Calculation

The portion of the cost for a repower project to be funded through the Carl Moyer Program is the difference between the total cost of purchasing and installing the new emission-certified engine or electric motor and the total cost of rebuilding the existing engine.

Only the amount of money provided by the program and any local district match funding is to be used in the cost-effectiveness calculations. The one-time incentive grant amount is to be amortized over the expected project life (at least five years) and with a discount rate of five percent. The amortization formula (given below) yields a capital recovery factor, which, when multiplied with the initial cost, gives the annual cost of a project over its expected lifetime.

Capital Recovery = $[(1 + i)^n (i)]/[(1 + i)^n - 1]$

Where, i = discount rate (5 percent)
n = project life (at least five years)

The discount rate of five percent reflects the opportunity cost of public funds for the Carl Moyer Program. This is the level of earning that could be reasonably expected by investing state funds in various financial instruments, such as U.S. Treasury securities. Cost-effectiveness is determined by dividing the annualized cost by the annual NOx emission reductions. These calculations are explained in detail in the next section of this chapter.

3. Examples

For the purposes of explaining the emission reduction and the cost effectiveness calculations from a particular stationary agricultural engine project, three examples are presented below.

Example 1 – Agricultural Irrigation Pump Repower: Consider a farmer faced with the opportunity to replace a 1980 model year diesel engine used to power an irrigation water pump. The farmer is replacing the old uncontrolled engine (13 g/bhp-hr NOx) with a new, certified off-road diesel engine (150 hp, 6.9 g/bhp-hr NOx), during the normal rebuild period. In this case, the cost of the new, emission-certified diesel engine is $7,900 whereas the cost to purchase a rebuilt engine would be $5,500. The cost of a non-resettable hour meter is $300. The new engine will operate 2,000 hours annually, for a project life of 5 years. The emission reduction and cost effectiveness for this project are calculated as follows:

Emission Reduction Calculation

Annual NOx Reductions (tons/year) =
[(Baseline NOx) - (Reduced NOx)] * (Horsepower Rating) * (Load Factor) * (Annual Operating Hours) * (ton/907,200 grams)

Where,

Baseline NOx Emissions = Emission level from an uncontrolled diesel engine (13.0 g/bhp-hr)
Reduced NOx Emissions = Certified NOx emission level from a new diesel engine (6.9 g/bhp-hr)
Load Factor = 75%
Annual Operating Hours = 2,000 hours/year
ton/907,200 grams Converts grams to tons

Hence, estimated annual NOx reductions are:

((13.0 **-** 6.9) g/bhp-hr)(150 bhp)(0.75)(2,000 hours/year)(ton/907,200 g) = **1.5 tons/year**

Cost and Cost-Effectiveness Calculations

The annualized cost is based on the portion of incremental project costs funded by the Carl Moyer Program, the expected life of the project (5 years at a minimum), and the interest rate (5 percent) used to amortize the project cost over the project life. The incremental capital cost to the operator for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

Incremental Capital Cost = $8,200 - $5,500 = $2,700
Max. Amount Funded = $2,700
Capital Recovery **=** $[(1 + 0.05)^5 (0.05)]/[(1 + 0.05)^5 – 1] = 0.23$
Annualized cost = (0.23)($2,700) = $621/year
Cost-Effectiveness = ($621/year)/(1.51 tons/year) = **$411/ton NOx reduced**

The project meets the cost-effectiveness limit of $12,000/ton NOx reduced and is within the maximum incentive amount of $10,000 for a diesel repower of a 100-174 bhp engine. This project would qualify for the maximum amount of grant funds ($2,700).

Example 2 - Agricultural Irrigation Pump Repower: Consider a similar example, where an uncontrolled diesel engine (1980, 13 g/bhp-hr NOx) used to power an irrigation water pump is replaced with a new, certified off-road diesel engine (150 hp, 6.9 g/bhp-hr NOx). However, in this example fuel consumption is provided. The cost of the new, emission-certified diesel engine is $7,900 whereas the cost to purchase a rebuilt engine would be $5,500. The farmer lists in the application that the new engine will use 4,600 gallons of fuel annually for a project life of 5 years. Since this farmer lists fuel consumption, a non-resettable hour meter is not needed. The emission reduction and cost effectiveness for this project are calculated as follows:

Emission Reduction Calculation

Annual NOx Reductions (tons/year) =
[(Baseline NOx) - (Reduced NOx)] * (Energy Cons. Factor) *
(Annual Fuel Consumption)*(ton/907,200 grams)

where,

Baseline NOx Emissions	= Emission level from an uncontrolled diesel engine (13.0 g/bhp-hr)
Reduced NOx Emissions	= Certified NOx emission level from a new diesel engine (6.9 g/bhp-hr)
Energy Consumption Factor	= 17.56 bhp-hr/gallon
Annual Fuel Consumption	= 4,600 gallons/year
ton/907,200 grams	Converts grams to tons

Hence, estimated annual NOx reductions are:

((13.0 - 6.9) g/bhp-hr)(17.56 bhp-hr/gal)(4,600 gal/year)(ton/907,200 g) = **0.5 tons/year**

Cost and Cost-Effectiveness Calculations

The annualized cost is based on the portion of incremental project costs funded by the Carl Moyer Program, the expected life of the project (5 years at a minimum), and the interest rate (5 percent) used to amortize the project cost over the project life. The incremental capital cost to the fleet operator for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

Incremental Capital Cost	= $7,900 - $5,500 = $2,400
Max. Amount Funded	= $2,400
Capital Recovery	= $[(1 + 0.05)^5 (0.05)]/[(1 + 0.05)^5 – 1] = 0.23$
Annualized cost	= (0.23)($2,400) = $552/year
Cost-Effectiveness	= ($552/year)/(0.54 tons/year) = **$1,022/ton NOx reduced**

The project meets the cost-effectiveness limit of $12,000/ton NOx reduced and is within the maximum incentive amount of $10,000 for a diesel repower of a 100-174 bhp engine. This project would also qualify for the maximum amount of grant funds.

Example 3 - Agricultural Irrigation Pump Electrification: Consider a farmer who applies for a Carl Moyer program grant for the purchase of an electric motor (0 g/bhp-hr NOx) to replace an uncontrolled diesel engine (150 bhp, 1980, 13 g/bhp-hr NOx) used to power an irrigation water pump. There is currently an electric power grid in the immediate vicinity of the pump. The cost of the new electric motor is $19,500 whereas the cost to rebuild the old engine would be $5,500. The cost to drop a power line and set up a circuit breaker is about $2,000. The cost to drop the line is considered an infrastructure cost, and would not be eligible for funding. However, the applicant would submit proof of payment to the district as documentation that a new line was installed. The old engine has historically used 4,600 gallons of diesel fuel annually. The emission reduction and cost effectiveness for this project are calculated as follows:

Emission Reduction Calculation

Annual NOx Reductions (tons/year) =
[(Baseline NOx) - (Reduced NOx)] * (Energy Cons. Factor) * (Annual Fuel Consumption) * (ton/907,200 grams)

Where,

Baseline NOx Emissions	= Emission level from an uncontrolled diesel engine (13.0 g/bhp-hr)
Reduced NOx Emissions	= Certified NOx emission level from a new diesel engine (0 g/bhp-hr)
Energy Consumption Factor	= 17.56 bhp-hr/gallon
Annual Fuel Consumption	= 4,600 gallons/year
ton/907,200 grams	Converts grams to tons

Hence, estimated annual NOx reductions are:

((13.0 - 0) g/bhp-hr)(17.56 bhp-hr/gal)(4,600 gal/year)(ton/907,200 g) = **1.2 tons/year**

Cost and Cost-Effectiveness Calculations

The annualized cost is based on the portion of incremental project costs funded by the Carl Moyer Program, the expected life of the project (5 years at a minimum), and the interest rate (5 percent) used to amortize the project cost over the project life. The incremental capital cost to the fleet operator for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

Incremental Capital Cost	= \$19,500 - \$5,500 = \$14,000
Max. Amount Funded	= \$14,000
Capital Recovery	= $[(1 + 0.05)^5 (0.05)]/[(1 + 0.05)^5 – 1] = 0.23$
Annualized cost	= (0.23)(\$14,000) = \$3,220/year
Cost-Effectiveness	= (\$3,220/year)/(1.2 tons/year) = **\$2,683/ton**

The project meets the cost-effectiveness limit of $12,000/ton NOx reduced. Since this project requires purchase of a new pump and motor, the project is not considered a repower. Hence the project would qualify for the maximum amount requested, which is $14,000.

E. Reporting and Monitoring

Stationary agricultural engine operators participating in the Carl Moyer Program must keep appropriate records during the life of the project. During the project life, the district has the authority to conduct periodic checks or solicit operating records from the applicant that has received Moyer funds. This is to ensure that the engine is being operated as stated in the project application.

1. Reporting

Records must be retained and updated throughout the project life and be made available to the district upon request. Annual records will be required for each engine and must contain, at a minimum, total actual hours operated, or estimated amount of fuel used. Where records of actual hours of operation are chosen, the engine must be equipped with a non-resettable hour meter. The cost of the hour meter shall be included in the capital cost of the engine for determining grant monies awarded. For electrification projects, the applicant must have documentation of payment to the local utility company for power installation.

2. Monitoring

Minimal monitoring may be necessary to ensure the program incentive monies are being applied toward the project as specified in the application. It is recommended that the districts conduct initial and/or periodic inspection of the equipment, especially when an electric motor is replaced for an internal combustion engine. To ease the tracking of the equipment over the life of the project, a district registration certificate could be issued to the equipment owner, consisting of minimal descriptive information.

E. References

1. California Air Pollution Control Officer's Association (CAPCOA) Portable Equipment Rule Piston IC Engine Technical Reference Document, May 19, 1995.

2. California Air Resources Board, Stationary Source Division, Emissions Assessment Branch, Process Evaluation Section, *CAPCOA/ARB Proposed Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Stationary Internal Combustion Engines*, draft report, December 3, 1997.

3. Sierra Research, Inc., *Evaluation of VOC and NOx Control Measures*, Report No. SR98-04-01, April 2, 1998.

4. Sonoma Technology, Inc., *Emission Inventory of Agricultural Internal Combustion Engines Used for Irrigation in the SJVUAPCD*, Final Report STI-95240-1569-FR, August 1996.

5. United States Environmental Protection Agency, *AP-42, Compilation of Air Pollutant Emission Factors*, Fifth Edition, Volume I, Appendix A, January 1995.

CHAPTER VII.

ADDITIONAL SOURCE CATEGORIES

This chapter describes staff's plan for including forklifts and airport ground support equipment (GSE) in the Carl Moyer Program. Staff is proposing to develop project requirements for those two categories and submit them to ARB's Executive Officer for approval. This chapter also describes how other projects not currently in the guidelines could be submitted to ARB's Executive Officer for approval on a case-by-case basis.

A. Forklifts

Forklifts can be powered by electric motors or by internal combustion engines (ICEs). Electric forklifts have no evaporative or tailpipe emissions, and minimal "upstream" emissions from the production of electricity to power the forklifts. Therefore, replacing internal combustion powered forklifts with electric forklifts where practicable can significantly reduce emissions from forklifts. Electric forklifts are typically used in indoor materials handling applications (e.g., forklifts at warehouse/supply buildings). Electric forklifts are common in applications that do not require large lift capacities. However, electric models with lift capacities of up to 12,000 pounds are available from a number of manufacturers, and a few manufacturers carry models with lift capacities up to 16,000 pounds.

Substituting an electric forklift for an internal combustion engine forklift significantly reduces emissions. Replacing an older electric forklift with a newer electric forklift does not reduce emissions. The Carl Moyer Program requirements for forklifts must be designed to target the replacement of internal combustion engine forklifts.

In developing the Carl Moyer Program requirements, staff will exclude those projects where electric-to-electric replacements are common, and include those categories where electric-to-electric replacements are very uncommon. Staff will also propose including categories where there is typically a mix of electric and internal combustion engine models. For those mixed categories, staff will look for additional criteria to target the replacement of ICE forklifts with electric forklifts. Staff is considering proposing that only those projects that require installation of a charger be eligible for funding.

The Industrial Truck Association has defined seven categories for material handling equipment. The categories that correspond to forklifts are:

- Class 1 forklifts are electric motor sit-down riders and electric counter-balanced trucks with cushion or pneumatic tires
- Class 2 forklifts are electric motor narrow aisle trucks with solid tires
- Class 3 includes electric motor hand trucks or hand/rider trucks with solid tires
- Class 4 forklifts are internal combustion sit-down rider forklifts with cushion tires
- Class 5 forklifts are internal combustion sit-down rider forklifts with pneumatic tires
- Class 7 forklifts are rough terrain forklift trucks with pneumatic tires which are traditionally powered by internal combustion engines

Class 2 and Class 3 forklifts are used in applications where internal combustion engine forklifts are not practical. There is no need to provide incentives for Class 2 or Class 3 forklifts as those electric models already dominate the market. Therefore, Class 2 and Class 3 forklifts would be excluded from the program.

Population data for 1995 indicate that there were over 41,000 ride-on type electric-powered forklifts in California in that year. At the same time there were over 50,000 gasoline and LPG-fueled forklifts in use in the state. Thus, about 45 percent of ride-on forklifts are electric. Those ride-on electric forklifts include both Class 1 and Class 2 forklifts. As stated, Class 2 forklifts would be excluded from the program. About 30 percent of ride-on forklifts are Class 1 forklifts. Class 1 forklifts compete directly with the forklifts in Classes 4 and 5, which are powered by internal combustion engines. Increasing the market share of Class 1 forklifts and decreasing the market share of Class 4 and 5 forklifts would reduce emissions. Because of the potential for emission reductions, staff proposes to include incentives for Class 1 forklifts in the Carl Moyer Program.

Electric forklifts are an appealing category for which to provide funding for several reasons. First, the potential emission benefits are significant. A typical LPG forklift being sold today will have lifetime emissions of 2.4 tons of NOx. Second, the cost-effectiveness and lifetime costs of electric forklifts are very positive. Third, industry has had significant experience with this equipment and has been able to demonstrate its effectiveness in a variety of applications. Despite all these advantages, sales of Class 1 electric forklifts have been stagnant. It is anticipated that incentive funds would not only obtain cost-effective emission benefits, but also have the potential to make a significant long-term impact on this industry.

Although Class 1 (electric forklifts) account for about 30 percent of ride-on forklifts overall, the percentage of electric forklifts in-use varies greatly from one application to the next. For example, grocery warehouses use electric forklifts almost exclusively, whereas a lumberyard would likely use a forklift powered by an internal combustion engine. In developing the project requirements for forklifts, staff will consider the need to target specific industries/applications and exclude others. Staff will also consider the need for caps on the maximum incentive, like the caps for other off-road categories.

To summarize, staff will develop project requirements for forklifts. Staff recommends providing incentives for the replacement of Class 4 and Class 5 ICE forklifts with Class 1 electric forklifts. The requirements will be structured so that categories where electric forklifts are not commonly used are eligible for incentives, and categories where electric forklifts are very prevalent are not eligible. In categories that are less clear cut, staff will develop and propose criteria that target ICE to electric replacements. In developing project criteria, staff will evaluate the need for a number of requirements. These could include a requirement for the installation of a charger, caps on the maximum incentive, like those applicable to other off-road categories, and other requirements.

B. Airport Ground Support Equipment (GSE)

Airport vehicles and ground support equipment are used to transport passengers as well as baggage and freight, to support maintenance and repair functions, and to provide power to various service functions. Vehicles and equipment at airports fall into two broad categories. "Land-side" vehicles and equipment are used on the passenger/entry side of the airport. "Air side" vehicles and equipment are used principally (at least half of the time) on the tarmac. For purposes of the Carl Moyer Program, the airport GSE project category is restricted to air side equipment. Land side vehicles and equipment would be included in the Carl Moyer Program categories described in other chapters, such as on-road vehicles and off-road equipment.

Airport GSE includes tugs for airplane pushback and hook-up, carts for moving people and materials, vehicles, forklifts and lifts, air conditioning tugs that provide power to the aircraft, belt and container loaders, and other equipment. Airport GSE does not include aircraft engines.

Replacing ICE models with electric models can significantly reduce emissions from airport GSE. The percentage of electric GSE varies considerably from airport to airport, and by airline. For example, Denver International Airport was built within the last ten years, and was designed for all electric GSE. Most of the airports in California use mainly internal combustion engine GSE. Los Angeles International Airport (LAX), for example, uses between 10 and 20 percent electric GSE. Some airlines are moving toward electric GSE. American Airlines, for example, has committed to converting all their GSE to electric over the next four years. Southwest, Delta, and other airlines also have some electric GSE.

There are no regulations requiring the use of electric GSE at airports. SIP Measure M15 calls for U.S. EPA to set new standards for aircraft engines. U.S. EPA's Federal Implementation Plan (FIP), which was superseded by California's SIP, did call for electric GSE at airports. As an outgrowth of the FIP/SIP activities, ARB, U.S. EPA, SCAQMD, the Air Transport Association (ATA), and other stakeholders in the South Coast area have been participating in a Public Consultative Process. The purpose of the consultative process is to consider approaches (besides aircraft standards) to reducing emissions at airports. The outcome of the consultative process is expected to be a Memorandum of Understanding signed by the stakeholders, agreeing to reduce emissions from airport GSE. The MOU will cover five airports in the South Coast area: LAX, Ontario, Orange County, Burbank, and Long Beach. Because those five airports are covered under the consultative process, they would not be eligible for incentives under the Carl Moyer Program.

Staff recommends that the other airports in the state be included in the Carl Moyer Program, and that incentives be provided to introduce new electric GSE at those airports. Staff proposes to develop project requirements for airport GSE. Staff will consider the types of equipment that should be included, whether caps on the maximum incentive (like those for off-road equipment) are appropriate, whether only those projects that require the installation of charging infrastructure should be funded, and other issues.

C. Other Projects

At the present time, forklifts and airport GSE are the only two project categories which staff plans to add to the Carl Moyer Program guidelines. However, it is very likely that there are other projects, not currently included in the guidelines, which could yield cost-effective emission reductions. To take advantage of such opportunities, and to build some flexibility into the Carl Moyer Program, staff proposes that other projects could be approved by ARB's Executive Officer on a case-by-case basis. Any additional projects approved on a case-by-case basis would need to meet the fundamental tenets of an incentive program (i.e. it must have real, quantifiable emission reductions). Districts could assist project proponents in presenting proposed projects to the Executive Officer for consideration.

CHAPTER VIII.

ISSUES

Support for the Carl Moyer Program has been very strong, with the general recognition that the program is needed to meet California's clean air commitments. However, there have been a number of issues raised, which is not surprising given the magnitude of the program and the number of project categories included. This chapter describes the issues considered during the development of the proposed guidelines. A number of these issues have been resolved, but a few remain controversial.

A. Funding Allocation

One of the main issues raised at working group meetings with the districts has been the proposed allocation of funding among the districts. A few district representatives commented that the proposed funding allocation for their district was insufficient. One district representative commented that funding should go to districts that currently have mobile source incentive programs, and not to districts in attainment areas. That district representative commented that funding should go to districts that have demonstrated that they can achieve cost-effective emission reductions, and that can implement the program quickly.

ARB staff recognizes the value of experience in administering incentive programs like district motor vehicle fee programs and the proposed Carl Moyer Program. District experience was critical to the development of these proposed guidelines, and will be extremely valuable in implementing the program. The great majority of Carl Moyer Program funding has been tentatively allocated to districts with experience administering incentive programs. However, ARB staff believes that the Carl Moyer Program is important to the improvement and maintenance of air quality throughout the state, and therefore proposes that $1 million of the total funding be allocated to districts in attainment areas. ARB staff has proposed requirements for reporting and review of district progress implementing the program. ARB encourages districts to implement the program quickly, and sign contracts with project applicants within one year. ARB staff has proposed provisions for reallocating funding that is not under contract within one year to districts that have demonstrated that they can effectively implement the program.

B. PM Emission Reductions

Representatives of a company that manufactures emission control devices, and representatives of an environmental group have commented that the program should require PM emission reductions in addition to the required NOx emission reductions.

Controlling PM emissions from diesel engines is a high priority for the ARB. ARB recently identified the fine particulate component of diesel exhaust as a toxic air contaminant. ARB has formed an advisory committee that will assess the effectiveness and the need for various control strategies, including: conducting an assessment of public exposure and preparing risk management guidelines, evaluating mobile and stationary source control measures, assessing the effect of fuel formulation, and investigating alternative control strategies (such as incentive programs.)

While the Carl Moyer Program is in its formative stage staff believes the program should focus on the main objective, which is to obtain cost-effective NOx reductions. ARB staff expects that the advisory committee would review the effectiveness of the Moyer program and assess the need to include specific PM reduction goals for future years.

ARB staff is confident that the Carl Moyer Program will achieve significant reductions in PM emissions. The majority of projects that will be funded will reduce PM emissions; alternative fuel transit buses and trucks, repowering off-road equipment with cleaner diesel engines, replacing stationary agricultural pump and forklift engines with electric motors, and other projects will reduce PM emissions. ARB staff believes that imposing a requirement on the number of projects that must achieve PM emission reductions in addition to NOx emission reductions is unnecessary, and could complicate program implementation. Therefore, ARB staff recommends that achieving PM reductions (in addition to the required NOx emission reductions) be a program goal, rather than a requirement.

C. Stationary Agricultural Pump Engines

District representatives and representatives of the agricultural community have commented that stationary agricultural engines should be eligible for incentives under the program. Proponents state that significant emission reductions can be achieved by replacing diesel ICE models with electric models, or with lower-emission ICE models.

About 90 percent of stationary agricultural pumps are powered by electric motors. There are no emission benefits to replacing an older electric pump with a new electric pump. However, there are applications where agricultural pumps powered by internal combustion engines are used. Replacing an ICE with an electric motor will result in significant emission reductions. The challenge for ARB staff has been developing guidelines that target the replacement of ICEs with lower-emission ICEs, or with electric motors. ARB staff has included stationary agricultural engines in the program. ARB staff believes the proposed project requirements effectively target appropriate ICE replacements.

D. Forklifts and Airport Ground Support Equipment

Members of the California Electric Transportation Coalition have commented that forklifts and airport ground support equipment (GSE) should be eligible for incentives under the Carl Moyer Program. They state that electric equipment is available now that can replace IC engine models and significantly reduce emissions. Proponents state that although about 45 percent of ride-on forklifts are electric, the market share of Class 1 electric forklifts has been stagnant. Therefore, proponents state that incentives are needed to increase market penetration of Class 1 forklifts. For airport GSE, members of the California Electric Transportation Coalition commented that the introduction of electric GSE is happening very slowly, and should be encouraged through the use of incentives.

In the forklift category, the challenge for ARB staff is to develop guidelines that target the replacement of ICE forklifts with electric forklifts, and to avoid electric-to-electric replacements. For airport GSE, the challenge is to develop guidelines that do not interfere with the development of an MOU calling for five airports to reduce emissions from airport GSE. ARB staff proposes to include forklifts and airport GSE in the program. ARB staff will develop and propose forklift project requirements that target replacement of ICE forklifts, and will develop and propose airport GSE that targets airports that are not going to be included in the MOU.

E. Excess Emission Settlement

ARB and the U.S. EPA recently completed settlement negotiations with engine manufacturers. Engine manufacturers were found to have used alternative injection strategies that improved fuel economy, but significantly increased NOx emissions over allowed levels. Under the terms of the settlement, the manufacturers must pay substantial penalties, and implement a number of Supplemental Environmental Projects (SEPs). Although manufacturers do not have to recall the engines, they must pay to have the engines fixed at the next rebuild (heavy-duty engines are typically rebuilt every five years). In addition, under the terms of the settlement, manufacturers must push forward the introduction of lower-emission engines from 2004 (as currently required) to October of 2002.

Under the California agreement, the state will receive about $20 million in fines, and another $15 million worth of SEPs. Former Governor Wilson called for the fine money to be dedicated to the Carl Moyer Program. Should the Legislature make the required appropriation, it would increase total funding for the Carl Moyer Program to $45 million.

The excess emissions settlement also affects the program through a revised baseline for heavy heavy-duty (Class 8) diesel trucks. Although the required standard for Class 8 trucks is 4 g/bhp-hr of NOx, because of the alternative injection strategies, the in-use emissions will be limited to 6 g/bhp-hr of NOx until October of 2002. That revised baseline has been included in the calculation methodology for the proposed program. Of course, the fact that the Class 8 truck diesel engines produce excess NOx emissions makes buying an alternative fuel truck certified to 2.5 g/bhp-hr NOx or less that much more attractive.

F. Alternative Fuel Transit and School Buses

At the September 1998 Board hearing, the Board adopted a resolution supporting immediate and continued efforts to replace diesel-fueled school and public transit buses with cleaner alternative-fuel buses. In keeping with that policy, staff has proposed not to provide incentives for diesel-to-diesel repowers for school or transit buses. Two districts have commented that we may forego potential emission benefits as a result of that policy. One district commented that diesel repowers could achieve emission benefits now, whereas some transit agencies may be reluctant to switch to alternative fuels and therefore put it off to the future. The other district is a rural district, and their representative stated that alternative fuel transit and school buses are not feasible in their district.

Staff believes that the Carl Moyer Program requirements should be consistent with stated Board policy. Furthermore, although diesel-to-diesel repowers may provide limited emissions benefits today, they could delay the significant long-term benefits that would result from switching to alternative fuels. Therefore, staff proposes incentives only for alternative-fuel school and transit buses.

G. Incremental Cost of Transit Buses

Transit bus purchases are subsidized with federal funds. Federal funds can be used to cover 80 percent or more of the cost of a transit bus, including the incremental cost. Therefore, ARB staff proposed that the Carl Moyer Program funding should only cover that portion of the incremental cost not paid for with federal funds. Transit bus project proponents commented that, although federal funds may cover about 80 percent of the cost of individual bus purchases, the pool of federal money allocated to a transit district is limited. Therefore, they state, a transit district cannot buy as many buses if they opt to go with alternative fuel buses instead of diesel buses. It is not ARB's intent to limit the number of transit buses that can be purchased. However, the Carl Moyer Program is designed to cover only the incremental cost of projects. ARB staff is currently investigating transit bus funding issues, and whether funding for alternative fuel buses might affect the number of buses that can be purchased.

H. Hydrocarbon Limitation (≤10% increase) for Retrofits

To be eligible for incentives under the Carl Moyer Program, a heavy-duty vehicle retrofit kit must be certified to an optional (credit) standard for NOx. Under retrofit certification requirements, the kit must be certified to a credit standard for one pollutant (NOx), and emissions of the other pollutants must not increase by more than 10 percent. A manufacturer of conversion systems for new and in-use engines commented that ARB should amend the retrofit regulations to allow credits for conversions that certify within the required standards (and eliminate the 10 percent limit).

The 10 percent limit was put in place to ensure that retrofit kit manufacturers did not lower emissions of one pollutant while significantly increasing emissions of another pollutant. Although the basis for that requirement is reasonable, in practice it has been problematic for the manufacturers of alternative fuel conversion kits. Diesel engines operate in a lean-fuel/oxygen rich mode. Therefore, CO, and HC emissions from diesel engines are very low, and considerably below the required standards. Ten percent of a very low emissions level is an extremely small increase, and in practice is difficult to meet for alternative fuel conversions. Even with the (more than 10 percent) increase, the alternative fuel conversion is still well below the required standards. But because of the 10 percent increase limit, the kit still could not be certified. In fact, there currently are no retrofit kits certified for heavy-duty engines.

This requirement also is an equity issue, because new engine conversions that are sold as OEM models are only required to meet the current standards. Thus, retrofit kit requirements in practice are more stringent than the new engine requirements.

Alternative fuel conversions have the potential to provide significant overall emissions benefits. Therefore, ARB staff is considering changing the certification requirements.

I. Match Funding from Private Companies

A number of people asked whether private companies would be allowed to provide match funding in lieu of the district. One port authority representative commented that private port tenants should be allowed to provide the required matching funds, since district motor vehicle fees cannot be used to fund marine projects.

ARB staff believes it is appropriate for districts to provide the required matching funds. This requirement will facilitate an equitable distribution of funds, in that it will prevent companies with "deep pockets" from tying up the majority of the funds. This requirement will also help ensure that districts carefully evaluate the projects they approve for funding. ARB staff believes allowing matching funds to be met on an overall program basis, rather than a project-by-project basis alleviates the restriction on the use of district motor vehicle fees. See Chapter I for further discussion and an example of how the proposed requirements relate to the restrictions on the use of motor vehicle fees.

Two other proposed requirements related to match funding are: 1) private companies may provide funds to "buy-down" the cost of a project so it meets the cost-effectiveness criterion and can be funded, and 2) port authorities may provide match funding in lieu of the districts. Those two requirements are explained in Chapter I, and neither has been raised as an issue.

J. Extra Incremental Cost for Early Engine Repowers

If an engine is replaced with a new engine (a repower project), it is typically done at the time when the engine is ready for a rebuild. Thus, the proposed incremental cost for repowers is the incremental cost over rebuild. A number of project proponents have asked that an extra allowance for incremental cost be given for engines that are replaced with a new engine before they are ready for a rebuild.

ARB staff believes that a blanket allowance for extra incremental cost for early repowers is not appropriate. First, early repowers are uncommon. Second, staff is concerned that a blanket allowance would lead to project proponents arguing for an incremental allowance for almost every project, since "ready for a rebuild" is subjective.

Projects where early repowers are a significant issue, such as conversion of an entire fleet to alternative fuel, may be submitted to ARB's Executive Officer for evaluation on a case-by-case basis.

CHAPTER IX.

SUMMARY AND RECOMMENDATIONS

A. Summary

These guidelines are the proposed requirements for the Carl Moyer Program. The guidelines establish the basic structure of the program, and the requirements for districts that will be implementing the program locally. The proposed guidelines are designed to ensure that the program achieves real, cost-effective emission reductions. The guidelines also include a tentative allocation of funds. The allocation will be finalized after districts submit their applications (with requests for funding and commitments to provide matching funds.)

Proposed project requirements have been developed for a variety of categories, including on-road vehicles, off-road equipment, marine vessels, locomotives, and stationary agricultural pumps.

ARB staff has committed to a number of tasks following the February board hearing. Staff will develop project criteria for forklifts and airport GSE. Staff will also modify a database currently used for reporting motor vehicle fee projects so that the database can be used to report Carl Moyer Program projects as well. Staff will also expedite review and approval of district program applications. And finally, ARB staff will assist with program outreach.

B. Recommendations

Staff recommends that the Board:

- Approve the proposed district program requirements

- Approve the proposed on-road, off-road, marine, locomotive, and stationary agricultural pump project requirements

- Support staff's proposed development of project requirements for forklifts and airport GSE

- Approve the tentative funding allocation

- Delegate to the Executive Officer the authority to approve proposed projects on a case-by-case basis

- Delegate to the Executive Officer the authority to approve the forklift and airport GSE project requirements after they are developed, and to approve other appropriate updates to the Guidelines as needed

- Support efforts to identify additional funding for the program, including but not limited to the excess emissions settlement funding