TITLE 13. CALIFORNIA AIR RESOURCES BOARD

NOTICE OF PUBLIC HEARING TO CONSIDER THE ADOPTION OF PROPOSED AIRBORNE TOXIC CONTROL MEASURE FOR IN-USE DIESEL-FUELED TRANSPORT REFRIGERATION UNITS (TRU) AND TRU GENERATOR SETS, AND FACILITIES WHERE TRUs OPERATE

The Air Resources Board (ARB or Board) will conduct a public hearing at the time and place noted below to consider adopting a regulation to reduce public exposure to diesel exhaust particulate matter (diesel PM) and other toxic air contaminants (TAC) by reducing in-use emissions from Transport Refrigeration Units (TRU) and TRU generator sets.

DATE: December 11, 2003

TIME: 9:00 a.m.

PLACE: California Environmental Protection Agency
Air Resources Board
Central Valley Auditorium
1001 I Street
Sacramento, California 95814

This item will be considered at a two-day meeting of the ARB, which will commence at 9:00 a.m., on Thursday, December 11, 2003, and may continue at 8:30 a.m., Friday, December 12, 2003. This item may not be considered until Friday, December 12, 2003. Please consult the agenda for the meeting, which will be available at least ten days before December 11, 2003, to determine the day on which this item will be considered.

If you have special accommodation or language needs, please contact the ARB's Clerk of the Board at (916) 322-5594 or sdorais@arb.ca.gov as soon as possible. TTY/TDD/Speech-to-Speech users may dial 7-1-1 for the California Relay Service.

INFORMATIVE DIGEST OF PROPOSED ACTION AND POLICY STATEMENT OVERVIEW

Sections Affected: Proposed adoption of Chapter 3 - Article 4, section 2022, title 13, California Code of Regulations (CCR).

Background: In 1998 the Board identified diesel particulate matter emissions from diesel-fueled engines as a toxic air contaminant. Two years later, the Board adopted the Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles (Diesel Risk Reduction Plan) in September 2000, which established a goal of reducing emissions and the resultant health risk from virtually all diesel-fueled engines and vehicles within the State of California by the year 2020. This Plan envisions that particulate matter emissions from diesel-fueled engines and vehicles should be reduced by 75 percent in 2010 and 85 percent in 2020. The Plan identified various methods for achieving the goals including new, more stringent standards for all new diesel-fueled engines and vehicles, the replacement of older in-use engines with new, cleaner engines, the use of diesel emission control strategies on in-use engines, and the use of low-sulfur diesel fuel.

The major sources of diesel PM are the approximately 1,250,000 diesel-fueled engines in vehicles and equipment used in California. The health impacts of diesel PM include increased incidence of lung cancer, chronic respiratory problems (such as asthma and bronchitis), cardiovascular disease, and increased hospital admissions and mortality. In California, diesel PM emissions are estimated to comprise 70 percent of the total potential cancer risk from all identified toxic air contaminants.

TRU diesel engines currently emit approximately two tons per day of diesel PM. The diesel PM emissions from TRUs are expected to increase to about 2.5 tons per day in 2010, and to about three tons per day in 2020 as more TRUs are placed into service. Because of the high potency of diesel PM and the potential for large numbers of TRUs to operate at one location, often times near residential areas, staff believes that there are situations where the estimated 70-year potential cancer risk resulting from exposure to diesel PM emissions from TRUs will be in excess of a 100 in a million.

On May 16, 2002, the Board approved the *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines* (13 CCR Sections 2700-2710). This rule establishes procedures for the verification of emission control strategies by ARB that can be applied on various diesel-fueled engines and vehicles to significantly reduce diesel PM emissions.

It is important to reduce diesel PM emissions from TRUs. H&SC sections 39666 and 39667 requires the ARB to adopt regulations to achieve the maximum possible reduction in public exposure to TACs through the application of best available control technology (BACT), or a more effective control method, in consideration of cost, risk, environmental impacts, and other specified factors.

Furthermore, the Children's Environmental Health Protection Act (Stats. 1999, Ch. 731) requires the California Environmental Protection Agency to specifically consider children in setting Ambient Air Quality Standards and in developing criteria for TACs. OEHHA identified diesel PM and several other TACs associated with motor vehicle exhaust among the top priority pollutants affecting children's health.

ARB staff has prepared an Initial Statement of Reasons (ISOR) for the proposed Airborne Toxic Control Measure for *In-Use Diesel-Fueled TRUs and TRU Gen Sets, and Facilities where TRUs Operate* (proposed ATCM) that, together with the needs assessment (Diesel Risk Reduction Plan), serves as the report on the need and appropriate degree of regulation for in-use TRUs.

Description of the Proposed Regulatory Action: The proposed ATCM is designed to reduce the general public's exposure to diesel PM, other toxic contaminants, and criteria air pollutants from TRUs.

Applicability

The requirements of the proposed ATCM would affect owners and operators of "in-use" diesel-fueled TRUs and TRU generator sets that operate in California. This would include all carriers, whether based in California or out-of-state, that transport perishable goods using refrigerated trucks, trailers, shipping containers, and railcars within the state. Most TRUs are owned or operated by corporations, businesses, and individuals. There are a few local municipalities, school districts, and correctional institutions that operate TRUs that may be affected. Staff estimates that there are currently approximately 32,000 California-based TRUs, and 7,500 on-highway truck and trailer equipped TRUs, and 1,700 railcar TRUs that are based outside of California that operate in California at any given time.

Requirements for in-use TRUs

The proposed ATCM would require in-use TRU engines that operate in California, including out-of-state based TRUs that operate in California, to meet specific performance standards that vary by horsepower range. The in-use performance standards have two levels of stringency that would be phased in over time beginning in 2008. By December 31, 2008, all 2001 and earlier TRU engines that operate in California would have to meet "low emission TRU" performance standards. All 2002 TRU engines would have to meet the low emission TRU performance standard by December 31, 2009. Each subsequent model year engine (2003, 2004, etc.) would have to meet the "ultra-low emission TRU" performance standards seven (7) years after the engine model year (2003 model year engine must meet the ultra low emission TRU performance standard in 2010, 2004 model year engines in 2011, etc). In 2015, any 2001 and earlier model year engines that are still in operation would have to meet the ultra low emission TRU performance standards. In 2016, any 2002 model year TRU engines in operation would have to meet the ultra low emission TRU performance standards. The average useful life of a TRU is 10 years. The proposed ATCM in effect reduces the useful life of TRUs to 7 years. This accelerated retrofit or replacement schedule will ensure that the entire TRU fleet will be ultra low emission TRUs by 2020. The proposed TRU performance standards are as follows:

(1) For engines less than (<) 25 hp:

- Low emission TRU performance standards
  - Meet a PM emission standard of 0.3 g/bhp-hr, or
  - Retrofit with a Level 2 or 3 Verified Diesel Emission Control System (verified control system[1]), or
  - Use an alternative technology.

- Ultra low TRU performance standards
  - A PM emission standard is not being proposed at this time[2] , or

[1] Verified Diesel Emission Control Strategy means an emission control strategy designed primarily for the reduction of diesel particulate matter emissions that has been verified per the *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines (13 CCR Sections 2700-2710).* PM reduction Level 1: ≥25%; Level 2: ≥50%; Level 3: ≥85% or 0.01 g/bhp-hr.

- Retrofit with a Level 3 verified control system, or
- Use an alternative technology.

(2) For engines equal to or greater than (≥) 25 hp:

- Low emission TRU performance standard
  - Meet a PM emission standard of 0.22 g/bhp-hr, or
  - Retrofit with a Level 2 or 3 verified control system, or
  - Use an alternative control technology.
- Ultra low TRU performance standard
  - Meet a PM emission standard 0.02 g/bhp-hr, or
  - Retrofit with a Level 3 verified emission control system, or
  - Use an alternative technology.

The PM performance standards are based on the Tier 4 nonroad standards proposed by U.S. EPA in their May 23, 2003 Notice of Proposed Rulemaking for Control of Emissions of Air Pollutants from Nonroad Diesel Engines and Fuel (hereinafter referred to as Nonroad Standards) (U.S. EPA 2003). The verified retrofit control levels are based on staff's technical evaluation of what retrofits are likely to become verified by 2008. Given this uncertainty, staff is proposing to conduct technology reviews in 2007 and 2009 to evaluate technology readiness for the in-use requirements. Part of that technology evaluation would be to consider whether more stringent emission standards are feasible in the later years of the ATCM and if so what implementation schedule is appropriate.

Alternative Technologies

TRUs that elect to use one of the "alternative technologies" listed in the ATCM would qualify as an ultra low TRU. These alternative technologies include the use of electric standby, cryogenic temperature control systems, alternative fuel, alternative diesel fuel, fuel cell power, or any other system approved by the Executive Officer.

Incentive

The proposal includes a provision that encourages operators of model year 2002 and earlier TRU engines to comply with the low emission TRU performance standards prior to December 31, 2008 (December 31, 2009 for model year 2002 only). This incentive would allow such engines to postpone, by up to three years, the date by which that engine must be replaced or retrofitted to comply with the ultra low TRU performance standard.

Compliance Provision

Staff is proposing the use of an ARB identification numbering system. The I.D. numbers would include codes that indicated key compliance information such as model year of engine. California-based TRUs would be required to have I.D. numbers. For out-of-

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[2] ARB will conduct a technology review in 2007 and determine what PM emission standard is appropriate and recommend amendment to the ATCM as needed.

state based TRUs that operate in California, the use of ARB I.D. numbers would be voluntary. However, without such a coding system an inspector would have to physically open up the TRU compartment to verify that the unit contains a complying engine or retrofit system. This could result in significant downtime for the truck. The coding allows a quick inspection so that the trucks can get back on the road as quickly as possible. Given this situation, we anticipate that most owners of out-of-state TRUs will obtain ARB I.D. numbers for their TRUs.

Initial and Annual Reporting Requirements

The proposed ATCM contains two reporting provisions. Owners of TRUs operating in California would be required to submit an initial report to ARB that provide information about the TRUs they operate in California. Updates would need to be provided as TRUs are purchased or sold. The information is needed to assist in the implementation of the ATCM. The second reporting provision applies to large facilities where TRUs operate. Distribution facilities with 20 or more doors serving a refrigerated storage area would be required to submit a one-time report to ARB. This information is needed to evaluate the overall effectiveness of the regulation in reducing diesel PM concentrations near facilities where numerous TRUs operate.

Warranty

If a Verified Diesel Emission Control Strategy (VDECS) fails during the warranty period, the owner or operator of the TRU or TRU generator set must replace it with the same VDECS or a higher verification classification level, if available.

If a VDECS fails outside its warranty period and a higher verification classification level VDECS is available, then the owner or operator of the TRU or TRU generator set shall upgrade to the highest level VDECS that is determined to be cost-effective by the Executive Officer.

Other Comparable Federal Regulations

There are no federal regulations comparable to the Proposed ATCM for in-use TRUs; however, the ATCM relies heavily on adoption and implementation of the proposed U.S. EPA's Tier 4 nonroad emissions standards for new diesel engines since engine replacement is one of many compliance pathways.

AVAILABILITY OF DOCUMENTS AND AGENCY CONTACT PERSONS

The Board staff has prepared a Staff Report: Initial Statement of Reasons (ISOR) for the proposed regulatory action, which includes a summary of the potential environmental and economic impacts of the proposal, if any. The ISOR is entitled, *Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units and TRU Generator Sets, and Facilities Where TRUs Operate.*

Copies of the ISOR and the full text of the proposed regulatory language may be obtained from the Public Information Office, Air Resources Board, 1001 I Street, Visitors and Environmental Services Center, 1st Floor, Sacramento, CA 95814, (916) 322-2990, at least 45 days prior to the scheduled hearing which will begin on December 11, 2003.

Upon its completion, the Final Statement of Reasons (FSOR) will also be available and copies may be requested from the agency contact persons in this notice, or may be accessed on the web site listed below.

This notice, the ISOR and all subsequent regulatory documents, including the Final Statement of Reasons, when completed, are available on the ARB Internet site for this rulemaking at http://www.arb.ca.gov/regact/trude03/trude03.htm.

Inquiries concerning the substance of the proposed regulations may be directed to the designated agency contact persons, Tony Andreoni, Manager of the Process Evaluation Section, Emission Assessment Branch, Stationary Source Division at (916) 324-6021 or by email at tandreon@arb.ca.gov, or Rod Hill, Air Resources Engineer, Stationary Source Division at (916) 323-0440 or by email at rhill@arb.ca.gov .

Further, the agency representative and designated back-up contact persons to whom nonsubstantive inquiries concerning the proposed administrative action may be directed are Artavia Edwards, Manager, Board Administration & Regulatory Coordination Unit, (916) 322-6070, or Alexa Malik, Regulations Coordinator, (916) 322-4011. The Board has compiled a record for this rulemaking action, which includes all the information upon which the proposal is based. This material is available for inspection upon request to the contact persons.

If you are a person with a disability and desire to obtain this document in an alternative format, please contact the ARB's Clerk of the Board at (916) 322-5594 or sdorais@arb.ca.gov as soon as possible. TTY/TDD/Speech-to-Speech users may dial 7-1-1 for the California Relay Service.

COSTS TO PUBLIC AGENCIES AND TO BUSINESSES AND PERSONS AFFECTED

The determinations of the Board's Executive Officer concerning the costs or savings necessarily incurred by public agencies and private persons and businesses in reasonable compliance with the proposed regulations are presented below.

Pursuant to Government Code section 11346.5(a)(5), the Executive Officer has determined that the proposed regulations will possibly impose a mandate on local agencies or school districts. The Executive Officer has further determined pursuant to Government Code section 11346.5(a)(6) that the proposed regulations will result in some additional costs to the Air Resources Board and other state agencies. In addition, the Executive Officer has also determined pursuant to Government Code section 11346.5(a)(6) that the proposed regulatory action will possibly create a cost to any local agency or school district that is required to be reimbursed under Part 7 (commencing with section 17500) of Division 4 of the Government Code or other nondiscretionary costs or savings imposed on local agencies. The Executive Officer further determined that the proposed regulations will not result in costs or savings in federal funding to the state.

Fiscal Impact on Local Agencies or School Districts

The Executive Office has determined that the proposed regulatory action will have an impact, although insignificant, on costs to local agencies or school districts since it will include a mandate a very small number of local agency or school district owned TRUs. Some minor costs will occur for the few local agencies and school districts that own or operate TRUs. We believe that the reporting costs to local agencies and to school districts will be negligible since many will be exempt from the facility reporting requirements, and the estimated operator reporting cost will be minor. Some costs will also occur in 2008 to upgrade TRUs to comply with the requirements in the ATCM. The capital cost of installing equipment in 2008 to comply with the ATCM will be between $2,000 and $20,000 per TRU. However, the cost directly attributable to the ATCM is assumed only to range between $2,000 to $6,000, since most of the TRUs that will have to comply in 2008 will be at the end of their useful life and would be scheduled for replacement in any event. Statewide, the total number of TRUs owned or operated by local agencies and school districts are not known, but are expected to be very few. Thus, the cost impact to any local agency or school district should be very small.

Fiscal Impact on State Agencies or Federal Funding to the State

Some minor costs will occur for correctional facilities that own and operate TRUs. We believe that the reporting costs to correctional facilities will be negligible since many will be exempt from the facility reporting requirements, and the estimated operator reporting cost will be minor. Some costs will also occur in 2008 to upgrade TRUs they own to meet the requirements in the ATCM. The capital cost of installing equipment to comply with the ATCM in 2008 will be between $2,000 and $20,000 per TRU. However, the cost directly attributable to the ATCM is assumed only to range between $2,000 to $6,000 per TRU since most of the TRUs that will have to comply in 2008 will be at the end of their useful life and would be scheduled for replacement in any event. The Department of Corrections (Corrections) owns approximately 20 TRUs. We believe that capital costs for Corrections in 2008, that are attributable to the ATCM, is between $40,000 and $120,000. Since these costs are insignificant compared to their overall budget, we believe that the costs will be able to be met within the existing budget.

The proposed ATCM will impose a cost to the ARB for TRU enforcement, for records management, and for issuing ARB identification numbers to operators or owners of TRUs. Initial costs to the ARB primarily involve developing the TRU database for tracking in-use TRUs and facility operations throughout the state. Additional cost will result from enforcement activities through the ARB's existing Heavy-Duty Vehicle Inspection program performed at various weigh stations throughout California and at various food distribution or cold storage facilities. The ARB is expected to incur annual costs to implement the TRU ATCM starting in the 2005 FY, but anticipates that the costs will be absorb within their existing budgets.

The Executive Officer has also determined that the proposed regulatory action will not create costs or savings in federal funding to the State.

Fiscal Impact to Businesses

The Executive Officer has made an initial determination that the proposed regulatory action will not have a significant statewide adverse economic impact directly affecting businesses, including the ability of California businesses to compete with businesses in other states, or on representative private persons.

In developing this regulatory proposal, the ARB staff evaluated the potential economic impacts that representative private persons or businesses might incur in reasonable compliance with the proposed ATCM. The Executive Officer has initially assessed that the proposed regulatory action will affect the businesses that operate TRUs or have facilities that are frequented by TRUs. The costs for businesses and individuals that operate TRUs or TRU generator sets are estimated to be in the range of $101 to $168 million, over a 13-year period, which results in a cost-effectiveness between $10 and $20 per pound of diesel PM reduced.

In accordance with Government Code sections 11346.3 and 11346.5(a)(10), the Executive Officer has determined that the proposed regulatory action may lead to creation or elimination of some businesses, the creation of new businesses or elimination of existing businesses within the State of California, or the expansion of businesses currently doing business within the State of California. Due to the long lead-time for compliance, wide range of compliance options, and small business exemption, we believe that most businesses will be able to meet the compliance costs. However, it is possible that a small number of businesses (those with marginal profitability) may experience financial difficulty in complying with the regulation. Businesses that may be created include those that furnish, install, and maintain diesel emission control systems, as well as those that provide alternative compliance strategies. Engine manufacturers, TRU manufacturers, and TRU sales and service dealers are likely to see an increase in business due to accelerated attrition and other options to meet the in-use requirements of the regulation.

The Executive Officer has also determined, pursuant to title 1, CCR, section 4, that the proposed regulatory action will have some impact on small businesses. We believe that a significant proportion of the TRU owners and operators are likely to be small businesses because approximately 80 percent of the TRU owners own 20 or less TRUs. Small business will incur costs in 2008 to retrofit and replace engines. ARB estimates the cost to a typical small business (own three TRUs) to be $6,000 to $60,000 in 2008. Of this total cost, ARB believes that $2,400 to $24,000 is attributable to the ATCM.

In accordance with Government Code sections 11346.3(c) and 11346.5(a)(11), the ARB's Executive Officer has found that the reporting requirements of the regulation that apply to businesses are necessary for the health, safety, and welfare of the people of the State of California.

In accordance with H&SC 43013(c), the Executive Officer has determined that the standards and other requirements in the proposed ATCM are necessary, cost-effective, and technologically feasible for agricultural operations (i.e., farm equipment).

A detailed assessment of the economic impacts of the proposed regulation can be found in the ISOR.

Consideration of Alternatives

Before taking final action on the proposed regulatory action, the Board must determine that no reasonable alternative considered by the agency or that has otherwise been identified and brought to the attention of the agency would be more effective in carrying out the purpose for which the action is proposed or would be as effective and less burdensome to affected private persons than the proposed action

SUBMITTAL OF COMMENTS

The public may present comments relating to this matter orally or in writing at the hearing, and in writing or by e-mail before the hearing. To be considered by the Board, written submissions must be received **no later than 12:00 noon, December 10, 2003,** and addressed to the following:

Postal mail is to be sent to:

Clerk of the Board
Air Resources Board
1001 "I" Street, 23rd Floor
Sacramento, California 95814

Electronic mail is to be sent to: trude03@listserv.arb.ca.gov and received at the ARB **no later than 12:00 noon, December 10, 2003.**

Facsimile submissions are to be transmitted to the Clerk of the Board at (916) 322-3928 and received at the ARB **no later than 12:00 noon, December 10, 2003.**

The Board requests but does not require 30 copies of any written submission. Also the ARB requests that written, facsimile, and e-mail statements be filed at least 10 days prior to the hearing so that ARB staff and Board Members have time to fully consider each comment. The ARB encourages members of the public to bring to the attention of staff in advance of the hearing any suggestions for modification of the proposed regulatory action.

STATUTORY AUTHORITY

This regulatory action is proposed under the authority granted to the ARB in the California Health and Safety Code sections 39600, 39601, 39618, 39658, 39659, 39666, 39667, 43013, and 43018. This action is proposed to implement, interpret, or make specific, Health and Safety Code sections 39618, 39650, 39658, 39659, 39666, 39667, 40717.9, 43013, and 43018.

HEARING PROCEDURES

The public hearing will be conducted in accordance with the California Administrative Procedure Act, Title 2, Division 3, Part 1, Chapter 3.5 (commencing with section 11340) of the Government Code.

Following the public hearing, the ARB may adopt the regulatory language as originally proposed or with non-substantial or grammatical modifications. The Board may also adopt the proposed regulatory language with other modifications if the modifications are sufficiently related to the originally proposed text that the public was adequately placed on notice that the regulatory language as modified could result from the proposed regulatory action. In the event that such modifications are made, the full regulatory text, with the modifications clearly indicated, will be made available to the public for written comment at least 15 days before it is adopted.

The public may request a copy of the modified regulatory text from the ARB's Public Information Office, Air Resources Board, 1001 I Street, Visitors and Environmental Services Center, 1st Floor, Sacramento, California 95814, (916) 322-2990.

CALIFORNIA AIR RESOURCES BOARD

Michael W. Scheible

for Catherine Witherspoon
Executive Officer

Date: October 14, 2003

"The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our Web-site at www.arb.ca.gov."

State of California
California Environmental Protection Agency
AIR RESOURCES BOARD

ERRATA

STAFF REPORT: INITIAL STATEMENT OF REASONS (ISOR) FOR PROPOSED RULEMAKING

AIRBORNE TOXIC CONTROL MEASURE FOR IN-USE DIESEL-FUELED TRANSPORT REFRIGERATION UNITS (TRU) AND TRU GENERATOR SETS, AND FACILITIES WHERE TRUs OPERATE

Public Hearing Date: December 11, 2003
Initial Date of Release of ISOR: October 24, 2003
Release date of Errata and Revised ISOR: October 28, 2003

This errata corrects several incorrect references in the ISOR that was initially released on October 24, 2003, correctly paginates the document so that the pagination corresponds to the Table of Contents, and corrects several punctuation and spelling errors. A summary of the corrected references follows. The balance of the revised ISOR is otherwise substantively the same as that which was released on October 24, 2003.

The revised ISOR replaces the version posted to the Air Resources Board's rulemaking WebPages on October 24, 2003.

Errata

Executive Summary, page E-14, first sentence: the reference to "10 years" has been changed to "12 years."

Chapter II, page II-2, top paragraph: the reference to "U.S. EPA has been changed to "United States Environmental Protection Agency (U.S. EPA)".

Chapter V, page V-13, 2nd paragraph, 4th sentence: the reference to "Figure VII-1" has been changed to "Figure VII-2".

Chapter V, page V-13, Figure V-3: the reference to "2010 (0.05 g/bhp-hr)" has been changed to "2020 (0.05 g/bhp-hr)"

Chapter, VIII, page VIII-2, Table VIII-1, footnote 4: the reference to "section C.2.3" has been changed to "section C.2.2".

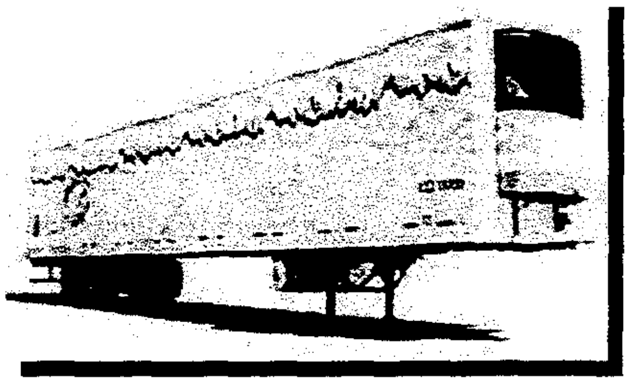
Chapter, VIII, page VIII-3, Table VIII-2, footnote 4: the reference to "section C.2.3" has been changed to "section C.2.2".

Chapter, VIII, page VIII-4, Table VIII-3, footnote 4: the reference to "section C.2.3" has been changed to "section C.2.2".

California Environmental Protection Agency
AIR RESOURCES BOARD

REVISED

STAFF REPORT: INITIAL STATEMENT OF REASONS FOR PROPOSED RULEMAKING



AIRBORNE TOXIC CONTROL MEASURE FOR IN-USE DIESEL-FUELED TRANSPORT REFRIGERATION UNITS (TRU) AND TRU GENERATOR SETS, AND FACILITIES WHERE TRUs OPERATE

Stationary Source Division
Emissions Assessment Branch

October 28, 2003

State of California
AIR RESOURCES BOARD

STAFF REPORT: INITIAL STATEMENT OF REASONS FOR PROPOSED RULEMAKING

Public Hearing to Consider

ADOPTION OF THE PROPOSED AIRBORNE TOXIC CONTROL MEASURE FOR IN-USE DIESEL-FUELED TRANSPORT REFRIGERATION UNITS (TRU) AND TRU GENERATOR SETS, AND FACILITIES WHERE TRUs OPERATE

To be considered by the Air Resources Board on December 11, 2003, at:

California Environmental Protection Agency
Headquarters Building
1001 "I" Street
Central Valley Auditorium
Sacramento, California

Stationary Source Division:
Peter D. Venturini, Chief
Robert D. Barham, Assistant Chief
Emission Assessment Branch:
Dan Donohoue, Chief
Process Evaluation Section:
Tony Andreoni, Manager

State of California
AIR RESOURCES BOARD

PROPOSED AIRBORNE TOXIC CONTROL MEASURE FOR IN-USE DIESEL-FUELED TRANSPORT REFRIGERATION UNITS (TRU) AND TRU GENERATOR SETS, AND FACILITIES WHERE TRUs OPERATE

Executive Summary and
Technical Support Document

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U.S. Environmental Protection Agency

Staff Report: Initial Statement of Reasons for the Proposed Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities where TRUs Operate

TABLE OF CONTENTS

Contents — Page

TABLE OF CONTENTS (continued)

Contents | Page

TABLE OF CONTENTS (continued)

Contents | Page

LIST OF TABLES

LIST OF FIGURES

State of California
AIR RESOURCES BOARD

Staff Report: Initial Statement of Reasons for the Proposed Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities where TRUs Operate

EXECUTIVE SUMMARY

This executive summary presents the Air Resources Board (ARB or Board) staff's *Proposed Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units (TRUs) and TRU Generator Sets, and Facilities where TRUs operate*. The proposed airborne toxic control measure (ATCM) is designed to reduce diesel particulate matter (diesel PM) emissions and resulting exposure from in-use TRUs and TRU generator sets which are powered by diesel engines and used to refrigerate temperature-sensitive products that are transported in insulated semi-trailer vans, truck vans, shipping containers, and rail cars.

The ARB, in addition to maintaining long-standing efforts to reduce emissions of ozone precursors, is now challenged to reduce emissions of diesel PM. In 1998, the Board identified diesel PM as a toxic air contaminant (TAC). Because of the amount of emissions to California's air and its potency, diesel PM is the number one contributor to the adverse health impacts of TACs known today.

Diesel exhaust is a complex mixture of thousands of gases and fine particles that contains more than 40 identified TACs. These include many known or suspected cancer-causing substances, such as benzene, arsenic and formaldehyde. In addition to increasing the risk of lung cancer, exposure to diesel exhaust can have other health effects as well. Furthermore, diesel exhaust can irritate the eyes, nose, throat and lungs, and it can cause coughs, headaches, light-headedness and nausea. Diesel exhaust is a major source of fine particulate pollution as well and numerous studies have linked elevated particle levels in the air to increased hospital admissions, emergency room visits, asthma attacks and premature deaths among those suffering from respiratory problems.

To reduce public exposure to diesel PM, the Board approved the *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (Diesel Risk Reduction Plan) in 2000. This comprehensive plan outlined steps to reduce diesel emissions from both new and existing diesel-fueled engines and vehicles. The goal of the Diesel Risk Reduction Plan is to reduce diesel PM emissions and associated potential cancer risks by 75 percent in 2010 and by 85 percent by 2020.

ARB staff is proposing this ATCM to reduce diesel PM emissions from TRU and TRU generator set diesel-fueled compression ignition engines. The proposed ATCM is one of many ATCMs that are being considered by the ARB to fulfill the goals of the Diesel Risk Reduction Plan. The ATCMs scheduled for Board consideration in the last quarter of 2003 and the first quarter of 2004 include measures to reduce emissions from residential and commercial solid waste collection vehicles, fuel cargo delivery trucks, stationary diesel-fueled engines, and portable engines.

Presented below is an overview which briefly discusses the emissions from new and existing TRU and TRU generator set engines, the proposed ATCM and its potential impacts from implementation, as well as plans for future activities. For simplicity, the discussion is presented in question-and-answer format using commonly asked questions about the ATCM. It should be noted that this summary provides only a brief discussion on these topics. The reader is directed to subsequent chapters in the main body of the report for more detailed information. Also, unless otherwise noted herein, all references to TRUs include TRU generator sets.

1. What are Transport Refrigeration Units and Generator sets?

A Transport Refrigeration Unit (TRU) is a refrigeration system powered by a diesel engine designed to refrigerate temperature-sensitive products that are transported in insulated semi-trailer vans, truck vans, shipping containers, and rail cars. The diesel engine is generally between 7 and 36 horsepower (hp) with the most common size being about 35 hp. TRUs include refrigeration systems where the diesel engine is directly connected to the refrigeration unit and refrigeration systems where a generator is powered by a diesel engine to provide electrical power to the refrigeration unit (TRU generator set).

2. What are the emissions, exposure, and risk due to TRU diesel engines?

There are currently about 31,000 TRUs and TRU generator sets based in California, another 7,500 out-of-state refrigerated trailers, and 1,700 railcar TRUs operating in California at any given time. The estimated emissions from TRU engines and TRU generator sets operating in California are shown in Table E-1. As shown, we estimate diesel PM emissions from TRUs and TRU generator sets to be almost two tons per day or 2.6 percent of the total statewide diesel PM emissions (base year 2000). Estimated oxides of nitrogen (NOx) emissions are higher at about 20 tons per day (less than one percent of the statewide inventory). Without additional regulations to reduce emissions, we anticipate that both diesel PM and NOx emissions from TRUs will grow in future years. Based on our emissions projections, the diesel PM emissions from TRUs will increase to almost 2.5 tons per day in 2010 and increase again to over three tons per day in 2020. The projected 2010 and 2020 emission estimates do not include projected emission reductions from the proposed United States Environmental Protection Agency (U.S. EPA) Tier 4 engine standards, and do not include emission reductions due to the proposed ATCM.

Table E-1: Estimated Statewide Emissions from TRUs and TRU Generator Sets

Emission Year	Total Emissions in Tons per Day (Percent of Total Statewide Diesel Emissions)*	
	PM	NOx
2000	2.0 (2.6%)	19.6
2010	2.5 (4.0%)	24.9
2020	3.1 (6.0%)	38.2

* The number in the parenthesis is the percent of the total statewide diesel PM emissions attributed to TRUs based on the October 2000 Diesel Risk Reduction Plan

The highest concentrations of diesel PM from TRUs are expected to occur at locations where numerous TRUs operate (i.e. distribution facilities, ports, and intermodal facilities). The diesel PM concentrations are dependent on the size (hp) of the engine, the age of the engine (emission rate depends on model year of engine), the number of hours of operation (run time) of the TRU engine at a facility, the distance to the nearest receptor, and meteorological conditions at the site.

Because a diesel PM monitoring technique is not currently available, diesel PM concentrations at locations where numerous TRUs operate were estimated using computer modeling techniques. To estimate exposure and the associated cancer risk near facilities where TRUs operate, staff used reasonable assumptions encompassing a fairly broad range of possible operating conditions for TRU engines. Based upon the assumptions and conditions evaluated, the results showed that facilities where numerous TRUs operate could potentially result in significant health risk to individuals living near the facilities.

To illustrate the potential near-source cancer risk, staff performed a risk assessment analysis on a generic (i.e., example) facility assuming a total on-site operating time for all TRUs of 300 hours per week. As shown in Figure E-1 below, at this estimated level of activity and assuming a current fleet diesel PM emission rate of 0.7 g/bhp-hr, staff estimates the potential cancer risk would be over 100 in a million at 250 meters (800 feet) from the center of the TRU activity. The estimated potential cancer risk would be in the 10 to 100 per million range between 250 and 1,000 meters (800 to 3,300 feet) and fall off to less than 10 per million at approximately 1,100 meters (3,600 feet). These risk values assume an exposure duration of 70 years for a nearby resident and uses the methodology specified in the latest (2003) OEHHA health risk assessment guidelines.

Figure E-1
Estimated Risk Range Versus Distance from Center of TRU Activity Area – Year 2000

Emission Rate														
2000 (0.7 g/bhp-hr)														
Distance from Center of Source (meters)	**100**	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**

KEY:

Potential Cancer Risk > 100 per million

Potential Cancer Risk ≥ 10 and < 100 per million

Potential Cancer Risks < 10 per million

*Assumes 300 hours per week of TRU engine operation at 60% load factor

3. What does the proposed TRU ATCM require?

The proposed ATCM would require in-use TRU engines that operate in California, including out-of-state TRUs while they are operating in California, to meet specific performance standards that vary by horsepower range. The in-use performance standards have two levels of stringency that would be phased-in over time. The first phase, beginning in 2008, is referred to as the low emission TRU performance standards. The second phase, beginning in 2010, is referred to as the ultra-low emission TRU performance standards. The proposed TRU performance standards are shown in Table E-2 below.

Table E-2
Proposed TRU and TRU Generator Set Performance Standards

Horsepower Category	PM Emissions Standard (grams/horsepower-hour)	Options for Meeting Performance Standard
Low Emission Performance Standards		
<25	0.30 g/hp-hr	▪ Level 2 or better verified control strategy (51 to 85% PM reduction) ▪ Alternative technologies
≥ 25	0.22 g/hp-hr	▪ Level 2 or better verified control strategy (51 to 85% PM reduction) ▪ Alternative technologies
Ultra-Low Emission Performance Standard		
<25	N/A	▪ Level 2 or better verified control strategy (51 to 85% PM reduction) ▪ Alternative technologies
≥ 25	0.02 g/hp-hr	▪ Level 3 verified control strategy (at least 85% PM reduction) ▪ Alternative technologies

The proposed ATCM would require owners of TRUs to meet more stringent performance standards at seven-year intervals until the TRU meets the ultra-low emission TRU performance standards. The phased in compliance schedule for various model engine years is shown below in Table E-3. For example, by December 31, 2008, all TRUs operating in the state with model year 2001 and older diesel engines will have to meet the low emission TRU performance standards. Any TRUs equipped with 2001 or older engines that are still in use in 2015 (2008 plus seven years) will have to meet the ultra-low TRU performance standards by December 31, 2015. TRUs equipped with 2002 model year diesel engines will have to meet the low emission TRU performance standard by December 31, 2009. Any TRUs equipped with a 2002 model year engine that is still in use in 2016 (2009 plus seven years) will have to meet the ultra-low TRU performance standards by December 31, 2016. TRUs equipped with 2003 model year diesel engines will have to meet the ultra-low emission performance standards by December 31, 2010. As shown in Table E-2 above, the low emission TRU performance standards can be met by either buying a new engine that meets the PM emission standard, retrofitting the existing engine with a level 2 (PM reduction of 51 to 85%) or better control system, or switching to an alternative technology.

Table E-3
Proposed TRU and TRU Generator Set Compliance Schedule

Model Year of Engine	Compliance Date for Low Emission Standard	Compliance Date for Ultra-Low Emission Standard
2001 or older	2008	2015*
2002	2009	2016*
2003	N/A	2010
Future years	N/A	Model year + 7

* Early compliance of low emission standard for model year 2002 or older may extend compliance date for ultra-low emission standard by up to three years

The average useful life of a TRU is 10 years. The proposed ATCM in effect reduces the useful life of in-use TRUs to seven years. This accelerated upgrade or replacement of TRUs will ensure that the majority of the TRU fleet will be comprised of ultra-low emission TRUs by 2020.

The proposed ATCM also contains two reporting provisions. Owners of TRUs operating in California would be required to submit an initial report to ARB that provides information about the TRUs they operate in California. Updates would need to be provided as TRUs are leased, purchased, or sold. The information is needed to assist in the implementation of the ATCM. The second reporting provision applies to large facilities where TRUs operate. Facilities with 20 or more doors serving a refrigerated storage area would be required to submit a one-time report to ARB. This information is needed to evaluate the overall effectiveness of the regulation in reducing diesel PM concentrations near facilities where numerous TRUs operate.

4. What businesses will be affected by the proposed ATCM?

The "in-use" requirements of the proposed ATCM would affect owners and operators of diesel-fueled TRUs that operate in California whether the TRUs are registered in the State or outside the State. This would include all carriers that transport perishable goods using refrigerated trucks, trailers, shipping containers, and railcars that come into California. There are a few local municipalities, school districts, and correctional institutions that operate TRUs that may be affected. Larger facilities where TRUs operate would also be affected.

5. What early reduction incentives are built into the ATCM?

The proposed ATCM includes provisions that encourage operators of 2002 and older model year TRU engines and TRU generator set engines to comply early with the low emission TRU performance standards by offering a delay in the ultra-low emission TRU compliance date. Staff is proposing that for each year of early compliance with the low emission TRU performance standards, a company can extend the compliance date with the ultra-low emissions TRU by one year, up to a maximum of three years. For example, if a 2002 model year TRU engine complies with the low emission TRU performance standards in 2006 (2006 is three years early since December 31, 2009 would be the actual compliance date for a model year 2002 engine), by using a verified control system, an operator does not have to comply with the ultra-low TRU performance standards until 2019. This provision is only available for 2002 and older engines. This early reduction incentive should provide a significant reduction in diesel PM sooner than the 2008 implementation date, thus greatly reducing the total statewide PM and the health risks at facilities.

6. What emission control strategies potentially could be used on TRU engines?

A variety of diesel emission control strategies could potentially be used for controlling emissions from these diesel engines, including "add-on" exhaust aftertreatment systems, fuel strategies, fuel additives, and engine modifications. Aftertreatment systems could be add-on technologies such as diesel particulate filters (DPF), flow-through-filters (FTF) and diesel oxidation catalysts (DOC). Fuel strategies include alternative fuels, alternative diesel fuels, and fuel additives. Alternative fuels include, but are not limited to, compressed natural gas (CNG), and liquefied petroleum gas (LPG). Dual-fuel pilot-ignition CNG or LPG fumigation engines are promising alternative fuel engine approaches. Alternative diesel fuels include, but are not limited to, water emulsion diesel fuels, biodiesel, and Fischer-Tropsch fuels. An example of a fuel additive is a fuel borne catalyst. These technologies can be combined to form additional diesel emission control strategies. In addition, repowering with a new, cleaner diesel engine is a possible strategy. Electric standby, cryogenic temperature control systems, and fuel cells are also possible diesel emission control strategies that could eliminate diesel emissions at facilities where TRUs operate.

Currently, there are no "verified" diesel emissions control strategies for TRU engines. A "verified" diesel emissions control strategy refers to an emission control system that has been evaluated by ARB for its emissions reduction capabilities and durability under the ARB's *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emission from Diesel Engines*[1] (Verification Procedure). Staff believes that verified retrofit control systems for TRUs will become available over the next few years. Emission control technology manufacturers have indicated they are close to applying for verification of several diesel emissions control strategies under the Verification Procedure. These include fuel borne catalysts (FBC), FBC with ultra-low sulfur diesel fuel and a catalyzed wire mesh filter, and PuriNox™. In addition, staff believes that new TRUs equipped with engines that meet the more stringent off-road standards will likely replace many older TRUs. ARB staff anticipates that new engines meeting the Tier 4 nonroad standard should be available sooner than 2008.

Alternative technologies such as electric standby, cryogenic refrigeration, CNG, LPG, LNG, and gasoline-powered engines are currently feasible and would not require verification[2].

7. Is staff proposing any review to ensure that the engine and retrofit technologies for requirements with future effective dates are achievable?

Yes. Staff is proposing that two technology reviews be conducted to assure reliable, cost-effective compliance options are available in time for implementation. The first technology review would be in late 2007, a year prior to the first in-use compliance date for the first level of in-use performance standard compliance. At this time, staff would thoroughly evaluate progress made toward applying advanced technologies to meet the in-use performance standards required by the end of 2008 for TRU engines in the proposed TRU ATCM. The second technology review would be in 2009 and would evaluate whether verified emission control technology is available and cost-effective for a broad spectrum of TRUs to meet the more stringent level of in-use performance standards that would go into effect by the end of 2010 and beyond.

8. How will compliance be verified and control measure effectiveness be monitored?

Staff is proposing a registration program that uses an ARB identification (I.D.) numbering system. The I.D. numbers would include codes that indicate key compliance information such as model year of engine. California-based TRUs would be required to have I.D. numbers. For out-of-state operators, obtaining an ARB I.D. number would be voluntary. However, without such a coding system, an inspector would have to physically open up the TRU compartment to verify that the unit contains a complying engine or retrofit system. This could result in significant downtime for the truck. The

[1] Approved by the Board in May 2002. Sections 2700 through 2710, Title 13, California Code of Regulations.

[2] Spark-ignited engines are regulated under the Off-road Large Spark-Ignition Engines 25 Horsepower and Greater regulation.

coding allows a quick inspection so that trucks can get back on the road as quickly as possible. Given this situation, we anticipate that most owners of out-of-state TRUs will obtain ARB I.D. numbers for their TRUs that operate in California.

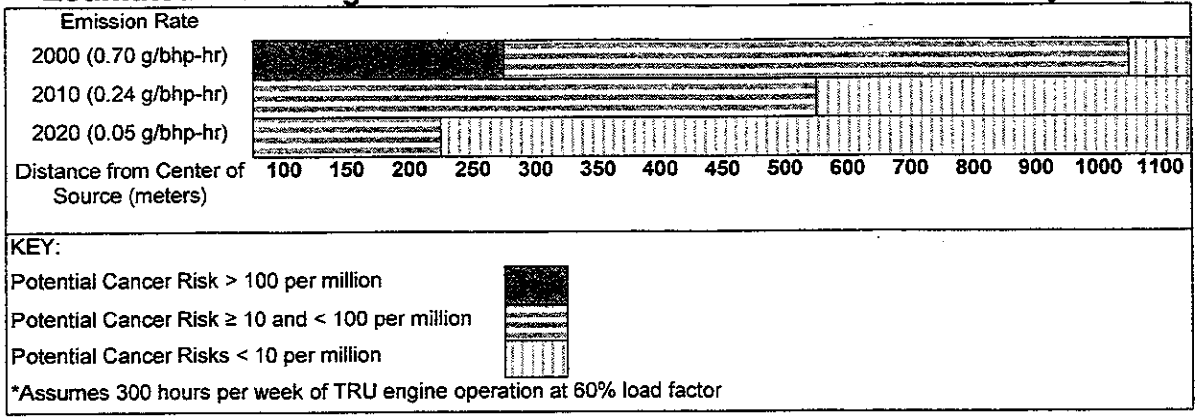
The proposed control measure would be enforced by ARB's Enforcement Division through roadside inspections conducted in conjunction with the Heavy Duty Vehicle Inspection Program. In addition, ARB inspectors would conduct audits at TRU operator terminals. As mentioned in question and answer number three, the proposed ATCM has reporting provisions that will assist ARB staff in monitoring the implementation of the ATCM and provide more accurate estimates of emission reductions.

9. What are the environmental impacts of the proposed ATCM?

The proposed ATCM will reduce diesel PM emissions and resulting exposures from TRUs operating throughout California. Staff estimated that the proposed ATCM, in conjunction with the proposed U.S. EPA Tier 4 nonroad engine standards for new engines, will reduce diesel PM emission factors by about 65 percent in 2010 and by about 92 percent in 2020. The potential total tons of diesel PM reduced by the implementation of the proposed ATCM and the U.S. EPA Tier 4 new nonroad engine standards are estimated to be approximately 3,000 tons by 2020, counting all implementation years. We also expect non-methane hydrocarbon emissions to be reduced by about 30 percent. Staff does not anticipate significant NOx reductions from this ATCM. However, some NOx reductions will result from accelerated turnover of the older fleet, or if diesel/LPG (dual fuel) TRU engines become a significant portion of the fleet. The dual fuel system can offer NOx reductions of up to 50 percent compared to a conventional diesel engine.

Reduction of potential cancer risk levels at locations where TRUs operate will result from the reduction in diesel PM emissions. Figure E-2, below, compares the cancer risk range at various distances assuming 300 hours of TRU engine run time per week. For year 2000, the current fleet average emission rate of 0.7 g/bhp-hr was used. The average fleet emission rate is assumed to be 0.24 g/bhp-hr in 2010 and 0.05 g/bhp-hr in 2020. These emission rates assume compliance with the ATCM and the proposed U.S. EPA Tier 4. Figure E-2 below also shows that the estimated near source risk is significantly reduced (by approximately 92 percent) as the diesel PM emission rate is reduced from the current fleet emission rate to the much lower emission rate in 2020.

Figure E-2
Estimated Risk Range versus Distance from Center of TRU Activity Area*



We anticipate significant health cost savings due to reduced mortality, incidences of cancer, PM related cardiovascular effects, chronic bronchitis, asthma, and hospital admissions for pneumonia and asthma-related conditions. These directly emitted diesel PM reductions are expected to reduce the number of premature deaths in California. ARB staff estimates that 211 premature deaths will be avoided by year 2020. Prior to 2020, cumulatively, it is estimated that 31 premature deaths would be avoided by 2010 and 129 by 2015. Additional health benefits are expected from the reduction of NOx emissions, which give rise to secondary PM from the conversion of NOx to PM2.5 nitrate. ARB staff has concluded that no significant adverse environmental impacts should occur under the proposed ATCM.

10 What are the estimated economic impacts of the proposed ATCM?

The economic impact of the TRU ATCM will vary depending on the compliance approach selected. Assuming that verified retrofit control devices are available to meet both the low emission and ultra-low emission performance standards in the ATCM, the estimated annual cost of the ATCM would range from $4.8 to $9 million per year between 2008 and to 2020. The estimated total cost for the retrofit compliance approach would be $87 million to $156 million (in 2002 dollars) for the 13-year compliance period. The cost to an individual choosing the retrofit control option is estimated to be between $2,000 and $2,300 per TRU. Operation and maintenance costs would add an additional $100 to $300 per year.

In the event that verified retrofit devices are not available, staff estimates that a strategy relying on new engine replacement or TRU replacement will result in annual costs of $4 to $9 million per year, and total cost ranging from $89 million to $156 million for the 13 year compliance period. These costs do not represent the total cost of engine/TRU replacement, but have been adjusted to take into consideration that many of the engines are approaching the end of their useful life of 10 years. Staff assumed that the ATCM was responsible for 40 percent of the engine replacement cost for TRUs 10 years old and newer, and 15 percent of the TRU replacement cost for TRUs that are 11 years and older. The cost to an individual purchasing a new engine for compliance is estimated to be $4,000 to $5,000 per unit. The cost to an individual purchasing a new TRU is estimated to be $10,000 to $20,000 depending on whether the TRU unit is for a straight truck or trailer. Both the new engine and TRU replacement option costs do not have any associated increase in operating costs.

We estimate the overall cost effectiveness of the proposed ATCM to be between $10 and $20 per pound ($/lb) of diesel PM reduced, considering only the benefits of reducing diesel PM. Additional benefits are likely to occur due to the reduction in reactive organic gases (ROG) and NOx emissions.

With regard to mortality benefits, we estimate the cost of avoiding one premature death to range between $282,000 to $564,000 (in 2002 dollars) based on attributing the cost of controls to reduce diesel PM. Compared to the U.S. EPA's established $6.3 million (in year 2000 dollars) for a 1990 income level as the mean value of avoiding one death (U.S. EPA 2003), this proposed ATCM is a very cost-effective mechanism to reduce premature deaths that would otherwise be caused by diesel PM emissions without this regulation. The cost range per death avoided because of this proposed regulation is 8 to 22 times lower than the U.S. EPA's benchmark for value of avoided death.

No significant economic impacts to school districts, local public agencies, state agencies, and federal agencies are expected, due to the low number of TRUs operated by them and their relatively few number of facilities that would be subject to this ATCM. Costs to ARB for initial outreach, educational efforts, and enforcement would be absorbed within existing budgets.

This regulation may lead to creation or elimination of businesses. Due to the long lead time for compliance, wide range of compliance options, and small business facility reporting exemption (facilities with less than 20 refrigerated doors), we believe that most businesses will be able to meet the compliance costs. However, it is possible that a small number of businesses (those with marginal profitability) may experience financial difficulty in complying with the regulation. Businesses that may be created include those that furnish, install, and maintain diesel emission control systems, as well as those that provide alternative compliance strategies. Engine manufacturers, TRU manufacturers, and TRU sales and service dealers are likely to see an increase in business due to accelerated attrition and other options to meet the in-use requirements of the regulation.

11. How will the proposed ATCM affect the State Implementation Plan (SIP)?

The ARB's *Proposed 2003 State and Federal Strategy for the California State Implementation Plan* (Proposed Strategy) describes defined state and federal measures that will reduce emissions and improve air quality statewide. Because this ATCM was still under development when the Proposed Strategy was released, it was not possible to project the expected ancillary reactive organic gas (ROG) emission reductions that would result from its implementation. However, once the TRU ATCM is adopted and the emission reductions are enforceable, ARB may claim any associated ROG benefits against our SIP commitments. The proposed TRU ATCM would reduce ROG emissions, which in turn would help decrease ambient ozone levels, thereby helping the South Coast air basin attain the federal ozone standard. In addition, reductions of direct diesel particulate will help decrease ambient particulate levels and make progress toward attainment of federal particulate matter standards in the South Coast and the San Joaquin Valley.

12. What actions did staff take to consult with interested parties?

Staff made extensive efforts to ensure that the public and affected parties were aware of, and had opportunity to participate in, the rule development process. Staff contacted major TRU and TRU generator set manufacturers, engine manufacturers, emission control system manufacturers, operators, and operator organizations both to alert affected industry and to gather information about the technology and operation of the equipment. The data and information collected from these sources was supplemented by approximately 25 facility tours and facility operator interviews. Staff also contacted State and local agencies that have involvement with TRU operators and the facilities where TRUs operate, informed them of the development of the ATCM, and requested information and data.

Staff discussed numerous regulatory approaches for controlling TRU and TRU generator set emissions with affected industry and the public during a public consultation meeting, nine workgroup meetings/conference calls, five public workshops, and a large number of stakeholder meetings, e-mails, and telephone conversations. Staff also conducted outreach with the agricultural community, grocers associations, trucking associations, cold storage warehouse associations, port terminal associations, and railroad associations. In addition, ARB's efforts to reduce diesel PM emissions, including TRU's, has also been discussed at several communities meetings as part of our Community Health Program. Information on our efforts was provided on April 1, 2003, at the Boyle Heights community meeting on air pollution, and on April 30, 2003 at the Wilmington community meeting.

Staff tracked available and emerging emission control methods and facilitated communication among control system manufacturers and TRU and TRU generator set manufacturers, engine manufacturers, and operators. This continuing effort has resulted in a number of demonstration projects and studies that have provided important information regarding the feasibility and efficacy of various PM control devices, retrofit technology, electrification, and alternative fuel use.

13. How does the proposed ATCM relate to ARB's goals on Environmental Justice?

The proposed ATCM is consistent with the ARB's Environmental Justice (EJ) Policy to reduce health risks from TACs in all communities, including low-income and minority communities. Many communities are located near where TRUs operate, such as heavily traveled freeways, storage and distribution facilities, railyards, and ports. By reducing emissions of diesel PM, other known TACs, and other air pollutants from TRUs and TRU gen sets, the proposed ATCM will provide air quality benefits by reducing exposure to and associated health risk from these pollutants near facilities where TRUs and TRU generator sets operate.

14. What other laws establish requirements for TRU engine emissions in California?

The U.S. EPA and ARB regulate TRU engines as mobile nonroad (off-road) engines. TRU engines less than 25 horsepower (<25 hp) became subject to U.S. EPA and ARB emission standards in 1995. Engines in the greater than or equal to 25 horsepower (≥25 hp) to less than 50 horsepower (< 50 hp) became subject to U.S. EPA and ARB emission standards in 1999. In April of 2003, U.S. EPA proposed new emission standards for engines in both of these horsepower categories. These new standards are referred to as the Tier 4 nonroad standards. The proposed effective date for the Tier 4 standards for <25 hp engines is 2008.

The proposed effective dates for the Tier 4 standards for engines in the ≥25 hp to <75 hp category are an "interim" standard in 2008 and a "long term" standard in 2013. The "long term" standard must be implemented in 2012 if the engine manufacturer elected not to meet the "interim" standard. Staff expects that the manufacturers of TRU engines will meet the "interim" 2008 standards. As soon as the U.S. EPA Tier 4 standards are adopted, ARB plans to adopt new engine standards that harmonize with the federal standards. Below are the existing and proposed PM emission standards (Figures E-3 and E-4) for the TRU engine horsepower categories based on the model year of the engine.

Figure E-3: PM Emission Standards for TRUs < 25 hp

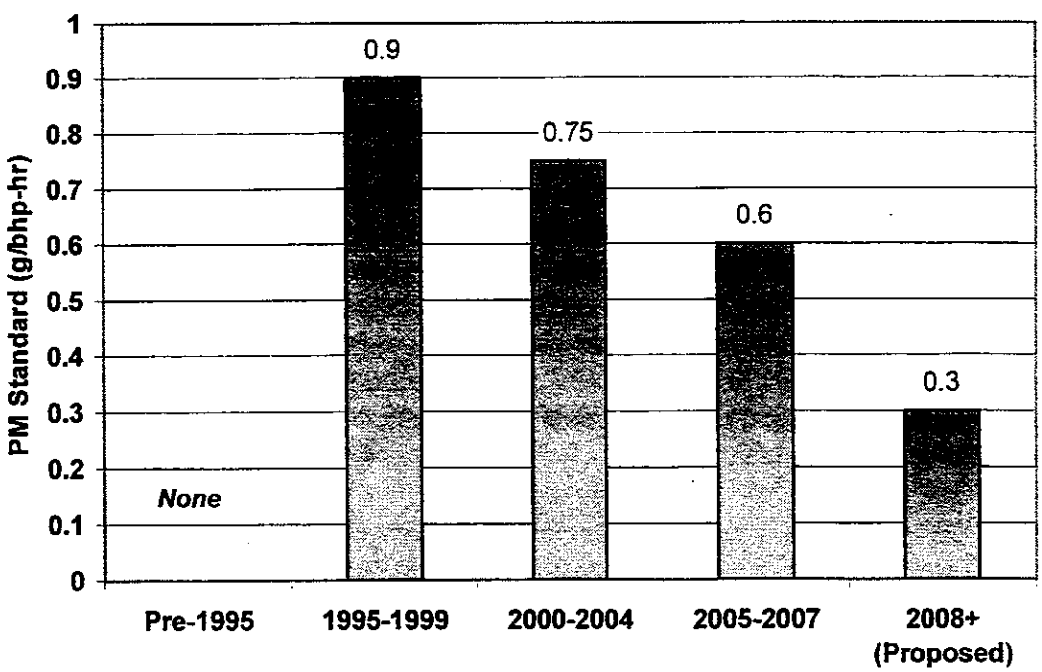
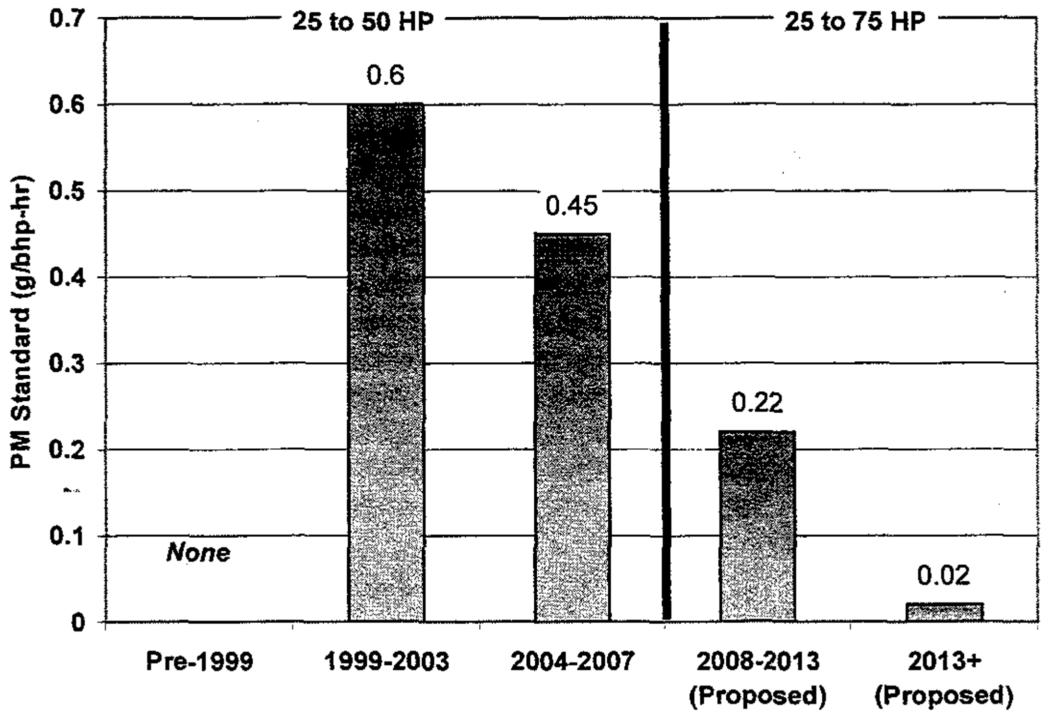


Figure E-4: PM Emission Standards for TRUs ≥ 25 HP



15. What future activities are planned?

In addition to activities associated with monitoring and implementing the proposed regulation, staff has recognized the need to continue collecting information about TRU operations, facility operations, and evaluating residual risk at facilities. Some of these activities include:

- Seek a Title I section 209(e) waiver from U.S. EPA.
- Work with affected business to develop outreach and training opportunities to assist operators and facilities in complying with the ATCM
- Development of TRU identification number issuing systems and database
- Conduct emission control technology reviews in 2007 and 2009
- Work with the U.S. EPA to propose long-term PM emission standard for less than 25 hp engines
- Conduct an analysis of the large facility data submitted in 2005.

16. What is staff's recommendation?

ARB staff recommends the Board adopt section 2022, Title 13, chapter 3, article 4, CCR, in its entirety. The regulation is set forth in the proposed regulation order in Appendix A.

In addition, staff recommends that the Board direct staff to conduct two technology reviews. The first, in 2007, would evaluate technology readiness for the in-use requirements that would begin to be phased in by the end of 2008 and continue phase-in over the next 12 years. Part of that technology evaluation would be to determine if more stringent standards for these pollutants would be feasible for <25 hp TRU engines in the 2010 to 2013 time-frame. In addition, ARB proposes a second technology review to be conducted in 2009 to evaluate whether technologies that would meet the ultra-low emission TRU performance standards would be available and cost-effective for a broad spectrum of the model year 2003 through 2005 TRU and TRU gen set engines that would need to come into compliance by the end of 2010 through 2012, respectively.

REFERENCES:

U.S. EPA, 2003. Control of Emissions of Air Pollutants from Nonroad Diesel Engines and Fuel, Proposed Rule Making Notice of Proposed Rule Making, Federal Register. Vol. 68 No. 100, May 23, 2003, pp. 28327-28603. U.S. Environmental Protection Agency.

State of California
AIR RESOURCES BOARD

Staff Report: Initial Statement of Reasons for the
Proposed Airborne Toxic Control Measure for
In-Use Diesel-Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities Where TRUs Operate

Technical Support Document

I. INTRODUCTION

A. Overview

The California Air Resources Board's (ARB or Board) mission is to protect public health, welfare, and ecological resources through the effective and efficient reduction of air pollutants, while recognizing and considering the effects on the economy of the State. ARB's vision is that all individuals in California, especially children and the elderly, can live, work, and play in a healthful environment – free from harmful exposure to air pollution. Diesel engine exhaust, is a source of unhealthful air pollutants including: gaseous- and particulate-phase toxic air contaminants (TAC), particulate matter, carbon monoxide, hydrocarbons, and oxides of nitrogen. Diesel-fueled Transport Refrigeration Units (TRU) and TRU generator set engines emit diesel exhaust particulate matter (diesel PM), a TAC. *Staff are proposing an Airborne Toxic Control Measure* (ATCM) to reduce diesel PM emissions from in-use TRUs and TRU generator sets because exposure to diesel PM causes adverse health effects.

This Staff Report for the Proposed ATCM includes:

- Background regulatory information (Chapter I);
- Discussion of the need for control of diesel particulate matter (Chapter II);
- A summary of public outreach (Chapter III);
- Discussion of diesel TRUs and TRU generator sets (Chapter IV);
- Potential emissions, exposure, and risk from diesel TRUs (Chapter (V);
- Availability and technological feasibility of potential control measures (Chapter VI);
- A summary and discussion of the proposed ATCM, including alternative requirements considered (Chapter VII);
- Economic impacts of the proposed control measure (Chapter VIII);
- Environmental impact of the proposed control measure (Chapter IX);
- The proposed text of the measure and other supplementary information (Appendices).

B. Purpose

The proposed ATCM is designed to reduce the general public's exposure to diesel PM and other TACs from TRUs and TRU generator sets and thereby reduce near-source risk at facilities where TRUs congregate. The proposed ATCM would require TRUs that operate in California to meet in-use performance standards in a two-step process using a phased compliance schedule. Older TRUs and TRU generator sets would initially comply with the first-step performance standards which are referred to as Low-Emission TRU (LETRU). Compliance with the second step of in-use Performance standards, referred to as the Ultra-Low Emission TRU (ULETRU), would be required approximately seven years after the compliance date for the LETRU requirements. Units that use alternative technologies that eliminate diesel engine operation while at a facility would qualify as ULETRU-compliant. Owner/Operators would be required to submit a report to ARB and update the ARB if changes occur. Larger facilities (≥ 20 loading dock doors serving refrigerated areas) that are visited by TRUs and TRU generator sets (e.g. grocery distribution centers) would be required to report information to ARB that indicates the level of TRU activity at the facility. ARB would use the information to determine if the ATCM adequately addressed residual risk near these facilities. Chapter VII of this Staff Report contains a discussion of the proposed ATCM. Appendix A contains the full text of the proposed ATCM.

C. Regulatory Authority

Several sections of the California Health and Safety Code (HSC) provide the ARB with authority to adopt the proposed ATCM. HSC sections 39600 (General Powers) and 39601 (Standards, Definitions, Rules, and Measures) confer to the ARB, the general authority and obligation to adopt rules and measures necessary to execute the Board's powers and duties imposed by State law. HSC sections 43013(b) and 43018 provide broad authority for adopting measures to reduce TACs and other air pollutant emissions from vehicular and other mobile sources. HSC section 39618 classifies refrigerated trailers as off-road mobile sources under ARB jurisdiction.

More specifically, California's Air Toxics Program, established under California law by AB 1807 (Stats. 1983, Ch. 1047) and set forth in Health and Safety Code sections 39650 through 39675, mandates the identification and control of air toxics in California. The identification phase of the Air Toxics Program requires the ARB, with participation of other state agencies, such as the Office of Environmental Health Hazard Assessment (OEHHA), to evaluate the health impacts of, and exposure to, substances and to identify those substances that pose the greatest health threat as TACs. The ARB's evaluation is made available to the public and is formally reviewed by the Scientific Review Panel (SRP) established under Health and Safety Code section 39670. Following the ARB's evaluation and the SRP's review, the Board may formally identify a TAC at a public hearing. Following the identification of a substance as a TAC, Health and Safety Code sections 39658, 39665, 39666, and 39667 requires the ARB, with the participation of the air pollution control and air quality management districts, and in consultation with affected sources and interested parties, to prepare a report on the need and appropriate degree of regulation for that substance.

In August 1998, the Board identified diesel PM as a TAC and in October 2000, the ARB published a "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-fueled Engines and Vehicles." In the Diesel Risk Reduction Plan, the ARB indentified TRU emissions associated with refrigerated warehouse distribution centers as creating potential cancer risks and included off-road engines in the plan to reduce diesel PM emissions.

In October 2001, the OEHHA, published a "Prioritization of Toxic Air Contaminants Under the Children's Environmental Health Protection Act." Appendix C-1 of this document lists all of the TACs found in diesel PM in the section for Particulate Emissions from Diesel-Fueled Engines. Table I-1 lists these TACs. The Board has determined that there was not sufficient scientific evidence available to support "safe" threshold exposure levels for the TACs listed in Table I-1. (ARB, 2000; OEHHA, 2001). Exposure to these TACs and to other air pollutants emitted by diesel-powered TRU engines would be reduced once the proposed ATCM is adopted by the Board.

Table I- 1
Toxic Air Contaminants Found in
Diesel Engine Exhaust

Acetaldehyde	Chlorobenzene	Methanol
Acrolein	Chromium compounds	Methyl ethyl Keytone
Aniline	Cobalt compounds	Napthalene
Antimony compounds	Cresol	Nickel
Arsenic	Cyanide compounds	4-Nitrobiphenyl
Benzene	Dibenzofuran	Phenol
Berillium compounds	Dibutylphthalate	Phosphorous
Biphenal	Ethyl benzene	Polycyclic Organic Matter (including PAHs)
Bis [2-Ethylhexyl]phthalate	Formaldehyde	Propionaldehyde
1,3-Butadiene	Hexane	Selenium compounds
Cadmium	Lead compounds	Styrene
Chlorinated dioxins & dibenzofurans	Magnesium compounds	Toluene
Chlorine	Mercury compounds	Xylene isomers and mixtures

(OEHHA, October 2001)

D. Regulatory Status

This section provides a regulatory context for the proposed ATCM by briefly discussing significant existing federal, state, and local air quality regulations and programs that apply to TRUs and TRU generator sets. It is not intended to address all of the air quality or other regulations that could possibly affect TRUs and TRU generator sets.

Federal and California Emission and Fuel Standards

Federal nonroad compression ignition engine emission standards are set forth for new engines in 40 Code of Federal Regulations (CFR) Part 89. California has harmonized with federal emission standards, as set forth in title 13 California Code of Regulations (CCR), Article 4, sections 2420-2427, under "Heavy Duty Off-road Diesel Cycle Engines." The off-road engine standards vary depending upon the engine model year and maximum rated power. Table I-2 shows the PM emission standards that TRU and TRU generator set engines were subject to Tier 1 and Tier 2.

TABLE I-2
Tier 1 and Tier 2 New Off-road CI Engine Standards (g/hp-hr)

HP Category	Compliance Year								
	1999	2000	2001	2002	2003	2004	2005	2006	2007
<25 hp	NA	0.75 (<11 hp) 0.60 (≥ 11 to <25 hp)					0.60		
≥ 25 to ≤ 50 hp	0.60					0.45			

Note: Light gray shaded areas indicate Tier 1 standards. Darker gray shaded areas indicate Tier 2 standards.

On April 15, 2003, U.S. EPA proposed more stringent Tier 4 standards for the control of emissions from nonroad compression ignition engines. ARB will adopt equivalent off-road standards in 2004. Table I-3 shows the proposed standards.

TABLE I-3
Proposed Tier 4 Nonroad CI Engine Standards (g/hp-hr)

HP Category	Compliance Year						
	2008	2009	2010	2011	2012	2013	2014
<25 hp	0.30[3] PM						
≥ 25 to <75 hp	0.22 PM					0.02 PM 3.5 NMHC+NOx	

Note: Light gray shaded area indicates the "interim" Tier 4 standard. The darker gray shaded area indicates the "long-term" Tier 4 standard.

Federal and California fuel standards specifically apply to manufacturers and distributors rather than to mobile sources or their operators. Nevertheless, these standards directly affect the fuel used in mobile sources, including TRUs and TRU generator sets. Fuel standards for sulfur content, aromatic content, and other fuel

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[3] ARB and U.S. EPA will perform a technical review in 2007 to evaluate the DOC or filter-based standard for <25 hp category in the 2010 to 2013 timeframe. If a more stringent final level for Tier 4 is adopted for this horsepower category, then a revision to this ATCM may add an ULETRU engine certification performance standard for <25 hp TRUs and TRU generator sets.

components and parameters play a critical role in meeting emission standards. Federal commercial fuel standards are set forth in 40 CFR Part 80 and California fuel standards are set forth in title 13 California Code of Regulations sections 2281 and 2282 (diesel). In July, 2003, a revision to CCR title 13, section 2281 was adopted by the ARB which allows only very low sulfur diesel (<15 ppm) in diesel fuel starting in 2006. Activities involving California nonvehicular diesel fuel are also subject to this requirement as if it were vehicular fuel. U.S. EPA plans to adopt a similar sulfur restriction that would go into effect in 2006 for on-road fuel use and in 2010 for nonroad fuel use. Fuel suppliers for California must meet both federal and California fuel standards.

California Statutes and Local Air District Rules

In addition to harmonized state/federal off-road/nonroad diesel engine emission standards, TRUs are subject to several other air quality-related statutes and regulations in the California Health and Safety Code.

HSC section 41700 is an important statutory requirement that applies to any source of air pollution whatsoever (with some very narrow exceptions), that prohibits any person from discharging such quantities of air contaminants which cause injury, detriment, nuisance, or annoyance to any considerable number of persons or the public, or which endanger the comfort, repose, health, or safety of any such persons or the public, or which cause or have the natural tendency to cause injury or damage to business or property."

HSC section 41701 also applies similarly to any source whatsoever and prohibits air contaminant emissions that obscure an observer's view to no more than Ringelmann 2 or an opacity of 40 percent.

Local air districts all have prohibitory rules that are at least as stringent as HSC sections 41700 and 41701. These two statutes and the local rules provide broad authority to air districts to enforce the statutory prohibition against any source whatsoever causing a nuisance or emitting excessive smoke.

Voluntary Retrofit Programs

Federal, State, and local programs have been developed to encourage less-polluting diesel engines. These programs include:

- U.S. EPA's Voluntary Diesel Retrofit Program;
- ARB's Carl Moyer Program
- EPA's "SmartWay Transport Initiative"

Although U.S. EPA plans to significantly reduce pollution from new diesel engines through several steps of new diesel engine emission standards, the effects of these rules will take many years to implement due to the long lives of diesel engines. EPA has developed the Voluntary Diesel Retrofit Program to help make a difference in the immediate future. The program will address pollution from diesel construction equipment and heavy-duty vehicles that are currently on the road today. The Program is building a market for clean diesel engines by working with state, local and industry partners to create demonstration projects around the country. The Web site at http://www.epa.gov/otaq/retrofit/ is designed to help fleet operators, air quality planners in State/local government, and retrofit manufacturers understand this program, and to obtain the information they need to create effective retrofit projects.

ARB's Carl Moyer Memorial Air Quality Standards Attainment Program provides funds on an incentive-basis for the incremental cost of cleaner than required engines and equipment. Eligible projects include cleaner on-road, off-road, marine, locomotive and stationary agricultural pump engines, as well as forklifts, airport ground support equipment, auxiliary power units, and transport refrigeration units. The program achieves near-term reductions in emissions of oxides of nitrogen (NOx), which are necessary for California to meet its clean air commitments under the State Implementation Plan. In addition, local air districts use these NOx emission reductions to meet commitments in their conformity plans, thus preventing the loss of federal funding for local areas throughout California. The program also reduces particulate matter (PM), a component of diesel exhaust. A recent change to the program guidelines clarified the intent that TRUs are eligible for these funds.

In the spring of 2002, California voters passed Proposition 40, the California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act. Proposition 40 allocates $50 million to the ARB over two years for distribution to air districts for projects that "affect air quality in State and local parks and recreation areas" in accordance with the Carl Moyer guidelines. Of these funds, the governor allocated $25 million to the ARB for the 2002/2003 fiscal year. Further information is available at http://www.arb.ca.gov/msprog/moyer/moyer.htm

EPA's SmartWay Transport initiative is a voluntary partnership between various freight industry sectors and EPA that establishes incentives for fuel efficiency improvements, emissions reductions affecting human health, especially in densely populated areas, and greenhouse gas emissions. The SmartWay Transport fleets component invites companies that either use or provide freight shipping services (shippers and carriers, respectively) to become SmartWay Transport partners by applying innovative strategies and technologies to improve fuel efficiency, reduce emissions, and promote new, clean technologies. Partners that meet program requirements and exceed performance thresholds will have SmartWay logo rights and get public visibility and recognition for having outstanding environmentally-efficient freight transport services. They will earn the right to highlight their environmental leadership to their customers and the public. Further information is available on the Web at www.epa.gov/otaq/smartway/index.htm

E. Summary

The proposed ATCM would reduce diesel PM emissions from TRU and TRU generator set engines sooner than what would be achieved through new engine standards, would provide information necessary to evaluate residual risk at larger facilities where TRUs operate, and would improve the accuracy of the TRU emissions inventory. The proposed ATCM would apply to all in-use TRUs and TRU generator sets that operate in California. Because TRUs and TRU generator sets can last for 30 years or more, an accelerated replacement or retrofit program is needed to assure that older, higher-emitting TRUs are either removed from the California population or emissions are reduced to meet more stringent in-use performance standards. This TRU ATCM is necessary because there are no air district regulations, local ordinances, and few (if any) written facility operating policies that address TRU emissions.

Voluntary TRU replacement and retrofit programs for TRUs have thus far been ineffective in removing old, higher emitting TRUs from the TRU population. Until recently, incentive programs have not been applied toward TRUs and then have only provided a limited amount of funding for specified purposes (e.g. NOx reductions). These incentive programs also usually require matching funds and are subject to future government budget allocations. Local funding programs, which are the source of most matching funds, have focussed on ozone precursor reductions, not PM reductions.

REFERENCES

ARB, 2000. California Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles*, Sacramento, California. October, 2000.

OEHHA, 2001. California. Office of Environmental Health Hazard Assessment. *Prioritization of Toxic Air Contaminants Under the Children's Environmental Health Protection Act*, Sacramento, California. October, 2001.

II. NEED FOR CONTROL OF DIESEL PARTICULATE MATTER

In 1998, the Air Resources Board (ARB or Board) identified diesel particulate matter (diesel PM) as a toxic air contaminant (TAC). Diesel PM is by far the most important TAC and contributes over 70 percent of the estimated risk from air toxics today. In September 2000, the ARB approved the "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles" (Diesel Risk Reduction Plan). The goal of the Diesel Risk Reduction Plan is to reduce diesel PM emissions and the associated cancer risk by 85 percent in 2020. In addition, in 2001, the Office of Environmental Health Hazard Assessment (OEHHA) identified diesel PM as one of the TACs that may cause children or infants to be more susceptible to illness pursuant to the requirements of Senate Bill 25 (1999, Escutia). Senate Bill 25 also requires the ARB to adopt control measures, as appropriate, to reduce the public's exposure to these special TACs (Health and Safety Code section 39669.5).

This proposed Airborne Toxic Control Measure (ATCM), to reduce diesel PM emissions from diesel-fueled transport refrigeration unit (TRU) engines, is one of a large group of regulations being developed to achieve the emission reduction goals of the Diesel Risk Reduction Plan for protecting the health of Californians by reducing the public's exposure to diesel PM. The proposed ATCM will also reduce emissions of volatile organic compounds (VOCs) and oxides of nitrogen (NOx), precursors to the formation of ozone.

This chapter describes the physical and chemical characteristics of diesel PM, and discusses the health effects of the pollutants emitted by diesel engines and the environmental benefits from the proposed regulation. As discussed below, it is important that steps be taken to reduce emissions from all diesel-fueled engines (including diesel-fueled TRU engines) to reduce public exposures to diesel PM and ozone, to make further progress in meeting the ambient air quality standards, and to improve visibility.

A. Physical and Chemical Characteristics of Diesel PM

Diesel engines emit a complex mixture of inorganic and organic compounds that exist in gaseous, liquid, and solid phases. The composition of this mixture will vary depending on engine type, operating conditions, fuel, lubricating oil, and whether or not an emission control system is present. The primary gas or vapor phase components include typical combustion gases and vapors such as carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), oxides of nitrogen (NOx), reactive organic gases (ROG), water vapor, and excess air (nitrogen and oxygen). Mass emission rates also vary by engine. For example, an uncontrolled 1987 34 horsepower (hp) diesel TRU engine could have a diesel PM emission rate of 0.76 grams per horsepower-hour (g/hp-hr), while a 2004 model year engine is required to meet a 0.45 g/hp-hr emission rate, and under the proposed Tier 4 nonroad standards, that same size engine will be required to meet a 0.02 g/hp-hr emission rate in 2013.

The emissions from diesel-fueled engines also contain potential cancer-causing substances such as arsenic, nickel, benzene, formaldehyde, and polycyclic aromatic hydrocarbons (PAHs). There are over 40 substances in emissions from diesel-fueled engines listed by the United States Environmental Protection Agency (U.S. EPA) as hazardous air pollutants and by the ARB as TACs. Fifteen of these substances are listed by the International Agency for Research as carcinogenic to humans, or as a probable or possible human carcinogen. The list includes the following substances: formaldehyde, acetaldehyde, 1,3-butadiene, antimony compounds, arsenic, benzene, beryllium compounds, inorganic lead, mercury compounds, bis(2-ethylhexyl)phthalate, dioxins and dibenzofurans, nickel, polycyclic organic matter (POM) including PAHs, and styrene.

Diesel PM is either directly emitted from diesel-powered engines (primary particulate matter) or is formed from the gaseous compounds emitted by a diesel engine (secondary particulate matter). Diesel PM consists of both solid and liquid material and can be divided into three primary constituents: the elemental carbon fraction, the soluble organic fraction, and the sulfate fraction.

Many of the diesel particles exist in the atmosphere as a carbon core with a coating of organic carbon compounds, or as sulfuric acid and ash, sulfuric acid aerosols, or sulfate particles associated with organic carbon. The organic fraction of the diesel particle contains compounds such as aldehydes, alkanes and alkenes, and high-molecular weight PAH and PAH-derivatives. Many of these PAHs and PAH-derivatives, especially nitro-PAHs, have been found to be potent mutagens and carcinogens. Nitro-PAH compounds can also be formed during transport through the atmosphere by reactions of adsorbed PAH with nitric acid and by gas-phase radical-initiated reactions in the presence of oxides of nitrogen. Fine particles may also be formed secondarily from gaseous precursors such as SO_2, NOx, or organic compounds. Fine particles can remain in the atmosphere for days to weeks and travel through the atmosphere for hundreds to thousands of kilometers, while coarse particles deposit to the earth within minutes to hours and within tens of kilometers from the emission source.

Almost all of the diesel particle mass is in the fine particle range of 10 microns or less in diameter (PM_{10}). Approximately 94 percent of the mass of these particles are less than 2.5 microns in diameter $PM_{2.5}$. Diesel PM can be distinguished from noncombustion sources of $PM_{2.5}$ by the high content of elemental carbon with the adsorbed organic compounds and the high number of ultrafine particles (organic carbon and sulfate).

The soluble organic fraction (SOF) consists of unburned organic compounds in the small fraction of the fuel and atomized and evaporated lube oil that escape oxidation. These compounds condense into liquid droplets or are adsorbed onto the surfaces of the elemental carbon particles. Several components of the SOF have been identified as individual toxic air contaminants.

B. Health Impacts of Exposure to Diesel PM, Ambient PM, and Ozone

The proposed ATCM will reduce the public's exposure to diesel PM, as well as reduce ambient particulate matter. In addition, the proposed ATCM is expected to result in reductions in emissions of NOx and VOC, which are precursors to the formation of ozone in the lower atmosphere. The primary health impacts of these air pollutants are discussed below.

Diesel Particulate Matter

Diesel PM is of specific concern because it poses a lung cancer hazard for humans as well as a hazard from noncancer respiratory effects such as pulmonary inflammation. Because of their small size, the particles are readily respirable and can effectively reach the lowest airways of the lung along with the adsorbed compounds, many of which are known or suspected mutagens and carcinogens. More than 30 human epidemiological studies have investigated the potential carcinogenicity of diesel PM. On average, these studies found that long-term occupational exposures to diesel exhaust were associated with a 40 percent increase in the relative risk of lung cancer (OEHHA, 1998). However, there is limited specific information that addresses the variable susceptibilities to the carcinogenicity of diesel exhaust within the general human population and vulnerable subgroups, such as infants and children and people with preexisting health conditions. Also, the genotoxicity of diesel exhaust and some of its chemical constituents have been reported in a number of studies (OEHHA, 1998).

Diesel PM was listed as a TAC by ARB in 1998 after an extensive review and evaluation of the scientific literature by OEHHA (ARB, 1998). Using the cancer unit risk factor developed by OEHHA for the TAC program and modeled ambient concentrations of diesel PM, it was estimated that for the year 2000, exposure to ambient concentrations of diesel PM (1.8 micrograms per cubic meter [$\mu g/m^3$]) represented a health risk of 540 potential cancer cases per million people exposed over a 70-year lifetime.

Another significant health effect of diesel exhaust exposure is its apparent ability to act as an adjuvant in allergic responses and possibly asthma (Diaz-Sanchez et al., 1996, Takano et al., 1998, Diaz-Sanchez et al., 1999). However, additional research is needed at diesel exhaust concentrations that more closely approximate current ambient levels before the role of diesel PM exposure in the increasing allergy and asthma rates is established.

Ambient Particulate Matter

Numerous epidemiological studies have shown that an increase in the ambient PM concentration can cause adverse health effects. The key health effects associated with ambient PM, of which diesel PM is a component, are premature mortality, aggravation of respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits, school absences, work loss days, and restricted activity days), aggravated asthma, acute respiratory symptoms (including aggravated coughing and difficult or painful breathing), chronic bronchitis, and decreased lung function that can be experienced as shortness of breath (U.S. EPA, 2000; U.S. EPA, 2003).

Health impacts from exposure to the fine particulate matter ($PM_{2.5}$) component of diesel exhaust have been calculated for California, using concentration-response equations from several epidemiological studies. Both mortality and morbidity effects have been associated with exposure to both direct diesel $PM_{2.5}$ and indirect diesel $PM_{2.5}$, the latter of which arises from the conversion of diesel NOx emissions to $PM_{2.5}$ nitrates. It was estimated that 2000 and 900 premature deaths resulted from long-term exposure to both 1.8 $\mu g/m^3$ of direct $PM_{2.5}$ and 0.81 $\mu g/m^3$ of indirect $PM_{2.5}$, respectively, for the year 2000. The mortality estimates are likely to exclude cancer cases, but may include some premature deaths due to cancer, because the epidemiological studies did not identify the cause of death. Exposure to fine particulate matter, including diesel $PM_{2.5}$ can also be linked to a number of heart and lung diseases.

<u>Ozone</u>

Diesel exhaust consists of hundreds of gas-phase, particle-phase, and semi-volatile organic compounds, including typical combustion products, such as CO_2, hydrogen, oxygen, and water vapor, as well as CO, VOCs, carbonyls, alkenes, aromatic hydrocarbons, PAHs, PAH derivatives, and SOx - compounds resulting from incomplete combustion. Ozone is formed by the reaction of VOCs and NOx in the atmosphere in the presence of heat and sunlight. The highest levels of ozone are produced when both VOC and NOx emissions are present in significant quantities on clear summer days. This pollutant is a powerful oxidant that can damage the respiratory tract, causing inflammation and irritation, which can result in breathing difficulties.

Studies have shown that there are impacts on public health and welfare from ozone at moderate levels that do not exceed the national 1-hour ozone standard. Short-term exposure to high ambient ozone concentrations have been linked to increased hospital admissions and emergency visits for respiratory problems (U.S. EPA, 2000). Repeated exposure to ozone can make people more susceptible to respiratory infection and lung inflammation and can aggravate preexisting respiratory diseases, such as asthma. Prolonged (6 to 8 hours), repeated exposure to ozone can cause inflammation of the lung, impairment of lung defense mechanisms, and possibly irreversible changes in lung structure, which over time could lead to premature aging of the lungs and/or chronic respiratory illnesses such as emphysema and chronic bronchitis.

The subgroups most susceptible to ozone health effects include individuals exercising outdoors and, children and people with preexisting lung disease such as asthma, and chronic pulmonary lung disease. Children are more at risk from ozone exposure because they typically are active outside during the summer when ozone levels are highest. Also, children are more at risk than adults from ozone exposure because their respiratory systems are still developing. Adults who are outdoors and moderately active during the summer months, such as construction workers and other outdoor workers, are also among those most at risk. These individuals, as well as people with respiratory illnesses such as asthma, especially asthmatic children, can experience reduced lung function and increased respiratory symptoms, such as chest pain and cough, when exposed to relatively low ozone levels during prolonged periods of moderate exertion.

C. Health and Environmental Benefits from the Proposed Regulation

Reducing diesel PM emissions from TRUs will have both public health and environmental benefits. The proposed ATCM will reduce localized potential cancer risks associated with transport refrigeration units that are near receptors and will also contribute to the reduction of the general exposure to diesel PM that occurs on a region-wide basis due to collective emissions from diesel-fueled engines. Additional benefits associated with the proposed regulation include further progress in meeting the ambient air quality standards for PM_{10}, $PM_{2.5}$, ozone, and enhancing visibility.

Reduced Diesel PM Emissions

The estimated reductions in diesel PM emissions and the associated benefits from reduced exposures and risk are discussed in detail in Chapter IX.

Reduced Ambient Particulate Matter Levels

Reducing diesel PM will also help efforts to achieve the ambient air quality standards for PM. Both the State of California and the U.S. EPA have established standards for the amount of PM_{10} in the ambient air. These standards define the maximum amount of PM that can be present in outdoor air. California's PM_{10} standards were first established in 1982 and updated June 20, 2002. The current PM_{10} standard is more protective of human health than the corresponding national standard. Additional California and federal standards were established for $PM_{2.5}$ to further protect public health (Table II-1).

PM levels in most areas of California exceed one or more of current state PM standards. The majority of California is designated as non-attainment for the State PM_{10} standard (ARB 2002). Diesel PM emission reductions from diesel-fueled engines will help protect public health and assist in furthering progress in meeting the ambient air quality standards for both PM_{10} and $PM_{2.5}$.

Table II-1
State and National PM Standards

California Standard		National Standard	
	PM_{10}		
Annual Arithmetic Mean	20 $\mu g/m^3$	Annual Arithmetic Mean	50 $\mu g/m^3$
24-Hour Average	50 $\mu g/m^3$	24-Hour Average	150 $\mu g/m^3$
	$PM_{2.5}$		
Annual Arithmetic Mean	12 $\mu g/m^3$	Annual Arithmetic Mean	15 $\mu g/m^3$
24-Hour Average	No separate State standard	24-Hour Average	65 $\mu g/m^3$

The emission reductions obtained from the implementation of this proposed ATCM will result in lower ambient PM levels and significant reductions of exposure to primary and secondary diesel PM. Lower ambient PM levels and reduced exposure mean reduction of the prevalence of the diseases attributed to diesel PM, reduced incidences of hospitalizations and prevention of premature deaths.

Reduced Ambient Ozone Levels

Emissions of NOx and VOC, precursors to the formation of ozone in the lower atmosphere, will also be reduced by the proposed regulation. In California, most major urban areas and many rural areas continue to be non-attainment for the State and federal 1-hour ambient air quality standard for ozone. Table II-2 shows the State and federal ozone standards in effect. Controlling emissions of ozone precursors would reduce the prevalence of respiratory problems associated with ozone exposure, and would reduce hospital admissions and emergency visits for respiratory problems. Ozone can also have adverse health impacts at concentrations that do not exceed the 1-hour NAAQS.

Table II-2
State and National Ozone Standards

California Standard		National Standard
1 hour	0.09ppm (180 $\mu g/m^3$)	0.12ppm (235 $\mu g/m^3$)
8 hour		0.08 ppm (157 $\mu g/m^3$)

Improved Visibility

In addition to the public health effects of fine particulate pollution, fine particulates including sulfates, nitrates, organics, soot, and soil dust contribute to the regional haze that impairs visibility.

In 1999, the U.S. EPA promulgated a regional haze regulation that calls for states to establish goals and emission reduction strategies for improving visibility in 156 mandatory Class I national parks and wilderness areas. California has 29 of these national parks and wilderness areas, including Yosemite, Redwood, and Joshua Tree National Parks. Reducing diesel PM from diesel-fueled TRUs will help improve visibility in these Class I areas.

REFERENCES

ARB, 1998. California Air Resources Board. *Report to the Air Resources Board on the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant; Appendix III, Part A, Exposure Assessment.* Sacramento, California. April 22, 1998.

ARB, 2002. California Air Resources Board. *The 2002 California Almanac of Emission and Air Quality*, Sacramento, California. 2002.

OEHHA, 1998. Office of Environmental Health Hazard Assessment. *Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant: Health Risk Assessment for Diesel Exhaust; Appendix III, Part B*, Sacramento, California. 1998.

Diaz-Sanchez et al, 1996. Diaz-Sanchez, D.; Tsien, A.; Casillas, A.; Dotson, A.R.; Saxon, A. *Enhanced Nasal Cytokine Production in Human Beings after in vivo Challenge with Diesel Exhaust Particles*; J. Allergy Clin. Immunol; 1996.

Diaz-Sanchez et al, 1999. Diaz-Sanchez, D.; Garcia, M.P.; Wang, M.; Jyrala, M.; Saxon, A. *Nasal Challenge with Diesel Exhaust Particles Can Induce Sensitization to a Neoallergen in the Human Mucosa;* J. Allergy Clin. Immunol. 1999, 104,
1183-1188.

Takano et al, 1998. Takano, H.; Ichinose, T.; Miyabara, Y.; Shibuya, T.; Lim, H.B.; Yoshikawa, T.; Sagai, M. *Inhalation of Diesel Exhaust Enhances Allergen-related Eosinophil Recruitment and Airway Hyperresponsiveness in Mice; Toxicol. Appl. Pharmacol;* 1998.

U.S. EPA, 2000. United States Environmental Protection Agency, Assessment and Standards Division, Office of Transportation and Air Quality. CD-ROM. *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements.* EPA 420-R-00-028, Research Triangle Park, North Carolina. December 2000.

U.S. EPA, 2003. United States Environmental Protection Agency, Assessment and Standards Division, Office of Transportation and Air Quality. CD-ROM. *Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel,* EPA 420-R-03-008, Research Triangle Park, North Carolina. April 2003.

III. PUBLIC OUTREACH

A. Outreach Efforts

Introduction

Public participation is a key requirement of California's regulatory process. The potential benefits of public participation rely upon public outreach to all communities, particularly those directly affected by a regulation. In addition, public outreach to low-income and minority communities is an important tool for fulfilling the Air Resources Board's (ARB or Board) commitment to environmental justice. Thus, throughout the development of the proposed airborne toxic control measure (ATCM), staff endeavored to identify affected industry and public organizations and to offer them opportunities to: 1) become informed about the proposed ATCM and the ATCM process; 2) provide pertinent information for ARB staff consideration; and 3) discuss comments and concerns.

Staff has used Internet web pages (http://www.arb.ca.gov/diesel/dieselrrp.htm and http://www.arb.ca.gov/diesel/tru.htm), and electronic and mail-out notices to alert organizations and individuals to workgroup meetings, public workshops, and the public hearing for the proposed ATCM. In addition, outreach efforts have included hundreds of personal contacts via telephone, electronic mail, regular mail, surveys, facility visits, and meetings. These contacts have included interactions with: transport refrigeration unit (TRU) and TRU generator set manufacturers, engine manufacturers, and operators; emission control system manufacturers; storage and/or distribution facility representatives; trucking, grocer, refrigerated warehouse and other local, national, and international trade association representatives; heating, refrigerating, and air conditioning engineers; representatives from federal agencies, including the U.S. Environmental Protection Agency (U.S. EPA) and U.S. Department of Agriculture (USDA); representatives from State agencies, including the Department of Health Services (DHS) and California Department of Food and Agriculture (DFA); representatives from California air pollution control and air quality management districts; and representatives from environmental, pollution prevention, public health advocate, and environmental justice organizations.

Major Outreach Activities

Major outreach activities for the proposed ATCM include:

- October 2000: publication of the "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles" (DRRP);
- February 2001 and January 2002: diesel particulate matter (PM) public consultation meetings;
- 2001 - ongoing: information about DRRP, including the proposed ATCM, discussed at community meetings held throughout California;

Major Outreach Activities (continued)

- 2001- ongoing: California Diesel Risk Reduction Program Transportation Refrigeration Units web page (http://www.arb.ca.gov/diesel/tru.htm) and list serve development and maintenance;
- 2001-ongoing: California Air Pollution Control Officers Association Toxics Committee updates;
- 2001-2003: manufacturer, operator, and State agency information gathering;
- January 2002 - October 2002: 25 storage and/or distribution facility site visits and interviews;
- June 2001 - July 2003: discussions with TRU and TRU generator set manufacturers, engine manufacturers, and U.S. EPA regarding a special TRU engine certification test cycle to determine compliance with proposed federal Tier 4 non-road emission standards;
- November 2001 - ongoing: disseminate information and encourage testing and demonstration of available and emerging emission control methods in partnership with emission control system, engine, TRU and TRU generator set manufacturers and others;
- August 2002 - ongoing: help design and fund studies of TRU electric stand-by use in partnership with the California Energy Commission, Carrier-Transicold, Clean Fuel Connection, Inc., In-N-Out Burgers, Norco Egg Ranch, Raley's, Riverside County Transportation Commission, Sacramento Metropolitan Air Quality Management District, and Sacramento Municipal Utility District;
- January 2002 - July 2003: nine proposed ATCM workgroup meetings/conference calls;
- April 2002 - October 2003: five proposed ATCM public workshops, with Webcast on June 2003. [Note: public workshops were also announced in Refrigerated Transporter Business Picture (business@business.email.primedia.com), a weekly electronic mail update of refrigerated transportation news and trends with a circulation of 15,000];
- May 2003: "Fact Sheet -Transport Refrigeration Units (TRUs)" published on web page in English and Spanish;
- June 2003: tours of two produce packing facilities followed by continued dialog with representatives of California Citrus Mutual and Nisei Farmers League;
- July 2003: staff observation of heavy-duty vehicle inspection at Antelope weigh scales; and
- October 2003: notice for public hearing to consider adoption of proposed ATCM and availability of this Staff Report.

In addition, staff participated in or contributed to:

- November 2000-February 2002: Four International Diesel Retrofit Advisory Committee meetings;
- July 2003: Truckload Carrier Association, Refrigerated Division, Annual Meeting; and
- September 2003: Electric Material Handling/Electric Idle Reduction for Trucks Workshop, presented by Sacramento Municipal Utility District and Electric Power Research Institute at McClellan Park.

B. Summary of Public Involvement

The public was initially made aware of the ARB intention to address off-road diesel-fueled engine emissions by the publication of the DRRP in October 2000. The DRRP specifically identified several types of off-road diesel-fueled engines, including those associated with transportation refrigeration, and discussed strategies to achieve and/or verify in-use engine emission reductions, including replacement, retro-fit, and compliance testing (ARB, 2000).

Staff contacted major TRU and TRU generator set manufacturers, engine manufacturers, operators, and operator organizations both to alert affected industry and to gather information about the technology and operation of the equipment. The information from these sources was supplemented by approximately 25 facility tours and interviews, workgroup and workshop discussions, and data provided by State and local agencies. The results of these information-gathering activities are summarized throughout this Staff Report. In addition, the ARB contracted with the University of California, Riverside College of Engineering Center for Environmental Research and Technology (CE-CERT) to perform data-logging studies for the purpose of determining representative TRU runtimes and exhaust temperatures (ARB, 2003).

Staff discussed numerous regulatory approaches for controlling TRU and TRU generator set emissions with affected industry and the public during two public consultation meetings, nine workgroup meetings/conference calls, five public workshops, and a large number of stakeholder meetings, e-mails, and telephone conversations. In particular, staff tracked available and emerging control methods and facilitated communication among control system manufacturers and TRU and TRU generator set manufacturers, engine manufacturers, and operators. This continuing effort has resulted in a number of demonstration projects and studies that have provided important information regarding the feasibility and efficacy of various particulate matter control devices, retrofit technology, electrification, and alternative fuel use.

After evaluating available study results and stakeholder comments, staff reconsidered initial proposals for facility electrification and emission standards for new TRU and TRU generator set engines. Instead, staff proposes to require a one-time major facility report in order to identify facilities, evaluate associated emissions, and determine the need for further regulation. In addition, staff has decided to harmonize California's new off-road engine emission standards with proposed federal Tier 4 new non-road engine emissions standards and require emission reductions for in-use equipment. For in-use TRU and TRU generator set engines, staff proposes performance standards that would require the utilization of best available control technology or other equally or more effective control methods. Furthermore, staff proposes early compliance credit as well as a phase-in period and multiple options for meeting in-use performance standards to provide the necessary flexibility and encouragement for achievement of maximum emission reductions as quickly as possible. The goal of the proposed ATCM is to achieve significant additional emission reductions from in-use equipment in conjunction with those anticipated from compliance with proposed federal Tier 4 standards for new engines.

REFERENCES

ARB, 2000. California Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles.* Sacramento, California. October 2000.

ARB, 2003. California Air Resources Board Stationary Source Division, *Summary of Information from Manufacturers, Operators, and Facilities.* Sacramento, California. July 2003.

IV. DIESEL TRANSPORT REFRIGERATION UNITS (TRU) AND TRU GENERATOR SETS

A. Introduction to TRUs and TRU Generator Sets

Each day, Californians use numerous perishable foods and other commodities that must be stored and transported in temperature-controlled environments. Table IV-1 lists general categories of these products and includes a few specific examples of required or recommended storage-transport temperatures. Mechanical refrigeration, the primary means of controlling temperature during transport, uses Transport Refrigeration Units (TRU) and TRU generator sets to ensure that temperature-sensitive cargoes arrive safely and in good condition (USDA, 2000).

For the purpose of the proposed airborne toxic control measure (ATCM), "TRU" means refrigeration systems powered by integral internal combustion engines designed to control the environment of temperature-sensitive products that are *transported in semi-trailer vans, truck vans, railcars, or shipping containers*. Since many products must be protected from freezing as well as warm ambient temperatures, TRUs may be capable of both cooling and heating. In the transportation industry, the term "refrigerated" is often used to refer to heating, as well as cooling.

"TRU generator set" means a generator set that is designed and used to provide electric power to electrically-driven refrigeration units of any kind. This includes, but is not limited to, generator sets that provide electricity to electrically-powered refrigeration systems for semi-trailer vans and shipping containers. TRU generator sets are commonly used in conjunction with ocean-going cargo containers while being transported on land by railcars or semi-trailers.

For the purposes of the proposed ATCM, this chapter addresses TRU and TRU generator sets that are powered by diesel fuel. This chapter does not address the use of mechanical refrigeration powered solely by electricity, a vehicle chassis-driven engine, or fuels other than diesel. Nor does it address TRUs or TRU generator sets using other means of maintaining temperature control such as icing or cryogenic refrigerants.

TABLE IV-1
Temperature-Sensitive Commodities

Commodity	Required or Recommended Storage-Transport Temperature
Fresh Fruits and Vegetables	
Examples: apples	-1.1 to 4.4°C (30 to 40°F)
bananas	13.3 to 14.4°C (56 to 58°F)
lettuce	0°C (32°F)
Dairy Products	
Examples: milk	0 to 1.1°C (32 to 34°F)
cheese	1 to 4°C (34 to 40°F)
ice cream	-29 to -26°C (-20 to -15°F)
Fresh and Cured Meat and Fresh Seafood	
Examples: fresh beef/pork/lamb	0 to 1.1°C (32 to 34°F)
bacon (cured, farm style)	16 to 18°C (61 to 64°F)
pork sausages	0°C (32°F)
Poultry and Eggs	
Examples: fresh chicken/turkey	-2.2 to 0°C (28 to 32°F)
fresh eggs	-3 to 1.1°C (26 to 34°F)
Frozen Foods	-18°C (0°F) or below
Live Plants	
Example: Christmas Trees	-5 to 10°C (23 to 50°F)
Film	
Examples: photographic, x-ray	Generally recommend ≤21°C (≤70°F); avoid fluctuations.
Human Blood and Blood Products	
Example: source plasma	>-5 but <10°C (>23 but <50°F)
Pharmaceuticals	
Example: insulin	Refrigerate [Can be kept unrefrigerated up to 28 days if temperature is <30°C (<86°F). Always keep at temperature > 0°C (>32°F)].
Chemicals	
Example: ion exchange resins	>-18 but <30 to 32°C (>0 but <86° to 90°F)

(CFR, 2002; DOW, 2003; Lilly, 2000; NARA, 2001; P&O Nedlloyd, 2003; USDA, 2000)

B. TRU and TRU Generator Set Manufacturers

Although the proposed ATCM contains no specific requirements for the manufacturers of TRUs, TRU generator sets or associated engines, manufacturers are expected to play a critical role in providing compliant equipment to owners/operators. Some of these manufacturers have already begun to test available and emerging emission reduction control technology and fuel alternatives in order to determine compatibility with existing equipment and reliability across a broad range of operating modes.

Currently, all TRUs and 95 percent of TRU generator sets used in California are manufactured by the Carrier Transicold Division, Carrier Corporation, or by

Thermo King, Ingersoll-Rand Corporation. About 5 percent of TRU generator sets used in California are manufactured by Klinge Corporation or Taylor Power Products. Recently, Zanotti Transblock North America began distribution and announced plans for assembling TRUs in North America.

The primary manufacturers of TRU and TRU generator set engines are Izusu American Motors, Kubota Engine America Corporation, and Yanmar Diesel America Corporation. The engines used in TRUs and TRU generator sets are designed solely to power refrigeration units and are not used for other applications. They are manufactured separate from the refrigeration units and are installed at TRU or TRU generator set manufacturing plants (Feitel, 2002; Klinge, 2001; Refrigerated Transporter, 2003; Sem, 2001).

C. TRU and TRU Generator Set Configurations

Once the manufacture of TRUs and TRU generator sets is complete, they may be configured in several different ways with semi-trailer vans, truck vans, railcars, and shipping containers produced by a large number of commercial transport manufacturing companies. Figure IV-1 identifies eight different TRU and TRU generator set configurations and Figure IV-1a through d depicts the more common configurations. These TRU- and TRU generator set-equipped conveyances are sold or leased to thousands of different commodity transporters as described in Section D of this chapter (ARB, 2003).

FIGURE IV-1
TRU and TRU Generator Set Configurations

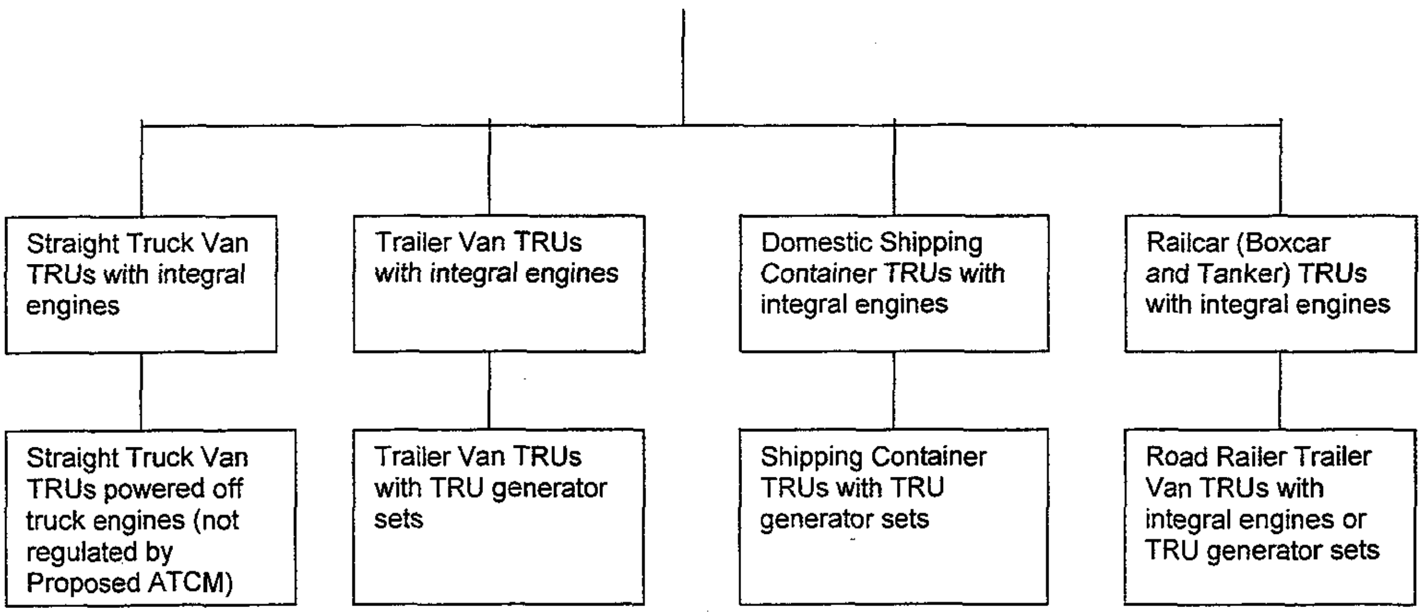
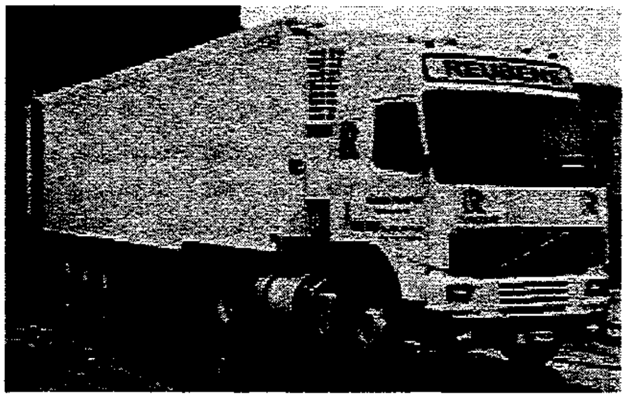
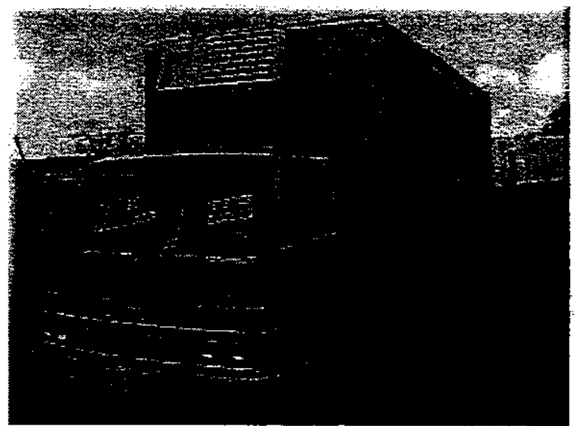


FIGURE IV-1 a-d

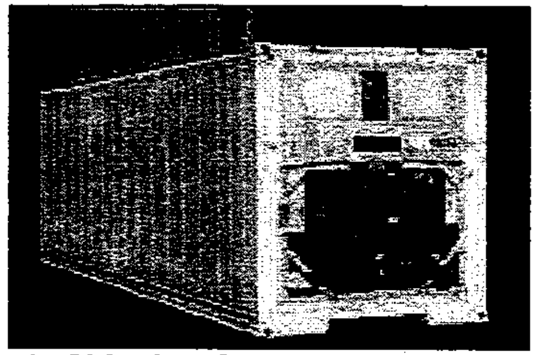


a. Semi-trailer Van with TRU



b. Truck Van with TRU

c. Railcar with TRU



d. Shipping Container that would use a TRU Generator Set on the Road

D. General Operation and Description of Commodity Transporters that use TRUs AND TRU Generator Sets

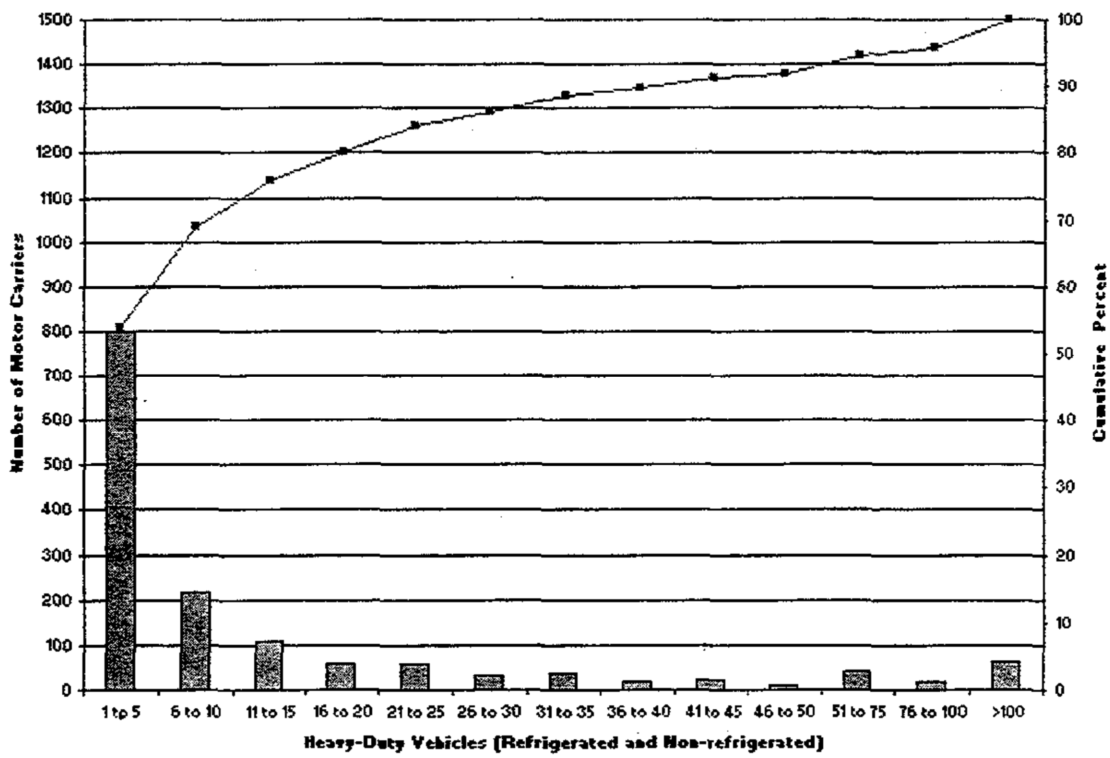
General Operation of Commodity Transporters

Based upon the 1997 Commodity Flow Survey published by the U.S. Census Bureau, semi-trailer vans and truck vans are estimated to transport approximately 83 percent by weight of all commodities in California. These motor vehicles may operate locally, regionally, intra-State, inter-State, or any combination thereof. They may also operate outside the United States in Canada and/or Mexico. However, they are usually based at (i.e., maintained at and/or dispatched from) one or more fixed locations or "terminals." The remaining 17 percent by weight of commodities are transported by air, water, pipeline, rail, or multiple modes. Staff identified commodity categories likely to require temperature control to estimate that approximately 11 percent of all commodities transported in California are likely to require the use of a TRU or TRU generator set (ARB, 2003; US Census, 1997).

Semi-trailer Van and Truck Van Operators

Semi-trailer van or truck van operators may be single individuals, partnerships, corporations, or other entities that own or lease these motor vehicles. Staff used data from the California Highway Patrol (CHP) Biennial Inspection of Terminals (BIT) Program and motor carrier insurance industry databases to estimate that between 1,500 and 5,500 California-based single and fleet motor carriers own or operate semi-trailer vans and truck vans equipped with TRUs. Motor carriers with more than one semi-trailer van/truck van frequently own or operate non-temperature-controlled heavy-duty vehicles as well as TRU-equipped vehicles. Figure IV-2 shows that 80 percent of California-based motor carriers with TRUs own or operate 20 or fewer temperature-controlled and/or non-temperature-controlled heavy-duty vehicles. About 40 percent of California-based motor carriers are for-hire single-vehicle owners/operators or commercial fleets and about 60 percent are private company/corporation fleets. Staff has concluded that public agency use of TRU-equipped vehicles is uncommon based upon TRU procurement information from the Department of General Services, interviews with several school districts, and a survey of 33 Department of Correction institutions (ARB, 2002; CHP, 2003; Duehring, 2002; Martis, 2003; TTS, 2003).

FIGURE IV-2
Estimated Fleet Size of Semi-Trailer Van/Truck Van Owners/Operators with (or likely to have) TRUs



Railcar and Shipping Container Operators

Railcar and shipping container carriers own or lease the refrigerated cars and containers they operate. Responsibilities for various aspects of operation and/or maintenance are frequently defined by the terms of a lease or other contractual agreement with railroad contractors, ship operators, shipping/receiving terminals, or others.

There is insufficient information to estimate the number of railcar carriers that operate in California. Approximately 30 refrigerated railcar carriers operated in the United States during 2002 and 2003 based upon information from the Universal Machine Language Equipment Register or UMLER file. The UMLER file is a comprehensive North American rail equipment information database used in distributing equipment, planning routes, etc. Many of the approximately 30 refrigerated railcar carriers that operated in the United States could also have operated in California.

Staff estimates that nearly 40 different refrigerated shipping container carriers operated in California during 2002 based upon shipping line refrigerated throughput for California's busiest oceanic shipping terminal, the Port of Long Beach (ARB, 2003; Chavez, 2003; Maples, 2003).

E. Terminals and Facilities where TRUs and TRU Generator Sets Operate

TRU or TRU generator set-equipped semi-trailer vans, truck vans, railcars, and shipping containers tend to congregate at "terminals" and "facilities" as defined in Appendix H of this Staff Report. Terminals and facilities may be co-located and facilities may own or operate TRUs or TRU generator sets independent of the vehicles that visit them. Although terminals and facilities are located throughout the State, they appear to be clustered near transportation corridor intersects and are often located in or near population centers in northern and southern California. As described in Chapter V, diesel PM emissions from TRU and TRU generator set engine operation at terminals and/or facilities may result in elevated diesel particulate matter (PM) concentrations in neighborhoods surrounding those sites.

The CHP BIT database for 2003 lists nearly 65,000 terminals for approximately 50,000 motor carriers in California. There are more terminals than motor carriers because a single motor carrier may operate from several terminal locations in the State. About one-third of the estimated 1,500 to 5,500 California-based motor carriers with (or likely to have) TRUs operate from multiple terminal locations. Since railcar and container operators may also own and/or operate semi-trailers to transport goods to wholesale and retail distribution facilities, the CHP database includes rail yards and "intermodal facilities" as defined in Appendix H that are co-located with motor carrier terminals. In addition, networks of rail yards and shipping terminals provide a system for servicing and dispatching railcars and shipping containers.

Comprehensive information regarding facilities frequented by TRUs and/or TRU generator sets is not available; however, staff used licensing agency databases provided by the California Department of Health Services (DHS), Department of Food and Agriculture (DFA), and U.S. Department of Agriculture (USDA) to identify approximately 7,740 facilities that handle refrigerated foods. These facilities include wholesale food distribution, milk plant, meat and poultry, and egg handling facilities (CHP, 2003; DFA, 2002; DHS, 2003; USDA, 2003).

REFERENCES

ARB 2002. California Air Resources Board Stationary Source Division, *Survey of California Department of Corrections Facilities*, Sacramento, California. 2002.

ARB, 2003. California Air Resources Board Stationary Source Division, *Summary of Information from Manufacturers, Operators, and Facilities*, Sacramento, California. July 2003.

CFR, 2002. Code of Federal Regulations. Title 21, Volume 7, Part 640, Revised as of April 1, 2002.

Chavez, 2003. John Chavez, Burlington Northern Santa Fe, to Rodney Hill, ARB Stationary Source Division, *Personal Communication (Electronic Mail)*, Sacramento, California. July 8, 2003.

CHP, 2003. California Highway Patrol. Biennial Inspection of Terminals (BIT) Program. CHP 385G, OPI 062. CD-ROM. California Highway Patrol, May 2003.

DFA, 2002. California Department of Food and Agriculture, California Department of Food and Agriculture Confidential Databases for Meat and Poultry - April 2002 Floppy Disk, Milk Plants - January 2002, and Egg Handlers - August 2002.

DHS, 2003. California Department of Health Services, California Department of Health Services Database for Wholesale Food Facilities, February 2003.

DOW, 2003. The Dow Chemical Company. *DOWEX Ion Exchange Resins. Tech Facts*. Form No. 177-1750-303XQRP. www.dow.com, July 10, 2003.

Duehring, 2002. Craig Duehring, Associate Procurement Engineer, California Department of General Services, to Jon Manji, ARB, Stationary Source Division, *Personal Communication (Telephone Conversation),* Sacramento, California. March 25, 2002.

Feitel, 2002. Ed Feitel, Taylor Power Products, to Rodney Hill, ARB Stationary Source Division, *Personal Communication (Electronic Mail)*, Sacramento, California. November 7, 2002.

Klinge, 2001. Henrik Klinge, Klinge Corporation, to Rodney Hill, ARB Stationary Source Division, *Personal Communication (Telephone Conversation)*, Sacramento, California. November 26, 2001.

Lilly, 2000. Eli Lilly and Company, Indianapolis, Indiana. *Information for the Patient.* PA 6603 AMP. August 3, 2000.

Maples, 2003. Sara Maples, Railinc, to Rodney Hill, ARB, Stationary Source Division, *Personal Communication (Electronic Mail)*, Sacramento, California. March 19, 2003.

Martis, 2003. Dave Martis, University of California, Riverside College of Engineering Center for Environmental Research and Technology, to Jon Manji, ARB Stationary Source Division, *Personal Communication (Electronic Mail)*, Sacramento, California. August 27, 2003.

NARA, 2001. U.S. National Archives and Records Administration, *Subchapter B - Records Management, Part 1232 - Audiovisual Records Management, Storage Conditions*. Last Revised: May 16, 2001. www.archives.gov/about_us/regulations/part_1232.html, Washington, D.C., July 15, 2003.

P&O Nedlloyd, 2003. P&O Nedlloyd, *Refrigerated Cargo - Live Plants*. www.ponl.com/topic/home_page/language_en/about_us/useful_information/refrigeration, July 30, 2003.

Refrigerated Transporter, 2003. *Zanotti Transblock Begins North American Distribution*, Refrigerated Transporter, Volume 2, Number 26, July 2003.

Sem, 2001. Tom Sem, Thermo King, to Tony Andreoni, ARB Stationary Source Division, *Personal Communication (Telephone Conversation)*, Sacramento, California. February 28, 2001.

TTS, 2003. Transportation Technical Services, Inc. National Motor Carrier Database (California), Private Fleet Database (California), and Owner/Operator Database. www.fleetseek.com, May-June 2003.

U.S. Census, 1997. U.S. Census Bureau. *California 1997 Economic Census: Transportation 1997 Commodity Flow Survey.* EC97TCF-CA. www.census.gov, Issued December 1999.

USDA, 2000. United States Department of Agriculture. Agricultural Marketing Service, Transportation and Marketing Programs. *Protecting Perishable Foods During Transport by Truck*. Handbook Number 669. Revised June 2000.

USDA, 2003. U.S. Department of Agriculture Databases for Hazard Analysis Critical Control Program (HACCP) Large and Small Facilities. Floppy Diskette. June 2003.

V. EMISSIONS, EXPOSURE, AND RISK FROM TRANSPORT REFRIGERATION UNIT OPERATIONS

Although transport refrigeration units (TRU) and TRU generator sets have relatively small engines, in the normal course of business, they can congregate in large numbers at distribution centers, ports, truck stops, and other facilities where their combined emissions could pose a significant health risk to those that live and work nearby. Exposure to these emissions could result in increased cancer risks and non-cancer health risks, such as irritation to the eyes and lungs, allergic reactions in the lungs, asthma exacerbation, blood toxicity, immune system dysfunction, and developmental disorders. Because ambient monitoring results are not available for diesel particulate matter (PM), estimates of the level of cancer risk are made using emission factors and various modeling techniques, as discussed below.

A. Estimation of California TRU and TRU Generator Set Populations and Emissions

Number of TRUs and TRU Generator Sets in California

Estimating the number of TRUs and TRU generator sets in California is difficult because there is no comprehensive registration program for this specific equipment, nor for the terminals or facilities where they congregate. In addition, Statewide information about TRUs and TRU generator sets has not been available from industry organizations. Therefore, staff estimated the year 2000 population of TRUs and TRU generator sets summarized in Table V-1 based upon national sales data and information from TRU engine manufacturers.

For the year 2000, the staff estimates that approximately 36,800 TRUs operating in California were associated with heavy-duty semi-trailer vans or truck vans. Table V-1 shows one-quarter of TRUs with 25 to 50 horsepower (hp) engines were associated with semi-trailer vans and truck vans based outside of California. The remaining TRUs were associated with semi-trailer vans and truck vans based in California. Air Resources Board (ARB) staff used the estimated number of California-based motor carriers with (or likely to have TRUs) (See Section D of Chapter IV) the estimated number of TRUs, and interviews with facility representatives, to estimate a range of 1 to 1,300, and an average of 5 to 20, TRUs per semi-trailer van/truck van operator.

According to data from the Universal Machine Language Equipment Register (UMLER file), approximately 8,800 mechanically-refrigerated railcars were operating in the United States in February 2002. Based upon UMLER information, national sales data, and surveys of several railroad operators in California, staff estimates that an average of 1,700 TRU-equipped railcars with 25 to 50 hp engines were operating in California at any given time in the year 2000.

TABLE V-1
Summary of Estimated
TRUs and TRU Generator Sets in California (Year 2000)

Transportation Mode	Horsepower	Number of TRUs	Number of TRU Generator Sets
California-based truck van	<15	4,600	Not Applicable
California-based truck van	15-25	1,900	Not Applicable
California-based semi-trailer	25-50	22,800	Not Applicable
Out-of-State semi-trailer	25-50	7,500	Not Applicable
Railcar	25-50	1,700	Not Applicable
California-based container on semi-trailer/railcar	25-50	Not Applicable	1,850
Total		**38,500**	**1,850**

Based on data provided by TRU generator set manufacturers and useful life, growth factor, and other assumptions in the Air Resources Board (ARB) OFFROAD model (See Appendix D of this Staff Report), staff estimates that approximately 1,850 TRU generator sets with 25 to 50 hp engines were operating in California in the year 2000. Generator sets are typically used to power the refrigeration units of shipping containers. Only a few land-transported domestic shipping containers are equipped with TRUs, the remaining use a generator set to provide electrical power to the shipping container refrigeration unit (ARB, 2003a; ARB, 2003b; CHP, 2003; Maples, 2003; TTS, 2003).

TRU and TRU Generator Set Emissions

Table V-2 shows Statewide emissions for year 2000 PM and oxides of nitrogen (NOx) emission estimates for TRUs and TRU generator sets. Because only diesel engine emissions were addressed in this analysis, the PM estimates may be considered to be diesel PM estimates. The TRU estimates are based on emission rates, population, and other data from the ARB OFFROAD model (See Appendix D). Since TRU generator sets use the same engines as 25 to 50 hp-size TRUs, staff used TRU engine emission rates from the ARB OFFROAD model and TRU generator set population, activity, and load factor data from manufacturers to calculate estimated year 2000 emissions for TRU generator sets. Because recent information from manufacturers indicates that emissions associated with TRU and TRU generator set engines may be 25 percent lower than other off-road engines of a similar horsepower, all PM emissions in

Table V-2 have been reduced by 25 percent from the OFFROAD Model Change Technical Memo (See Appendix D) to avoid overestimating diesel PM from this equipment. The TRU emissions inventory will continue to be refined as data is collected through the implementation of the proposed Airborne Toxic Control Measure (ATCM). Based upon the adjusted tons per day estimate, in 2000, an estimated total of 745 tons per year of diesel PM were emitted from TRUs and TRU generator sets in California. This means that TRU and TRU generator set emissions constitute approximately 2.6 percent of the total Statewide diesel PM emissions (i.e., 28,000 tons per year) estimated in the ARB "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles," October, 2000.

TABLE V-2
Estimated Statewide Emissions for Year 2000
TRU and TRU Generator Sets (tons per day)

Horsepower	PM	NOx
<15 (truck/trailer)	0.04	0.84
15-25 (truck/trailer)	0.03	0.44
25-50 (truck/trailer)	1.36	12.67
25-50 (out-of-State truck/trailer)	0.45	4.18
25-50 (rail)	0.10	0.93
25-50 (generator sets)	0.05	0.52
Total	**2.03**	**19.58**

Tables V-3 and V-4 show estimated year 2010 and 2020 emissions for TRUs predicted by the ARB OFFROAD model and for TRU generator sets as calculated by staff using ARB OFFROAD model assumptions and manufacturers data. As in Table V-2, all PM emission estimates in Tables V-3 and V-4 have been reduced by 25 percent from the OFFROAD Model Change Memo (See Appendix D) because recent information from manufacturers indicate emissions associated with TRU and TRU generator set engines may be 25 percent lower than other off-road engines of a similar horsepower.

Estimates for 2010 and 2020 reflect only effective emission standards to date, not the proposed ATCM requirements or proposed United States Environmental Protection Agency (U.S. EPA) Tier 4 standards. Chapters VII and IX of this Staff Report discuss how the proposed ATCM and the U.S. EPA Tier 4 standards are expected to affect diesel PM and other air pollutant emissions (ARB, 2000; ARB, 2003a; ARB, 2003b).

TABLE V-3
Estimated Statewide Emissions for Year 2010
TRU and TRU Generator Sets (tons per day)

Horsepower	PM	NOx
<15 (truck/trailer)	0.04	0.81
15-25 (truck/trailer)	0.03	0.47
25-50 (truck/trailer)	1.65	16.37
25-50 (out-of-State truck/trailer)	0.55	5.40
25-50 (rail)	0.12	1.21
25-50 (generator sets)	0.07	0.66
Total	**2.46**	**24.92**

TABLE V-4
Estimated Statewide Emissions for Year 2020
TRU and TRU Generator Sets (tons per day)

Horsepower	PM	NOx
<15 (truck/trailer)	0.07	1.00
15-25 (truck/trailer)	0.04	0.55
25-50 (truck/trailer)	2.04	25.00
25-50 (out-of-State truck/trailer)	0.68	8.25
25-50 (rail)	0.15	1.84
25-50 (generator sets)	0.13	1.56
Total	**3.11**	**38.20**

Effect of Engine Size, Age, and Operation on Emissions

Generally, emissions of diesel PM and other air pollutants are expected to increase with the size, age, and operating hours of the engine associated with a TRU or TRU generator set. A brief discussion of size, age, and operation has been included because these factors may indicate potential areas for emission reduction.

1. Size and Age

The population inventory estimates TRU and TRU generator set engines to range from less than 15 to 50 hp with the most common size being about 35 hp.

Based upon manufacturer data, staff estimates the useful life (i.e., the age at which at least 50 percent of the originally sold equipment population still exists) of TRU and TRU generator set engines at 10 years; however, some of the remaining engines could last twice as long. Staff facility inspections and interviews indicate that the age of engines associated with TRUs and TRU generator sets ranges from new (i.e., the current model year) to up to 30 or more years old. There is limited emission rate information available on uncontrolled 50 hp or less engines manufactured prior to 1998. These pre-1998 engines are expected to emit significantly more air pollutants than those manufactured in later model years. Thus, a large, later model engine may actually emit less diesel PM and other pollutants than a smaller, but older, TRU or TRU generator set engine (ARB, 2003a; ARB, 2003b).

2. TRU and TRU Generator Set Operation

The staff estimates that TRUs and TRU generator sets operate an average of 1,000 to 1,500 hours per year (i.e., approximately 3 to 4 hours per day). Daily operating hours for individual TRUs and TRU generator sets depend upon many variables, including: ambient temperature; cargo size; commodity air flow requirements and set point (i.e., required or recommended transport temperature); mode of transport; trip length; refrigerated compartment insulation; number of deliveries (i.e., door openings); and facility loading and unloading variables.

TRU and TRU generator sets may or may not operate continuously while perishable cargo is in transit. Some TRUs are designed to cycle on and off while maintaining a set point temperature. Also, when possible, semi-trailer van and truck van drivers shut off TRUs during delivery stops in order to prevent icing and preserve diesel fuel. However, multi-temperature loads are likely to require TRU operation during deliveries in order to preserve air flow and temperature requirements in each compartment of a trailer van. For goods requiring continuous air flow (e.g., fresh fruits and vegetables susceptible to mold), TRU engines must run continuously to generate power for electrically-driven fans. Other goods (e.g., meat, dairy products, and unpasteurized beer) only require the engine to run as needed to maintain a set point temperature.

TRU generator sets do not cycle on and off as some TRUs do. However, while aboard ship, the refrigeration units of temperature-controlled shipping containers typically use the ship's power rather than TRU generator set engines. At large seaports, such as Oakland and Long Beach, a refrigerated container uses shore power until it is placed on a flat-bed railcar or semi-trailer. At smaller shipping yards, 25 to 50 hp "pin-on" TRU generator sets provide the necessary power to run the refrigeration unit. Generally, a "pin-on" TRU generator set is also used for a container's land journey. In addition, a small number of semi-trailers are equipped with TRU generator sets that can provide power to container refrigeration units.

Based upon interviews conducted by staff at facilities served by semi-trailer vans and truck vans, the typical trip length ranges from 20 minutes for a local delivery to several days for a long-haul delivery. Facility representatives indicate that the average time semi-trailer vans and truck vans spend on the road is about 13 hours per trip. A TRU could be expected to operate from one-half to all of the transit time, depending on the number of deliveries and on whether or not the semi-trailer van or truck van carries an additional temperature-sensitive cargo on "back-haul" (i.e., the return trip to the terminal and/or storage and distribution facility).

Additional variables that influence the operation and emissions of TRUs and/or TRU generator sets at facilities, include: the number of in-bound and out-bound loads per week; size and variety of cargoes handled; loading methods; and number of available workers, loading dock doors, and parking spaces. Moreover, TRU and/or TRU generator set operation at a single facility may vary depending upon the season, ambient temperatures, and changes in market demand and/or products.

At storage and distribution facilities, semi-trailer and truck van TRUs are usually operated before loading (i.e., to "pre-chill" the cargo area) and sometimes during loading and unloading. The pre-chill time may range from zero to two hours depending upon the van size, cargo set point temperature, TRU cooling capacity, and ambient temperature. For example, to prevent the adverse effects of thawing and re-freezing, pre-chilling is a common practice when transporting ice cream which has a set point temperature of -29°C (-20°F). Trailer vans tend to take longer to pre-chill because they are larger than truck vans. Also, pre-chilling takes longer during California's warm summer months than at other times of the year.

Loading or unloading cargo usually takes about one hour or less. Semi-trailer vans tend to take longer to load or unload because they are usually larger and carry more cargo than truck vans. Most storage and distribution facilities schedule appointments for loading and unloading, but a driver that arrives early to unload must operate the TRU while waiting for an available loading dock door and personnel to do the unloading. In addition, TRUs must operate during any delay between loading and dispatch unless the facility is one of the few that provides, and the TRU is equipped to operate on, electrical stand-by power. Such delays are not unusual and may last between zero and 24 hours depending upon driver availability and scheduling. Departure times are usually scheduled so loads will arrive at their destination at a predetermined time when unloading personnel are available (ARB, 2003a;
ARB, 2003b).

UC Riverside, College of Engineering Center for Environmental Research and Technology (CE-CERT) conducted data gathering and analysis for ARB to learn more about TRU operation. Specific goals were to learn about representative TRU engine runtimes (e.g. non-mobile engine runtime at facilities, mobile engine runtime on the road), and TRU engine exhaust temperature profiles (e.g. percentage of time at various exhaust temperatures). Trailer TRUs from an egg distribution company, a grocery distribution company, and a wholesale restaurant supply company were instrumented with thermocouples, global positioning system (GPS) units, and data loggers. Appendix J includes an example plot of this data.

Staff recognizes that this data represents only three of many possible industry types and that operations may differ from one facility to the next within the industry types studied. A final report had not been completed.

B. An Overview of Health Risk Assessment

A health risk assessment (HRA) is an evaluation or report that a risk assessor (e.g., ARB, district, consultant, or facility operator) develops to describe the potential a person or population may have of developing adverse health effects from exposure to diesel PM emissions or from other toxic air contaminants (TACs). Some health effects that are evaluated could include cancer, developmental effects, or respiratory illness. The exposure pathways included in an HRA depend on the TACs that a person (receptor) may be exposed to, and can include breathing, the ingestion of soil, water, crops, fish, meat, milk, and eggs, and dermal exposure. For this HRA, we are evaluating the cancer health impacts for diesel particulate via the breathing or inhalation pathway only.

Generally, to develop an HRA, the risk assessor would perform or consider information developed under the following four steps. The four steps are Hazard Identification, Dose-Response Assessment, Exposure Assessment, and Risk Characterization.

Hazard Identification

In the first step, the risk assessor would determine if a hazard exists, and if so, would identify the exact pollutant(s) of concern and the type of effect, such as cancer or non-cancer effects.

For this assessment, the pollutant of concern, diesel particulate from internal combustion engines, has been formally identified under the Assembly Bill (AB) 1807 Program as a TAC through an open, regulatory process by the ARB (ARB 1998a).

Dose-Response Assessment

In this step of risk assessment, the assessor would characterize the relationship between exposure to a pollutant and the incidence or occurrence of an adverse health effect.

This step of the HRA is performed for the ARB by Office of Environmental Health Hazard Assessment (OEHHA). OEHHA supplies these dose-response relationships in the form of cancer potency factors or unit risk factors (URFs) for carcinogenic effects and reference exposure levels (RELs) for non-carcinogenic effects. The URFs and RELs that are used in California can be found in one of three references: (1) The OEHHA Air Toxics Hot Spots Program Risk Assessment Guidelines, Part III, Technical Support Document for the Determination of Noncancer Chronic Reference Exposure Levels, January, 2001; (2) The OEHHA Air Toxics Hot Spots Program Risk Assessment Guidelines, Part I, The Determination of Acute RELs for Airborne Toxicants, March 1999; and (3) The OEHHA Air Toxics Hot Spots Program Risk *Assessment Guidelines, Part II, Technical Support Document for Describing Available* Cancer Potency Factors, April 1999. The individual URF for diesel particulate from internal combustion engines used for this HRA is 3.0×10^{-4} per microgram per cubic meter ($\mu g/m^3$) ambient concentration of diesel particulate.

Exposure Assessment

In this step of the risk assessment, the risk assessor estimates the extent of public exposure by looking at who is likely to be exposed, how exposure will occur (e.g., inhalation and ingestion), and the magnitude of exposure.

For TRU operations, the receptors that are likely to be exposed include residents or off-site workers located near the facility. Onsite workers certainly could also be impacted by the emissions; however, they are not included in this HRA because Cal/OSHA has jurisdiction over on-site workers. Exposure was evaluated for diesel particulate via the breathing or inhalation pathway only. The magnitude of exposure was assessed through the following process. Emission rates were developed using emission parameters determined from site visits, and from facility and manufacturer data gathering, and input from industry representatives. During the site visits, other information such as physical dimensions of the source, operation schedules, and receptor locations were obtained. Computer air dispersion modeling was used to provide downwind ground-level concentrations of the diesel PM at near-source locations.

Risk Characterization

This is the final step of risk assessment. In this step, the risk assessor combines information derived from the previous steps. Modeled concentrations, which are determined through exposure assessment, are combined with the URF for cancer risk determined under the dose-response assessment. This step integrates this information to quantify the potential cancer risk and/or chronic or acute noncancer effects.

C. The Tools used for this Risk Assessment

The tools and information that are used to estimate the potential health impacts from a facility include air dispersion modeling and pollutant-specific health effects values. Information required for the air dispersion model include emission rate estimates, physical descriptions of the source, emission release parameters, and meteorological data. Combining the output from the air dispersion model and the pollutant-specific health values provides an estimate of the off-site potential cancer and non-cancer health impacts from the emissions of a TAC. For this assessment, we are estimating the potential health impacts from diesel PM emissions during TRU operations. A brief description of the air dispersion modeling and pollutant-specific health effects values is provided in this Chapter. A more detailed discussion of the air dispersion modeling and parameters used for determining individual cancer risk is presented in Appendix E.

Air Dispersion Modeling

Air dispersion models are used to estimate the downwind, ground-level concentrations of a pollutant after it is emitted from a facility. The downwind concentration is a function of the quantity of emissions, release parameters at the source, and appropriate meteorological conditions. The two models that were used for this HRA are SCREEN3, version 96043, and Industrial Source Complex Short Term (ISCST3), version 02035. Appendix E provides additional details on the modeling results illustrating how the outputs from these models are used to calculate potential health impacts. Appendix F provides the results of the sensitivity studies used to determine the variability of results due to changes in modeling parameters. The U.S. EPA recommends the SCREEN3 model for first order screening calculations and ISCST3 model for refined air dispersion modeling (U.S. EPA, 1995a; U.S. EPA, 1995b). Both models are currently used by the ARB, air districts, and other states.

Pollutant-Specific Health Effects Values

Dose-response or pollutant-specific health effects values are developed to characterize the relationship between an exposure to a pollutant and the incidence or occurrence of an adverse health effect. A URF or cancer potency factor is used when estimating potential cancer risks and RELs are used to assess potential non-cancer health impacts.

A URF is defined as the estimated upper-confidence limit (usually 95%) probability of a person contracting cancer as a result of constant exposure to a concentration of one microgram per cubic meter ($\mu g/m^3$) over a 70-year lifetime. In other words, using the URF for diesel particulate, 3.0×10^{-4} $(\mu g/m^3)^{-1}$, the potential excess cancer risk for a person continuously exposed over a 70-year lifetime to 1.0 $\mu g/m^3$ of diesel particulate is estimated to be no greater than 300 chances in 1 million (OEHHA, 2002).

D. Potential Health Effects of Diesel Exhaust Particulate Matter

This section summarizes the potential health impacts that can result from exposure to diesel particulate, both cancer and non-cancer health effects. The probable route of human exposure to diesel particulate is inhalation. In August 1998, the ARB formally identified diesel particulate as a TAC following a 10-year review process (ARB, 1998a). This marked the completion of the identification phase of the process to address the potential for adverse health effects associated with diesel PM emissions.

Although OEHHA has shown both chronic cancer and non-cancer impacts due to exposure to diesel PM, the cancer health risk impacts are so much higher than the non-cancer health impacts, only cancer risks were quantified for this assessment.

Cancer

The International Agency for Research on Cancer (IARC) concluded in 1989 that there is sufficient evidence that whole diesel engine exhaust probably causes cancer in humans and classified diesel exhaust in Group 2A: Probable human carcinogen (IARC, 1989). The OEHHA staff has performed an extensive assessment of the potential health effects of diesel PM, reviewing available carcinogenicity data. The OEHHA concluded that exposures to diesel PM resulted in an increased risk of cancer.

Epidemiological studies in truck drivers, transport and equipment workers, dock workers, and railway workers, reported a statistically significant increase in the incidence of lung cancer associated with exposure to diesel exhaust. Two studies reported no category with a risk ratio elevated for exposure to diesel exhaust (ARB 1998b).

Non-cancer

The OEHHA found that exposures to diesel PM resulted in an increase in long-term (chronic) non-cancer health effects including a greater incidence of cough, labored breathing, chest tightness, wheezing, and bronchitis. At this time OEHHA has not quantified short-term (acute) non-cancer health effects.

E. Health Risk Assessment for TRUs

This section examines the potential cancer health risks associated with exposure to diesel PM emissions from TRUs. Additional details on the methodology and assumptions used to estimate the health risks are presented in Appendix E of this report.

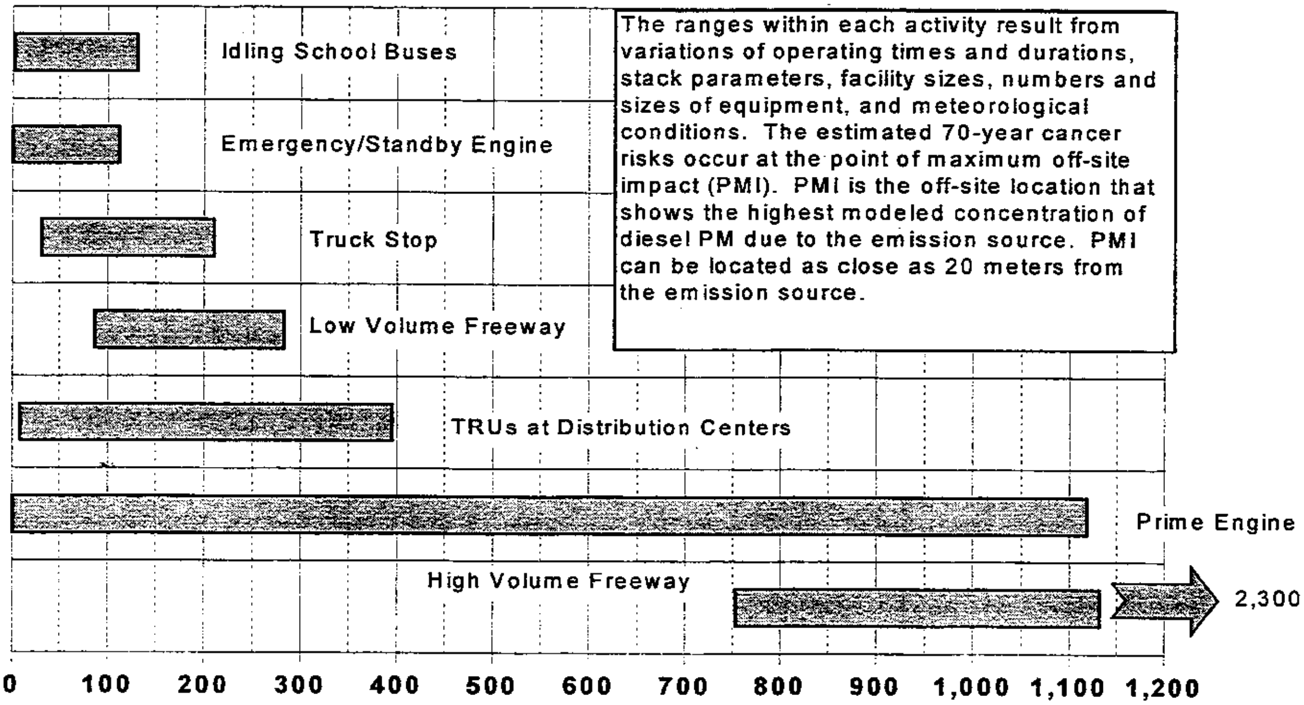
Risk assessment is a complex process that requires the analysis of many variables to simulate real-world situations. There are five key variables that can impact the results of a health risk assessment for the operation of diesel TRUs: 1) the amount of diesel PM emissions from the TRU engines operating at the facility, 2) the meteorological conditions which can affect the dispersion of diesel PM in the air, 3) the distance the receptor is from the emission source, 4) the duration of exposure to the diesel PM emissions, and 5) the inhalation rate of the receptor. Diesel PM emissions are a function of the total annual hours of TRU engine operations. Meteorological conditions can have a large impact on the resultant ambient concentrations of diesel PM with higher concentrations found along the predominant wind direction and under calm wind conditions. The meteorological conditions and proximity of the receptor to the source(s) of emissions affect the concentration of the diesel PM in the air where the receptor is located. In addition, the exposure duration and inhalation rates are key factors in determining potential risk, with longer exposure times and higher inhalation rates typically resulting in higher estimated risk levels. For this analysis staff assumed the 70 year exposure duration and inhalation rate recommended for estimating health impacts in the current OEHHA guidelines (OEHHA, 2003).

Because risk estimates for TRU operations are dependent on numerous factors and because these factors vary at each facility, ARB staff developed a generic (i.e. example) risk assessment for TRU facilities. Emission rates used in modeling were based on current average Statewide emission factors and anticipated lower emission standards coupled with the typical TRU engine size. Meteorological data from West Los Angeles was selected to evaluate meteorological conditions with lower wind speeds and more persistent wind directions, which will result in less pollutant dispersion and higher estimated ambient concentrations. Additionally, meteorological data for Sacramento, Oakland, and Pico Rivera were used to model health risk impacts to show the diversity of results due to meteorological conditions. Meteorological data from these areas encompass the range of meteorological conditions expected in California. The U.S. EPA ISCST3 air dispersion model was used to estimate the annual average diesel PM concentration from 100 meters to 1500 meters from the source.

Consistent with the current risk assessment methodology recommended by the OEHHA and used by ARB in evaluating potential cancer risk from diesel PM emission sources, we assumed that nearby receptors would be exposed to emissions for 70 years (OEHHA, 2003). This exposure duration represents an "upper-bound" of the possible exposure duration. The potential cancer risk was estimated by multiplying the modeled annual average concentrations of diesel PM adjusted for the duration of exposure.

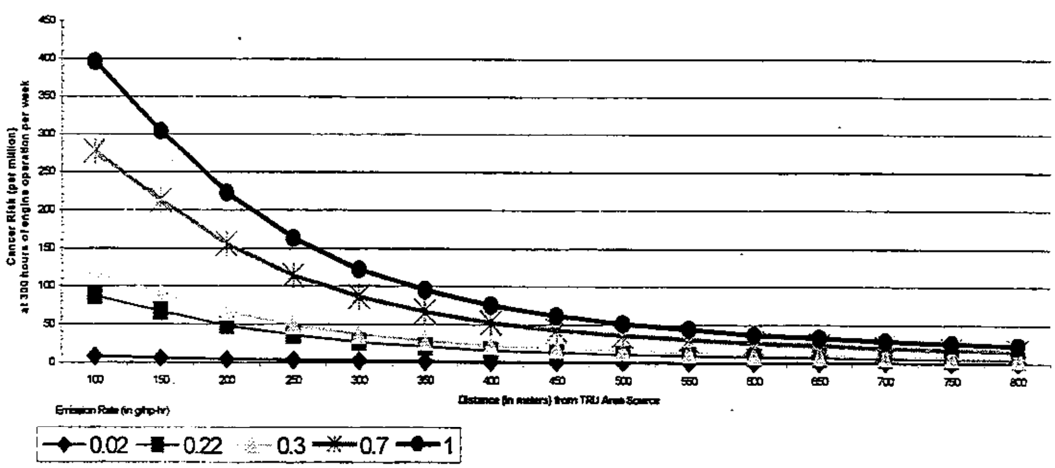
Based on our analysis under the conditions and assumptions outlined above, the estimated potential cancer risk due to emissions from diesel-fueled TRU engines ranged from approximately 8 to over 390 cancers per million. The low end in each case represents a very clean engine operating only a few hours annually, and the high end is an engine with a relatively high emission rate operating for many hours each year. As shown in Figure V-1, when compared to other activities using diesel-fueled engines, it can be concluded that diesel-fueled TRU engines could pose significant near-source risks to individuals living in close proximity to the engines. Figure V-2 shows potential cancer risks to nearby receptors due to 300 hours per week of TRU operations at various emission rates (1.0, 0.7, 0.3, 0.22, and 0.02 grams per horsepower-hour [g/hp-hr]).

Figure V-1: Potential Range of Cancer Risks due to Activities using Diesel-Fueled Engines



(Note: The risk ranges for the non-stationary engine scenarios, excluding the TRUs, are taken from the Diesel Risk Reduction Plan. The upper bounds have been adjusted to reflect the 95th percentile breathing rate. The upper bounds for the TRU engines are for 1.0 g/bhp-hr engines operating 600 hr/wk, 52 wk/yr.)

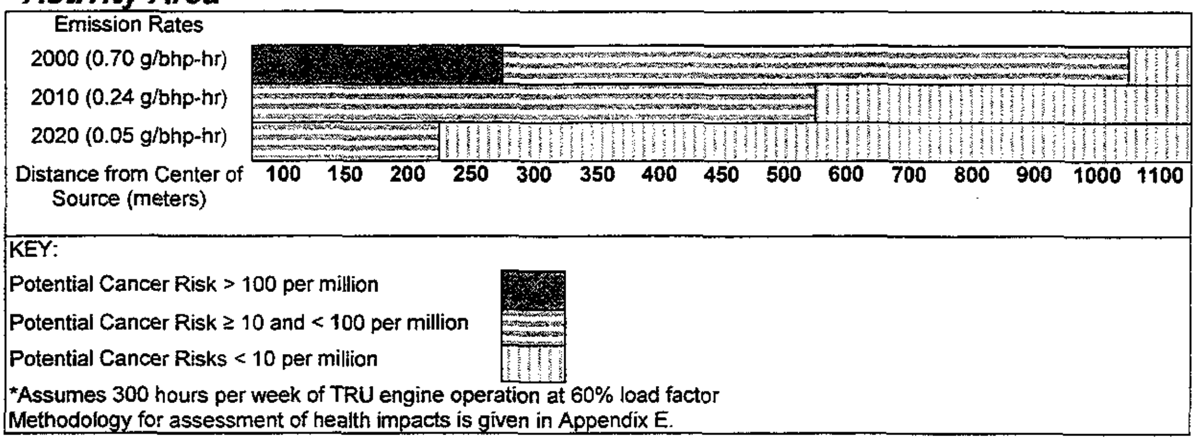
Figure V-2: Comparison of Potential Cancer Health Impacts for TRU Operations based on Particulate Emission Rates (West Los Angeles Meteorological Data)



The estimated potential cancer risk level presented here is based on a number of assumptions. The potential cancer risk for actual situations may be less than or greater than those presented here. For example, increasing the hours of TRU engine operations would increase the potential risk levels. Decreasing the exposure duration, or increasing the distance from the source to the receptor location would decrease the potential risk levels. The estimated risk levels would also decrease over time as lower-emitting diesel engines are used in TRUs. Therefore, the results presented are not directly applicable to any particular facility or operation. Rather, this information is intended to provide an indication as to the potential relative levels of risk that may be observed from TRU operations at facilities. All parameters and assumptions, along with the methodology for estimating these health risks are included in Appendix E.

Reduction of potential cancer risk levels at locations where TRUs operate is a direct result of the reduction of diesel PM emissions. Figure V-3 compared the cancer risk range at various distances assuming 300 hours of TRU activity per week. For year 2000, the current fleet average emission rate of 0.7 g/bhp-hr was used. As shown in Figure VII-2 in Chapter VII, taking into account the implementation of the TRU ATCM and the Tier 4 nonroad new engine emission standards, the average Statewide fleet emission rate would be reduced 65 percent to 0.24 g/bhp-hr in 2010. In 2020, the Statewide fleet PM emission rate would be reduced 92 percent from the 2000 baseline year to 0.05 g/bhp-hr. Figure V-3 below illustrates the significant reduction of the estimated near source risk as the diesel PM emission rate is reduced from the current fleet emission rate to the much lower emission rate in 2020.

Figure V-3: Estimated Risk Range versus Distance from Center of TRU Activity Area*



REFERENCES

ARB, 1998a. California Air Resources Board and Office of Environmental Health Hazard Assessment. *Proposed Identification of Diesel Exhaust as Toxic Air Contaminant. Staff Report.* Sacramento: ARB and OEHHA, June 1998.

ARB, 1998b. California Air Resources Board and Office of Environmental Health Hazard Assessment. *Proposed Identification of Diesel Exhaust as Toxic Air Contaminant. Appendix III, Part A, Exposure Assessment.* Sacramento: ARB and OEHHA. CD-ROM. April 22, 1998.

ARB, 2000. California Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles.* Sacramento, California. October 2000.

ARB, 2003a. California Air Resources Board Planning and Technical Support Division. *OFFROAD Modeling Change Technical Memo: Revisions to the Diesel Transport Refrigeration Units (TRU) Inventory,* October 10, 2003.

ARB, 2003b. California Air Resources Board Stationary Source Division, *Summary of Information from Manufacturers, Operators, and Facilities,* July 2003.

CHP, 2003. California Highway Patrol. *Biennial Inspection of Terminals (BIT) Program. CHP 385G, OPI 062.* CD-ROM. California Highway Patrol, May 2003.

IARC, 1989. International Agency for Research on Cancer (IARC). *IARC Monograph on the Evaluation of Carcinogenic Risks to Humans: Diesel and Gasoline Engine Exhausts and some Nitroarenes.* 46:41-57. World Health Organization. Lyon, France. 1989.

Maples, 2003. *Personal Communication (Electronic Mail),* Sara Maples, Railinc, to Rodney Hill, ARB, Stationary Source Division, March 19, 2003.

OEHHA, 2002. Office of Environmental Health Hazard Assessment (OEHHA), *Air Toxic Hot Spots Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors. CD-ROM.* December, 2002.

OEHHA, 2003. Office of Environmental Health Hazard Assessment (OEHHA), *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments.* www.oehha.ca.gov/air/hot_spots/HRSguide.html. August, 2003.

TTS, 2003. Transportation Technical Services, Inc. *National Motor Carrier Database (California), Private Fleet Database (California), and Owner/Operator Database.* Fleetseek.com. May-June 2003.

U.S. EPA, 1995a. United States Environmental Protection Agency (U.S. EPA), *ISCST3 Model User's Guide, Volume I, EPA-454/B-95-003a.* CD-ROM. Research Triangle Park, North Carolina, September 1995.

U.S. EPA, 1995b. United States Environmental Protection Agency (U.S. EPA), *ISCST3 Model User's Guide, Volume II, EPA-454/B-95-003b.* CD-ROM. Research Triangle Park, North Carolina, September 1995.

VI. AVAILABILITY AND TECHNOLOGICAL FEASIBILITY OF CONTROL MEASURES

In this chapter of the staff report, we provide descriptions of particulate matter (PM) reduction emission control strategies currently available and projected to be available in the near future. We focus on those we believe may be employed to comply with the proposed Airborne Toxic Control Measure (ATCM). Additional information on the wide variety of emission reduction options for diesel fueled engines is provided in the Diesel Risk Reduction Plan (ARB, 2000). Unless otherwise noted herein, all references to Transport Refrigeration Units (TRU) include TRU generator sets. The term "facilities", as used herein, refers to facilities where TRUs operate, as defined in the regulation.

Diesel engines have long been the engines of choice for TRUs because of the efficiency and durability of diesel engines as well as the operators' familiarity with diesel engine technology. Alternative fueled engines have not been able to compete against the diesel engine for these very reasons. However, emerging technologies have potential for playing a part toward reducing diesel PM emissions.

A variety of diesel emission control strategies (DECS) can be used for controlling emissions from diesel engines, including aftertreatment hardware, fuel strategies, and engine modifications. Aftertreatment hardware could be add-on technologies such as diesel particulate filters (DPF) and diesel oxidation catalysts (DOC). Fuel strategies include alternative fuels, alternative diesel fuels, and fuel additives. Alternative fuels include, but are not limited to, compressed natural gas (CNG) and liquefied petroleum gas (LPG). An example of a fuel additive is a fuel borne catalyst. These technologies can be combined to form additional DECS. In addition, repowering with a cleaner diesel engine is a possible strategy.

Staff worked with emission control system manufacturers, TRU manufacturers, TRU engine manufacturers, and many other stakeholders to develop a *TRU Diesel PM Control Technology Option Matrix* (Matrix), which is included in Appendix B. The Matrix lists potentially viable compliance options. Included for each option is the potential PM and nitrogen oxide (NOx) control efficiency, an indication of known demonstrations of the technology in TRUs, cost information, an indication of its verification status, and any significant pros and/or cons that may be associated with its use. Footnotes in the Matrix in Appendix B indicate the source of the information.

In addition to requiring in-use TRUs to meet in-use performance standards in accordance with a compliance schedule, the proposed TRU ATCM also includes monitoring, recordkeeping, and reporting requirements for all TRU operators and applicable facilities. In recent years, there has been dramatic growth in the availability of automated equipment identification, tracking, and management systems that aid in the logistics of goods distribution. Such technologies could be adapted to help fleet owner/operators of TRUs and the facilities that attract refrigerated trucks, trailers, and containers to comply with the monitoring, recordkeeping and reporting requirements of the proposed regulation. Relevant discussion is provided in the last section of this chapter.

A. Verification of Diesel Emission Control Strategies

As a way to thoroughly evaluate the emissions reduction capabilities and durability of a variety of DECS, the Air Resources Board (ARB or Board) has developed the *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines*[4] (Verification Procedure). The purpose of the Verification Procedure is to verify in-use strategies, which through the use of sound principles of science and engineering, control emissions of PM and NOx from diesel-fueled compression-ignition engines.

It should be noted that several of the technologies listed in the Matrix would not require verification (e.g. electric standby, cryogenic refrigeration, CNG, LPG and gasoline-powered engines, and fuel cells). Some of these technologies may need to meet other emission standards (e.g. Large Spark-Ignited Engine Standards). Currently, none of the technologies listed in the Matrix requiring verification have been verified for use on TRU engines. A complete and up-to-date list of verified DECS and the engine families for which they have been verified, along with letters of verification, may be found on the ARB web site: http://www.arb.ca.gov/diesel/verifieddevices/verdev.htm.

In addition to the information included in the Matrix shown in Appendix B, general descriptions of some of the technologies are provided below.

B. Passive Diesel Particulate Filters

In general, a DPF consists of a porous substrate that permits gases in the exhaust to pass through but traps the PM in the exhaust. DPFs are very efficient in reducing PM emissions, achieving typical PM reductions in excess of 90 percent. Most DPFs employ some means to periodically regenerate the filter (i.e., burn off the accumulated PM). These can be divided into two types of systems, passive and active.

A passive catalyzed DPF reduces PM, carbon monoxide (CO) and hydrocarbon (HC) emissions through catalytic oxidation and filtration. Most of the DPFs sold in the United States use substrates consisting of ceramic wall-flow monoliths to capture the diesel particulates. Some manufacturers offer silicon carbide or other metallic substrates, but these are less commonly used in the United States. These wall-flow monoliths are either coated with a catalyst material, typically a platinum group metal, or a separate catalyst is installed upstream of the particulate filter. The filter is positioned in the exhaust stream to trap or collect a significant fraction of the particulate emissions while allowing the exhaust gases to pass through the system.

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[4] Approved by the Board in May 2002. Sections 2700 through 2710, Title 13, California Code of Regulations.

Effective operation of a DPF requires a balance between PM collection and PM oxidation, or regeneration. Regeneration is accomplished by either raising the exhaust gas temperature or by lowering the PM ignition temperature through the use of a catalyst. The type of filter technology that uses a catalyst to lower the PM ignition temperature is termed a passive DPF, because no outside source of energy or intervention is required for regeneration. A passive DPF is a very attractive means of reducing diesel PM emissions because of the combination of high reductions in PM emissions and minimal operation and maintenance requirements.

Passive DPFs have been successfully used in numerous applications. In the last 10 years, over 10,000 filter systems have been retrofitted on trucks and buses worldwide. Internationally, retrofit programs exist in Sweden, Germany, Switzerland, Hong Kong, Taiwan, London, Paris, Mexico City, and Tokyo (MECA, 2003). In the United States, the use of DPFs is growing more common, with DPF retrofit programs underway in California, New York, and Texas. In California, diesel-fueled school buses, solid waste collection vehicles, urban transit buses, medium-duty delivery vehicles, people movers, and fuel tanker trucks have been retrofitted with DPFs through various demonstration programs. The TRU application may be more difficult than those cited above due to engines running at lower loads. This results in lower exhaust temperatures, making passive regeneration less reliable, especially in the winter when refrigeration loads (and thus engine loads) are even lower (Yanmar, 2002). Since TRUs are used to refrigerate perishable goods, reliability is essential to perishable goods safety.

C. Active Diesel Particulate Filters

An active DPF system uses an external source of heat to oxidize the PM or an intake air throttle to reduce intake air and increase the exhaust temperature. The most common methods of generating additional heat for oxidation involve electrical regeneration by passing a current through the filter medium, injecting fuel to provide additional heat for particle oxidation, or adding a fuel-borne catalyst or other reagent to initiate regeneration. Microwave energy can also be used to regenerate the filter (Nixdorf, 2003). Use of an intake throttle momentarily reduces the amount of excess air, so the exhaust temperature rises as a result of not having to heat the excess air (Mayer, 2003). Some active DPFs induce regeneration automatically on-board the vehicle or equipment when a specified backpressure is reached. Others use an indicator, such as a warning light, to alert the operator that regeneration is needed, and require the operator to initiate the regeneration process. Some active systems collect and store diesel PM over the course of a full shift and are regenerated at the end of the shift with the vehicle or equipment shut off. A number of the filters are removed and regenerated externally at a regeneration station.

For applications in which the engine-out PM is relatively high, and the exhaust temperature is relatively cool, active regenerating systems may be more effective than a passive DPF (Zelenka, 2001). Because active DPFs are not dependent on the heat carried in the exhaust for regeneration, they potentially have a broader range of application than passive DPFs (Mayer, 2001). Active DPFs have been used successfully in Europe since the early 1990's (Zelenka, 2002). However, staff is unaware of any completed demonstrations of active DPFs with TRU engines.

D. Flow-Through Filters

Flow-through filter (FTF) technology is a relatively new method for reducing diesel PM emissions. Unlike a DPF, in which only gases can pass through the substrate, the FTF does not physically "trap" and accumulate PM. Instead, exhaust flows through a medium (such as a wire mesh) that has a high density of torturous flow channels, thus giving rise to turbulent flow conditions. The medium is typically treated with an oxidizing catalyst that is able to reduce emissions of PM, HC, and CO, or used in conjunction with a fuel-borne catalyst. Any particles that are not oxidized within the FTF flow out with the rest of the exhaust and do not accumulate. Consequently, the filtration efficiency of an FTF is lower than that of a DPF, but the FTF is much less likely to plug under unfavorable conditions, such as high PM emissions and low exhaust temperatures (Brück, 2001). The FTF, therefore, is a candidate for use in applications unsuitable for DPFs.

Staff expects that a catalyzed FTF will achieve between 30 and 60 percent PM reduction, lower than a DPF, for a Level 1 or 2 verification. Relative to a DOC, which typically has straight flow passages and laminar flow conditions, the FTF achieves a greater PM reduction owing to enhanced contact of PM with catalytic surfaces and longer residence times. The better performance of an FTF when compared to a DOC may come at the cost of increased backpressure. Capital costs of an FTF will likely be between $1,500 and $2000 (Valentine, 2003).

E. Diesel Oxidation Catalyst

A DOC reduces emissions of CO, HC, and the soluble organic fraction of diesel PM through catalytic oxidation alone. Exhaust gases are not filtered, as with the DPF. In the presence of a catalyst material and oxygen, CO, HC, and the soluble organic fraction undergo a chemical reaction and are converted into carbon dioxide and water. Some manufacturers integrate HC traps (zeolites) and sulfate suppressants into their oxidation catalysts. HC traps enhance HC reduction efficiency at lower exhaust temperatures and sulfate suppressants minimize the generation of sulfates at higher exhaust temperatures (DieselNet, 2002). A DOC can reduce total PM emissions up to 30 percent. PM emission reductions at this higher end are typically associated with engines that emit "wet" PM (i.e. particles that have a higher percentage of soluble organic fraction (SOF) adsorbed onto the particle surface). Older engines or engines that have less efficient fuel combustion typically produce PM with a higher SOF adsorbed onto the elemental carbon. Engines that more efficiently combust the fuel would have less SOF adsorbed onto the elemental carbon, so the PM emission reductions would be less on a percentage basis.

This technology is commercially available and devices have been installed in over 20,000 buses and highway trucks in the U.S. and Europe (MECA, 2003). As a result of the United States Environmental Protection Agency (U.S. EPA) Urban Bus Retrofit/Rebuild program, several models have been certified by the U.S. EPA and through the ARB aftermarket parts certification program. Nationwide, thousands of DOCs are installed on urban transit buses with engines older than 1994 model years.

In general, DOCs function well on all vehicle and equipment types. ARB has begun a demonstration to explore the applicability of DOCs on older, higher emitting solid waste collection vehicles. Only one known proof of concept test has been conducted on a TRU engine.

F. Fuel Additives

A fuel additive is a DECS when it is designed to be added to fuel or fuel systems so that it is present in-cylinder during combustion and its addition causes a reduction in exhaust emissions. Additives can reduce the total mass of PM, with variable effects on CO, NOx and gaseous HC production. An additive added to diesel fuel in order to aid in soot removal by decreasing the ignition temperature of the carbonaceous exhaust is often called a fuel borne catalyst (FBC). PM emission reductions of up to 25 percent have been measured for FBCs alone (Valentine, 2000).

FBCs used in conjunction with DOCs have resulted in PM emission reductions of 50 percent and when used with both passive and active filter systems to improve fuel economy, aid system performance, and decrease mass PM emissions in excess of 95 percent (Valentine, 2000). FBC/DPF systems are in wide spread use in Europe in both on-road and off-road, mobile and stationary applications and typically achieve a minimum of 85 percent reduction in PM emissions. Additives based on cerium, platinum, iron, and strontium are currently available, or may become available for use in the future in California (DieselNet, 2003).

Cerium based additives are in wide spread use in Europe and are VERT-approved when used with DPFs. VERT is a Swiss project for curtailing emissions from diesel engines in tunnel construction. A cerium-based additive is part of Peugeot's new passenger car filter-based system and, in addition to on-road applications, cerium additives are used off-road in construction and forklift applications (DieselNet, 2003).

Platinum-Cerium FBC mixtures at 4 to 8 parts per million have been demonstrated on a fleet of 100 grocery distribution TRUs using Clean Diesel Technologies Platinum Plus DFX™. PM emission reductions were estimated to be 10 to 25 percent (Valentine, 2002).

G. Alternative Diesel Fuels

An alternative diesel fuel is a fuel that is not just a reformulated diesel fuel and can be used in a diesel engine without modification to the engine (although minor modifications may enhance performance). This definition of alternative diesel fuels includes emulsified fuels, biodiesel fuels, and Fischer-Tropsch (F-T) fuels. The emissions effects of these fuels can vary widely.

Before any alternative fuel can be used to comply with a diesel PM control measure, it would have to be verified through the Verification Procedure, which includes a special section (CCR, title 13, §2710) that deals specifically with these fuels. No alternative diesel fuels are currently verified by ARB under the Verification Procedure.

Note: It should be noted that in order to qualify as an ultra-low emission TRU compliance option (see Chapter VII), an alternative diesel fuel must not contain any conventional diesel fuel. Specifically, emulsified diesel fuels would not qualify, and biodiesel and F-T fuels must be used in the "neat" form (100 percent biodiesel or F-T).

Water Emulsion Diesel Fuels

A demonstrated alternative diesel fuel that reduces both PM and NOx emissions is an emulsion of diesel fuel and water. The process mixes water with diesel and adds an agent to keep the fuel and water from separating. The water is suspended in droplets within the fuel, creating a cooling effect in the combustion chamber that decreases NOx emissions. A fuel-water emulsion creates a leaner fuel environment in the engine, thus lowering PM emissions. The major manufacturer of this fuel-water emulsion is Lubrizol Corporation, which produces PuriNOx™ (U.S. EPA, 2002a).

According to data submitted for the ARB fuels certification procedure, PuriNOx™, achieved a 14 percent reduction in NOx emissions and a 63 percent reduction in PM emissions, based on tests on one engine (ARB, 2001). Similar results were found in a U.S. EPA analysis. According to U.S. EPA's analysis of available literature, a medium to heavy heavy-duty vehicle may achieve between a 51 and 58 percent reduction in PM in conjunction with a 10 to 13 percent reduction in NOx emissions (U.S. EPA, 2002a).

PuriNOx™ has been used in a variety of vehicles, including construction equipment and transit buses, but not on TRUs to date. The California Department of Transportation has experience with this fuel. They found that engines did not require engine modifications. But, fuel filters plugged more frequently at the initial conversion and required removal, bypass, or change of filters that were equipped with water separators. The emulsion does tend to break down and separation occurs when stored for over 30 days without agitation or fuel turn over. There are also cold weather compatibility issues (Heiner, 2003). Several companies operating at the Port of Los Angeles are also using PuriNOx™.

Note: It should be noted that water emulsion diesel fuels could not be used to qualify as an ultra-low emission TRU compliance option under the TRU ATCM (see Chapter VII) since conventional diesel fuel is a component. However, it could qualify as a Level 2 verified DECS since PM emission reductions exceed 50 percent, but would have to be verified under the Verification Procedure before it could be used as a compliance option.

Biodiesel

Biodiesel is a mono-alkyl ester-based oxygenated fuel, a fuel made from vegetable oils, such as oilseed plants or used vegetable oil, or animal fats. It has similar properties to petroleum-based diesel fuel, and can be blended into petroleum-based diesel fuel at any ratio. Biodiesel is most commonly blended into petroleum-based diesel fuel at 20 percent, and called B20. Pure biodiesel is called B100 or "neat" biodiesel.

Using publicly available data, the U.S. EPA recently analyzed the impacts of biodiesel on exhaust emissions from heavy-duty on-road engines (U.S. EPA, 2002b). While biodiesel and biodiesel blends reduce PM, HC, and CO emissions, NOx emissions increase, depending on the biodiesel to diesel fuel blend ratio. As the proportion of biodiesel increases, the PM, HC, and CO emissions decrease while the NOx emissions increase. Table VI-1 shows the average biodiesel emissions compared to emissions for conventional diesel.

Table VI-1
Average Biodiesel Emissions Compared to Conventional Diesel Emissions

Pollutant	**B100**	**B20**
Hydrocarbons	-67%	-20%
Carbon Monoxide	-48%	-12%
Particulate Matter	-47%	-12%
Nitrogen Oxides	+12%	+2%

In addition, the U.S. EPA states a B20 blend is predicted to reduce fuel economy by one to two percent. The data were qualified with conclusions that the impact of biodiesel on emissions varied depending on the type of feedstock (soybean, rapeseed, or animal fats) and the quality of the diesel fuel used in biodiesel blends. Biodiesel made from animal fats has the smallest NOx increase (3 percent for animal-based compared to 16 percent for soybean-based for B100).

Biodiesel has been used successfully in heavy-duty diesel-fueled vehicles. However, tests conducted by ThermoKing on TRU engines were not as encouraging. Severe injector tip deposits, head and piston deposits, stuck and broken rings, oil pan deposits, and lubricating oil dilution were just some of the problems encountered (Sem, 2003a). Further testing is planned to investigate the causes.

Biodiesel also costs more than conventional diesel fuel. Table VI-2 provides pricing data from the Energy Management Institutes Alternative Fuels Index, a weekly benchmark for alternative fuels (EMI, 2003).

Table VI-2
Price Comparisons – B100 Biodiesel to Conventional Diesel

City	B100	#2 Diesel	Incremental Difference
L.A.	$2.09	$0.97	$1.12
San Francisco	$2.00	$0.98	$1.02
National Average	$2.06	$0.85	$1.21

Prices shown in the above table exclude tax and delivery.

As discussed earlier, in order to qualify as an ultra-low emission TRU compliance option (see Chapter VII), biodiesel would qualify only if used in the "neat" form (100 percent biodiesel).

Fischer-Tropsch Synthetic Diesel Fuel

In the TRU ATCM, F-T fuels fall under the definition of "Ultra-Low-Aromatic Synthetic Diesel Fuel," which means fuel produced from natural gas, coal, or biomass by the Fischer-Tropsch gas-to-liquid chemical conversion process, or similar process. Such a fuel must meet the following properties listed in Table VI-3:

Table VI-3
Fischer-Tropsch Fuel Properties

Property	ASTM	Value
Sulfur Content (ppmw)	D5453-93	<1
Total Aromatic Content (wt %)	D5186-96	<1.5%
Polynuclear Aromatic Content (wt %)	D5186-96	<0.5%
Natural Cetane Number	D613-84	>74

These properties make this fuel very attractive from a diesel emissions reduction standpoint. Table VI-4 shows the emission reductions for F-T synthetic fuel compared to California diesel fuel (CEC, 2000).

Table VI-4
Fischer-Tropsch Emission Reductions

Pollutant	F-T Emission Reductions
PM	30%
NMHC	23%
NOx	5%
CO	39%

No engine modifications are required and F-T fuel appears to be compatible with exhaust aftertreatment devices. However, there may be cold weather compatibility issues since highly n-paraffinic F-T diesel begins to gel at 34 °F (Heiner, 2003). Changes in processing conditions may improve the cold-flow characteristics, but additives don't help for "neat" F-T diesel (McCormick, 2003).

The availability of F-T diesel fuel may limit its use, at least in the short-term. Current sources of F-T diesel fuel are not domestic, with two major plants in South Africa and one in Malasia (Yakobson, 2003). But since the late-1990s, every major oil company has announced plans to build pilot plants or commercial plants to produce F-T fuel, improving the potential role this fuel could play in reducing diesel engine exhaust emissions. There will be 10 large-scale F-T diesel fuel plants by 2020 producing about 2.5 percent of the world diesel demand – enough to fill the U.S. West Coast demand for diesel fuel (Davies, 2003).

The cost of F-T fuel is 15 to 25 cents more per gallon than California diesel fuel. There is a two to three percent fuel penalty due to reduced energy content (Yowell, 2001), but the power loss is not noticeable (Heiner, 2003).

H. Alternative Fuels

Conventional diesel engines are internal combustion, compression-ignition engines. In contrast, engines that operate on an alternative fuel, such as CNG, liquefied natural gas (LNG), and LPG, are usually spark-ignited. The exception is dual-fueled pilot-ignition engines. Engines certified to operate on alternative fuels produce substantially lower PM and NOx emissions than diesel-fueled engines not equipped with exhaust aftertreatment. CNG-fueled TRU engines have been demonstrated, but are currently not currently in demand (Sem, 2001). LPG-fueled TRU engines have been under development, but have never made it to the demonstration phase due to lack of customer interest. Fuel tank weight, operating range, infrastructure costs, and the cost of meeting the Large Spark-Ignition Engine emission standards cause the lack of demand for further development.

Dual-Fuel Pilot-Injection CNG/LPG Fumigation

A dual-fuel pilot ignition engine is a compression-ignition engine that operates on natural gas or propane but uses diesel as a pilot ignition source. The total use of diesel is around six percent of the fuel consumed. ARB has defined this engine in its proposed TRU ATCM as an engine that uses diesel fuel at a ratio of no more than one part diesel fuel to ten parts total fuel on an energy equivalent basis. Furthermore, the engine cannot idle or operate solely on diesel fuel at any time. A TRU engine that meets this definition and is verified under the Verification Procedure would be classified as an alternative-fuel engine, and would qualify as an ultra-low emission TRU (see Chapter VII) under this TRU ATCM.

Thermoking and Woodward Governor have tested a proof-of-concept CNG dual-fuel pilot injection design. They have indicated they plan to develop a commercial version for both CNG and LPG that would be verified under the Verification Procedure. This technology could be used for both retrofit and on new engines (Sem, 2001).

I. New Engines – for Repower or in Original Equipment

The "interim" Tier 4 particulate emission standards proposed by U.S. EPA will take effect nationally and in California beginning with model year (MY) 2008 for engine manufacturers that opt to meet the "interim" standards, and MY 2013 for "long term" Tier 4. Manufacturers that don't opt to meet the "interim" standards would be required to comply in 2012 with the "long term" standards. Because the devices used to meet the more stringent 2013 standards for greater than or equal to (≥) 25 hp engines are made less efficient by sulfur in the exhaust stream, the level of sulfur in vehicular diesel fuel will also be reduced by 90 percent, relative to current California diesel fuel sulfur levels, to less than (<) 15 ppmw. This is required by mid-2006 (13 CCR, §2281). The <15 ppm sulfur limits will also apply to nonvehicular diesel fuel, effective September 1, 2006.

As discussed in the Requirements section of Chapter VII, new MY 2008 through MY 2012 engines certified to meet the "interim" Tier 4 nonroad diesel engine standards will meet the low emission TRU in-use performance standards for all TRU engines (see Chapter VII). Similarly, MY 2013 and subsequent MY engines that are certified to meet the "long term" Tier 4 standards would meet the ultra-low emission TRU in-use performance standards (see Chapter VII) for ≥ 25 hp TRU engines. This would not be true for <25 hp TRU engines because there is no engine certification value for the ultra-low emission TRU in-use performance standard included in the proposal.

Repowering TRUs with these engines according to the compliance schedule is one option. However, there may be some engine compatibility problems with this approach due to dimensional/spatial and electrical differences. New Tier 2 engines (2004 and beyond) would not be compatible with pre-Tier 2 engines for a significant number of models. This option is non-viable for many greater than (>) 25 hp TRU models and most, if not all, <25 hp TRU models (straight truck TRUs) (Sem, 2003b; Guzman, 2003).

TRU replacement though could be an option if engine repowering is not possible. Replacing older TRUs powered by TRU engines that do not comply with the in-use performance standards with new TRUs (original equipment) that are powered with engines that comply with the new engine standards is also a compliance option that would be available to operators.

J. Electric Standby

TRU manufacturers currently offer electric standby (E/S) as an option for most truck TRU models, but relatively few trailer TRU models offer this. E/S-equipped TRUs allow the TRU engine to be shut off when a compatible power supply is available at a facility so TRU diesel engine emissions are eliminated. As currently designed, however, the electric motors used for E/S are only sized to hold a temperature set point (Guzman, 2002a). The motors do not have sufficient power to be used to pre-cool the transport van enclosure in a reasonable amount of time prior to loading (Guzman, 2002b; Sem, 2002b). That said, in Europe, 40 to 50 percent of the trailer TRUs are equipped with E/S, but the trailer vans are shorter there due to tighter maneuvering needs (Sem, 2002b). Increasing the power rating of the electric motors used in E/S would require significant redesign due to space and structural limitations.

There are also electric power infrastructure compatibility issues. Most E/S units are designed to use three-phase power, which is available at most new facilities, but older facilities (typically small facilities) may have only single-phase power available. Also, there are a number of three-phase voltages used at facilities (e.g. 240, 408, 430, 440, and 480 volt). Plug compatibility can be an issue since there are dozens of plug configurations available for three-phase connections. There are also safety concerns with plugging into a high voltage power source and with "drive-offs" (drivers failing to disconnect before driving away).

The cost of the E/S option adds $2,000 to $2,600 to the cost of a trailer TRU and $350 to $600 to a truck TRU. Adding the power infrastructure at the facilities where TRUs operate is expensive. Loading door outlets cost about $1,250 each if no transformer upgrades are necessary. With transformer upgrades, the cost goes up to $5,000 per outlet for 480 volt and $7,000 per outlet for 208 volt (Warf, 2002). For power outlets in the parking areas, the costs go up significantly due to trenching costs (Joffee, 2002).

In addition, no attempts to retrofit an E/S to units that are not factory-equipped are known to have been completed. Previous interest in retrofitting has been blunted by cost estimates that were prohibitively high – $6,000 to $8,000 (Guzman, 2002b). However, the E/S retrofit approach is now being evaluated very closely in a demonstration project funded with Congestion Mitigation Air Quality, the South Coast Air Quality Management District Technology Advancement Office, and Carl Moyer Program funds. About 30 TRUs will be retrofit and loading dock power will be added at a distribution facility.

Currently, only 0.5 to three percent of trailer TRUs and 40 to 80 percent of truck TRUs are equipped with E/S, according to ThermoKing and Carrier. Captive fleets and grocery distribution centers that own the TRUs they operate are the most likely to have trailer TRUs equipped with E/S. For-hire carriers are reluctant to pay the extra cost to buy the E/S option because there are very few facilities equipped to provide electric power. Furthermore, facilities are reluctant to add power plug-ins because few carriers have the E/S option and they don't want to pay for the electric power for carriers bringing goods in.

IdleAire Technologies Corporation may help break this stalemate syndrome with the Phase 2 Advanced Truck/Trailer Electrification Technology which provides power, communications, cab air conditioning and other services designed to eliminate truck idling, and TRU engine operations at truck stops. Ten truck stops are currently operating this technology across the U.S. with another dozen under construction. Four are currently operating in California. About 150 truck stops are currently under agreement to add this technology across the country, 12 of which are in California (IdleAire, 2003).

Hybrid Electric TRU

Recently, Carrier Transicold announced the use of a hybrid electric TRU design in the continental U.S. The diesel engine drives a generator that, in turn, powers an electric semi-hermetic refrigeration compressor and electrically driven fans, all controlled by an advanced microprocessor. The design eliminates many parts that require maintenance, repair, or replacement, thereby reducing maintenance costs and improving reliability. Belts, idlers, clutches, compressor shaft seals, solenoid valves, and vibration isolators are eliminated. This hybrid electric TRU is easily adaptable to run on electric grid power when at a facility, so that diesel engine operation is eliminated.

This hybrid design is currently marketed in Europe. Carrier representatives indicate the cost is higher than a traditional TRU, but costs less than it would to retrofit a traditional TRU with an electric standby system. One big advantage is that the hybrid design provides full unit refrigeration capacity in standby mode. Carrier also maintains the hybrid design is adaptable for future use with fuel cell technology (Murdock, 2003).

K. Cryogenic Temperature Control Systems

Cryogenic Temperature Control Systems heat and cool using a cryogen, such as liquid carbon dioxide or liquid nitrogen that is routed through an evaporator coil that cools air blown over the coil. The ThermoKing cryogenic system uses a vapor motor to drive a fan and alternator, and a propane-fired heater superheats the carbon dioxide for heating and defrosting. Since there is no diesel engine, TRU engine emissions are eliminated. Refrigerated vans that use "pure" cryogenic systems would not fall under applicability of this regulation.

Capital costs for these types of systems are about 10 percent higher than a diesel TRU (Geisen, 2002), but the facility infrastructure costs for cryogenic fuel adds to the capital cost. And, operating costs for liquid carbon dioxide are typically about double the diesel fuel-operating costs and go up with the distance from the source. Carbon dioxide is readily available near oil refineries because it is a byproduct of the refining process.

These systems are being marketed in Europe and the U.S. There have been several demonstrations in the U.S. – one in Chicago and one in Southern California (Viegas, 2003).

Care must be taken to ensure cryogenic systems are not used in applications that are unsuitable for the technology. An evaluation of operating practices and equipment use may reveal logistical improvements would be necessary for successful application. Several key considerations follow:

- Proximity of distribution center to sources of cryogenic "fuel" affects operating costs
- Loads should be pre-cooled to set-point prior to loading, to conserve cryogenic "fuel"
- Loading warm return crates uses more cryogenic "fuel," reducing distribution range
- Multiple door opening delivery routes should use door curtains to conserve cryogen
- Long delivery runs may exceed on-board cryogen capacity
- Poor or deteriorated insulation and door seals increase cryogen use and decrease range
- Mixed temperature loads can be problematic for units designed for single temp

Operator willingness to improve logistical operating practices may be the key to compatible application of this technology.

L. Fuel Cells

Compared to a conventional diesel-powered TRU, fuel cell TRUs would offer zero or near-zero-emissions (e.g. smog-forming and diesel PM) and lower greenhouse gas emissions. A fuel cell using pure hydrogen produces no pollution. However, the production of hydrogen gas for use in fuel cells is expected to result in extremely low air pollution emissions. Fuel cells are currently being developed by many auto manufacturers, and have generated interest and enthusiasm among industry, environmentalists, and consumers for other types of applications.

At this time, there are no fuel cells appropriately sized for use on a TRU, but electrically-driven TRUs could be powered by fuel cells on or off the road (e.g. at a facility). Another possible approach is a hybrid, with a fuel cell providing electric power to the TRU equipped with electric drive while operating at a facility and a diesel engine powering the TRU while operating in remote areas. The size and weight of the fuel cell and fuel may be a limitation. The University of California, Davis, Institute of Transportation Studies is exploring this concept. Red Coat International (Wilhelm, 2003) and General Hydrogen (Sokoloski, 2003) have also expressed intent to develop fuel cells for TRU applications.

M. Technology Combinations

A trend in technologies presented to ARB for verification is for applicants to combine more than one technology to maximize the amount of diesel PM reduction. This section discusses some of these combinations, including technologies not yet verified.

Fuel Borne Catalyst plus Hardware Combinations

A FBC can be combined with any of the three hardware technologies discussed above (e.g. DPF, DOC, or FTF). Although no combination system using an FBC has been verified yet for TRUs, Clean Diesel Technologies has reported to ARB staff that an application has been submitted to verify a FBC plus catalyzed wire mesh filter (a type of flow-through filter). Emission reduction claims are as follows: 65 percent PM, 75 percent hydrocarbon and carbon monoxide, and five percent NOx using ultra-low sulfur diesel fuel. This combination would cost between $1,500 and $2,000, could be installed in about two hours, and would add from $0.06 to $0.13 per gallon for the FBC additive. The dosing system for the fuel delivery truck or fueling station would cost between $150 and $350, which would be spread out over a number of units being fueled (Valentine, 2003).

The combination of an FBC with a DPF functions similarly to a catalyzed DPF, but an FBC allows the DPF to be lightly catalyzed. The FBC enhances DPF regeneration by encouraging better contact between the PM and the catalyst material during the in-cylinder combustion and exhaust processes. The FBC plus DPF combination reduces both the carbonaceous and soluble organic fractions of diesel PM. The primary benefit of this combination is a reduction in the amount of NO_2 generated as a proportion of NOx.

Hybrid Cryogenic Temperature Control Systems

Hybrid Cryogenic Temperature Control Systems use a cryogenic temperature control system in conjunction with a diesel engine. The hybrid cryogenic systems currently offered by ThermoKing are designed to provide a very high cooling capacity to recover from door openings on loads of perishable products that are very sensitive to temperature drops (e.g. ice cream). It may be possible to use a hybrid cryogenic system to eliminate engine operation at a facility, resorting to engine operation while on the road.

N. Demonstrations

Some of the technologies listed in the Matrix (Appendix B) have been demonstrated in TRU engines. The degree of success has been mixed, but ARB staff believes that there is sufficient time before compliance dates to develop the more viable options into reliable commercial products.

In addition, staff has worked with emission control system (ECS) manufacturers to generate interest in the TRU application. Staff has provided information and introduced the ECS manufacturers to the TRU manufacturers and the TRU engine manufacturers. Some of this effort has lead to ECS development efforts and demonstrations on TRUs.

For example, TTM's Andreas Mayer, of Switzerland, has been working with ThermoKing and several other European companies to test a number of active regenerating strategies for TRU engines, including hydrocarbon injection onto the face of a catalyst, heatable oxidizing catalyst, and intake throttle. Negotiations are in progress with a California partner who would shepherd the commercial system through the Verification Procedure, and provide marketing, installation, and customer support. A California fleet has expressed interest in participating in this demonstration.

O. International Experiences

In 2000, the ARB established the International Diesel Retrofit Advisory Committee, which met six times from 2000 through 2002, to provide ARB with technical information regarding retrofitting diesel engines. In addition to technical experts in the United States, ARB invited knowledgeable persons from countries in Europe and Asia with diesel vehicle retrofit programs to join the group.

P. Technology Reviews

Although there may be many feasible technology options that are being developed or that could be developed, none have been verified to date under the Verification Procedure and it would be difficult, if not impossible to predict when this may occur. Therefore, staff is proposing that two technology reviews be conducted to assure reliable, cost-effective compliance options are available in time for implementation.

The first technology review would be in late 2007, a year prior to the first in-use compliance date, which would be December 31, 2008. Staff would thoroughly evaluate progress made toward applying advanced technologies to meet the in-use performance standards required for TRU engines in the proposed ATCM. Part of this technology review would also look ahead to the 2013 "long term" nonroad engine standard for PM for <25 hp engines to determine if a more stringent level would be feasible. As discussed above, EPA's May 23, 2003 Notice of Proposed Rulemaking for nonroad diesel engine standards did not include a "long term" PM standard for <25 hp diesel engines. But the EPA proposal did include a recommendation for a technology review in 2007 to evaluate technologies for <25 hp engines and to evaluate whether a more stringent "long term" standards would be feasible. ARB staff is proposing a technology review that would be conducted in conjunction with the U.S. EPA technology review.

The second technology review would be in 2009 and would evaluate whether verified PM emission control technology is available and cost-effective for a broad spectrum of TRUs to meet the ULETRU in-use performance standards (see Chapter VII) that would go into effect from 2010 through 2012. If technologies are found to be available and cost-effective, then the ULETRU in-use performance standard would be retained.

Q. Automated Equipment Identification and Recordkeeping

In recent years, the availability of automated equipment identification, tracking, and management systems has increased dramatically. Such technologies could be used to help fleet owner/operators of TRUs, and applicable facilities to comply with the requirements of the proposed regulation. An example of this type of application is the use of global positioning systems (GPS) data to compile required fuel tax and mileage trip reports for the Department of Transportation. Transportation Service LLP's software collects the GPS data and prepares the report, making the process easier, faster, more accurate and more economical than collecting and auditing paper copies of driver trip reports (Refrigerated Transporter, 2003b).

The record keeping and reporting requirements of the proposed ATCM are described in more detail in Chapter VII. In short, all in-use TRUs operating in California would required to meet in-use performance standards in accordance with a compliance schedule. This would entail replacing old engines with new engines or installing a verified DECS that meets the appropriate in-use performance standard. Alternative technologies could also be used as an optional compliance path. To qualify, these alternative technologies either eliminate the emissions of diesel PM or eliminate the operation of the TRU engine while the TRU is at a facility. Verifying compliance in this regard would be essential from the TRU operator's perspective, which is where this new technology may come into play.

In addition, staff have surveyed TRU operators and facilities and found that the amount of time TRU engines operate at a facility as opposed to total engine run time is not currently monitored. The proposed regulation would require facilities to monitor and report the annual amount of time TRU engines operate while at the facility and in total (e.g. on the road and at facility). This operating activity data would provide a measure of the TRU engine emissions while at a facility and in total, and could be used to evaluate public health risk near these facilities and improve the accuracy of statewide emissions.

The facility monitoring and reporting requirement would apply to the TRU engines associated with hauling inbound goods and outbound goods. Most TRUs are equipped with engine-hour meters that monitor the engine run time for scheduled preventive maintenance. But simply monitoring total annual engine run time would not be appropriate since this would not provide an indication of the engine emissions while at a facility. Staff envision the need for facilities to monitor the date and time that refrigerated trucks, trailers, and containers enter and leave a facility, as well as the hour meter reading at each of these events. Comparing the entry and exit hour meter readings would provide the engine run time while at the facility.

Technologies may exist, or could be modified or developed, that could automate this work. Many newer TRUs are equipped with data acquisition systems that provide TRU switch-on time and refrigeration system performance information related to food safety. As an augmentation of this existing capability, automated equipment identification and information management technology could be integrated with the data acquisition systems. ThermoKing offers GPS tracking systems capable of locating TRUs within a few yards. And, Trimble Navigation LTD offers real time asset tracking and monitoring, using a transmitter attached to the microprocessor or datalogger to pass information to a base station receiver. A standard personal computer picks up the information and processes it with special software (Refrigerated Transporter, 2002).

Other existing technologies could also be applied. Each TRU could be equipped with a transponder or other means of quick identification. Transponders could be set to transmit identification information and coded data when activated by a radio frequency signal from an "interrogator" or "reader" when a refrigerated truck, trailer, or container entered and left an affected facility. The transponder would reflect part of the RF signal back to an antenna, communicating a code that identifies the unit, whether and how it complies with in-use performance standards, and the hour meter reading. The readers would provide input to a computer.

For compliance strategies that rely on a certain mode of operation while a TRU is at a facility and a different mode while the TRU is away from a facility (e.g. electric standby, cryogenic cooling, and advanced technologies), the transponder code would indicate the compliance strategy used on either side of a "virtual facility fence line". In this case, GPS and other automated data collection devices would be used to show TRU location with respect to the fence line and status of compliance. Compliance reports could be generated automatically by a computer and sent to ARB on schedule. Such automated data collection and reporting systems are feasible and may be available with some development and may be less expensive and more reliable than manual methods of recordkeeping and reporting.

Trimble's web site advertises real-time (up to the minute) asset tracking and monitoring service plans ranging from $20 to $50 per month. Optional messaging capability is offered for $10 to $15 per month. A range of vehicle-mounted sensors is available to record real time data. Transcore Wireless' LinkTrak with Data Tracker system costs $1495 to purchase the hardware. Alternative lease costs are $44 per month for 4 years, with ownership of the equipment at 4 years. The LinkTrak system allows remote, real time monitoring of trailer location. The Data Tracker provides the capability to remotely monitor various parameters of interest. An add-on for reading and sending the odometer/hour meter reading would cost an additional $10 and should be available in the next six months. A recurring network charge of $45 - $50 per month also applies (TransCore, 2003).

REFERENCES

ARB, 2000. California Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles.* Sacramento, California. October 2000.

ARB, 2001. California Air Resources Board. *Dean C. Simeroth, Chief, Criteria Pollutants Branch, ARB, Letter to Thomas J Sheahan, Managing Director, Legislative and Regulatory, Lubrizol Corporation, Wickliffe, Ohio.* January 31, 2001.

Brück, 2001. Brück, R., P. Hirth, M. Reizig, P. Treiber, J. Breuer, *Metal Supported Flow-Through Particle Trap; a Non-Blocking Solution*, SAE 2001-01-1950.

CEC, 2000. California Energy Commission, *Gas-to-Liquids (GTL) Fuel Fact Sheet*, http://www.energy.ca.gov/afvs/synthetic_diesel.html, Sacramento, California. July 13, 2000.

Davies, 2003. Roger Davies, Shell Gas and Power. *Gas to Liquids (Fischer Tropsch Diesel) Supple and Economics.* Presented at Alternative Diesel Fuels Symposium, Sacramento, California. August 19, 2003.

DieselNet, 2002. *DieselNet Technology Guide: Diesel Oxidation Catalysts*, www.dieselnet.com.

DieselNet, 2003. DieselNet, *DieselNet Technology Guide: Diesel Filter Systems, Filters with Fuel Additives*, www.dieselnet.com.

EMI, 2003. Energy Management Institute. *Alternative Fuels Index*. July 17, 2003. vol. 1, Issue 22

Geisen, 2002. Robert Geisen (forwarded by Tom Sem) ThermoKing Corp to Rod Hill Stationary Source Division, ARB, *Personal Communication (Electronic Mail)*, Sacramento, California. March 13, 2002.

Guzman, 2002a. Peter Guzman, Carrier Transicold, to Rod Hill, ARB Stationary Source Division, ARB, *Personal Communication (Telephone Conversation),* Sacramento, California. April 8, 2002.

Guzman, 2002b. Peter Guzman, Carrier Transicold, to Rod Hill, ARB Stationary Source Division, ARB, *Special TRU Electrification Workgroup Conference Call Meeting,* Sacramento, California. May 28, 2002.

Guzman, 2003. Peter Guzman, Carrier Transicold, to Rod Hill, ARB Stationary Source Division, ARB, *Personal Communication (Telephone Conversation),* Sacramento, California. July 1, 2003.

Heiner, 2003. Marc Heiner, CalTrans. *CalTrans Greening the Fleet,* Presented at Alternative Diesel Fuels Symposium, Sacramento, California. August 20, 2003.

IdleAire, 2003. IdleAire Web site, IdleAire Deployment page, http://www.idleaire.com/about/deployment, September 2, 2003

Joffee, 2002. Enid Joffee, Clean Fuels Connection, Special TRU Electrification Workgroup Conference Call Meeting, April 30, 2002.

Mayer, 2001. Mayer, A., P. Nöthinger, R. Zbinden, R. Evéquoz, *Particle Trap Selection for Retrofitting Vehicle Fleets Based on Representative Exhaust Temperature Profiles.* SAE 2001-01-0187.

Mayer, 2003. Mayer, A., Th. Lutz, Chr. Lämmie, M. Wyser, F. Legerer, *Engine Intake Throttling for Active Regeneration of Diesel Particulate Filters.* SAE 2003-01-0381.

McCormick, 2003. Bob McCormick and Teresa Alleman, National Renewable Energy Laboratory. Presented at Alternative Diesel Fuels Symposium, Sacramento, California. August 19, 2003.

MECA, 2003. *Clean Air Facts – Emission Control Retrofit of Existing Diesel Engines,* Manufacturers of Emission Controls Association. www.meca.org.

Murdock, 2003. Michael Murdoc, Carrier Transicold, *TRU Technology Options,* Presented at SMUD/EPRI Idle Reduction Workshop, McClellan AFB, Sacramento, California. September 17, 2003.

Nixdorf, 2003, Richard Nixdorf, Industrial Ceramic Solutions, LLC, to Rod Hill, Stationary Source Division, ARB, *Personal communication (electronic mai),* Oakridge, Tennessee. April 12, 2003.

Refrigerated Transporter, 2002. *ThermKing Upgrades Tracking, Monitoring Capability," and Trimble Offers GPRS Service,* Refrigerated Transporter, Volume 39, Number 19, December 2002, page 47.

Refrigerated Transporter, 2003. *GPS Downloading Simplifies Tax Reporting,* Refrigerated Transporter, volume 39, number 20, January 2003, page 34.

Sem, 2001. Tom Sem, Thermo King, to Tony Andreoni, ARB Stationary Source Division, *Personal Communication (Telephone Conversation),* Sacramento, California. February 28, 2001.

Sem, 2002a. Tom Sem, ThermoKing Corp. to Rodney Hill, ARB Stationary Source Division, *Personal Communication (Electronic Mail),* Sacramento, California. May 22, 2002.

Sem, 2002b. Tom Sem, ThermoKing Corp. to Rodney Hill, ARB Stationary Source Division, *Personal Communication (Electronic Mail)*, Sacramento, California. March 13, 2002.

Sem, 2003a. Sem, T. R. *Performance of Various Lubricating Oils in Biodiesel-Fueled Engines. Plan B Project.* Submitted to the Faculty of the Graduate School of the University of Minnesota, May 2003.

Sem, 2003b. Tom Sem, ThermoKing Corp. to Rodney Hill, ARB Stationary Source Division, *Personal Communication (Electronic Mail)*, Sacramento, California. June 23, 2003.

Sokoloski, 2003. Darren Sokoloski of General Hydrogen with Tony Andreoni, ARB Stationary Source Division, *Personal Communication, Record of Conversation,* August 22, 2003.

TransCore, 2003. Shawn O'Dell of TransCore with Rod Hill of ARB Stationary Source Division, *Personal Communication, Record of Conversation,* September 24, 2003.

U.S. EPA, 2002a. United States Environmental Protection Agency (U. S. EPA). *Impacts of Lubrizol's PuriNOx Water/Diesel Emulsion on Exhaust Emissions from Heavy-Duty Engines – Draft Technical Report.* EPA420-P-02-007, http://www.epa.gov/otaq/model/p02002.pdf, Research Triangle Park, North Carolina.

U.S. EPA, 2002b. United States Environmental Protection Agency, *A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions – Draft Technical Report,* EPA420-P-02-001,. http://www.epa.gov/otaq/models/analysis/biodsl/p02001.pdf, Research Triangle Park, North Carolina. October 2002.

Valentine, 2000. Valentine, J., J. Peter-Hoblyn, Dr. G. Acres. *Emissions Reduction and Improved Fuel Economy Performance from Bimetallic Platinum/Cerium Diesel Fuel Additives at Ultra-Low Dose Rates.* SAE 2000-01-1934.

Valentine, 2002. James Valentine, Clean Diesel Technologies with Rod Hill, ARB Stationary Source Division, *Personal Communication, Record of Conversation,* February 26, 2002.

Valentine, 2003. Jim Valentine, Clean Diesel Technologies, to Rod Hill, ARB Stationary Source Division, *Personal communication (electronic mail),* September 30, 2003.

Viegas, 2003. Presentation by Herman Viegas, ThermoKing Corporation, at Stewart & Stevenson in West Sacramento, August, 6, 2003.

Warf, 2002. Bill Warf, Sacramento Municipal Utility District, to Steve Cruz, Public Policy Alliance. *Personal communication (electronic mail),* April 3, 2002.

Wilhelm, 2003. D. Lloyd Wilhelm, Red Coat International, with Rod Hill, ARB Stationary Source Division, *Personal Communication. Record of Conversation,* January 29, 2003.

Yakobson, 2003. Dennis L. Yakobson, Rentech, Inc. *Fischer Tropsch Diesel – Meeting the California Supply Challenge,* Presented at Alternative Diesel Fuels Symposium, Sacramento, CA, August 20, 2003.

Yanmar, 2002. Yanmar Diesel Engine Corporation, *Exhaust Temperature Profiile – ThermoKing TRUs Utilizing Yanmar Engines.* Buffalo Grove, Illinois. January 16, 2002.

Yowell, 2001. Gary Yowell, California Energy Commission to Rod Hill, ARB Stationary Source Division, *Personal communication (electronic mail),* Sacramento, California. June 12, 2001.

Zelenka, 2001. Zelenka, P., S. Schmidt, G. Elfinger. *Active Regeneration Aid as a Key Element for Safe Particle Trap Use*, SAE 2001-01-3199.

Zelenka, 2002. Zelenka, P., C. Telford, D. Pye, N. Birkby, *Development of Full-Flow Burner DPF System for Heavy Duty Diesel Engines*, SAE 2002-01-27887.

VII. THE PROPOSED AIRBORNE TOXIC CONTROL MEASURE AND ALTERNATIVES

In this chapter, we provide a plain English discussion of the key requirements of the proposed air toxic control measure (ATCM) for in-use diesel-fueled transport refrigeration units (TRU) and TRU generator sets, and facilities where TRUs operate. This chapter begins with a general summary of the ATCM. Each major requirement of the ATCM is discussed and explained. This chapter is intended to satisfy the requirements of Government Code section 11343.2, which requires that a noncontrolling "plain English" summary of the regulation be made available to the public. Unless otherwise noted herein, all references to TRUs include TRU generator sets. The term "facilities", as used herein, refers to facilities where TRUs operate, as defined in the regulation.

A. Summary of the Proposed ATCM

The proposed ATCM for In-Use Diesel-Fueled TRUs and TRU Generator Sets, and Facilities Where TRUs Operate is included in Appendix A. The regulation is designed to reduce the general public's exposure to diesel particulate matter (PM), other toxic contaminants, and air pollutants from TRUs. In addition, the ATCM would include record keeping and reporting requirements to provide staff up-to-date information on TRU operations at facilities where TRUs congregate.

The "in-use" requirements of the proposed ATCM would affect owners and operators of diesel-fueled TRUs that operate in California. This would include all carriers that transport perishable goods using refrigerated trucks, trailers, shipping containers, and railcars. There are a few local municipalities, school districts, and correctional institutions that operate TRUs that may be affected. Larger facilities where TRUs operate would also be affected. Military tactical support equipment would be exempt.

The proposed ATCM would require in-use TRU engines to meet performance standards, which vary by horsepower. The in-use performance standards have two levels of stringency that would be phased in over time. The first phase is called the "low emission TRU," or LETRU. The second phase is called "ultra-low-emission TRU" or ULETRU. Each of these standards can be met a number of ways. One way is to use an engine that is certified to the appropriate diesel PM emission level (e.g. repower with cleaner engine or replace the old TRU with a new or newer TRU with a cleaner engine). A second way is to equip the engine with the appropriate level of Verified Diesel Emissions Control Strategy (VDECS). A third way is to use an alternative technology that eliminates TRU diesel engine operation (and emissions) while at a facility. More detail will be provided below in the discussion of the requirements.

The engine certification values of the in-use performance standards are based on the Tier 4 nonroad standards proposed by U.S. EPA in their May 23, 2003 Notice of Proposed Rulemaking for Control of Emissions of Air Pollutants from Nonroad Diesel Engines and Fuel (hereinafter referred to as Nonroad Standards) (U.S. EPA 2003).

Staff is proposing to conduct a technology review in 2007 to evaluate technology readiness for the in-use requirements that would begin to be phased in by the end of 2008 and continue phase-in over the next 12 years. Part of the technology evaluation would be to determine if more stringent standards for these pollutants would be feasible for less than (<) 25 hp TRU engines in the 2010 to 2013 time-frame. In addition, ARB proposes a second technology review to be conducted in 2009 to evaluate whether technologies that would meet the ULETRU performance standard would be available and cost-effective for a broad spectrum of the model year 2003 through 2005 TRU and TRU generator set engines that would need to come into compliance by the end of 2010 through 2012, respectively.

TRU engines that use one of the "alternative technologies" listed in the ATCM would qualify as ULETRU for both horsepower categories, provided they meet certain operating conditions. In general, these operating conditions would eliminate diesel engine emissions at a facility, except during an emergency. These alternatives include the use of electric standby, cryogenic temperature control systems, alternative fuel, alternative diesel fuel, fuel cell power, or any other system approved by the Executive Officer to not emit diesel PM or increase public health risk while at a facility.

The proposal includes a provision that rewards operators for early compliance with the LETRU in-use performance standard by delaying the compliance date for meeting ULETRU in-use performance standard by an equal amount of time (e.g. one year of early compliance with LETRU is rewarded by a one year delay in compliance with ULETRU). The maximum delay in ULETRU compliance allowed would be three years.

Staff is proposing the use of an ARB identification (I.D.) numbering system for California-based TRUs. The intent is to expedite the inspection procedure and prevent false compliance claims. Such a system would be designed to prevent lengthy compliance inspections that would delay shipment of perishable goods. Similarly, non-California-based operators could voluntarily apply for ARB I.D. numbers for TRUs that are based outside of California but which operate in California.

The proposed ATCM includes provisions for operator reporting that would allow staff to monitor the implementation of the ATCM and provide more accurate estimates of pollutant reductions. Affected facilities (with ≥ 20 loading dock doors serving refrigerated storage areas) would be required to provide a one-time report that would help staff understand TRU operations at facilities better and to evaluate residual risk as the ATCM is implemented. Operator and facility data would be evaluated to determine if there is a need for a follow-on regulation to address residual risk to the public near certain types of facilities.

B. Discussion of the Proposed ATCM

Purpose

As specified in subsection (a) of the proposed ATCM, the regulation uses a phased approach to reduce the diesel PM emissions from in-use TRUs that operate in California. The resulting benefit would be reduced exposure to toxic air contaminants, including diesel PM, near facilities where TRUs operate. The main focus of this regulation is to reduce health risks near facilities where TRUs operate. However, depending on the compliance strategies chosen by TRU owner/operators, emissions that occur during on-road transport and related risk near roadways would also be reduced.

Applicability

As specified in subsection (b) of the proposed ATCM, the regulation would apply to owners and operators of diesel-fueled TRUs and TRU generator sets that are installed on trucks, trailers, railcars, and containers and which operate in the State of California. This would include operators that are based in California and provide both intrastate and interstate refrigerated carrier operations that use TRUs. This regulation would also apply to TRU operators based outside California, that deliver or pick up perishable goods to facilities in California and provide intrastate or interstate transport. In essence, all carriers that transport perishable goods in California using TRUs would be applicable under this regulation to the extent that they operate TRUs in California (e.g. the TRUs that they operate in California would have to comply with this regulation).

In addition, the regulation would apply to facilities located in California where perishable goods are loaded or unloaded for distribution through 20 or more loading dock doors serving refrigerated areas. Of these facilities, the ATCM facility requirements would only apply to those where the TRUs operating at the facility are owned, leased, or contracted for by the facility, its parent company, affiliate, or subsidiary and which operate under facility control. Facility control occurs when the facility determines the arrival, departure, loading and unloading, shipping and receiving of cargo. Facility control also occurs if the facility's parent company, affiliate, or subsidiary controls TRUs for the facility. Staff suspects that these facilities would be where the potential for elevated residual risk levels would be the greatest after the in-use performance standards were implemented. Also, the cost of record keeping and reporting should be more easily absorbed by these larger facilities and corporations.

Exemptions

Several clarifications on applicability are included here in the discussion of exemptions. First, engine-driven air conditioners don't meet the definition of TRU. Second, the regulation only applies to diesel-fueled TRUs and TRU generator sets. As defined, a TRU is a refrigeration system powered by an integral internal combustion engine, so, this regulation would not apply to refrigerated transport systems that use a fully cryogenic cooling system (e.g. uses liquid carbon dioxide or liquid nitrogen). In addition, refrigerated transport that uses electrically driven refrigeration systems would not be applicable, but the generator set that typically provides the electric power (TRU generator set) would be applicable.

The facility requirements in this proposed regulation would not apply to facilities where no loading or unloading of perishable goods occurs, such as truck stops and intermodal facilities. Also, the facility reporting requirements in the proposed regulation do not apply to any facility that does not have control over any TRU and TRU generator set operations or does not own, lease, or operate TRUs at the facility. Examples of this would again include intermodal facilities and some cold storage warehouses that do not have control over TRUs, as defined, that would not be applicable. However, if a cold storage facility had any sort of facility control (as defined in the regulation) over TRUs, the facility requirements would apply. For example, if the arrival, departure, loading, unloading, shipping and/or receiving of cargo is determined by the facility, then the facility would be subject to the requirements of this regulation. As a hypothetical instance, a cold storage facility that allows businesses to operate on a day-to-day basis out of the facility or which schedules the arrival of refrigerated trailers and employs workers to load and unload perishable goods into these refrigerated trucks would need to comply with the facility record keeping and reporting requirements of the proposed ATCM.

The above discussion applies only to the facility requirements of the proposed regulation. A facility that is also a TRU operator would be required to meet other applicable requirements of the proposed regulation.

As specified in subsection (c) of the proposed ATCM, the regulation does not apply to military tactical support equipment.

Definitions

Most of the definitions listed in subsection (d) of the proposed ATCM were developed by staff, with input from the TRU Workgroup. Staff working on this ATCM also coordinated with staff working on other diesel PM ATCMs to provide consistency where it was practical. Please refer to Appendix A, subsection (d) for a list of definitions.

Requirements

As specified in subsection (e) of the proposed ATCM, the proposed regulation would require in-use TRUs to meet performance standards, which vary by engine horsepower. The in-use performance standards have two in-use emission categories that correspond to two levels of stringency that would be phased in over time. The first in-use emission category is called the "low emission TRU," (LETRU). The second, more stringent in-use emission category is called "ultra-low-emission TRU" (ULETRU). Each of these in-use emission categories represent performance standards that can be met a number of ways, as discussed below. A TRU engine that meets ULETRU in-use performance standard automatically meets the less stringent LETRU in-use performance standard.

Table VII-1 shows the in-use performance standards that apply to <25 hp TRU and TRU generator set engines. Further explanation follows the table.

Table VII-1
<25 hp TRU and TRU Generator Set In-Use PM Performance Standards

In-Use Emission Category	Engine Certification (g/hp-hr)	Level of VDECS TRU or Engine Equipped with
Low Emission TRU (LETRU or L)	0.30	Level 2
Ultra-Low Emission TRU (ULETRU or U)	NA	Level 3

Less than 25 hp TRU and TRU generator set engines can meet the LETRU in-use performance standard with an engine, or engine and emissions control system, that is certified to 0.30 grams per horsepower-hour (g/hp-hr) or by installing a Level 2 verified diesel emission control strategy (VDECS), which would reduce diesel PM emissions at least 50 percent and up to 84 percent. The ULETRU in-use performance standard for <25 hp engines can be met by using a Level 3 VDECS, which would reduce PM emissions by 85 percent or greater. There would be no corresponding engine certification value for ULETRU in the <25 hp category because U.S EPA did not include a "long term" Tier 4 level in their Nonroad Standards. EPA has proposed the possible addition of a more stringent "long term" level, pending their technology review in 2007. If a more stringent level is adopted by U.S. EPA for <25 hp nonroad engines in the final rulemaking, or as the result of the technology review, then ARB may amend the TRU ATCM to include this as an engine certification value for the ULETRU in-use emission category.

Table VII-2 shows the in-use performance standards that apply to greater than or equal to (≥) 25 hp TRU and TRU generator set engines. Further explanation follows the table.

Table VII-2
≥ 25 hp TRU and TRU Generator Set In-Use PM Performance Standards

In-Use Emission Category	Engine Certification (g/hp-hr)	Level of VDECS TRU or Engine Equipped with
Low Emission TRU (LETRU or L)	0.22	Level 2
Ultra-Low Emission TRU (ULETRU or U)	0.02	Level 3

Greater than or equal to (≥) 25 hp TRU and TRU generator set engines can meet the LETRU in-use performance standard with an engine or engine and emission control system that is certified to 0.22 g/hp-hr or by installing a Level 2 VDECS on an in-use engine. Level 2 would reduce diesel PM by 50 percent to 84 percent. The ULETRU standard for ≥ 25 hp engines can be met with an engine or engine and emission control system that is certified to 0.02 g/hp-hr or by using a Level 3 VDECS on an in-use engine, which would reduce diesel PM emissions 85 percent or greater. A TRU engine that meet the ULETRU in-use performance standard would also meets the less stringent LETRU in-use performance standard.

The engine certification values of the in-use performance standards are based on the U.S. EPA Tier 4 Nonroad Standards. Once U.S. EPA promulgates these regulations, ARB will adopt, in separate rulemaking, equivalent diesel engine standards that would also apply to new diesel engines. By design, this proposed ATCM's in-use engine compliance dates are one year later than the U.S. EPA's proposed Tier 4 Nonroad Standard compliance dates for new engines. This was done so that as new engines become available that comply with the Tier 4 standards, TRU operators could elect to repower with these new engines to comply with in-use requirements.

Another way to comply would be to demonstrate that an in-use engine met the appropriate in-use performance standard engine certification level. In this example, the engine certification Executive Order numbers that were granted to the TRU engine manufactures when the engine was new would need to be provided to staff. Staff plan to work with TRU and TRU engine manufacturers to develop a cross reference listing of engine models, engine certification Executive Orders, engine emission factors, and deterioration rates. This listing would include an indication of the in-use performance standard met (e.g. LETRU or ULETRU). Staff would make this list available to TRU operators on ARB's TRU web site.

U.S. EPA's May 23, 2003 proposal allows the use of a new steady-state test cycle for TRU engines (ref 40 CFR Part 89, Subpart G, section 1039.645). The proposed test cycle is intended to be more representative of the way TRU engines actually operate than the currently used 8-mode test cycle, which includes modes of operation that TRUs never use (e.g. idle at no-load, 10 percent and 100 percent of rated torque at rate speed, and 100 percent of rated torque at intermediate speed). The proposed test cycle has four modes: 75 percent and 50 percent torque at maximum test speed, and 75 percent and 50 percent torque at intermediate test speed. The weighting factors for each of these four modes would be split equally at 25 percent. TRU engine manufacturers have told staff that some Tier 1 and many Tier 2 TRU engines may be able to meet the LETRU in-use performance standards, if the engine certification data is evaluated with the steady-state TRU test cycle. Initial staff evaluation of modal engine certification data indicates that emission factors will be less for the proposed test cycle compared to the current test cycle. The amount of PM emission factor reduction ranges from 25 percent to 60 percent, depending on engine model. But, staff found that nitrogen oxide (NOx) emission factors may increase for some engines when using the proposed steady state TRU test cycle.

Staff supports the proposed TRU test cycle, provided manufacturers use the test cycle for all pollutants. Staff also supports this provision of EPA's proposal, as applied to new engine certifications since it allows an optimized reduction of actual emissions and prevents the costly over-design of the emission control system to cover modes of operation that are not used in practice.

However, the retroactive use of the steady-state TRU test cycle to re-evaluate Tier 1 and Tier 2 engine emissions to meet the in-use performance standard engine certification levels would not be allowed, according to U.S. EPA. This policy position is supported by ARB as well.

The other in-use compliance approach mentioned above would be to install the appropriate level of VDECS. As discussed in Chapter VI, diesel emission control strategies must be verified by ARB's Mobile Source Control Division under the *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines (13 CCR Sections 2700 – 2710)* before they can qualify as a VDECS. Staff believes that use of the required level of VDECS for each in-use emission category will result in engine PM emission rates that are roughly equivalent to that required by the engine certification levels assigned to each category. For example, a 34 hp Tier 2 engine meeting a 0.45 g/hp-hr certification standard that used a Level 2 VDECS (50 percent to 84 percent PM reduction) to comply with the proposed LETRU in-use performance standard would then have PM emissions that would be at least equivalent to the proposed LETRU in-use performance standards under the engine certification level of 0.22 g/hp-hr.

As noted above, EPA has proposed a technology review in 2007 that would evaluate the progress made toward applying advanced PM and NOx control technologies to the <25 hp engine category. Part of that evaluation would be to determine if more stringent standards for these pollutants was feasible for the 2010 to 2013 time-frame. ARB would conduct a similar technology review in 2007 to evaluate whether verified control technologies are available and cost-effective for a broad range of models in time for the end of 2008 compliance date. In addition, ARB would conduct a second technology review in 2009 to evaluate whether technologies that would meet the ULETRU in-use performance standard would be available and cost-effective for a broad spectrum of TRU engines that would need to come into compliance starting at the end of 2010. A discussion of cost-effectiveness is included in Chapter VIII.

TRU owner/operators that voluntarily use one of the "alternative technologies" listed in the ATCM would qualify the TRU engine as ULETRU for both horsepower categories, provided they meet certain conditions. In general, these conditions would eliminate diesel engine emissions at a facility, except during an emergency. Some of these alternatives would still involve the use of a TRU engine (e.g. electric standby) during on-road transport away from the facility. In such cases, it is staff's intent to allow a reasonable amount of TRU engine operation during ingress and egress yard maneuvering operations ("reasonable" means a few minutes). These alternative technologies include the use of electric standby, cryogenic temperature control systems, alternative fuel, alternative diesel fuel, fuel cell power, or any other system approved by the Executive Officer to not emit diesel PM or increase public health risk while at a facility. Alternative technologies only qualify toward compliance with the ULETRU in-use performance standard requirement if they eliminate diesel engine operations at facilities. The use of an alternative technology would obviously satisfy the less stringent LETRU in-use performance standards, provided diesel engine operations were eliminated at the facility. Conditions are included in each of the listings for eligible alternative technologies to reinforce the obligation to eliminate diesel engine operations at the facility.

If operators are unable to eliminate the operation of the TRU diesel engine while at all facilities, then the alternative technology would not be in compliance. This leads to the conclusion that alternative technologies may only work for facilities that are also operators of captured fleets of TRUs. Captured fleets involve operators whose TRUs only go to the operator's facilities. In this case, the operators' facilities would all be equipped with the infrastructure necessary to ensure the TRU engine operations are eliminated while the TRU is at that facility. Although captured fleets may be natural candidates for alternative technologies, other operators may also be able to use alternative technologies as long as they can meet the conditions that eliminate the engine operation while at a facility.

Compliance Dates

Compliance dates for meeting the in-use performance standards are phased in over time. Compliance dates for <25 hp TRU and TRU generator set engines are shown in Table VII-3, with further explanation following the table.

Table VII-3
<25 hp TRU and TRU Generator Set Engines
In-Use Compliance Dates

	In-Use Compliance Year													
MY	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20
2001 & Older									U	U	U	U	U	U
2002										U	U	U	U	U
2003				U	U	U	U	U	U	U	U	U	U	U
2004					U	U	U	U	U	U	U	U	U	U
2005						U	U	U	U	U	U	U	U	U
2006							U	U	U	U	U	U	U	U
2007								U	U	U	U	U	U	U
2008									U	U	U	U	U	U
2009										U	U	U	U	U
2010											U	U	U	U
2011												U	U	U
2012													U	U
2013														U

The TRU engine model years are shown in the left column. In-use compliance years are shown across the top. The compliance date is December 31st of the compliance year shown. Black shaded areas are years with no requirements since in-use compliance year precedes model year. Dark shaded areas without letter codes have no requirements, pending in-use compliance date. "L" means must meet LETRU in-use performance standards. "U" means must meet ULETRU in-use performance standards.

The first row under the column heading in the table shows that 2001 and older model year TRU engines would come into compliance with the LETRU in-use performance standards by the end of 2008. This is true for both horsepower categories (see below). The second row below the column headings shows the 2002 TRU engines would come into compliance with LETRU in-use performance standards by the end of 2009. From the third row on (2003 and subsequent model years), the ULETRU in-use performance standard would have to be met by the end of the seventh year past the model year.

Compliance dates for ≥ 25 hp TRU and TRU generator set engines are shown in Table VII-4, which uses the same layout and nomenclature as just described for the <25 hp TRU engines.

Table VII-4
≥ 25 hp TRU and TRU Generator Set Engines
In-Use Compliance Dates

MY	In-Use Compliance Year													
	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20
'01 & Older		L	L	L	L	L	L	L	U	U	U	U	U	U
'02			L	L	L	L	L	L	L	U	U	U	U	U
'03				U	U	U	U	U	U	U	U	U	U	U
'04					U	U	U	U	U	U	U	U	U	U
'05						U	U	U	U	U	U	U	U	U
'06							U	U	U	U	U	U	U	U
'07								U	U	U	U	U	U	U
'08									U	U	U	U	U	U
'09										U	U	U	U	U
'10'											U	U	U	U
'11												U	U	U
'12													U	U
'13														

For ≥ 25 hp TRU engines, the proposed nonroad diesel new engine standards for a model year 2013 engine would be the same as the ULETRU in-use performance standard (0.02 g/hp-hr). Therefore, 2013 and subsequent model year TRU engines in the ≥ 25 hp category would automatically comply with the ULETRU in-use performance standards and the VDECS compliance approach would "sunset." For <25 hp TRU engines, however, this would not be true because, as proposed, there would be no in-use performance standard for the ULETRU engine certification level. Into the foreseeable future, operators of <25 hp TRU engines would have to use a Level 2 or Level 3 VDECS after the end of 7 years beyond the model year of the engine to comply with the proposed ULETRU in-use performance standards. If a more stringent "long term" Tier 4 PM standard is adopted for <25 hp nonroad diesel engines, ARB would amend this ATCM to include that standard as the in-use ULETRU engine certification value. Then, a similar "sunset" to the VDECS requirement would take effect, similar to that described for the ≥ 25 hp category.

Staff plans to conduct notification and outreach to operators and facilities to explain and clarify these in-use requirements.

Early Compliance Incentive

The proposed ATCM includes a provision to encourage operators of 2002 and older model year TRU engines to comply early with LETRU in-use performance standards. A year delay in meeting the ULETRU in-use compliance date would be provided for each year of early compliance with the LETRU in-use performance standards (e.g. one year of early compliance with LETRU results in a one year delay in compliance with ULETRU standards). The maximum delay allowed would be three years. For example, a model year 2001 TRU engine would normally be required to comply with LETRU performance standards by the end of 2008 and ULETRU in-use performance standards by the end of 2015. But if the operator brought this TRU engine into compliance with the LETRU in-use performance standards at the end of 2005 (3 years early), then the ULETRU in-use performance standard compliance date would be delayed three years, until the end of 2018. In this example, there would be 13 years between the LETRU and ULETRU compliance dates and the TRU would be 17 years old when ULETRU compliance occurred. This may be a likely time to retire the TRU (or sell it out-of-state), rather than retrofit the engine to comply with the ULETRU in-use performance standard. Staff believes that this incentive would reduce the burden of compliance on operators by spreading out the costs over several years ahead of time and still accelerate attrition near the end of the equipment life.

The ULETRU in-use performance standard compliance delay granted would be rounded to the nearest full year. If LETRU compliance was demonstrated to have occurred 183 days or more earlier than required, then a one year delay would be granted. If LETRU compliance is demonstrated to have occurred 182 days or less early, then no delay would be granted.

This compliance delay would not be available to the TRU operator if the TRU engine manufacturer is using the early compliance with engine emission standards in any averaging, banking, and trading program (either U.S. EPA's or the California equivalent program). Allowing both a delay and an emission reduction credit would cause an emissions accounting discrepancy such that emissions benefits would be lost or exaggerated.

In addition, early compliance with the LETRU in-use performance standard is possible only if real emission reductions occur as a result of early compliance. For example, installing a Level 2 VDECS one year before the LETRU requirement deadline would count toward a one year ULETRU compliance delay. Replacing an old engine with a new engine that was certified to meet the LETRU in-use performance standard under engine certification would also count, provided the new engine PM emissions factor was less then the existing engine PM emission factor. However, simply showing that an in-use engine met the LETRU in-use engine certification level when it was certified as a new engine, without otherwise reducing diesel PM emissions, would not count toward a

ULETRU delay. However, as noted previously, this approach could be used to show LETRU compliance for the normal compliance deadline. To reinforce the point, the ULETRU compliance delay will only be granted if real emission reductions occur.

ARB Identification Numbers

Staff is proposing the use of an ARB identification (I.D.) numbering system for TRUs and TRU generator sets to help expedite the inspection procedure (which is intended to prevent shipping delays of perishable goods), and to prevent false compliance claims. Owner/operators of all California-based TRUs and TRU generator sets would be required to apply for an ARB I.D. number for each new and in-use TRU engine under their control. If the TRU engine was an early compliance unit or had achieved compliance at any level, the operator would be required to provide details that ARB could use to confirm compliance at time of inspection. ARB would then issue a coded I.D. number that operators would be required to paint on each TRU chassis housing in clear view. The I.D. numbers would indicate the level of compliance achieved. Inspectors in the field would use the I.D. number verify compliance and carrier information. Similarly, non-California-based operators could voluntarily apply for ARB I.D. numbers for TRUs that are based outside of California but which operate from time to time in California. The intent of offering such an approach to non-California-based operators would be to avoid shipping delays of perishable goods coming into and going out of California.

Fuel Requirements

The regulation includes fuel requirements that would apply to TRU operators that voluntarily opt to use alternative diesel fuel to meet the in-use requirements. Record keeping would be required to assure continued exclusive use of the chosen alternative diesel fuel for operations in California. Furthermore, to qualify for compliance with in-use requirements, only alternative diesel fuels that have been verified under the Verification Procedure would be allowed to be used.

In addition, if an operator chose a VDECS that required certain fuel properties to be met in order to achieve the required PM reduction, then the operator would be required to only fuel the subject TRU with fuel that meets these specifications when operating in the state of California. Operators would be responsible for making appropriate arrangements with any contractor that provides fueling services to TRUs under their control to assure exclusive use of the chosen alternative diesel fuel.

Furthermore, if an operator chose a VDECS that required certain fuel properties to be met in order to prevent damage to the VDECS or an increase in toxic air contaminants, other harmful compounds, or in the nature of the emitted PM, the operator would be required to fuel the subject TRU only with fuel that meets those specifications.

The proposed regulation does not include a requirement to use CARB diesel in TRUs. However, it should be noted that TRUs can only be fueled in California with vehicular

CARB diesel, starting September 1, 2006, in accordance with California Code of Regulations, Title 13, Section 2281(a)(4).

Record Keeping and Reporting

As specified in subsection (f) of the proposed ATCM, the proposal includes provisions for TRU operator reporting that would allow staff to obtain more accurate information on of the number of TRUs and TRU operators in California, to monitor the implementation of the ATCM, to estimate pollutant reductions based on compliance choices the operators make, and to facilitate inspections by ARB's Enforcement Division. Starting in 2009, affected TRU operators would be required to report TRU inventory information about the TRUs they operate (e.g. make, model, serial number), the terminals where they domicile TRUs, and how and when they come into compliance with the in-use requirements of the ATCM. Additional reports would be required within 30 days of any changes to this information.

Large facilities where TRUs operate would also be required to submit a one-time report to ARB by the end of January, 2005 which would provide more accurate information about how TRUs operate at facilities. Staff would use the information to evaluate the effectiveness of the regulation and address any remaining risk at facilities after the implementation of the proposed ATCM. Operator and facility data would be evaluated to determine if there is a need for a follow-on regulation to address residual near-source risk at facilities. Some of the information requested would be used to determine if it would be possible to narrow the scope of applicability of such a follow-on regulation (e.g. the North American Industrial Classification System codes applicable to the facility, the number of loading dock doors serving refrigerated areas, the square feet of refrigerated storage space). Record keeping that supports the information reported would also be required to be compiled and made available to ARB inspectors upon request for three years.

The TRU ATCM currently requires submittal to ARB by mail, however, staff plan to develop the potential for electronic report submittals in time for both operator and facility reporting deadlines. In addition, staff plans to conduct outreach to operators and facilities to explain and clarify these reporting requirements.

Prohibitions

As specified in subsection (g) of the proposed ATCM, people engaged in the State in the business of selling, renting or leasing new or used TRUs would be prohibited from importing, delivering, purchasing, receiving, or acquiring new or used TRU engines that do not comply with the ATCM. And, people engaged in California in the business of selling new and used TRU engines would be prohibited from selling to any resident of the State or a person that could reasonably be expected to do business in the state a new or used TRU engine that does not comply with the ATCM. In addition, people engaged in the State in the business of renting or leasing new or used TRU engines would be prohibited from renting, leasing, or offering for rent or lease, any new or used

TRU engine in the State that did not comply with the ATCM. Finally, the operators of facilities and operators of affected TRUs would be prohibited from taking action to divert TRUs to alternative staging areas in order to circumvent the requirements of the regulation.

C. Alternatives Considered

The Government Code section 11346.2 requires the ARB to consider and evaluate reasonable alternatives to the proposed regulation and provide the reasons for rejecting those alternatives. Staff identified two alternatives to the proposed control measure: "no action" and require electric-powered refrigeration systems while transport units are at a facility. Each of the two alternatives were evaluated addressing applicability, effectiveness, enforceability, and cost/resource requirements.

This section discusses each of the two alternatives and provides reasons for rejecting those alternatives.

Alternative One – No Action

The "no action" alternative would rely on progressively more stringent State and federal emission standards for new nonroad engines to come into effect over time.

Prior to 1995 there were no emissions standards for <25 hp nonroad diesel engines. Small Off-road Engine (SORE) standards applied to <25 hp diesel engines for 1995 through 1999 model years. Tier 1 nonroad standards affected model year 2000 through 2004. Tier 2 standards for <25 hp diesel engines will take effect in 2005, followed by Tier 4 standards in 2008.

Similarly, prior to 1999, there were no emission standards for ≥ 25 hp to <50 hp nonroad diesel engines. Tier 1 nonroad standards affected model year 1999 through 2003. Tier 2 standards for ≥ 25 hp to 50 hp diesel engines will take effect in 2005. U.S. EPA's proposed Tier 4 standards would apply to ≥ 25 hp to <75 hp diesel engines (note modified horsepower range) with two compliance pathways. Engine manufacturers can opt to meet "interim" Tier 4 standards in 2008 and "long term" Tier 4 emission standards in 2013. Alternatively, they may skip the "interim" standards in 2008 and meet the "long-term" emission standards in 2012, one year earlier.

1. Applicability

This alternative could be applied to the purchase of new TRU engines.

2. Effectiveness

According the TRU manufacturers, the life of a TRU engine is between 12,000 hours and 20,000 hours, depending on the whether the TRU is a truck or trailer model and the quality of preventive maintenance. Some TRU operators, on the other hand, claim they can get 25,000 to 30,000 hours out of trailer TRU engines. Annual engine hour accrual varies significantly, resulting in a wide range in the life of a TRU engine in terms of years. High-use TRUs can accrue these hours in 7 to 10 years. Low-use TRUs could result in older engines with higher emission rates that could be in the field for many years. Staff has discovered TRU engines in the field that are over 30 years old. Staff believes that TRU engine attrition rates must be accelerated to remove older TRU engines from the inventory and reduce public health risk in a reasonable amount of time. The "no action" alternative would not accelerate engine attrition rates and reduce the potential health risk posed by TRU diesel engines. Therefore, the "no action" alternative was rejected by staff.

3. Enforceability

The U.S. EPA and ARB currently share enforcement responsibilities for assuring new nonroad diesel engines meet the nonroad engine emission standards.

4. Cost and Resource Requirements

This alternative would not cause any increase in the current cost and resource requirements.

Alternative Two – Require Electric-Powered Refrigeration Systems while Transport Refrigeration Units are at a Facility

This alternative was described in Chapter VI – Availability and Technical Feasibility of Control Measures under the heading "Electric Standby". In order to reduce diesel PM emissions and related risk to an acceptable level, staff believes that TRUs would need to be plugged into "grid" power at all times while at a facility, except when not in operation, when being moved around the facility yard, or during an emergency. To accomplish this, all TRUs would have to be equipped with electric standby (E/S) and power outlets would be necessary at parking areas and loading dock doors. The cost of the electric power infrastructure that would be necessary is significant. Most of the TRU models designed for straight trucks (<25 hp) have the E/S option available and about 40 percent to 80 percent of the straight trucks in the field today are equipped with E/S. Only about half of the TRU models designed for trailers (>25 hp) have the E/S option available and about 0.5 percent to three percent of the trailers in the field today are equipped with E/S. The acceptable level of risk, according to many local air districts is 10 excess cancer cases per million over 70 years.

Staff proposed this alternative as a prescriptive requirement in the early phases of control measure development. Regulatory concepts were developed and presented to stakeholders at several TRU Workgroup meetings, where cost and feasibility issues were raised. A series of special TRU electrification workgroup meetings were also conducted to explore solutions to these issues. Staff learned that this approach had some significant issues, as discussed below. A more detailed discussion of these issues and others is included in Chapter VI.

Although staff elected to abandon the "electric standby" option, it was retained in the proposed ATCM as one of the "alternative technologies" that may be used to achieve compliance. Operators that choose this option may be successful in resolving some of the attendant issues, paving the way for more common use.

1. Applicability

This alternative has limited applicability because not all TRU models offer the electric standby option. But, if electric standby became available on all models (through extensive redesigns of some models), it could be applied at facilities affected by the proposed regulation. This alternative may not be practical at intermodal facilities and rail switchyards. Many complex issues related to who would be the responsible party in the event of violations (e.g. unit found operating on conventional diesel power because compatible infrastructure unavailable) and who pays for the electric power would need to be resolved in advance.

2. Effectiveness

This alternative would virtually eliminate TRU engine operating time at the facilities currently affected by the proposed regulation, and therefore, would eliminate diesel PM emissions. However, this would occur at a very high cost since the majority of existing TRU models would have to be scrapped or sold out of state because retrofits are prohibitively expensive or impossible due to design constraints (see Cost and Resource Requirements below).

3. Enforceability

A compliance verification system would need to be devised (e.g. active equipment identification transponders, fenceline global positioning systems (GPS), and data loggers) and ARB staff would need to conduct surveillance, make unannounced inspections, and conduct audits to assure compliance with the requirement that TRUs be plugged into grid power when in use at a facility. It would be difficult to ensure that all TRUs coming into a facility that were not under facility control were in compliance. For example, most inbound loads are typically operated by carriers that fall outside the control of the facility.

4. Cost and Resource Requirements

As currently designed, the electric motors used for E/S are only sized to hold a set point temperature and do not have sufficient power to be used to pre-cool the transport van enclosure in a reasonable amount of time prior to loading. Increasing the power rating of the electric motors used in E/S would require significant redesign due to space and structural limitations. The cost for the E/S option may be higher in the first few years to recover development costs.

There are also electric power infrastructure compatibility issues. Most E/S units are designed to use three-phase power, which is available at most new facilities, but older facilities (typically small facilities) may have only single-phase power available. Also, there are a number of three-phase voltages used at facilities (e.g. 240, 408, 430, 440, and 480 volt). Also, plug compatibility could be an issue since there are dozens of plug configurations available for three-phase connections. There are safety concerns with plugging into a high voltage power source, especially during inclement weather, and with "drive-off" damage (drivers failing to disconnect the power before driving away).

The cost of the E/S option adds $2,000 to $2,600 to the cost of a trailer TRU and $350 to $600 to a truck TRU. Adding the power infrastructure at the facilities where TRUs operate is also expensive. Loading door outlets cost about $1,250 each if no transformer upgrades are necessary. With transformer upgrades, the cost goes up to $5,000 per outlet for 480 volt and $7,000 per outlet for 208 volt (Warf, 2002). For power outlets in the truck and trailer parking areas, electrical codes require power distribution to be underground, so infrastructure costs go up significantly due to trenching.

Currently, only 0.5 percent to three percent of trailer TRUs and 40 percent to 80 percent of truck TRUs are equipped with E/S, according to ThermoKing and Carrier. No attempts to retrofit an E/S to units that are not factory-equipped are known to have been completed. Previous interest in retrofitting has been blunted by cost estimates that were prohibitively high – in the $6,000 to $8,000 range (Guzman, 2002).

For-hire carriers using trailers are reluctant to pay the extra cost to buy the E/S option because there are very few facilities equipped to provide electric power. Furthermore, facilities are reluctant to add power plug-ins because few carriers have the E/S option and they don't want to pay for the electric power for carriers bringing goods in.

Enforcement would be conducted by ARB Enforcement Division. Cost estimates for enforcement of the proposed ATCM are included in Chapter VIII. Staff believes that enforcement costs for this alternative would be similar to those for the proposed ATCM.

D. Evaluation of the Proposed ATCM

Staff evaluated the proposed control measure against the same criteria that the alternatives were evaluated against: applicability, effectiveness, enforceability, and cost/resource requirements.

Applicability

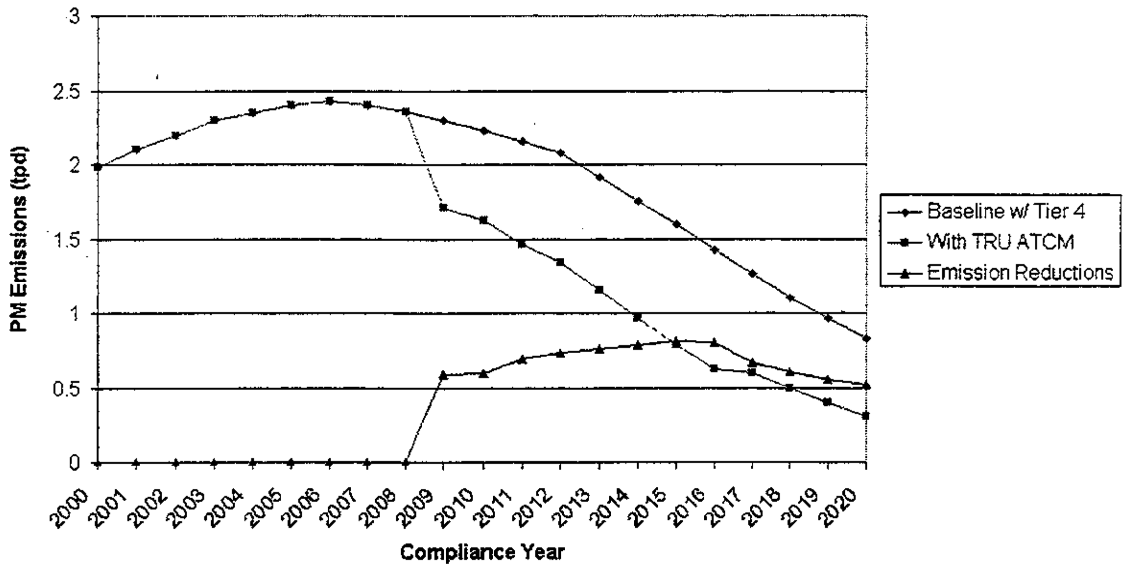
The proposed control measure could be applied to in-use operators of TRUs to reduce diesel PM from in-use TRUs and TRU generator sets operated in California. TRU operators would also be required to keep records and submit reports. Large facilities would be required to keep records and provide a one-time report.

Effectiveness

The proposed control measure would reduce diesel PM emissions from in-use TRUs faster than normal attrition rates would with progressively more stringent new nonroad engine emission standards. Figure VII-1 shows a comparison of the annual TRU PM emissions resulting from new engine standards being implemented and the annual emissions as the proposed ATCM is concurrently implemented. Emission reductions are also shown in this figure. The ATCM would require 2002 and older model year TRU engines to reduce emissions by 50 percent when they comply with the LETRU in-use performance standards. Also, an 85 percent reduction in PM emissions would apply to all TRUs, meeting the ULETRU in-use performance standards, until new TRU engines meet ULETRU.

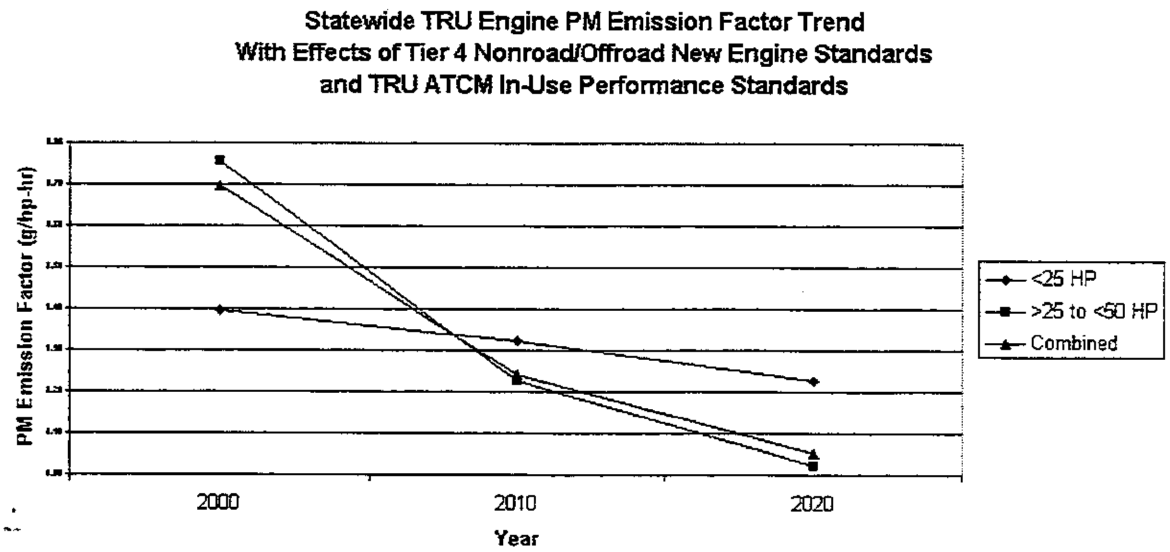
Figure VII-1

TRU PM Emissions for All Types and Horsepower Categories Includes Proposed Tier 4 NonRoad Standards and Estimated Adjustment for Manufacturer-Provided Emission Factors



Staff estimated Statewide fleet PM emission factors for all TRUs operating in California for 2000, 2010, and 2020, taking into account the Tier 4 nonroad new engine emission standards and the implementation of the TRU ATCM. Historical engine emission factors that were provided by TRU engine manufacturers were incorporated into this estimate for model years where data was available for all engine manufacturers. Figure VII-2 displays the results. The graph shows that there would be a 65 percent reduction in the Statewide PM emission factor for TRU engines between 2000 and 2010 and a 92 percent reduction between 2000 and 2020.

Figure VII-2



The recordkeeping and reporting provisions would provide the information necessary to monitor the effectiveness of the ATCM in reducing risk and address any remaining risk after the implementation.

Enforceability

The proposed control measure would be enforced by ARB's Enforcement Division in conjunction with the Heavy Duty Vehicle Inspection Program through inspections at border crossings, CHP scales and other locations that do not hinder traffic flow. In addition, ARB inspectors would conduct audits at TRU operator terminals. The proposed control measure offers a number of compliance options, so ARB inspectors would have to acquire a basic understanding of each option. But, the proposed control measure is more enforceable than Alternative Two (Require Electric-Powered Refrigeration Systems While Transport Refrigeration Units are at a Facility). While the use of electric standby is still offered as a compliance option, fewer operators would use that pathway than would have been the case under Alternative Two, so staff believes the enforcement challenges would be less overall.

Cost and Resource Requirements

The proposed control measure would have a fiscal impact on the State, as well as an economic impact on the operators and facilities where TRUs operate. Enforcement would be conducted by ARB Enforcement Division. Cost estimates for enforcement and compliance for this ATCM are included in Chapter VIII.

E. Statewide Emissions and Risk Reduction Benefits of the Proposed ATCM

A discussion of the Statewide baseline TRU PM emissions is included in a section in Chapter V – Emissions, Exposure, and Risk from Diesel TRUs. Statewide TRU emissions are also discussed for various scenarios in Chapter VIII – Economic Impacts. And, staff modeled the emission reductions that may be realized by implementing the proposed ATCM. Emission reductions due to the proposed ATCM is included Chapter IX – Environmental Impacts.

REFERENCES

Guzman, 2002. Peter Guzman, Carrier Transicold, Special TRU Electrification Workgroup Conference Call Meeting, May 28, 2002.

U.S. EPA, 2003. U.S. Environmental Protection Agency, *Control of Emissions of Air Pollutants from Nonroad Diesel Engines and Fuel, Proposed Rule Making* Notice of Proposed Rule Making, Federal Register. Vol. 68 No. 100, pp. 28327-28603, May 23, 2003.

Warf, 2002. Bill Warf, Sacramento Municipal Utility District, to Steve Cruz, Public Policy Alliance. *Personal communication (electronic mail),* April 3, 2002.

VIII. ECONOMIC IMPACTS

This chapter presents the estimated costs and economic impacts associated with implementation of the proposed airborne toxic control measure (ATCM) to regulate diesel-fueled engines associated with in-use transport refrigeration units (TRUs) and TRU generator sets. The discussion includes estimates of capital and recurring costs for potential compliance options and an analysis of the proposed ATCM's cost effectiveness. The compliance options addressed include engine retrofit, engine replacement, TRU replacement, and alternative technologies.

Unless otherwise noted, all references to TRUs in this chapter include TRU generator sets. Also, in this chapter, the term "facilities" refers to facilities where TRUs operate as defined in the proposed ATCM.

A. Summary

Staff estimates that the total cost of the proposed ATCM to affected businesses would range from $87 million to $156 million over the 13-year effective life of the ATCM (i.e., 2008-2020). No significant economic impacts to school districts, local public agencies, State agencies, or federal agencies are expected because few of these agencies operate TRUs or facilities that are subject to the ATCM. ARB administrative costs for initial outreach and educational efforts, as well as enforcement duties, would be absorbed within existing budgets and resources.

Affected businesses may use several means to comply with the proposed ATCM, including engine retrofit, engine replacement, TRU replacement, and alternative technologies such as electric standby and the use of cryogenic temperature control. Table VIII-1 summarizes the capital and annual per-unit costs of making an in-use TRU compliant with the proposed ATCM. These estimates do not include any reporting or recordkeeping costs incurred by TRU operators as a result of the ATCM. The capital cost is the full up-front cost of the compliance technology, including hardware and installation costs. The annual cost includes operating and maintenance expenses that are over and above those normally incurred when operating a diesel fuel-powered TRU, as well as capital payments for compliant equipment. The capital payments are based on the assumption that the capital cost is financed via a loan that is repaid over 10-years at a 5 percent annual real interest rate.

Table VIII-1

Estimated Cost-Per-TRU for Affected Businesses[1]

Technology	Capital Cost[2] (dollars/unit)	Annual Cost[3] (2008-2020)
Engine Retrofit (VDECS)	$2,050 (high-end cost)[4]	$560 (high-end cost)[4]
Engine Replacement [5] <25 hp (truck) ≥25 to 50 hp (trailer)	 $4,000 $5,000	 $500[6] $650[6]
TRU Replacement[5] <25 hp (truck) ≥25 to 50 hp (trailer)	 $10,000 $20,000	 $1,300[6] $2,600[6]
Electric Standby	$15,600	$2,500
Cryogenic	$22,000	$9,000

1. Estimates include California-based and out-of-state businesses operating TRUs in California.
2. The capital cost estimate assumes a lump-sum, one-time cost.
3. Assuming a 10-year useful life and a real interest rate of five percent, the annual cost estimate includes yearly loan payments for equipment and operating and maintenance costs. It does not include reporting costs.
4. The high-end cost estimate for VDECS retrofit is discussed in Section C.2.2 of this chapter.
5. This estimate represents full replacement cost. (Note: Elsewhere in this chapter, replacement cost has been prorated.)
6. For the purpose of evaluating cost to individual businesses, only a portion of the annual cost (40 percent of replacement cost for TRU engines 10-years-old and newer and 15 percent of replacement cost for TRUs 11-years-old and older) is attributable to this ATCM for TRU engine and TRU replacement. This annual cost estimate is based on the assumption that there is no difference in operating/maintenance costs for existing and replacement engines or TRUs. The estimated amount represents uniform payments to cover the capital cost.

For individual businesses, the compliance cost will vary depending on the compliance option selected and the number of TRUs owned/operated. Tables VIII-2 and VIII-3 show the estimated capital and annual cost for a small business with 1 to 20 TRUs (Table VIII-2) and for a typical business with 21 to 250 TRUs (Table VIII-3). In contrast to Table VIII-1, Tables VIII-2 and VIII-3 include recordkeeping/reporting costs in the capital cost estimates to reflect the proposed ATCM's requirement for a one-time report submittal with updates as necessary.

Table VIII-2

Estimated Cost for a Small Business TRU Operator[1]

Technology	Capital Cost[2]		Annual Cost[3] (2008-2020)	
	1 unit	20 units	1 unit	20 units
Engine Retrofit (VDECS)	$300 (high-end cost)[4]	$5,300 (high-end cost)[4]	$600 (high-end cost)[4]	$11,000 (high-end cost)[4]
Engine Replacement [5] <25 hp (truck) ≥25 to 50 hp (trailer)	$600 $700	$10,400 $13,000	$600[6] $700[6]	$10,400[6] $13,000[6]
TRU Replacement[5] <25 hp (truck) ≥25 to 50 hp (trailer)	$1,300 $2,600	$26,000 $52,000	$1,300[6] $2,600[6]	$26,000[6] $52,000[6]
Electric Standby	$2,000	$40,400	$2,500	$50,800
Cryogenic	$2,900	$57,000	$9,000	$180,000

1. Estimates include California-based and out-of-state businesses operating TRUs in California.
2. The capital cost estimate assumes that new equipment will be paid for in yearly loan payments amortized over 10 years. The capital cost also includes an estimate of operator reporting costs.
3. Assuming a 10-year useful life and a real interest rate of five percent, the annual cost estimate includes yearly loan payments for equipment and operating and maintenance costs. It does not include reporting costs.
4. The high-end cost estimate for VDECS retrofit is discussed in Section C.2.2. of this chapter
5. This estimate represents yearly loan payments for the full replacement cost of equipment.
6. For the purpose of evaluating cost to individual businesses, only a portion of the annual cost (40 percent of replacement cost for TRU engines 10-years-old and newer and 15 percent of replacement cost for TRUs 11-years-old and older) is attributable to this ATCM for TRU engine and TRU replacement. This annual cost estimate is based on the assumption that there is no difference in operating/maintenance costs for existing and replacement engines or TRUs. The estimated amount represents uniform payments to cover the capital cost.

Table VIII-3

Estimated Cost for a Typical Business TRU Operator[1]

Technology	Capital Cost[2]		Annual Cost[3] (2008-2020)	
	21 units	250 units	21 units	250 units
Engine Retrofit (VDECS)	$5,600 (high-end cost)[4]	$67,000 (high-end cost)[4]	$7,900 (high-end cost)[4]	$139,000 (high-end cost)[4]
Engine Replacement [5] <25 hp (truck) ≥25 to 50 hp (trailer)	 $11,000 $14,000	 $130,000 $162,000	 $11,000[6] $14,000[6]	 $130,000[6] $162,000[6]
TRU Replacement[5] <25 hp (truck) ≥25 to 50 hp (trailer)	 $27,000 $54,000	 $324,000 $648,000	 $27,000[6] $54,000[6]	 $324,000[6] $648,000[6]
Electric Standby	$42,000	$505,000	$53,000	$635,000
Cryogenic	$60,000	$713,000	$189,000	$2,300,000

1. Estimates include California-based and out-of-state businesses operating TRUs in California.
2. The capital cost estimate assumes that new equipment will be paid for in yearly loan payments amortized over 10 years. The capital cost also includes an estimate of operator reporting costs.
3. Assuming a 10-year useful life and a real interest rate of five percent, the annual cost estimate includes yearly loan payments for equipment and operating and maintenance costs. It does not include reporting costs.
4. The high-end cost estimate for the VDECS retrofit is discussed in Section C.2.2 of this chapter.
5. This estimate represents yearly loan payments for the full replacement cost of equipment.
6. For the purpose of evaluating cost to individual businesses, only a portion of the annual cost (40 percent of replacement cost for TRU engines 10-years-old and newer and 15 percent of replacement cost for TRUs 11-years-old and older) is attributable to this ATCM for TRU engine and TRU replacement. This annual cost estimate is based on the assumption that there is no difference in operating/maintenance costs for existing and replacement engines or TRUs. The estimated amount represents uniform payments to cover the capital cost.

Staff also estimated the proposed ATCM's cost effectiveness as cost per pound of diesel particulate matter (PM) reduced. Diesel PM reduction from the proposed ATCM has been estimated to range from 383,000 to 592,000 pounds per year over the 2008-2020 effective life of the regulation. Considering only the benefits of reducing primary diesel PM emissions, the cost effectiveness of the proposed ATCM ranges between $10 to $20 per pound of diesel PM reduced. Additional benefits are expected to occur due to the reduction in reactive organic gases (ROG) and oxides of nitrogen (NO_x) emissions, but are not quantified in this analysis due to insufficient data. Table VIII-4 compares the cost effectiveness of the proposed ATCM with that of the Proposed Stationary Compression Ignition Engines ATCM and the recently adopted On-Road Heavy-Duty Residential and Commercial Solid Waste Collection Vehicles Control Measure.

Table VIII-4

Cost-Effectiveness Comparison - TRU ATCM and Two Other Diesel PM ATCMs

Regulation	Cost Effectiveness
Proposed TRU ATCM (Adoption Hearing Scheduled for December 11, 2003)	$10-$20 per pound of diesel PM reduced
Proposed Stationary Compression Ignition Engines ATCM (Adoption Hearing Scheduled for November 20, 2003)	$4-$26 per pound of diesel PM reduced
On-Road Heavy-Duty Residential and Commercial Solid Waste Collection Vehicles Control Measure (Adopted September 25, 2003)	$67 per pound of diesel PM reduced

(ARB, 2003a; ARB, 2003b)

Further information regarding the assumptions and methodologies used to estimate the proposed ATCM's costs and economic impacts is provided in the remainder of this chapter and in Appendix G of this Staff Report.

B. Analysis of Potential Impacts to State and Other Agencies

1. Legal Requirements Applicable to the Economic Impact Analysis

Government Code Section 11346.3 requires State agencies (including ARB) to evaluate the potential for adverse economic impacts on California businesses and individuals when proposing to adopt or amend any administrative regulation, including a regulation such as the proposed ATCM. The evaluation must include the impact of the proposed regulation upon California jobs, business expansion, elimination, or creation; and businesses' ability to compete with those of other states.

Health and Safety Code Section 57005 further requires the ARB to perform an economic impact analysis of submitted alternatives to a proposed regulation before the adoption of any major regulation. A "major regulation" is defined as a regulation that would potentially cost California businesses more than 10 million dollars in any single year. Since the proposed ATCM is expected to cost California businesses more than 10 million dollars in a single year, an economic analysis of alternatives to the proposed regulation is provided in Section D of this chapter.

In addition, Government Code Section 11357 and guidelines adopted by the Department of Finance (DOF) require the ARB and other State agencies to estimate a proposed regulation's associated cost or savings to any local, State, or Federal agency. The agency proposing a regulation is also required to determine whether, as a result of the regulation, any cost to local agencies or school districts is reimbursable by the State. Pursuant to Government Code Section 17566, any cost to school districts, transit agencies, or other local public agencies as a result of the proposed ATCM would not be reimbursable because private sector businesses would be subject to the same requirements and costs (ARB, 2002).

Local municipalities or school districts that operate TRUs may experience compliance costs to the extent that they own and/or operate TRUs and facilities visited by TRUs. Examination of Department of Motor Vehicles (DMV) records indicates that there is a very small number (less than 1,000) of TRUs owned by local municipalities or school districts statewide. The proposed rulemaking does not constitute a reimbursable mandate because the proposed regulation applies to all entities that are visited by or operate TRUs in the state and does not impose unique requirements on local agencies (County of Los Angeles vs. State of California, 43Cal 3d 46 [Jan 1987]).

2. Costs to ARB

One-time expenses for compliance education and outreach efforts before the regulation takes effect in the amount of $6,500 to $12,000 (itemized in Appendix G, Section A) will be absorbed within existing budgets and resources. The compliance date for facility reporting is Jan. 31, 2005. The cost of the ARB's enforcement efforts will also be absorbed within existing budgets and resources.

3. Costs to Other State Agencies

An extremely small number of TRUs are operated by state agencies. The State of California Department of General Services (DGS), Office of Fleet Administration (OFA), was contacted to determine the quantity of TRUs operated by state agencies. OFA does not maintain records that show the number of TRUs operated by state agencies. In normal situations, all state motor vehicle purchases are handled by the DGS Procurement Division (PD). PD was contacted to determine the quantity of TRU-equipped trucks and trailers purchased for state agencies in the last five years. Less than 12 TRUs were purchased in the time period from 1996 – 2001.

Department of Motor Vehicle records were also examined to determine the number of TRUs that might be operated by state agencies. While the number of vehicles with Fee-Exempt license plates can be identified, DMV records are not detailed enough to show the exact number of state-owned trucks and trailers that have TRUs and are subject to the regulation.

Based on the above information, we believe that the number of TRUs operated by state agencies is very small and therefore any compliance costs will have a negligible impact on other State agencies.

4. Costs to Other Governmental Agencies (Other Than State Agencies)

Other agencies not included in previous categories include school districts, as well as Federal and local governmental agencies. Staff has been unable to identify any TRUs operated by these districts and agencies; if any exist, staff is certain that they represent an insignificant portion of the total statewide TRU population.

C. Economic Impact Analysis

1. Assumptions Used in This Analysis

This analysis is performed in the year 2003, and unless otherwise stated, all costs are given in 2002 dollars. Where future costs are mentioned, they have been adjusted to 2002 dollars using standard accepted economic analysis procedures. A real interest rate of five percent (a 7 percent nominal rate minus an assumed 2 percent inflation rate) is used through out this analysis, unless otherwise noted.

Since this ATCM affects an extremely wide range of business types and sizes, the use of single cost figures or averages can be misleading, because business revenues, profit margins, and other financial characteristics can vary greatly between the different industry types within the range of affected businesses. For example, the business characteristics of a sole proprietor refrigerated trucking firm can vary greatly from those of a grocery distribution company or a cold storage warehouse. To recognize the distinctly different characteristics of the affected businesses, most costs used in this analysis are expressed as cost ranges.

Estimated costs for the ATCM are those within the 2004 – 2020 time period. This period was chosen to include the major portion of costs attributable to the ATCM. This time period (and the estimated costs) encompass all of the facility reporting and nearly all of the in-use (retrofit and operator reporting) compliance costs. The in-use compliance requirement starts in 2008 through 2020, affecting in rolling stages (compliance required seven years after the model year of the TRU) all TRUs through the 2013 model year. All 2014 and later model year TRUs (≥ 25 HP) are scheduled to meet the U.S. EPA Tier 4 standards, and are not affected by this ATCM.

Since the year 2008 has unusual circumstances, the ATCM cost for this year is treated differently than those for other years (2009 - 2020) of the analysis. In 2008, ATCM compliance costs are incurred, but there is no emission benefit attributable to the ATCM due to the December 31, 2008 compliance deadline; it is assumed that the majority of TRUs would not come into compliance until close to the deadline, producing negligible emission reductions attributable to that year. Because of this, it is not possible to calculate a cost-effectiveness figure for this year. However, the 2008 cost is valid and its effect is considered in the cost calculations. The 2008 cost is taken into consideration by converting it to 2009 dollars, and then converting that amount into a uniform payment series, which is then added to the annual costs for each of the years from 2009 - 2020. This conversion process for the 2008 cost is also done for the 2005 - 2008 costs for the Engine/TRU Replacement scenario.

Initial (or capital) costs, as discussed in this chapter, are the up-front costs of a compliance technology. These costs include items such as emission control devices, other components needed for the installation and functioning of such devices, and installation labor. A business may choose to pay the initial costs as a lump sum or one-time payment, or may decide to borrow funds. Since the cost of borrowing funds is higher than assuming a one-time payment, this analysis assumes that businesses will borrow funds to pay for the initial cost of compliance. The initial costs are expressed as a uniform series of payments over the assumed 10-year life of the compliance technology, at a real interest rate of 5 percent. Because the operator reporting cost is assumed to be a one-time cost, it is included in the initial cost.

Annual costs are those attributable to the ongoing operation of the compliance technology; maintenance and items that are consumed during normal operation (such as fuel-borne catalyst). The annual costs are variable, depending upon the amount of usage. For this reason, in the cost-estimate matrices in Appendix G, annual usage (and corresponding cost) figures of 1,100, 1,200, & 3,000 hours are used, representing typical usage for TRU generator sets, TRUs in short-haul operation, and long-haul operation, respectively. Since this analysis assumes the initial cost is financed, the annual cost also includes a payment towards the initial cost.

For the oldest in-use TRUs, compliance with LETRU standards must be achieved in 2008 and 2009, and, if still in service seven years after the corresponding compliance year, must meet ULETRU standards. This amounts to paying compliance costs twice for a given TRU. At the time these oldest units must comply with ULETRU standards, years 2015 and 2016, these TRUs will be a minimum of 14 years old, which is well past the average TRU life of 10 years. Since the majority of these older TRUs will have been replaced, and the remainder close to the end of their service life, staff anticipates that very few or none of the affected businesses will choose to pay the cost of ULETRU compliance. For this reason, the cost of ULETRU compliance for those TRUs having to meet LETRU standards is assumed to be zero.

Given that the last TRUs required to comply with the in-use provisions of the regulation (from Model Year 2013) will do so in the year 2020, to do a complete analysis of costs requires examining costs out to the 10-year point, starting with the compliance year. In this case, this would mean extending the analysis period out to the year 2029. Since both cost and emission reduction estimates are needed for cost-effectiveness analysis purposes, and emission reduction estimates for the years 2021 – 2029 are not currently available, costs for the 2021 – 2029 time period were not included, nor were the emission benefits included in the estimates for the ATCM's total cost and cost-effectiveness figures. This same methodology was also followed for the cost-effectiveness calculations for the two alternatives in Section D.

Although the facility reporting cost is expected to be incurred by businesses in the 2004 calendar year, it has been included in the total cost calculations, expressed as an annual cost range over the thirteen-year analysis period (2008 – 2020.) The facility reporting cost has not been included in the cost-effectiveness calculations, to maintain consistency with the analysis procedures used in other similar ATCMs, such as those for Limiting School Bus Idling and Idling at Schools, On-Road Heavy-Duty Residential and Commercial Solid Waste Collection Vehicles, and Stationary Compression Ignition Engines.

The purpose of the facility reporting requirement of this ATCM is to gather additional information to determine the need for additional future regulation or control of this emission source category. This information-gathering work is typically performed during the development of an ATCM; despite the persistent and exhaustive efforts of ARB staff, affected stakeholders did not voluntarily provide requested information, thereby necessitating its request through regulatory means.

Since the costs associated with the facility reporting requirement are normally attributed to the regulatory development process, they are not usually quantified nor included in the cost of an ATCM. However, due to the unique circumstances encountered with the development of this ATCM, the facility reporting costs are quantified and reported in this analysis. These reporting costs are included in the reported total cost of the ATCM, but are excluded from the reported cost-effectiveness figures, in keeping with the methodology used for similar ATCMs.

In comparing the VDECS Retrofit and Engine/TRU Replacement scenarios for the in-use compliance cost estimate in the next section, it is assumed that both strategies produce an equal PM emission reduction benefit. For the VDECS Retrofit scenario, the costs discussed are those over and above the cost of the diesel technology currently in use. The Replacement scenario assumes that some TRU operators will replace their TRUs (or TRU engines) earlier than normal, due to the ATCM. Since an average TRU life of 10 years is assumed, along with an ATCM-mandated replacement of seven years, 40 percent of the replacement cost of the engine (for TRUs 10 years old and newer) and 15 percent of the TRU replacement cost (for TRUs 11 years and older) was attributed to accelerated replacement due to the ATCM. For TRUs that are 10 years old and newer, a feasible PM emission reduction strategy is replacing an existing engine with an engine meeting current standards. However, for TRUs older than 11 years, due to physical compatibility considerations, replacing existing engines in TRUs with new engines is not generally considered feasible. Under the Replacement scenario, it is assumed that these older TRUs would be replaced with new TRUs.

These cost estimates are based on current and known technology; staff believes that it is likely that the costs will decrease as technology improves and production and sales volumes increase. The impact of VDECS certification costs upon in-use compliance technology costs to the end users will vary according to product sales volumes and the degree of certification testing required for a given product. Compliance technology costs used in this staff report reflect manufacturers' best-estimated retail product costs.

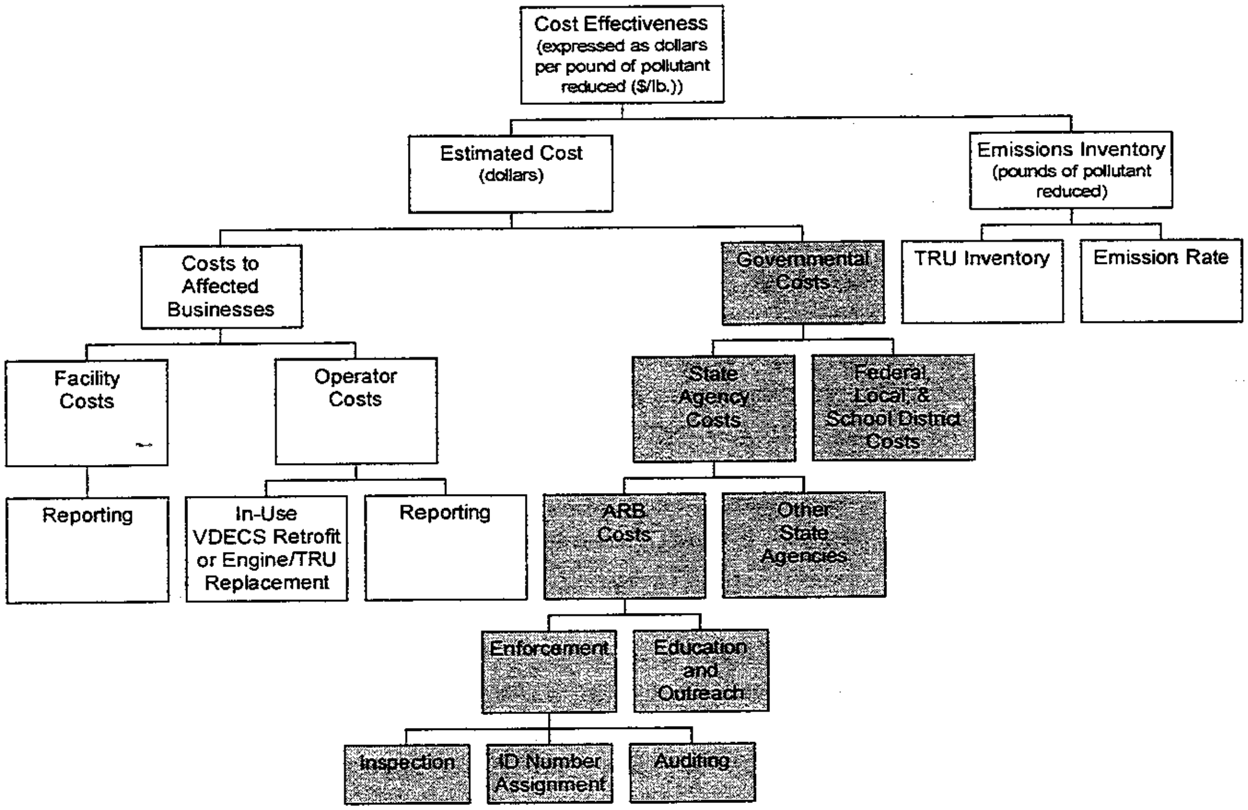
2. Cost Discussion

Businesses with California facilities visited by TRUs and/or operating TRUs in California will incur compliance costs as discussed below, to the extent that they have operations that meet the applicability requirements in this ATCM. Examples of these businesses (which may include governmental entities to a minor degree) include but are not limited to the following: wholesale food distribution & storage warehouses, perishable food production/processing facilities, and refrigerated/frozen product transportation services. The total number of businesses affected by the ATCM is estimated at 4,700 – 10,000, including those located outside California.

Figure VIII-1 illustrates the relationship between the various cost categories and their use in generating the ATCM's cost effectiveness estimates. Only the costs incurred by businesses are discussed in this section; costs to governmental agencies (shaded boxes) are discussed in Section B of this chapter and Appendix G. The emissions inventory (including TRU population figures) is discussed in detail in Chapter V and Appendix D.

Figure VIII-1

Cost Analysis Overview



The total cost estimate (using the VDECS Retrofit scenario) is $5.0 million - $14 million per year over a 13-year period (2008 –2020), with a total ATCM cost within the range of $87 million - $156 million. These figures are composed of the facility reporting and operator costs as discussed below. The cost –effectiveness figures in Section D are calculated using only the operator costs; a full discussion of the rationale for this convention is in that section.

The ATCM requires TRU operators to meet performance standards. Although the median TRU life is estimated at about 10 years, the ATCM seeks emission benefits by accelerating attrition of older TRUs and requiring in-use TRUs to meet lower emission performance standards. The standards can be met by using any of a variety of compliance options appropriate for their business situation. These options include accelerated attrition (early replacement) of the TRU, engine replacement, emission control retrofit, and alternative (non-diesel) technology use. Added flexibility in complying with the ATCM's provisions is extended to those operators who meet regulatory requirements earlier than mandated and will likely result in lower compliance costs.

In this analysis, all of the VDECS Retrofit cost is included in the total cost figure for the ATCM, since the sole reason for retrofit would be compliance with this ATCM. For the Replacement scenario, 15 percent of the new TRU cost and 40 percent of the engine replacement cost is assigned to the ATCM. This cost prorating is done to reflect the ATCM's accelerated attrition effect on the TRU fleet—businesses that normally replace TRUs after 10 years would have to do so (or perform an engine replacement or VDECS retrofit) at the seven-year point. It is not appropriate to assign the entire cost of engine/TRU replacement to the ATCM, since businesses purchase TRUs or replace engines as a normal business practice.

Due to the large size of the matrices used to prepare the costs estimates, they are located in Appendix G.

2.1. Facility Reporting Cost

Facilities meeting the eligibility criteria in the ATCM will need to submit a one-time report to ARB by January 31, 2005. The eligibility criteria exclude smaller businesses from the facility reporting requirement. From Appendix G, Section, B.1.2., it is estimated that 2,705 California facilities will be subject to the reporting requirement. The cost of this requirement is expected to be incurred by businesses in 2004, to meet the report submission deadline of January 31, 2005.

The physical facility information requested (number of refrigerated doors, etc.) is information familiar to the facility operations manager or equivalent personnel. It is estimated that this information will take 30 minutes to assemble and record on the reporting form. Assuming a labor rate of $40.00/hour, this cost is estimated at $20 per facility.

The cost of TRU engine run time and other load-specific information requested will vary depending upon the volume of refrigerated load activity at a facility. Since all facilities have existing logging procedures for refrigerated load arrival and departures, it is assumed that this would be the most logical point at which to capture the requested information. Depending on facility preference and volume of activity, load-specific information could be recorded by hand using logging sheets, written on existing paperwork such as bills of lading, or tracked by computer. All of this information would have to be compiled at regular intervals for submission. It is assumed that smaller facilities or those not currently using computers to track goods movement would not start using computers and would track load-specific information by hand. Those facilities currently using computers to track goods movement are assumed to use existing computer systems to track the requested load-specific information.

The assumptions used to estimate this cost range are as follows:

- ✓ Estimated range of refrigerated load activity: 2 – 500 per week, or 104 – 26,000 per year

- ✓ Manual recording of load-specific information: 5 minutes per load
- ✓ Computer recording of load-specific information: 2 minutes per load
- ✓ Manual compiling of information: 120 minutes
- ✓ Retrieval of computer report for compilation: 60 minutes

It is also assumed that manual recording and compilation will be used for facilities at the lower end of the range, and computer recording will be used for facilities at the high end of the range. Using the assumptions given, and a labor rate of $40.00/hour, the costs are as follows:

Low End of Facility Reporting Cost Range

Assuming Manual Recording of Information:

Providing Instruction to Staff:	2 Hrs.
Modification of Tracking System to Capture Load-Specific Information:	4 Hrs.
Physical Facility Information	0.5 Hrs.
104 Refrigerated Loads/year @ 5 min. recording time/load:	8.67 Hrs.
Compilation of load-specific information, per year:	2 Hrs.
Total:	**17.2 Hours**

17.2 Hours @ $40.00/Hour = $688

High End of Facility Reporting Cost Range

Assuming Computer Recording of Information:

Providing Instruction to Staff:	3 Hrs.
Modification to Computer System to allow tracking of load-specific information:	8 Hrs.
Physical Facility Information	0.5 Hrs.
13,000 Refrigerated Loads/year @ 2 min. recording time/load:	433 Hrs.
Compilation of load-specific information, per year:	2 Hrs.
Total:	**446.5 Hours**

446.5 Hours @ $40.00/Hour = $17,860

The cost range for an individual facility report is therefore $688 – $17,860 ($700 – $18,000, rounded). The high end of the range represents the very largest high-volume facilities in California, and the reporting costs represent a very small percentage of their operating revenue.

Multiplying the low and high end of this range by the number of facilities (2,705, from Appendix G, Section B.1.2.) will give the range of reporting costs for those facilities subject to the reporting requirements: $1,861,040 - $48,311,300. Converting this range to a uniform series of payments over the thirteen-year analysis period gives an annual facility reporting cost of $198,200 - $5,145,135 ($200,000 - $5.2 million, rounded.)

2.2. VDECS Retrofit Scenario

VDECS is believed to be the most likely in-use compliance approach. This scenario assumes low- and high-cost business situations to construct a range of likely in-use costs. The first two scenarios listed in Matrix 1 (Appendix G) contain the estimated in-use ATCM compliance cost range. The low-end scenario assumes 1,200 hours per year (typical short-haul duty) TRU operation, with the use of fuel-borne catalyst (FBC) and a catalyzed wire mesh filter (CWMF) for LETRU compliance and liquefied-petroleum gas (LPG) dual-fuel pilot injection for ULETRU compliance. The high-end scenario assumes 3,000 hours per year (typical long-haul duty) TRU operation, with the use of fuel-borne catalyst (FBC) and a catalyzed wire mesh filter (CWMF) for LETRU compliance and liquefied-petroleum gas (LPG) dual-fuel pilot injection for ULETRU compliance. Both scenarios assume that TRU generator sets are operated 1,100 hours per year. Under each scenario, it is assumed that the listed technologies will be used by all of the in-use TRUs.

The statewide total costs include the following:

	Low	High
Annual In-Use Compliance Cost (from Matrix 2, low- & high-cost scenarios) (includes in-use compliance costs, annual operator reporting costs, and 2008 adjustment)	$4,834,485	$8,986,214
Facility Reporting Cost		
Low End (annualized):	$198,200	
High End (annualized):		$5,145,153
Range of Annual Estimated Cost:	$5,032,685	$14,131,367
Range of Annual Estimated Cost (rounded):	**$5,000,000**	**$14,000,000**

This is the annual total cost range for the 13-year phase-in period (2008 – 2020) of the regulation. From Matrix 2 (Appendix G), the lifetime (2008-2020) statewide total cost range is $87 million – $156 million.

2.2a. Engine/TRU Replacement Scenario

Under this scenario, it is assumed that engine and TRU replacement would be used to achieve ATCM compliance for in-use units. This analysis is performed as a back-up to the VDECS Retrofit scenario. This scenario considers the cost of engine/TRU replacement only, and does not include the cost of truck or trailer replacement. Table VIII-1 lists the engine/TRU replacement costs.

Since engine replacement is only a feasible emission reduction strategy for those units 10 years old and newer, it was assumed that this would be only done for these units. For units 11 years and older, it was assumed that these units would be replaced with new. In both situations, since the unit would be approaching the end of its useful life, it was assumed that only a fraction of the replacement cost would be attributable to the ATCM. The reason for this is that businesses would normally set aside funds for TRU replacement, and the ATCM would accelerate the replacement cycle. For those units 10 years old and newer, this fraction was set at 0.40. For the 11 year and older units, the fraction was set at 0.15. Using the same methodology as for the VDECS Retrofit scenario calculations, from Matrix 2a (Appendix G), the ATCM cost was estimated at $89 million - $156 million over the 13-year phase-in period of the ATCM with an annual cost in the range of $5.8 million - $14 million. Thus, the total and annual cost estimate for the ATCM remain about the same whether the VDECS Retrofit or Engine/TRU Replacement scenarios are used.

2.3. Operator Reporting Cost

All TRU operators that meet the reporting requirement criteria as outlined in the ATCM must file a report with ARB by January 31, 2009. Any subsequent changes to the reported information must be submitted to ARB as they occur. Since the extent to which businesses will submit updated information to ARB is unknown, the cost of updates is not included in this analysis; update costs are expected to be minor, given the brief amount of information requested in the initial report.

Operator reporting requirements are estimated to be relatively minor, since most of the information requested by ARB is contained in records already normally maintained by businesses, such as the number of TRUs operated by the business, TRU make(s) and model(s), etc.

The number of TRU operators multiplied by the estimated reporting cost will give the total statewide cost of the operator reporting requirement. The estimated number of businesses that operate TRUs in California (including out-of-state businesses operating TRUs in California) is the range from 1,969 – 7,332 (from Table G-2, Appendix G); and the estimated per-business cost range is $40 - $320, given an hourly labor rate of $40 per hour and a range of one to eight hours to gather the information and submit it to ARB. Using these figures, the statewide range of the operator in-use reporting cost is $78,760 – 2,346,240 ($80,000 - $2.4 million, rounded).

2.4 Operator Cost Total

The total cost of compliance to a TRU operator is the sum of the VDECS Retrofit cost and the Operator Reporting cost from the preceding two Sections (C.2.2. & C.2.3.). Matrix 2 (Appendix G) lists the sum of these two costs on an annual basis, and also includes the 2008 cost adjustment as discussed earlier in Section C.1. The total statewide operator cost range is $4.8 – $9.0 million annually for the years 2009 – 2020, with the total for all of these years being $84 million - $89 million. These figures do not include the facility reporting cost discussed earlier

2.5. Small Business Costs

From Appendix G, Table G-1, TRU operators with 20 or fewer TRUs would fall into the small business category. It is estimated that 81 percent of the total number of affected businesses would be in this category. Applying this percentage to the total number of businesses operating TRUs gives the number of small businesses operating TRUs, which is expressed as the range 1,595 – 5,939.

Small businesses may be subject to the In-Use and Operator Reporting Requirements and are excluded from the Facility Reporting Requirement. The exact compliance cost will depend upon the compliance technology chosen and the number of TRUs operated by a business. Assuming a range of one to 20 TRUs operated by a small business, and given the annualized capital and maintenance costs from Matrix 1 (Appendix G), the initial costs are estimated as follows:

	Low	High
Initial Operator In-Use Compliance Costs[5]		
Low End (one TRU using the low-cost scenario from Matrix 1) ($265 annualized capital cost):	$265	
High End (20 TRUs using the high-cost scenario from Matrix 1) ($265 annualized capital cost times 20 TRUs):		$5,300
Operator Reporting Cost		
For this range of TRU business size, it was assumed that this cost would be constant. One hour to prepare report x $40.00/hr.:	$ 40	$ 40
Range of Initial Small Business Compliance Costs:	$305	$5,340
Range of Initial Small Business Compliance Costs (rounded):	**$300**	**$5,300**

[5] This estimate assumes that the initial (capital) costs will be financed- the amount shown is the first in a series of annual payments for 10 years.

For the annual ongoing costs for a small business, it was assumed that a small business operator would have between one to twenty TRUs, and given the annualized capital and maintenance costs from Matrix 1 (Appendix G), the annual costs can be estimated as follows:

	Low	High
Annual Operator In-Use Compliance Costs[6]		
Low End (one TRU using the low-cost scenario from Matrix 1) ($265 annualized cap. cost plus $107 annual maint. cost):	$372	
High End (20 TRUs using the high-cost scenario from Matrix 1) (($265 annualized cap. cost plus $291 annual maint. cost) times 20 TRUs):		$11,120
Range of Annual Small Business Compliance Costs:	$ 372	$11,120
Range of Annual Small Business Compliance Costs (rounded):	**$ 400**	**$11,000**

2.6. Typical Business Costs

Subtracting the number of small business TRU operators from the total number of TRU operators will give the number of typical businesses that operate TRUs, defined as operators with 21 or more TRUs. Using the percentage of small businesses (TRU operators) from Appendix G, Table G-1, It is estimated that 19 percent (100 percent total minus 81 percent small businesses) of the affected businesses would be considered typical businesses. Applying this percentage to the total number of TRU operators gives the number of typical businesses operating TRUs, which is expressed as the range of 374 – 1,393.

The exact compliance cost will depend upon the compliance technology chosen and the number of TRUs operated by a typical business. Assuming a range of 21 to 250 TRUs operated by a typical business, and given the annualized capital and maintenance costs from Matrix 1 (Appendix G), the initial costs are estimated as follows:

[6] Includes annual finance payment for initial cost.

	Low	High
Initial Operator In-Use Compliance Costs[7]		
Low End (21 TRUs using the low-cost scenario from Matrix 1) ($265 annualized capital cost x 21 TRUs):	$5,565	
High End (250 TRUs using the high-cost scenario from Matrix 1) ($265 annualized capital cost x 250 TRUs):		$66,250
Operator Reporting Cost (from Section C.2.4.)		
Low End	$40	
High End		$320
Range of Initial Typical Business Compliance Costs:	$5,605	$66,570
Range of Initial Typical Business Compliance Costs (rounded):	**$5,600**	**$67,000**

To estimate the annual ongoing costs for a typical business, it was assumed that a business operator would have between 21 to 250 TRUs. Using this range, and given the annualized capital and maintenance costs from Matrix 1 (Appendix G), the costs are estimated as follows:

	Low	High
Annual Operator In-Use Compliance Costs[8]		
Low End (using the low-cost scenario from Matrix 1) (($265 annualized capital cost plus $107 annual maintenance cost) x 21 TRUs):	$7,812	
High End (using the high-cost scenario from Matrix 1) (($265 annualized capital cost plus $291 annual maintenance cost) x 250 TRUs):		$139,000
Range of Annual Typical Business Compliance Costs:	$7,812	$139,000
Range of Annual Typical Business Compliance Costs (rounded):	**$7,800**	**$139,000**

D. Cost-Effectiveness Analysis of the Proposed ATCM

Health and Safety Code Sections 39658 & 39665 through 39667 require the Air Resources Board to determine the need and appropriate degree of regulation for substances identified as toxic air contaminants. This proposed ATCM is the result of this process, as applied to diesel engine exhaust particulate matter (diesel PM) emissions from TRUs.

[7] This estimate assumes that the initial costs will be financed- amount shown is the first in a series of annual payments for 10 years.
[8] Includes annual finance payment for initial cost.

The proposed ATCM applies to existing businesses and uses existing technologies. It may lead to the creation or elimination of businesses. Due to the long lead time given for compliance and a wide range of compliance options, staff believes that most businesses will be able to meet the compliance costs. However, it is possible that a small number of businesses (those with marginal profitability) may have difficulty in complying with the ATCM. Staff believes that this ATCM may lead to the alteration of job duties within existing businesses, as well as a small increase in new jobs due to the creation of business opportunities as discussed below. This may be offset by the loss of a few businesses (and attendant jobs) that are unable to comply with the ATCM. Staff believes that there will be little or no significant change in the total number of businesses or jobs.

Businesses that may be created include those that furnish, install, and maintain diesel emission control systems, as well as those that provide alternative (non-diesel) in-use compliance strategies. Engine manufacturers, TRU manufacturers, and TRU sales and service dealers are likely to see an increase in business due to accelerated attrition and implementation of other compliance options to meet the in-use requirements of the ATCM.

The proposed ATCM applies to all TRU operators in California. Thus, it would not disadvantage California operators over out-of-state operators. The affected facilities are all local businesses and are not subject to competition from similar businesses in other states. An insignificant number of facilities located close to the California border may relocate out of state.

Economic productivity may be reduced as businesses devote labor and capital to comply with the ATCM. Individuals may be impacted to the extent that affected businesses are able to pass on the compliance costs to their customers.

1. Estimated Benefits

All Californians will benefit from the decreased exposure to diesel PM, identified by the State of California as a toxic air contaminant, with resultant decreases in incidences of cancer, PM-related cardiovascular effects, chronic bronchitis, asthma, and hospital admissions from pneumonia, asthma-related conditions, and other health effects. Additional health benefits are expected (but not quantified in this analysis) from reductions in NO_x emissions, which are precursors to secondary PM.

Implementation of the ATCM is estimated to produce a reduction of 383,000 to 592,000 pounds (192 – 296 tons) of diesel PM (Appendix D) in California annually during most (years 2009 – 2020; zero PM reduction is calculated for year 2008, due to the in-use compliance date of December 31, 2008) of the phase-in period of the ATCM. The total estimated PM reduction over the lifetime (2008 – 2020) of the ATCM is 6,000,000 pounds (approximately 3,000 tons), which translates into an estimated 211 premature deaths avoided by the year 2020.

The cost range per death avoided is 8 to 22 times lower than the U.S. EPA's benchmark for value of avoided death. Therefore, this ATCM is considered a cost-effective mechanism to reduce premature deaths that would otherwise be caused by diesel PM emissions without this ATCM. Please refer to Chapter IX for a more complete discussion of the heath benefits attributable to this ATCM.

2. Comparison of ATCM to Alternatives

The analysis in this section does not include the facility reporting cost. The facility reporting cost was not included to keep the cost-effectiveness calculation methodology consistent with that of other similar ATCMs, such as those for Limiting School Bus Idling and Idling at Schools, On-Road Heavy-Duty Residential and Commercial Solid Waste Collection Vehicles, and Stationary Compression Ignition Engines. However, the facility reporting cost is included in the total cost figure in Section C. Each cost quoted below is an annual cost range, in year 2002 dollars, for the 13-year phase-in period of the ATCM.

The alternative technologies used in this comparison were chosen from the technology matrix in Chapter VI and Appendix B, for their relatively greater estimated PM emission reductions.

2.1. TRU ATCM Cost

The annual regulation cost is the sum of the in-use compliance cost and the operator reporting cost: $4,834,485 - $8,986,214 (from Matrix 2, Appendix G) ($4.8 million – $9.0 million, rounded). The PM emission reduction attributable to the ATCM are within the range of 383,000 to 592,000 pounds per year for the years 2009 – 2020, for a total of six million pounds for the same period. Although the in-use compliance requirement starts in 2008, there is no PM emission benefit in that year (see discussion in Section C.1.). Therefore, a cost-effectiveness figure for that year cannot be calculated. However, the year 2008 cost is spread out over the 2009 – 2020 analysis period and is therefore included in both the total and annual costs (and consequently, the cost-effectiveness figures) for the ATCM.

2.2. Alternative 1 Cost

The annual cost for alternative 1, 100 percent use of electricity for TRU refrigeration at facilities (electric standby), is $26,453,816 – $48,894,414 (from Matrix 3, Appendix G) ($27 million – $49 million, rounded).

The calculations for the relative emission reduction effectiveness of this alternative as compared to the ATCM are shown in Matrix 3. An emission reduction of 50 percent of the baseline was assumed, since use of electric power while at a facility produces zero diesel PM emissions, TRU engine operation while moving will still produce PM emissions. The emission reduction of 50 percent of baseline TRU emissions was attributed to use of electric power for the TRU while at a facility, and was divided into both the low-end and high-end emission reductions attributable to the regulation to give the relative effectiveness of this alternative. The current statewide lack of appropriate support infrastructure (electrical hook-ups at facilities) and high cost are major factors that may preclude the use of this alternative on a statewide basis. However, in business circumstances amenable to this compliance technology, it may be feasible. One example where this technology may be feasible is in captive fleets where refrigerated vehicles travel over regular routes between company-controlled stops. In this situation, electric hook-ups for the TRUs may be provided at every stop.

For TRU generator sets only, the use of electricity is not considered a viable alternative technology, since a TRU generator set's function is to supply electrical power to a TRU and an electrical hookup at a facility is not a practical substitute for a generator set while a TRU is moving. To reflect this assumption, Matrix 3 (and the analysis) does not show an emission reduction for the application of this alternative to TRU generator sets. The annual PM emission reduction attributable to this alternative is within the range of 189,800 to 748,250 pounds.

2.3. Alternative 2 Cost

The annual cost for alternative 2, 100 percent use of cryogenic technology for TRU refrigeration at facilities, is $105,259,952 – $186,955,416 (from Matrix 4, Appendix G) ($105 million – $187 million, rounded).

The calculations for the relative emission reduction effectiveness of this alternative as compared to the ATCM are shown in Matrix 4. An emission reduction of 100 percent of the baseline was assumed, since the use of cryogenic technology produces zero diesel PM emissions under all situations. The emission reduction of 100 percent of baseline TRU emissions was divided into both the low-end and high-end emission reductions attributable to the regulation to give the relative effectiveness of this alternative. While the elimination of diesel PM emissions associated with this technology is highly desirable, it should be noted that the lack of appropriate support infrastructure in some geographic areas and high cost would likely prevent statewide use of this alternative. However, this compliance technology may be feasible in niche markets where business circumstances are favorable to this technology.

For TRU generator sets only, the use of cryogenic technology is not considered a viable alternative, since cryogenic technology is intended to replace the refrigeration function of a TRU and is not suitable for replacing the electrical-power generation function of a TRU generator set. To reflect this assumption, Matrix 4 (and the analysis) does not show an emission reduction for the application of this alternative to TRU generator sets.

The annual PM reduction attributable to this alternative is within the range of 327,040 to 1,368,750 pounds for the period from 2008 – 2020.

A summary of the cost-effectiveness (expressed in dollars per pound of PM reduced) comparison between the ATCM and the two alternatives is shown in the table below:

Table VIII- 5

Cost-Effectiveness Comparison – ATCM and Selected Alternatives

	Annual PM Emission Reduction	Annual Cost (facility reporting cost not included) ($)	Annual Cost Effectiveness ($/lb. PM avoided)
ATCM - VDECS Retrofit - Engine/TRU Replacement	383,000 – 592,000	4.8 million – 9.0 million	10 – 20 (rounded)
Alternative 1 - Electric Standby	189,800 – 748,250	32 million – 57 million	52 – 231
Alternative 2 - Cryogenic Technology	327,040 – 1,368,750	113 million – 198 million	24 – 366

REFERENCES

ARB, 2002. California Air Resources Board. *Staff Report: Initial Statement of Reasons for Proposed Rulemaking Airborne Toxic Control Measure to Limit School Bus Idling and Idling at Schools*. Sacramento, California. October 2002.

ARB, 2003a. California Air Resources Board. *Staff Report: Initial Statement of Reasons, Supplemental Report, Proposed Diesel Particulate Matter Control Measure for On-Road Heavy-Duty Residential and Commercial Solid Waste Collection Vehicles.* August 8, 2003.

ARB, 2003b. California Air Resources Board. *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Airborne Toxic Control Measure for Stationary Compression-Ignition Engines.* September 2003.

IX. ENVIRONMENTAL IMPACTS

The proposed Airborne Toxic Control Measure (ATCM) is intended to protect the health of California citizens by reducing exposure to emissions from diesel-fueled transport refrigeration units (TRUs) and TRU generator sets. An additional consideration is the impact the proposed ATCM may have on the environment. Based upon available information, the Air Resources Board (ARB or Board) staff has determined that no significant adverse environmental impacts should occur as the result of adopting the proposed ATCM. This chapter describes the potential impacts that the proposed ATCM may have on the environment (i.e., air, land and water), State Implementation Plan, near-source emissions, and environmental justice.

A. Legal Requirements

The California Environmental Quality Act (CEQA) and ARB policy require an analysis to determine the potential environmental impacts of proposed regulations. Because the ARB's program involving the adoption of regulations has been certified by the Secretary of Resources pursuant to Public Resources Code section 21080.5, the CEQA environmental analysis requirements may be included in the Initial Statement of Reasons (ISOR) for this rulemaking. In the ISOR, ARB must include a "functionally equivalent" document, rather than adhering to the format described in CEQA of an Initial Study, a Negative Declaration, and an Environmental Impact Report. In addition, staff will respond, in the Final Statement of Reasons for the ATCM, to all significant environmental issues raised by the public during the public review period or at the Board public hearing.

Public Resources Code section 21159 requires that the environmental impact analysis conducted by ARB include the following:

- An analysis of reasonably foreseeable environmental impacts of the methods of compliance;
- An analysis of reasonably foreseeable feasible mitigation measures; and
- An analysis of reasonably foreseeable alternative means of compliance with the ATCM.

Compliance with the proposed ATCM is expected to directly affect air quality and potentially affect other environmental media as well. Our analysis of the reasonable foreseeable environmental impacts of the methods of compliance is presented below.

Regarding mitigation measures, CEQA requires an agency to identify and adopt feasible mitigation measures that would minimize any significant adverse environmental impacts described in the environmental analysis.

The proposed ATCM is needed to reduce the risk from exposures to diesel PM as required by Health and Safety Code (H&SC) sections 39666 and 39667, and to fulfill the goals of the October 2000 Diesel Risk Reduction Plan. Alternatives to the proposed ATCM have been discussed earlier in Chapter VII of this report. ARB staff have concluded that there are no alternative means of compliance with the requirements of H&SC sections 39666 and 39667 that will achieve similar diesel PM emission reductions at a lower cost.

B. Effects on Ambient Air Quality

The proposed ATCM is expected to directly impact air quality and is designed to reduce the exposure to diesel PM emissions from in use TRUs and TRU generator set engines by requiring them to be retrofitted, replaced, or re-powered. TRUs and TRU generator sets emit diesel PM, nitrogen oxides (NOx), carbon monoxide (CO), reactive organic gases (ROG) along with several other pollutants that have the potential to cause cancer and other health effects.

The projected daily emissions of diesel PM and NOx from TRUs and TRU generator sets with implementation of the proposed ATCM is provided in Table IX-1 for the years 2010 and 2020. The year 2000 is considered to be the baseline year for these emissions. This data shows there would be a 0.4 tons per day PM emission reduction in 2010 compared to 2000 PM emissions, and similarly, a 1.7 tons per day reduction in 2020. There would be an increase in NOx emissions over time compared to 2000 because the TRU engine population increases at a faster rate than the amount of emissions reduced per engine. The net increase is attributed to the population growth outpacing the NOx reduction benefits of the ATCM and Tier 4 nonroad new engine standards.

Table IX-1
Projected Emissions with Implementation of the Proposed ATCM

Emission Year	Total Emissions (Tons per Day)	
	PM	NOx
2000[1]	2.0	19.1
2010	1.6	24.5
2020	0.3	28.2

1. This is the baseline year for these emissions.

Table IX-2 presents the projected emission reductions due to the proposed ATCM in 2010 and 2020 compared to 2008 (i.e., the year the proposed ATCM emission reductions would begin to be implemented). In 2008, only the Tier 4 nonroad/off-road new engine emission standards are considered. Staff estimates that implementation of the proposed ACTM would reduce PM emissions from TRUs and TRU generator sets by approximately 0.6 tons per day in 2010, and 0.5 tons per day in 2020. Also, the ATCM would reduce NOx emissions by 0.9 and 1.0 tons per day for 2010 and 2020, respectively.

Table IX-2
Emission Benefits from Implementation of the Proposed ATCM

Emission Year	Total Emission Reductions (Tons per Day)	
	PM	NOx
2010	0.6	0.9
2020	0.5	1.0

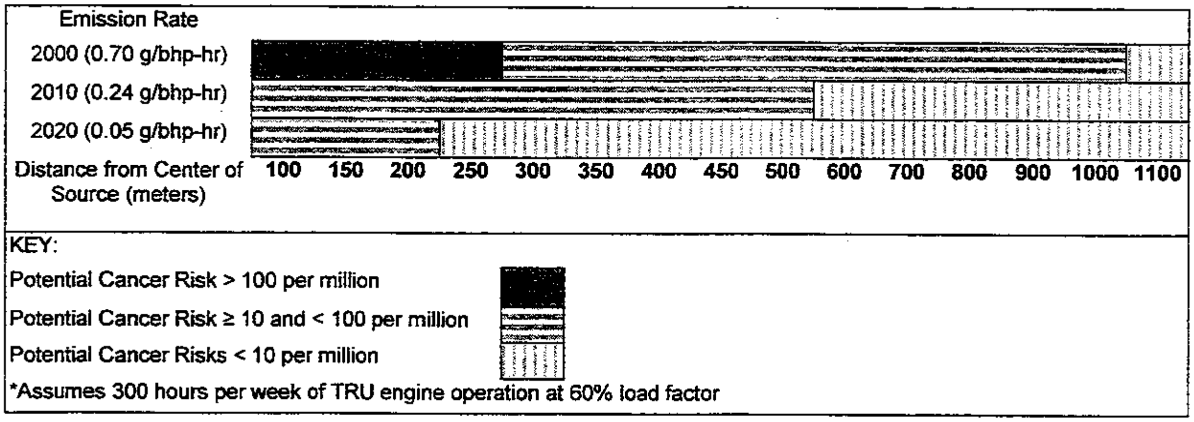
When the emission benefits are added up for the entire implementation period (2008 through 2020), the total PM emission reductions would be close to 3,000 tons. Appendix D discusses these emission reductions in more detail.

C. Near-Source Emission Impacts Due to Diesel TRU Engines

Exposure to diesel PM emissions from TRU engines is known to cause adverse health effects. In California, there are currently about 31,000 TRUs and TRU generator sets, 7,500 out-of-state refrigerated trailers, and 1,700 railcar TRUs operating at any given time. The highest concentrations of diesel PM from TRUs are expected to occur at locations where numerous TRUs operate (i.e. distribution facilities, ports, and intermodal facilities). Facilities where numerous TRUs operate could potentially result in significant potential health risk to individuals living near the facilities.

Reduction of potential cancer risk levels at locations where TRUs operate would be a direct result of the reduction in diesel PM emissions. Figure IX-1, below, compares the cancer risk range at various distances assuming 300 hours of TRU activity per week. For year 2000, the current fleet average emission rate of 0.7 g/bhp-hr was used. The average fleet emission rate is assumed to be 0.24 g/bhp-hr in 2010 and 0.05 g/bhp-hr in 2020. These emission rates assume compliance with the ATCM and the proposed U.S. EPA Tier 4 standards. Figure IX-1 also shows that the near source risk is significantly reduced (by approximately 92 percent) as the diesel PM emission rate is reduced from the current fleet emission rate to the much lower emission rate in 2020.

Figure IX-1
Estimated Risk Range versus Distance from Center of TRU Activity Area*



D. State Implementation Plan – Air Quality Benefit Analysis

The ARB *Proposed 2003 State and Federal Strategy for the California State Implementation Plan* (Proposed Strategy) describes defined State and federal measures that will reduce emissions and improve air quality statewide.

The identified measures will also help the South Coast air basin attain the federal ozone and PM standards by the applicable attainment dates. The measures identified by ARB staff and staff of the South Coast Air Quality Management District in the District's Air Quality Management Plan are estimated to achieve about one-third of the emission reductions needed to attain the 1-hour federal ozone standard in the Los Angeles area. To bridge the gap, the Proposed Strategy describes the need for additional emission reductions, beyond the defined measures, to attain the federal 1-hour ozone standard in the South Coast. We expect that the San Joaquin Valley will also need additional emission reductions to meet the 1-hour federal ozone standard. The ARB has already approved five of the defined strategies. The Board will consider the remaining defined strategies and the long-term strategy in Fall 2003.

ROG emission reductions, which would aid our ozone control strategy, can be realized from implementation of diesel particulate control strategies. In addition, reductions of direct emissions of diesel particulate will help decrease ambient particulate levels and make progress toward attainment of federal particulate matter standards in the South Coast and the San Joaquin Valley. Because this ATCM was still under development when the Proposed Strategy was released, it was not possible to project the expected ancillary ROG benefits of the control strategy. However, once an ATCM is adopted and the emission reductions are enforceable, ARB may claim any associated ROG benefits against the State Implementation Plan (SIP) commitments.

The ROG benefits of the proposed ATCM may vary significantly depending upon the compliance mechanism chosen by the regulated industry. Because of this uncertainty, ARB staff intends to closely monitor the implementation of the proposed ATCM to provide the most accurate estimate of ROG and PM reductions to credit toward the SIP obligations. As shown previously, Table IX-2 provides an illustration of the emission reductions that might accrue from the implementation of the proposed ATCM.

To meet ARB's legal obligation to provide for attainment, ARB staff will continue to pursue every available emission reduction opportunity. If ARB staff believes that it is technically and economically feasible to achieve more emission reductions from an individual measure than originally envisioned in the Proposed Strategy, we will do so. In addition, ARB plans to lead a multi-agency effort to identify, develop, adopt, and implement further control strategies, beyond those described in the Proposed Strategy.

E. Health Benefits of Reductions of Diesel PM Emissions

The emission reductions obtained from this ATCM will result in lower ambient PM levels and significant reductions of exposure to primary and secondary diesel PM. Lower ambient PM levels and reduced exposure, in turn, will result in a reduction of the prevalence of the diseases attributed to PM and diesel PM, including reduced incidences of hospitalizations for cardio-respiratory disease, and prevention of premature deaths.

Primary Diesel PM

Lloyd and Cackette (2001) estimated that, based on the Krewski et al. (2000) study[9], exposures of diesel $PM_{2.5}$ ambient concentrations at a level of 1.8 $\mu g/m^3$ resulted in a mean estimate of 1,985 cases of premature deaths per year in California. The diesel PM emissions corresponding to the direct diesel ambient population-weighted PM concentration of 1.8 $\mu g/m^3$ are 28,000 tons per year (ARB, 2000). Based on this information, we estimate that reducing 14.11 tons per year of diesel PM emissions would result in one fewer premature death (1,985 deaths*14.11 tons/28,000 tons). Comparing the $PM_{2.5}$ emission before and after this ATCM, the proposed ATCM is expected to reduce PM emissions by approximately 3,000 tons by the end of year 2020, and therefore prevent an

[9] Although there are two mortality estimates in the report by Lloyd and Cackette – one based on work by Pope *et al.* (1995) and the other based on Krewski *et al.*(2000) we selected the estimate based on the Krewski's work. For Krewski *et al.*(2000), an independent team of scientific experts commissioned by the Health Effects Institute conducted an extensive reexamination and reanalysis of the health effect data and studies, including Pope *et al.* (1995) The reanalysis resulted in the relative risk being based on changes in mean levels of $PM_{2.5}$, as opposed to the median levels from the original Pope *et al.* (1995) study. The Krewski *et al.*(2000) reanalysis includes broader geographic areas than the original study (63 cities vs. 50 cities). Further, the U.S. EPA has been using Krewski's study for its regulatory impact analyses since 2000.

estimated 211 premature deaths (103-318, 95 percent confidence interval (95% CI) by year 2020. Prior to 2020, cumulatively, it is estimated that 31 premature deaths (15-46, 95% CI) would be avoided by 2010 and 129 (63-194, 95% CI) by 2015. Additional health benefits are expected from the reduction of NOx emissions, which give rise to secondary PM from the conversion of NOx to $PM_{2.5}$ nitrate.

To estimate the cost of control per premature death prevented, we multiplied the estimated tons of diesel PM that would result in one fewer premature death (14.11 tons per year) by the average present value of cost-effectiveness ($10 to $20 per pound of PM range or $20,000 to $40,000 per ton). The resulting estimated cost of control per premature death prevented ranged from $282,000 to $564,000 in 2002 dollars. The U.S. EPA has established $6.3 million (in year 2000 dollars) for a 1990 income level as the mean value of avoiding one death (U.S. EPA, 2003). As real income increases, the value of a life may rise. U.S. EPA further adjusted the $6.3 million value to about $8 million (in 2000 dollars) for a 2020 income level. Assuming that real income grew at a constant rate from 1990 and will continue at the same rate to 2020, we adjusted the value of avoiding one death for the income growth. Since the control cost is expressed in 2002 discounted value, accordingly, we discounted values of avoiding a premature death in the future back to the year 2002. In U.S. EPA's guidance of social discounting, it recommends using both three and seven percent discount rates (U.S. EPA, 2000). Using these rates, and the annual avoided deaths as weights, the weighted average value of reducing a future premature death discounted back to year 2002 is $3.5 million at seven percent discount rate, and $5.6 million at three percent. The cost range per death avoided because of this proposed regulation is 8 to 22 times lower than the U.S. EPA's benchmark for value of avoided death. This rule is, therefore, a cost-effective mechanism to reduce premature deaths that would otherwise be caused by diesel PM emissions without this ATCM.

The benefits of reducing diesel emissions are based on a statewide average diesel emission value, such as in the Lloyd and Cackette analysis, containing off-road emissions from a number of categories that occur well away from population centers. Diesel-fueled TRUs and their diesel emissions are more concentrated in urban areas, thus a greater reduction of the emissions as a result of the regulation are expected to occur in urban areas, as compared to rural areas. Emission reductions are, therefore, likely to have greater benefits than those estimated by Lloyd and Cackette. Thus, the proposed rule is likely more cost-effective than the above estimate would suggest.

Reduced Ambient Ozone Levels

Emissions of NOx and ROG are precursors to the formation of ozone in the lower atmosphere. Exhaust from diesel engines contributes a substantial fraction of ozone precursors in any metropolitan area. Therefore, reductions in NOx and ROG from diesel engines would make a considerable contribution to reducing exposures to ambient ozone. Controlling emissions of ozone precursors would reduce the prevalence of the types of respiratory problems associated with ozone exposure and would reduce hospital admissions and emergency visits for respiratory problems.

F. Reasonably Foreseeable Environmental Impacts as a Result of Potential Compliance Methods

We have identified potential adverse environmental impacts from the use of diesel oxidation catalysts (DOCs) and diesel particulate filters (DPF) that may be used to comply with the proposed ATCM. These include a potential increase in sulfate PM, a potential increase in NO_2 from some DPFs, and the potential for creating hazardous wastes. As described below, options are available to mitigate these potential adverse impacts.

Diesel Oxidation Catalyst

Two potential adverse environmental impacts of the use of DOCs have been identified. First, as is the case with most processes that incorporating catalytic oxidation, the formation of sulfates increases at higher temperatures. Depending on the exhaust temperature and sulfur content of the fuel, the increase in sulfate particles may offset the reductions in soluble organic fraction emissions. Using low sulfur diesel fuel can minimize this effect. Second, a DOC could be considered a "hazardous waste" at the end of its useful life depending on the materials used in the catalytic coating. Because catalytic converters have been used on gasoline powered on-road vehicles for many years, there is a very well established market for these items (see, for example, http://www.pacific.recycle.net – an Internet posting of buyers and sellers of various scrap materials). In the recycling process, the converters are broken down, and the metal is added to the scrap-metal stream for recycling, while the catalysts (one or a combination of the platinum group metals) are extracted and reused.

Because of platinum's high activity as an oxidation catalyst, it is the predominant platinum group metal used in the production of DOCs. There is a very active market for reclaimed platinum for use in new catalytic converters, jewelry, fuel cells, cathode ray tube screens, catalysts used during petroleum refining operations, dental alloys, oxygen sensors, platinum electrode spark plugs, medical equipment, and platinum-based drugs for cancer treatment, to name a few (Kendall, 2002; Kendall, 2003).

Catalyzed Diesel Particulate Filters

These devices are composed of a ceramic DPF along with a platinum catalyst to accelerate the oxidation of carbon-containing emissions and significantly reduce diesel PM emissions. This is an obvious positive environmental impact. However, there are also inorganic solid particles present in diesel exhaust, which are captured by DPFs. These inorganic materials are metals derived from engine oil, diesel fuel, or engine wear and tear. While the PM filter is capable of capturing inorganic materials, these materials are not oxidized into a gaseous form and expelled. Because these materials would otherwise be released into the air, the filters are benefiting the environment by capturing these metallic particles, known as "ash." However, the ash that is collected in the PM filter must be removed from the filter periodically to maintain the filter effectiveness.

Ash collected from a diesel engine using a typical lubrication oil and no fuel additives has been analyzed and is primarily composed of oxides of the following elements: calcium, zinc, phosphorus, silicon, sulfur, and iron. Zinc is the element of primary concern because, if present in high enough concentrations, it can make the waste a hazardous waste. Title 22, California Code of Regulations (CCR), section 66261.24 establishes two limits for zinc in a waste: 250 milligrams per liter for the Soluble Threshold Limit Concentration and 5,000 milligrams per kilogram for the Total Threshold Limit Concentration. The presence of zinc at or above these levels would cause ash to be characterized as a hazardous waste.

Under California law, it is the generator's responsibility to determine if waste is hazardous. Applicable hazardous waste laws are found in the H&SC, division 20; title 22, CCR, division 4.5; and title 40 of the Code of Federal Regulations. Staff recommends owners that install a DPF on an engine to contact both the manufacturer of the diesel emission control system and the California Department of Toxic Substances Control (DTSC) for advice on proper waste management.

ARB staff consulted with personnel of the DTSC regarding management of the ash from DPFs. DTSC personnel advised ARB that it has a list of facilities that accept waste from businesses that qualify as a conditionally exempt small quantity generator. Such a business can dispose of a specific quantify of hazardous waste at certain Household Hazardous Waste events, usually for a small fee. Specific information regarding the identification of and acceptable disposal methods for wastes is available from the California DTSC.[10]

High-pressure water and detergent is sometimes used to remove ash from DPFs. However, this practice would generate wastewater containing metal oxides, and possibly considered hazardous waste, that can not be discharged to the sanitary

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[10] Information can be obtained from local duty officers and from the DTSC web site at http://www.dtsc.ca.gov.

sewer or storm drains. Technology is currently available for reclamation of zinc from waste. For example, the Swedish company MEAB has developed processes for extracting zinc and cadmium from various effluents and industrial waste streams. Whether reclamation for reuse will be economically beneficial remains to be seen. (MEAB, 2003). Some DPF cleaning techniques can cause ash to be illegally released directly into the air/or work environment potentially exposing the public and/or workers to zinc and other metal oxides.

Because of the time and costs associated with filter maintenance, there are also efforts by industry to reduce the amount of ash formed. Most of the ash is formed from the inorganic materials in engine oil, particularly from zinc-containing additives necessary to control acidification of engine oil – due in part to sulfuric acid derived from sulfur in diesel fuel. As the sulfur content of diesel fuel is decreased, the need for acid neutralizing additives in engine oil should also decrease. A number of technical programs are ongoing to determine the impact of changes in oil ash content and other characteristics of engine oil on exhaust emission control technologies and engine wear and performance.

It may also be possible to reduce the ash level in diesel exhaust by reducing oil consumption from diesel engines. Diesel engine manufacturers over the years have reduced engine oil consumption in order to reduce PM emissions and to reduce operating costs for engine owners. Further improvements in oil consumption may be possible in order to reduce ash accumulation rates in DPFs.

In addition, measurements of NOx emissions for heavy-duty diesel vehicles equipped with passive catalyzed DPFs have shown an increase in the NO_2 portion of total NOx emissions, although the total NOx emissions remain approximately the same. In some applications, passive catalyzed DPFs can promote the conversion of nitrogen oxide (NO) emissions to NO_2 during filter regeneration. More NO_2 is created than is actually being used in the regeneration process; and the excess is emitted. The NO_2 to NOx ratios could range from 20 to 70 percent, depending on factors such as the DPF systems, the sulfur level in the diesel fuel, and the duty cycle (DaMassa, 2002).

Formation of NO_2 is a concern because it irritates the lungs and lowers resistance to respiratory infections. Individuals with respiratory problems, such as asthma, are more susceptible to the effects. In young children, NO_2 may also impair lung development. In addition, a higher NO_2/NOx ratio in the exhaust could potentially result in higher initial NO_2 concentrations in the atmosphere which, in turn, could result in higher ozone concentrations.

Model simulations have shown that a NO_2 to NO_X emission ratio of approximately 20 percent would nearly eliminate any impact of increased NO_2 emissions (DaMassa, 2002). According to the model, at the NO_2 to NOx ratio of 20 percent, there will be a decrease of the 24-hour ozone exposure (greater than 90 parts per billion) by two percent while an increase of the peak 1-hour NO_2 by six percent (which is still within the NO_2 standard).

The health benefits derived from the use of PM filters are immediate and offset the possible adverse effects of increases in NO_2 emissions. For this reason, a cap of 20 percent NO_2 to NOx emission ratio was established for all diesel emission control systems through the ARB Verified Diesel Emission Control System procedure (Verification Procedure). ARB staff believes most TRU and TRU generator set operators will choose to install verified systems on their engines. For these engines, the 20 percent NO_2 to NOx emission ratio can be met. There is the potential, however, for the use of systems that exceed the 20 percent cap. The ARB will monitor this and determine if any additional requirements need to be incorporated into the ATCM.

Finally, DPFs can emit carbon dioxide (CO_2), a greenhouse gas, as a result of oxidizing PM. The contribution of CO_2 emissions from TRUs and TRU generator sets using DPFs, and how much these emissions contribute to global warming, is unknown.

Alternative Fuels

As discussed in sections G and H of Chapter VI, a number of alternative fuels and alternative diesel fuels show great promise in their potential to reduce diesel PM emissions. These include biodiesel, Fischer-Tropsch fuels, and alternative fuels such as natural gas. No significant negative environmental impacts have been determined from the use of alternative fuels. With respect to alternative diesel fuels, there may be a slight increase in NOx emissions as a result of biodiesel use (Hofman/Solseng, 2002).

To ensure there are no adverse impacts from the use of alternative diesel fuels, the proposed ATCM requires any alternative diesel-fuel or fuel additives used in a TRU or generator set to be verified under the ARB Verification Procedure. The Verification Procedure permits verification only if a multimedia evaluation of the use of the alternative diesel fuel or additive has been conducted. In addition, verification requires a determination by the California Environmental Policy Council that such use will not cause a significant adverse impact on public health or the environment pursuant to H&SC section 43830.8 (see Public Resource Code, section 71017).

Fuel Borne Catalysts

Other options for reducing diesel PM emissions is the use of fuel borne catalysts (FBCs). FBCs may be added to diesel fuel to decrease the ignition temperature of the carbonaceous exhaust in order to aid in soot removal from DPFs. When FBCs are used without a DPF, trace amounts would be emitted with the engine exhaust. Currently, a FBC should be used with a filter to capture emissions. The contribution of emissions from FBCs is unknown.

G. Reasonably Foreseeable Mitigation Measures

ARB staff has concluded that no significant adverse environmental impacts should occur from adoption of and compliance with the proposed ATCM. Therefore, no mitigation measures would be necessary.

H. Reasonably Foreseeable Alternative Means of Compliance with the Proposed ATCM

Alternatives to the proposed ATCM are discussed in Chapter VII, Section C of this report. ARB staff has concluded that the proposed ATCM provides the most effective and least burdensome approach to reducing children's and the general public's exposure to diesel PM and other air pollutants emitted from diesel-fueled stationary engines.

I. Environmental Justice

The ARB is committed to integrating environmental justice in all of its activities. On December 13, 2001, the Board approved "Policies and Actions for Environmental Justice," which formally established a framework for incorporating Environmental Justice into ARB programs, consistent with the directives of State law. "Environmental Justice " or "EJ" is defined as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies. These policies apply to all communities in California, but recognize that environmental justice issues have been raised more in the context of low-income and minority communities.

The EJ policies are intended to promote the fair treatment of all Californians and cover the full spectrum of ARB activities. Underlying these policies is a recognition that the ARB needs to engage community members in a meaningful way as it carries out its activities. People should have the best possible information about the air they breathe and what is being done to reduce unhealthful air pollution in their communities. The ARB recognizes its obligation to work closely with all communities, environmental and public health organizations, industry, business owners, other agencies, and all interested parties to successfully implement these policies (ARB, 2001).

Chapter III of this Staff Report generally describes the efforts made to apprise the public about the development of the proposed ATCM. Specific outreach efforts to environmental justice communities and activities have included the following:

- Since the identification of diesel PM as a toxic air contaminant (TAC) in 1998, the public has been more aware of the health risks posed by this TAC. At many of the ARB's community outreach meetings over the past few years, the public has raised questions regarding efforts to reduce exposure to diesel PM. At these meetings in April 2003, ARB staff told the public about the Diesel Risk Reduction Plan, adopted in 2000, and described some of the measures in that plan, including the proposed ATCM. These meetings were held in association with Children's Environmental Health Protection Program air monitoring studies in Barrio Logan (San Diego), Boyle Heights (Los Angeles), Wilmington (Los Angeles), and other low-income and minority communities.

- The ARB's Environmental Justice Policies and Action web page (http://www.arb.ca.gov/ch/programs/ej/ej.htm) has provided a direct link to the proposed ATCM web page via "Improving Air Quality: Diesel Risk Reduction Plan or California Air Toxics Program." The proposed ATCM web page provides accessibility to: draft versions of the ATCM; the Staff Report (including the proposed ATCM); a fact sheet in both English and Spanish; meeting and contact information; and list serve subscription.

- Environmental justice, children's health, community, and environmental activists have been notified by electronic and/or regular mail about the public workshops, the public hearing, and the availability of this Staff Report. Moreover, the ARB provides web cast access for the proposed ATCM public workshops and hearing to allow virtually everyone in the State to participate.

The proposed ATCM is consistent with the ARB EJ policy to reduce health risk from TACs in all communities, including low-income and minority communities. The proposed ATCM would reduce diesel PM emissions and health risk from thousands of TRUs and TRU generator sets operating throughout California. In addition, staff anticipates significant diesel PM emission and health risk reductions to occur in neighborhoods surrounding heavily-traveled freeways, storage and distribution facilities, rail yards, and ports where TRU and TRU generator set activity is concentrated. These neighborhoods are frequently co-located with low-income and minority communities.

REFERENCES:

ARB, 2000. California Resources Board. *The Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles*, Sacramento, California. October 2000.

ARB, 2001. California Air Resources Board. *Policies and Actions for Environmental Justice*. Sacramento, California. Sacramento, California. April 2001.

DaMassa, 2002. DaMassa, John. *Presentation: Air Quality Effects of Trap-Related Emissions (Updated)*, California Air Resources Board, Sacramento, California. February 6, 2002.

Hofman/Solseng, 2002. Hofman, V. and Solseng, E. *Biodiesel Fuel Use in an Unmodified Diesel Engine*, American Society of Agricultural Engineers Annual Meeting; September 27-28, 2002.

Kendall, 2002. Kendall, Tom; Johnson Matthey. *Platinum 2002*; http://www.platinum.matthey.com/publications/1051543656.html; May 2002.

Kendall, 2003. Kendall, Tom; Johnson Matthey. *Platinum 2003*; http://www.platinum.matthey.com/publications/1059138410.html; May 2003.

Krewski et al, 2000. Krewski D.; Burnett R.; Goldberg M.; Hoover K.; Stemiatychi J.; Jerrett M.; Abrahamovicz M.; White W. *Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality*, Health Effects Institute, Cambridge, Massachusetts; 2000.

Lloyd and Cackette, 2001. Lloyd, A.C.; Cackette, T.A.; *Diesel Engines: Environmental Impact and Control*; J Air Waste Manage. Assoc. 2001, 51: 809-847.

MEAB, 2003. Metallextraktion AB (MEAB). *http://www.meab-mx.se/en/index.htm*; August 2003.

Pope et al, 1995. Pope, C.A.; Thun, M.J.; Namboodiri, M.M.; Dockery, D.W.; Evans, J.S.; Speizer, F.E.; Heath, C.W. *Particulate Air Pollution as a Predictor of Mortality in Prospective Study of U.S. Adults*, Am. J. Respir. Crit. Care Med.; 1995.

U.S. EPA, 2000. United States Environmental Protection Agency, *Guidelines for Preparing Economic Analyses;* . Research Triangle Park, North Carolina. April 2003. September 2000.

U.S. EPA, 2003. United States Environmental Protection Agency, Assessment and Standards Division, Office of Transportation and Air Quality, *Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel*. EPA420-R-03-008. CD-ROM. Research Triangle Park, North Carolina. April 2003.

APPENDICES

APPENDIX A

PROPOSED REGULATION ORDER: TITLE 13 AIRBORNE TOXIC CONTROL MEASURES FOR IN-USE DIESEL-FUELED TRANSPORT REFRIGERATION UNITS (TRU) AND TRU GENERATOR SETS, AND FACILITIES WHERE TRUs OPERATE

** PROPOSED REGULATION ORDER **

Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities Where TRUs Operate

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Adopt new Section 2022, Title 13, Article 4, within Chapter 3, Division 3, California Code of Regulations, to read as follows: (Note: the entire text of section 2022 set forth below is new language proposed to be added to the California Code of Regulations.)

(a) ***Purpose***. *Diesel particulate matter (PM) was identified in 1998 as a toxic air* contaminant. This regulation implements provisions of the Diesel Risk Reduction Plan, adopted by the Air Resources Board in October, 2000, as mandated by the Health and Safety Code Sections 39650-39675, to reduce emissions of substances that have been determined to be toxic air contaminants. Specifically, this regulation will use a phased approach to reduce the diesel PM emissions from in-use transport refrigeration units (TRUs) and TRU generator (gen) set equipment used to power electrically driven refrigerated shipping containers and trailers that are operated in California.

(b) **Applicability**.

(1) Except as provided in subsection (c), this regulation applies to owners and operators of diesel-fueled TRUs and TRU gen sets (see definition of operator and owner in section (d)) that operate in the State of California. This specifically includes operators and owners of TRUs and TRU gen sets that are installed on trucks, trailers, shipping containers, or railcars.

(2) This regulation applies to facilities located in California with 20 or more loading dock doors serving refrigerated areas where perishable goods are loaded or unloaded for distribution on trucks, trailers, shipping containers, or rail cars that are equipped with TRUs and TRU gen sets and that are owned, leased, or contracted for by the facility, its parent company, affiliate, or subsidiary that are under facility control (see definition).

(3) To the extent not already covered under subsections (b)(1) and (b)(2), above, subsection (g) of this regulation shall apply to any person engaged in this State in the business of selling to an ultimate purchaser, or renting or leasing new or used TRUs or TRU gen sets, including, but not limited to, manufacturers, distributors, and dealers.

(4) *Severability. If any subsection, paragraph, subparagraph, sentence, clause,* phrase, or portion of this regulations is, for any reason, held invalid, unconstitutional, or unenforceable by any court of competent jurisdiction, such portion shall be deemed as a separate, distinct, and independent provision, and

such holding shall not affect the validity of the remaining portions of the regulation.

(c) **Exemptions**. This regulation does not apply to military tactical support equipment.

(d) **Definitions**. For purposes of this regulation, the following definitions apply:

(1) "Affiliate or Affiliation" refers to a relationship of direct or indirect control or shared interests between the subject business and another business.

(2) "Alternative Fuel" means natural gas, propane, ethanol, methanol, or advanced technologies that do not rely on diesel fuel, except as a pilot ignition source at an average ratio of less than 1 part diesel fuel to 10 parts total fuel on an energy equivalent basis. Alternative fuels also means any of these fuels used in combination with each other or in combination with other non-diesel fuels. Alternative-fueled engines shall not have the capability of idling or operating solely on diesel fuel at any time.

(3) "Alternative-Fueled Engine" means an engine that is fueled with a fuel meeting the definition of alternative fuel.

(4) "Alternative Diesel Fuel" means any fuel used in diesel engines that is not a reformulated diesel fuel as defined in Sections 2281 and 2282 of Title 13, of the California Code of Regulations, and does not require engine or fuel system modifications for the engine to operate, although minor modifications (e.g. recalibration of the engine fuel control) may enhance performance. Examples of alternative diesel fuels include, but are not limited to, biodiesel, Fischer Tropsch fuels, and emulsions of water in diesel fuel. Natural gas is not an alternative diesel fuel. An emission control strategy using a fuel additive will be treated as an alternative diesel fuel based strategy unless:

(A) The additive is supplied to the vehicle or engine fuel by an on-board dosing mechanism, or

(B) The additive is directly mixed into the base fuel inside the fuel tank of the vehicle or engine, or

(C) The additive and base fuel are not mixed until vehicle or engine fueling commences, and no more additive plus base fuel combination is mixed than required for a single fueling of a single engine or vehicle

(5) "ARB" means the California Air Resources Board.

(6) "B100 Biodiesel Fuel" means 100% biodiesel fuel derived from vegetable oil or animal fat and complying with ASTM D 6751-02 and commonly or commercially known, sold, or represented as "neat" biodiesel or B100. B100 biodiesel fuel is an alternative diesel fuel.

(7) "B100 Biodiesel-Fueled" (compression-ignition engine) means a compression-ignition engine that is fueled by B100 biodiesel fuel.

(8) "Business" means an entity organized for profit including, but not limited to, an individual, sole proprietorship, partnership, limited liability partnership, corporation, limited liability company, joint venture, association or cooperative; or solely for purposes of the Prompt Payment Act (Government Code 927 et seq.), a duly authorized nonprofit corporation.

(9) "California-Based TRUs and TRU Gen Sets" means TRUs and TRU gen sets that owner/operators have been regularly assigned to terminals within California.

(10) "CARB Diesel Fuel" means any diesel fuel that meets the specifications defined in *13 CCR 2281* and *13 CCR 2282*.

(11) "Carbon Monoxide (CO)" means a colorless, odorless gas resulting from the incomplete combustion of hydrocarbon fuels.

(12) "Carrier" means any person, party, or entity who undertakes the transport of goods from one point to another.

(13) "Compression Ignition (CI) Engine" means an internal combustion engine with operating characteristics significantly similar to the theoretical diesel combustion cycle. The regulation of power by controlling fuel supply in lieu of a throttle is indicative of a compression ignition engine.

(14) "Consignee" (see receiver).

(15) "Consignor" (see shipper).

(16) "Cryogenic Temperature Control System" means a heating and cooling system that uses a cryogen, such as liquid carbon dioxide or liquid nitrogen that is routed through an evaporator coil that cools air blown over the coil. The cryogenic system uses a vapor motor to drive a fan and alternator, and a propane-fired heater superheats the carbon dioxide for heating and defrosting.

(17) "Diesel Fuel" means any fuel that is commonly or commercially known, sold, or represented as diesel fuel No. 1-D or 2-D, pursuant to the specifications in *ASTM Standard Specification for Diesel Fuel Oils D975-98*.

(18) "Diesel-Fueled" means fueled by diesel fuel or CARB diesel fuel in whole or in part, except as allowed for a pilot ignition source under the definition for "alternative fuel".

(19) "Diesel Oxidation Catalyst (DOC)" means the use of a catalyst to promote the oxidation processes in diesel exhaust. Usually refers to an emission control

device that includes a flow-through substrate where the surfaces that contact the exhaust flow have been catalyzed to reduce emissions of the organic fraction of diesel particulates, gas-phase hydrocarbons, and carbon monoxide.

(20)"Diesel Particulate Filter (DPF)" means an emission control technology that reduces PM emissions by trapping the particles in a flow filter substrate. Periodically the collected particles are either physically removed or oxidized (burned off) in a process called regeneration.

(21) "Diesel Particulate Matter" means the particles found in the exhaust of diesel-fueled CI engines. Diesel PM may agglomerate and adsorb other species to form structures of complex physical and chemical properties.

(22) "Dual-Fuel Engine" means an engine designed to operate on a combination of alternative fuel, such as compressed natural gas (CNG) or liquefied petroleum gas (LPG), and conventional fuel, such as diesel or gasoline. These engines have two separate fuel systems, which either inject both fuels simultaneously into the engine combustion chamber or fumigate the gaseous fuel with the intake air and inject the liquid fuel into the combustion chamber.

(23)"Emergency" means any of the following times:
- (A) A failure or loss of normal power service that is not part of an "interruptible service contract" (see definition in subsection (d));
- (B) A failure of a facility's internal power distribution system, provided the failure is beyond the reasonable control of the operator;
- (C) When an affected facility is placed under an involuntary "rotating outage" (see definition in subsection (d)).

(24)"Emission Control Strategy" means any device, system, or strategy employed with a diesel-fueled CI engine that is intended to reduce emissions. Examples of emission control strategies include, but are not limited to, particulate filters, diesel oxidation catalysts, selective catalytic reduction systems, alternative fuels, fuel additives used in combination with particulate filters, alternative diesel fuels, and combinations of the above.

(25)"Emissions Rate" means the weight of a pollutant emitted per unit of time (e.g., grams per second).

(26)"Executive Officer" means the Executive Officer of the California Air Resources Board or his or her delegate.

(27)"Facility" means any facility where TRU-equipped trucks, trailers, containers or railcars are loaded or unloaded with perishable goods. This includes, but is not limited to, grocery distribution centers, food service distribution centers, cold storage warehouses, and intermodal facilities. Each business entity at a commercial development is a separate facility for the purposes of this regulation, provided the businesses are "independently owned and operated" (see definition in subsection (d)).

(28)"Facility Control (of TRUs or TRU Gen Sets)" means the TRUs or TRU gen sets located at the facility are owned or leased by the facility, its parent company, affiliate, or a subsidiary, or under contract for the purpose of providing carrier service to the facility, and the TRUs' or TRU gen sets' arrival, departure, loading, unloading, shipping and/or receiving of cargo is determined by the facility, parent company, affiliate, or subsidiary (e.g scheduled receiving, dispatched shipments).

(29)"Fischer-Tropsch Diesel Fuel" See "ultra-low-aromatic synthetic diesel fuel".

(30)"Fuel Additive" means any substance designed to be added to fuel or fuel systems or other engine-related engine systems such that it is present in-cylinder during combustion and has any of the following effects: decreased emissions, improved fuel economy, increased performance of the engine; or assists diesel emission control strategies in decreasing emissions, or improving fuel economy or increasing performance of the engine.

(31)"Generator Set (gen set)" means a CI engine coupled to a generator used as a source of electricity.

(32)"Hybrid Cryogenic Temperature Control System" means a temperature control system that uses a cryogenic temperature control system in conjunction with a diesel engine.

(33)"Independently Owned and Operated" means a business concern that independently manages and controls the day-to-day operations of its own business through its ownership and management, without undue influence by an outside entity or person that may have an ownership and/or financial interest in the management responsibilities of the applicant business or small business.

(34)"Intermodal Facility" means a facility involved in the movement of goods in one and the same loading unit or vehicle which uses successively several modes of transport without handling of the goods themselves in changing modes. Such a facility is typically involved in loading and unloading shipping containers and trailer vans to and from railcars, trucks, and ocean-going ships.

(35)"Interruptible Service Contract" means any arrangement in which a nonresidential electrical customer agrees to reduce or consider reducing its electrical consumption during periods of peak demand or at the request of the System Operator in exchange for compensation, or assurances not to be blacked out or other similar non-monetary assurances.

(36)"In Use TRU, TRU gen set, or engine" means a TRU, TRU gen set, or engine that is not a "new" TRU, TRU gen set, or engine.

(37)"Low Emission TRU (LETRU or L)" means a TRU or TRU gen set that meets the performance standards described under paragraph (e)(1)(A)(i) or (ii).

(38)"Manufacturer" means a business as defined in Government Code § 14837(c).

(39)"Military tactical support equipment (TSE)" means equipment that meets military specifications, owned by the U.S. Department of Defense and/or the U.S. military services, and used in combat, combat support, combat service support, tactical or relief operations, or training for such operations.

(40)"Model Year (MY)" means diesel-fueled engine manufacturer's annual production period, which includes January 1st of a calendar year, or if the manufacturer has no annual production period, the calendar year.

(41)"New TRU, TRU Gen Set, or Engine" means any TRU, TRU gen set, or engine that has never been subject to a retail sale or lease to an "ultimate purchaser" (see definition in subsection (d)).

(42)"Nitrogen Oxide (NOx)" means compounds of nitric oxide (NO), nitrogen dioxide (NO_2), and other oxides of nitrogen. Nitrogen oxides are typically created during combustion processes and are major contributors to smog formation and acid deposition.

(43)"Non-methane Hydrocarbons (NMHC)" means the sum of all hydrocarbon air pollutants except methane. NMHCs are precursors to ozone formation.

(44)"Operate" means to start, cause to function, program the temperature controller, select an operating program or otherwise control, fuel, monitor to assure proper operation, or keep in operation.

(45)"Operator" means any person, party or entity that operates a TRU or TRU gen set for the purposes of transporting perishable goods, excluding an employee driver and third party maintenance and repair service, and including but not limited to:

(A) Manufacturer, producer, supplier, carrier, shipper, consignor, consignee, receiver, distribution center, or warehouse of perishable goods;

(B) An individual, trust, firm, joint stock company, business concern, partnership, limited liability company, association, or corporation including but not limited to, a government corporation;

(C) Any city, county, district, commission, the state or any department, agency, or political subdivision thereof, any interstate body, and the federal government or any department or agency thereof to the extent permitted by law; or

(46)"Owner" means any person that legally holds the title (or its equivalent) showing ownership of a TRU or TRU gen set, excluding a bank or other financial lending institution, and including but not limited to:

(A) Manufacturer, producer, supplier, carrier, shipper, consignor, consignee, receiver, distribution center, warehouse;

(B) An individual, trust, firm, joint stock company, business concern, partnership, limited liability company, association, or corporation including but not limited to, a government corporation;

(C) Any city, county, district, commission, the state or any department, agency, or political subdivision thereof, any interstate body, and the federal government or any department or agency thereof to the extent permitted by law; or

(47)"Owner/Operator" means a requirement applies to the owner and/or operator of a TRU or TRU gen set, as determined by agreement or contract between the parties if the two are separate business entities.

(48)"Parent Company" means a company that has a controlling interest in another company, usually through ownership of more than one-half the voting stock.

(49)"Particulate Matter (PM)" means the particles found in the exhaust of CI engines, which may agglomerate and adsorb other species to form structures of complex physical and chemical properties.

(50)"Rated Brake Horsepower" means the power delivered, according to the statement of the engine manufacturer, at the rated speed.

(51)"Real Emission Reductions" means that an action is taken that results in reductions in the PM emission rate of an in-use engine (e.g. a VDECS is installed that reduced the PM emissions rate by more than 50%).

(52)"Receiver" means the person, party, or entity that receives shipped goods, cargo, or commodities.

(53)"Refrigerated Shipping Container TRU" means a shipping container equipped with a TRU.

(54)"Rotating Outage" means a controlled involuntary curtailment of electrical power service to consumers as ordered by the system operator - see definition in subsection (d).

(55)"Shipper" means the person, party, or entity who usually owns or supplies the commodities shipped by a carrier.

(56)"System Operator" means one of the several organizations that control energy in California. System operators include, but are not limited to, the California Independent System Operator, the Los Angeles Department of Water and Power, the Imperial Irrigation District, the Sacramento Municipal Utility District.

(57)"Terminal" means any place where a TRU-equipped truck, trailer, container, railcar or TRU gen set is regularly garaged, maintained, operated, or dispatched from, including a dispatch office, cross-dock facility, maintenance shop, business, or private residence.

(58)"Transport Refrigeration Unit (TRU)" means refrigeration systems powered by integral internal combustion engines designed to control the environment of temperature sensitive products that are transported in semi-trailer vans, truck vans, reefer railcars, or shipping containers. TRUs may be capable of both cooling and heating.

(59)"TRU Generator Set (TRU gen set)" means a generator set that is designed and used to provide electric power to electrically driven refrigeration units of any kind. This includes, but is not limited to gen sets that provide electricity to electrically powered refrigeration systems for semi-trailer vans and shipping containers.

(60)"Ultimate Purchaser" means with respect to a new TRU, TRU gen set, or engine, the first person who in good faith purchases a new TRU, TRU gen set, or engine for purposes other than resale.

(61)"Ultra-Low-Aromatic Synthetic Diesel Fuel" means fuel produced from natural gas, coal, or biomass by the Fischer-Tropsch gas-to-liquid chemical conversion process, or similar process that meets the following properties:

Table 1

Property	ASTM	Value
Sulfur Content (ppmw)	D5453-93	<1
Total Aromatic Content (wt %)	D5186-96	<1.5%
Polynuclear Aromatic Content (wt %)	D5186-96	<0.5%
Natural Cetane Number	D613-84	>74

(62)"Ultra-Low Emission TRU (ULETRU or U)" means a TRU or TRU gen set that meets the performance standards described under subparagraph (e)(1)(A)(i) and (ii) or that uses an "alternative technology" in accordance with subparagraph (e)(1)(A)(iii).

(63)"Verification Classification Level" means the classification assigned to a Diesel Emission Control Strategy by the Executive Officer as defined in the *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emission from Diesel Engines (13 CCR Sections 2700 – 2710)*. PM reductions correspond as follows: Level 1: $\geq$ 25%; Level 2: $\geq$50%; Level 3: $\geq$85% or 0.01 g/hp-hr.

(64)"Verified Diesel Emission Control Strategy" (VDECS) means an emission control strategy designed primarily for the reduction of diesel particulate matter emissions that has been verified per the *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines (13 CCR Sections 2700 – 2710)*. Examples of diesel retrofit systems that may be verified include, but are not limited to, diesel particulate filters, diesel oxidation catalysts, fuel additives (e.g. fuel-borne catalysts), alternative fuels (e.g. dual fuel), alternative diesel fuels, and combinations of the above.

(e) **Requirements**.

(1) **In-use Operation**:

(A) **In-Use Performance Standards:** In accordance with the schedule set forth below in paragraph (e)(1)(B), no owner/operator shall operate a TRU or TRU gen set in California unless it meets the in-use emission category performance standards set forth below.

(i) In-Use performance standard categories for TRU and TRU gen set engines with rated brake horsepower less than 25 horsepower (<25 hp) are shown in Table 2, along with the engine certification standards or the level of Verified Diesel Emission Control Strategy (VDECS) (see definition) that is necessary to qualify for each category.

Table 2
<25 HP TRU and TRU Gen Set In-Use PM Performance Standards

In-Use Emission Category	Engine Certification (g/hp-hr)	Level of VDECS Equipped with
Low Emission TRU (LETRU or L)	0.30	Level 2
Ultra-Low Emission TRU (ULETRU or U)	NA[1]	Level 3

a. Compliance can be achieved by:

1. Replacing the engine with a certified engine meeting the applicable Tier 4 "Interim" nonroad/offroad emissions standards for all regulated pollutants and the in-use PM performance standard. Only engines for which certification data has been provided to ARB Stationary Source Division shall be considered in compliance. The Executive Officer will consider such submittals, publish, and make available a list of qualifying engines.
2. Equipping the engine with the required Level of VDECS.

(ii) In-Use performance standard categories for TRU and TRU gen sets engines with rated brake horsepower greater than or equal to 25 horsepower (≥ 25 hp) are shown in Table 3, along with the engine certification standards or the level of VDECS that is necessary to qualify for each category.

Table 3
≥ 25 HP TRU and TRU Gen Set In-Use PM Performance Standards

In-Use Emission Category	Engine Certification (g/hp-hr)	Level of VDECS Equipped with
Low Emission TRU (LETRU or L)	0.22	Level 2
Ultra-Low Emission TRU (ULETRU or U)	0.02	Level 3

a. Compliance can be achieved by:

1. Replacing the engine with a certified engine meeting the applicable Tier 4 "Interim" nonroad/offroad emissions standards for all regulated pollutants and the in-use PM performance standard. Only engines for which certification data has been provided to ARB

[1] Not Applicable - ARB and U.S. EPA will perform a technical review in 2007 to evaluate DOC or filter-based standard for <25 hp category new engines in 2013. If a more stringent "long term" level for new tier 4 (as identified in the May 23, 2003 Notice of Proposed Rulemaking to Control Emissions of Air Pollution from Nonroad Diesel Engines and Fuel) engines is adopted by U.S. EPA for this horsepower category, the Board will consider adopting an engine certification in-use performance standard for ULETRU for <25 hp TRUs and TRU gen sets.

Stationary Source Division shall be considered in compliance. The Executive Officer will consider such submittals, publish, and make available a list of qualifying engines.

2. *Equipping the engine with the required Level of VDECS.*

(iii) As an alternative to meeting the ULETRU in-use performance standards in subsection (e)(1)(A)(i) and (ii), an owner/operator may operate a TRU or TRU gen set in California meeting one of the *Alternative Technology* options listed below. Alternative Technologies qualify to meet the ULETRU in-use performance standard only if the TRU or TRU gen set is operated under the conditions included in the description listed below.

a. Electric standby, provided that the TRU is not operated under diesel engine power while at a facility, except during an emergency.

b. Cryogenic temperature control systems or hybrid cryogenic temperature control systems, provided that the TRU does not operate under diesel engine power while at a facility, except during an emergency.

c. Alternative-fueled engines (see definition in subsection (d)). If the engine is a CI engine, a VDECS is required.

Note: If the engine is not a compression ignition diesel fueled engine, this regulation would not apply, but the engine may have to meet other emission standards (e.g. large spark-ignited engine standards if >25 hp).

d. Fuel exclusively with an alternative-diesel-fuel (see definition in subsection (d)) that has been verified as a VDECS, provided it is used in accordance with the requirements of subsection (e)(2)(A) and the alternative-diesel-fuel contains no convention diesel fuel.

e. Power by fuel cells. If a reformer is used, then emissions must be evaluated and verified through the *Verification Procedure Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines.*

f. Equip with any other system approved by the Executive Officer to not emit diesel PM or increase public health risk while at a facility.

(B) **In-Use Compliance Dates.**

(i) No owner/operator shall operate a 2001 and older model year (MY) TRU or TRU gen set engine in California unless it meets the in-use performance criteria set forth in paragraph (e)(1)(A) for

a. LETRU on or before December 31, 2008, <u>and</u>

b. ULETRU on or before December 31, 2015, as shown in Tables 4 and 5.

(ii) No owner/operator shall operate a 2002 MY TRU or TRU gen set engine in California unless it meets the in-use performance criteria set forth in paragraph (e)(1)(A) for

a. LETRU on or before December 31, 2009, <u>and</u>

b. ULETRU on or before December 31, 2016, as shown in Tables 4 and 5.

(iii) No owner/operator shall operate a 2003 MY and subsequent MY TRU or TRU gen set engine in California unless it meets the in-use performance criteria set forth in paragraph (e)(1)(A) for ULETRU on or before December 31st of the seventh year past the unit's model year, as shown in Tables 4 and 5.

Table 4: <25 HP TRU and TRU Gen Set Engines
In-Use Compliance Dates

MY	In-Use Compliance Year[2]													
	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20
'01 & Older									U	U	U	U	U	U
'02										U	U	U	U	U
'03[3]				U	U	U	U	U	U	U	U	U	U	U
'04					U	U	U	U	U	U	U	U	U	U
'05						U	U	U	U	U	U	U	U	U
'06							U	U	U	U	U	U	U	U
'07								U	U	U	U	U	U	U
'08									U	U	U	U	U	U
'09										U	U	U	U	U
'10											U	U	U	U
'11												U	U	U
'12													U	U
'13														U

[2] Compliance date is December 31st of the compliance year shown. "MY" means model year. Black shaded areas are years with no requirements since in-use compliance year precedes model year . Dark shaded areas without letter codes have no requirements, pending in-use compliance date. "L" means must meet LETRU in-use performance standards. "U" means must meet ULETRU in-use performance standards.

[3] TRUs and TRU gen sets with MY 2003 engines and subsequent MY engines shall be required to comply with ULETRU requirements by the end of the seventh year after the model year. The exception to this is ≥25 hp 2013 and subsequent model years, since these model years would meet ULETRU in-use performance standards as new engines.

Table 5: ≥ 25 HP TRU and TRU Gen Set Engines
In-Use Compliance Dates

MY	In-Use Compliance Year[4]													
	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20
'01 & Older									U	U	U	U	U	U
'02										U	U	U	U	U
'03[5]				U	U	U	U	U	U	U	U	U	U	U
'04					U	U	U	U	U	U	U	U	U	U
'05						U	U	U	U	U	U	U	U	U
'06							U	U	U	U	U	U	U	U
'07								U	U	U	U	U	U	U
'08									U	U	U	U	U	U
'09										U	U	U	U	U
'10'											U	U	U	U
'11												U	U	U
'12													U	U
'13														

(C) **Replacements Due to Failures.**

(i) If a VDECS fails within its warranty period, the owner/operator of the TRU or TRU gen set must replace it with the same VDECS or a higher verification classification level, if available.

(ii) If a VDECS fails outside its warranty period and a higher verification classification level VDECS is available, then the owner/operator of the TRU or TRU gen set shall upgrade to the highest level VDECS required under paragraph (e)(1)(A)(i) and (ii) that is determined to be cost-effective by the Executive Officer.

(D) **In-Use recordkeeping and reporting.** In-use recordkeeping and reporting shall be completed by the operator in accordance with the requirements of subsection (f)(1).

(E) **ARB Identification Numbering Requirements.** Identification numbers will be issued to help expedite the inspection procedure and prevent shipping delays.

(i) California-based TRUs and TRU gen sets:

[4] Compliance date is December 31st of the compliance year shown. "MY" means model year. Black shaded areas are years with no requirements since in-use compliance year precedes model year . Dark shaded areas without letter codes have no requirements, pending in-use compliance date. "L" means must meet LETRU in-use performance standards. "U" means must meet ULETRU in-use performance standards.

[5] TRUs and TRU gen sets with MY 2003 engines and subsequent MY engines shall be required to comply with ULETRU requirements by the end of the seventh year after the model year. The exception to this is ≥25 hp 2013 and subsequent model years, since these model years would meet ULETRU in-use performance standards as new engines.

a. On or before January 31, 2009, owner/operators of all California-based TRUs and TRU gen sets subject to this regulation shall apply for an ARB identification number for all California-based TRUs or TRU gen sets operated by the operator by submitting an application that includes the information listed below.

1. Operator name, address, and contact information for the responsible official (e.g. phone number, email address, fax number)

2. Owner name, address, and contact information (if other than operator)

3. TRU or TRU gen set make, model, model year, and serial number

4. TRU engine make, model, model year, and serial number

5. Terminal or terminals that the TRU is assigned to with address and contact information

6. Other associated identification numbers, which may include (as applicable):

   A. Vehicle Identification Number (truck's or trailer's VIN)

   B. Vehicle license number (e.g. truck's or trailer's)

   C. Railcar recording mark and car number

   D. Container number

   E. Company equipment number (if any)

7. Compliance status with paragraph (e)(1)(A) requirements. If compliance not as-yet required, mark N/A.

   A. Date when compliance was achieved

   B. What performance standard was met (e.g. LETRU or ULETRU)

   C. How compliance was achieved (e.g. new compliant TRU, TRU engine replacement, or description of VDECS that was used)

   D. Identify who did the installation work (if applicable)

b. Applications shall be submitted by one of the following methods:

   1. Mail or deliver a physical report to ARB at the address listed immediately below:

      California Air Resources Board
      Stationary Source Division
      P.O. Box 2815
      Sacramento, CA 95812

   2. Electronically submit through ARB's web site. The web address will be identified in an advisory.

c. TRUs and TRU gen sets added to an operator's TRU operations after January 31, 2009 shall be brought into compliance with subsection (e)(1)(E). An application shall be submitted to ARB within 30 days of the unit entering the operator's control:

   1. Requesting an ARB I.D. number for a new TRU or TRU gen set that was not previously numbered, or

   2. Requesting a change in owner or operator (or other pertinent application information) for used equipment that already has an ARB I.D. number.

d. Failure to apply or submittal of false information is a violation of state law subject to civil penalty.

e. On or before February 1, 2009, the Executive Officer shall begin issuing identification numbers to TRU and TRU gen set operators for each unit based in California for which a complete application has been filed. The number will include a 2-digit prefix for model year (e.g. 2001 model year would have a prefix 01); a 6-digit serial number; a check-digit, and a letter indicating compliance status with in-use performance standards (either "L" or "U"). In the event that an operator applies for an early compliance certificate in accordance with subsection (e)(1)(F), ARB will also issue a certificate which acknowledges early compliance per (e)(1)(F)(iii).

f. Within 30 days of receipt of the ARB-issued identification number, owner/operators shall permanently affix or paint the identification number on the TRU or TRU gen set chassis housing in clear view according to the following specification:

1. The ARB identification number shall be preceded by the letters "**ARB**"

2. Letters and numbers shall contrast sharply in color with the color of the background surface on which the letters are placed.

3. The location of the I.D. number shall be as follows:

   A. Truck and trailer TRUs - both sides of TRU chassis housing

   B. Rail car and container TRUs– both sides of the TRU

   C. TRU gen sets – both sides of gen set housing

4. Letters and numbers shall be readily legible during daylight hours, from a distance of 50 feet (15.24 meters) while unit is stationary.

5. Marking shall be kept maintained in a manner that retains the legibility required by the subparagraph immediately above.

(ii) Non-California-based TRUs and TRU Gen Sets:

a. Operators of non-California-based TRUs and TRU gen sets may voluntarily apply for ARB identification numbers for TRUs that are based outside of California but operate within California during the normal course of business. Non-California-based operators may voluntarily submit the same application information listed above in subparagraph (e)(1)(E)(i)a., above, using the same methods of submittal listed in subparagraph (e)(1)(e)(i)b., above. Upon application approval, ARB would issue identification numbers to the operator in accordance with subparagraph (e)(1)(E)(i)e., above. The non-California-based operator would then permanently affix or paint the identification number on the TRU or TRU gen set chassis in clear view, in accordance with (e)(1)(E)(i)f., above.

(F) **Early Compliance with LETRU In-Use Performance Standards.**

(i) For 2002 and older MY TRU and TRU gen set engines, operators or owners that meet the LETRU in-use performance standard earlier than required in paragraph (e)(1)(B) may apply to the Executive Officer for a delay in the ULETRU in-use performance standard. Except as provided below, early compliance would be achieved through any of the options available in paragraph (e)(1)(A).

a. This delay would not be available to the operator or owner if the engine manufacturer of the replacement engine is using the early compliance with engine emissions standards in U.S. EPA's Averaging, Banking, and Trading Program (or California's equivalent program)

b. Early compliance is conditioned upon real emission reductions (refer to definition in sub section (d)) occurring earlier than the applicable compliance deadline.

(ii) Early LETRU compliance with real emission reductions would allow specific units to delay compliance with ULETRU in-use performance standards by up to three years, according to the rounding conventions and examples listed below.

a. Each year of early compliance with the LETRU in-use performance standards would be rewarded with 1 year delay in the ULETRU in-use performance standard.

1. One full year early compliance qualifies for one full year delay in meeting ULETRU compliance.

2. Two full years early compliance qualifies for two full years delay in meeting ULETRU compliance.

3. Three full years early compliance qualifies for three full years delay in meeting ULETRU compliance.

b. A partial year of early LETRU compliance would be rounded to the nearest full year for the delayed ULETRU requirements.

1. Early LETRU compliance of 183 days or more in a calendar year would count toward a one year ULETRU delay

2. Early LETRU compliance of 182 days or less in a calendar year would not count toward a ULETRU delay.

(iii) Upon receipt of an application to delay ULETRU compliance, the Executive Officer shall determine if the application demonstrates early compliance with LETRU in-use performance standards in accordance with subsection (e)(1)(F)(i), and if the application is approved, shall delay the in-use ULETRU compliance date for specific TRUs and TRU gen sets operating in California in accordance with subparagraph (e)(1)(F)(ii).

(iv) Upon approval of the application, ARB shall issue a certificate and ARB identification number in accordance with subsection (e)(1)(E)(i)e. which acknowledges early compliance with LETRU requirements and discloses the number of years delay granted, and resulting ULETRU compliance date.

(v) The operator shall maintain a legible copy of the certificate in a water-tight sleeve mounted inside the TRU or TRU gen set chassis housing. The operator shall paint the identification number in clear view in accordance with subsection (e)(1)(E)(i)f. on the specific TRU or TRU gen set that was granted the compliance extension.

(2) **Fuel Requirements**:

(A) **Operators Choosing to Use Alternative-Diesel-Fuels**. Operators choosing to use alternative-diesel-fuels in compression ignition TRU and TRU gen set engines to meet the requirements of subsection (e)(1) shall:

(i) Maintain records in accordance with subsection (f)(1)(B) of this regulation.

(ii) Use only fuel that is a VDECS alternative diesel fuel that contains no conventional diesel fuel in TRUs or TRU gen sets operated in California.

(iii) Permanently affix a label in clear view near the fill spout that identifies the proper fuel that is required to be in compliance.

(iv) In the event that the operator decides to revert to using CARB diesel fuel, the operator shall comply with the requirements of subsection (e)(1) within 10 days of discontinuation of alternative diesel fuel use. Within 10 days of discontinuation, the operator shall notify the Executive Officer in writing of this change in fuel use and shall include an update to any ARB I.D. number application or annual report submitted to comply with subsections (e)(1)(E), (e)(1)(F), or (f)(1).

(B) **Operators that Retrofit TRUs or TRU Gen Sets with a VDECS**. Operators that retrofit TRUs or TRU gen sets with a VDECS that requires certain fuel properties to be met in order to achieve the required PM reduction or PM emissions shall only fuel the subject TRU or TRU gen set with fuel that meets these specifications when operating in the state of California. In addition, operators that choose a VDECS that requires certain fuel properties to be met in order to prevent damage to the VDEC or an increase in toxic air contaminants, other harmful compounds, or in the nature of the emitted PM shall only fuel the subject TRU or TRU gen set with fuel that meets these specifications.

(f) Monitoring, Recordkeeping, and Reporting Requirements

(1) **TRU and TRU gen set operator recordkeeping and reporting.**

(A) **Operator Reporting.**

(i) All operators subject to this regulation shall submit an Operator Report to ARB by January 31, 2009 that shall include the following information:

a. Operator name, address, and contact information for the responsible official (phone number, email address, fax number).

b. List of all terminals owned or leased by the operator located within California, with address, phone number, and terminal contact name.

c. TRU and TRU gen set inventory information for each TRU and TRU gen set based in California that is owned or leased by the operator:

1. TRU or gen set make, model, model year, and serial number

2. TRU owner, and if other than operator, owner name, address, and contact.

3. Engine make, model, model year, and serial number

4. Terminal(s) that the TRU is assigned to

5. ARB TRU or TRU gen set identification number, if already issued. If the ARB identification number has not been issued or there has been a change in the other identification numbers listed below since the prior annual report, then provide the following identification numbers (as applicable):

A. Vehicle Identification Number

B. Vehicle license number

C. Railcar recording mark and car number

D. Container number

E. Company equipment number

6. Compliance status with paragraph (e)(1)(A) requirements.

(ii) The Operator Report shall be updated within 30 days when changes to any of the above operator information occur.

a. Operator Reports shall be submitted by one of the following methods:

1. Mail or deliver a physical report to ARB at the address listed immediately below:

   California Air Resources Board
   Stationary Source Division
   P.O. Box 2815
   Sacramento, CA 95812

2. Electronically submit through ARB's web site. The web address will be identified in an advisory.

(iii) Failure to report or submittal of false information is a violation of state law subject to civil penalty.

(B) **Alternative Diesel Fuel Use and Fuel Additive Recordkeeping and Reporting.**

(i) Operators that choose a compliance pathway that involves the use of alternative-diesel-fuel in accordance with subparagraph (e)(1)(A)(iii)d. (e.g. B100 biodiesel fuel or ultra-low-aromatic synthetic diesel fuel) and/or a VDECS that includes the use of a fuel additive (e.g. fuel-borne catalyst) shall maintain records that document exclusive use of the chosen fuel or additive for each affected CI engine and hours of operation. Appropriate records would be copies of receipts or invoices of appropriate fuel and/or fuel additive and daily operating hour logs.

(ii) Records shall be kept available for a minimum of three (3) years and shall be compiled and made available to the ARB upon request.

(iii) Failure to keep records or submittal of false information is a violation of state law subject to civil penalty.

(2) **Facility monitoring, recordkeeping, and reporting.**

(A) **Facility Reporting**. All facilities subject to this subsection shall submit a Facility Report to ARB by January 31, 2005, containing the following information, as of December 31, 2004:

(i) Contact information for the facility's responsible official.

(ii) Provide all North American Industrial Classification System codes (NAICS) applicable to the facility.

(iii) The number of loading dock doors serving refrigerated storage space

(iv) The number of square feet of refrigerated storage space.

(v) The number of TRUs or TRU gen sets under facility control by model year and horsepower category.

(vi) The number of refrigerated trucks, trailers, containers, or railcars leased or rented.

(vii) The total annual TRU engine operating hours for all TRUs or TRU gen sets under facility control during 2004.

(viii) The average weekly number of inbound refrigerated trucks, trailers, containers, and railcars delivering goods to the facility during 2004.

(ix) The average weekly number of outbound refrigerated trucks, trailers, containers and railcars delivering goods from the facility during 2004.

(x) The average total number of hours per week that outbound TRU or TRU gen set engines operate while at the facility during 2004.

(xi) The average total number of hours per week that inbound TRU or TRU gen set engines operate while at the facility during 2004.

(B) **Recordkeeping.** Recordkeeping that substantiates the information reported in the Facility Report shall be maintained and shall be compiled and made available to State inspectors upon request for a minimum of three (3) years.

(C) ***Facility Report Submittals***. *Facility Reports shall be submitted by one of* the following methods:

(i) Mail or deliver a physical report to ARB at the address listed immediately below:

California Air Resources Board
Stationary Source Division
P.O. Box 2815
Sacramento, CA 95812

(ii) Electronically submit through ARB's web site. The web address will be identified in an advisory.

(D) **Failure to report or submittal of false information**. Failure to report or submittal of false information is a violation of state law subject to civil penalty.

(g) Prohibitions

(1) No person who is engaged in this State in the business of selling to an ultimate purchaser, or renting or leasing new or used TRUs or TRU gen sets, including, but not limited to, manufacturers, distributors, and dealers, shall intentionally or negligently import, deliver, purchase, receive, or otherwise acquire a new or used TRU or TRU gen set engine that does not meet the performance requirements or alternatives set forth in section (e)(1) above.

(2) No person who is engaged in this State in the business of selling to an ultimate purchaser new or used TRU or TRU gen set engines, including, but not limited to, manufacturers, distributors, and dealers, shall sell, or offer to sell, to an ultimate purchaser who is a resident of this State or a person that could reasonably be expected to do business in this State a new or used TRU or TRU gen set engine that does not meet the performance requirements or alternatives set forth in section (e)(1) above.

(3) No person who is engaged in this State in the business of renting or leasing new or used TRU or TRU gen set engines, including, but not limited to, manufacturers, distributors, and dealers, shall lease, offer to lease, rent, or offer to rent, in this state any new or used TRU or TRU gen set engine that does not meet the performance requirements or alternatives set forth in section (e)(1) above.

(4) Operators of affected facilities and operators of affected TRUs and TRU gen sets are prohibited from taking action to divert affected TRUs to alternate staging areas in order to circumvent the requirements of this section.

NOTE: Authority cited: sections 39600, 39601, 39618, 39658, 39659, 39666, 39667, 43013, 43018, California Health and Safety Code. Reference: sections 39618, 39650, 39658, 39659, 39666, 39667, 40717.9, 43013, and 43018.

APPENDIX B

TRU
DIESEL PM
CONTROL TECHNOLOGY OPTION MATRIX

TRU Diesel PM Control Tecl. ology Option Matrix[1] 10-1-03

Technology	PM/Nox Control Efficiency	Demonstrated in TRUs?	Cost[2]	Verified with ARB for TRU?	Pros	Cons
Biodiesel (100%)	25-50% PM; 12% NOx increase (can be reduced with additives and fuel system adjustments).[3]	No, but 200 hour tests on Yanmar 3-cylinder DI engine passed EMA tests with no problems.[4]	$1.25 to $1.50/gal plus taxes[5]; additional fueling infrastructure costs, if dual fuel needs.	No	No engine modifications necessary for post-1993; compared to diesel: higher Cetane, better lubricity, better energy balance, no sulfur, reduces greenhouse gas emissions, substantial reductions in PAH emissions.	Cost, higher BSFC, Viton hoses and seals required, shorter shelf life due to microbe growth (controlled with additives), higher pour point affects cold weather performance, operating practices necessary for contaminated rags, special monitoring & reporting required to assure use.
Electric standby	100% when in use at facility.	Yes	Truck: $350-$600 Trailer: $2000-$2600, plus facility infrastructure.[6]	NA	Dramatic reductions in health risk near facilities. Option now available for truck models and some trailer models.	No health risk reductions along roadways, current retrofit costs high.
Ultra-low aromatic synthetic diesel fuel: Fischer-Tropsch (GTL) Diesel	30% PM; 4-11% NOx[7]	No	$0.15 to $0.25 per gal more than CARB diesel.[8]	No	Available now. 0- 5 ppm sulfur, no aromatics in fuel – very low PAH emissions, 70+ cetane # - lower NOx.	Special monitoring & reporting required to assure use, 2-3% fuel penalty, Viton hoses and seals required, dual fuel infrastructure may be necessary, limited availability (but over 12 new plants under construction or design review for 2008 production.[9]

[1] Trade names mentioned herein do not imply ARB endorsement.
[2] Costs shown are based on best information now available. Annualized cost and cost-effectiveness will be analyzed as technologies are demonstrated.
[3] Dr. Shane Tyson, National Renewable Energy Lab; Technical Assistance Fact Sheet, U.S. Department of Energy, May 2001; R. L. McCormick, et. Al. Colorado School of Mines, "NOx Solutions for Biodiesel" Final Report to National Renewable Energy Labs, Contract No. XCO-0-30088-01.
[4] Peterson, C., Hammond, B., Reese, D., Thompson, J., Beck, S., "Performance and Durability Testing of Diesel Engines Using Ethyl and Methyl Ester Fuels", December, 1995. (Download at www.biodiesel.org.)
[5] Margi Marrero, National Biodiesel Board, 5-8-02 comments at TRU Workgroup meeting.
[6] Range of retail costs provided by ThermoKing and Carrier Transicold.
[7] California Energy Commission, "Gas-toLiquids (GTL) Fuel Fact Sheet", July 13, 2000.
[8] Gary Yowell, California Energy Commission, June 12, 2001 email to Rod Hill.
[9] See footnote 7.

807

808

Technology	PM/Nox Contr l Efficiency	Demonstrated in TRUs?	Cost	Verified with ARB for TRU?	Pros	Cons
Cryogenic Refrigeration (open cycle)[10]	100% PM 100% NOx	New trailer & truck models in production, hybrid systems in production for retrofit on straight truck units and under development for trailer units.	Cost models available. Unit list price is within 10% of diesel unit.	NA	Elimination of PM and NOx emissions, noise levels of 60 dB or less, available now for new truck and trailer, hybrid cryogenic systems currently available for retrofit on straight trucks.	Infrastructure for cryogenic fuel needs to be expanded for use in TRUs.
Active Particle Traps – electric regeneration (Rypos Trap)[11]	70-90% PM	No	Unknown	No	Independent of exhaust temp, sulfur level tolerant, low back pressure, no NO2 issue unless catalyzed.	Durability & cost unknown, may require generator upgrade, ash handling as hazardous waste, no CO or HC emission reduction.
Active Particle Trap – microwave regenerated[12]	95-98% PM	No	$500 - $1,000	No	Independent of Exhaust temp, sulfur level tolerant, low back pressure, low thermal mass, low power consumption	Durability needs additional testing.
Diesel Oxidation Catalysts (DOC))[13]	16-30% PM	R&D only	$400 - $600, $167 install'n, $64 - $712 annual maint.	No	Commercially available, installed on thousands of larger engines.	Sulfur content >500 ppm affects performance and durability.
CNG		Yes		NA	Available now. Reduces NOx and PM simultaneously.	Significant compliance costs for >25 hp LSI[14] Regulation, gaseous fuel supply, storage system, compression station, periodic tank inspections.
LPG		Under development		NA	Reduces NOx and PM simultaneously.	Same as CNG. Fuel cost is about twice that of conventional diesel.
Gasoline				NA	Reduces NOx & PM simultaneously, available at the pump.	Same LSI issue as for CNG and LNG, shorter engine life.

[10] Robert Geisen, Manager, Product Engineering, ThermoKing Corporation, March 13, 2002 email to Rod Hill. Also, reference Aurthur D Little Report for South Coast Air Quality Management District, February 28, 2001, SCAQMD Contract #97141.
[11] Frank DePetrillo, Rypos Inc, Innovative Clean Air Technologies proposal, "A Plan to Retrifit 3 Diesel Generatiors with Rypos/Bekaert System", February 20, 2001.
[12] Richard Nixdorf, Industrial Ceramic Solutions provided information for this entry, April 12, 2003.
[13] Nett Technologies, Catalytic Exhaust Products, Ltd; and Engelhard Corp provided the information for this entry, excerpted from the Diesel Risk Reduction Plan, Appendix IX
[14] LSI stands for [illegible]ge Spark-Ignited Engine.

Technology	PM/NOx Control Efficiency	Demonstrated in TRUs?	Cost	Verified with ARB for TRU?	Pros	Cons
Water emulsions-Lubrizol/PuriNox™ (Northern CA) or Chevron Texaco Proformix™[15] (Southern CA)	63% PM (74% with DOC); 14% NOx	No	$0.15 to $0.20 per gal more than CARB diesel in like quantities and like delivery distance.	No	Available now, EPA registered and verified, no engine modifications necessary, reduces NOx and PM reductions simultaneously, qualification for emission reduction credit.	Requires periodic agitation to extend shelf life, up to 20% power loss at peak power output, BSFC volumetric increase up to 15%, cold weather product not available in California.
Dual-fuel CNG/LPG Fumigation[16]	40-85% PM; 20-80% NOx	Yes	Conversion ~$800. Fuel tank cost is $4K to $4.5K for CNG, $350 for LPG. CNG - $0.98/equiv diesel gal[17]	No	Lower fuel costs (depends on current cost of fuels), reduced engine oil change frequency.	Gaseous fuel supply & storage system, compression station, periodic tank inspections, added fuel tank weight cuts into payload, marginal emission benefit at low speed/torque.
Fuel-borne Catalysts (FBC) @ 4-8 ppm[18]	10-25% PM (with no increase in the number of nanoparticles), minor reductions or no change in NOx[19]	Yes	On-board dosing system: $500-$1,000 (factory), $1500 to $3000 for field retrofit, + $0.05 to $0.10/gal. Slow release fuel filter could be $200-$300.	Clean Diesel Technologies in process. Rhodia and Lubrizol also in process for different dosing rates.	Improves fuel economy 10-20%, can be used in conjunction with a particle trap to enhance emission reduction.	Special monitoring and reporting required to assure FBC use, 5 year shelf life, if properly packaged to eliminate light exposure, higher FBC dosing rates may required trap to prevent ultrafines.
FBC + ULSD + B20 (Fuelborne catalyst plus ultra-low sulfur diesel plus 20% biodiesel)[20]	30-40% PM, No NOx increase.	No	$0.30 – 0.40/gal combined premium for biodiesel and FBC components.	No	No increase in NOx or BSFC.	Special monitoring and reporting required to assure biodiesel and FBC use. Higher FBC dosing rates may require trap to prevent ultra-fines.

[15] Lubrizol Corporation press release announcing CARB verification of PuriNox, 2-01-02; Kimberly Jones, Lubrizol Corp., 5/30/01 phone conversation with Rod Hill; Bill Hagstrand, Lubrizol Corp. email to Rod Hill, 7-7-03.
[16] Tom Sem, ThermoKing Corp., 1-29-02 email to Rod Hill and 7-29-02 follow-up questions. ARB has not reviewed detailed data.
[17] LNG cost/equivalent gallon from HEB in Texas. CNG cost/equivalent gallon from PG&E web site, 10/28/02.
[18] Jim Valentine, Clean Diesel Technologies, 9-10-02 email to Rod Hill.
[19] Valentine, J. M., Peter-Hoblyn, J. D., Acres, Dr. G. K., "Emission Reduction and Improved Fuel Economy Performance from a Bimetallic Platinum/Cerium Diesel Fuel Additive at Ultra-Low Dose Rates", SAE Paper #2000-01-1934.
[20] Information provided by Jim Valentine, Clean Diesel Technologies, 9-10-02.

608

810

Techn l gy	PM/NOx Control Efficiency	Demonstrated in TRUs?	Cost	Verified with ARB for TRU?	Pros	Cons
Passive Particle Traps (catalyzed diesel particulate filters – CDPFs)[21]	85-95% PM	Yes, but some issues with first prototype.	MECA[22] est. \$3,300 to \$5,000 initial cost[23], \$167 installation, \$156 annual maintenance.	No	Automatic regeneration if exhaust achieves regeneration temperature for necessary duration, CO & HC reductions.	Difficult match due to low exhaust temperatures; back pressure affects fuel economy, engine performance & life; annual maint., ash handling as hazardous waste, low sulfur fuel required to avoid sulfate formation, Increased NO2 emissions with some catalysts.
FBC + ULSD + DOC[24]	30-40% PM, 10% NOx	Testing underway @ Clean Air Systems (CAS)	\$300 to \$500 + \$0.05 to \$0.10/gal.	CDT in process.	Lightly catalyzed lower cost DOC; 3-7% fuel economy improvement; No NO_2 increase.	Special monitoring and reporting required to assure FBC use. Higher FBC dosing rates may require filter to prevent ultra-fines.
FBC + ULSD + DOC + FTF (flow-through filter).[25]	50-60% PM, 10% NOx	Testing underway @ CAS	\$600 to \$1000 + \$0.05 to \$0.10/gal	CDT in process.	Lightly catalyzed lower cost DOC; 3-7% fuel economy improvement; No NO_2 increase.	Special monitoring and reporting required to assure FBC use. Higher FBC dosing rates may require filter to prevent ultra-fines.
FBC + ULSD + Lightly Catalyzed DFP[26]	85% PM, 10% NOx	Testing underway @ CAS & TRU Mfr.	\$1500 to \$3500 + \$0.05 to \$0.10/gal	No	Lightly catalyzed lower cost DPF; passive regeneration @ 280 °C – 320 °C, No BSFC penalty; No NO_2 increase.	Must match exhaust temperatures, ash handling as hazardous waste.
Fuel Cells[27]	100% PM; 100% NOx (near zero emissions)	No	Unknown	NA	Near-zero emissions, lower greenhouse gas emissions, fuel economy, quieter operation, energy diversity.	Technical issues remain to integrate components to meet consumers' performance and cost demands.

[21] Nett Technologies, Engelhard Corp, and Clean Air Systems provided the information for this entry, excerpted from the Diesel Risk Reduction Plan, Appendix IX
[22] MECA stands for Manufacturers of Emission Controls Association.
[23] ThermoKing's experience is lower initial costs than MECA's estimate.
[24] Information provided by Jim Valentine, Clean Diesel Technologies, email to Rod Hill, 9-10-02.
[25] Information provided by Jim Valentine, Clean Diesel Technologies, email to Rod Hill, 9-10-02.
[26] Information provided by Jim Valentine, Clean Diesel Technologies, email to Rod Hill, 9-10-02.
[27] ARB Fact Sh[illegible] *Fuel Cell Electric Vehicles*, 1-09-02.

APPENDIX C

SUMMARY OF INFORMATION FROM MANUFACTURERS, OPERATORS, AND FACILITIES

APPENDIX C

SUMMARY OF INFORMATION FROM MANUFACTURERS, OPERATORS, AND FACILITIES

A. General Information

The table below summarizes general information gathered during the development of the Proposed Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units (TRUs) and TRU Generator Sets, and Facilities Where TRUs Operate (proposed ATCM). Staff greatly appreciate the cooperation of the many manufacturers, operators, and facility representatives who provided information about TRUs and TRU generator sets and their operation in California.

Information Requested	Responses
TRU and TRU Generator Set Configurations	• Straight Truck Van TRU with integral engine • Straight Truck Van TRU powered off truck engine • Semi-trailer Van TRU • Semi-trailer Van TRU with TRU generator set • Domestic Shipping Container TRU with integral engines • Shipping Container TRUs with TRU generator sets • Railcar TRUs with integral engines • "Road Railer" Trailer Van TRUs with integral engines or TRU generator sets
Responsibility for Operation and Maintenance	• By owner-operator; • Under terms of lease; and/or • Under terms of other contracts or agreements
TRU and TRU Generator Set Engine Life	20,000 to 30,000 hours of operation; however, most are replaced earlier (e.g. when vehicle is replaced)
TRU and TRU Generator Set Operation	1,000 to 3,000 hours per year; most cycle on and off but will continuously operate to run a fan when cargoes require continuous air flow
Age of Semi-trailer/Truck Vans, Railcars	Current Model Year to 30 or more years
Geographic Range of Commodity Transport by Semi-trailer/ Truck Vans	• Local • Regional • Intra-state • Inter-state • Canada • Mexico • Any combination of the above
Number of TRUs Per Semi-trailer/Truck Vans	Range: 1 to 1,300
Semi-trailer/Truck Van Road Time Per Trip	Range: 20 minutes to 72 hours Average or Mode: 13 hours
Semi-trailer/Truck Van Pre-chill Time	Range: 0 to 2 hours Average: 1 hour

Information Requested	Responses
Semi-trailer/Truck Van Time From Finished Loading to Departure	Range: 0 to 24 hours
Facility Operation	The majority of facilities schedule appointments for unloading. Electrical stand-by is not commonly provided because most TRUs are not equipped to operate on electrical stand-by and installation is costly.

APPENDIX D

OFFROAD MODEL CHANGE
TECHNICAL MEMO

ADDENDUM

to

OFFROAD Modeling Change Technical Memo

The OFFROAD Modeling Change Memo discussed that during the process of updating the emissions inventory for TRUs, engine manufacturers were asked to provide staff with data regarding TRU and TRU generator set PM engine emission rates. Although some manufacturers responded by providing PM emission factor estimates, no test data was received. The zero-hour rates provided by the manufacturers suggest lower zero-hour emission rates than currently assumed in the OFFROAD model. Staff attempted to validate these estimates by reviewing engine certification data in both the U.S. EPA and ARB engine certification data bases. However, using the engine models and engine families provided by the TRU engine manufacturers resulted in finding only a small fraction of the engines that have been used in TRUs since these engines required emissions certification. In the absence of new test data and engine certification data, staff chose to utilize the current OFFROAD PM emission factors.

It was noted in the OFFROAD Modeling Memo, however, that based on the manufacturers submission, the possibility exists that the zero hour emissions estimates of TRUs may be lower than currently assumed. To get an estimate of the potential magnitude of this difference, staff used the PM emission factors provided by the engine manufacturers to estimate the year 2000 statewide fleet average PM emissions factors for each horsepower category. Staff substituted the average manufacturer PM emission factor for each model year in which data was available from all engine manufacturers supplying engines in a horsepower category. The OFFROAD Model PM emission factors were applied to those model years where data was not available from all engine manufacturers supplying engines in a horsepower category. These factors were applied to the remaining model year populations of TRU and TRU generator sets that were modeled to be in use in year 2000. Deterioration factors from the OFFROAD Model and fuel factors that adjust emissions for sulfur content were applied. This produced a statewide PM emission factor that averaged 25percent less considering all horsepower categories than what was estimated using just the OFFROAD Model emission factors.

This difference was determined to be large enough to warrant an adjustment in the PM Emissions for years 2000 through 2020. The values that were calculated from the OFFROAD Model were multiplied by 75 percent to revise the PM emissions for 2000 from 2.65 tons per day to 1.98 tons per day and for 2010, the PM emissions were revised similarly from 3.19 tons per day to 2.23 tons per day. Table D-1 shows these revised emissions. Table D-1 also includes the assumptions that Tier 4 Nonroad emission standards would be implemented in 2008 ("interim standards) and 2013 ("long term standards) and that the ATCM would be implemented according to the proposed schedule.

Table D-1

TRU and TRU Generator Sets In Use Compliance Program Emissions Benefit

For Particulate Matter (PM) Emissions

CY	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
<15														
Baseline tpd	0.044	0.043	0.041	0.040	0.038	0.037	0.036	0.035	0.034	0.034	0.034	0.034	0.034	0.034
After tpd	0.044	0.043	0.033	0.032	0.029	0.027	0.025	0.024	0.022	0.022	0.022	0.023	0.024	0.025
Benefit tpd	0.000	0.000	0.008	0.008	0.009	0.010	0.011	0.012	0.012	0.012	0.011	0.011	0.010	0.010
15-25														
Baseline tpd	0.026	0.025	0.024	0.023	0.023	0.022	0.021	0.021	0.020	0.020	0.020	0.020	0.020	0.020
After tpd	0.026	0.025	0.019	0.019	0.017	0.016	0.015	0.014	0.013	0.013	0.013	0.013	0.014	0.014
Benefit tpd	0.000	0.000	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.006	0.006	0.006
25-50ca														
Baseline tpd	1.599	1.568	1.527	1.481	1.431	1.375	1.265	1.155	1.045	0.931	0.819	0.711	0.613	0.524
After tpd	1.599	1.568	1.131	1.075	0.963	0.880	0.754	0.631	0.506	0.396	0.380	0.308	0.245	0.180
Benefit tpd	0.000	0.000	0.396	0.405	0.467	0.495	0.511	0.524	0.539	0.535	0.439	0.403	0.368	0.345
25-50fed														
Baseline tpd	0.528	0.517	0.504	0.489	0.472	0.454	0.418	0.381	0.345	0.307	0.270	0.235	0.202	0.173
After tpd	0.528	0.517	0.373	0.355	0.318	0.290	0.249	0.208	0.167	0.131	0.125	0.102	0.081	0.059
Benefit tpd	0.000	0.000	0.131	0.134	0.154	0.163	0.169	0.173	0.178	0.176	0.145	0.133	0.122	0.114
25-50rail														
Baseline tpd	0.120	0.118	0.115	0.111	0.107	0.102	0.094	0.085	0.077	0.069	0.060	0.052	0.045	0.039
After tpd	0.120	0.118	0.084	0.080	0.072	0.065	0.056	0.047	0.037	0.029	0.028	0.023	0.018	0.013
Benefit tpd	0.000	0.000	0.030	0.031	0.035	0.037	0.038	0.039	0.040	0.040	0.032	0.030	0.027	0.025
25-50gensets														
Baseline tpd	0.084	0.084	0.085	0.085	0.086	0.087	0.083	0.078	0.073	0.067	0.060	0.053	0.047	0.042
After tpd	0.084	0.084	0.069	0.067	0.063	0.060	0.053	0.046	0.038	0.031	0.031	0.026	0.021	0.016
Benefit tpd	0.000	0.000	0.016	0.018	0.023	0.027	0.030	0.033	0.035	0.035	0.029	0.028	0.026	0.025

Sums from above

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Baseline w/ Tier 4	1.98	2.1	2.2	2.3	2.35	2.4	2.43	2.401	2.356	2.296	2.228	2.156	2.077	1.917	1.756	1.594	1.427	1.262	1.104	0.962	0.832
With TRU ATCM	1.98	2.1	2.2	2.3	2.35	2.4	2.43	2.401	2.356	1.710	1.628	1.462	1.338	1.152	0.970	0.783	0.623	0.599	0.495	0.402	0.307
Em Reduxns (tpd)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.586	0.600	0.695	0.739	0.765	0.786	0.811	0.805	0.664	0.610	0.559	0.525
Em Redux (tpy)	0	0	0	0	0	0	0	0	0	214	219	254	270	279	287	296	294	242	223	204	191

"Baseline" includes the effects of implementing "interim" Tier 4 Nonroad standards in 2008 and "long term" Tier 4 in 2013.

"After" includes the effects of implementing the TRU ATCM in-use performance standards with the following assumptions:

- 50% reduction for model year 2001 and previous, starting 2009 (December 31, 2008 compliance date).
- 50% reduction for model year 2002, starting 2010 (December 31, 2009 compliance date).
- 85% reduction for model years 2003 and subsequent, starting 7 years after model year (December 31, 2010 compliance date for 2007).
- 85% reduction for model year 2001 and previous, starting 2016 (December 31, 2015 compliance date).
- 85% reduction for model year 2002, starting 2017 (December 31, 2016 compliance date).

Staff plans to continue the effort to identify the certified emission values for all TRU engines that have been certified and the related deterioration factors that would apply. These factors will be used to improve the accuracy of the TRU and TRU generator set emission inventory.

TRU and TRU generator set NOx emissions were estimated using the OFFROAD Model as shown in Table D-2. The estimate included the assumptions that the Tier 4 Nonroad emission standards would be implemented in 2008 ("interim standards) and 2013 ("long term standards) and that there would be a 10 percent NOx reduction associated with implementation of the TRU ATCM.

Table D-2

TRU and TRU Generator Sets In Use Compliance Program Emissions Benefit For Oxides of Nitrogen (NOx) Emissions														
CY	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
<15														
Baseline tpd	0.832	0.822	0.814	0.807	0.804	0.805	0.809	0.819	0.838	0.860	0.887	0.918	0.954	0.995
After tpd	0.832	0.822	0.780	0.775	0.772	0.773	0.780	0.791	0.811	0.833	0.860	0.891	0.926	0.966
Benefit tpd	0.000	0.000	0.034	0.033	0.032	0.031	0.030	0.028	0.027	0.027	0.027	0.027	0.028	0.029
15-25														
Baseline tpd	0.474	0.474	0.474	0.475	0.476	0.479	0.482	0.487	0.494	0.503	0.513	0.525	0.538	0.553
After tpd	0.474	0.474	0.456	0.456	0.458	0.460	0.464	0.470	0.478	0.486	0.496	0.508	0.521	0.536
Benefit tpd	0.000	0.000	0.018	0.018	0.018	0.018	0.018	0.017	0.017	0.016	0.017	0.017	0.017	0.017
25-50ca														
Baseline tpd	15.202	15.550	15.933	16.368	16.874	17.442	17.392	17.419	17.486	17.578	17.706	17.859	18.059	18.298
After tpd	15.202	15.550	15.336	15.769	16.267	16.835	16.783	16.798	16.845	12.057	17.152	17.279	17.449	17.655
Benefit tpd	0.000	0.000	0.597	0.600	0.607	0.607	0.609	0.621	0.641	5.521	0.554	0.580	0.610	0.643
25-50fed														
Baseline tpd	5.017	5.132	5.258	5.402	5.569	5.756	5.740	5.748	5.771	5.801	5.843	5.894	5.960	6.038
After tpd	5.017	5.132	5.061	5.204	5.368	5.556	5.539	5.544	5.559	3.979	5.660	5.702	5.758	5.826
Benefit tpd	0.000	0.000	0.197	0.198	0.200	0.200	0.201	0.205	0.212	1.822	0.183	0.191	0.201	0.212
25-50rail														
Baseline tpd	1.120	1.146	1.174	1.206	1.243	1.285	1.282	1.284	1.288	1.295	1.305	1.316	1.331	1.348
After tpd	1.120	1.146	1.130	1.162	1.199	1.241	1.237	1.238	1.241	0.888	1.264	1.273	1.286	1.301
Benefit tpd	0.000	0.000	0.044	0.044	0.045	0.045	0.045	0.046	0.047	0.407	0.041	0.043	0.045	0.047
25-50gensets														
Baseline tpd	0.914	0.978	1.051	1.136	1.232	1.341	1.391	1.451	1.515	1.585	1.665	1.755	1.858	1.974
After tpd	0.914	0.978	1.025	1.106	1.200	1.306	1.353	1.409	1.469	1.175	1.623	1.710	1.809	1.921
Benefit tpd	0.000	0.000	0.026	0.029	0.032	0.035	0.039	0.042	0.046	0.410	0.042	0.045	0.049	0.053
Total Benefit tpd	0.000	0.000	0.916	0.922	0.935	0.937	0.941	0.958	0.990	8.203	0.862	0.903	0.950	1.002
Prepared by Sandee Kidd														
Date October 9, 2003														
In use compliance scenario provided by Toni Andreoni is shown in the worksheet "compliance".														
"Baseline" emissions assume that Tier 4 Nonroad standards are implemented in 2008 ("interim" standards) and 2013 ("long term" sta														
"After" emissions includes the effects of implementing the TRU ATCM in-use performance standards and assumes a 10% NOx reduc														

OFFROAD Modeling Change Technical Memo

SUBJECT: Revisions to the Diesel Transport Refrigeration Units (TRU) Inventory

LEAD: Sandee Kidd

SUMMARY

Transport refrigeration units (TRUs) are diesel powered cooling units that are installed on vehicles used in transporting produce, meat, dairy products, and other perishable goods. TRUs are found on refrigerated vans, trucks, trailers, and railroad cars.

TRU emissions are estimated in the Air Resources Board's (ARB or Board) OFFROAD model. Since late 2002, ARB staff obtained more up to date population and activity estimates from surveys of TRU manufacturers. We analyzed these data and are proposing to use the results to revise the input factors to the OFFROAD model. Staff proposes to revise the population, activity, load factor, average horsepower, survival rates, and useful life estimates for TRUs. These modifications are projected to decrease the emissions inventory of oxides of nitrogen (NOx) by 6.72 tons per day, and increase hydrocarbons (HC) by 4.60 tons per day and particulate matter (PM) by 0.03 tons per day, statewide in the year 2000 (See Table 1). For 2010, the emissions inventory is projected to increase by 0.84 tons per day for PM, 4.31 tons per day for NOx, and 4.61 tons per day for HC compared to the current estimates (See Table 2).

Table 1
Statewide TRU Emissions Inventory in Tons per Day in 2000

	PM	PM	NOx	NOx	HC	HC
Horsepower	**Existing**	**Proposed**	**Existing**	**Proposed**	**Existing**	**Proposed**
<15 hp	NA	0.06	NA	0.84	NA	0.11
15-25-hp	0.02	0.04	0.20	0.44	0.03	0.09
25-50 hp (CA)	0.43	1.82	2.80	12.67	1.64	6.75
25-50 hp Out-of-state	NA	0.60	NA	4.18	NA	2.22
25-50 hp (Rail)	NA	0.13	NA	0.93	NA	0.49
> 50 hp	2.17	NA	22.78	NA	3.39	NA
Totals	**2.62**	**2.65**	**25.78**	**19.06**	**5.06**	**9.66**

Table 2
Statewide TRU Emissions Inventory in Tons per Day in 2010

	PM	PM	NOx	NOx	HC	HC
Horsepower	**Existing**	**Proposed**	**Existing**	**Proposed**	**Existing**	**Proposed**
<15 hp	NA	0.06	NA	0.81	NA	0.09
15-25-hp	0.01	0.04	0.15	0.47	0.02	0.06
25-50 hp (CA)	0.40	2.20	2.64	16.37	1.35	6.11
25-50 hp Out-of-state	NA	0.73	NA	5.40	NA	2.02
25-50 hp Rail	NA	0.16	NA	1.21	NA	0.45
> 50 hp	1.94	NA	17.16	NA	2.56	NA
Totals	**2.35**	**3.19**	**19.95**	**24.26**	**3.93**	**8.74**

BACKGROUND

The emissions inventory for TRUs is calculated in the OFFROAD model in tons per day using the following equation:

Emission Inventory = Emission Rate*Population*Activity*Average Horsepower*Load Factor

The emission rates are pollutant specific and are expressed in grams/horsepower-hour (gms/hp-hr). Activity is expressed in hours/year or hours/day of engine run time. The "average horsepower" is defined as the average maximum rated horsepower within each horsepower group. The "load factor" is the average operation level in a given application and is expressed as a percent of the engine manufacturer's maximum horsepower ratings. The population estimate is a function of original sales, useful life and survival rate of the equipment.

With the exception of the emission rates, all other factors used in the current emissions inventory calculations were obtained from the 1997 Power Systems Research (PSR) report. PSR is an independent marketing firm involved in research and development related to engine product life cycles. The ARB approved the current emission inventory for diesel-powered TRUs in January of 2000.

INPUT FACTORS

Useful Life

Useful life is defined as the age at which at least fifty percent of the originally sold equipment population still exists. However, some of the remaining engines could last twice as long. Currently, the useful life for TRU's in the OFFROAD model is assumed to be 16 years. The staff proposes to reduce this estimate to 10 years based on the responses to the survey of TRU manufacturers.

Survival Rate

The survival rate curve describes the percentage of the original equipment population remaining in the fleet as a function of age. For TRU's, this estimate was obtained from the PSR database. However, based on conversations with manufacturers, it was determined that in the last ten years, the trend showing a rapid decrease in the population may not be realistic. Therefore, the survival rate of TRUs 11 to 20 years old was revised to reflect a more gradual decrease in population. In addition, survival rate for age 0 was modified from 0.5 to 1.0 to reflect that age 0 includes sales for the entire calendar year. Table 3 compares the survival rates from PSR at the useful life of 10 and 16 years, to the proposed survival rate.

TRU Sales

The current estimate of the population of TRUs by horsepower group was obtained from PSR. The proposed revision to the population was derived from national TRU sales data provided by TRU manufacturers and TRU engine manufacturers, reported for a twelve year period between 1991 and 2002 for each horsepower category. A curve fit of the data was performed to estimate the sales going back to 1981 for each horsepower category (See Charts 1, 2, and 3). The "Original Sales" data shown in Charts 1, 2, and 3 represent an estimate of the number of TRUs originally sold in a particular year in the entire U.S. and should not be confused with the actual population in a given calendar year.

Using the 1997 Commodity Flow Survey data from the U.S. Census Website (www.census.gov), it was determined that the truck ton-mile share in California compared to the entire U.S. for refrigerated goods is 6.4 percent. Refrigerated goods include meats, agricultural products and other prepared perishable goods. Therefore, 6.4 percent of the U.S. TRU sales in all horsepower groups were assumed to be in California.

Table 3
Comparison of TRU Survival Rates from Original Sales (%)

Age	Current (PSR) Survival Rate Useful Life = 10	Proposed Survival rate Useful Life = 10	Current (PSR) Survival rate Useful Life = 16
0	0.50	1.00	0.50
1	0.98	0.98	0.99
2	0.97	0.97	0.98
3	0.95	0.95	0.97
4	0.92	0.92	0.96
5	0.90	0.90	0.95
6	0.87	0.87	0.93
7	0.83	0.83	0.91
8	0.80	0.80	0.90
9	0.75	0.75	0.88
10	0.50	0.67	0.84
11	0.25	0.59	0.83
12	0.20	0.49	0.82
13	0.17	0.38	0.80
14	0.13	0.26	0.76
15	0.10	0.12	0.70
16	0.08	0.08	0.50
17	0.05	0.05	0.30
18	0.03	0.03	0.24
19	0.02	0.02	0.20
20	NA	NA	0.18
21	NA	NA	0.17
22	NA	NA	0.16
23	NA	NA	0.12
24	NA	NA	0.10
25	NA	NA	0.09
26	NA	NA	0.07
27	NA	NA	0.05
28	NA	NA	0.04
29	NA	NA	0.028
30	NA	NA	0.017
31	NA	NA	0.010
32	NA	NA	0.005

Chart1: TRU U.S. Sales for < 15 hp engines

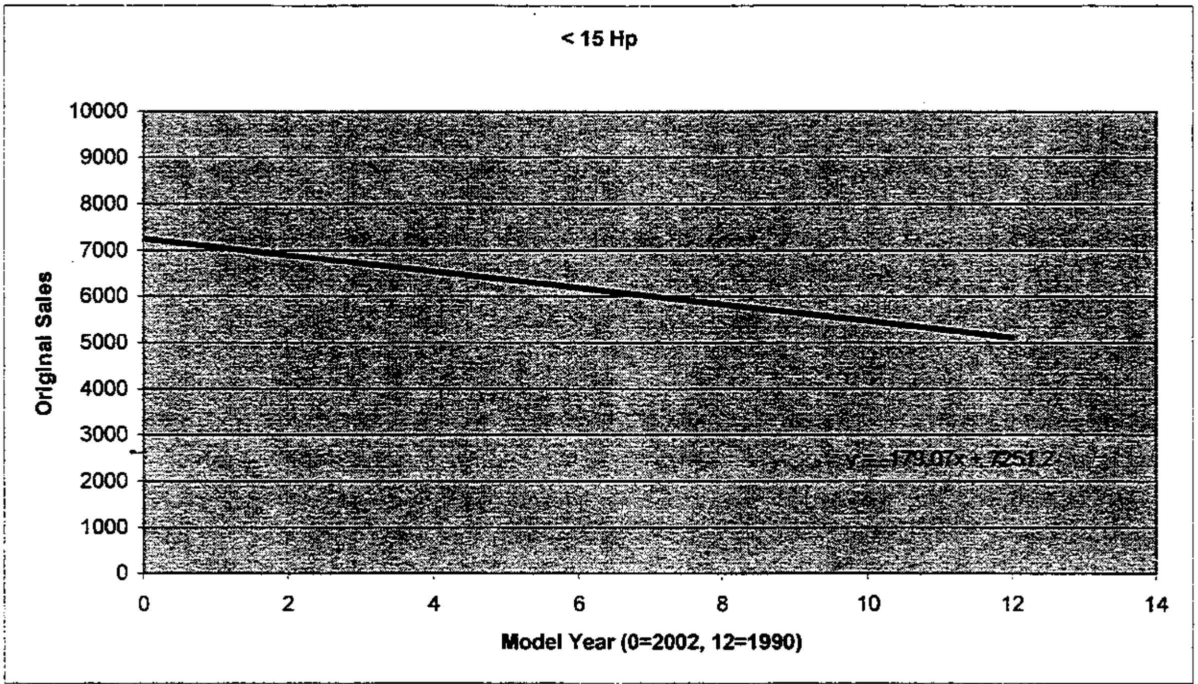


Chart 2: TRU U.S. Sales for 15-25 hp engines

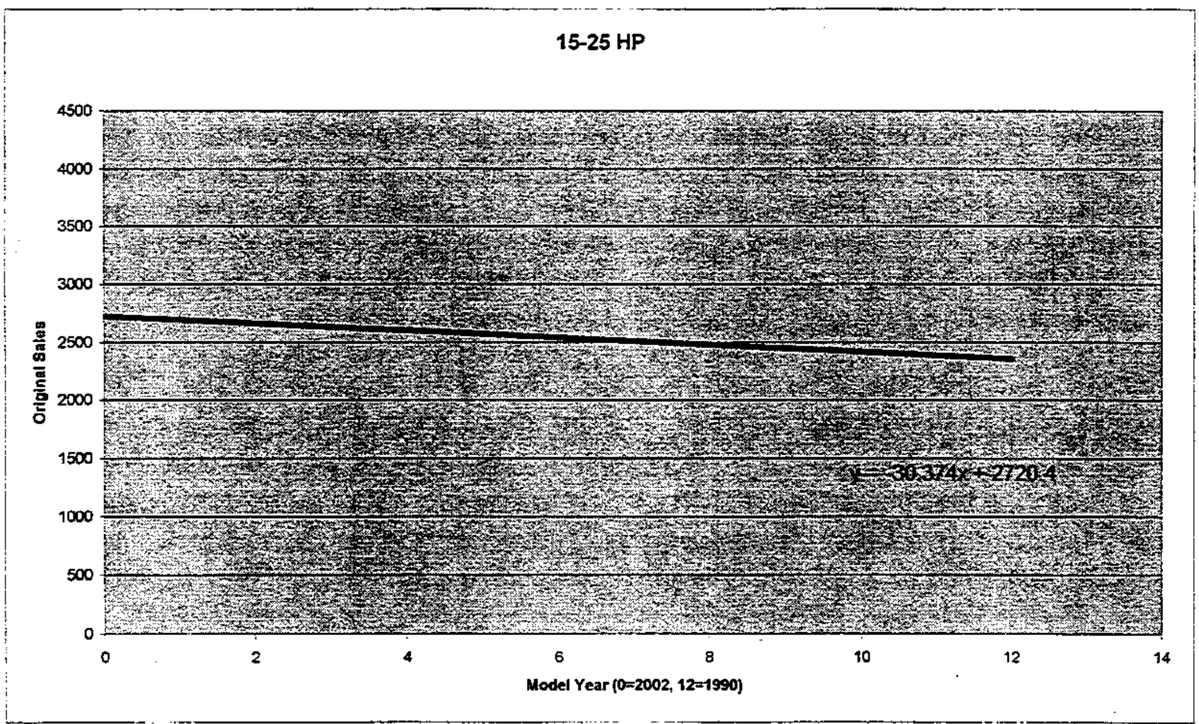
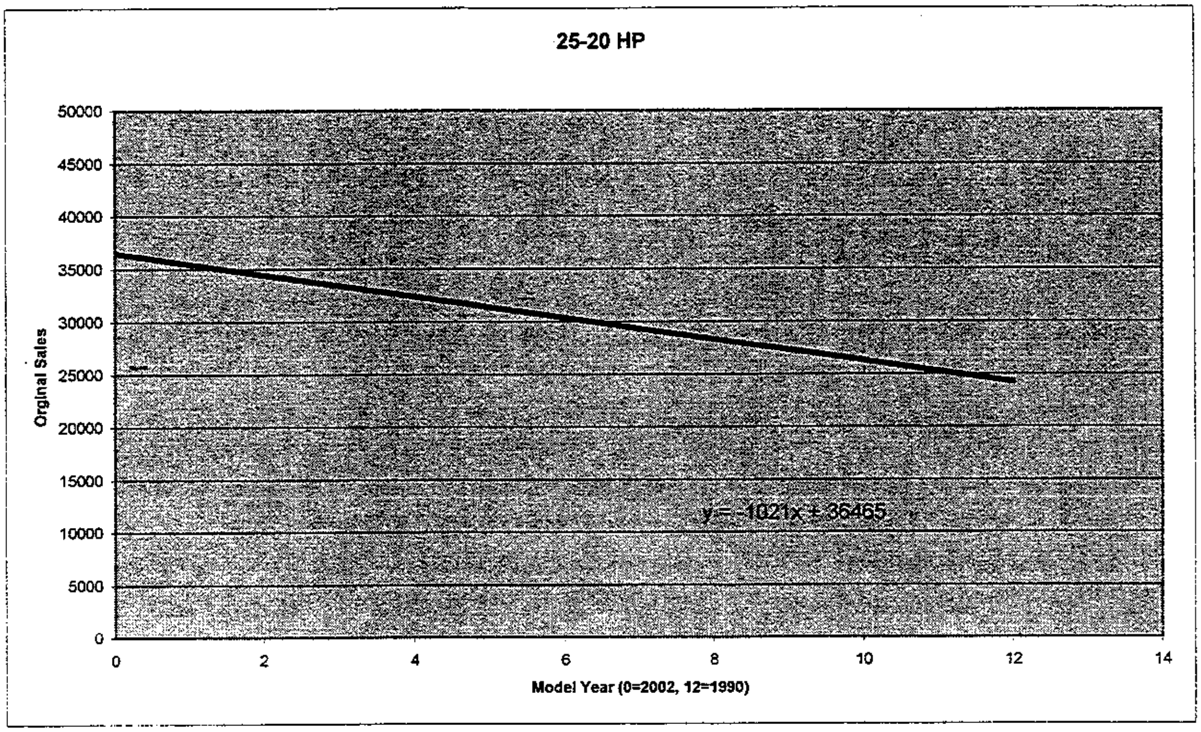


Chart 3: TRU U.S. Sales for 25-50 hp engines



Population

(CALIFORNIA REGISTERED TRU)

Using the manufacturers sales data and sales equations, 20 years of sales were estimated and the revised survival rates were applied to update the TRU population assumed to be installed on California registered, on-road vehicles as shown in Table 4. These numbers will be used in the offroad model.

(Out of State TRU)

In California's on-road vehicle emissions inventory model, EMFAC2002, it is assumed that 25 percent of the total heavy-heavy duty diesel (HHDD) truck population that travels on California roads are trucks registered outside of California. This equates to 33 percent of the California only HHDD trucks. Using the estimate cited above for the 25-50 hp category, staff included an additional 7,515 TRUs into the 25-50 hp group to account for TRUs operating in California that are installed on trucks registered out of state. For purposes of emissions calculation, staff assumed that these out of state TRUs have the same age distribution and usage as TRUs installed on California registered trucks.

(Railcar TRUs)

ARB staff also sent surveys to several railroad operators that do business in California regarding the use of refrigerated railcars. Staff used the American Association of Railroads UMLER files to obtain the U.S. population of railcars with mechanical refrigeration systems (reefer railcars). Reefer railcars use TRUs in the 25-50 hp group. Using the Commodity Flow Survey data mentioned earlier, it was determined that the rail ton-miles in California compared to the entire U.S. for refrigerated goods is 19 percent. Therefore, 19 percent of the U.S. reefer railcar usage was assumed to occur in California. Due to the lack of additional information, staff again assumed the same age distribution and usage for railcar TRUs as that used for TRUs that are installed on California registered trucks (See Table 4).

Table 4
Statewide TRU Population in CY 2000

Horsepower Group	Existing Population	Proposed Population
<15 hp (Ca)	0	4623
15-25 hp (Ca)	1517	1947
25-50 hp (Ca)	8412	22772
25-50 hp (Out of State)	0	7515
25-50 hp (Rail)	0	1678
>50 hp	30902	0
Total	**40831**	**38535**

Unlike the existing estimates in the OFFROAD model, data provided by manufacturers and railroad operators indicated that there are a significant number of TRUs under 15 hp and there are no TRUs over 50 hp.

Average Horsepower, Load Factor, and Usage

Each engine in a specific application is assumed to operate for the average annual number of hours at the average load factor number. The average horsepower values, load factor, and usage estimates currently used in the OFFROAD model were taken from the PSR database. Survey responses obtained from the manufacturers also provided data to update these estimates. The revised estimates are compared to current estimates in Table 6 that summarizes all of the current and proposed input factors used to calculate the TRU emissions inventory.

Growth Factors

Growth factors (GF) used to forecast yearly sales beyond the year 2000 are derived from socio-economic indicators (e.g., housing units and manufacturing employment) that are assumed to have a close relationship with the off-road equipment categories. Growth factors contained in the OFFROAD model were obtained from the 1994 study by California State University, Fullerton (CSUF) entitled "A study to Develop Projected Activity for Non-Road Mobile Categories in California, 1970-2020." Growth factors for the proposed revisions of the OFFROAD model for the TRU category are derived from the average growth indicated by yearly sales data provided by the manufacturers. Actual, rather than average growth factors were used for years where the sales data were available. Table 5 shows the growth factors by hp for 2003+ calendar years.

Table 5
Yearly Growth Factors for TRU for Calendar years 2003+

HP	GF (%)
<15	4.58
15-25	3.04
25-50	5.20

Table 6
TRU Input Factors

HP GROUPS	<15 hp	15-25 hp	25-50 hp	>50 hp
Average hp				
Existing	NA	17	39	56
Proposed	10	17	34	NA
Activity (hrs/yr)				
Existing	NA	750	1341	1341
Proposed	1038	1038	1465	NA
Load Factor				
Existing	NA	0.50	0.28	0.28
Proposed	0.64	0.64	0.53	NA
Population (CY 2000)				
Existing	0	1517	8412	30902
Proposed	4623	1947	31965	NA
Useful Life (yrs)				
Existing	NA	6	16	16
Proposed	10	10	10	NA
Fleet Average NOx gms/hp-hr (CY 2000)				
Existing	NA	6.82	7.53	11.61
Proposed	9.04	6.64	6.89	NA
Fleet Average PM gms/hp-hr (CY 2000)				
Existing	NA	0.60	1.15	1.10
Proposed	0.65	0.57	1.00	NA
Fleet Average HC gms/hp-hr (CY2000)				
Existing	NA	1.03	4.04	1.73
Proposed	1.19	1.28	3.72	NA

Emission Rates

The emission rates used in this analysis are those currently used in the OFFROAD model. These rates are based on pre-1995 diesel fuel. Fuel correction factors are applied in the model to reflect lower emissions due to low sulfur and aromatic content of 1995+ diesel fuel in California. Staff is not proposing to modify these estimates at this time (See Attachment A). Although the basic emission rates did not change, the proposed fleet average emissions as shown in Table 6 differ because the population distribution has been revised.

During the process of updating the emissions inventory for TRUs, engine manufacturers were asked to provide staff with data regarding their emission rates. Although some manufacturers responded by providing emission factor estimates, no test data was received. The zero hour rates provided by the manufacturers suggest lower zero hour emission rates than currently assumed in the OFFROAD model. Staff attempted to validate these estimates using certification data but found that only a small fraction of the in-use engines was represented in the manufacturers' submissions.

In the absence of new test data, staff chose to utilize the current OFFROAD emission factors. It should be noted, however, that based on the manufacturer submission, the possibility exists that the zero hour emissions estimates of TRUs may be lower than currently assumed. The current inventory reflect our best available estimate but the inventory will continue to be refined and improved as more data is collected.

GENERATOR SETS FOR TRUS (25-50HP)

The methodology used to estimate the emission inventory for generator sets used in TRU applications is similar to that described earlier in this document. Sales data were provided by generator set manufacturers for a ten year period between 1991 and 2000. Similar to TRUs, a curve fit of the data was performed to estimate the sales going back to 1981. Based on TRU generator set manufacturer's responses to ARB's surveys, the average horsepower, load factor and the activity was assumed to be 31 hp, 0.45 and 1100 hours per year, respectively. The useful life used was 10 years, which is the same as used for TRUs. In addition, emission factors used are the same as TRUs. Based on yearly sales data the yearly average growth factor was determined to be 10.2 percent. Table 7 shows the population along with the emissions in tons per day for the years 2000 and 2010.

Table 7
Statewide TRU Related Generator Sets for TRUs Emissions Inventory
(tons per day)

	PM Proposed	NOX Proposed	HC Proposed	POPULATION Proposed
CY 2000	0.08	0.59	0.29	1844
CY 2010	0.13	1.14	0.30	4870

REASON FOR CHANGE

In support of pending regulation and in light of new data made available by TRU manufacturers, staff is proposing to update the emissions inventory for this segment of the off-road engine population as outlined above.

METHODOLOGY

The current estimates of population, average horsepower, activity and load factor will be updated to conform to the data recently provided by TRU manufacturers. Reflecting these proposed changes will affect the emissions inventory for this category of engines.

Attachment A

MY Specific Emission Rates for Diesel Engines

		ZH (g/hp-hr)	DR (g/hp-hr2)	ZH (g/hp-hr)	DR (g/hp-hr2)	ZH (g/hp-hr)	DR (g/hp-hr2)	ZH (g/hp-hr)	DR (g/hp-hr2)
HP	Year	ROG	ROG	CO	CO	NOX	NOX	PM	PM
15	1994	1.50	0.00	5.00	0.00	10.00	0.00	1.00	0.00
15	1999	1.05	0.00	5.00	0.00	9.35	0.00	0.57	0.00
15	2004	0.68	0.00	3.47	0.00	6.08	0.00	0.47	0.00
15	2020	0.49	0.00	3.47	0.00	4.37	0.00	0.38	0.00
25	1994	1.84	0.00	5.00	0.00	6.92	0.00	0.764	0.00
25	1999	0.90	0.00	5.00	0.00	6.92	0.00	0.673	0.00
25	2004	0.64	0.00	2.34	0.00	5.79	0.00	0.382	0.00
25	2020	0.61	0.00	2.34	0.00	4.57	0.00	0.382	0.00
50	1987	1.84	2.35E-04	5.00	5.13E-04	6.90	1.04E-04	0.76	5.89E-05
50	1998	1.80	2.30E-04	5.00	5.13E-04	6.90	1.04E-04	0.76	5.89E-05
50	2003	1.45	1.85E-04	4.10	4.20E-04	5.55	1.03E-04	0.60	4.65E-05
50	2004	0.64	9.80E-05	3.27	3.34E-04	5.10	9.33E-05	0.43	3.36E-05
50	2005	0.37	6.90E-05	3.00	3.05E-04	4.95	9.67E-05	0.38	2.93E-05
50	2007	0.24	5.45E-05	2.86	2.90E-04	4.88	9.83E-05	0.35	2.72E-05
50	2020	0.10	4.00E-05	2.72	1.27E-04	4.80	1.00E-04	0.32	2.50E-05

*NOTE:
- 15 — 0 to 15 hp
- 25 — 16 to < 25 hp
- 50 — 25 to 50 hp

Composite Emission Factor = ZH + (DR * cumulative hours)

ZH - Zero hour

DR - Deterioration rate

831

APPENDIX E

METHODOLOGY FOR ESTIMATING THE POTENTIAL HEALTH IMPACTS FROM DIESEL TRANSPORT REFRIGERATION UNIT ENGINES

Methodology

This appendix presents the methodology used to estimate the potential cancer risk from exposure to diesel particulate matter (diesel PM) from Transport Refrigeration Units (TRU) with diesel engines. This methodology was developed to assist in the development of the proposed *Airborne Toxic Measure for In-Use Diesel-Fueled Transport Refrigeration Units and TRU Generator Sets, and Facilities where TRUs Operate.* The assumptions used to determine these potential cancer risks are not based on TRUs at a specific distribution facility, rather a generic (i.e. example) facility was developed. The source parameters selected include a broad range of possible operating scenarios. These estimated risks are used to provide an approximate range of potential risk levels from diesel TRU engine operations. Actual risk levels will vary due to site specific parameters, including the number of TRUs operating, emission rates, operating schedules, site configuration, site meteorology, and distance to receptors.

The methodology used in this risk assessment is consistent with the Tier-1 analysis presented in the draft OEHHA, Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA, 2003). These OEHHA draft guidelines and this assessment utilize health and exposure assessment information that is contained in the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors (OEHHA, 2003); and the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part IV, Technical Support Document for Exposure Analysis and Stochastic Analysis (OEHHA 2000), respectively.

The cancer health risk estimates provide "qualitative" assessment of the potential impacts due to the operation of diesel TRUs. Actual cancer health risks will depend on actual site specific parameters, including number of diesel TRUs operating at the facility, diesel particulate emission rates, facility operation schedules and configuration, and site meteorology. Actual risk will also vary depending on the distance a receptor is from the facility, the duration of exposure, and the inhalation rate.

A. Source Description

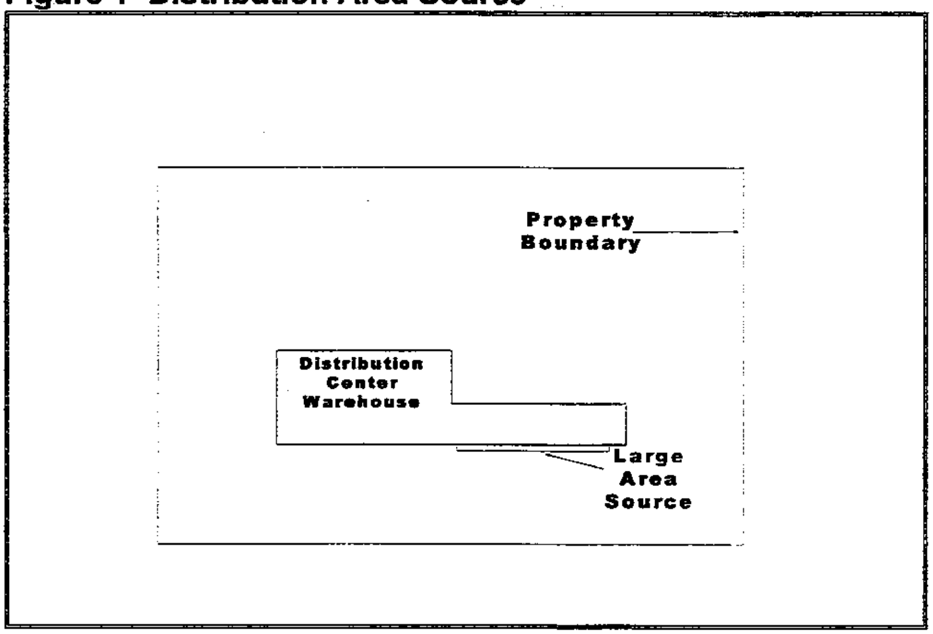
Potential cancer health risks due to diesel TRU operations are from emissions of diesel particulate matter (diesel PM). For these analyses, the emission sources were characterized as area sources where trailers equipped with diesel TRUs were expected to operate. Sensitivity studies were done to show that the point of maximum impact, usually the property boundary, shows little difference between characterizing the emissions as an area source comprised all TRU emissions or as numerous small point sources. These studies are shown in Appendix F.

The area source is modeled where the trailers sit while pulling down the trailers' interior temperature, filling the trailer with perishables, or delivering perishable goods. The distribution center sources were characterized as small, medium, and large areas of emissions. This section describes the parameters and results from the large distribution center area source (Figure 1). This figure is only given as an illustration of the modeling layouts and is not to scale.

The diesel TRUs operating within the large area source were assumed to be 35 horsepower (hp) with a 60 percent load factor and engine run time (no cycle-off time) as shown in Table 2 through Table 6. The hourly emission rate was conservatively assumed to be 0.7 grams per hp-hour (g/hp-hr), which is slightly less than the ARB year 2000 OFFROAD composite average model emission rate. Analyses were also developed using other diesel PM emission rates, including 1.0, 0.3, 0.22, and 0.02 g/hp-hr. Operation of the diesel TRUs within the area source was assumed to occur between 2 PM and 7AM, 7 days per week.

Sensitivity studies were done to determine buoyancy and final plume height achieved due to stack gas temperature and upward velocity. These studies led to the determination of a daytime and nighttime plume height used for the initial area source height, as shown in Table 1.

Figure 1 Distribution Area Source

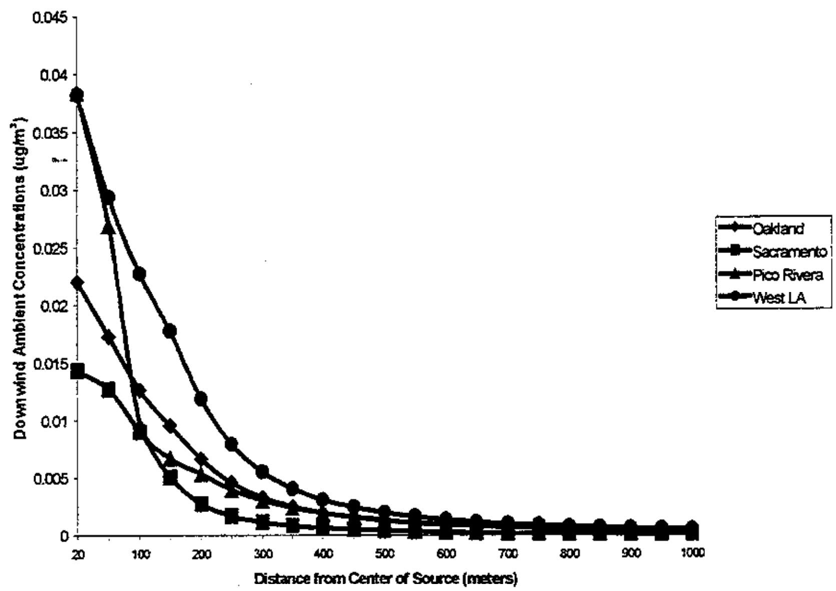


B. Dispersion Modeling Methods

The dispersion of the diesel PM emissions was estimated using the United States Environmental Protection Agency (U. S. EPA) ISCST3. ISCST3 can estimate potential ambient annual average concentrations of diesel PM as a result of diesel PM emissions from area sources.

The analyses used actual meteorological data collected at the West Los Angeles meteorological site during 1981. The West Los Angeles meteorological data provides a more conservative estimate of risk than most of the other 30 meteorological data sets available to ARB because this site tends to have lower average wind speeds predominantly from the same direction resulting in less dispersion of pollutants. Other representative meteorological data reviewed for these analyses include Sacramento, Oakland, and Pico Rivera. Figure 2 shows a comparison of maximum concentrations for the 4 meteorological data sets used for this assessment.

Figure 2 Comparison of Downwind Ambient Concentrations based on Four Meteorological Data Sets Used



Polar coordinate receptors were placed at specific incremental distances from the area sources to determine the maximum off-site impacts. For the large area source, receptors were placed at 50 meter increments from 100 meters to 500 meters and at 100 meter increments from 500 meters to 800 meters. Table 1 shows the source and modeling parameters used for this assessment.

Table 1: Dispersion Modeling Parameters

Source Type	area
Dispersion Setting	urban
Receptor Height	1.5 meters
Initial Vertical Dispersion Parameter (σ_z)	2.5 meters
Area Source Width	16.8 meters
Area Source Length	218.8 meters
PM Emission Factor	0.7 grams/hp-hr
Day (7 AM to 7 PM) Plume Height	4.46 meters
Night (7 PM to 7 AM) Plume Height	12.79 meters

C. Health Risk Assessment Methods

Maximum offsite concentrations were used to estimate potential cancer risk due to emissions of diesel PM. The maximum offsite ambient annual concentration, in micrograms per cubic meter ($\mu g/m^3$), is applied to the unit risk factor (URF) developed for diesel PM by OEHHA. This URF is 300 excess cancers per million people per $\mu g/m^3$ of exposure to diesel PM and assumes a residential exposure of 70 years. Other exposure parameters in OEHHA risk assessment guidelines (OEHHA, 2000 and OEHHA, 2003), including the revised breathing rate and cancer potency factor, are reflected in the assessment results.

Table 2 through Table 6 present the estimated range of potential cancer health risks at nearby receptor locations due to exposures to five diesel TRU PM emission rates (0.7, 1.0, 0.3, 0.22, and 0. 2 g/hp-hr) from a large area source. The cancer health risks are shown based on hours of diesel TRU operation and downwind distance of the receptor. The horizontal line shaded boxes show where potential cancer risks are greater than or equal to (≥) 100 per million. The grey shaded boxes show where potential cancer risks are less than (<) 10 per million. The unshaded boxes show where the potential cancer risk is ≥ 10 and < 100 per million.

Table 2 Estimated Range of Potential Cancer Health Risks (per million) due to TRUs Operating at a Large Distribution Area Source – 0.7 g/bhp-hr

Total Hours of TRU Engine Operation		Downwind Distance (m) from Center of Area Source											
Per Week	Per Year	100	150	200	250	300	350	400	450	500	600	700	800
100	5,200												
150	7,800												
200	10,400												
250	13,000												
300	15,600												
350	18,200												
400	20,800												
450	23,400												
500	26,000												
600	31,200												
700	36,400												
800	41,600												
900	46,800												
1,000	52,000												
1,100	57,200												
1,200	62,400												
1,300	67,600												
1,400	72,800												
1,500	78,000												

Meteorological Data: West LA (1981)
Emission Parameters: Engine Size - 35 hp, Engine Load Factor - 60%, Area Source.
Grey Shading shows Cancer Risks < 10/million
No Shading shows Cancer Risks ≥ 10/million and < 100/million
Horizontal Line Shading shows Cancer Risks ≥ 100/million
Annual emissions assume 52 weeks of operation

Table 3 Estimated Range of Potential Cancer Health Risks (per million) due to TRUs Operating at a Large Distribution Area Source – 1.0 g/bhp-hr

Total Hours of TRU Engine Operation		Downwind Distance (m) from Center of Area Source											
Per Week	Per Year	100	150	200	250	300	350	400	450	500	600	700	800
100	5,200												
150	7,800												
200	10,400												
250	13,000												
300	15,600												
350	18,200												
400	20,800												
450	23,400												
500	26,000												
600	31,200												
700	36,400												
800	41,600												
900	46,800												
1,000	52,000												
1,100	57,200												
1,200	62,400												
1,300	67,600												
1,400	72,800												
1,500	78,000												

Meteorological Data: West LA (1981)
Emission Parameters: Engine Size - 35 hp, Engine Load Factor - 60%, Area Source.
Grey Shading shows Cancer Risks < 10/million
No Shading shows Cancer Risks ≥ 10/million and < 100/million
Horizontal Line Shading shows Cancer Risks ≥ 100/million
Annual emissions assume 52 weeks of operation

Table 4 Estimated Range of Potential Cancer Health Risks (per million) due to TRUs Operating at a Large Distribution Area Source – 0.3 g/bhp-hr

Total Hours of TRU Engine Operation		Downwind Distance (m) from Center of Area Source											
Per Week	Per Year	100	150	200	250	300	350	400	450	500	600	700	800
100	5,200												
150	7,800												
200	10,400												
250	13,000												
300	15,600												
350	18,200												
400	20,800												
450	23,400												
500	26,000												
600	31,200												
700	36,400												
800	41,600												
900	46,800												
1,000	52,000												
1,100	57,200												
1,200	62,400												
1,300	67,600												
1,400	72,800												
1,500	78,000												

Meteorological Data: West LA (1981)
Emission Parameters: Engine Size - 35 hp, Engine Load Factor - 60%, Area Source.
Grey Shading shows Cancer Risks < 10/million
No Shading shows Cancer Risks ≥ 10/million and < 100/million
Horizontal Line Shading shows Cancer Risks ≥ 100/million
Annual emissions assume 52 weeks of operation

Table 5 Estimated Range of Potential Cancer Health Risks (per million) due to TRUs Operating at a Large Distribution Area Source – 0.22 g/bhp-hr

Total Hours of TRU Engine Operation		Downwind Distance (m) from Center of Area Source											
Per Week	Per Year	100	150	200	250	300	350	400	450	500	600	700	800
100	5,200												
150	7,800												
200	10,400												
250	13,000												
300	15,600												
350	18,200												
400	20,800												
450	23,400												
500	26,000												
600	31,200												
700	36,400												
800	41,600												
900	46,800												
1,000	52,000												
1,100	57,200												
1,200	62,400												
1,300	67,600												
1,400	72,800												
1,500	78,000												

Meteorological Data: West LA (1981)
Emission Parameters: Engine Size - 35 hp, Engine Load Factor - 60%, Area Source.
Grey Shading shows Cancer Risks < 10/million
No Shading shows Cancer Risks ≥ 10/million and < 100/million
Horizontal Line Shading shows Cancer Risks ≥ 100/million
Annual emissions assume 52 weeks of operation

Table 6 Estimated Range of Potential Cancer Health Risks (per million) due to TRUs Operating at a Large Distribution Area Source – 0.02 g/bhp-hr

Total Hours of TRU Engine Operation		Downwind Distance (m) from Center of Area Source											
Per Week	Per Year	100	150	200	250	300	350	400	450	500	600	700	800
100	5,200												
150	7,800												
200	10,400												
250	13,000												
300	15,600												
350	18,200												
400	20,800												
450	23,400												
500	26,000												
600	31,200												
700	36,400												
800	41,600												
900	46,800												
1,000	52,000												
1,100	57,200												
1,200	62,400												
1,300	67,600												
1,400	72,800												
1,500	78,000												

Meteorological Data: West LA (1981)
Emission Parameters: Engine Size - 35 hp, Engine Load Factor - 60%, Area Source.
Grey Shading shows Cancer Risks < 10/million
No Shading shows Cancer Risks ≥ 10/million and < 100/million
Horizontal Line Shading shows Cancer Risks ≥ 100/million
Annual emissions assume 52 weeks of operation

References

OEHHA, 2000. Office of Environmental Health Hazard Assessment (OEHHA), *Air Toxics "Hot Spots" Program Risk Assessment Guidelines Part IV Technical Support Document for Exposure Assessment and Stochastic Analysis.* www.oehha.ca.gov/air/hot_spots/finalStoc.html. September 2000.

OEHHA, 2002. Office of Environmental Health Hazard Assessment (OEHHA), *Air Toxics Hot Spots Program Risk Assessment Guidelines: Part II Technical Support Document for Describing Available Cancer Potency Factors.* www.oehha.ca.gov/air/cancer_guide/TSD2.html. December 2002.

OEHHA, 2003. Office of Environmental Health Hazard Assessment (OEHHA), *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments.* www.oehha.ca.gov/air/hot_spots/HRSguide.html. August 2003.

APPENDIX F

DIESEL TRANSPORT REFRIGERATION UNIT ENGINES SENSITIVITY STUDIES FOR DISPERSION MODELING

Initial Plume Height and Buoyancy Flux

Although the sources for the TRU health risk assessment were treated as area sources, it is recognized that the emission plume will have upward buoyancy flux due to the upward velocity of the engine exhaust and the temperature difference between the engine exhaust and the ambient air. To demonstrate this upward buoyancy, ARB staff performed several screening analyses based on: high speed versus low speed of the TRU engine; high exhaust temperature versus low exhaust temperature; night time ambient air temperatures versus day time ambient air temperatures; and unstable versus stable meteorological conditions.

Using SCREEN3, ARB staff charted the effective plume height based on scenarios encompassing the above variables. The largest difference in effective plume height was found when comparing night time and day time effective plume heights. These daytime and night time effective plume heights were used as the initial emission height based on operations occurring during day time hours (7 AM to 7 PM) or night time hours (7 PM to 7 AM). Ambient temperatures used to estimate these effective plume heights were 302 K (84° F) for operations occurring during day time hours and 280 K (44° F) for operations occurring during night time hours. Atmospheric stability was set to emulate conservative day and night time conditions. For these analyses SCREEN3 was modeled using "F" stability for night conditions and "D" stability for day conditions. The resulting effective plume heights, and initial emission heights used for our analyses were a day time initial emission height of 4.46 meters and an initial emission height of 12.79 meters for night time conditions.

The initial vertical dispersion parameter (σ_z) used for this analysis both for day and night time conditions was 2.5 meters. This value was determined using the methods described in the ISCST3 user's guide.

Characterization as an area source and a point source

Sensitivity studies were done to demonstrate that impacts from TRU emissions would show little difference when the source is characterized as area or point. The table below shows a comparison of cancer health impacts due to a TRU engine modeled as an area source and as a point source. The table is only used to illustrate the similarity of modeled impacts as point and area sources particularly.

Difference in Potential Cancer Risk due to Point and Area Source TRUs (Risk per million)

Total TRU Hours of Operation per Week	Downwind Distance (m) from Sources									
	40	60	80	100	120	140	160	180	200	220
7	-24	-10	-5	-3	-1	-1	-1	-1	-1	-1
14	-48	-19	-9	-4	-2	-2	-2	-2	-2	-2
20	-69	-27	-13	-6	-4	-3	-3	-2	-3	-2
30	-103	-40	-19	-9	-6	-4	-4	-4	-3	-3
40	-137	-53	-25	-12	-8	-6	-6	-5	-4	-4
50	-171	-67	-32	-15	-10	-7	-6	-6	-5	-4

Meteorological Data: West Los Angeles (1981)
Emission Rate = 0.7 g/bhp-hr.
Emission Parameters: Engine Size - 35 hp, Load Factor - 60%.
Annual emissions assume 52 weeks of operation, 6 AM - 9 PM

APPENDIX G

SUMMARY OF MISCELLANEOUS METHODOLOGIES FOR COST ANALYSIS

APPENDIX G

SUMMARY OF MISCELLANEOUS METHODOLOGIES FOR COST ANALYSIS

A. Costs to ARB

One-time compliance education and outreach costs are estimated as follows:

	Low	High
In-House Educational Material Design (8 pages, black-and-white):	$1,000	$1,000
Printing Cost for Educational Material— 8 pages x $0.05/page x 4,674 – 10,073 stakeholders:	$1,870	$4,015
Postage— $0.60/piece x 4,674 – 10,073 stakeholders:	$2,804	$6,022
Printing Cost for Educational Material (Trade Show Distribution[1])— 8 pages x $0.05/page x 2,000 pieces:	$ 800	$ 800
Total:	$6,474	$11,837
Total (rounded):	**$6,500**	**$12,000**

The proposed ATCM will impose a cost to the ARB for TRU enforcement, for record management, and for issuing ARB identification numbers to operators or owners of TRUs. Initial costs to the ARB primarily involve developing the TRU database for tracking in-use TRUs and facility operations throughout the state. Additional cost will be incurred from enforcement activities through the ARB's existing Heavy-Duty Vehicle Inspection Program performed at various CHP weigh stations throughout California and at various food distribution or cold storage facilities. The ARB is expected to incur annual costs to implement the TRU ATCM, but anticipates that the costs will be absorbed within existing budgets.

The Executive Officer has also determined that the proposed regulatory action will not create costs or savings in federal funding to the State.

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[1] Trade show distribution is assumed to be through existing ARB Enforcement Division trade show participation; may also include distribution of educational materials to TRU and engine manufacturers and dealers as needed.

B. Determination of Number of Affected Businesses, Including the Establishment of a Small Business Definition for the Purposes of This ATCM

The total number of businesses directly affected by this ATCM consists of those businesses visited by and/or operating TRUs within the State of California. The number of affected businesses differs from the TRU inventory discussed in earlier chapters of this report due to the fact that affected businesses may own or operate more than one TRU, or none at all; some businesses are only visited by TRUs and do not operate any.

A relatively small number (less than 100) of affected businesses are involved in direct TRU-related activities, such as the distribution, sale, and servicing of TRUs.

B.1. Number of Businesses Operating TRUs

Direct information on the number of businesses that operate TRUs is not available. TRUs are not subject to any known registration program, and although Department of Motor Vehicles (DMV) registration records do indicate whether a truck or trailer is refrigerated, it is not possible to determine from the records if the vehicle has a TRU that is subject to this regulation.

For the analysis purposes of this ATCM, the following criteria were used to determine if a business may be classified as meeting the small business definition:

Table G-1
Summary of Small Business Determination Criteria

Business Type	Small Business Criteria	Estimated Percentage of Affected Businesses Meeting Sm. Bus. Criteria
Facility Visited by TRUs	Has Fewer Than 20 Employees	81
TRU Operator	Has 20 or Fewer TRUs	66

Meeting the small business criteria does not relieve business owners of any obligations under this ATCM. The small business criteria were used for analysis purposes and establishment of the facility reporting requirement threshold.

Typical businesses are considered the remainder of the affected business population; 19 percent of facilities, 34 percent of TRU operators.

B.1.1. Number of TRU Operators

The number of operators was estimated by examination of the California Highway Patrol (CHP) Biennial Inspection of Terminals (BIT) list and an insurance industry-based list (FleetSeek) of vehicle operators. The examination eliminated from the lists those businesses whose names obviously indicated that they were unlikely to have TRUs; for example, concrete sales and construction businesses. From these lists, the estimated number of California vehicle operators possibly having TRUs is 1,477 to 5,500. It is estimated that 25% of the total TRUs in California are from out of state; we apply this percentage to estimate the number of out-of-state businesses operating TRUs in California:

Lower Limit of Estimated Range (California operators) x 0.33 = Estimated Out-of-State Operators
(33% of smaller number equals 25% of total)

1,477 x 0.33 = 492

Performing the same calculation on the upper limit of the estimated range (California operators) gives 1,832 out-of-state operators. (ARB, 2003)

To summarize:

Table G-2
Estimated Number of TRU Operators

	Low	High
California	1,477	5,500
Out-of-State	492	1,832
Total	1,969	7,332
Total (rounded)	2,000	7,300

B.1.2. Number of Facilities Where TRUs Operate

Direct information on the number of California facilities where TRUs operate is not available. The facility requirement of this regulation only applies to facilities located in California. Since most facilities where TRUs operate are subject to state or federal licensing programs, lists of the licensees in the programs that were likely to involve TRUs (wholesale food distribution, dairy products, etc.) were obtained and the number of facilities was tabulated. It is recognized that some facilities may appear on more than one list, due to overlapping licensing requirements and/or business conditions that may require more than one license. This possible duplication will tend to overstate the actual number of facilities; however, the extent of this effect is minor, and may be partially or totally offset by businesses that may not appear on the lists. (DFA, 2002) (DHS,2003) (USDA, 2003)

Table G-3
Facility Count From Licensing Program Lists

Name of Licensing Program	Number of Facilities	Affected Facilities
CA Dept of Health Services—Wholesale Food Facilities	6,413	2,164
CA Dept. of Food & Agriculture—Meat & Poultry	620	209
CA Dept. of Food & Agriculture—Milk Plants	50	17
CA Dept. of Food & Agriculture—Egg Handlers	350	118
US Dept. of Agriculture—HACCP Large Facility	12	4
US Dept. of Agriculture—HACCP Small Facility	294	99
US Dept. of Agriculture—HACCP Very Small Facility	278	94
Total	8,017	2,705

This is the estimated number of California facilities where TRUs operate; however, not all facilities will experience costs associated with the reporting requirement of this regulation. Only facilities meeting certain criteria must report. Due to a lack of data, complete adjustments to the total number of facilities to determine the actual number of facilities that must complete and submit a facility report are not possible. However, for a subset of the DHS licensee list, data on the number of employees per facility are available. This is one of the criteria for determining if a facility must submit a report. Using these data, a percentage of facilities with 20 or more employees was determined, and this percentage was applied to the facility total to provide some adjustment to refine the total number of facilities that must submit a report.

Number of Facilities With 20 or More Employees / Total Number of Facilities Reporting Number of Employees Information = Ratio of Facilities With 20 or More Employees

635/1882 = 0.3374 ~ 33.74%

Total Number of Facilities x Ratio of Facilities With 20 or More Employees = Adjusted Total Number of Facilities (itemization is shown in the table above)

8,017 x 0.3374 = 2,705 ~ 2,700 (rounded)

Since data were not available to adjust the total for the other criteria triggering a facility report, the number calculated above is considered the upper bound of the estimated number of facilities that are required to report. This is a conservative estimate, as it assumes that all facilities with 20 or more employees will have to provide a facility report, when it is known that an undetermined number of facilities will be exempted due to other provisions in the regulation. To provide a conservative lower bound, the same number was used for the lower bound. This was done to account for facilities that may not appear in any of the consulted licensee lists.

Adding the number of operators and facilities gives the total number of businesses affected:

Table G-4
Total Number of Affected Businesses

Category	Low	High
Number of Operators	1,969	7,332
Number of Facilities (20 or more employees)	2,705	2,705
Total	4,674	10,037
Total (rounded)	4,700	10,000

B.2 Number of Small Businesses Affected by the Regulation

The determination as to whether a given business can be considered small is typically performed by examining one or more indicators of the business' activity level (revenue, number of employees, etc.) and comparing the indicator(s) against the limits contained in the small business definition. Small business definitions can vary by type of industry and from organization to organization making the definition. Typically, small business definitions are established with a specific objective in mind, such as eligibility for financial assistance or preferential treatment in awarding purchase orders. Based upon the analysis below, small businesses (for the purpose of this analysis) are considered *those operating 20 or fewer* TRUs; *facilities with fewer than 20 employees are also* considered small businesses.

B.2.1. Operators (Small Business)

Both California Highway Patrol (CHP) and insurance industry data (FleetSeek) were examined for indicators that could be used to determine appropriate criteria for assessing whether a business could be considered small. Although revenue information is available, it is incomplete and therefore was considered unsuitable for analysis purposes. Other common business activity indicators, such as the number of employees, business physical size, etc., were not readily available for the data set.

Complete information was available on the number of vehicles per business, and though detailed information on the number of vehicles with TRUs for a given business was not available, it is assumed that the number of vehicles per business is an indicator of the volume of business activity of a company. It was also assumed that the number of vehicles was equal to the number of TRUs operated by a business.

Given the range of vehicle fleet sizes (one to over 100 per business), and the assumption that businesses with one to five vehicles could safely be considered small businesses, a chart of the frequency distribution of the number of vehicles (Estimated Fleet Size of Motor Carriers with (or Likely to Have) TRUs) (Chart 2 in this Appendix) *was examined for a natural break point in the distribution. Starting from the smallest* fleet size (one to five vehicles) and working towards the largest, the number of businesses (carriers) drops quickly, not rising again until the 21 to 25 vehicle point. At this break point in the distribution, 1,084 fleets have 20 or fewer vehicles and are assumed to be small businesses. This is based on examination of a data set consisting of information for 1,338 fleets. Dividing the total number of operators (total number of businesses analyzed) by the number of small businesses gives a ratio that can be applied to the operator numbers calculated above to give the number of small businesses.

Number of Small Businesses / Total Number of Businesses Analyzed = Ratio of Small Businesses (operators)

1,084 / 1,338 = 0.8102

Applying this ratio to the operator estimates above gives the following range:

Table G-5
Number of Small Businesses (operators)

	Low	High
California	1,197	4,456
Out-of-State	399	1,484
Total	1,596	5,940
Total (rounded)	1,600	6,000

B.2.2 Facilities (Small Business)

The number of employees per facility was the indicator examined to determine appropriate criteria for assessing whether a business could be considered small. Other common business activity indicators, such as annual revenue, business physical size, etc., were not readily available. Number of employees per facility data were available for 1,882 facilities. Examination of a chart of the frequency distribution of the number of employees per facility (Number of Employees per Facility 6 (2/bin)) (Chart 1 in this Appendix) shows that there is a drop in the frequency distribution at the 20 employee point, with a rise in the number of facilities with less than or greater than this quantity. At this break point in the distribution, 1,247 facilities have fewer than 20 employees and are assumed to be small businesses. Using the quantity of facilities with fewer than 20 employees and the total number of facilities for which employee quantity data are available, a ratio can be calculated:

Quantity of Facilities With Fewer Than 20 Employees / Total Number of Facilities With Available Data = Ratio of Small Businesses (facilities)

1,247/1882 = 0.6625

Applying this ratio to the estimated number of facilities from above gives the following number:

8,017 x 0.6625 = 5,311

This is the number of facilities that would be considered small businesses and would not be included in the facility reporting requirements outlined in the ATCM. Therefore, these businesses would not incur any costs associated with facility reporting.

The only small businesses affected by the ATCM would be those operating TRUs. Since none of the facilities classified as a small business under the criteria given above are affected by the facility provisions of this ATCM, their contribution to the total number of affected small businesses is zero.

Table G-6
Number of Small Businesses Affected by the Regulation (total)

	Low	High
California	1,197	4,456
Out-of-State	399	1,484
Total	1,596	5,940
Total (rounded)	1,600	6,000

ATCM Annual Total Cost Apportionment Between Facilities and TRU Operators

To place the ATCM costs in perspective, the costs attributed to both facilities and operators are expressed below as percentages.

The range of annual (for a 13-year period) operator and facility costs are itemized as follows:

	Low	High
Operators—		
In-Use:	$4,175,634	$8,113,805
Reporting:	$78,760	$2,346,240
Sub-Total:	$4,254,394	$10,460,045
Percentage of Total:	96	67
Facilities—		
Reporting (annualized):	$198,200	$5,145,153
Sub-Total:	$198,200	$5,145,153
Percentage of Total:	4	33
Total	$4,452,594	$15,605,198
Total (rounded):	$4,500,000	$16,000,000

C. Cost Analysis Matrices and Charts

Matrix 1

Used to calculate the in-use compliance cost for the low and high ends of the cost range for VDECS Scenario (assumed 100% application of the listed technologies to the in-use fleet at time of compliance) and the two alternatives, Electric Standby Retrofit (Alternative #1) and Cryogenic Technology (Alternative #2). As for the VDECS Scenario, 100% application of the listed technology to the eligible in-use fleet is assumed.)

For each scenario, the TRU engine population for each category is multiplied by the costs for the assumed compliance technology. Costs used are initial and annual, with the initial cost (cost of compliance equipment and installation labor) spread out over an assumed ten-year useful life, taking into account the time value of money. The annual cost includes recurring costs attributable to the compliance technology, over and above those currently experienced by a TRU operator for diesel use. The costs per engine category are then summed for a given year to arrive at an annual cost, for that year.

Matrix 1a

This matrix is used to calculate the in-use compliance cost for the engine/TRU replacement scenario. Instead of VDECS in-use compliance costs, this matrix uses engine and TRU replacement costs for the calculations. It uses the same methodology as Matrix #1, but apportions an assumed fifteen percent for new TRUs and forty percent for engine replacement to calculate the in-use compliance cost for this scenario.

Matrix 2

For the VDECS scenario, this matrix is used to calculate the ATCM's annual and total costs, as well as its cost effectiveness.

Matrix 2a

For the engine/TRU replacement scenario, this matrix is used to calculate the annual and total costs, as well as the cost effectiveness.

Matrix 3

This matrix is used to calculate the cost effectiveness, as well as the annual and total costs of Alternative #1.

Matrix 4

This matrix is used to calculate the cost effectiveness, as well as the annual and total costs of Alternative #2.

Chart 1

Used to examine the distribution of the number of employees per facility and select a threshold for a small business definition for facilities visited by TRUs.

Chart 2

This chart shows the distribution of fleet sizes for motor carriers with (or likely to have) TRUs. Used to help select a small business threshold for TRU operators.

References

ARB, 2003. Air Resources Board. Preliminary Draft Summary—California Motor Carriers With (or Likely to Have) TRUs. June 6, 2003

DFA, 2002. California Department of Food and Agriculture, California Department of Food and Agriculture Confidential Databases for Meat and Poultry - April 2002 Floppy Disk, Milk Plants - January 2002, and Egg Handlers - August 2002.

DHS, 2003. California Department of Health Services, California Department of Health Services Database for Wholesale Food Facilities, February 2003.

USDA, 2003. U.S. Department of Agriculture Databases for Hazard Analysis Critical Control Program (HACCP) Large and Small Facilities. Floppy Diskette. June 2003.

In-Use Complia[illegible] Range Estimates Oct. 12, 03 #1

This Matrix calculates the in-use cost of compliance for TRUs and TRU gen sets ("TRUs".) It takes the annual TRU population numbers (same as used for emissions inventory purposes) and multiplies them by the capital and annual costs for the compliance technology shown.
The capital costs are amortized over an assumed ten-year useful life, and all annual costs are converted to constant year (2002) dollars using standard present worth analysis techniques.
Four different scenarios are shown, the first two are the low and high cost ends of the range of expected in-use compliance costs, and the last two are the alternative technologies examined for the economic impact statement in the Form 399.
In each scenario, on a year-by-year basis, population figures for each engine category are multiplied by a compliance cost component (annualized capital or annual maintenance); these products are then summed to determine the compliance cost for a given year.

Interest Rates Used for Present Worth Analysis		
Capital Costs:	0.05	Real interest rate, which is a 7% nominal rate minus an assumed 2% inflation rate
Annual Costs:	0.05	Real interest rate, which is a 7% nominal rate minus an assumed 2% inflation rate

Assumptions: 10-year useful life for compliance technology; capital cost is amortized over a 10-year period.

Low-Cost Scenario: Assume 1200 Hours/Year TRU/Gen Set Operation

In-Use Compliance Technology Used

	Cap. Cost	Ann. Cost - TRUs	Ann. Cost - Gen Sets	Notes
LETRU: FBC + CWMF	$2,050	$107	$97	FBC = Fuel-Borne Catalyst, CWMF = Catalyzed Wire Mesh Filter
ULETRU: LPG Dual-Fuel Pilot Injection	$2,300	$0	$0	

Engine Population Category

Engine Model Year	Calendar Year	< 15hp	15-25 hp	25-50 hp CA-based	25-50 hp Out-of-State	25-50 hp Gen Sets CA-based	25-50 hp Gen Sets Out-of-State	25-50 hp Reefer Railcar	Total 25-50 hp (Info Only)	Total (this year)	Annualized Capital Cost[1]
-2001	2008	2125	880	11162	3721	656	285	622	16846	18851	$265
2002	2009	311	124	1419	473	156	52	105	2205	2640	$265
2003	2010	328	128	1493	498	172	57	110	2330	2784	$298
2004	2011	340	132	1571	524	169	63	116	2463	2935	$298
2005	2012	356	136	1652	551	209	70	122	2604	3098	$298
2006	2013	372	140	1738	579	230	77	128	2752	3264	$298
2007	2014	389	144	1829	610	254	85	135	2913	3448	$298
2008	2015	407	148	1924	641	279	93	142	3079	3634	$298
2009	2016	426	153	2024	675	308	103	149	3259	3838	$298
2010	2017	445	157	2129	710	339	113	157	3448	4050	$298
2011	2018	465	162	2240	747	374	125	165	3651	4276	$298
2012	2019	486	167	2356	785	412	137	174	3864	4517	$298
2013	2020	509	172	*	*	*	*	*	*	681	$298
	2021	*	*	*	*	*	*	*	*	*	
	2022	*	*	*	*	*	*	*	*	*	
	2023	*	*	*	*	*	*	*	*	*	
	2024	*	*	*	*	*	*	*	*	*	
	2025	*	*	*	*	*	*	*	*	*	
	2026	*	*	*	*	*	*	*	*	*	
	2027	*	*	*	*	*	*	*	*	*	
	2028	*	*	*	*	*	*	*	*	*	
	2029	*	*	*	*	*	*	*	*	*	
										59014	Total

Capital Cost Subtotal

Calendar Year	< 15hp												
2008	$564,134												
2009	$564,134	$82,563											
2010	$564,134	$82,563	$97,099										
2011	$564,134	$82,563	$97,099	$101,269									
2012	$564,134	$82,563	$97,099	$101,269	$106,035								
2013	$564,134	$82,563	$97,099	$101,269	$106,035	$110,800							
2014	$564,134	$82,563	$97,099	$101,269	$106,035	$110,800	$115,664						
2015	$564,134	$82,563	$97,099	$101,269	$106,035	$110,800	$115,664	$121,225					
2016	$564,134	$82,563	$97,099	$101,269	$106,035	$110,800	$115,664	$121,225	$126,884				
2017	$564,134	$82,563	$97,099	$101,269	$106,035	$110,800	$115,664	$121,225	$126,884	$132,543			
2018		$82,563	$97,099	$101,269	$106,035	$110,800	$115,664	$121,225	$126,884	$132,543	$138,500		
2019			$97,099	$101,269	$106,035	$110,800	$115,664	$121,225	$126,884	$132,543	$138,500	$144,755	
2020				$101,269	$106,035	$110,800	$115,664	$121,225	$126,884	$132,543	$138,500	$144,755	$151,606
2021					$106,035	$110,800	$115,664	$121,225	$126,884	$132,543	$138,500	$144,755	$151,606
2022						$110,800	$115,664	$121,225	$126,884	$132,543	$138,500	$144,755	$151,606
2023							$115,664	$121,225	$126,884	$132,543	$138,500	$144,755	$151,606
2024								$121,225	$126,884	$132,543	$138,500	$144,755	$151,606
2025									$126,884	$132,543	$138,500	$144,755	$151,606
2026										$132,543	$138,500	$144,755	$151,606
2027											$138,500	$144,755	$151,606
2028												$144,755	$151,606
2029													$151,606

Capital Cost Subtotal

Calendar Year	15-25 hp										
2008	$233,618										
2009	$233,618	$32,919									
2010	$233,618	$32,919	$38,125								
2011	$233,618	$32,919	$38,125	$39,316							
2012	$233,618	$32,919	$38,125	$39,316	$40,508						
2013	$233,618	$32,919	$38,125	$39,316	$40,508	$41,699					
2014	$233,618	$32,919	$38,125	$39,316	$40,508	$41,699	$42,890				
2015	$233,618	$32,919	$38,125	$39,316	$40,508	$41,699	$42,890	$44,082			
2016	$233,618	$32,919	$38,125	$39,316	$40,508	$41,699	$42,890	$44,082	$45,571		
2017	$233,618	$32,919	$38,125	$39,316	$40,508	$41,699	$42,890	$44,082	$45,571	$46,762	
2018		$32,919	$38,125	$39,316	$40,508	$41,699	$42,890	$44,082	$45,571	$46,762	$48,252
2019			$38,125	$39,316	$40,508	$41,699	$42,890	$44,082	$45,571	$46,762	$48,252
2020				$39,316	$40,508	$41,699	$42,890	$44,082	$45,571	$46,762	$48,252
2021					$40,508	$41,699	$42,890	$44,082	$45,571	$46,762	$48,252
2022						$41,699	$42,890	$44,082	$45,571	$46,762	$48,252
2023							$42,890	$44,082	$45,571	$46,762	$48,252
2024								$44,082	$45,571	$46,762	$48,252
2025									$45,571	$46,762	$48,252
2026										$46,762	$48,252
2027											$48,252
2028											
2029											

* In-Use Affected Population = 0; Assumes Full Introduction of EPA Tier 4 Engines into TRU/Gen Set Fleet

[1] This is the annualized capital cost of the appropriate in-use compliance technology used to meet LETRU or ULETRU requirements as appropriate. The interest rate used is given at the top of this matrix.

[2] This is the annual cost of maintaining the in-use complaince technology over and above that for diesel technology. It may include items such as more-frequent engine servicing, cost of fuel-borne catalyst or other additive, and/or servicing of emission-control device(s).

High-Cost Scenario: Assume 3,000 Hours/Year TRU/Gen Set Operation

In-Use Compliance Technology Used

	Cap. Cost	Ann. Cost - TRUs	Ann. Cost - Gen Sets	Notes
LETRU: FBC + CWMF	$2,050	$281	$97	FBC = Fuel-Borne Catalyst, CWMF = Catalyzed Wire Mesh Filter
ULETRU: LPG Dual-Fuel Pilot Injection	$2,300	$0	$0	

Engine Population Category

Engine Model Year	Calendar Year	< 15hp	15-25 hp	25-50 hp CA-based	25-50 hp Out-of-State	25-50 hp Gen Sets CA-based	25-50 hp Gen Sets Out-of-State	25-50 hp Reefer Railcar	Total 25-50 hp (Info Only)	Total (this year)	Annualized Capital Cost[1]
-2001	2008	2125	880	11162	3721	656	285	622	16846	18851	$265
2002	2009	311	124	1419	473	156	52	105	2205	2640	$265
2003	2010	328	128	1493	498	172	57	110	2330	2784	$298
2004	2011	340	132	1571	524	169	63	116	2463	2935	$298
2005	2012	356	136	1652	551	209	70	122	2604	3098	$298
2006	2013	372	140	1738	579	230	77	128	2752	3264	$298
2007	2014	389	144	1829	610	254	85	135	2913	3448	$298
2008	2015	407	148	1924	641	279	93	142	3079	3634	$298
2009	2016	426	153	2024	675	308	103	149	3259	3838	$298
2010	2017	445	157	2129	710	339	113	157	3448	4050	$298
2011	2018	465	162	2240	747	374	125	165	3651	4276	$298
2012	2019	486	167	2356	785	412	137	174	3864	4517	$298
2013	2020	509	172	*	*	*	*	*	*	681	$298
	2021	*	*	*	*	*	*	*	*	*	
	2022	*	*	*	*	*	*	*	*	*	
	2023	*	*	*	*	*	*	*	*	*	
	2024	*	*	*	*	*	*	*	*	*	
	2025	*	*	*	*	*	*	*	*	*	
	2026	*	*	*	*	*	*	*	*	*	
	2027	*	*	*	*	*	*	*	*	*	
	2028	*	*	*	*	*	*	*	*	*	
	2029	*	*	*	*	*	*	*	*	*	
										59014	Total

Capital Cost Subtotal

Calendar Year	< 15hp												
2008	$564,134												
2009	$564,134	$82,563											
2010	$564,134	$82,563	$97,099										
2011	$564,134	$82,563	$97,099	$101,269									
2012	$564,134	$82,563	$97,099	$101,269	$106,035								
2013	$564,134	$82,563	$97,099	$101,269	$106,035	$110,800							
2014	$564,134	$82,563	$97,099	$101,269	$106,035	$110,800	$115,664						
2015	$564,134	$82,563	$97,099	$101,269	$106,035	$110,800	$115,664	$121,225					
2016	$564,134	$82,563	$97,099	$101,269	$106,035	$110,800	$115,664	$121,225	$126,884				
2017	$564,134	$82,563	$97,099	$101,269	$106,035	$110,800	$115,664	$121,225	$126,884	$132,543			
2018		$82,563	$97,099	$101,269	$106,035	$110,800	$115,664	$121,225	$126,884	$132,543	$138,500		
2019			$97,099	$101,269	$106,035	$110,800	$115,664	$121,225	$126,884	$132,543	$138,500	$144,755	
2020				$101,269	$106,035	$110,800	$115,664	$121,225	$126,884	$132,543	$138,500	$144,755	$151,606
2021					$106,035	$110,800	$115,664	$121,225	$126,884	$132,543	$138,500	$144,755	$151,606
2022						$110,800	$115,664	$121,225	$126,884	$132,543	$138,500	$144,755	$151,606
2023							$115,664	$121,225	$126,884	$132,543	$138,500	$144,755	$151,606
2024								$121,225	$126,884	$132,543	$138,500	$144,755	$151,606
2025									$126,884	$132,543	$138,500	$144,755	$151,606
2026										$132,543	$138,500	$144,755	$151,606
2027											$138,500	$144,755	$151,606
2028												$144,755	$151,606
2029													$151,606

Capital Cost Subtotal

Calendar Year	15-25 hp										
2008	$233,618										
2009	$233,618	$32,919									
2010	$233,618	$32,919	$38,125								
2011	$233,618	$32,919	$38,125	$39,316							
2012	$233,618	$32,919	$38,125	$39,316	$40,508						
2013	$233,618	$32,919	$38,125	$39,316	$40,508	$41,699					
2014	$233,618	$32,919	$38,125	$39,316	$40,508	$41,699	$42,890				
2015	$233,618	$32,919	$38,125	$39,316	$40,508	$41,699	$42,890	$44,082			
2016	$233,618	$32,919	$38,125	$39,316	$40,508	$41,699	$42,890	$44,082	$45,571		
2017	$233,618	$32,919	$38,125	$39,316	$40,508	$41,699	$42,890	$44,082	$45,571	$46,762	
2018		$32,919	$38,125	$39,316	$40,508	$41,699	$42,890	$44,082	$45,571	$46,762	$48,252
2019			$38,125	$39,316	$40,508	$41,699	$42,890	$44,082	$45,571	$46,762	$48,252
2020				$39,316	$40,508	$41,699	$42,890	$44,082	$45,571	$46,762	$48,252
2021					$40,508	$41,699	$42,890	$44,082	$45,571	$46,762	$48,252
2022						$41,699	$42,890	$44,082	$45,571	$46,762	$48,252
2023							$42,890	$44,082	$45,571	$46,762	$48,252
2024								$44,082	$45,571	$46,762	$48,252
2025									$45,571	$46,762	$48,252
2026										$46,762	$48,252
2027											$48,252
2028											
2029											

* In-Use Affected Population = 0; Assumes Full Introduction of EPA Tier 4 Engines into TRU/Gen Set Fleet

[1] This is the annualized capital cost of the appropriate in-use compliance technology used to meet LETRU or ULETRU requirements as appropriate. The interest rate used is given at the top of this matrix.

[2] This is the annual cost of maintaining the in-use complaince technology over and above that for diesel technology. It may include items such as more-frequent engine servicing, cost of fuel-borne catalyst or other additive, and/or servicing of emission-control device(s).

198

Matrix #1

Alternative 1 Scenario: Use of Electric Standby Retrofit-- Assume 1,200 Hours/Year TRU/Gen Set Operation[3]

In-Use Compliance Technology Used	Cap. Cost	Ann. Cost - TRUs	Ann. Cost - Gen Sets	Notes
LETRU: Electric Standby Retrofit	$15,600	$519		
ULETRU: Electric Standby Retrofit	$15,600	$519		

Engine Population Category / Capital Cost Subtotal

Engine Model Year	Calendar Year	< 15hp	15-25 hp	25-50 hp CA-based	25-50 hp Out-of-State	25-50 hp Gen Sets CA-based	25-50 hp Gen Sets Out-of-State	25-50 hp Reefer Railcar	Total 25-50 hp (Info Only)	Total (this year)	Annualized Capital Cost[1]	< 15hp												
-2001	2008	2125	880	11162	3721	856	285	822	16846	19851	$2,020	$4,292,925												
2002	2009	311	124	1419	473	156	52	105	2205	2640	$2,020	$4,292,925	$628,282											
2003	2010	326	128	1493	498	172	57	110	2330	2784	$2,020	$4,292,925	$628,282	$658,585										
2004	2011	340	132	1571	524	189	63	118	2463	2935	$2,020	$4,292,925	$628,282	$658,585	$686,868									
2005	2012	356	136	1652	551	209	70	122	2604	3096	$2,020	$4,292,925	$628,282	$658,585	$686,868	$719,191								
2006	2013	372	140	1738	579	230	77	128	2752	3264	$2,020	$4,292,925	$628,282	$658,585	$686,868	$719,191	$751,514							
2007	2014	389	144	1829	610	254	85	135	2913	3446	$2,020	$4,292,925	$628,282	$658,585	$686,868	$719,191	$751,514	$785,858						
2008	2015	407	148	1924	641	279	93	142	3079	3634	$2,020	$4,292,925	$628,282	$658,585	$686,868	$719,191	$751,514	$785,858	$822,221					
2009	2016	426	153	2024	675	306	103	149	3259	3838	$2,020	$4,292,925	$628,282	$658,585	$686,868	$719,191	$751,514	$785,858	$822,221	$860,605				
2010	2017	445	157	2129	710	339	113	157	3448	4050	$2,020	$4,292,925	$628,282	$658,585	$686,868	$719,191	$751,514	$785,858	$822,221	$860,605	$898,989			
2011	2018	465	162	2240	747	374	126	165	3651	4278	$2,020		$628,282	$658,585	$686,868	$719,191	$751,514	$785,858	$822,221	$860,605	$898,989	$939,393		
2012	2019	486	167	2356	785	412	137	174	3864	4517	$2,020			$658,585	$686,868	$719,191	$751,514	$785,858	$822,221	$860,605	$898,989	$939,393	$981,817	
2013	2020	509	172	*	*	*	*	*	*	681	$2,020				$686,868	$719,191	$751,514	$785,858	$822,221	$860,605	$898,989	$939,393	$981,817	$1,028,282
	2021	*	*	*	*	*	*	*	*	*						$719,191	$751,514	$785,858	$822,221	$860,605	$898,989	$939,393	$981,817	$1,028,282
	2022	*	*	*	*	*	*	*	*	*							$751,514	$785,858	$822,221	$860,605	$898,989	$939,393	$981,817	$1,028,282
	2023	*	*	*	*	*	*	*	*	*								$785,858	$822,221	$860,605	$898,989	$939,393	$981,817	$1,028,282
	2024	*	*	*	*	*	*	*	*	*									$822,221	$860,605	$898,989	$939,393	$981,817	$1,028,282
	2025	*	*	*	*	*	*	*	*	*										$860,605	$898,989	$939,393	$981,817	$1,028,282
	2026	*	*	*	*	*	*	*	*	*											$898,989	$939,393	$981,817	$1,028,282
	2027	*	*	*	*	*	*	*	*	*												$939,393	$981,817	$1,028,282
	2028	*	*	*	*	*	*	*	*	*													$981,817	$1,028,282
	2029	*	*	*	*	*	*	*	*	*														$1,028,282
										59014	Total													

Capital Cost Subtotal

Calendar Year	15-25 hp										
2008	$1,777,776										
2009	$1,777,776	$250,505									
2010	$1,777,776	$250,505	$258,586								
2011	$1,777,776	$250,505	$258,586	$266,666							
2012	$1,777,776	$250,505	$258,586	$266,666	$274,747						
2013	$1,777,776	$250,505	$258,586	$266,666	$274,747	$282,828					
2014	$1,777,776	$250,505	$258,586	$266,666	$274,747	$282,828	$290,909				
2015	$1,777,776	$250,505	$258,586	$266,666	$274,747	$282,828	$290,909	$298,990			
2016	$1,777,776	$250,505	$258,586	$266,666	$274,747	$282,828	$290,909	$298,990	$309,091		
2017	$1,777,776	$250,505	$258,586	$266,666	$274,747	$282,828	$290,909	$298,990	$309,091	$317,171	
2018		$250,505	$258,586	$266,666	$274,747	$282,828	$290,909	$298,990	$309,091	$317,171	$327,272
2019			$258,586	$266,666	$274,747	$282,828	$290,909	$298,990	$309,091	$317,171	$327,272
2020				$266,666	$274,747	$282,828	$290,909	$298,990	$309,091	$317,171	$327,272
2021					$274,747	$282,828	$290,909	$298,990	$309,091	$317,171	$327,272
2022						$282,828	$290,909	$298,990	$309,091	$317,171	$327,272
2023							$290,909	$298,990	$309,091	$317,171	$327,272
2024								$298,990	$309,091	$317,171	$327,272
2025									$309,091	$317,171	$327,272
2026										$317,171	$327,272
2027											$327,272
2028											
2029											

[4] In-Use Affected Population = 0; Assumes Full Introduction of EPA Tier 4 Engines into TRU/Gen Set Fleet

[1] This is the annualized capital cost of the appropriate in-use compliance technology used to meet LETRU or ULETRU requirements as appropriate. The interest rate used is given at the top of this matrix.

[2] This is the annual cost of maintaining the in-use compliance technology over and above that for diesel technology. It may include items such as more-frequent engine servicing, cost of fuel-borne catalyst or other additive, and/or servicing of emission-control device(s).

[3] Use of electric standby retrofit technology not appropriate for gen sets-- cost figures do not include gen sets.

Alternative 2 Scenario: Use of Cryogenic Technology-- Assume 1,200 Hours/Year TRU Operation[4]

In-Use Compliance Technology Used	Cap. Cost	Ann. Cost - TRUs	Ann. Cost - Gen Sets	Notes
LETRU: Full Cryogenic Refrig	$22,007	$6,133		
ULETRU: Full Cryogenic Refrig	$22,007	$6,133		

Engine Population Category / Capital Cost Subtotal

Engine Model Year	Calendar Year	< 15hp	15-25 hp	25-50 hp CA-based	25-50 hp Out-of-State	25-50 hp Gen Sets CA-based	25-50 hp Gen Sets Out-of-State	25-50 hp Reefer Railcar	Total 25-50 hp (Info Only)	Total (this year)	Annualized Capital Cost[5]	< 15hp												
-2001	2008	2125	880	11162	3721	856	285	822	16846	19851	$2,850	$6,056,051												
2002	2009	311	124	1419	473	156	52	105	2205	2640	$2,850	$6,056,051	$886,321											
2003	2010	326	128	1493	498	172	57	110	2330	2784	$2,850	$6,056,051	$886,321	$929,070										
2004	2011	340	132	1571	524	189	63	118	2463	2935	$2,850	$6,056,051	$886,321	$929,070	$968,968									
2005	2012	356	136	1652	551	209	70	122	2604	3096	$2,850	$6,056,051	$886,321	$929,070	$968,968	$1,014,567								
2006	2013	372	140	1738	579	230	77	128	2752	3264	$2,850	$6,056,051	$886,321	$929,070	$968,968	$1,014,567	$1,060,165							
2007	2014	389	144	1829	610	254	85	135	2913	3446	$2,850	$6,056,051	$886,321	$929,070	$968,968	$1,014,567	$1,060,165	$1,108,614						
2008	2015	407	148	1924	641	279	93	142	3079	3634	$2,850	$6,056,051	$886,321	$929,070	$968,968	$1,014,567	$1,060,165	$1,108,614	$1,159,912					
2009	2016	426	153	2024	675	306	103	149	3259	3838	$2,850	$6,056,051	$886,321	$929,070	$968,968	$1,014,567	$1,060,165	$1,108,614	$1,159,912	$1,214,060				
2010	2017	445	157	2129	710	339	113	157	3448	4050	$2,850	$6,056,051	$886,321	$929,070	$968,968	$1,014,567	$1,060,165	$1,108,614	$1,159,912	$1,214,060	$1,268,208			
2011	2018	465	162	2240	747	374	126	165	3651	4278	$2,850		$886,321	$929,070	$968,968	$1,014,567	$1,060,165	$1,108,614	$1,159,912	$1,214,060	$1,268,208	$1,325,207		
2012	2019	486	167	2356	785	412	137	174	3864	4517	$2,850			$929,070	$968,968	$1,014,567	$1,060,165	$1,108,614	$1,159,912	$1,214,060	$1,268,208	$1,325,207	$1,385,055	
2013	2020	509	172	*	*	*	*	*	*	681	$2,850				$968,968	$1,014,567	$1,060,165	$1,108,614	$1,159,912	$1,214,060	$1,268,208	$1,325,207	$1,385,055	$1,450,602
	2021	*	*	*	*	*	*	*	*	*						$1,014,567	$1,060,165	$1,108,614	$1,159,912	$1,214,060	$1,268,208	$1,325,207	$1,385,055	$1,450,602
	2022	*	*	*	*	*	*	*	*	*							$1,060,165	$1,108,614	$1,159,912	$1,214,060	$1,268,208	$1,325,207	$1,385,055	$1,450,602
	2023	*	*	*	*	*	*	*	*	*								$1,108,614	$1,159,912	$1,214,060	$1,268,208	$1,325,207	$1,385,055	$1,450,602
	2024	*	*	*	*	*	*	*	*	*									$1,159,912	$1,214,060	$1,268,208	$1,325,207	$1,385,055	$1,450,602
	2025	*	*	*	*	*	*	*	*	*										$1,214,060	$1,268,208	$1,325,207	$1,385,055	$1,450,602
	2026	*	*	*	*	*	*	*	*	*											$1,268,208	$1,325,207	$1,385,055	$1,450,602
	2027	*	*	*	*	*	*	*	*	*												$1,325,207	$1,385,055	$1,450,602
	2028	*	*	*	*	*	*	*	*	*													$1,385,055	$1,450,602
	2029	*	*	*	*	*	*	*	*	*														$1,450,602
										59014	Total													

Capital Cost Subtotal

Calendar Year	15-25 hp										
2008	$2,507,918										
2009	$2,507,918	$353,388									
2010	$2,507,918	$353,388	$364,788								
2011	$2,507,918	$353,388	$364,788	$376,188							
2012	$2,507,918	$353,388	$364,788	$376,188	$387,587						
2013	$2,507,918	$353,388	$364,788	$376,188	$387,587	$398,987					
2014	$2,507,918	$353,388	$364,788	$376,188	$387,587	$398,987	$410,387				
2015	$2,507,918	$353,388	$364,788	$376,188	$387,587	$398,987	$410,387	$421,786			
2016	$2,507,918	$353,388	$364,788	$376,188	$387,587	$398,987	$410,387	$421,786	$436,036		
2017	$2,507,918	$353,388	$364,788	$376,188	$387,587	$398,987	$410,387	$421,786	$436,036	$447,435	
2018		$353,388	$364,788	$376,188	$387,587	$398,987	$410,387	$421,786	$436,036	$447,435	$461,685
2019			$364,788	$376,188	$387,587	$398,987	$410,387	$421,786	$436,036	$447,435	$461,685
2020				$376,188	$387,587	$398,987	$410,387	$421,786	$436,036	$447,435	$461,685
2021					$387,587	$398,987	$410,387	$421,786	$436,036	$447,435	$461,685
2022						$398,987	$410,387	$421,786	$436,036	$447,435	$461,685
2023							$410,387	$421,786	$436,036	$447,435	$461,685
2024								$421,786	$436,036	$447,435	$461,685
2025									$436,036	$447,435	$461,685
2026										$447,435	$461,685
2027											$461,685
2028											
2029											

[4] In-Use Affected Population = 0; Assumes Full Introduction of EPA Tier 4 Engines into TRU/Gen Set Fleet

[5] This is the annualized capital cost of the appropriate in-use compliance technology used to meet LETRU or ULETRU requirements as appropriate. The interest rate used is given at the top of this matrix.

[7] This is the annual cost of maintaining the in-use compliance technology over and above that for diesel technology. It may include items such as more-frequent engine servicing, cost of fuel-borne catalyst or other additive, and/or servicing of emission-control device(s).

[6] Use of cryogenic technology not appropriate for gen sets-- cost figures do not include gen sets.

862

			Capital Cost Subtotal													Capital Cost Subtotal													Capital Cost Subtotal		
		25-50 hp CA-based													25-50 hp Out-of-State													25-50 hp Gen Sets CA-based			
		$2,963,232													$987,832													$227,247			
		$2,963,232	$376,709												$987,832	$125,570												$227,247	$41,414		
		$2,963,232	$376,709	$444,690											$987,832	$125,570	$148,329											$227,247	$41,414	$51,230	
		$2,963,232	$376,709	$444,690	$467,922										$987,832	$125,570	$148,329	$156,073										$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048									$987,832	$125,570	$148,329	$156,073	$164,115									$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048	$517,663								$987,832	$125,570	$148,329	$156,073	$164,115	$172,455								$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048	$517,663	$544,768							$987,832	$125,570	$148,329	$156,073	$164,115	$172,455	$181,689							$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048	$517,663	$544,768	$573,063						$987,832	$125,570	$148,329	$156,073	$164,115	$172,455	$181,689	$190,922						$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048	$517,663	$544,768	$573,063	$602,848					$987,832	$125,570	$148,329	$156,073	$164,115	$172,455	$181,689	$190,922	$201,049					$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048	$517,663	$544,768	$573,063	$602,848	$634,123				$987,832	$125,570	$148,329	$156,073	$164,115	$172,455	$181,689	$190,922	$201,049	$211,474				$227,247	$41,414	$51,230	$56,294
			$376,709	$444,690	$467,922	$492,048	$517,663	$544,768	$573,063	$602,848	$634,123	$667,184				$125,570	$148,329	$156,073	$164,115	$172,455	$181,689	$190,922	$201,049	$211,474	$222,494				$41,414	$51,230	$56,294
$49,741				$444,690	$467,922	$492,048	$517,663	$544,768	$573,063	$602,848	$634,123	$667,184	$701,735				$148,329	$156,073	$164,115	$172,455	$181,689	$190,922	$201,049	$211,474	$222,494	$233,812				$51,230	$56,294
$49,741	$51,230				$467,922	$492,048	$517,663	$544,768	$573,063	$602,848	$634,123	$667,184	$701,735	$0				$156,073	$164,115	$172,455	$181,689	$190,922	$201,049	$211,474	$222,494	$233,812	$0				$56,294
$49,741	$51,230					$492,048	$517,663	$544,768	$573,063	$602,848	$634,123	$667,184	$701,735	$0					$164,115	$172,455	$181,689	$190,922	$201,049	$211,474	$222,494	$233,812	$0				
$49,741	$51,230						$517,663	$544,768	$573,063	$602,848	$634,123	$667,184	$701,735	$0						$172,455	$181,689	$190,922	$201,049	$211,474	$222,494	$233,812	$0				
$49,741	$51,230							$544,768	$573,063	$602,848	$634,123	$667,184	$701,735	$0							$181,689	$190,922	$201,049	$211,474	$222,494	$233,812	$0				
$49,741	$51,230								$573,063	$602,848	$634,123	$667,184	$701,735	$0								$190,922	$201,049	$211,474	$222,494	$233,812	$0				
$49,741	$51,230									$602,848	$634,123	$667,184	$701,735	$0									$201,049	$211,474	$222,494	$233,812	$0				
$49,741	$51,230										$634,123	$667,184	$701,735	$0										$211,474	$222,494	$233,812	$0				
$49,741	$51,230											$667,184	$701,735	$0											$222,494	$233,812	$0				
$49,741	$51,230												$701,735	$0												$233,812	$0				
	$51,230													$0													$0				

			Capital Cost Subtotal													Capital Cost Subtotal													Capital Cost Subtotal		
		25-50 hp CA-based													25-50 hp Out-of-State													25-50 hp Gen Sets CA-based			
		$2,963,232													$987,832													$227,247			
		$2,963,232	$376,709												$987,832	$125,570												$227,247	$41,414		
		$2,963,232	$376,709	$444,690											$987,832	$125,570	$148,329											$227,247	$41,414	$51,230	
		$2,963,232	$376,709	$444,690	$467,922										$987,832	$125,570	$148,329	$156,073										$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048									$987,832	$125,570	$148,329	$156,073	$164,115									$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048	$517,663								$987,832	$125,570	$148,329	$156,073	$164,115	$172,455								$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048	$517,663	$544,768							$987,832	$125,570	$148,329	$156,073	$164,115	$172,455	$181,689							$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048	$517,663	$544,768	$573,063						$987,832	$125,570	$148,329	$156,073	$164,115	$172,455	$181,689	$190,922						$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048	$517,663	$544,768	$573,063	$602,848					$987,832	$125,570	$148,329	$156,073	$164,115	$172,455	$181,689	$190,922	$201,049					$227,247	$41,414	$51,230	$56,294
		$2,963,232	$376,709	$444,690	$467,922	$492,048	$517,663	$544,768	$573,063	$602,848	$634,123				$987,832	$125,570	$148,329	$156,073	$164,115	$172,455	$181,689	$190,922	$201,049	$211,474				$227,247	$41,414	$51,230	$56,294
			$376,709	$444,690	$467,922	$492,048	$517,663	$544,768	$573,063	$602,848	$634,123	$667,184				$125,570	$148,329	$156,073	$164,115	$172,455	$181,689	$190,922	$201,049	$211,474	$222,494				$41,414	$51,230	$56,294
$49,741				$444,690	$467,922	$492,048	$517,663	$544,768	$573,063	$602,848	$634,123	$667,184	$701,735				$148,329	$156,073	$164,115	$172,455	$181,689	$190,922	$201,049	$211,474	$222,494	$233,812				$51,230	$56,294
$49,741	$51,230				$467,922	$492,048	$517,663	$544,768	$573,063	$602,848	$634,123	$667,184	$701,735	$0				$156,073	$164,115	$172,455	$181,689	$190,922	$201,049	$211,474	$222,494	$233,812	$0				$56,294
$49,741	$51,230					$492,048	$517,663	$544,768	$573,063	$602,848	$634,123	$667,184	$701,735	$0					$164,115	$172,455	$181,689	$190,922	$201,049	$211,474	$222,494	$233,812	$0				
$49,741	$51,230						$517,663	$544,768	$573,063	$602,848	$634,123	$667,184	$701,735	$0						$172,455	$181,689	$190,922	$201,049	$211,474	$222,494	$233,812	$0				
$49,741	$51,230							$544,768	$573,063	$602,848	$634,123	$667,184	$701,735	$0							$181,689	$190,922	$201,049	$211,474	$222,494	$233,812	$0				
$49,741	$51,230								$573,063	$602,848	$634,123	$667,184	$701,735	$0								$190,922	$201,049	$211,474	$222,494	$233,812	$0				
$49,741	$51,230									$602,848	$634,123	$667,184	$701,735	$0									$201,049	$211,474	$222,494	$233,812	$0				
$49,741	$51,230										$634,123	$667,184	$701,735	$0										$211,474	$222,494	$233,812	$0				
$49,741	$51,230											$667,184	$701,735	$0											$222,494	$233,812	$0				
$49,741	$51,230												$701,735	$0												$233,812	$0				
	$51,230													$0													$0				

863

864

Matrix #1

		25-50 hp CA-based	Capital Cost Subtotal											
		$22,549,472												
		$22,549,472	$2,866,664											
		$22,549,472	$2,866,664	$3,016,159										
		$22,549,472	$2,866,664	$3,016,159	$3,173,734									
		$22,549,472	$2,866,664	$3,016,159	$3,173,734	$3,337,370								
		$22,549,472	$2,866,664	$3,016,159	$3,173,734	$3,337,370	$3,511,108							
		$22,549,472	$2,866,664	$3,016,159	$3,173,734	$3,337,370	$3,511,108	$3,694,946						
		$22,549,472	$2,866,664	$3,016,159	$3,173,734	$3,337,370	$3,511,108	$3,694,946	$3,888,665					
		$22,549,472	$2,866,664	$3,016,159	$3,173,734	$3,337,370	$3,511,108	$3,694,946	$3,888,665	$4,088,685				
		$22,549,472	$2,866,664	$3,016,159	$3,173,734	$3,337,370	$3,511,108	$3,694,946	$3,888,665	$4,088,685	$4,301,006			
			$2,866,664	$3,016,159	$3,173,734	$3,337,370	$3,511,108	$3,694,946	$3,888,665	$4,088,685	$4,301,006	$4,525,248		
$337,373				$3,016,159	$3,173,734	$3,337,370	$3,511,108	$3,694,946	$3,888,665	$4,088,685	$4,301,006	$4,525,248	$4,759,591	
$337,373	$347,474				$3,173,734	$3,337,370	$3,511,108	$3,694,946	$3,888,665	$4,088,685	$4,301,006	$4,525,248	$4,759,591	$0
$337,373	$347,474					$3,337,370	$3,511,108	$3,694,946	$3,888,665	$4,088,685	$4,301,006	$4,525,248	$4,759,591	$0
$337,373	$347,474						$3,511,108	$3,694,946	$3,888,665	$4,088,685	$4,301,006	$4,525,248	$4,759,591	$0
$337,373	$347,474							$3,694,946	$3,888,665	$4,088,685	$4,301,006	$4,525,248	$4,759,591	$0
$337,373	$347,474								$3,888,665	$4,088,685	$4,301,006	$4,525,248	$4,759,591	$0
$337,373	$347,474									$4,088,685	$4,301,006	$4,525,248	$4,759,591	$0
$337,373	$347,474										$4,301,006	$4,525,248	$4,759,591	$0
$337,373	$347,474											$4,525,248	$4,759,591	$0
$337,373	$347,474												$4,759,591	$0
	$347,474													$0

25-50 hp Out-of-State	Capital Cost Subtotal												25-50 hp Gen Sets CA-based	Capital Cost Subtotal	Use of electric st	
$7,517,164																
$7,517,164	$955,555															
$7,517,164	$955,555	$1,006,060														
$7,517,164	$955,555	$1,006,060	$1,058,585													
$7,517,164	$955,555	$1,006,060	$1,058,585	$1,113,130												
$7,517,164	$955,555	$1,006,060	$1,058,585	$1,113,130	$1,169,696											
$7,517,164	$955,555	$1,006,060	$1,058,585	$1,113,130	$1,169,696	$1,232,322										
$7,517,164	$955,555	$1,006,060	$1,058,585	$1,113,130	$1,169,696	$1,232,322	$1,294,946									
$7,517,164	$955,555	$1,006,060	$1,058,585	$1,113,130	$1,169,696	$1,232,322	$1,294,946	$1,363,635								
$7,517,164	$955,555	$1,006,060	$1,058,585	$1,113,130	$1,169,696	$1,232,322	$1,294,946	$1,363,635	$1,434,342							
	$955,555	$1,006,060	$1,058,585	$1,113,130	$1,169,696	$1,232,322	$1,294,946	$1,363,635	$1,434,342	$1,509,069						
		$1,006,060	$1,058,585	$1,113,130	$1,169,696	$1,232,322	$1,294,946	$1,363,635	$1,434,342	$1,509,069	$1,585,657					
			$1,058,585	$1,113,130	$1,169,696	$1,232,322	$1,294,946	$1,363,635	$1,434,342	$1,509,069	$1,585,657	$0				
				$1,113,130	$1,169,696	$1,232,322	$1,294,946	$1,363,635	$1,434,342	$1,509,069	$1,585,657	$0				
					$1,169,696	$1,232,322	$1,294,946	$1,363,635	$1,434,342	$1,509,069	$1,585,657	$0				
						$1,232,322	$1,294,946	$1,363,635	$1,434,342	$1,509,069	$1,585,657	$0				
							$1,294,946	$1,363,635	$1,434,342	$1,509,069	$1,585,657	$0				
								$1,363,635	$1,434,342	$1,509,069	$1,585,657	$0				
									$1,434,342	$1,509,069	$1,585,657	$0				
										$1,509,069	$1,585,657	$0				
											$1,585,657	$0				
												$0				

		25-50 hp CA-based	Capital Cost Subtotal											
		$31,810,656												
		$31,810,656	$4,044,017											
		$31,810,656	$4,044,017	$4,254,910										
		$31,810,656	$4,044,017	$4,254,910	$4,477,203									
		$31,810,656	$4,044,017	$4,254,910	$4,477,203	$4,708,046								
		$31,810,656	$4,044,017	$4,254,910	$4,477,203	$4,708,046	$4,953,137							
		$31,810,656	$4,044,017	$4,254,910	$4,477,203	$4,708,046	$4,953,137	$5,212,479						
		$31,810,656	$4,044,017	$4,254,910	$4,477,203	$4,708,046	$4,953,137	$5,212,479	$5,483,220					
		$31,810,656	$4,044,017	$4,254,910	$4,477,203	$4,708,046	$4,953,137	$5,212,479	$5,483,220	$5,768,211				
		$31,810,656	$4,044,017	$4,254,910	$4,477,203	$4,708,046	$4,953,137	$5,212,479	$5,483,220	$5,768,211	$6,067,451			
			$4,044,017	$4,254,910	$4,477,203	$4,708,046	$4,953,137	$5,212,479	$5,483,220	$5,768,211	$6,067,451	$6,383,791		
$475,934				$4,254,910	$4,477,203	$4,708,046	$4,953,137	$5,212,479	$5,483,220	$5,768,211	$6,067,451	$6,383,791	$6,714,380	
$475,934	$490,184				$4,477,203	$4,708,046	$4,953,137	$5,212,479	$5,483,220	$5,768,211	$6,067,451	$6,383,791	$6,714,380	$0
$475,934	$490,184					$4,708,046	$4,953,137	$5,212,479	$5,483,220	$5,768,211	$6,067,451	$6,383,791	$6,714,380	$0
$475,934	$490,184						$4,953,137	$5,212,479	$5,483,220	$5,768,211	$6,067,451	$6,383,791	$6,714,380	$0
$475,934	$490,184							$5,212,479	$5,483,220	$5,768,211	$6,067,451	$6,383,791	$6,714,380	$0
$475,934	$490,184								$5,483,220	$5,768,211	$6,067,451	$6,383,791	$6,714,380	$0
$475,934	$490,184									$5,768,211	$6,067,451	$6,383,791	$6,714,380	$0
$475,934	$490,184										$6,067,451	$6,383,791	$6,714,380	$0
$475,934	$490,184											$6,383,791	$6,714,380	$0
$475,934	$490,184												$6,714,380	$0
	$490,184													$0

25-50 hp Out-of-State	Capital Cost Subtotal												25-50 hp Gen Sets CA-based	Capital Cost Subtotal	Use of cryogenic	
$10,604,502																
$10,604,502	$1,348,006															
$10,604,502	$1,348,006	$1,419,253														
$10,604,502	$1,348,006	$1,419,253	$1,493,351													
$10,604,502	$1,348,006	$1,419,253	$1,493,351	$1,570,298												
$10,604,502	$1,348,006	$1,419,253	$1,493,351	$1,570,298	$1,650,096											
$10,604,502	$1,348,006	$1,419,253	$1,493,351	$1,570,298	$1,650,096	$1,738,443										
$10,604,502	$1,348,006	$1,419,253	$1,493,351	$1,570,298	$1,650,096	$1,738,443	$1,826,790									
$10,604,502	$1,348,006	$1,419,253	$1,493,351	$1,570,298	$1,650,096	$1,738,443	$1,826,790	$1,923,687								
$10,604,502	$1,348,006	$1,419,253	$1,493,351	$1,570,298	$1,650,096	$1,738,443	$1,826,790	$1,923,687	$2,023,434							
	$1,348,006	$1,419,253	$1,493,351	$1,570,298	$1,650,096	$1,738,443	$1,826,790	$1,923,687	$2,023,434	$2,128,880						
		$1,419,253	$1,493,351	$1,570,298	$1,650,096	$1,738,443	$1,826,790	$1,923,687	$2,023,434	$2,128,880	$2,237,177					
			$1,493,351	$1,570,298	$1,650,096	$1,738,443	$1,826,790	$1,923,687	$2,023,434	$2,128,880	$2,237,177	$0				
				$1,570,298	$1,650,096	$1,738,443	$1,826,790	$1,923,687	$2,023,434	$2,128,880	$2,237,177	$0				
					$1,650,096	$1,738,443	$1,826,790	$1,923,687	$2,023,434	$2,128,880	$2,237,177	$0				
						$1,738,443	$1,826,790	$1,923,687	$2,023,434	$2,128,880	$2,237,177	$0				
							$1,826,790	$1,923,687	$2,023,434	$2,128,880	$2,237,177	$0				
								$1,923,687	$2,023,434	$2,128,880	$2,237,177	$0				
									$2,023,434	$2,128,880	$2,237,177	$0				
										$2,128,880	$2,237,177	$0				
											$2,237,177	$0				
												$0				

									Capital Cost Subtotal 25-50 hp Gen Sets Out-of-State													Capital Cost Subtotal 25-50 hp Reefer Railcars											
									$75,660													$218,220											
									$75,660	$13,805												$218,220	$27,675										
									$75,660	$13,805	$16,977											$218,220	$27,675	$32,784									
									$75,660	$13,805	$16,977	$18,765										$218,220	$27,675	$32,784	$34,551								
$62,251									$75,660	$13,805	$16,977	$18,765	$20,850									$218,220	$27,675	$32,784	$34,551	$36,338							
$62,251	$68,506								$75,660	$13,805	$16,977	$18,765	$20,850	$22,934								$218,220	$27,675	$32,784	$34,551	$36,338	$38,125						
$62,251	$68,506	$75,654							$75,660	$13,805	$16,977	$18,765	$20,850	$22,934	$25,317							$218,220	$27,675	$32,784	$34,551	$36,338	$38,125	$40,210					
$62,251	$68,506	$75,654	$83,100						$75,660	$13,805	$16,977	$18,765	$20,850	$22,934	$25,317	$27,700						$218,220	$27,675	$32,784	$34,551	$36,338	$38,125	$40,210	$42,295				
$62,251	$68,506	$75,654	$83,100	$91,738					$75,660	$13,805	$16,977	$18,765	$20,850	$22,934	$25,317	$27,700	$30,679					$218,220	$27,675	$32,784	$34,551	$36,338	$38,125	$40,210	$42,295	$44,380			
$62,251	$68,506	$75,654	$83,100	$91,738	$100,971				$75,660	$13,805	$16,977	$18,765	$20,850	$22,934	$25,317	$27,700	$30,679	$33,657				$218,220	$27,675	$32,784	$34,551	$36,338	$38,125	$40,210	$42,295	$44,380	$46,762		
$62,251	$68,506	$75,654	$83,100	$91,738	$100,971	$111,396				$13,805	$16,977	$18,765	$20,850	$22,934	$25,317	$27,700	$30,679	$33,657	$37,231				$27,675	$32,784	$34,551	$36,338	$38,125	$40,210	$42,295	$44,380	$46,762	$49,145	
$62,251	$68,506	$75,654	$83,100	$91,738	$100,971	$111,396	$122,714				$16,977	$18,765	$20,850	$22,934	$25,317	$27,700	$30,679	$33,657	$37,231	$40,805				$32,784	$34,551	$36,338	$38,125	$40,210	$42,295	$44,380	$46,762	$49,145	$51,826
$62,251	$68,506	$75,654	$83,100	$91,738	$100,971	$111,396	$122,714	$0				$18,765	$20,850	$22,934	$25,317	$27,700	$30,679	$33,657	$37,231	$40,805	$0				$34,551	$36,338	$38,125	$40,210	$42,295	$44,380	$46,762	$49,145	$51,826
$62,251	$68,506	$75,654	$83,100	$91,738	$100,971	$111,396	$122,714	$0					$20,850	$22,934	$25,317	$27,700	$30,679	$33,657	$37,231	$40,805	$0					$36,338	$38,125	$40,210	$42,295	$44,380	$46,762	$49,145	$51,826
	$68,506	$75,654	$83,100	$91,738	$100,971	$111,396	$122,714	$0						$22,934	$25,317	$27,700	$30,679	$33,657	$37,231	$40,805	$0						$38,125	$40,210	$42,295	$44,380	$46,762	$49,145	$51,826
		$75,654	$83,100	$91,738	$100,971	$111,396	$122,714	$0							$25,317	$27,700	$30,679	$33,657	$37,231	$40,805	$0							$40,210	$42,295	$44,380	$46,762	$49,145	$51,826
			$83,100	$91,738	$100,971	$111,396	$122,714	$0								$27,700	$30,679	$33,657	$37,231	$40,805	$0								$42,295	$44,380	$46,762	$49,145	$51,826
				$91,738	$100,971	$111,396	$122,714	$0									$30,679	$33,657	$37,231	$40,805	$0									$44,380	$46,762	$49,145	$51,826
					$100,971	$111,396	$122,714	$0										$33,657	$37,231	$40,805	$0										$46,762	$49,145	$51,826
						$111,396	$122,714	$0											$37,231	$40,805	$0											$49,145	$51,826
							$122,714	$0												$40,805	$0												$51,826
								$0													$0												
																																2008 - 2020 Capital Co	

									Capital Cost Subtotal 25-50 hp Gen Sets Out-of-State													Capital Cost Subtotal 25-50 hp Reefer Railcars											
									$75,660													$218,220											
									$75,660	$13,805												$218,220	$27,675										
									$75,660	$13,805	$16,977											$218,220	$27,675	$32,784									
									$75,660	$13,805	$16,977	$18,765										$218,220	$27,675	$32,784	$34,551								
$62,251									$75,660	$13,805	$16,977	$18,765	$20,850									$218,220	$27,675	$32,784	$34,551	$36,338							
$62,251	$68,506								$75,660	$13,805	$16,977	$18,765	$20,850	$22,934								$218,220	$27,675	$32,784	$34,551	$36,338	$38,125						
$62,251	$68,506	$75,654							$75,660	$13,805	$16,977	$18,765	$20,850	$22,934	$25,317							$218,220	$27,675	$32,784	$34,551	$36,338	$38,125	$40,210					
$62,251	$68,506	$75,654	$83,100						$75,660	$13,805	$16,977	$18,765	$20,850	$22,934	$25,317	$27,700						$218,220	$27,675	$32,784	$34,551	$36,338	$38,125	$40,210	$42,295				
$62,251	$68,506	$75,654	$83,100	$91,738					$75,660	$13,805	$16,977	$18,765	$20,850	$22,934	$25,317	$27,700	$30,679					$218,220	$27,675	$32,784	$34,551	$36,338	$38,125	$40,210	$42,295	$44,380			
$62,251	$68,506	$75,654	$83,100	$91,738	$100,971				$75,660	$13,805	$16,977	$18,765	$20,850	$22,934	$25,317	$27,700	$30,679	$33,657				$218,220	$27,675	$32,784	$34,551	$36,338	$38,125	$40,210	$42,295	$44,380	$46,762		
$62,251	$68,506	$75,654	$83,100	$91,738	$100,971	$111,396				$13,805	$16,977	$18,765	$20,850	$22,934	$25,317	$27,700	$30,679	$33,657	$37,231				$27,675	$32,784	$34,551	$36,338	$38,125	$40,210	$42,295	$44,380	$46,762	$49,145	
$62,251	$68,506	$75,654	$83,100	$91,738	$100,971	$111,396	$122,714				$16,977	$18,765	$20,850	$22,934	$25,317	$27,700	$30,679	$33,657	$37,231	$40,805				$32,784	$34,551	$36,338	$38,125	$40,210	$42,295	$44,380	$46,762	$49,145	$51,826
$62,251	$68,506	$75,654	$83,100	$91,738	$100,971	$111,396	$122,714	$0				$18,765	$20,850	$22,934	$25,317	$27,700	$30,679	$33,657	$37,231	$40,805	$0				$34,551	$36,338	$38,125	$40,210	$42,295	$44,380	$46,762	$49,145	$51,826
$62,251	$68,506	$75,654	$83,100	$91,738	$100,971	$111,396	$122,714	$0					$20,850	$22,934	$25,317	$27,700	$30,679	$33,657	$37,231	$40,805	$0					$36,338	$38,125	$40,210	$42,295	$44,380	$46,762	$49,145	$51,826
	$68,506	$75,654	$83,100	$91,738	$100,971	$111,396	$122,714	$0						$22,934	$25,317	$27,700	$30,679	$33,657	$37,231	$40,805	$0						$38,125	$40,210	$42,295	$44,380	$46,762	$49,145	$51,826
		$75,654	$83,100	$91,738	$100,971	$111,396	$122,714	$0							$25,317	$27,700	$30,679	$33,657	$37,231	$40,805	$0							$40,210	$42,295	$44,380	$46,762	$49,145	$51,826
			$83,100	$91,738	$100,971	$111,396	$122,714	$0								$27,700	$30,679	$33,657	$37,231	$40,805	$0								$42,295	$44,380	$46,762	$49,145	$51,826
				$91,738	$100,971	$111,396	$122,714	$0									$30,679	$33,657	$37,231	$40,805	$0									$44,380	$46,762	$49,145	$51,826
					$100,971	$111,396	$122,714	$0										$33,657	$37,231	$40,805	$0										$46,762	$49,145	$51,826
						$111,396	$122,714	$0											$37,231	$40,805	$0											$49,145	$51,826
							$122,714	$0												$40,805	$0												$51,826
								$0													$0												
																																2008 - 2020 Capital Co	

Matrix #1

998

Capital Cost Subtotal

ndby technology not appropriate for gen sets-- cost figures do not include gen sets. | 25-50 hp Gen Sets Out-of-State

Capital Cost Subtotal

Use of electric standby technology not appropriate for gen sets-- cost figures do not include gen set

25-50 hp Reefer Railcars											
$1,660,604											
$1,660,604	$212,121										
$1,660,604	$212,121	$222,222									
$1,660,604	$212,121	$222,222	$234,343								
$1,660,604	$212,121	$222,222	$234,343	$246,464							
$1,660,604	$212,121	$222,222	$234,343	$246,464	$258,586						
$1,660,604	$212,121	$222,222	$234,343	$246,464	$258,586	$272,727					
$1,660,604	$212,121	$222,222	$234,343	$246,464	$258,586	$272,727	$286,868				
$1,660,604	$212,121	$222,222	$234,343	$246,464	$258,586	$272,727	$286,868	$301,010			
$1,660,604	$212,121	$222,222	$234,343	$246,464	$258,586	$272,727	$286,868	$301,010	$317,171		
	$212,121	$222,222	$234,343	$246,464	$258,586	$272,727	$286,868	$301,010	$317,171	$333,333	
		$222,222	$234,343	$246,464	$258,586	$272,727	$286,868	$301,010	$317,171	$333,333	$351,515
			$234,343	$246,464	$258,586	$272,727	$286,868	$301,010	$317,171	$333,333	$351,515
				$246,464	$258,586	$272,727	$286,868	$301,010	$317,171	$333,333	$351,515
					$258,586	$272,727	$286,868	$301,010	$317,171	$333,333	$351,515
						$272,727	$286,868	$301,010	$317,171	$333,333	$351,515
							$286,868	$301,010	$317,171	$333,333	$351,515
								$301,010	$317,171	$333,333	$351,515
									$317,171	$333,333	$351,515
										$333,333	$351,515
											$351,515

2008 - 2020 Capital Co

Capital Cost Subtotal

echnology not appropriate for gen sets-- cost figures do not include gen sets. | 25-50 hp Gen Sets Out-of-State

Capital Cost Subtotal

Use of cryogenic technology not appropriate for gen sets-- cost figures do not include gen sets.

25-50 hp Reefer Railcars											
$2,342,623											
$2,342,623	$299,240										
$2,342,623	$299,240	$313,490									
$2,342,623	$299,240	$313,490	$330,569								
$2,342,623	$299,240	$313,490	$330,569	$347,669							
$2,342,623	$299,240	$313,490	$330,569	$347,669	$364,768						
$2,342,623	$299,240	$313,490	$330,569	$347,669	$364,768	$384,737					
$2,342,623	$299,240	$313,490	$330,569	$347,669	$364,768	$384,737	$404,687				
$2,342,623	$299,240	$313,490	$330,569	$347,669	$364,768	$384,737	$404,687	$424,636			
$2,342,623	$299,240	$313,490	$330,569	$347,669	$364,768	$384,737	$404,687	$424,636	$447,435		
	$299,240	$313,490	$330,569	$347,669	$364,768	$384,737	$404,687	$424,636	$447,435	$470,235	
		$313,490	$330,569	$347,669	$364,768	$384,737	$404,687	$424,636	$447,435	$470,235	$495,884
			$330,569	$347,669	$364,768	$384,737	$404,687	$424,636	$447,435	$470,235	$495,884
				$347,669	$364,768	$384,737	$404,687	$424,636	$447,435	$470,235	$495,884
					$364,768	$384,737	$404,687	$424,636	$447,435	$470,235	$495,884
						$384,737	$404,687	$424,636	$447,435	$470,235	$495,884
							$404,687	$424,636	$447,435	$470,235	$495,884
								$424,636	$447,435	$470,235	$495,884
									$447,435	$470,235	$495,884
										$470,235	$495,884
											$495,884

2008 - 2020 Capital Co

	Capital Cost Subtotal			Maintenance Cost Subtotal														Maintenance Cost Subtotal													Maintenance Cos	
	Capital Cost Sub-Total	Capital Cost Sub-Total (2002 $)	Annual Mtce Cost[2]	< 15hp													15-25 hp													25-50 hp CA-based		
	$5,269,944	$3,932,514	$107	$227,375													$94,160													$1,194,334		
	$5,970,785	$4,243,335	$107	$227,375	$33,277												$94,160	$13,268												$1,194,334	$151,833	
	$6,800,013	$4,602,518	$0	$227,375	$33,277	$0											$94,160	$13,268	$0											$1,194,334	$151,833	$0
	$7,674,202	$4,948,859	$0	$227,375	$33,277	$0	$0										$94,160	$13,268	$0	$0										$1,194,334	$151,833	$0
	$8,596,346	$5,277,411	$0	$227,375	$33,277	$0	$0	$0									$94,160	$13,268	$0	$0	$0									$1,194,334	$151,833	$0
	$9,568,528	$5,594,520	$0	$227,375	$33,277	$0	$0	$0	$0								$94,160	$13,268	$0	$0	$0	$0								$1,194,334	$151,833	$0
	$10,594,919	$5,899,648	$0	$227,375	$33,277	$0	$0	$0	$0	$0							$94,160	$13,268	$0	$0	$0	$0	$0							$1,194,334	$151,833	$0
	$11,677,306	$6,192,725	$0	$227,375	$33,277	$0	$0	$0	$0	$0	$0						$94,160	$13,268	$0	$0	$0	$0	$0	$0						$1,194,334	$151,833	$0
	$12,820,455	$6,475,201	$0	$227,375	$33,277	$0	$0	$0	$0	$0	$0	$0					$94,160	$13,268	$0	$0	$0	$0	$0	$0	$0					$1,194,334	$151,833	$0
	$14,026,747	$6,747,105	$0	$227,375	$33,277	$0	$0	$0	$0	$0	$0	$0	$0				$94,160	$13,268	$0	$0	$0	$0	$0	$0	$0	$0				$1,194,334	$151,833	$0
	$10,031,005	$4,595,319	$0		$33,277	$0	$0	$0	$0	$0	$0	$0	$0	$0				$13,268	$0	$0	$0	$0	$0	$0	$0	$0	$0				$151,833	$0
	$10,675,540	$4,657,703	$0			$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0
$0	$10,049,161	$4,175,634	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0			
$0	$9,174,971	$3,830,848						$0	$0	$0	$0	$0	$0	$0	$0	$0					$0	$0	$0	$0	$0	$0	$0	$0	$0			
$0	$8,252,828	$3,110,404							$0	$0	$0	$0	$0	$0	$0	$0						$0	$0	$0	$0	$0	$0	$0	$0			
$0	$7,280,645	$2,613,332								$0	$0	$0	$0	$0	$0	$0							$0	$0	$0	$0	$0	$0	$0			
$0	$6,254,254	$2,138,018									$0	$0	$0	$0	$0	$0								$0	$0	$0	$0	$0	$0			
$0	$5,171,867	$1,683,812										$0	$0	$0	$0	$0									$0	$0	$0	$0	$0			
$0	$4,028,719	$1,249,177											$0	$0	$0	$0										$0	$0	$0	$0			
$0	$2,822,427	$833,470												$0	$0	$0											$0	$0	$0			
$0	$1,548,224	$435,424													$0	$0												$0	$0			
$0	$202,836	$54,329														$0													$0			
st Subtotal (In 2002 $):		$67,340,489																														

	Capital Cost Subtotal			Maintenance Cost Subtotal														Maintenance Cost Subtotal													Maintenance Cos	
	Capital Cost Sub-Total	Capital Cost Sub-Total (2002 $)	Annual Mtce Cost[2]	< 15hp													15-25 hp													25-50 hp CA-based		
	$5,269,944	$3,932,514	$291	$618,375													$94,160													$1,194,334		
	$5,970,796	$4,243,335	$291	$618,375	$90,501												$94,160	$13,268												$1,194,334	$151,833	
	$6,800,013	$4,602,518	$0	$618,375	$90,501	$0											$94,160	$13,268	$0											$1,194,334	$151,833	$0
	$7,674,202	$4,948,859	$0	$618,375	$90,501	$0	$0										$94,160	$13,268	$0	$0										$1,194,334	$151,833	$0
	$8,596,346	$5,277,411	$0	$618,375	$90,501	$0	$0	$0									$94,160	$13,268	$0	$0	$0									$1,194,334	$151,833	$0
	$9,568,526	$5,594,520	$0	$618,375	$90,501	$0	$0	$0	$0								$94,160	$13,268	$0	$0	$0	$0								$1,194,334	$151,833	$0
	$10,594,919	$5,899,648	$0	$618,375	$90,501	$0	$0	$0	$0	$0							$94,160	$13,268	$0	$0	$0	$0	$0							$1,194,334	$151,833	$0
	$11,677,306	$6,192,725	$0	$618,375	$90,501	$0	$0	$0	$0	$0	$0						$94,160	$13,268	$0	$0	$0	$0	$0	$0						$1,194,334	$151,833	$0
	$12,820,455	$6,475,201	$0	$618,375	$90,501	$0	$0	$0	$0	$0	$0	$0					$94,160	$13,268	$0	$0	$0	$0	$0	$0	$0					$1,194,334	$151,833	$0
	$14,026,747	$6,747,105	$0	$618,375	$90,501	$0	$0	$0	$0	$0	$0	$0	$0				$94,160	$13,268	$0	$0	$0	$0	$0	$0	$0	$0				$1,194,334	$151,833	$0
	$10,031,005	$4,595,319	$0		$90,501	$0	$0	$0	$0	$0	$0	$0	$0	$0				$13,268	$0	$0	$0	$0	$0	$0	$0	$0	$0				$151,833	$0
	$10,675,540	$4,657,703	$0			$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0
$0	$10,049,161	$4,175,634	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0			
$0	$9,174,971	$3,830,848						$0	$0	$0	$0	$0	$0	$0	$0	$0					$0	$0	$0	$0	$0	$0	$0	$0	$0			
$0	$8,252,828	$3,110,404							$0	$0	$0	$0	$0	$0	$0	$0						$0	$0	$0	$0	$0	$0	$0	$0			
$0	$7,280,645	$2,613,332								$0	$0	$0	$0	$0	$0	$0							$0	$0	$0	$0	$0	$0	$0			
$0	$6,254,254	$2,138,018									$0	$0	$0	$0	$0	$0								$0	$0	$0	$0	$0	$0			
$0	$5,171,867	$1,683,812										$0	$0	$0	$0	$0									$0	$0	$0	$0	$0			
$0	$4,028,719	$1,249,177											$0	$0	$0	$0										$0	$0	$0	$0			
$0	$2,822,427	$833,470												$0	$0	$0											$0	$0	$0			
$0	$1,548,224	$435,424													$0	$0												$0	$0			
$0	$202,836	$54,329														$0													$0			
st Subtotal (In 2002 $):		$67,340,489																														

Matrix #1

898

	Capital Cost Subtotal		Maintenance Cost Subtotal													
	Capital Cost Sub Total	Capital Cost Sub-Total (2002 $)	Annual Mtce Cost²	< 15hp												
	$37,797,942	$28,205,406	$519	$1,102,675												
	$42,711,065	$30,353,959	$519	$1,102,675	$161,409											
	$47,672,679	$32,402,114	$519	$1,102,675	$161,409	$169,194										
	$53,292,676	$34,353,063	$519	$1,102,675	$161,409	$169,194	$176,460									
	$58,983,779	$36,310,924	$519	$1,102,675	$161,409	$169,194	$176,460	$184,764								
	$64,957,611	$37,979,311	$519	$1,102,675	$161,409	$169,194	$176,460	$184,764	$193,068							
	$71,234,272	$39,865,908	$519	$1,102,675	$161,409	$169,194	$176,460	$184,764	$193,068	$201,891						
	$77,624,165	$41,271,616	$519	$1,102,675	$161,409	$169,194	$176,460	$184,764	$193,068	$201,891	$211,233					
	$84,747,390	$42,603,191	$519	$1,102,675	$161,409	$169,194	$176,460	$184,764	$193,068	$201,891	$211,233	$221,094				
	$92,016,070	$44,261,303	$519	$1,102,675	$161,409	$169,194	$176,460	$184,764	$193,068	$201,891	$211,233	$221,094	$230,955			
	$61,852,463	$28,335,328	$519		$161,409	$169,194	$176,460	$184,764	$193,068	$201,891	$211,233	$221,094	$230,955	$241,335		
	$64,955,491	$26,339,865	$519			$169,194	$176,460	$184,764	$193,068	$201,891	$211,233	$221,094	$230,955	$241,335	$252,234	
$0	$61,169,638	$25,417,247	$519				$176,460	$184,764	$193,068	$201,891	$211,233	$221,094	$230,955	$241,335	$252,234	$264,171
$0	$55,749,439	$22,061,946						$184,764	$193,068	$201,891	$211,233	$221,094	$230,955	$241,335	$252,234	$264,171
$0	$50,056,536	$18,866,536							$193,068	$201,891	$211,233	$221,094	$230,955	$241,335	$252,234	$264,171
$0	$44,084,804	$15,823,904								$201,891	$211,233	$221,094	$230,955	$241,335	$252,234	$264,171
$0	$37,808,043	$12,924,075									$211,233	$221,094	$230,955	$241,335	$252,234	$264,171
$0	$31,218,151	$10,163,734										$221,094	$230,955	$241,335	$252,234	$264,171
$0	$24,294,925	$7,533,077											$230,955	$241,335	$252,234	$264,171
$0	$17,026,246	$5,027,898												$241,335	$252,234	$264,171
$0	$9,391,610	$2,641,366													$252,234	$264,171
$0	$1,375,756	$366,464														$264,171
t Subtotal (in 2002 $):		$449,899,434														

	Maintenance Cost Subtotal													Maintenance Co		
	15-25 hp													25-50 hp CA-based		
	$456,720													$5,793,078		
	$456,720	$64,356												$5,793,078	$738,461	
	$456,720	$64,356	$66,432											$5,793,078	$738,461	$774,867
	$456,720	$64,356	$66,432	$68,508										$5,793,078	$738,461	$774,867
	$456,720	$64,356	$66,432	$68,508	$70,584									$5,793,078	$738,461	$774,867
	$456,720	$64,356	$66,432	$68,508	$70,584	$72,660								$5,793,078	$738,461	$774,867
	$456,720	$64,356	$66,432	$68,508	$70,584	$72,660	$74,736							$5,793,078	$738,461	$774,867
	$456,720	$64,356	$66,432	$68,508	$70,584	$72,660	$74,736	$76,812						$5,793,078	$738,461	$774,867
	$456,720	$64,356	$66,432	$68,508	$70,584	$72,660	$74,736	$76,812	$79,407					$5,793,078	$738,461	$774,867
	$456,720	$64,356	$66,432	$68,508	$70,584	$72,660	$74,736	$76,812	$79,407	$81,483				$5,793,078	$738,461	$774,867
		$64,356	$66,432	$68,508	$70,584	$72,660	$74,736	$76,812	$79,407	$81,483	$84,078				$738,461	$774,867
			$66,432	$68,508	$70,584	$72,660	$74,736	$76,812	$79,407	$81,483	$84,078	$86,673				$774,867
$0				$68,508	$70,584	$72,660	$74,736	$76,812	$79,407	$81,483	$84,078	$86,673	$89,268			
$0					$70,584	$72,660	$74,736	$76,812	$79,407	$81,483	$84,078	$86,673	$89,268			
$0						$72,660	$74,736	$76,812	$79,407	$81,483	$84,078	$86,673	$89,268			
$0							$74,736	$76,812	$79,407	$81,483	$84,078	$86,673	$89,268			
$0								$76,812	$79,407	$81,483	$84,078	$86,673	$89,268			
$0									$79,407	$81,483	$84,078	$86,673	$89,268			
$0										$81,483	$84,078	$86,673	$89,268			
$0											$84,078	$86,673	$89,268			
$0												$86,673	$89,268			
$0													$89,268			

	Capital Cost Subtotal		Maintenance Cost Subtotal													
	Capital Cost Sub Total	Capital Cost Sub-Total (2002 $)	Annual Mtce Cost²	< 15hp												
	$53,321,751	$39,749,511	$6,133	$13,032,625												
	$60,252,723	$42,820,485	$6,133	$13,032,625	$1,907,363											
	$67,534,234	$45,708,026	$6,133	$13,032,625	$1,907,363	$1,999,358										
	$75,160,633	$48,492,042	$6,133	$13,032,625	$1,907,363	$1,999,358	$2,085,220									
	$83,208,720	$51,082,836	$6,133	$13,032,625	$1,907,363	$1,999,358	$2,085,220	$2,183,348								
	$91,635,894	$53,677,608	$6,133	$13,032,625	$1,907,363	$1,999,358	$2,085,220	$2,183,348	$2,281,476							
	$100,490,853	$55,856,800	$6,133	$13,032,625	$1,907,363	$1,999,358	$2,085,220	$2,183,348	$2,281,476	$2,385,737						
	$109,786,845	$58,227,383	$6,133	$13,032,625	$1,907,363	$1,999,358	$2,085,220	$2,183,348	$2,281,476	$2,385,737	$2,496,131					
	$119,553,878	$60,382,681	$6,133	$13,032,625	$1,907,363	$1,999,358	$2,085,220	$2,183,348	$2,281,476	$2,385,737	$2,496,131	$2,612,656				
	$129,807,541	$62,439,647	$6,133	$13,032,625	$1,907,363	$1,999,358	$2,085,220	$2,183,348	$2,281,476	$2,385,737	$2,496,131	$2,612,656	$2,729,165			
	$87,255,567	$39,872,760	$6,133		$1,907,363	$1,999,358	$2,085,220	$2,183,348	$2,281,476	$2,385,737	$2,496,131	$2,612,656	$2,729,165	$2,851,845		
	$91,633,044	$39,970,183	$6,133			$1,999,358	$2,085,220	$2,183,348	$2,281,476	$2,385,737	$2,496,131	$2,612,656	$2,729,165	$2,851,845	$2,980,638	
$0	$88,202,319	$35,856,241	$6,133				$2,085,220	$2,183,348	$2,281,476	$2,385,737	$2,496,131	$2,612,656	$2,729,165	$2,851,845	$2,980,638	$3,121,697
$0	$78,648,020	$31,122,901						$2,183,348	$2,281,476	$2,385,737	$2,496,131	$2,612,656	$2,729,165	$2,851,845	$2,980,638	$3,121,697
$0	$70,617,833	$26,816,119							$2,281,476	$2,385,737	$2,496,131	$2,612,656	$2,729,165	$2,851,845	$2,980,638	$3,121,697
$0	$62,190,660	$22,322,882								$2,385,737	$2,496,131	$2,612,656	$2,729,165	$2,851,845	$2,980,638	$3,121,697
$0	$53,336,000	$18,232,805									$2,496,131	$2,612,656	$2,729,165	$2,851,845	$2,980,638	$3,121,697
$0	$44,039,605	$14,338,032										$2,612,656	$2,729,165	$2,851,845	$2,980,638	$3,121,697
$0	$34,272,976	$10,626,850											$2,729,165	$2,851,845	$2,980,638	$3,121,697
$0	$24,019,012	$7,092,861												$2,851,845	$2,980,638	$3,121,697
$0	$13,249,215	$3,726,216													$2,980,638	$3,121,697
$0	$1,940,786	$519,836														$3,121,697
t Subtotal (in 2002 $):		$634,262,227														

	Maintenance Cost Subtotal													Maintenance Co		
	15-25 hp													25-50 hp CA-based		
	$5,397,040													$68,456,546		
	$5,397,040	$760,492												$68,456,546	$8,702,727	
	$5,397,040	$760,492	$785,024											$68,456,546	$8,702,727	$9,156,569
	$5,397,040	$760,492	$785,024	$809,556										$68,456,546	$8,702,727	$9,156,569
	$5,397,040	$760,492	$785,024	$809,556	$834,088									$68,456,546	$8,702,727	$9,156,569
	$5,397,040	$760,492	$785,024	$809,556	$834,088	$858,620								$68,456,546	$8,702,727	$9,156,569
	$5,397,040	$760,492	$785,024	$809,556	$834,088	$858,620	$883,152							$68,456,546	$8,702,727	$9,156,569
	$5,397,040	$760,492	$785,024	$809,556	$834,088	$858,620	$883,152	$907,684						$68,456,546	$8,702,727	$9,156,569
	$5,397,040	$760,492	$785,024	$809,556	$834,088	$858,620	$883,152	$907,684	$938,349					$68,456,546	$8,702,727	$9,156,569
	$5,397,040	$760,492	$785,024	$809,556	$834,088	$858,620	$883,152	$907,684	$938,349	$962,881				$68,456,546	$8,702,727	$9,156,569
		$760,492	$785,024	$809,556	$834,088	$858,620	$883,152	$907,684	$938,349	$962,881	$993,546				$8,702,727	$9,156,569
			$785,024	$809,556	$834,088	$858,620	$883,152	$907,684	$938,349	$962,881	$993,546	$1,024,211				$9,156,569
$0				$809,556	$834,088	$858,620	$883,152	$907,684	$938,349	$962,881	$993,546	$1,024,211	$1,054,876			
$0					$834,088	$858,620	$883,152	$907,684	$938,349	$962,881	$993,546	$1,024,211	$1,054,876			
$0						$858,620	$883,152	$907,684	$938,349	$962,881	$993,546	$1,024,211	$1,054,876			
$0							$883,152	$907,684	$938,349	$962,881	$993,546	$1,024,211	$1,054,876			
$0								$907,684	$938,349	$962,881	$993,546	$1,024,211	$1,054,876			
$0									$938,349	$962,881	$993,546	$1,024,211	$1,054,876			
$0										$962,881	$993,546	$1,024,211	$1,054,876			
$0											$993,546	$1,024,211	$1,054,876			
$0												$1,024,211	$1,054,876			
$0													$1,054,876			

t Subtotal										25-50 hp Out-of-State	Maintenance Cost Subtotal												25-50 hp Gen Sets CA-based	Maintenance Cost Subtotal							
										$398,147													$83,032								
										$398,147	$50,611												$83,032	$15,132							
										$398,147	$50,611	$0											$83,032	$15,132	$0						
$0										$398,147	$50,611	$0	$0										$83,032	$15,132	$0	$0					
$0	$0									$398,147	$50,611	$0	$0	$0									$83,032	$15,132	$0	$0	$0				
$0	$0	$0								$398,147	$50,611	$0	$0	$0	$0								$83,032	$15,132	$0	$0	$0	$0			
$0	$0	$0	$0							$398,147	$50,611	$0	$0	$0	$0	$0							$83,032	$15,132	$0	$0	$0	$0	$0		
$0	$0	$0	$0	$0						$398,147	$50,611	$0	$0	$0	$0	$0	$0						$83,032	$15,132	$0	$0	$0	$0	$0	$0	
$0	$0	$0	$0	$0	$0					$398,147	$50,611	$0	$0	$0	$0	$0	$0	$0					$83,032	$15,132	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0				$398,147	$50,611	$0	$0	$0	$0	$0	$0	$0	$0				$83,032	$15,132	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0				$50,611	$0	$0	$0	$0	$0	$0	$0	$0	$0				$15,132	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0	$0					$0	$0	$0	$0	$0	$0	$0	$0	$0					$0	$0	$0	$0	$0
		$0	$0	$0	$0	$0	$0	$0	$0						$0	$0	$0	$0	$0	$0	$0	$0						$0	$0	$0	$0
			$0	$0	$0	$0	$0	$0	$0							$0	$0	$0	$0	$0	$0	$0							$0	$0	$0
				$0	$0	$0	$0	$0	$0								$0	$0	$0	$0	$0	$0								$0	$0
					$0	$0	$0	$0	$0									$0	$0	$0	$0	$0									$0
						$0	$0	$0	$0										$0	$0	$0	$0									
							$0	$0	$0											$0	$0	$0									
								$0	$0												$0	$0									
									$0													$0									

t Subtotal										25-50 hp Out-of-State	Maintenance Cost Subtotal												25-50 hp Gen Sets CA-based	Maintenance Cost Subtotal							
										$398,147													$83,032								
										$398,147	$50,611												$83,032	$15,132							
										$398,147	$50,611	$0											$83,032	$15,132	$0						
$0										$398,147	$50,611	$0	$0										$83,032	$15,132	$0	$0					
$0	$0									$398,147	$50,611	$0	$0	$0									$83,032	$15,132	$0	$0	$0				
$0	$0	$0								$398,147	$50,611	$0	$0	$0	$0								$83,032	$15,132	$0	$0	$0	$0			
$0	$0	$0	$0							$398,147	$50,611	$0	$0	$0	$0	$0							$83,032	$15,132	$0	$0	$0	$0	$0		
$0	$0	$0	$0	$0						$398,147	$50,611	$0	$0	$0	$0	$0	$0						$83,032	$15,132	$0	$0	$0	$0	$0	$0	
$0	$0	$0	$0	$0	$0					$398,147	$50,611	$0	$0	$0	$0	$0	$0	$0					$83,032	$15,132	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0				$398,147	$50,611	$0	$0	$0	$0	$0	$0	$0	$0				$83,032	$15,132	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0				$50,611	$0	$0	$0	$0	$0	$0	$0	$0	$0				$15,132	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0	$0					$0	$0	$0	$0	$0	$0	$0	$0	$0					$0	$0	$0	$0	$0
		$0	$0	$0	$0	$0	$0	$0	$0						$0	$0	$0	$0	$0	$0	$0	$0						$0	$0	$0	$0
			$0	$0	$0	$0	$0	$0	$0							$0	$0	$0	$0	$0	$0	$0							$0	$0	$0
				$0	$0	$0	$0	$0	$0								$0	$0	$0	$0	$0	$0								$0	$0
					$0	$0	$0	$0	$0									$0	$0	$0	$0	$0									$0
						$0	$0	$0	$0										$0	$0	$0	$0									
							$0	$0	$0											$0	$0	$0									
								$0	$0												$0	$0									
									$0													$0									

869

Matrix #1

t Subtotal											Maintenance Cost Subtotal													Maintenance Cost Subtotal
										25-50 hp Out-of-State													25-50 hp Gen Sets CA-based	Use of electric standby not appropriate for gen sets-- cost figure
										$1,931,199														
										$1,931,199	$245,487													
										$1,931,199	$245,487	$258,482												
$815,349										$1,931,199	$245,487	$258,482	$271,956											
$815,349	$857,388									$1,931,199	$245,487	$258,482	$271,956	$285,969										
$815,349	$857,388	$902,022								$1,931,199	$245,487	$258,482	$271,956	$285,969	$300,501									
$815,349	$857,388	$902,022	$949,251							$1,931,199	$245,487	$258,482	$271,956	$285,969	$300,501	$316,590								
$815,349	$857,388	$902,022	$949,251	$998,556						$1,931,199	$245,487	$258,482	$271,956	$285,969	$300,501	$316,590	$332,679							
$815,349	$857,388	$902,022	$949,251	$998,556	$1,050,456					$1,931,199	$245,487	$258,482	$271,956	$285,969	$300,501	$316,590	$332,679	$350,325						
$815,349	$857,388	$902,022	$949,251	$998,556	$1,050,456	$1,104,951				$1,931,199	$245,487	$258,482	$271,956	$285,969	$300,501	$316,590	$332,679	$350,325	$368,490					
$815,349	$857,388	$902,022	$949,251	$998,556	$1,050,456	$1,104,951	$1,162,560				$245,487	$258,482	$271,956	$285,969	$300,501	$316,590	$332,679	$350,325	$368,490	$387,693				
$815,349	$857,388	$902,022	$949,251	$998,556	$1,050,456	$1,104,951	$1,162,560	$1,222,764				$258,482	$271,956	$285,969	$300,501	$316,590	$332,679	$350,325	$368,490	$387,693	$407,415			
$815,349	$857,388	$902,022	$949,251	$998,556	$1,050,456	$1,104,951	$1,162,560	$1,222,764	$0				$271,956	$285,969	$300,501	$316,590	$332,679	$350,325	$368,490	$387,693	$407,415	$0		
	$857,388	$902,022	$949,251	$998,556	$1,050,456	$1,104,951	$1,162,560	$1,222,764	$0					$285,969	$300,501	$316,590	$332,679	$350,325	$368,490	$387,693	$407,415	$0		
		$902,022	$949,251	$998,556	$1,050,456	$1,104,951	$1,162,560	$1,222,764	$0						$300,501	$316,590	$332,679	$350,325	$368,490	$387,693	$407,415	$0		
			$949,251	$998,556	$1,050,456	$1,104,951	$1,162,560	$1,222,764	$0							$316,590	$332,679	$350,325	$368,490	$387,693	$407,415	$0		
				$998,556	$1,050,456	$1,104,951	$1,162,560	$1,222,764	$0								$332,679	$350,325	$368,490	$387,693	$407,415	$0		
					$1,050,456	$1,104,951	$1,162,560	$1,222,764	$0									$350,325	$368,490	$387,693	$407,415	$0		
						$1,104,951	$1,162,560	$1,222,764	$0										$368,490	$387,693	$407,415	$0		
							$1,162,560	$1,222,764	$0											$387,693	$407,415	$0		
								$1,222,764	$0												$407,415	$0		
									$0													$0		

t Subtotal											Maintenance Cost Subtotal													Maintenance Cost Subtotal
										25-50 hp Out-of-State													25-50 hp Gen Sets CA-based	Use of cryogenic technology not appropriate for gen sets-- cost
										$22,820,893														
										$22,820,893	$2,900,909													
										$22,820,893	$2,900,909	$3,054,234												
$9,634,943										$22,820,893	$2,900,909	$3,054,234	$3,213,692											
$9,634,943	$10,131,716									$22,820,893	$2,900,909	$3,054,234	$3,213,692	$3,379,283										
$9,634,943	$10,131,716	$10,659,154								$22,820,893	$2,900,909	$3,054,234	$3,213,692	$3,379,283	$3,551,007									
$9,634,943	$10,131,716	$10,659,154	$11,217,257							$22,820,893	$2,900,909	$3,054,234	$3,213,692	$3,379,283	$3,551,007	$3,741,130								
$9,634,943	$10,131,716	$10,659,154	$11,217,257	$11,799,892						$22,820,893	$2,900,909	$3,054,234	$3,213,692	$3,379,283	$3,551,007	$3,741,130	$3,931,253							
$9,634,943	$10,131,716	$10,659,154	$11,217,257	$11,799,892	$12,413,192					$22,820,893	$2,900,909	$3,054,234	$3,213,692	$3,379,283	$3,551,007	$3,741,130	$3,931,253	$4,139,775						
$9,634,943	$10,131,716	$10,659,154	$11,217,257	$11,799,892	$12,413,192	$13,057,157				$22,820,893	$2,900,909	$3,054,234	$3,213,692	$3,379,283	$3,551,007	$3,741,130	$3,931,253	$4,139,775	$4,354,430					
$9,634,943	$10,131,716	$10,659,154	$11,217,257	$11,799,892	$12,413,192	$13,057,157	$13,737,920				$2,900,909	$3,054,234	$3,213,692	$3,379,283	$3,551,007	$3,741,130	$3,931,253	$4,139,775	$4,354,430	$4,581,351				
$9,634,943	$10,131,716	$10,659,154	$11,217,257	$11,799,892	$12,413,192	$13,057,157	$13,737,920	$14,449,348				$3,054,234	$3,213,692	$3,379,283	$3,551,007	$3,741,130	$3,931,253	$4,139,775	$4,354,430	$4,581,351	$4,814,405			
$9,634,943	$10,131,716	$10,659,154	$11,217,257	$11,799,892	$12,413,192	$13,057,157	$13,737,920	$14,449,348	$0				$3,213,692	$3,379,283	$3,551,007	$3,741,130	$3,931,253	$4,139,775	$4,354,430	$4,581,351	$4,814,405	$0		
	$10,131,716	$10,659,154	$11,217,257	$11,799,892	$12,413,192	$13,057,157	$13,737,920	$14,449,348	$0					$3,379,283	$3,551,007	$3,741,130	$3,931,253	$4,139,775	$4,354,430	$4,581,351	$4,814,405	$0		
		$10,659,154	$11,217,257	$11,799,892	$12,413,192	$13,057,157	$13,737,920	$14,449,348	$0						$3,551,007	$3,741,130	$3,931,253	$4,139,775	$4,354,430	$4,581,351	$4,814,405	$0		
			$11,217,257	$11,799,892	$12,413,192	$13,057,157	$13,737,920	$14,449,348	$0							$3,741,130	$3,931,253	$4,139,775	$4,354,430	$4,581,351	$4,814,405	$0		
				$11,799,892	$12,413,192	$13,057,157	$13,737,920	$14,449,348	$0								$3,931,253	$4,139,775	$4,354,430	$4,581,351	$4,814,405	$0		
					$12,413,192	$13,057,157	$13,737,920	$14,449,348	$0									$4,139,775	$4,354,430	$4,581,351	$4,814,405	$0		
						$13,057,157	$13,737,920	$14,449,348	$0										$4,354,430	$4,581,351	$4,814,405	$0		
							$13,737,920	$14,449,348	$0											$4,581,351	$4,814,405	$0		
								$14,449,348	$0												$4,814,405	$0		
									$0													$0		

870

					Maintenance Cost Subtotal													Maintenance Cost Subtotal												Maintenance Cost Subtotal			
				25-50 hp Gen Sets Out-of-State													25-50 hp Reefer Railcars													Maint Cost Sub-Total	Maintenance Cost Sub-Total (2002 $)	Total Annual In-Use Cost	Total Annual In-Use Cost (2002 $)
				$27,645													$67,954													$2,112,647	$1,576,490	$7,343,591	$5,509,003
				$27,645	$5,044												$67,954	$11,235												$2,393,047	$1,700,694	$8,363,645	$5,944,029
				$27,645	$5,044	$0											$67,954	$11,235	$0											$2,393,047	$1,619,708	$9,193,060	$6,222,225
				$27,645	$5,044	$0	$0										$67,954	$11,235	$0	$0										$2,393,047	$1,542,579	$10,087,249	$6,489,439
				$27,645	$5,044	$0	$0	$0									$67,954	$11,235	$0	$0	$0									$2,393,047	$1,469,123	$10,889,393	$6,746,534
				$27,645	$5,044	$0	$0	$0	$0								$67,954	$11,235	$0	$0	$0	$0								$2,393,047	$1,399,165	$11,861,575	$6,993,665
				$27,645	$5,044	$0	$0	$0	$0	$0							$67,954	$11,235	$0	$0	$0	$0	$0							$2,393,047	$1,332,538	$12,887,968	$7,232,186
				$27,645	$5,044	$0	$0	$0	$0	$0	$0						$67,954	$11,235	$0	$0	$0	$0	$0	$0						$2,393,047	$1,269,084	$14,070,353	$7,461,809
				$27,645	$5,044	$0	$0	$0	$0	$0	$0	$0					$67,954	$11,235	$0	$0	$0	$0	$0	$0	$0					$2,393,047	$1,208,651	$15,213,502	$7,683,852
$0				$27,645	$5,044	$0	$0	$0	$0	$0	$0	$0	$0				$67,954	$11,235	$0	$0	$0	$0	$0	$0	$0	$0				$2,393,047	$1,151,097	$16,419,764	$7,898,202
$0	$0				$5,044	$0	$0	$0	$0	$0	$0	$0	$0	$0				$11,235	$0	$0	$0	$0	$0	$0	$0	$0	$0			$260,400	$128,454	$10,311,405	$4,723,774
$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0		$0	$0	$10,675,540	$4,657,703
$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$10,049,161	$4,175,834
$0	$0	$0	$0					$0	$0	$0	$0	$0	$0	$0	$0	$0					$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$9,174,971	$3,830,849
$0	$0	$0	$0						$0	$0	$0	$0	$0	$0	$0	$0						$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$8,252,826	$3,110,404
$0	$0	$0	$0							$0	$0	$0	$0	$0	$0	$0							$0	$0	$0	$0	$0	$0	$0	$0	$0	$7,280,645	$2,613,332
$0	$0	$0	$0								$0	$0	$0	$0	$0	$0								$0	$0	$0	$0	$0	$0	$0	$0	$6,254,254	$2,138,016
$0	$0	$0	$0									$0	$0	$0	$0	$0									$0	$0	$0	$0	$0	$0	$0	$5,171,867	$1,683,812
$0	$0	$0	$0										$0	$0	$0	$0										$0	$0	$0	$0	$0	$0	$4,028,719	$1,249,177
	$0	$0	$0											$0	$0	$0											$0	$0	$0	$0	$0	$2,822,427	$833,470
		$0	$0												$0	$0												$0	$0	$0	$0	$1,548,224	$435,424
			$0													$0													$0	$0	$0	$202,836	$54,329

2008-2020 Maintenance Cost Subtotal (In 2002 $): $14,397,584

2008 - 2020 Total In-Use Compliance Cost (In 2002 $): $61,738,073

Low-Cost Scenario

					Maintenance Cost Subtotal													Maintenance Cost Subtotal												Maintenance Cost Subtotal			
				25-50 hp Gen Sets Out-of-State													25-50 hp Reefer Railcars													Maint Cost Sub-Total	Maintenance Cost Sub-Total (2002 $)	Total Annual In-Use Cost	Total Annual In-Use Cost (2002 $)
				$27,645													$67,954													$2,503,647	$1,868,260	$7,773,691	$5,800,773
				$27,645	$5,044												$67,954	$11,235												$2,841,271	$2,019,236	$8,812,069	$6,262,573
				$27,645	$5,044	$0											$67,954	$11,235	$0											$2,841,271	$1,923,084	$9,641,284	$6,525,600
				$27,645	$5,044	$0	$0										$67,954	$11,235	$0	$0										$2,841,271	$1,831,509	$10,515,473	$6,778,368
				$27,645	$5,044	$0	$0	$0									$67,954	$11,235	$0	$0	$0									$2,841,271	$1,744,294	$11,437,617	$7,021,705
				$27,645	$5,044	$0	$0	$0	$0								$67,954	$11,235	$0	$0	$0	$0								$2,841,271	$1,661,232	$12,409,788	$7,253,753
				$27,645	$5,044	$0	$0	$0	$0	$0							$67,954	$11,235	$0	$0	$0	$0	$0							$2,841,271	$1,582,126	$13,438,190	$7,481,774
				$27,645	$5,044	$0	$0	$0	$0	$0	$0						$67,954	$11,235	$0	$0	$0	$0	$0	$0						$2,841,271	$1,506,787	$14,518,577	$7,699,512
				$27,645	$5,044	$0	$0	$0	$0	$0	$0	$0					$67,954	$11,235	$0	$0	$0	$0	$0	$0	$0					$2,841,271	$1,435,035	$15,661,726	$7,910,236
$0				$27,645	$5,044	$0	$0	$0	$0	$0	$0	$0	$0				$67,954	$11,235	$0	$0	$0	$0	$0	$0	$0	$0				$2,841,271	$1,366,700	$16,868,018	$8,113,605
$0	$0				$5,044	$0	$0	$0	$0	$0	$0	$0	$0	$0				$11,235	$0	$0	$0	$0	$0	$0	$0	$0	$0			$337,624	$164,869	$10,368,826	$4,749,988
$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0		$0	$0	$10,675,540	$4,657,703
$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$10,049,161	$4,175,834
$0	$0	$0	$0					$0	$0	$0	$0	$0	$0	$0	$0	$0					$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$9,174,971	$3,830,848
$0	$0	$0	$0						$0	$0	$0	$0	$0	$0	$0	$0						$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$8,252,826	$3,110,404
$0	$0	$0	$0							$0	$0	$0	$0	$0	$0	$0							$0	$0	$0	$0	$0	$0	$0	$0	$0	$7,280,645	$2,613,332
$0	$0	$0	$0								$0	$0	$0	$0	$0	$0								$0	$0	$0	$0	$0	$0	$0	$0	$6,254,254	$2,138,016
$0	$0	$0	$0									$0	$0	$0	$0	$0									$0	$0	$0	$0	$0	$0	$0	$5,171,867	$1,683,812
$0	$0	$0	$0										$0	$0	$0	$0										$0	$0	$0	$0	$0	$0	$4,028,719	$1,249,177
	$0	$0	$0											$0	$0	$0											$0	$0	$0	$0	$0	$2,822,427	$833,470
		$0	$0												$0	$0												$0	$0	$0	$0	$1,548,224	$435,424
			$0													$0													$0	$0	$0	$202,836	$54,329

2008 - 2020 Maintenance Cost Subtotal (In 2002 $): $17,092,834

2008 - 2020 Total In-Use Compliance Cost (In 2002 $): $64,433,423

High-Cost Scenario

Matrix #1

Maintenance Cost Subtotal | Maintenance Cost Subtotal | Maintenance Cost Subtotal

...s do not include gen sets. | 25-50 hp Gen Sets Out-of-State | Use of electric standby not appropriate for gen sets-- cost figures do not include gen sets.

25-50 hp Reefer Railcars													Maint Cost Sub-Total	Maintenance Cost Sub-Total (2002 $)	Total Annual In-Use Cost	Total Annual In-Use Cost (2002 $)
$426,616													$9,710,490	$7,249,117	$47,508,432	$35,451,523
$426,616	$54,495												$10,972,698	$7,798,082	$53,683,788	$39,152,051
$426,616	$54,495	$57,090											$12,298,743	$8,324,273	$60,171,422	$40,728,307
$426,616	$54,495	$57,090	$60,204										$13,691,220	$8,828,482	$66,984,098	$43,178,846
$426,616	$54,495	$57,090	$60,204	$63,316									$15,153,243	$9,302,777	$74,137,022	$45,513,701
$426,616	$54,495	$57,090	$60,204	$63,316	$66,432								$16,687,926	$9,757,085	$81,645,437	$47,736,398
$426,616	$54,495	$57,090	$60,204	$63,316	$66,432	$70,065							$18,300,459	$10,190,380	$89,534,731	$49,856,209
$426,616	$54,495	$57,090	$60,204	$63,316	$66,432	$70,065	$73,698						$19,993,437	$10,603,847	$97,817,803	$51,874,763
$426,616	$54,495	$57,090	$60,204	$63,316	$66,432	$70,065	$73,698	$77,331					$21,772,050	$10,996,365	$106,518,440	$53,798,558
$426,616	$54,495	$57,090	$60,204	$63,316	$66,432	$70,065	$73,698	$77,331	$81,463				$23,639,412	$11,370,661	$115,655,482	$55,632,294
	$54,495	$57,090	$60,204	$63,316	$66,432	$70,065	$73,698	$77,331	$81,463	$85,635			$15,890,223	$7,278,494	$77,742,888	$35,614,820
		$57,090	$60,204	$63,316	$66,432	$70,065	$73,698	$77,331	$81,463	$85,635	$90,306		$16,667,407	$7,280,650	$81,642,888	$35,620,626
			$60,204	$63,316	$66,432	$70,065	$73,698	$77,331	$81,463	$85,635	$90,306	$0	$15,714,601	$6,528,824	$76,884,437	$31,947,072
				$63,316	$66,432	$70,065	$73,698	$77,331	$81,463	$85,635	$90,306	$0	$14,322,324	$5,667,830	$70,071,763	$27,729,778
					$66,432	$70,065	$73,698	$77,331	$81,463	$85,635	$90,306	$0	$12,660,301	$4,846,812	$62,618,837	$23,713,440
						$70,065	$73,698	$77,331	$81,463	$85,635	$90,306	$0	$11,325,616	$4,066,244	$55,410,422	$19,889,149
							$73,698	$77,331	$81,463	$85,635	$90,306	$0	$9,713,065	$3,320,417	$47,521,128	$16,245,091
								$77,331	$81,463	$85,635	$90,306	$0	$8,020,107	$2,611,117	$39,238,256	$12,774,851
									$81,463	$85,635	$90,306	$0	$6,241,494	$1,935,207	$30,536,418	$9,468,364
										$85,635	$90,306	$0	$4,374,132	$1,261,693	$21,400,378	$6,319,691
											$90,306	$0	$2,412,631	$476,560	$11,804,741	$3,318,974
												$0	$353,439	$84,665	$1,729,185	$483,162
										2008 - 2020 Maintenance Cost Subtotal (In 2002 $):				$118,604,456		
												2008 - 2020 Total In-Use Compliance Cost (In 2002 $):				$565,103,892
												Alternative 1 Scenario (electric standby)				

Maintenance Cost Subtotal | Maintenance Cost Subtotal | Maintenance Cost Subtotal

...figures do not include gen sets. | 25-50 hp Gen Sets Out-of-State | Use of cryogenic technology not appropriate for gen sets-- cost figures do not include gen...

25-50 hp Reefer Railcars													Maint Cost Sub-Total 25-50 hp	Maintenance Cost Sub-Total (2002 $)	Total Annual In-Use Cost	Total Annual In-Use Cost (2002 $)
$5,041,326													$114,746,430	$88,627,045	$180,070,161	$128,416,656
$5,041,326	$643,965												$129,663,888	$92,149,703	$189,818,809	$134,870,169
$5,041,326	$643,965	$674,630											$146,333,701	$96,397,968	$212,407,936	$144,077,389
$5,041,326	$643,965	$674,630	$711,426										$161,788,840	$104,290,335	$230,960,073	$152,752,378
$5,041,326	$643,965	$674,630	$711,426	$748,226									$179,065,201	$108,930,500	$262,273,921	$161,013,438
$5,041,326	$643,965	$674,630	$711,426	$748,226	$785,024								$197,200,462	$115,299,038	$285,436,379	$169,878,847
$5,041,326	$643,965	$674,630	$711,426	$748,226	$785,024	$827,855							$216,255,713	$120,419,273	$316,746,269	$176,376,173
$5,041,326	$643,965	$674,630	$711,426	$748,226	$785,024	$827,855	$870,686						$236,281,658	$126,294,849	$346,048,807	$183,610,612
$5,041,326	$643,965	$674,630	$711,426	$748,226	$785,024	$827,855	$870,686	$913,617					$257,279,360	$129,143,658	$376,632,926	$190,326,235
$5,041,326	$643,965	$674,630	$711,426	$748,226	$785,024	$827,855	$870,686	$913,617	$962,881				$279,345,884	$134,170,146	$409,163,425	$196,808,763
	$643,965	$674,630	$711,426	$748,226	$785,024	$827,855	$870,686	$913,617	$962,881	$1,011,945			$187,774,061	$86,021,461	$275,030,646	$126,994,261
		$674,630	$711,426	$748,226	$785,024	$827,855	$870,686	$913,617	$962,881	$1,011,945	$1,067,142		$197,194,349	$86,025,241	$288,827,303	$126,014,435
			$711,426	$748,226	$785,024	$827,855	$870,686	$913,617	$962,881	$1,011,945	$1,067,142	$0	$185,701,107	$77,162,646	$271,993,420	$113,010,866
				$748,226	$785,024	$827,855	$870,686	$913,617	$962,881	$1,011,945	$1,067,142	$0	$169,240,266	$66,876,495	$247,882,266	$98,098,396
					$785,024	$827,855	$870,686	$913,617	$962,881	$1,011,945	$1,067,142	$0	$151,969,607	$57,278,747	$222,587,440	$83,890,665
						$827,855	$870,686	$913,617	$962,881	$1,011,945	$1,067,142	$0	$133,834,326	$48,032,609	$196,024,866	$70,361,072
							$870,686	$913,617	$962,881	$1,011,945	$1,067,142	$0	$114,779,095	$39,237,219	$168,115,085	$57,470,124
								$913,617	$962,881	$1,011,945	$1,067,142	$0	$94,773,249	$30,855,450	$138,812,854	$45,193,482
									$962,881	$1,011,945	$1,067,142	$0	$73,755,456	$22,869,201	$108,028,434	$33,496,161
										$1,011,945	$1,067,142	$0	$51,686,924	$15,263,863	$75,707,836	$22,356,763
											$1,067,142	$0	$28,512,317	$8,018,835	$41,761,032	$11,746,044
												$0	$4,176,573	$1,118,666	$6,117,360	$1,638,524
										2008-2020 Maintenance Cost Subtotal (In 2002 $):				$1,384,811,062		
												2008 - 2020 Total In-Use Compliance Cost (In 2002 $):				$1,889,183,288
												Alternative 2 Scenario (cryogenic)				

Total

873

874

In-Use Compliance Cost Range Estimates Oct. 14, 03

This Matrix calculates the in-use cost of compliance for TRUs and TRU gen sets ("TRUs".) It takes the annual TRU population numbers (same as used for emissions inventory purposes) and multiplies them by the capital and annual costs for the compliance technology shown.
The capital costs are amortized over an assumed ten-year useful life, and all annual costs are converted to constant year (2002) dollars using standard present worth analysis techniques.

In this scenario, on a year-by-year basis, population figures for each engine category are multiplied by the annualized capital cost and the early retirement allowance factor; these products are then summed to determine the compliance cost for a given year.

Interest Rates Used for Present Worth Analysis

Capital Costs: 0.05 Real interest rate, which is a 7% nominal rate minus an assumed 2% inflation rate
Annual Costs: 0.05 Real interest rate, which is a 7% nominal rate minus an assumed 2% inflation rate

Assumptions: 10-year useful life for compliance technology; capital cost is amortized over a 10-year period.

Lack of VDECS Scenario:

				Early Retirement Allowance Profile (cost factor attributable to ATCM) Year									
Compliance Scenario	Size	Cap. Cost	Ann. Cost	1	2	3	4	5	6	7	8	9	10
LETRU: TRU Replacement	<15 HP	$10,000	$0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	15-25 HP	$15,000	$0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	>25 HP	$20,000	$0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
LETRU-GEN: Replacement w/new	>25 HP	$12,000	$0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
ULETRU: Engine Replacement	<15 HP	$4,000	$0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	15-25 HP	$4,500	$0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	>25 HP	$5,000	$0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
ULETRU-GEN: Engine Replacement	>25	$5,000	$0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Engine Population Category

Engine Model Year	Calendar Year	< 15hp	15-25 hp	25-50 hp CA-based	25-50 hp Out-of-State	25-50 hp Gen Sets CA-based	25-50 hp Gen Sets Out-of-State	Reefer 25-50 hp Railcar	Total 25-50 hp (Info Only)	Total (this year)
-2001	2008 All	2125	880	11162	3721	856	285	822	16846	19851
-1998	2008	1061	462	6045	2015	509	170	539	9278	10801
1999	2008	322	195	2215	738	80	27	89	3149	3666
2000	2008	353	139	1803	601	124	41	94	2663	3155
2001	2008	383	84	1099	366	142	47	100	1754	2221
2002	2009	311	124	1419	473	156	52	105	2205	2640
2003	2010	326	128	1493	498	172	57	110	2330	2784
2004	2011	340	132	1571	524	189	63	116	2463	2935
2005	2012	356	136	1652	551	209	70	122	2604	3096
2006	2013	372	140	1738	579	230	77	128	2752	3264
2007	2014	389	144	1829	610	254	85	135	2913	3446
2008	2015	407	148	1924	641	279	93	142	3079	3634
2009	2016	426	153	2024	675	308	103	149	3259	3838
2010	2017	445	157	2129	710	339	113	157	3448	4050
2011	2018	465	162	2240	747	374	125	165	3651	4278
2012	2019	486	167	2356	785	412	137	174	3864	4517
2013	2020	509	172	*	*	*	*	*	*	681
	2021	*	*	*	*	*	*	*	*	*
	2022	*	*	*	*	*	*	*	*	*

Engine Model Year	Calendar Year	< 15HP Capital Cost Subtotal															< 15HP	Capital Cost Subtotal	< 15HP
-2001	2008 All																		
-1998	2008	$1,373,995																$1,373,995	$206,099
1999	2008	$1,373,995	$416,990															$1,790,985	$206,099
2000	2008	$1,373,995	$416,990	$457,135														$2,248,120	$206,099
2001	2008	$1,373,995	$416,990	$457,135	$495,985													$2,744,105	$206,099
2002	2009	$1,373,995	$416,990	$457,135	$495,985	$402,745												$3,146,850	$206,099
2003	2010	$1,373,995	$416,990	$457,135	$495,985	$402,745	$168,868											$3,315,718	$206,099
2004	2011	$1,373,995	$416,990	$457,135	$495,985	$402,745	$168,868	$176,120										$3,491,838	$206,099
2005	2012	$1,373,995	$416,990	$457,136	$495,985	$402,745	$168,868	$176,120	$184,408									$3,676,246	$206,099
2006	2013	$1,373,995	$416,990	$457,135	$495,985	$402,745	$168,868	$176,120	$184,408	$192,696								$3,868,942	$206,099
2007	2014	$1,373,995	$416,990	$457,135	$495,985	$402,745	$168,868	$176,120	$184,408	$192,696	$201,502							$4,070,444	$206,099
2008	2015		$416,990	$457,135	$495,985	$402,745	$168,868	$176,120	$184,408	$192,696	$201,502	$210,826						$2,907,275	
2009	2016			$457,135	$495,985	$402,745	$168,868	$176,120	$184,408	$192,696	$201,502	$210,826	$220,668					$2,710,953	
2010	2017				$495,985	$402,745	$168,868	$176,120	$184,408	$192,696	$201,502	$210,826	$220,668	$230,510				$2,484,328	
2011	2018					$402,745	$168,868	$176,120	$184,408	$192,696	$201,502	$210,826	$220,668	$230,510	$240,870			$2,229,213	
2012	2019						$168,868	$176,120	$184,408	$192,696	$201,502	$210,826	$220,668	$230,510	$240,870	$251,748		$2,078,216	
2013	2020							$176,120	$184,408	$192,696	$201,502	$210,826	$220,668	$230,510	$240,870	$251,748	$263,662	$2,173,010	
	2021								$184,408	$192,696	$201,502	$210,826	$220,668	$230,510	$240,870	$251,748	$263,662	$1,996,890	
	2022									$192,696	$201,502	$210,826	$220,668	$230,510	$240,870	$251,748	$263,662	$1,812,482	

875

Early Retirement														< 15HP	Early Retirement Cost Subtotal	15-25 HP	Capital Cost Subtotal											
															$206,009	$897,435												
$62,549															$268,648	$897,435	$378,788											
$62,549	$68,570														$337,218	$897,435	$378,788	$270,008										
$62,549	$68,570	$74,398													$411,616	$897,435	$378,788	$270,008	$163,170									
$62,549	$68,570	$74,398	$80,412												$472,028	$897,435	$378,788	$270,008	$163,170	$240,870								
$62,549	$68,570	$74,398	$80,412	$87,547											$539,575	$897,435	$378,788	$270,008	$163,170	$240,870	$74,592							
$62,549	$68,570	$74,398	$80,412	$87,547	$70,448										$610,023	$897,435	$378,788	$270,008	$163,170	$240,870	$74,592	$76,923						
$62,549	$68,570	$74,398	$80,412	$87,547	$70,448	$73,763									$683,766	$897,435	$378,788	$270,008	$163,170	$240,870	$74,592	$76,923	$79,254					
$62,549	$68,570	$74,398	$80,412	$87,547	$70,448	$73,763	$77,078								$760,864	$897,435	$378,788	$270,008	$163,170	$240,870	$74,592	$76,923	$79,254	$81,585				
$62,549	$68,570	$74,398	$80,412	$87,547	$70,448	$73,763	$77,078	$80,601							$841,465	$897,435	$378,788	$270,008	$163,170	$240,870	$74,592	$76,923	$79,254	$81,585	$83,916			
$62,549	$68,570	$74,398	$80,412	$87,547	$70,448	$73,763	$77,078	$80,601	$84,330						$719,696		$378,788	$270,008	$163,170	$240,870	$74,592	$76,923	$79,254	$81,585	$83,916	$86,247		
	$68,570	$74,398	$80,412	$87,547	$70,448	$73,763	$77,078	$80,601	$84,330	$88,267					$745,415			$270,008	$163,170	$240,870	$74,592	$76,923	$79,254	$81,585	$83,916	$86,247	$89,161	
		$74,398	$80,412	$87,547	$70,448	$73,763	$77,078	$80,601	$84,330	$88,267	$92,204				$769,049				$163,170	$240,870	$74,592	$76,923	$79,254	$81,585	$83,916	$86,247	$89,161	$91,492
			$80,412	$87,547	$70,448	$73,763	$77,078	$80,601	$84,330	$88,267	$92,204	$96,348			$790,999					$240,870	$74,592	$76,923	$79,254	$81,585	$83,916	$86,247	$89,161	$91,492
				$87,547	$70,448	$73,763	$77,078	$80,601	$84,330	$88,267	$92,204	$96,348	$100,699		$831,286						$74,592	$76,923	$79,254	$81,585	$83,916	$86,247	$89,161	$91,492
					$70,448	$73,763	$77,078	$80,601	$84,330	$88,267	$92,204	$96,348	$100,699	$105,465	$869,204							$76,923	$79,254	$81,585	$83,916	$86,247	$89,161	$91,492
						$73,763	$77,078	$80,601	$84,330	$88,267	$92,204	$96,348	$100,699	$105,465	$798,756								$79,254	$81,585	$83,916	$86,247	$89,161	$91,492
							$77,078	$80,601	$84,330	$88,267	$92,204	$96,348	$100,699	$105,465	$724,993									$81,585	$83,916	$86,247	$89,161	$91,492

		15-25 HP	Capital Cost Subtotal	15-25 HP Early Retirement															15-25 HP	Early Retirement Cost Subtotal	25-50 HP CA-based Capital Cost Subtotal						
			$897,435	$134,615																$134,615	$15,656,550						
			$1,276,223	$134,615	$56,818															$191,433	$15,656,550	$5,736,850					
			$1,546,230	$134,615	$56,818	$40,501														$231,935	$15,656,550	$5,736,850	$4,669,770				
			$1,709,400	$134,615	$56,818	$40,501	$24,476													$256,410	$15,656,550	$5,736,850	$4,669,770	$2,846,410			
			$1,950,270	$134,615	$56,818	$40,501	$24,476	$36,131												$292,541	$15,656,550	$5,736,850	$4,669,770	$2,846,410	$3,675,210		
			$2,024,862	$134,615	$56,818	$40,501	$24,476	$36,131	$29,837											$322,377	$15,656,550	$5,736,850	$4,669,770	$2,846,410	$3,675,210	$966,718	
			$2,101,785	$134,615	$56,818	$40,501	$24,476	$36,131	$29,837	$30,769										$353,147	$15,656,550	$5,736,850	$4,669,770	$2,846,410	$3,675,210	$966,718	$1,017,223
			$2,181,039	$134,615	$56,818	$40,501	$24,476	$36,131	$29,837	$30,769	$31,702									$384,848	$15,656,550	$5,736,850	$4,669,770	$2,846,410	$3,675,210	$966,718	$1,017,223
			$2,262,624	$134,615	$56,818	$40,501	$24,476	$36,131	$29,837	$30,769	$31,702	$32,634								$417,482	$15,656,550	$5,736,850	$4,669,770	$2,846,410	$3,675,210	$966,718	$1,017,223
			$2,346,540	$134,615	$56,818	$40,501	$24,476	$36,131	$29,837	$30,769	$31,702	$32,634	$33,566							$451,049	$15,656,550	$5,736,850	$4,669,770	$2,846,410	$3,675,210	$966,718	$1,017,223
			$1,535,352		$56,818	$40,501	$24,476	$36,131	$29,837	$30,769	$31,702	$32,634	$33,566							$316,433		$5,736,850	$4,669,770	$2,846,410	$3,675,210	$966,718	$1,017,223
			$1,245,725			$40,501	$24,476	$36,131	$29,837	$30,769	$31,702	$32,634	$33,566	$34,499	$35,664					$329,778			$4,669,770	$2,846,410	$3,675,210	$966,718	$1,017,223
			$1,067,210				$24,476	$36,131	$29,837	$30,769	$31,702	$32,634	$33,566	$34,499	$35,664	$36,597				$326,874				$2,846,410	$3,675,210	$966,718	$1,017,223
$94,406			$998,445					$36,131	$29,837	$30,769	$31,702	$32,634	$33,566	$34,499	$35,664	$36,597	$37,762			$339,161					$3,675,210	$966,718	$1,017,223
$94,406	$97,319		$854,894						$29,837	$30,769	$31,702	$32,634	$33,566	$34,499	$35,664	$36,597	$37,762	$38,928		$341,958						$966,718	$1,017,223
$94,406	$97,319	$100,233	$860,535							$30,769	$31,702	$32,634	$33,566	$34,499	$35,664	$36,597	$37,762	$38,928	$40,093	$352,214							$1,017,223
$94,406	$97,319	$100,233	$803,612								$31,702	$32,634	$33,566	$34,499	$35,664	$36,597	$37,762	$38,928	$40,093	$321,445							
$94,406	$97,319	$100,233	$724,356									$32,634	$33,566	$34,499	$35,664	$36,597	$37,762	$38,928	$40,093	$289,743							

877

878

								25-50 HP CA-based	Capital Cost Subtotal	25-50 HP CA-based Early Retirement															25-50 HP CA-[illegible]
									$15,656,550	$2,348,483															
									$21,393,400	$2,348,483	$660,528														
									$26,063,170	$2,348,483	$660,528	$700,466													
									$28,909,580	$2,348,483	$660,528	$700,466	$426,962												
									$32,584,790	$2,348,483	$660,528	$700,466	$426,962	$551,282											
									$33,551,508	$2,348,483	$660,528	$700,466	$426,962	$551,282	$386,687										
									$34,568,730	$2,348,483	$660,528	$700,466	$426,962	$551,282	$386,687	$406,889									
$1,069,670									$35,638,400	$2,348,483	$660,528	$700,466	$426,962	$551,282	$386,687	$406,889	$427,868								
$1,069,670	$1,125,355								$36,763,755	$2,348,483	$660,528	$700,466	$426,962	$551,282	$386,687	$406,889	$427,868	$450,142							
$1,069,670	$1,125,355	$1,184,278							$37,948,033	$2,348,483	$660,528	$700,466	$426,962	$551,282	$386,687	$406,889	$427,868	$450,142	$473,711						
$1,069,670	$1,125,355	$1,184,278	$1,245,790						$23,537,273		$660,528	$700,466	$426,962	$551,282	$386,687	$406,889	$427,868	$450,142	$473,711	$498,316					
$1,069,670	$1,125,355	$1,184,278	$1,245,790	$1,310,540					$19,110,863			$700,466	$426,962	$551,282	$386,687	$406,889	$427,868	$450,142	$473,711	$498,316	$524,216				
$1,069,670	$1,125,355	$1,184,278	$1,245,790	$1,310,540	$1,378,528				$16,819,720				$426,962	$551,282	$386,687	$406,889	$427,868	$450,142	$473,711	$498,316	$524,216	$551,411			
$1,069,670	$1,125,355	$1,184,278	$1,245,790	$1,310,540	$1,378,528	$1,450,400			$14,423,710					$551,282	$386,687	$406,889	$427,868	$450,142	$473,711	$498,316	$524,216	$551,411	$580,160		
$1,069,670	$1,125,355	$1,184,278	$1,245,790	$1,310,540	$1,378,528	$1,450,400	$1,525,510		$12,274,010						$386,687	$406,889	$427,868	$450,142	$473,711	$498,316	$524,216	$551,411	$580,160	$610,204	
$1,069,670	$1,125,355	$1,184,278	$1,245,790	$1,310,540	$1,378,528	$1,450,400	$1,525,510	$0	$11,307,293							$406,889	$427,868	$450,142	$473,711	$498,316	$524,216	$551,411	$580,160	$610,204	$0
$1,069,670	$1,125,355	$1,184,278	$1,245,790	$1,310,540	$1,378,528	$1,450,400	$1,525,510	$0	$10,290,070								$427,868	$450,142	$473,711	$498,316	$524,216	$551,411	$580,160	$610,204	$0
	$1,125,355	$1,184,278	$1,245,790	$1,310,540	$1,378,528	$1,450,400	$1,525,510	$0	$9,220,400									$450,142	$473,711	$498,316	$524,216	$551,411	$580,160	$610,204	$0

-based Early Retirement Cost Subtotal	25-50 HP Out-of-State	Capital Cost Subtotal															25-50 HP Out-of-State Capital Cost Subtotal	25-50 HP Out-of-State	Early Retirement							
$2,348,483	$5,218,850																$5,218,850	$782,828								
$3,209,010	$5,218,850	$1,911,420															$7,130,270	$782,828	$286,713							
$3,909,476	$5,218,850	$1,911,420	$1,556,590														$8,686,860	$782,828	$286,713	$233,489						
$4,336,437	$5,218,850	$1,911,420	$1,556,590	$947,940													$9,634,800	$782,828	$286,713	$233,489	$142,191					
$4,887,719	$5,218,850	$1,911,420	$1,556,590	$947,940	$1,225,070												$10,859,870	$782,828	$286,713	$233,489	$142,191	$183,761				
$5,274,406	$5,218,850	$1,911,420	$1,556,590	$947,940	$1,225,070	$322,455											$11,182,325	$782,828	$286,713	$233,489	$142,191	$183,761	$128,982			
$5,681,295	$5,218,850	$1,911,420	$1,556,590	$947,940	$1,225,070	$322,455	$339,290										$11,521,615	$782,828	$286,713	$233,489	$142,191	$183,761	$128,982	$135,716		
$6,109,163	$5,218,850	$1,911,420	$1,556,590	$947,940	$1,225,070	$322,455	$339,290	$356,773									$11,878,388	$782,828	$286,713	$233,489	$142,191	$183,761	$128,982	$135,716	$142,709	
$6,559,305	$5,218,850	$1,911,420	$1,556,590	$947,940	$1,225,070	$322,455	$339,290	$356,773	$374,903								$12,253,290	$782,828	$286,713	$233,489	$142,191	$183,761	$128,982	$135,716	$142,709	$149,961
$7,033,016	$5,218,850	$1,911,420	$1,556,590	$947,940	$1,225,070	$322,455	$339,290	$356,773	$374,903	$394,976							$12,848,265	$782,828	$286,713	$233,489	$142,191	$183,761	$128,982	$135,716	$142,709	$149,961
$5,182,849		$1,911,420	$1,556,590	$947,940	$1,225,070	$322,455	$339,290	$356,773	$374,903	$394,975	$415,048						$7,844,463		$286,713	$233,489	$142,191	$183,761	$128,982	$135,716	$142,709	$149,961
$4,846,538			$1,556,590	$947,940	$1,225,070	$322,455	$339,290	$356,773	$374,903	$394,975	$415,048	$437,063					$6,370,105			$233,489	$142,191	$183,761	$128,982	$135,716	$142,709	$149,961
$4,697,483				$947,940	$1,225,070	$322,455	$339,290	$356,773	$374,903	$394,975	$415,048	$437,063	$459,725				$5,273,240				$142,191	$183,761	$128,982	$135,716	$142,709	$149,961
$4,850,682					$1,225,070	$322,455	$339,290	$356,773	$374,903	$394,975	$415,048	$437,063	$459,725	$483,683			$4,808,983					$183,761	$128,982	$135,716	$142,709	$149,961
$4,909,604						$322,455	$339,290	$356,773	$374,903	$394,975	$415,048	$437,063	$459,725	$483,683	$508,288		$4,092,200						$128,982	$135,716	$142,709	$149,961
$4,522,917							$339,290	$356,773	$374,903	$394,975	$415,048	$437,063	$459,725	$483,683	$508,288	$0	$3,769,745							$135,716	$142,709	$149,961
$4,116,028								$356,773	$374,903	$394,975	$415,048	$437,063	$459,725	$483,683	$508,288	$0	$3,430,455								$142,709	$149,961
$3,668,160									$374,903	$394,975	$415,048	$437,063	$459,725	$483,683	$508,288	$0	$3,073,683									$149,961

088

						25-50 HP Out-of-State	Early Retirement Cost Subtotal	25-50 HP Gen Sets CA-based		Capital Cost Subtotal												25-50 HP Gen Sets CA-based		Capital Cost Subtotal	25-50 HP Gen Sets CA-based		Early R
							$782,828	$790,986																$790,986	$118,646		
							$1,069,541	$790,986	$124,320															$915,306	$118,646	$18,648	
							$1,303,029	$790,986	$124,320	$192,696														$1,108,002	$118,646	$18,648	$28,904
							$1,445,220	$790,986	$124,320	$192,696	$220,688													$1,328,670	$118,646	$18,648	$28,904
							$1,628,981	$790,986	$124,320	$192,696	$220,688	$242,424												$1,571,094	$118,646	$18,648	$28,904
							$1,757,963	$790,986	$124,320	$192,696	$220,688	$242,424	$111,370											$1,682,464	$118,646	$18,648	$28,904
							$1,893,679	$790,986	$124,320	$192,696	$220,688	$242,424	$111,370	$122,378										$1,804,642	$118,646	$18,648	$28,904
							$2,036,388	$790,986	$124,320	$192,696	$220,688	$242,424	$111,370	$122,378	$135,328									$1,940,169	$118,646	$18,648	$28,904
							$2,186,349	$790,986	$124,320	$192,696	$220,688	$242,424	$111,370	$122,378	$135,328	$148,925								$2,089,094	$118,646	$18,648	$28,904
$157,990							$2,344,339	$790,986	$124,320	$192,696	$220,688	$242,424	$111,370	$122,378	$135,328	$148,925	$164,465							$2,253,559	$118,646	$18,648	$28,904
$157,990	$166,019						$1,727,530		$124,320	$192,696	$220,688	$242,424	$111,370	$122,378	$135,328	$148,925	$164,465	$180,653						$1,643,226		$18,648	$28,904
$157,990	$166,019	$174,825					$1,615,642			$192,696	$220,688	$242,424	$111,370	$122,378	$135,328	$148,925	$164,465	$180,653	$199,430					$1,718,336			$28,904
$157,990	$166,019	$174,825	$183,890				$1,566,044				$220,688	$242,424	$111,370	$122,378	$135,328	$148,925	$164,465	$180,653	$199,430	$219,503				$1,745,142			
$157,990	$166,019	$174,825	$183,890	$193,473			$1,617,326					$242,424	$111,370	$122,378	$135,328	$148,925	$164,465	$180,653	$199,430	$219,503	$242,165			$1,766,839			
$157,990	$166,019	$174,825	$183,890	$193,473	$203,315		$1,636,680						$111,370	$122,378	$135,328	$148,925	$164,465	$180,653	$199,430	$219,503	$242,165	$266,770		$1,790,985			
$157,990	$166,019	$174,825	$183,890	$193,473	$203,315	$0	$1,607,898							$122,378	$135,328	$148,925	$164,465	$180,653	$199,430	$219,503	$242,165	$266,770	$0	$1,679,618			
$157,990	$166,019	$174,825	$183,890	$193,473	$203,315	$0	$1,372,182								$135,328	$148,925	$164,465	$180,653	$199,430	$219,503	$242,165	$266,770	$0	$1,557,238			
$157,990	$166,019	$174,825	$183,890	$193,473	$203,315	$0	$1,229,473									$148,925	$164,465	$180,653	$199,430	$219,503	$242,165	$266,770	$0	$1,421,910			

25-50 HP Gen Sets CA-based

Capital Cost Subtotal

25-50 HP Gen Sets CA-based

Early Retirement

25-50 HP Gen Sets CA-based

Early Retirement Cost Subtotal

25-50 HP Gen Sets Out-of-State

													$118,648	$264,180															
													$137,298	$264,180	$41,958														
													$166,200	$264,180	$41,958	$63,714													
$33,100													$199,301	$264,180	$41,958	$63,714	$73,038												
$33,100	$36,364												$235,664	$264,180	$41,958	$63,714	$73,038	$80,808											
$33,100	$36,364	$44,548											$280,212	$264,180	$41,958	$63,714	$73,038	$80,808	$36,908										
$33,100	$36,364	$44,548	$48,951										$329,163	$264,180	$41,958	$63,714	$73,038	$80,808	$36,908	$40,793									
$33,100	$36,364	$44,548	$48,951	$54,131									$383,294	$264,180	$41,958	$63,714	$73,038	$80,808	$36,908	$40,793	$45,325								
$33,100	$36,364	$44,548	$48,951	$54,131	$59,570								$442,864	$264,180	$41,958	$63,714	$73,038	$80,808	$36,908	$40,793	$45,325	$49,858							
$33,100	$36,364	$44,548	$48,951	$54,131	$59,570	$65,786							$508,650	$264,180	$41,958	$63,714	$73,038	$80,808	$36,908	$40,793	$45,325	$49,858	$55,038						
$33,100	$36,364	$44,548	$48,951	$54,131	$59,570	$65,786	$72,261						$462,263		$41,958	$63,714	$73,038	$80,808	$36,908	$40,793	$45,325	$49,858	$55,038	$60,218					
$33,100	$36,364	$44,548	$48,951	$54,131	$59,570	$65,786	$72,261	$79,772					$523,387			$63,714	$73,038	$80,808	$36,908	$40,793	$45,325	$49,858	$55,038	$60,218	$66,693				
$33,100	$36,364	$44,548	$48,951	$54,131	$59,570	$65,786	$72,261	$79,772	$87,601				$582,284				$73,038	$80,808	$36,908	$40,793	$45,325	$49,858	$55,038	$60,218	$66,693	$73,168			
	$36,364	$44,548	$48,951	$54,131	$59,570	$65,786	$72,261	$79,772	$87,601	$96,866			$646,050					$80,808	$36,908	$40,793	$45,325	$49,858	$55,038	$60,218	$66,693	$73,168	$80,938		
		$44,548	$48,951	$54,131	$59,570	$65,786	$72,261	$79,772	$87,601	$96,866	$106,708		$716,394						$36,908	$40,793	$45,325	$49,858	$55,038	$60,218	$66,693	$73,168	$80,938	$88,708	
			$48,951	$54,131	$59,570	$65,786	$72,261	$79,772	$87,601	$96,866	$106,708	$0	$671,848							$40,793	$45,325	$49,858	$55,038	$60,218	$66,693	$73,168	$80,938	$88,708	$0
				$54,131	$59,570	$65,786	$72,261	$79,772	$87,601	$96,866	$106,708	$0	$622,895								$45,325	$49,858	$55,038	$60,218	$66,693	$73,168	$80,938	$88,708	$0
					$59,570	$65,786	$72,261	$79,772	$87,601	$96,866	$106,708	$0	$568,764									$49,858	$55,038	$60,218	$66,693	$73,168	$80,938	$88,708	$0

881

25-50 HP Gen Sets CA-based

Capital Cost Subtotal

25-50 HP Gen Sets CA-based

Early Retirement

25-50 HP Gen Sets CA-based

Early Retirement Cost Subtotal

25-50 HP Gen Sets Out-of-State

$264,180	$39,627																$39,627	$1,396,010										
$306,138	$39,627	$6,294															$46,921	$1,396,010	$230,510									
$369,852	$39,627	$6,294	$9,557														$55,478	$1,396,010	$230,510	$243,460								
$442,890	$39,627	$6,294	$9,557	$10,956													$66,434	$1,396,010	$230,510	$243,460	$259,000							
$523,698	$39,627	$6,294	$9,557	$10,956	$12,121												$78,655	$1,396,010	$230,510	$243,460	$259,000	$271,950						
$560,606	$39,627	$6,294	$9,557	$10,956	$12,121	$14,763											$93,318	$1,396,010	$230,510	$243,460	$259,000	$271,950	$71,225					
$601,398	$39,627	$6,294	$9,557	$10,956	$12,121	$14,763	$16,317										$109,635	$1,396,010	$230,510	$243,460	$259,000	$271,950	$71,225	$75,110				
$646,723	$39,627	$6,294	$9,557	$10,956	$12,121	$14,763	$16,317	$18,130									$127,765	$1,396,010	$230,510	$243,460	$259,000	$271,950	$71,225	$75,110	$78,995			
$690,561	$39,627	$6,294	$9,557	$10,956	$12,121	$14,763	$16,317	$18,130	$19,943								$147,708	$1,396,010	$230,510	$243,460	$259,000	$271,950	$71,225	$75,110	$78,995	$82,880		
$751,618	$39,627	$6,294	$9,557	$10,956	$12,121	$14,763	$16,317	$18,130	$19,943	$22,015							$169,723	$1,396,010	$230,510	$243,460	$259,000	$271,950	$71,225	$75,110	$78,995	$82,880	$87,413	
$547,656		$6,294	$9,557	$10,956	$12,121	$14,763	$16,317	$18,130	$19,943	$22,015	$24,087						$164,163		$230,510	$243,460	$259,000	$271,950	$71,225	$75,110	$78,995	$82,880	$87,413	$91,945
$572,390			$9,557	$10,956	$12,121	$14,763	$16,317	$18,130	$19,943	$22,015	$24,087	$26,677					$174,566			$243,460	$259,000	$271,950	$71,225	$75,110	$78,995	$82,880	$87,413	$91,945
$581,844				$10,956	$12,121	$14,763	$16,317	$18,130	$19,943	$22,015	$24,087	$26,677	$29,267				$194,276				$259,000	$271,950	$71,225	$75,110	$78,995	$82,880	$87,413	$91,945
$569,743					$12,121	$14,763	$16,317	$18,130	$19,943	$22,015	$24,087	$26,677	$29,267	$32,375			$215,695					$271,950	$71,225	$75,110	$78,995	$82,880	$87,413	$91,945
$597,643						$14,763	$16,317	$18,130	$19,943	$22,015	$24,087	$26,677	$29,267	$32,375	$35,483		$239,057						$71,225	$75,110	$78,995	$82,880	$87,413	$91,945
$560,735							$16,317	$18,130	$19,943	$22,015	$24,087	$26,677	$29,267	$32,375	$35,483	$0	$224,294							$75,110	$78,995	$82,880	$87,413	$91,945
$519,943								$18,130	$19,943	$22,015	$24,087	$26,677	$29,267	$32,375	$35,483	$0	$207,977								$78,995	$82,880	$87,413	$91,945
$474,618									$19,943	$22,015	$24,087	$26,677	$29,267	$32,375	$35,483	$0	$169,847									$82,880	$87,413	$91,945

						25-50 HP Gen Sets CA-based		Capital Cost Subtotal	25-50 HP Gen Sets CA-based			Early Retirement												25-50 HP Gen Sets CA-based	Early Retirement Cost Subtotal	25-50 HP Gen Se C
					$1,396,010	$209,402																$209,402	$19,101,626	$2,865,244		$2,865,244
					$1,626,520	$209,402	$34,577															$243,978	$25,698,794	$3,854,819		$3,854,819
					$1,869,980	$209,402	$34,577	$36,519														$280,497	$31,280,615	$4,689,092		$4,689,092
					$2,128,980	$209,402	$34,577	$36,519	$38,850													$319,347	$34,996,327	$5,249,449		$5,249,449
					$2,400,930	$209,402	$34,577	$36,519	$38,850	$40,793												$360,140	$37,692,762	$5,653,914		$5,653,914
					$2,472,155	$209,402	$34,577	$36,519	$38,850	$40,793	$28,490											$386,630	$37,063,783	$5,384,680	$474,366	$5,859,046
					$2,547,265	$209,402	$34,577	$36,519	$38,850	$40,793	$28,490	$30,044										$418,674	$36,509,020	$5,128,267	$928,229	$6,056,496
					$2,626,260	$209,402	$34,577	$36,519	$38,850	$40,793	$28,490	$30,044	$31,598									$450,272	$35,967,474	$4,884,064	$1,362,819	$6,246,883
					$2,709,140	$209,402	$34,577	$36,519	$38,850	$40,793	$28,490	$30,044	$31,598	$33,152								$483,424	$35,456,955	$4,651,489	$1,778,810	$6,430,300
					$2,796,553	$209,402	$34,577	$36,519	$38,850	$40,793	$28,490	$30,044	$31,598	$33,152	$34,965							$518,389	$34,977,749	$4,429,990	$2,177,793	$6,607,783
					$1,492,488		$34,577	$36,519	$38,850	$40,793	$28,490	$30,044	$31,598	$33,152	$34,965	$36,778						$345,765	$20,951,793	$2,182,763	$2,541,722	$4,724,484
$96,478					$1,358,455			$36,519	$38,850	$40,793	$28,490	$30,044	$31,598	$33,152	$34,965	$36,778	$38,591					$349,780	$16,711,146	$1,409,038	$2,927,023	$4,336,062
$96,478	$101,658				$1,216,653				$38,850	$40,793	$28,490	$30,044	$31,598	$33,152	$34,965	$36,778	$38,591	$40,663				$353,924	$13,558,975	$804,161	$3,279,160	$4,083,322
$96,478	$101,658	$106,838			$1,064,490					$40,793	$28,490	$30,044	$31,598	$33,152	$34,965	$36,778	$38,591	$40,663	$42,735			$357,809	$11,856,488	$421,657	$3,617,842	$4,039,499
$96,478	$101,658	$106,838	$112,685		$905,205						$28,490	$30,044	$31,598	$33,152	$34,965	$36,778	$38,591	$40,663	$42,735	$45,066		$362,082	$9,867,318		$3,942,927	$3,942,927
$96,478	$101,658	$106,838	$112,665	$0	$833,980							$30,044	$31,598	$33,152	$34,965	$36,778	$38,591	$40,663	$42,735	$45,066	$0	$333,592	$8,811,079		$3,524,432	$3,524,432
$96,478	$101,658	$106,838	$112,665	$0	$758,870								$31,598	$33,152	$34,965	$36,778	$38,591	$40,663	$42,735	$45,066	$0	$303,546	$410,491,902	$51,608,828	$20,554,924	$78,163,752
$96,478	$101,658	$106,838	$112,665	$0	$679,675									$33,152	$34,965	$36,778	$38,591	$40,663	$42,735	$45,066	$0	$271,950				

883

884

$16,236,382
$21,843,976
$26,571,523
$28,746,876
$32,038,848
$31,224,737
$30,452,524
$29,720,591
$29,028,655
$28,369,966
$16,227,309
$12,375,065
$9,476,654
$7,816,987
$5,914,391
$5,286,648
$332,328,150

#2

Annual Cost-Effectiveness (regulation, PM only)
10/17/2003

The variable used to establish the low and high end scenarios is the annual usage;
1,200 hours/year for the low end (typical short-haul usage) and 3,000 hours/year for the high end (typical long-haul usage.)

VDECS Retrofit: Low-Cost Scenario

Operator Cost Range (2002 $)
(basis for calculations belo\
$78,760 $2,346,240

Interest rate for 2008 Cost Pmt. Adj. 0.05

Year	Emission Benefits (tpy)	Annual In-Use Cost (2002 $) (low-cost scenario)	Annual Operator Reporting Cost Range (low)	(high)	In-Use & Operating Costs = Total Ann. Operating Cost (low)	(high)	2008 In-Use Cost Payment Adj. (low)	(high)	PM Cost Effectiveness (In-Use & Rept. Costs Only) $/lb. (low)	$/lb (high)	Not Used for Cost-Effectiveness Calculation: Fac. Rep. Cost Range (low)	(high)	Total Annual Cost (low)	(high)
2000		$0	$0	$0	$0	$0								
2001		$0	$0	$0	$0	$0								
2002		$0	$0	$0	$0	$0								
2003		$0	$0	$0	$0	$0								
2004		$0	$0	$0	$0	$0								
2005		$0	$0	$0	$0	$0								
2006		$0	$0	$0	$0	$0								
2007		$0	$0	$0	$0	$0								
2008	#REF!	$5,509,003	$52,461	$1,563,399	$5,561,464	$7,072,402			See Footnote 1		$198,200	$5,145,153	$198,200	$5,145,153
2009	#REF!	$5,944,029			$5,944,029	$5,944,029	$6,602,679	$6,781,673	#REF!	#REF!	$198,200	$5,145,153	$6,801,079	$11,927,026
2010	#REF!	$6,222,225			$6,222,225	$6,222,225	$6,881,075	$7,060,069	#REF!	#REF!	$198,200	$5,145,153	$7,079,275	$12,205,222
2011	#REF!	$6,489,439			$6,489,439	$6,489,439	$7,148,289	$7,327,283	#REF!	#REF!	$198,200	$5,145,153	$7,346,489	$12,472,436
2012	#REF!	$6,746,534			$6,746,534	$6,746,534	$7,405,385	$7,584,378	#REF!	#REF!	$198,200	$5,145,153	$7,603,585	$12,729,531
2013	#REF!	$6,993,685			$6,993,685	$6,993,685	$7,652,536	$7,831,529	#REF!	#REF!	$198,200	$5,145,153	$7,850,736	$12,976,682
2014	#REF!	$7,232,186			$7,232,186	$7,232,186	$7,891,036	$8,070,030	#REF!	#REF!	$198,200	$5,145,153	$8,089,236	$13,215,183
2015	#REF!	$7,461,809			$7,461,809	$7,461,809	$8,120,659	$8,299,653	#REF!	#REF!	$198,200	$5,145,153	$8,318,859	$13,444,806
2016	#REF!	$7,683,852			$7,683,852	$7,683,852	$8,342,703	$8,521,696	#REF!	#REF!	$198,200	$5,145,153	$8,540,903	$13,666,849
2017	#REF!	$7,898,202			$7,898,202	$7,898,202	$8,557,052	$8,736,046	#REF!	#REF!	$198,200	$5,145,153	$8,755,252	$13,881,199
2018	#REF!	$4,723,774			$4,723,774	$4,723,774	$5,382,624	$5,561,618	#REF!	#REF!	$198,200	$5,145,153	$5,580,824	$10,706,771
2019	#REF!	$4,657,703			$4,657,703	$4,657,703	$5,316,553	$5,495,547	#REF!	#REF!	$198,200	$5,145,153	$5,514,753	$10,640,700
2020	#REF!	$4,175,634			$4,175,634	$4,175,634	$4,834,485	$5,013,478	#REF!	#REF!	$198,200	$5,145,153	$5,032,685	$10,158,631
	#REF!	Tons PM Reduced (13 Yrs.)				Totals:	$84,135,277	$86,283,198	#REF!	#REF!	$2,576,600	$66,886,989	$86,711,877	$153,170,187
									Minimum	Maximum			Total Cost Range (2002 $)	

[1]These columns take the 2008 in-use cost and converts it into uniform payments for the years 2009 - 2020
by doing the following: converting the 2008 in-use cost to 2009 dollars, and then converting that amount to a uniform payment series; interest rate used is 5%.
This calculation is performed to account for the 2008 in-use costs, since a cost-effectiveness figure cannot be calculated for this year due to zero PM emission reduction.

VDECS Retrofit: High-Cost Scenario

Operator Cost Range (2002 $)
(basis for calculations below)
$78,760 $2,346,240

Year	Emission Benefits (tpy)	Annual In-Use Cost (2002$) (high-cost scenario)	Annual Operator Reporting Cost Range (low)	(high)	In-Use & Operating Costs = Total Ann. Operating Cost (low)	(high)	2008 In-Use Cost Payment Adj. (low)	(high)	PM Cost Effectiveness (In-Use & Rept. Costs Only) $/lb. (low)	$/lb (high)	Not Used for Cost-Effectiveness Calculation: Fac. Rep. Cost Range (low)	(high)	Total Annual Cost (low)	(high)
2000		$0	$0	$0	$0	$0								
2001		$0	$0	$0	$0	$0								
2002		$0	$0	$0	$0	$0								
2003		$0	$0	$0	$0	$0								
2004		$0	$0	$0	$0	$0								
2005		$0	$0	$0	$0	$0								
2006		$0	$0	$0	$0	$0								
2007		$0	$0	$0	$0	$0								
2008	#REF!	$5,800,773	$52,461	$1,563,399	$5,853,255	$7,364,172			See Footnote 1		$198,200	$5,145,153	$198,200	$5,145,153
2009	#REF!	$6,262,573			$6,262,573	$6,262,573	$6,955,989	$7,134,982	#REF!	#REF!	$198,200	$5,145,153	$7,154,189	$12,280,135
2010	#REF!	$6,525,600			$6,525,600	$6,525,600	$7,219,016	$7,398,009	#REF!	#REF!	$198,200	$5,145,153	$7,417,216	$12,543,162
2011	#REF!	$6,778,368			$6,778,368	$6,778,368	$7,471,784	$7,650,777	#REF!	#REF!	$198,200	$5,145,153	$7,669,984	$12,795,930
2012	#REF!	$7,021,705			$7,021,705	$7,021,705	$7,715,120	$7,894,114	#REF!	#REF!	$198,200	$5,145,153	$7,913,320	$13,039,267
2013	#REF!	$7,255,753			$7,255,753	$7,255,753	$7,949,168	$8,128,162	#REF!	#REF!	$198,200	$5,145,153	$8,147,368	$13,273,315
2014	#REF!	$7,481,774			$7,481,774	$7,481,774	$8,175,189	$8,354,183	#REF!	#REF!	$198,200	$5,145,153	$8,373,389	$13,499,336
2015	#REF!	$7,699,512			$7,699,512	$7,699,512	$8,392,927	$8,571,921	#REF!	#REF!	$198,200	$5,145,153	$8,591,127	$13,717,074
2016	#REF!	$7,910,236			$7,910,236	$7,910,236	$8,603,651	$8,782,645	#REF!	#REF!	$198,200	$5,145,153	$8,801,851	$13,927,798
2017	#REF!	$8,113,805			$8,113,805	$8,113,805	$8,807,221	$8,986,214	#REF!	#REF!	$198,200	$5,145,153	$9,005,421	$14,131,367
2018	#REF!	$4,749,989			$4,749,989	$4,749,989	$5,443,404	$5,622,398	#REF!	#REF!	$198,200	$5,145,153	$5,641,604	$10,767,551
2019	#REF!	$4,657,703			$4,657,703	$4,657,703	$5,351,118	$5,530,112	#REF!	#REF!	$198,200	$5,145,153	$5,549,318	$10,675,265
2020	#REF!	$4,175,634			$4,175,634	$4,175,634	$4,869,050	$5,048,043	#REF!	#REF!	$198,200	$5,145,153	$5,067,250	$10,193,196
	#REF!	Tons PM Reduced (13 Yrs.)				Totals:	$86,953,637	$89,101,558	#REF!	#REF!	$2,576,600	$66,886,989	$89,530,237	$155,988,547
									Minimum	Maximum			Total Cost Range (2002 $)	

[1]These columns take the 2008 in-use cost and converts it into uniform payments for the years 2009 - 2020
by doing the following: converting the 2008 costs to 2009 dollars, and then converting that amount to a uniform payment series; interest rate used is 5%.
This calculation is performed to account for the 2008 in-use costs, since a cost-effectiveness figure cannot be calculated for this year due to zero PM emission reduction.

885

Annual Cost-Effectiveness (regulation, PM only)

10/17/2003

This scenario assumes that VDECS retrofits are <u>not</u> used, and that engine replacement is used for 10 years and newer units, per the ATCM requirements, and that TRU replacement is used for 11 years and older units.

<u>Engine/TRU Replacement Scenario</u>

Operator Cost Range (2002 $)
(basis for calculations below)
$78,760 $2,346,240

Int. rate for 2008 Cost Pmt. Adj.: 0.05

Year	Emission Benefits (tpy)	Annual In-Use Cost (2002 $)	Annual Operator Reporting Cost Range (low)	(high)	In-Use & Operating Costs = Total Ann. Operating Cost (low)	(high)	In-Use Cost Payment Adj. [1] (low)	(high)	PM Cost Effectiveness (In-Use & Rept. Costs Only) $/lb. (low)	$/lb (high)	Not Used for Cost-Effectiveness Calculation: Fac. Rep. Cost Range (low)	(high)	Total Annual Cost (low)	(high)
2000			$0	$0	$0	$0								
2001			$0	$0	$0	$0								
2002			$0	$0	$0	$0								
2003			$0	$0	$0	$0								
2004			$0	$0	$0	$0								
2005		$2,865,244	$0	$0	$2,865,244	$2,865,244								
2006		$3,854,819	$0	$0	$3,854,819	$3,854,819								
2007		$4,689,092	$0	$0	$4,689,092	$4,689,092								
2008	#REF!	$5,249,449	$52,481	$1,563,399	$5,301,930	$6,812,848			See Footnote 1		$198,200	$5,145,153	$198,200	$5,145,153
2009	#REF!	$5,653,914			$5,653,914	$5,653,914	$7,761,708	$7,940,702	#REF!	#REF!	$198,200	$5,145,153	$7,959,908	$13,085,855
2010	#REF!	$5,859,046			$5,859,046	$5,859,046	$7,966,840	$8,145,833	#REF!	#REF!	$198,200	$5,145,153	$8,165,040	$13,290,986
2011	#REF!	$6,056,496			$6,056,496	$6,056,496	$8,164,290	$8,343,284	#REF!	#REF!	$198,200	$5,145,153	$8,362,490	$13,488,437
2012	#REF!	$6,246,883			$6,246,883	$6,246,883	$8,354,677	$8,533,670	#REF!	#REF!	$198,200	$5,145,153	$8,552,877	$13,678,823
2013	#REF!	$6,430,300			$6,430,300	$6,430,300	$8,538,094	$8,717,087	#REF!	#REF!	$198,200	$5,145,153	$8,736,294	$13,862,240
2014	#REF!	$6,607,783			$6,607,783	$6,607,783	$8,715,577	$8,894,570	#REF!	#REF!	$198,200	$5,145,153	$8,913,777	$14,039,723
2015	#REF!	$4,724,484			$4,724,484	$4,724,484	$6,832,278	$7,011,271	#REF!	#REF!	$198,200	$5,145,153	$7,030,478	$12,156,424
2016	#REF!	$4,336,062			$4,336,062	$4,336,062	$6,443,855	$6,622,849	#REF!	#REF!	$198,200	$5,145,153	$6,642,055	$11,768,002
2017	#REF!	$4,083,322			$4,083,322	$4,083,322	$6,191,115	$6,370,109	#REF!	#REF!	$198,200	$5,145,153	$6,389,315	$11,515,262
2018	#REF!	$4,039,499			$4,039,499	$4,039,499	$6,147,293	$6,326,286	#REF!	#REF!	$198,200	$5,145,153	$6,345,493	$11,471,439
2019	#REF!	$3,942,927			$3,942,927	$3,942,927	$6,050,721	$6,229,714	#REF!	#REF!	$198,200	$5,145,153	$6,248,921	$11,374,867
2020	#REF!	$3,524,432			$3,524,432	$3,524,432	$5,632,226	$5,811,219	#REF!	#REF!	$198,200	$5,145,153	$5,830,426	$10,956,372
	#REF!					Totals:	$86,798,674	$88,946,595	**#REF!**	**#REF!**	$2,576,600	$66,886,989	$89,375,274	$155,833,584
				Tots (all yrs):	**$78,216,233**	**$79,727,150**			**Minimum**	**Maximum**			Total Cost Range (2002 $)	

[1]These columns take the 2005 - 2008 in-use costs and converts them into uniform payments for the years 2009 - 2020 by doing the following: converting the 2008 in-use cost to 2009 dollars, and then converting that amount to a uniform payment series; interest rate used is 5%. This calculation is performed to account for the 2008 in-use costs, since a cost-effectiveness figure cannot be calculated for this year due to zero PM emission reduction.

887

Statewide TRU PM Emissions

Scenario #1: LETRU & ULETRU = Electric Standby (revised to reflect 50% emission reduction assumption & non-use w/ gen sets)
(used to calculate Alternative 1 C/E)

Em = Em Rate*Pop*Activity*Avg HP*Load Fctr

<15 hp

Activity = 1038hr/yr, Avg HP = 10 hp, Load Fctr = 0.64
Em = Em Rate*Pop*1038*10*.64

Year	Population	Avg Em Fctr New Std Only	Avg Em Fctr New&In-Use Stds	Emissions (tpd) New Stds Only	Emissions (tpd) New&In-Use Stds
2000	4623	0.87	0.87	0.080	0.080
2001	4449	0.86	0.86	0.077	0.077
2002	4501	0.83	0.83	0.075	0.075
2003	4557	0.81	0.81	0.074	0.074
2004	4623	0.79	0.79	0.073	0.073
2005	4701	0.76	0.76	0.072	0.072
2006	4787	0.74	0.74	0.071	0.071
2007	4879	0.72	0.72	0.070	0.070
2008	4974	0.67	0.58	0.067	0.058
2009	5067	0.62	0.55	0.063	0.056
2010	5174	0.57	0.48	0.059	0.050
2011	5307	0.53	0.42	0.056	0.044
2012	5449	0.48	0.36	0.053	0.039
2013	5621	0.45	0.30	0.050	0.034
2014	5822	0.42	0.25	0.049	0.029
2015	6068	0.39	0.21	0.048	0.025
2016	6354	0.37	0.19	0.047	0.024
2017	6635	0.35	0.19	0.047	0.026
2018	6935	0.34	0.19	0.047	0.027
2019	7248	0.33	0.19	0.047	0.028
2020	7578	0.32	0.19	0.048	0.029

15-25 hp

Activity = 1038hr/yr, Avg HP = 17 hp, Load Fctr = 0.64
Em = Em Rate*Pop*1038*17*.64

Year	Population	Avg Em Fctr New Std Only	Avg Em Fctr New&In-Use Stds	Emissions (tpd) New Stds Only	Emissions (tpd) New&In-Use Stds
2000	1947	0.87	0.87	0.058	0.058
2001	1898	0.86	0.86	0.055	0.055
2002	1897	0.83	0.83	0.054	0.054
2003	1899	0.81	0.81	0.052	0.052
2004	1905	0.79	0.79	0.051	0.051
2005	1914	0.77	0.77	0.050	0.050
2006	1927	0.74	0.74	0.049	0.049
2007	1945	0.72	0.72	0.048	0.048
2008	1961	0.67	0.58	0.045	0.039
2009	1973	0.63	0.55	0.042	0.037
2010	1989	0.58	0.49	0.039	0.033
2011	2012	0.53	0.42	0.037	0.029
2012	2040	0.49	0.36	0.034	0.025
2013	2073	0.46	0.30	0.032	0.021
2014	2112	0.43	0.25	0.031	0.018
2015	2167	0.40	0.20	0.030	0.015
2016	2231	0.38	0.18	0.029	0.014
2017	2296	0.36	0.18	0.028	0.014
2018	2364	0.34	0.19	0.028	0.015
2019	2434	0.33	0.19	0.027	0.015
2020	2507	0.32	0.19	0.027	0.016

Relative Emission Reduction Effectiveness Compared to Limits of Reg

Year	Em. Red. Alt.1 (tpd) [1]	Em. Red. Reg. (low end, tpd)	Em. Red. Reg. (high end, tpd)	% More Effect. Than Reg. (l)	% More Effect. Than Reg. (h)
2008	0.937	0.498	0.948	88	-1
2009	0.859	0.416	0.853	107	1
2010	0.786	0.237	0.733	232	7
2011	0.718	0.234	0.684	207	5
2012	0.657	0.474	0.681	39	-4
2013	0.570	0.5	0.639	14	-11
2014	0.495	0.538	0.618	-8	-20
2015	0.436	0.61	0.593	-29	-27
2016	0.384	0.599	0.549	-36	-30
2017	0.337	0.55	0.497	-39	-32
2018	0.294	0.513	0.458	-43	-36
2019	0.256	0.488	0.43	-47	-40
2020	0.224	0.474	0.348	-53	-36
Total tpd:	6.954				

1 This is 1/2 the baseline, since it is assumed that 1/2 of baseline emissions will still be generated during on-road (mobile) operation.

Tot. PM red.(lbs. 5076198

688

25-50 hp TRUs, reefer railcars, gen sets

Activity = 1465hr/yr, Avg HP = 34 hp, Load Fctr = 0.53
Em = Em Rate*Pop*1465*34*.53

Year	CA-Based Population	Out-of-State Population	Reefer Railcar Population	CA Gen Set Population	OOS Gen Set Population	Total 25-50 hp Population	Avg Em Fctr New Stds Only	Avg Em Fctr New&In-Use Stds	Emissions (tpd). New Stds Only	Emissions (tpd) New&In-Use Stds
2000	22772	7591	1678	0	0	32041	0.98	0.98	2.501	2.501
2001	22606	7535	1666	0	0	31807	0.92	0.92	2.332	2.332
2002	22778	7593	1678	0	0	32049	0.89	0.89	2.281	2.281
2003	22986	7662	1694	0	0	32341	0.87	0.87	2.231	2.231
2004	23230	7743	1712	0	0	32685	0.83	0.83	2.151	2.151
2005	23515	7838	1733	0	0	33086	0.79	0.79	2.073	2.073
2006	23814	7938	1755	0	0	33507	0.75	0.75	1.992	1.992
2007	24112	8037	1777	0	0	33926	0.71	0.71	1.909	1.909
2008	24409	8136	1799	0	0	34343	0.64	0.48	1.763	1.324
2009	24714	8238	1821	0	0	34774	0.58	0.46	1.614	1.248
2010	25109	8370	1850	0	0	35329	0.52	0.45	1.473	1.273
2011	25638	8546	1889	0	0	36073	0.47	0.40	1.344	1.152
2012	26266	8755	1935	0	0	36957	0.42	0.28	1.226	0.826
2013	27033	9011	1992	0	0	38035	0.35	0.21	1.057	0.641
2014	28006	9335	2064	0	0	39405	0.29	0.15	0.911	0.469
2015	29226	9742	2154	0	0	41122	0.24	0.09	0.794	0.296
2016	30650	10217	2259	0	0	43126	0.20	0.06	0.692	0.208
2017	32165	10722	2370	0	0	45257	0.17	0.04	0.598	0.157
2018	33785	11262	2489	0	0	47535	0.14	0.03	0.513	0.105
2019	35509	11836	2616	0	0	49961	0.11	0.01	0.438	0.052
2020	37344	12448	2752	0	0	52543	0.09	0.00	0.372	0.000

Operator Cost Range (2002 $)
(basis for calculations below)
$78,760 $2,346,240

Composite PM Emissions of all TRU HP ranges

Year	Emissions (tpd) New Stds Only	Annual In-Use Cost	Ann. Op. Rep. Costs (low)	Ann. Op. Rep. Costs (high)	Total Ann. Oper. Cost (low)	Total Ann. Oper. Cost (high)	Annual Cost-Effectiveness In-Use Only $/lb. (low)	In-Use Only $/lb (high)
2000	2.640	$0	$0	$0	$0	$0		
2001	2.464	$0	$0	$0	$0	$0		
2002	2.410	$0	$0	$0	$0	$0		
2003	2.357	$0	$0	$0	$0	$0		
2004	2.276	$0	$0	$0	$0	$0		
2005	2.194	$0	$0	$0	$0	$0		
2006	2.112	$0	$0	$0	$0	$0		
2007	2.028	$0	$0	$0	$0	$0		
2008	1.875	$35,451,523	$58,772	$1,750,800	$35,510,295	$37,202,324	51.90	54.37
2009	1.719	$38,152,051	$55,973	$1,667,429	$38,208,024	$39,819,479	60.90	63.47
2010	1.571	$40,726,387	$53,308	$1,588,028	$40,779,695	$42,314,415	71.10	73.78
2011	1.437	$43,178,546	$50,769	$1,512,407	$43,229,315	$44,690,953	82.43	85.22
2012	1.314	$45,513,701	$48,352	$1,440,388	$45,562,052	$46,954,088	95.02	97.92
2013	1.140	$47,736,396	$46,049	$1,371,798	$47,782,445	$49,108,194	114.84	118.02
2014	0.990	$49,856,289	$43,857	$1,306,474	$49,900,145	$51,162,763	138.04	141.53
2015	0.872	$51,874,763	$41,768	$1,244,261	$51,916,531	$53,119,024	163.20	166.98
2016	0.768	$53,799,556	$39,779	$1,185,011	$53,839,335	$54,984,566	191.95	196.03
2017	0.673	$55,632,264	$37,885	$1,128,582	$55,670,149	$56,760,846	226.48	230.92
2018	0.588	$35,614,820	$36,081	$1,074,840	$35,650,901	$36,689,660	166.11	170.95
2019	0.513	$35,620,526	$34,363	$1,023,657	$35,654,889	$36,644,183	190.60	195.89
2020	0.448	$31,947,072	$32,726	$974,911	$31,979,798	$32,921,983	195.67	201.44
	11821.700		$579,682	$17,268,565	$565,683,574	$582,372,477	**Low = 52**	**H = 231**

Tons PM **$565,103,892 2008-2020 Total (in 2002 $)**

Statewi.. .RU PM Emissions

Scenario #2: LETRU & ULETRU = Full Cryogenic Refrigeration to LETRU & ULETRU, 1200 Hr/Yr. Scenario (revised to equalize effectiveness against lower and upper emission benefit of reg; also changed to reflect non-use w/ TRU gen sets.)
(used to calculate Alternative 2 C/E)

Em = Em Rate*Pop*Activity*Avg HP*Load Fctr

<15 hp

Activity = 1038hr/yr, Avg HP = 10 hp, Load Fctr = 0.64
Em = Em Rate*Pop*1038*10*.64

Year	Population	Avg Em Fctr New Std Only	Avg Em Fctr New&In-Use Stds	Emissions (tpd) New Stds Only	Emissions (tpd) New&In-Use Stds
2000	4623	0.87	0.87	0.080	0.080
2001	4449	0.86	0.86	0.077	0.077
2002	4501	0.83	0.83	0.075	0.075
2003	4557	0.81	0.81	0.074	0.074
2004	4623	0.79	0.79	0.073	0.073
2005	4701	0.76	0.76	0.072	0.072
2006	4787	0.74	0.74	0.071	0.071
2007	4879	0.72	0.72	0.070	0.070
2008	4974	0.67	0.58	0.067	0.058
2009	5067	0.62	0.55	0.063	0.056
2010	5174	0.57	0.48	0.059	0.050
2011	5307	0.53	0.42	0.056	0.044
2012	5449	0.48	0.36	0.053	0.039
2013	5621	0.45	0.30	0.050	0.034
2014	5822	0.42	0.25	0.049	0.029
2015	6068	0.39	0.21	0.048	0.025
2016	6354	0.37	0.19	0.047	0.024
2017	6635	0.35	0.19	0.047	0.026
2018	6935	0.34	0.19	0.047	0.027
2019	7248	0.33	0.19	0.047	0.028
2020	7578	0.32	0.19	0.048	0.029

15-25 hp

Activity = 1038hr/yr, Avg HP = 17 hp, Load Fctr = 0.64
Em = Em Rate*Pop*1038*17*.64

Year	Population	Avg Em Fctr New Std Only	Avg Em Fctr New&In-Use Stds	Emissions (tpd) New Stds Only	Emissions (tpd) New&In-Use Stds
2000	1947	0.87	0.87	0.058	0.058
2001	1898	0.86	0.86	0.055	0.055
2002	1897	0.83	0.83	0.054	0.054
2003	1899	0.81	0.81	0.052	0.052
2004	1905	0.79	0.79	0.051	0.051
2005	1914	0.77	0.77	0.050	0.050
2006	1927	0.74	0.74	0.049	0.049
2007	1945	0.72	0.72	0.048	0.048
2008	1961	0.67	0.58	0.045	0.039
2009	1973	0.63	0.55	0.042	0.037
2010	1989	0.58	0.49	0.039	0.033
2011	2012	0.53	0.42	0.037	0.029
2012	2040	0.49	0.36	0.034	0.025
2013	2073	0.46	0.30	0.032	0.021
2014	2112	0.43	0.25	0.031	0.018
2015	2167	0.40	0.20	0.030	0.015
2016	2231	0.38	0.18	0.029	0.014
2017	2296	0.36	0.18	0.028	0.014
2018	2364	0.34	0.19	0.028	0.015
2019	2434	0.33	0.19	0.027	0.015
2020	2507	0.32	0.19	0.027	0.016

Relative Emission Reduction Effectiveness Compared to Limits of Reg

Year	Em. Red. Alt.2 (tpd)	Em. Red. Reg. (low end, tpd)	Em. Red. Reg. (high end, tpd)	% More Effect. Than Reg. (l)	% More Effect. Than Reg. (h)
2008	1.875	0.498	0.948	276	98
2009	1.719	0.416	0.853	313	102
2010	1.571	0.237	0.733	563	114
2011	1.437	0.234	0.684	514	110
2012	1.314	0.474	0.681	177	93
2013	1.140	0.5	0.639	128	78
2014	0.990	0.538	0.618	84	60
2015	0.872	0.61	0.593	43	47
2016	0.768	0.599	0.549	28	40
2017	0.673	0.55	0.497	22	36
2018	0.588	0.513	0.458	15	28
2019	0.513	0.488	0.43	5	19
2020	0.448	0.474	0.348	-6	29
Total (tpd):	13.907				
Tot. PM Red.(lb	10152397				

Matrix #4

25-50 hp TRUs, reefer railcars, gen sets

Activity = 1465hr/yr, Avg HP = 34 hp, Load Fctr = 0.63
Em = Em Rate*Pop*1465*34*.63

Year	CA-Based Population	Out-of-State Population	Reefer Railcar Population	CA Gen Set Population	OOS Gen Set Population	Total 25-50 hp Population	Avg Em Fctr New Stds Only	Avg Em Fctr New&In-Use Stds	Emissions (tpd) New Stds Only	Emissions (tpd) New&In-Use Stds
2000	22772	7591	1678	0	0	32041	0.98	0.98	2.501	2.501
2001	22606	7535	1666	0	0	31807	0.92	0.92	2.332	2.332
2002	22778	7593	1678	0	0	32049	0.89	0.89	2.281	2.281
2003	22986	7662	1694	0	0	32341	0.87	0.87	2.231	2.231
2004	23230	7743	1712	0	0	32685	0.83	0.83	2.151	2.151
2005	23515	7838	1733	0	0	33086	0.79	0.79	2.073	2.073
2006	23814	7938	1755	0	0	33507	0.75	0.75	1.992	1.992
2007	24112	8037	1777	0	0	33926	0.71	0.71	1.909	1.909
2008	24409	8136	1799	0	0	34343	0.64	0.48	1.763	1.324
2009	24714	8238	1821	0	0	34774	0.58	0.45	1.614	1.248
2010	25109	8370	1850	0	0	35329	0.52	0.45	1.473	1.273
2011	25638	8546	1889	0	0	36073	0.47	0.40	1.344	1.152
2012	26266	8755	1935	0	0	36957	0.42	0.28	1.226	0.826
2013	27033	9011	1992	0	0	38035	0.35	0.21	1.057	0.641
2014	28006	9335	2064	0	0	39405	0.29	0.15	0.911	0.469
2015	29226	9742	2154	0	0	41122	0.24	0.09	0.794	0.296
2016	30650	10217	2259	0	0	43126	0.20	0.06	0.692	0.208
2017	32165	10722	2370	0	0	45257	0.17	0.04	0.598	0.157
2018	33785	11262	2489	0	0	47535	0.14	0.03	0.513	0.105
2019	35509	11836	2616	0	0	49961	0.11	0.01	0.438	0.052
2020	37344	12448	2752	0	0	52543	0.09	0.00	0.372	0.000

Operator Cost Range (2002 $)
(basis for calculations below)
$78,760 $2,346,240

Composite PM Emissions of all TRU HP ranges

Year	Emissions (tpd) New Stds On	Emission Red. From Reg. (low end of range)	Emission Benefit Adjustment Factor (low)	Emission Red. From Reg. (high end of range)	Emission Benefit Adjustment Factor (high)	Annual In-Use Cost	Ann. Op. Rep. Costs (low)	Ann. Op. Rep. Costs (high)	Total Ann. Oper. Cost (low)	Total Ann. Oper. Cost (high)	In-Use Only $/lb. (low)	In-Use Only $/lb (high)
2000	2.640					$0	$0	$0	$0	$0		
2001	2.464					$0	$0	$0	$0	$0		
2002	2.410					$0	$0	$0	$0	$0		
2003	2.357					$0	$0	$0	$0	$0		
2004	2.276					$0	$0	$0	$0	$0		
2005	2.194					$0	$0	$0	$0	$0		
2006	2.112					$0	$0	$0	$0	$0		
2007	2.028					$0	$0	$0	$0	$0		
2008	1.875	0.498	0.266	0.948	0.506	$125,416,556	$58,772	$1,750,800	$125,475,328	$127,167,357	24.36	47.00
2009	1.719	0.416	0.242	0.853	0.496	$134,970,188	$55,973	$1,667,429	$135,026,162	$136,637,617	26.04	54.04
2010	1.571	0.237	0.151	0.733	0.466	$144,077,398	$53,308	$1,588,028	$144,130,705	$145,665,425	18.95	59.24
2011	1.437	0.234	0.163	0.684	0.476	$152,752,378	$50,769	$1,512,407	$152,803,147	$154,264,785	23.73	70.02
2012	1.314	0.474	0.361	0.681	0.518	$161,013,436	$48,352	$1,440,388	$161,061,788	$162,453,824	60.60	87.81
2013	1.140	0.5	0.439	0.639	0.561	$168,876,647	$46,049	$1,371,798	$168,922,696	$170,248,445	89.03	114.67
2014	0.990	0.538	0.543	0.618	0.624	$176,376,173	$43,857	$1,306,474	$176,420,030	$177,682,647	132.55	153.35
2015	0.872	0.61	0.700	0.593	0.680	$183,516,912	$41,768	$1,244,261	$183,558,680	$184,761,173	201.92	197.58
2016	0.768	0.599	0.779	0.549	0.714	$190,326,235	$39,779	$1,185,011	$190,366,015	$191,511,246	264.52	243.89
2017	0.673	0.55	0.817	0.497	0.738	$196,809,793	$37,885	$1,128,582	$196,847,678	$197,938,375	327.01	297.14
2018	0.588	0.513	0.872	0.458	0.779	$125,994,251	$36,081	$1,074,840	$126,030,332	$127,069,090	256.17	230.59
2019	0.513	0.488	0.952	0.43	0.839	$126,014,435	$34,363	$1,023,657	$126,048,797	$127,038,091	320.80	284.89
2020	0.448	0.474	1.059	0.348	0.777	$113,018,886	$32,726	$974,911	$113,051,613	$113,993,798	366.12	271.03
	11821.700						$579,682	$17,288,565	$1,999,742,971	$2,016,431,873	Low = 24	H = 366
	Tons PM											

$1,999,163,268 2008-2020 Total (in 2002 $)

Chart 1
Estimated Fleet Size of Motor Carriers with (or Likely to Have) TRUs

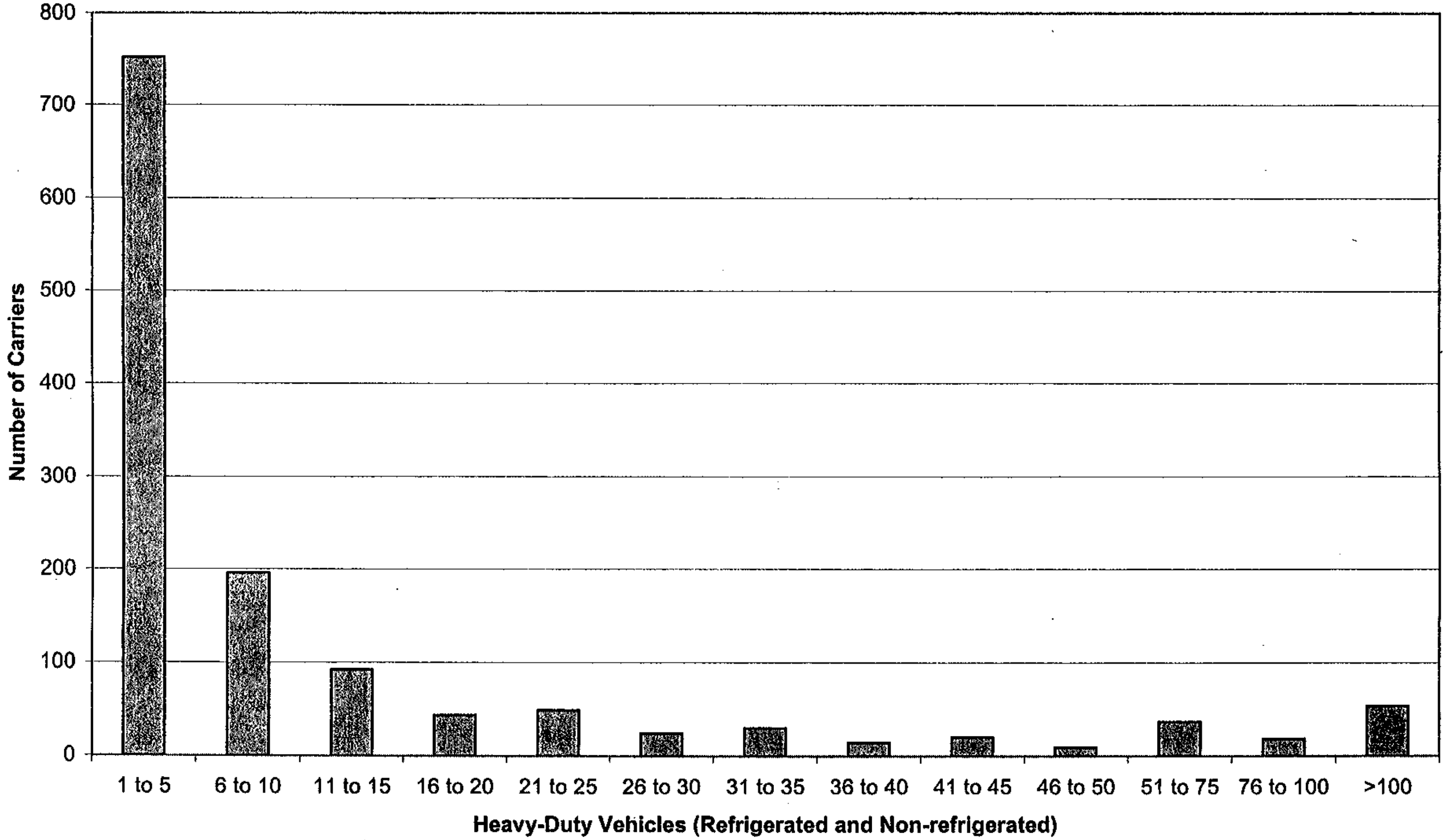
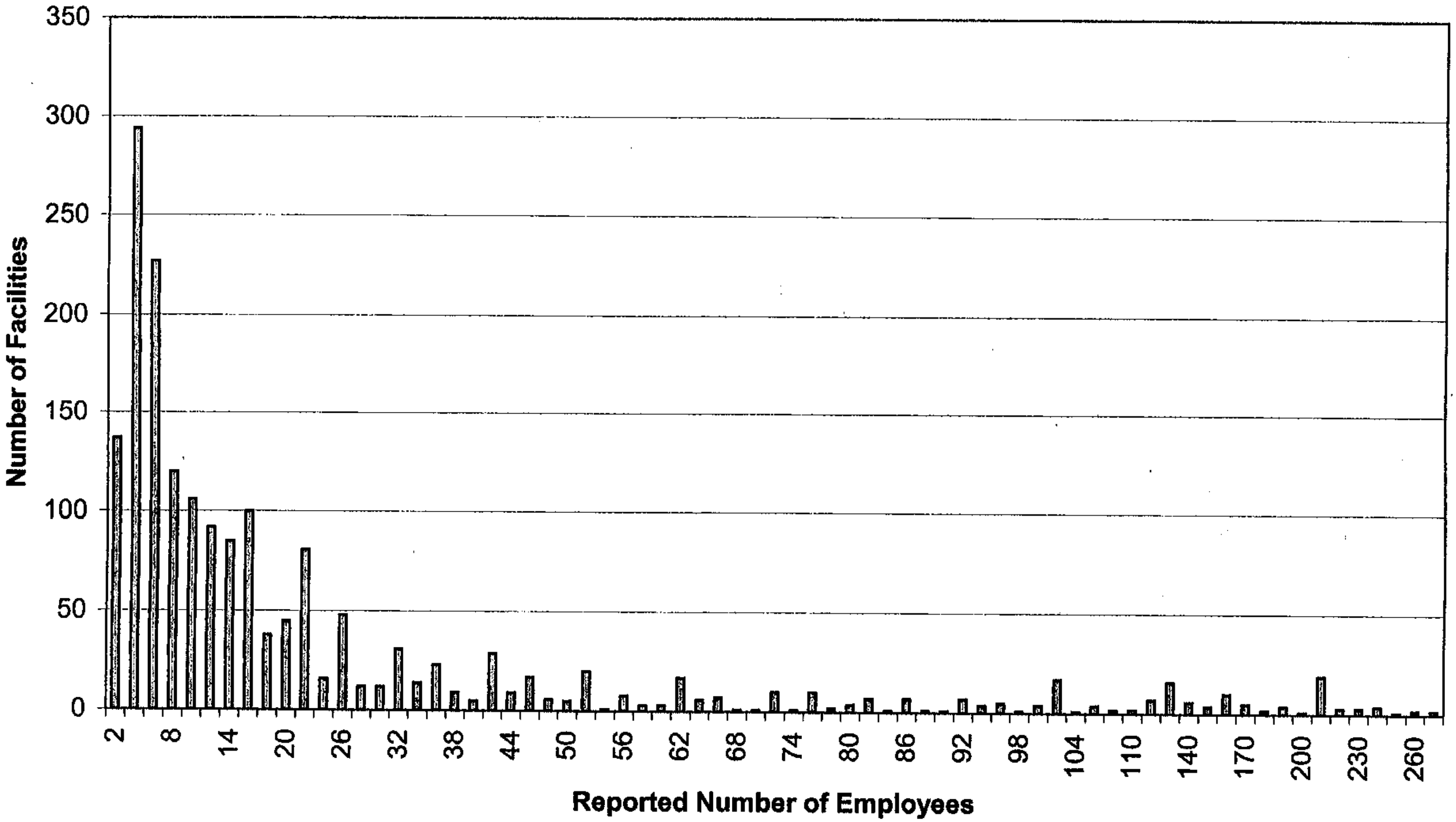


Chart 2
Number of Employees per Facility 6 (2/bin)



Source: DHS Wholesale Food Facility Database (all)

11/4/2003

APPENDIX H

GLOSSARY OF TERMS

APPENDIX H

GLOSSARY OF TERMS

AB 1807 (Tanner): [Glossary][1] A California state law (Health and Safety Code Section 39650 et seq.) which became effective in January of 1984 and established the framework for California's toxic air contaminant identification and control program.

Activity Factor: [ARB, 2003b. Preliminary Draft OFFROAD Modeling Change Technical Memo, July 18, 2003] Activity expressed in hour per year or hours per day of engine run time.

Acute Exposure: [Glossary] One or a series of short-term exposures generally lasting less than 24 hours.

Acute Health Effect: [Glossary]A health effect that occurs over a relatively short period of time (e.g., minutes or hours). The term is used to describe brief exposures and effects which appear promptly after exposure.

Additives: [DieselNet][2] Chemicals added to fuel in very small quantities to improve and maintain fuel quality and/or to lower emissions. See also "fuel additives"

Aftertreatment Devices: [DieselNet] Devices which remove pollutants from exhaust gases after the gas leaves combustion chamber (e.g., catalytic converters or diesel particulate filters). The term "exhaust gas aftertreatment" is considered derogatory by some in the emission control industry, but there is no consensus on the use of such alternatives as "post-combustion treatment" or "exhaust emission control".

Airborne Toxic Control Measure (ATCM): [Glossary] A control measure adopted by the ARB (Health and Safety Code Section 39666 et seq.), which reduces emissions of toxic air contaminants.

Air Quality Simulation Model: [Glossary] A mathematical relationship between emissions and air quality which simulates on a computer the transport, dispersion, and transformation of compounds emitted into the air.

Air Toxics: [Glossary] A generic term referring to a harmful chemical or group of chemicals in the air. Substances that are especially harmful to health, such as those considered under U.S. EPA's hazardous air pollutant program or California's AB 1807and/or AB 2588 air toxics programs, are considered to be air toxics. Technically, any compound that is in the air and has the potential to produce adverse health effects is an air toxic.

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[1] From Air Resources Board's *Glossary of Air Pollution Terms*, available at http://www.arb.ca.gov/html/gloss.htm
[2] From DieselNet's *Glossary of Terms*, available at http://www.dieselnet.com/glossary.html

Ambient Air: [Glossary] The air occurring at a particular time and place outside of structures. Often used interchangeably with "outdoor air."

American Society for Testing and Materials (ASTM): [Glossary] A nonprofit organization that provides a forum for producers, consumers, and representatives of government and industry, to write laboratory test standards for materials, products, systems, and services. ASTM publishes standard test methods, specifications, practices, guides, classifications, and terminology

Area-Wide Sources: [Glossary] Sources of pollution where the emissions are spread over a wide area, such as consumer products, fireplaces, road dust and farming operations. Area-wide sources do not include mobile sources or stationary sources.

Best Available Control Technology (BACT): [Glossary] The most up-to-date methods, systems, techniques, and production processes available to achieve the greatest feasible emission reductions for given regulated air pollutants and processes. BACT is a requirement of NSR (New Source Review) and PSD (Prevention of Significant Deterioration).

Biodiesel: [DieselNet] The mono alkyl esters of long chain fatty acids derived from renewable lipid feedstocks, such as vegetable oils and animal fats, for use in compression ignition (diesel) engines. Manufactured by transestrification of the organic feedstock by methanol.

B100 Biodiesel Fuel: [TRU][3] 100% biodiesel fuel derived from vegetable oil or animal fat and complying with ASTM D 6751-02 (or most current version) and commonly or commercially known, sold, or represented as "neat" biodiesel or B100.

Brake Power or Brake Horsepower: [ISO][4] The observed power measured at the crankshaft or its equivalent, the engine being equipped only with the standard auxiliaries necessary for its operation on the test bed.

California Air Resources Board (CARB): [Glossary] The State's lead air quality agency consisting of an eleven-member board appointed by the Governor and several hundred employees. CARB is responsible for attainment and maintenance of the state and federal air quality standards, and is fully responsible for motor vehicle pollution control. It oversees county and regional air pollution management programs.

CARB Diesel Fuel: [TRU] Any diesel fuel that meets the specifications defined in *13 CCR 2281* and *13 CCR 2282*.

Carbon Dioxide (CO2): [Glossary] A colorless, odorless gas that occurs naturally in the Earth's atmosphere. Significant quantities are also emitted into the air by fossil fuel combustion.

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[3] As defined in the proposed TRU ATCM.
[4] International Standards Organization 8178, Parts 1 and 4.

Carbon Monoxide (CO): [Glossary] A colorless, odorless gas resulting from the incomplete combustion of hydrocarbon fuels. CO interferes with the blood's ability to carry oxygen to the body's tissues and results in numerous adverse health effects. Over 80% of the CO emitted in urban areas is contributed by motor vehicles. CO is a criteria air pollutant.

Carcinogen: [Glossary] A cancer-causing substance.

Carl Moyer Fund: [Glossary] A multi-million dollar incentive grant program designed to encourage reduction of emissions from heavy-duty engines. The grants cover the additional cost of cleaner technologies for on-road, off-road, marine, locomotive and agricultural pump engines, as well as forklifts and airport ground support equipment. Note: Proposed revision would also include TRUs.

Catalyst: [Glossary] A substance that can increase or decrease the rate of a chemical reaction between the other chemical species without being consumed in the process.

Cetane Number: [DieselNet] A measure of ignition quality of diesel fuel. The higher the cetane number the easier the fuel ignites when injected into an engine. Cetane number is determined by an engine test using two reference fuel blends of known cetane numbers. The reference fuels are prepared by blending normal cetane (n-hexadecane), having a value of 100, with heptamethyl nonane, having a value of 15.

Chronic Exposure: [Glossary] Long-term exposure, usually lasting one year to a lifetime.

Chronic Health Effect: [Glossary] A health effect that occurs over a relatively long period of time (e.g., months or years).

Cloud Point (CP): [DieselNet] A measure of the ability of a diesel fuel to operate under cold weather conditions. Defined as the temperature at which wax first becomes visible when diesel fuel is cooled under standardized test conditions (ASTM D2500).

Cold Curtains: [TK][5] Flexible vinyl curtains used to reduce air exchange between the refrigerated compartment and the outside during door openings.

Cold Plate: [TK] Eutectic plate. A refrigeration unit consisting of a condenser section and several large "plates" containing a eutectic solution. Usually at night (when the vehicle is parked), the electric-powered condenser section is operated to freeze the eutectic solution in the plates. During the day, these plates absorb heat from the refrigerated compartment without reliance on an diesel engine or electric motor. (See *Eutectic Solution*)

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[5] ThermoKing Corporation's "Terms of Industry"

Common Carrier: [TLI][6] A transportation company which provides service to the general public at published rates.

Compression Ignition (CI) Engine: [TRU] An internal combustion engine with operating characteristics significantly similar to the theoretical diesel combustion cycle. The regulation of power by controlling fuel supply in lieu of a throttle is indicative of a compression ignition engine.

Compressed Natural Gas (CNG): [DieselNet] Natural gas compressed to a volume and density that is practical as a portable fuel supply.

Consignee: [PONL][7] The party such as mentioned in the transport document by whom the goods, cargo or containers are to be received.

Container: [TLI] A truck trailer body that can be detached from the chassis for loading into a vessel, a rail car, or stacked in a container depot. Containers may be ventilated, insulated, refrigerated, flat rack, vehicle rack, open top, bulk liquid, or equipped with interior devices. A container may be 20 feet, 40 feet, 45 feet, 48 feet, or 50 feet in length, 8'0" or 8'6" in width, and 8'6" or 9'6" in height.

Container Number: [PONL] Identification number of a container consisting of prefix and serial number and check digit. (e.g. KNLU 123456-7)
See also: Container Serial Number and Container Prefix

Container Prefix: [PONL] A four letter code that forms the first part of a container identification number indicating the owner of a container.

Container Serial Number: [PONL] A seven digit serial number (6 plus 1 Check Digit) that forms the second part of a container identification number.

Contract Carrier: [TLI] Any person not a common carrier who, under special or individual contracts or agreements, transports passengers or property for compensation.

Cordierite: [DieselNet] A ceramic material of the formula 2MgO-2Al2O3-5SiO2 which is used for automotive flow-through catalyst substrates and ceramic wall-flow diesel filters.

Cost-Effectiveness: [Glossary] The cost of an emission control measure assessed in terms of dollars-per-pound, or dollars-per-ton, of air emissions reduced.

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[6] The Logistics Institute of the Georgia Institute of Technology's *Logistics Glossary* at http://www.tli.gatech.edu/apps/glossary/
[7] P&O Nedlloyd, *A to Z of Shipping Terms* at http://www.ponl.com/topic/home_page/about_us/useful_information/a-z_of_shipping_terms/a

Cryogenic Temperature Control System: [TK] A heating and cooling system that uses a cryogen, such as carbon dioxide or liquid nitrogen that is routed through an evaporator coil that cools air blown over the coil. The cryogenic system uses a vapor motor to drive a fan and alternator, and a propane-fired heater superheats the carbon dioxide for heating and defrosting.

Cube Out: [TLI] When a container or vessel has reached its volumetric capacity before its permitted weight limit.

Cycle Time/Cycle Factor: Percent of TRU switch-on time that the engine is running. This time varies with type of load (set point and air flow needs), ambient temperature, trailer insulation and door seal condition, number of door openings, etc. Some units operate all of the time (e.g. deep frozen ice cream or products that need continuous air flow) while others shut off when set point is reached. The cycle factor is used when only the TRU switch-on time is known to get to engine operating hours. It is not used when actual engine hours are known.

Data Logger: [TK] An electronic device that monitors and stores unit operating and temperature data for later review. Examples: DMS, DAS, DRS and AccuTrac.

Defrost: [TK] The removal of accumulated ice from an evaporator coil. Periodic defrost is necessary when the evaporator coil is operating below freezing temperature and is especially frequent when air passing through the evaporator contains high humidity.

Depot: [PONL] The place designated by the carrier where empty containers are kept in stock and received from or delivered to the container operators or merchants.

Diesel Engine: [Glossary] A type of internal combustion engine that uses low-volatility petroleum fuel and fuel injectors and initiates combustion using compression ignition (as opposed to spark ignition that is used with gasoline engines).

Diesel Oxidation Catalyst (DOC): [TRU] The use of a catalyst to promote the oxidation processes in diesel exhaust. Usually refers to an emission control device that includes a flow-through substrate where the surfaces that contact the exhaust flow have been catalyzed to reduce emissions of the organic fraction of diesel particulates, gas-phase hydrocarbons, and carbon monoxide..

Diesel Particulate Filter (DPF): [TRU] An emission control technology that reduces PM emissions by trapping the particles in a flow filter substrate. Periodically, the collected particles are either physically removed or oxidized (burned off) in a process called regeneration.

Diesel Particulate Matter (diesel PM): [TRU] The particles found in the exhaust of diesel-fueled CI engines which may agglomerate and adsorb other species to form structures of complex physical and chemical properties

Dispatch: [PONL] The process of sending goods.

Dispersion Model: [Glossary] See air quality simulation model above.

Distribution Center: [PONL] A warehouse for the receipt, the storage and the dispersal of goods among customers.

Document Holder: [PONL] Usually fastened to the door on the front of a container. May contain e.g. a certificate of approval of the container.

Dose-Response: [Glossary] The relationship between the dose of a pollutant and the response (or effect) it produces on a biological system.

Dual-Fuel Vehicle: [DieselNet] A vehicle designed to operate on a combination of alternative fuel, such as compressed natural gas (CNG) or liquefied petroleum gas (LPG), and conventional fuel, such as diesel or gasoline. These vehicles have two separate fuel systems, which inject both fuels simultaneously into the engine combustion chamber.

Economy of Scale: [PONL] A phenomenon which encourages the production of larger volumes of a commodity to reduce its unit cost by distributing fixed costs over a greater quantity.

Elemental Carbon (EC): [DieselNet] Inorganic carbon, as opposed to carbon in organic compounds, sometimes used as a surrogate measure for diesel particulate matter, especially in occupational health environments. Elemental carbon usually accounts for 40-60% of the total DPM mass.

Emission Factor: [Glossary] For stationary sources, the relationship between the amount of pollution produced and the amount of raw material processed or burned. For mobile sources, the relationship between the amount of pollution produced and the number of vehicle miles traveled. By using the emission factor of a pollutant and specific data regarding quantities of materials used by a given source, it is possible to compute emissions for the source. This approach is used in preparing an emissions inventory.

Emission Inventory: [Glossary] An estimate of the amount of pollutants emitted into the atmosphere from major mobile, stationary, area-wide, and natural source categories over a specific period of time such as a day or a year.

Emission Rate: [Glossary] The weight of a pollutant emitted per unit of time (e.g., tons/year).

Emission Standard: [Glossary] The maximum amount of a pollutant that is allowed to be discharged from a polluting source such as an automobile or smoke stack.

Environmental Justice: [Glossary] The fair treatment of people of all races and incomes with respect to development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment implies that no person or group of people should shoulder a disproportionate share of negative environmental and economic impacts resulting from the execution of environmental programs.

Epidemiology: [Glossary] The study of the occurrence and distribution of disease within a population.

Exposure: [Glossary] The concentration of the pollutant in the air multiplied by the population exposed to that concentration over a specified time period.

Exposure Assessment: [Glossary] Measurement or estimation of the magnitude, frequency, duration and route of exposure to a substance for the populations of interest.

Facility: [TRU] Any facility where TRU-equipped trucks, trailers, containers or railcars are loaded or unloaded with perishable goods. This includes, but is not limited to, grocery distribution centers, good service distribution centers, cold storage warehouses, and intermodal facilities. Each business entity at a commercial development is a separate facility (for the purposes of the proposed ATCM) provided the businesses are independently owned and operated.

Flash Point: [DieselNet] The temperature at which a combustible liquid gives off just enough vapor to produce a vapor/air mixture that will ignite when a flame is applied. The flash point is measured in a standardized apparatus using standard test methods, such as ASTM D93 or ISO 2719.

Fleet: [PONL] Any group of means of transport acting together or under one control.

Fuel Cell: [Glossary] An electrochemical cell which captures the electrical energy of a chemical reaction between fuels such as liquid hydrogen and liquid oxygen and converts it directly and continuously into the energy of a direct electrical current.

Generator Set (Gen Set): [TLI] A portable generator which can be attached to a refrigerated container to power the refrigeration unit during transit.

Health Risk Assessment (HRA): [Glossary] A document that identifies the risks and quantities of possible adverse health effects that may result from exposure to emissions of toxic air contaminants. A health risk assessment cannot predict specific health effects; it only describes the increased possibility of adverse health effects based on the best scientific information available.

"Hot Spot": [Glossary] See toxic hot spot.

Hybrid Cryogenic Temperature Control System: [TK] A temperature control system that uses a cryogenic temperature control system in conjunction with a diesel engine.

Hydrocarbons: [Glossary] Compounds containing various combinations of hydrogen and carbon atoms. They may be emitted into the air by natural sources (e.g., trees) and as a result of fossil and vegetative fuel combustion, fuel volatilization, and solvent use. Hydrocarbons are a major contributor to smog. (See also Reactive Organic Gases).

Independently Owned and Operated: [TRU] A business concern that independently manages and controls the day-to-day operations of its own business through its ownership and management, without undue influence by an outside entity or person that may have an ownership and/or financial interest in the management responsibilities of the applicant business or small business.

Indirect Source: [Glossary] Any facility, building, structure, or installation, or combination thereof, which generates or attracts mobile source activity that results in emissions of any pollutant (or precursor) for which there is a state ambient air quality standard. Examples of indirect sources include employment sites, shopping centers, sports facilities, housing developments, airports, commercial and industrial development, and parking lots and garages.

Individual Cancer Risk: [Glossary] The probability, expressed as chances in a million, that a person experiencing 70 years of continuous area-wide outdoor exposure to a toxic air contaminant will develop cancer.

Intermodal: [TLI] Used to denote movements of cargo containers interchangeably between transportation modes (i.e motor, water, and air carriers) and where the equipment is compatible within the multiple systems.

Intermodal Facility: [TRU] A facility involved in the movement of goods in one and the same loading unit or vehicle which uses successively several modes of transport without handling of the goods themselves in changing modes. Such a facility is typically involved in loading and unloading shipping containers and trailer vans to and from railcars, trucks, and ocean-going ships.

Intermodal Transport: [PONL] The movement of goods (containers) in one and the same loading unit or vehicle which uses successively several modes of transport without handling of the goods themselves in changing modes.

Internal Combustion Engine: [Glossary] An engine in which both the heat energy and the ensuing mechanical energy are produced inside the engine. Includes gas turbines, spark ignition gas, and compression ignition diesel engines.

Interruptible Service Contract: [TRU] any arrangement in which a nonresidential electrical customer agrees to reduce or consider reducing its electrical consumption during periods of peak demand or at the request of the System Operator in exchange for compensation, or assurances not to be blacked out or other similar non-monetary assurances.

In Use (CI engine): [TRU] Not a "new" CI engine.

Lease: [PONL] A contract by which one party gives to another party the use of property or equipment, e.g. containers, for a specified time against fixed payments.

Leasing Company: [PONL] The company from which property or equipment is taken on lease.

Leasing Contract: [PONL] A contract for the leasing of property or equipment.

Lessee: [PONL] The party to whom the possession of specified property has been conveyed for a period of time in return for rental payments.

Lessor: [PONL] The party who conveys specified property to another for a period of time in return for the receipt of rent.

Liquefied Natural Gas (LNG): [DieselNet] Natural gas that has been refrigerated to cryonic temperatures where the gas condenses into a liquid.

Liquefied Petroleum Gas (LPG): [DieselNet] A mixture of low-boiling hydrocarbons that exists in a liquid state at ambient temperatures when under moderate pressures (less than 1.5 MPa or 200 psi). LPG is a by-product from the processing of natural gas and from petroleum refining. Major components of LPG are propane (min. 85% content in the U.S.), butane and propylene.

Load Factor: [ARB, 2003b. Preliminary Draft OFFROAD Modeling Technical Change Memo, July 18, 2003] The average operation level in a given application expressed as a percent of the engine manufacturer's maximum horsepower ratings.

Logistics: [TLI] That part of the supply chain process that plans, implements, and controls the efficient flow and storage of goods, services, and related information from the point of origin to the point of consumption in to meet customers' requirements.

Lubricity: [Glossary] A measure of the ability of an oil or other compound to lubricate (reduce friction) between two surfaces in contact.

Marking: [TLI] Letters, numbers, and other symbols placed on cargo packages to facilitate identification. See Shipping Marks

Mechanical Refrigeration: [U.S. Department of Agriculture Handbook 669, Revised June 2000] Refrigerant is circulated through the refrigeration system by a compressor driven by a gasoline, diesel, or electrical motor.

Mobile Sources: [Glossary] Sources of air pollution such as automobiles, motorcycles, trucks, off-road vehicles, boats, and airplanes.

Mode: [ISO] An engine operating point characterized by the speed and a torque (or an output).

Model Year (MY): [TRU] A diesel-fueled engine manufacturer's annual production period, which includes January 1st of a calendar year, or if the manufacturer has no annual production period, the calendar year.

Morbidity: [Glossary] Rate of disease incidence.

Mortality: [Glossary] Death rate.

Motor Carrier: [Based Upon 13 CCR §1201(q) and TRU]: The registered owner, lessee, or licensee of one or more straight trucks, tractors, trailers, or semi-trailers.

Mutagenic: [Glossary] The ability of a chemical or physical agent to produce heritable changes in the DNA of living cells.

Nitrogen Oxides (NOx): [Glossary] A general term pertaining to compounds of nitric oxide (NO), nitrogen dioxide (NO2), and other oxides of nitrogen. Nitrogen oxides are typically created during combustion processes, and are major contributors to smog formation and acid deposition. NO2 is a criteria air pollutant, and may result in numerous adverse health effects.

Nitric Oxide (NO): [Glossary] Precursor of ozone, NO2, and nitrate; nitric oxide is usually emitted from combustion processes. Nitric oxide is converted to nitrogen dioxide (NO2) in the atmosphere, and then becomes involved in the photochemical processes and/or particulate formation. (See Nitrogen Oxides.)

Noncarcinogenic Effects: [Glossary] Non-cancer health effects which may include birth defects, organ damage, morbidity, and death.

Non-Methane Hydrocarbon (NMHC): [Glossary] The sum of all hydrocarbon air pollutants except methane. NMHCs are significant precursors to ozone formation.

No-Observed-Adverse-Effect-Level (NOAEL): [Glossary] A term used in risk assessment. An exposure level at which there are no statistically or biologically significant increases in the frequency or severity of adverse effects between an exposed population and a comparable non-exposed population.

No-Observed-Effect-Level (NOEL): [Glossary] A term used in risk assessment. An exposure level at which there are no statistically or biologically significant difference or severity of any effect between an exposed population and a comparable non-exposed population.

Nose: [TLI] The front of a container or trailer – opposite the tail.

Office of Environmental Health Hazard Assessment (OEHHA): [Glossary] A department within the California Environmental Protection Agency that is responsible for evaluating chemicals for adverse health impacts and establishing safe exposure levels. OEHHA also assists in performing health risk assessments and developing risk assessment procedures for air quality management purposes.

Original Equipment Manufacturer (OEM): [DieselNet] Manufacturers of equipment (such as engines, vehicles, etc.) that provide the original product design and materials for its assembly and manufacture. OEMs are directly responsible for manufacturing and modifying the products, making them commercially available, and providing the warranty.

Owner/Operator: [TRU] (For the purposes of the proposed ATCM) A requirement applies to the owner and/or operator of a TRU or TRU generator set, as determined by agreement or contract if the two are separate entities.

Oxidation: [Glossary] The chemical reaction of a substance with oxygen or a reaction in which the atoms in an element lose electrons and its valence is correspondingly increased.

Ozone: [Glossary] A strong smelling, pale blue, reactive toxic chemical gas consisting of three oxygen atoms. It is a product of the photochemical process involving the sun's energy and ozone precursors, such as hydrocarbons and oxides of nitrogen. Ozone exists in the upper atmosphere ozone layer (stratospheric ozone) as well as at the Earth's surface in the troposphere (ozone). Ozone in the troposphere causes numerous adverse health effects and is a criteria air pollutant. It is a major component of smog.

Ozone Precursors: [Glossary] Chemicals such as non-methane hydrocarbons and oxides of nitrogen, occurring either naturally or as a result of human activities, which contribute to the formation of ozone, a major component of smog.

Particulate Matter (PM): [Glossary] Any material, except pure water, that exists in the solid or liquid state in the atmosphere. The size of particulate matter can vary from coarse, wind-blown dust particles to fine particle combustion products.

PM2.5: [Glossary] Includes tiny particles with an aerodynamic diameter less than or equal to a nominal 2.5 microns. This fraction of particulate matter penetrates most deeply into the lungs.

PM10 (Particulate Matter): [Glossary] A criteria air pollutant consisting of small particles with an aerodynamic diameter less than or equal to a nominal 10 microns (about 1/7 the diameter of a single human hair). Their small size allows them to make their way to the air sacs deep within the lungs where they may be deposited and result in adverse health effects . PM10 also causes visibility reduction.

Polycyclic Aromatic Hydrocarbons (PAHs): [Glossary] Organic compounds which include only carbon and hydrogen with a fused ring structure containing at least two benzene (six-sided) rings. PAHs may also contain additional fused rings that are not six-sided. The combustion of organic substances is a common source of atmospheric PAHs.

Pour Point: [DieselNet] A measure of the ability of a diesel fuel to operate under cold weather conditions. Defined as the temperature at which the amount of wax out of solution is sufficient to gel the fuel when tested under standard conditions (ASTM D97).

Primary Particles: [Glossary] Particles that are directly emitted from combustion and fugitive dust sources. (Compare with Secondary Particle.)

Proposition 65: [Glossary] Safe Drinking and Toxic Enforcement Act of 1986, also known as Proposition 65. This Act is codified in California Health and Safety Code Section 25249.5, et seq. No person in the course of doing business shall knowingly discharge or release a chemical known to the state to cause cancer or reproductive toxicity into water or into land where such chemical passes or probably will pass into any source of drinking water, without first giving clear and reasonable warning to such individual.

Rail Car: [PONL] A wheeled wagon used for the carriage of cargo by rail.

Rated Power: [ISO] Power delivered, according to the statement of the manufacturer, at the rated speed.

Rated Speed: [ISO] Speed at which, according to the statement of the manufacturer, the rate power is delivered.

Reference Exposure Level (REL): [Glossary] A term used in risk assessment. It is the concentration at or below which no adverse health effects are anticipated for a specified exposure period.

Refrigerated Shipping Container TRU: [TRU] A shipping container equipped with a TRU.

Residual Risk: [Glossary] The quantity of health risk remaining after application of emission control.

Risk Assessment: [Glossary] An evaluation of risk which estimates the relationship between exposure to a harmful substance and the likelihood that harm will result from that exposure.

Risk Management: [Glossary] An evaluation of the need for and feasibility of reducing risk. It includes consideration of magnitude of risk, available control technologies, and economic feasibility.

Scientific Review Panel (SRP): [Glossary] Mandated by AB 1807, this nine-member panel advises the ARB, OEHHA, and the California Department of Pesticide Regulation on the scientific adequacy of the risk assessment portion of reports issued by those three agencies in the process of identifying substances as toxic air contaminants.

Secondary Particle: [Glossary] Particles that are formed in the atmosphere. Secondary particles are products of the chemical reactions between gases, such as nitrates, sulfur oxides, ammonia, and organic products.

Semi Trailer: [PONL] A vehicle without motive power and with one or more axles designed to be drawn by a truck tractor and constructed in such way that a portion of its weight and that of its load rest upon e.g. the fifth wheel of the towing vehicle.

Set Point: [TK] The temperature selected on a thermostat or microprocessor controller. This is normally the desired box temperature.

Smog: [Glossary] A combination of smoke and other particulates, ozone, hydrocarbons, nitrogen oxides, and other chemically reactive compounds which, under certain conditions of weather and sunlight, may result in a murky brown haze that causes adverse health effects . The primary source of smog in California is motor vehicles.

Shipper: [TLI] The person or company who is usually the supplier or owner of commodities shipped. Also called Consignor.

Soluble Organic Fraction (SOF): [DieselNet] The organic fraction of diesel particulates. SOF includes heavy hydrocarbons derived from the fuel and from the engine lubricating oil. The term "soluble" originates from the analytical method used to measure SOF which is based on extraction of particulate matter samples using organic solvents.

Soot: [Glossary] Very fine carbon particles that have a black appearance when emitted into the air.]

Source: [Glossary] Any place or object from which air pollutants are released. Sources that are fixed in space are stationary sources and sources that move are mobile sources.

Stakeholders: [Glossary] Citizens, environmentalists, businesses, and government representatives that have a stake or concern about how air quality is managed.

Stand-by Time [Carrier][8] Actual time that the electric standby motor operates – time when the TRU is under total electric power.

Straight Truck: [TK] A truck consisting of a driver's cab and attached box or bed for transporting cargo. Not a semi-truck which consists of a trailer pulled by a tractor.

Sulfates: [Glossary] (See Sulfur Oxides.)

Sulfur Dioxide (SO2): [Glossary] A strong smelling, colorless gas that is formed by the combustion of fossil fuels. Power plants, which may use coal or oil high in sulfur content, can be major sources of SO2. SO2 and other sulfur oxides contribute to the problem of acid deposition. SO2 is a criteria air pollutant.

Sulfur Oxides: [Glossary] Pungent, colorless gases (sulfates are solids) formed primarily by the combustion of sulfur-containing fossil fuels, especially coal and oil. Considered major air pollutants, sulfur oxides may impact human health and damage vegetation.

Switch On Time (SON): [Carrier] Total time that the unit is switched on and cooling a load. The clock keeps running even when the engine is off

Terminal: [TRU] Any place where a TRU-equipped truck, trailer, container, railcar or TRU gen set is regularly garaged, maintained, operated, or dispatched from, including a dispatch office, cross-dock facility, maintenance shop, business, or private residence.

Test Cycle: [ISO] A sequence of engine test modes each with a defined speed, torque, and weighting factor, where the weighting factors only apply if the test results are expressed in g/kWh.

Toxic Air Contaminant (TAC): [Glossary] An air pollutant, identified in regulation by the ARB, which may cause or contribute to an increase in deaths or in serious illness, or which may pose a present or potential hazard to human health. TACs are considered under a different regulatory process (California Health and Safety Code Section 39650 et seq.) than pollutants subject to CAAQSs. Health effects to TACs may occur at extremely low levels, and it is typically difficult to identify levels of exposure which do not produce adverse health effects. For more information, click here.

Toxic Hot Spot: [Glossary] A location where emissions from specific sources may expose individuals and population groups to elevated risks of adverse health effects -- including but not limited to cancer – and contribute to the cumulative health risks of emissions from other sources in the area.

Tractor: [TLI] Unit of highway motive power used to pull one or more trailers/containers.

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[8] Provided by Carrier Transicold Corporation's Peter Guzman.

Trailer: [PONL] A vehicle without motive power, designed for the carriage of cargo and to be towed by a motor vehicle.

Transponder: [PONL] A device (chip) used for identification, which automatically transmits certain coded data when actuated by a special signal from an interrogator.

Transport: [TLI] To move cargo from one place to another.

Transport Refrigeration Unit (TRU): [TRU] Refrigeration systems powered by integral internal combustion engines designed to control the environment of temperature sensitive products that are transported in semi-trailer vans, truck vans, reefer railcars, or shipping containers. TRUs may be capable of both cooling and heating.

TRU Generator Set: [TRU] A generator set that is designed and used to provide electric power to electrically driven transport refrigeration units of any kind. This includes, but is not limited to generator sets that provide electricity to electrically powered trailer-mounted TRUs and shipping containers.

Ultra-Low-Aromatic Synthetic Diesel Fuel: [TRU] Fuel produced from natural gas by the Fischer-Tropsch gas-to-liquid chemical conversion process, or similar process that meets the following properties:

Property	ASTM	Value
Sulfur Content (ppmw)	D5453	<1
Aromatic Content (wt %)	D51876-99	1.5%
Polynuclear aromatic hydrocarbon (wt %)	-	0.5%
Cetane Number	D613	>74

Unit Risk Number: [Glossary] The number of potential excess cancer cases from a lifetime exposure to one microgram per cubic meter (μ/m3) of a given substance. For example, a unit risk value of 5.5x10-6 would indicate an estimated 5.5 cancer cases per million people exposed to an average concentration of 1 μ/m3 of a specific carcinogen for 70 years.

Verification Classification Level: [TRU] The classification assigned to a Diesel Emission Control Strategy by the Executive Officer as defined in the *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emission from Diesel Engines (13 CCR Sections 2700 – 2710)*. PM reductions correspond as follows: Level 1: ≥25%; Level 2: ≥50%; Level 3: ≥85% or 0.01 g/hp-hr.

Verified Diesel Emission Control Strategy (VDECS): [TRU] An emission control strategy designed primarily for the reduction of diesel particulate matter emissions that has been verified per the *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines* (13 CCR

Sections 2700-2710). Examples of diesel retrofit systems that may be verified include, but are not limited to, diesel particulate filters, diesel oxidation catalysts, fuel additives (e.g., fuel-borne catalysts), alternative diesel fuels, and combinations of the above.

APPENDIX I

ACRONYMS

Appendix I

LIST OF ACRONYMS AND ABBREVIATIONS

$/lb	Dollars per pound
AB	Assembly bill
ARB, or the Board	Air Resources Board
ATCM	Airborne Toxic Control Measure
B100	100% biodiesel
BACT	Best available control technology
°C	Degrees Celsius
CARB	California Air Resource Board
CCR	California Code of Regulations
CHP	California Highway Patrol
CI	Compression ignition
CNG	Compressed natural gas
CO	Carbon monoxide
DECS	Diesel Emission Control System or Strategy
DOC	Diesel Oxidation Catalyst
DPF	Diesel particulate filter
DRRP, or Diesel Risk Reduction Plan	Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles Risk Reduction Plan
DFA	Department of Food and Agriculture
DHS	Department of Health Services
DTSC	Department of Toxic Substances Control
ED	Enforcement Division of ARB
EO	Executive Officer of the Air Resource Board
E/S	Electric standby
°F	Degrees Fahrenheit
FTF	Flow-through filter
g/hp-hr	Grams per horsepower-hour
>	Greater than
HC	Hydrocarbon
H&SC	Health and Safety Code
<	Less than
LETRU	Low Emissions Transport Refrigeration Unit
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
Low sulfur diesel fuel	Diesel fuel with less than 15 ppmw sulfur content
$\mu g/m^3$	Microgram per cubic meter
MY	Model year
Moyer Program	Carl Moyer Memorial Air Quality Standards Attainment Program
NMHC	Non-methane hydrocarbons
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen

NOV	Notice of violation
OEHHA	Office of Environmental Health Hazard Assessment
O & M	Operation and maintenance
PM	Particulate matter
ppmw	Parts per million by weight
PTSD	Planning and Technical Support Division of ARB
SCAQMD	South Coast Air Quality Management District
SJVAPCD	San Joaquin Air Pollution Control District
SSD	Stationary Source Division of ARB
TAC	Toxic air contaminant
tpd	Tons per day
TRU	Transport Refrigeration Unit
ULETRU	Ultra-Low Emission Transport Refrigeration Unit
USDA	United States Department of Agriculture
U. S. EPA	United States Environmental Protection Agency
VDECS	Verified Diesel Emission Control Strategy
VIN	Vehicle identification number
VOC	Volatile organic carbon

APPENDIX J

ACTIVITY ANALYSIS OF TRANSPORT REFRIGERATION UNITS

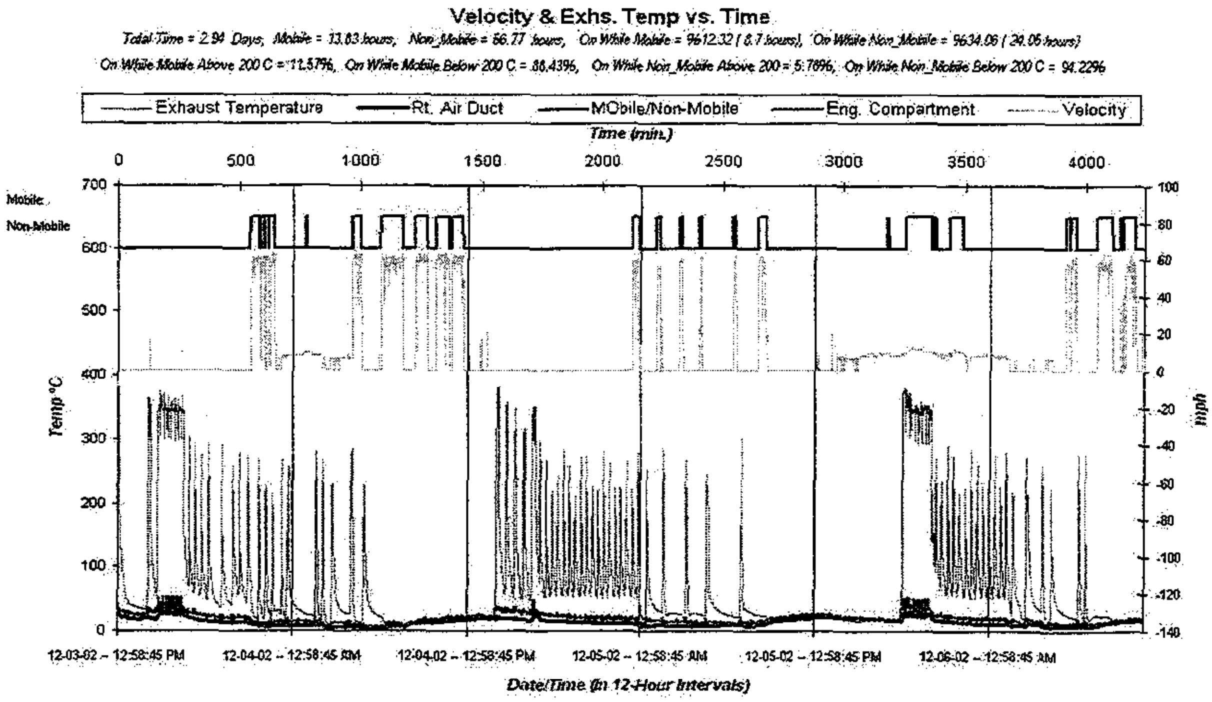
ACTIVITY ANALYSIS OF TRANSPORT REFRIGERATION UNITS

This project was conducted by the University of California - Riverside, College of Engineering Center for Environmental Research and Technology. The final report for this project had not been completed as of the publication of the staff report for the proposed TRU ATCM. The purpose of the project was to study diesel engines that are used in transport refrigeration units (TRUs). The primary objective was to characterize duty cycles and operating parameters of diesel-powered TRUs operated in assorted real-world applications.

To achieve that goal, UCR worked with several companies that allowed them to put data loggers on their operating units. Twenty-seven trailer TRUs were monitored while delivering a variety of goods over inter and intra-city routes from an egg distribution company, a grocery distribution company, and a wholesale restaurant supply company. The data loggers recorded the exhaust temperature of the TRU as well as the temperature in the refrigerated compartment as a function of time. An overlay of the global positioning system (GPS) data as a function of time allowed an analysis of whether emissions occurred while the TRU was on the road, or the TRU was stationary and presumably in a distribution center. From these data the cumulative time that the exhaust temperature spent as a function of temperature was calculated to help choose suitable control technology.

An example of the time series plots for a data logger output is show in Figure J-1, below. Results show that the units spent most of their operating time while stationary and presumably at the distribution center.

Figure J-1



The frequency distribution of the exhaust temperatures shown in Figure J-1 is shown in Figure J-2.

Figure J-2