EXHAUSTED BY DIESEL

How America's Dependence on Diesel Engines Threatens Our Health

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INTRODUCTION

Everyone is familiar with the black cloud that belches out of some diesel trucks and buses when they accelerate. This choking cloud is not only offensive, but growing evidence shows that it is also a health hazard. Diesel exhaust is a complex mixture of fine particles and toxic organic materials which come from the combustion of diesel fuel. Much of this toxic mix is contributed to our environment by mobile sources such as trucks, buses, and trains. Diesel exhaust contains hundreds of constituent chemicals, dozens of which are recognized human toxicants, carcinogens, reproductive hazards, or endocrine disruptors.[1]

In 1990, California identified diesel exhaust as "known to the State of California to cause cancer."[2] Diesel exhaust has long been considered to be a probable human carcinogen by the National Institute of Occupational Safety and Health (NIOSH) and the International Agency for Research on Cancer (IARC).[3] The U.S. Environmental Protection Agency (U.S. EPA) recently concluded in a draft report that diesel exhaust is highly likely to be a human carcinogen.[4] California Environmental Protection Agency (Cal EPA) is in the process of designating diesel exhaust as a toxic air contaminant based in large part on evidence that exposure causes cancer.[5] [6]The state's independent panel of scientists unanimously endorsed designation of diesel exhaust as a toxic air contaminant on April 22, 1998. These agencies and independent scientists based their designations on the weight of evidence from an extensive array of scientific studies.

As we learn more about the health effects from diesel exhaust and the high levels of exposure in our communities, we must reconsider the widespread use of diesel engines.

In addition to its load of carcinogens, diesel exhaust is also a major source of tiny sooty particles. For the same load and engine conditions, diesel engines spew out 100 times more sooty particles compared to gasoline engines.[10] In the past decade there have been numerous scientific studies evaluating the relationship between airborne particle pollution and human health effects.[7] Since 1988, 23 human exposure studies have evaluated acute effects of particle exposures. Almost all of these studies showed short-term impairment of respiratory function in healthy individuals and greater effects in people with asthma, especially adolescents. Eleven community health studies linked particle pollution to increased hospital admissions for respiratory diseases, chronic obstructive pulmonary diseases (COPD), pneumonia, heart disease, and death.[8] Most of 38 epidemiological studies published between 1988 and 1996 found a significant association between ambient levels of particles in the air and deaths from cardiac and respiratory problems.[9]

Diesel vehicles are commonplace. Virtually all heavy trucks and many buses burn diesel fuel. These vehicles, together with diesel engines used in various industrial applications—irrigation and agriculture, construction, shipping and port activities, oil drilling and mining, and railroads—expel diesel exhaust into the air we breathe. Especially in cities, diesel exhaust is a feature of everyday life.

As we learn more about the health effects from diesel exhaust and the high levels of exposure in our communities, we must reconsider the widespread use of diesel engines. So far the U.S. EPA and state governments, including the California Air Resources Board, have accepted diesel engines as the norm, and have only tried to reduce the levels of pollution coming from those engines. We conclude in this report that, while these efforts may be of some benefit, we can and must do more. We will only achieve our goals of reducing smog and particulate pollution, and reducing the serious cancer threats posed by diesel exhaust, if our state and federal governments act aggressively to replace diesel-fueled engines with cleaner alternatives. As we discuss in this report, alternatives to diesel, such as natural gas and electric vehicles, are currently available for many applications. Many companies have successfully used alternative fuel trucks and buses, but more must be done to accelerate the transition to make these engines more available and economically viable. We strongly support state and federal government incentive programs that provide financial assistance for owners of diesel vehicles and equipment who seek to switch to cleaner alternative fuels.

The Natural Resources Defense Council (NRDC) and the Coalition for Clean Air (Coalition) have initiated a "Dump Dirty Diesel" campaign in California, which is building on NRDC's ongoing effort to phase out diesel buses in New York City and the joint efforts of NRDC and the Coalition to phase out the use of diesel buses in Los Angeles. As part of the campaign, NRDC and the Coalition have undertaken an extensive study of diesel exhaust hazards in California. Over the past year, the two organizations have worked with internationally recognized experts on diesel exhaust. These experts have analyzed the available scientific information, generated specific estimates of the cancer risk from diesel exhaust exposure, and applied these estimates to highly impacted California communities. NRDC and the Coalition have performed extensive exposure monitoring in communities located near distribution centers where diesel truck traffic is heavy.

These affected communities, and the workers at these distribution facilities are paying the price for our society's addiction to diesel engines.

The conclusion from this intensive study is that facilities with heavy truck traffic are exposing local communities to diesel exhaust concentrations far above the average levels in outdoor air. These affected communities, and the workers at these distribution facilities with heavy diesel truck traffic, are bearing a disproportionate burden of the health risks and are paying the price for our society's addiction to diesel engines.

Because government agencies have failed to protect the public from diesel exhaust, NRDC, the Coalition, and the Environmental Law Foundation intend to take their campaign to the courts, initiating a series of lawsuits under California's toxics initiative, Proposition 65. The public interest groups hope by this report and their litigation to push a change nationwide toward cleaner and safer trucks, buses and other vehicles. Only by forcing companies to reassess their use of diesel powered vehicles can we break our dependence on diesel and protect the health of the public.

HIGHLIGHTS

• Diesel exhaust is a mixture containing over 450 different components, including vapors and fine particles coated with organic substances.[10] Over 40 chemicals in diesel exhaust are considered toxic air contaminants by the State of California (see Table 1). Exposure to this mixture may result in cancer, respiratory effects, and other health problems.

• California's Scientific Review Panel has unanimously endorsed the official listing of diesel exhaust as a toxic air contaminant, due to its cancer and non-cancer health effects.

• Diesel exhaust has been listed as a known carcinogen under California's Safe Drinking Water and Toxic Enforcement Act (Prop. 65) since 1990.[2] Many components of diesel exhaust, such as benzene, arsenic, dioxins, and formaldehyde, are also known carcinogens in California. Other components, such as toluene and dioxins, are known reproductive toxicants.

• For the same load and engine conditions, diesel engines spew out 100 times more sooty particles than gasoline engines.[10] As a result, diesel engines account for an estimated 26 percent of the total hazardous particulate pollution (PM_{10}) in our air, and 66 percent of the particulate pollution from on-road sources.[11]

• Diesel engines also produce nearly 20 percent of the total nitrogen oxides (NO_x) in outdoor air and 26 percent of the total NO_x from on-road sources.[12] Nitrogen oxides are a major contributor to ozone production and smog.

• The health risk from diesel exposure is greater for children, the elderly, people who have respiratory problems or who smoke, people who regularly strenuously exercise in diesel-polluted areas, and people who work or live near diesel exhaust sources.

• According to an expert estimate, lifetime exposure to diesel exhaust at the outdoor average concentration (2.2 micrograms per cubic meter ($\mu g/m^3$), may result in about one in every 2,000 people developing cancer due to this exposure. This estimate increases to as many as one in every 1,200 at levels found in the South Coast Air Basin in Southern California (3.6 $\mu g/m^3$), and to even higher risks for those living near freeways or in highly polluted urban communities.[13]

• Dozens of studies link airborne fine particle concentrations to increased hospital admissions for respiratory diseases, chronic obstructive lung disease, pneumonia, heart disease and death.[14] Recent evidence indicates that diesel exhaust exposure may contribute to asthma.[15]

• About 127 million Americans — half of the nation's population — live in regions with air quality that does not meet federal standards for certain air pollutants.[16] More than 60 percent of preadolescent children, including children with asthma, live in "nonattainment" areas. In the United States, there are an estimated 10.3 million people living with asthma.[17]

• In California, there are six million children under the age of fourteen, 90 percent of whom live in areas that fail to meet state and federal air quality standards.[18] According to the American Lung Association, there are over a half million children with asthma in California.

• Asthma is on the rise. In the United States, age-specific death rates from the disease increased 118 percent between 1980 and 1993.[19] African-American and Latino children have a higher risk of asthma than white children.[20] Moreover, African-American children are four times more likely to die from asthma compared to Caucasian children.[19]

• Cleaner alternatives to diesel engines are readily available. Alternatives include electric, liquefied natural gas (LNG) or compressed natural gas (CNG) buses and trucks.

• Although initial purchase prices may be higher for alternative fuel buses and trucks, federal, state, and local funds are available to offset these higher costs. These funds are specifically ear-marked for clean technologies and would not otherwise be available for these purchases.

• For transit authorities, use of alternative fuel buses can generate operational cost savings. Sacramento RTD's CNG bus fleet is currently demonstrating cost savings of 20-40% per mile when compared to diesel counterparts. Over its lifetime, a CNG bus will save 190,000 gallons of diesel fuel compared to a new diesel bus, decreasing our dependency on petroleum.[21]

• Diesel buses and trucks are important contributors to smog (ground-level ozone) and fine toxic soot, two pollutants that have recently come under increased scrutiny because of their important public health impacts. Purchasing alternative fuel vehicles will reduce smog and fine soot emissions considerably. For example, operating a natural gas bus instead of a new diesel bus is equivalent to eliminating the smog and soot from 17-33 passenger cars.

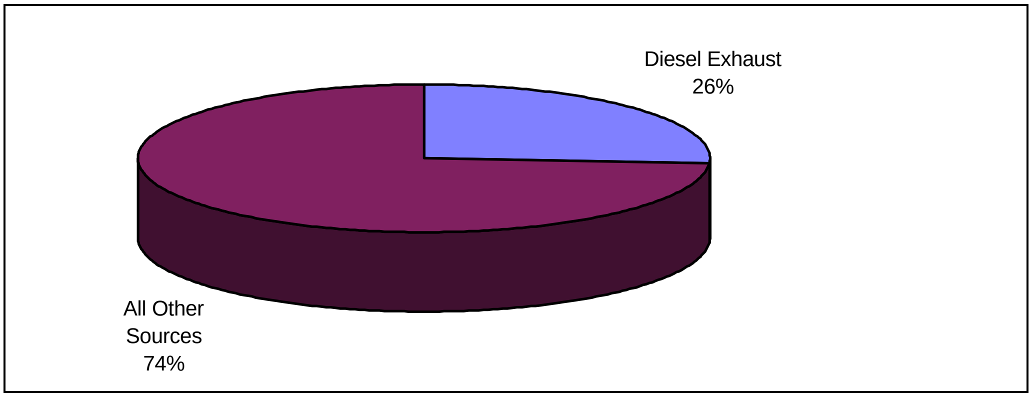
DIESEL: HEAVY USE AND HIGH EXPOSURES

Nationally, trucks are moving an increasingly large portion of freight, and most heavy trucks are fueled by diesel. From 1950 to 1985 the miles driven by trucks in the United States increased by 235 percent and tons carried by trucks increased by 169 percent.[22] Trucks are now carrying a heavier load while traveling farther, increasing their overall emissions. In 1995, over half a million diesel trucks and over 20,000 diesel buses were sold in the United States, representing a doubling of annual sales since 1980.[23] A total of around 6 million heavy trucks, tractor-trailers, and buses were registered for use in the United States in 1995.[24] That same year, diesel vehicles nationwide consumed 37 billion gallons of diesel fuel.[25] California's 1995 diesel fuel consumption was roughly 2.1 billion gallons.[26] California and other western states have experienced higher than average growth in motor vehicle travel and have also experienced increased total vehicle emissions.[27]

Exhaust from heavy-duty diesel engines contains between 100 to 200 times more small particles than gasoline engine exhaust.

Diesel exhaust is a major contributor to various types of air pollution, including smog-forming oxides of nitrogen (NO_x) and fine particles ($PM_{2.5}$). In 1996, diesel exhaust accounted for over one quarter of the 23,393,000 tons per year of NO_x pollution produced nationally.[28] In California, an estimated 26 percent of particles (PM_{10}) in outdoor air come from diesel engines.[11] Exhaust from heavy-duty diesel engines contains between 100 to 200 times more small particles than gasoline engine exhaust.[29]

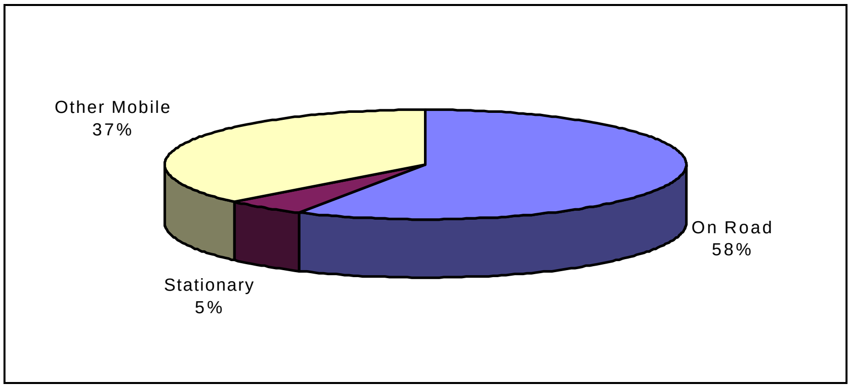
• Figure 1: 1996 Diesel Exhaust Contribution to National NO_x Emissions



Source: Office of Air Quality Planning and Standards. *National Air Pollutant Emission Trends, 1900-1996*. United States Environmental Protection Agency. Appendix A. December 1997.

The California Air Resources Board estimates, based on a 1995 emissions inventory, that approximately 27,000 tons of diesel exhaust particles are emitted into California's air annually.[30] As Figure 2 illustrates, on-road mobile sources (heavy-duty trucks and buses, together with far smaller numbers of light-duty cars and trucks) are the major contributors, emitting 58 percent (approximately 15,680 tons per year) of total diesel exhaust particle emissions in California. Other mobile sources (mobile equipment, ships, trains, and off-road vehicles) contribute about 9,820 tons per year (37 percent). Stationary sources such as diesel generators, drilling equipment, and pumps contribute the remaining 1,400 tons per year (5 percent).

• Figure 2: Sources of Diesel Particle Emissions in California, 1995



Source: California Air Resources Board, *Emission Inventory 1995, Technical Support Division,* October 1997.

Small particles, such as those in diesel exhaust, are particularly hazardous because they penetrate deeper into the recesses of the lungs, and tend to remain in the lungs and surrounding lymph nodes rather than being cleared efficiently from the body.

Further, a study published by the Health Effects Institute reports that more than 98 percent of the total number of particles in diesel exhaust are less than 1 micron in size.[31] Small particles, such as those in diesel exhaust, are particularly hazardous because they penetrate deeper into the recesses of the lungs, and tend to remain in the lungs and surrounding lymph nodes rather than being cleared efficiently from the body[32] (see Focus #1 below).

The California Air Resources Board in its 1998 draft report on diesel estimated that the average diesel exhaust particle concentration in California outdoor air in 1995 was 2.2 micrograms/cubic meter ($\mu g/m^3$).[33] This estimate averages levels in urban areas and rural areas, giving extra weight to the urban areas to account for the denser population. For example, average outdoor concentrations of diesel exhaust ranged from a low of 0.2 $\mu g/m^3$ in the Great Basin valleys, to a high of 3.6 $\mu g/m^3$ in the South Coast Air Basin.[34] Obviously people are exposed to the actual levels in their particular local environment, rather than the statewide or regional average.

The limited data available on actual measurements (rather than estimates) of diesel exposure show that in cities like Stockton, Fresno and Bakersfield—cities with typically lower truck and bus traffic than more urban areas—sampling from actual sites frequently measured particulate levels from motor vehicles near or above 10 $\mu g/m^3$ (three times the level suggested as a statewide average).[35] A majority of the sites where the Air Resources Board measured particulate levels—and from which it estimated the statewide average diesel exhaust levels—were sites remote from heavy diesel traffic and from businesses that rely on diesel transport. [36]

Other data support a conclusion that the CARB exposure models underestimate actual exposures to diesel exhaust. In a study conducted in Los Angeles in the 1980s, diesel exhaust accounted for approximately 7 percent of the fine particles emitted into the air. Average ambient levels of diesel exhaust particles ranged from 1 to 3 $\mu g/m^3$ in areas with low levels of air pollution. The highest average levels of diesel particles were approximately 10 $\mu g/m^3$ during winter months. Other areas may have it even worse. For example, an estimated 52.8 percent of the airborne particles found in Manhattan's streets come from diesel tailpipes.[37] With total measured particles averaging roughly 50 $\mu g/m^3$ on an annualized basis, that means the diesel exhaust concentration may be as high as 26.4 μg/m^3 - far higher than most American cities.

Short-term or peak exposures to diesel particulate matter, especially in urban settings such as street canyons, are usually higher than monthly or annual average concentrations.[38] For example, researchers have shown that "urban canyons" between high buildings in cities can concentrate diesel exhaust levels to as high as 8.8 μg/m^3 from light-duty diesel vehicles alone.[39] Because the Air Resources Board estimates that 96 percent of California's on-road diesel exhaust particles are emitted by heavy-duty vehicles,[11] we can expect very high concentrations of diesel particles in urban streets where truck and bus traffic is high. In 1998, monitoring conducted by NRDC and the Coalition in such areas confirmed concentrations of diesel exhaust above 50 μg/m^3 for a significant portion of the monitoring period.[40]

According to the Air Resources Board, most people spend more than 22 hours each day indoors.[41] Indoor air contains diesel exhaust at levels which are affected both by outdoor concentrations and by the method of building ventilation. Modern buildings with heating, ventilation and air conditioning (HVAC) systems sometimes have particle filtration systems which can reduce diesel exhaust levels. Buildings with older or less expensive ventilation systems usually lack particle filtration. Where building inhabitants open windows and doors to ventilate the building, indoor diesel exhaust concentrations have been found to be just as high as outdoor levels.[42] If loading docks or garages where diesel trucks may idle are located near an air intake for the building, exposures may be greater than expected indoors, even in a tightly sealed building.

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Focus #1: Particles - Smaller is Worse[43]

The air we breathe contains not only gases, such as oxygen and carbon dioxide, but also numerous small particles, mostly invisible to the naked eye. These particles come from dust, fabrics, plant materials, and numerous sources of anthropogenic (human-made) pollution, such as industrial facilities and motor vehicles. All particles are not created equal. Larger particles, including the majority of naturally occurring particles, don't remain in the air for very long, and rapidly settle to the ground. Finer particles remain suspended in air for far longer, sometimes for weeks, and they can travel in winds hundreds of miles from their sources.

The larger particles don't actually get inhaled deep into the lungs. Instead they are captured by fine hairs and mucus in the nose, throat, and large airways (trachea and bronchi). These particles are then quickly cleared from the body by sneezing, coughing, or swallowing. Clearance occurs in 2-24 hours in healthy people. Small particles, less than about 10 microns in diameter (less than 1/7 the width of a human hair) are more likely to make their way past the upper airways and penetrate into the deeper portions of the lungs. Ultra-tiny particles, such as those in diesel exhaust, are even more likely to find their way into the deepest tissues of the lungs.[*] There the particles need to be cleared by cells of the immune system, a process which takes months or years. Some of the tiny particles are never cleared from the body, but instead accumulate in the lungs and the lymph nodes.[44] Autopsy studies of people living in urban areas show significant blackening of the lungs due to accumulation of fine particles.[45]

[*] By far the largest deposition in the deepest airways occurs for particles between .005 and 2 micron (μ) in size. Calculation by Dale Hattis, Ph.D. based on International Commission on Radiologtical Protection, Human Respiratory Tract Model for Radiological Protection, ICRP Publication 66, Elsevier Science Inc., Tarrytown, N. Y.

The small particles which come from diesel exhaust are particularly dangerous because they are coated with a mixture of chemicals such as polycyclic aromatic hydrocarbons,

Focus #1: Particles - Smaller is Worse (Cont.)

nitroaromatics, benzene, dioxins, and other toxicants. The particles act like a special delivery system which places these toxic chemicals deep within our bodies. Some asthma medications use the principle of delivering a beneficial drug in a fine inhaled aerosol. Diesel exhaust is like a perversion of a drug delivery system which delivers hazardous toxicants into our lungs. The particles are retained in the body along with the toxic chemical hitchhikers which would otherwise be quickly eliminated. Thus the particles lengthen our exposures to the toxicants in diesel exhaust.

HUMAN HEALTH IMPACTS

The scientific evidence is clear: diesel exhaust is a complex mixture comprised of hazardous particles and vapors, some of which are known carcinogens and others probable carcinogens. Diesel exposure poses a significant and avoidable increase in human health risks. Compelling evidence from dozens of well-designed studies supports the conclusion that diesel exhaust causes cancer. In addition, fine particles from diesel exhaust aggravate respiratory illnesses such as bronchitis, emphysema and asthma and are associated with premature deaths from cardio-pulmonary disorders.[9] The evidence of health effects is derived from extensive studies of human workers as well as some studies in animals, and observations of various kinds of mutagenic activity in culture systems. Based on extensive evidence, 41 constituents of diesel exhaust have been listed by the State of California as Toxic Air Contaminants, as shown in Table 1. The only reasonable conclusion one can draw from the massive scientific evidence is that exposure to diesel exhaust significantly increases human health risks.

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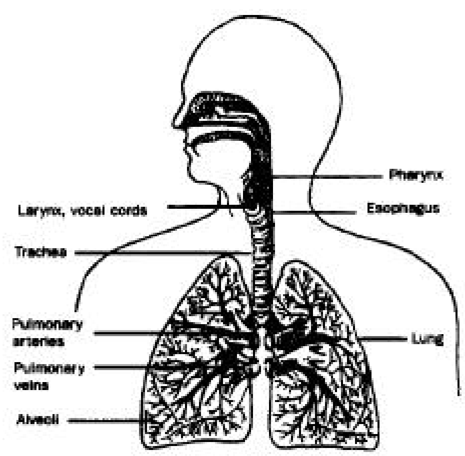
• Figure 3: The Human Airway



Source: Office of Technology Assessment, Identifying and Controlling Pulmonary Toxicants: Background Paper, OTA-BP-PA-91, June 1992.

• Table 1: Substances in Diesel Exhaust Listed by Cal EPA as Toxic Air Contaminants

acetaldehyde	inorganic lead
acrolein	manganese compounds
aniline	mercury compounds
antimony compounds	methanol
arsenic	methyl ethyl ketone
benzene	naphthalene
beryllium compounds	nickel
biphenyl	4-nitrobiphenyl
bis[2-ethylhexyl]phthalate	phenol
1,3-butadiene	phosphorus
cadmium	polycyclic organic matter, including
chlorine	polycyclic aromatic hydrocarbons (PAHs)
chlorobenzene	and their derivatives
chromium compounds	propionaldehyde
cobalt compounds	selenium compounds
cresol isomers	styrene
cyanide compounds	toluene
dibutylphthalate	xylene isomers and mixtures
dioxins and dibenzofurans	o-xylenes
ethyl benzene	m-xylenes
formaldehyde	p-xylenes

Note: California Health and Safety Code section 39655 defines a "toxic air contaminant" as "an air pollutant which may cause or contribute to an increase in mortality or in serious illness, or which may pose a present or potential hazard to human health."

Studies consistently demonstrate that exposure to diesel exhaust for ten years or more does significantly increase the human incidence of lung cancer, and possibly of bladder cancers.

DIESEL EXHAUST AND CANCER: BEYOND A REASONABLE DOUBT

Many studies have shown that diesel exhaust causes mutations in chromosomes and damage to DNA, processes which are believed to be important in the causation of cancer.[10] There is also overwhelming evidence from studies of workers occupationally exposed to diesel exhaust revealing an increased cancer risk. Most of the over two dozen well-designed worker studies found lung cancer increases in those exposed to diesel exhaust for over a decade.[46] Similar increases in risk are found in studies that controlled for cigarette smoking, as in those where information about smoking was unavailable. A recent analysis shows that consistent findings of an approximately 30 percent increase in risk of lung cancer among diesel exposed workers is highly unlikely to be due to chance, confounders (such as smoking), or bias.[47] Unfortunately, many of these studies are limited by imprecise estimates of exposure levels, particularly for occupational exposures that occurred in the past.[*] The

[*] This limitation often means that the studies may underestimate human risk, as when studies designate all workers with any diesel exposure at all to a category of "exposed" workers, despite the fact that many had exposures little if any greater than the average person whose workplace involves no exposure to diesel.

task of studying exposure to diesel exhaust is further complicated by the fact that there is no standard methodology for measurement of exposure, and there is uncertainty about which component or components of diesel exhaust may be most significant in inducing disease.

Despite these difficulties, the occupational studies consistently demonstrate that exposure to diesel exhaust for ten years or more does significantly increase the human incidence of lung cancer, and possibly of bladder cancers. U.S. EPA, Cal EPA, the National Institute of Occupational Safety and Health, and the International Agency for Research on Cancer have all consistently agreed on the relationship between diesel exhaust exposure and lung cancer.[48] Numerous independent analyses of the data by top scientists have come to the same conclusions.[49]

Many animal studies also indicate that inhalation of diesel exhaust causes cancer.[50] The studies primarily found tumors of the lung, but some also noted increased tumors at other sites.[51] However, the relevance of these studies has been questioned since the animals were exposed to very high diesel exhaust levels and the resulting inflammation and cell proliferation does not appear to occur at occupational or ambient diesel exposure levels.

Quantifying the Cancer Risk from Diesel Exhaust

Despite the extensive scientific data available, there is still uncertainty concerning exactly how potent a carcinogen diesel exhaust really is. Dale Hattis, Ph.D., a nationally recognized expert on diesel exhaust from Clark University, performed an independent calculation, based on the Cal EPA draft analysis, that sought to characterize the current uncertainty and estimate the diesel cancer risk.[52] Among a million people exposed chronically to 1 microgram per cubic meter ($\mu g/m^3$) of diesel exhaust, Dr. Hattis's estimated 90 percent confidence range indicates that 34 to 650 people might be expected to develop lung cancer. The average estimate is 230 per million so exposed.[53]

Applying these risk estimates, over a lifetime, exposure to diesel exhaust may cause 12,000 or more *additional cancer cases in California alone.*

Unfortunately, most people are exposed to more than 1 $\mu g/m^3$ of diesel exhaust every day. In fact, the California Air Resources Board estimates that the average total exposure for Californians who spend most of their time indoors is 1.54 $\mu g/m^3$ of diesel exhaust, while the average outdoor air concentration of diesel exhaust in California in 1995 is 2.2 $\mu g/m^3$. These estimates were arrived at by averaging levels in both rural and urban areas.[54] Estimates of diesel exhaust exposure levels in urban areas range as high as 23 $\mu g/m^3$. Chronic exposure at these levels would potentially result in many more lung cancer cases. We expect exposure levels in rural and urban areas throughout the country to be similar to those found in California.

The U.S. EPA suggests that a cancer risk may be “negligible” if a substance induces one excess cancer out of a million people exposed over a lifetime. Using the mean value in Dr. Hattis's uncertainty distribution for diesel exhaust potency, the expectation is that exposure to the average levels of diesel exhaust found in California—of 1.54 $\mu g/m^3$ of diesel exhaust—is likely to result in an excess risk over a person’s lifetime of about 350 cancers per million exposed.[55] This risk is far above U.S. EPA’s “negligible risk” level. Applying these risk estimates, over a lifetime, exposure to diesel exhaust may cause 12,000 *or more* additional cancer cases in California alone.[56] The potential health risks nationally are staggering.

Moreover, these risk estimates are for the "average" person who breathes less than the statewide outdoor average concentration levels of diesel exhaust. People who are exposed to higher than average levels of diesel exhaust, such as urban residents, people living near major roads, distribution centers and other diesel “hot spots,” and occupationally exposed individuals, would have higher risks of lung cancer from diesel. These estimates indicate the magnitude of the task before us in reducing the diesel risk and only hint at the enormous human tragedy due to diesel exposure. Lung cancer has a poor prognosis; the five-year survival rate is less than 14 percent.[57] Thus if 350 excess lung cancers are projected per million people exposed, 300 of these victims would likely die within five years.

Airborne particulate matter smaller than 10 microns in size, also called PM_{10}, are respirable particles, meaning that they can make their way deep into our lungs. Even smaller particles, smaller than 2.5 microns in size ($PM_{2.5}$), are even more likely to lodge and linger in the deepest air sacs of the lung. More than 98 percent of the total number of particles in diesel exhaust are $PM_{2.5}$.[31] PM_{10} has been regulated by the Air Resources Board since 1982 and by U.S. EPA since 1987. However, efforts to control PM_{10} alone will not suffice to reduce diesel exhaust concentrations to safe levels. Because measures of PM_{10} are mass-based, control strategies emphasize reductions of larger, heavier particles, such as those occurring from earth-moving in construction and agriculture, and are unlikely to focus on reducing the $PM_{2.5}$ from diesel combustion. Recognizing the significant risks posed by tiny particles, U.S. EPA adopted new National Ambient Air Quality Standards for particles under 2.5 microns in size, which went into effect on September 16, 1997.[58]

Lung Damage

Recent research indicates that diesel exhaust may increase the frequency and severity of asthma exacerbations and may lead to inflammation of the airways that can cause or worsen asthma.

Great advances have been made in the 1990s in understanding the health effects of fine particles. Since 1987, more than two dozen community health studies have linked respirable particle concentrations below the level of the current air quality standards to reductions in lung function, and increased hospital and emergency room admissions. Long-term exposure has been related to decreases in lung function in both children[59] and adults.[60] Recurrent respiratory illnesses in children are associated with increased particulate exposures, and such a pattern of childhood illness may be a risk factor for later susceptibility to lung damage.[61]

Particulate matter exposure causes changes in lung function and inflammation of the small airways.[62] Furthermore, exposure to acidic particles may cause constriction of the bronchi and impair clearance processes which normally remove particles and infectious organisms from the airways.[63] The consequences may include aggravation of existing respiratory problems, more frequent or severe damage to tissues, or greater loss of lung function.

Infections and Asthma

Particulate exposure may increase susceptibility to bacterial or viral respiratory infections, and may increase the incidence of respiratory disease in vulnerable members of the population, including the elderly, people with chronic pulmonary diseases, and people with immune system dysfunction.[64] In the presence of pre-existing heart or lung disease, respiratory exacerbations induced by air pollutants may lead to death.

Recent research indicates that diesel exhaust may increase the frequency and severity of asthma exacerbations and may lead to inflammation of the airways that can cause or worsen asthma.[65] This information is quite new and extremely important in light of the fact that the incidence of asthma is on the rise, increasing nearly 40 percent among U.S. children between 1981 and 1988.[66] There are an estimated 10.3 million people in the United States with asthma.[67] The death rate from asthma has increased by 118 percent from 1980 to 1993.[68] Asthma occurs far more frequently in African-American and Latino children;[69] indeed, African-American children are four times more likely to die from asthma than white children.[70] Children of Latino mothers have a rate of asthma two-and-a-half times higher than whites and more than one-and-a-half times higher than African-Americans.

Premature Death

In December 1993, Harvard researchers published the results of a sixteen-year-long community health study that tracked the health of 8,000 adults in six U.S. cities with differing levels of air pollution. After adjusting for age and smoking, researchers found that residents of the most polluted city had a 26 percent higher mortality rate than those living in the least polluted city.[71] This translated into a one- to two-year shorter lifespan for residents of the most polluted cities.[72] Another major study corroborated these findings. The study correlated American Cancer Society data on the health of 1.2 million adults with air pollution data in 151 U.S. metropolitan areas. The study found that people living in the most polluted area had a 17 percent greater risk of mortality than people living in the least polluted city.[73]

A number of prestigious international panels, including a British Committee on the Medical Effects of Air Pollutants and a Committee of the Health Council of the Netherlands, have concluded that there is a cause-and-effect relationship between particulate pollution and premature death.[74] Such a conclusion is warranted based on the consistency of the association in different studies and situations, the dose-response relationship, and the biological plausibility.

In 1996, U.S. EPA published a risk assessment focusing on Southeast Los Angeles County. The U.S. EPA estimates over 3,000 excess deaths occur annually due to levels of particle pollution above the current federal standards in this particular area of Los Angeles alone.[75] The federal agency estimated more than 52,000 episodes of respiratory symptoms each year—including about 1,000 hospital admissions—from the particle levels observed in 1995 in Southeast Los Angeles. U.S. EPA estimates more than 40,000 particle-related health effects (including 300 to 700 deaths) would occur in Los Angeles even if the area brought pollution down to the current federal particle standards.

NRDC performed a study entitled *Breath Taking: Premature Mortality Due to Particulate Air Pollution in 239 American Cities*, which was based on the risk relationships identified in the American Cancer Society and Harvard studies. In this study, released in May, 1996, NRDC applied the known risk relationships to a variety of urban areas where particle levels had been adequately monitored. We found that nationally over 50,000 premature deaths per year may be attributable to the existing levels of particles in the air.

We found that nationally over 50,000 premature deaths per year may be attributable to the existing levels of particles in the air.

Other Non-Cancer Impacts

Many of the individual constituents of diesel exhaust are known to produce harmful effects. Benzene, for example, is known to cause disorders of the blood and the blood-forming tissues.[76] Formaldehyde and acetaldehyde can cause irritation of the eyes, nose, and throat.[77] Toluene, lead, cadmium, and mercury are known to cause birth defects and other reproductive problems.[78] Dioxins are toxic to the immune system, interfere with hormone function, and are toxic to reproduction.[79] These non-cancer effects of diesel exhaust components can also be serious and damaging. The extent to which these effects may occur from current exposure levels is unclear.

Focus #2: The "Great" Diesel Invention

In 1892, Rudolf Diesel invented the diesel "compression ignition" engine. A diesel engine operates by introducing air and fuel into the cylinder and compressing it to a point where the temperature is high enough to ignite the fuel without the necessity of a spark plug. This type of compression ignition system produces a significant amount of power and is fuel-efficient and durable.

The use of diesel engines spread throughout the United States and Europe after 1900, ultimately replacing steam-powered engines. Diesel engines operate on fairly inexpensive fuel oils and can withstand heavy loads at relatively low speeds.[80] Conventional gasoline engines were unable to perform as well under heavy load conditions and required more expensive fuel. Due to the heavy weight of the early engines, diesel was used almost exclusively for heavy-duty power generation in marine transportation and to a limited extent in industrial establishments.

The market for diesels broadened due to technological advances in the late 1930s that raised the operating speeds and decreased the engine weight, allowing the use of diesel engines for on-road applications. General Motors developed a two-cycle diesel engine that was suitable for railroad use, and was later adapted to drive trucks and buses. This was the beginning of a dependence on diesel for movement of freight and passengers, which has lasted through this century.

WHO IS MOST AT RISK?

Most of the human studies on the health risks of diesel exhaust looked exclusively at healthy, adult men. To extrapolate from male worker studies to the general population may not adequately protect women, children, and the elderly. Furthermore, worker studies provide little information about health effects in people with chronic illnesses or depressed immune systems. We do know something about the susceptibility of some of these groups from research on the health effects of fine particle pollution.

CHILDREN

During months with peak particulate pollution levels, average hospital admissions for respiratory illness in children nearly tripled.

Children represent the largest subgroup of the population susceptible to the effects of air pollution.[81] Compared with adults, children spend more time outdoors, particularly at midday and during the afternoons when air quality is poorest, and engage in more vigorous physical activity.[82] As a result, children average a higher breathing rate, and receive greater relative doses of any pollutants in the air. At rest, an infant's metabolic rate and air intake is about twice that of an adult.[83] A forty-five pound child inhales over 9,000 liters of air per day.[84]

Children also have narrower airways and their lungs are still developing. Irritation caused by air pollutants that would produce only a slight response in an adult can result in potentially significant obstruction in the airways of a young child.[85] Furthermore, children have more frequent respiratory and other illnesses, perhaps due to incompletely developed immune protection.

Elevated levels of particulate pollution have been linked with an increased incidence of respiratory symptoms in children.[86] In an ongoing study comparing air pollution in six U.S. cities and the respiratory health of individuals living in those cities, the frequencies of coughs, bronchitis, and lower respiratory illnesses in preadolescent children were significantly associated with increased levels of acidic fine particles.[87] Illness and symptom rates were twice as high in the community with the highest air pollution concentrations compared with the community with the lowest concentrations. Rates of chronic cough, bronchitis, and chest illness during one school year were positively associated with particulate pollution.[88] One study suggested that though all children are at risk for increased respiratory symptoms due to particulate pollution, children with preexisting respiratory conditions (wheezing, asthma) are at greater risk.[89] In a diary study of 625 Swiss children between birth and five years of age, respiratory symptoms were associated with particulate concentrations, while the duration of symptoms was associated with levels of nitrogen oxide. Symptoms included coughing, upper respiratory episodes, and breathing difficulty.[90]

Hospital admission for respiratory illness is strongly associated with particulate air pollution and the association is stronger for children than adults. During months with peak particulate pollution levels, average hospital admissions for respiratory illness in children nearly tripled, whereas for adults comparable hospital admissions increased by 44 percent.[91] Several studies have demonstrated that children living near major roadways have poorer lung function than children living in cleaner areas.[92] The same studies showed that girls were more affected than boys. Lung function in both sexes was correlated with estimated levels of diesel exhaust measured in the schools.[93]

THE ELDERLY

Substantial scientific evidence suggests that the elderly and those with pre-existing heart and lung disease are at greatest risk of premature mortality due to particulate air pollution. Several important studies have shown that those over 65 years of age are at greater risk of requiring emergency room services on days with higher particulate pollution.[94] In addition, the relationship between particle exposure and death was about three times greater in the elderly.[95] Because cardio-pulmonary disease is more common in older people, and cardiovascular and pulmonary function declines with age, the elderly are likely to have heightened sensitivity to particle exposure. To the extent that the elderly and chronically ill are slower to remove particles from deep lung tissues, they are likely to have greater risk from diesel exhaust exposure, because the time needed to clear small particles from the lungs appears to increase the risk of tumor development.[96]

EXPOSURES ADD UP OVER A LIFETIME

Exposure to diesel exhaust for nearly every human begins at birth and lasts throughout our lifetime.

Cancers induced by diesel exhaust involve a latency period of a number of years between damaging exposure and development of cancer: risk increases with increasing duration of exposure.[97] Exposure to diesel exhaust for nearly every human begins at birth and lasts throughout our lifetime. Neither animal, nor worker studies on diesel exhaust adequately capture this feature of the general public's exposure. Most of the animal studies involving diesel exhaust inhalation begin exposure with "adolescent" rats.[98] For these reasons, direct extrapolation from traditional animal exposure studies as well as extrapolation from worker studies are likely to underestimate the risk to the public, whose exposure to ambient diesel exhaust begins in early childhood and lasts for many decades.

Focus #3: "Clean Diesel" is Still Dirty

Some industry advocates argue that 1996 model year and later diesel engines using new diesel fuel are "clean diesel" and are not a health threat. However, diesel engines—new and old—continue to pose cancer threats. In fact, recent studies suggest that, despite a substantial reduction in the total weight of particulate matter, the total number of particles in emissions from the more advanced 1991-model diesel engine is 15 to 35 times greater than the number of particles from the 1988 engine when both engines were operated without emission control devices. Thus, newer diesel may be emitting smaller particles but not fewer particles.[99] Furthermore, these smaller particles are more likely to penetrate deeper in the lungs and to be trapped and retained. "Clean diesel" may not decrease risk from diesel exhaust exposure.

In addition, even the "cleaner," post-1996 diesel engines emit more smog forming nitrogen oxides and particulates than comparable alternative fueled engines. Diesel engines certified in 1998 emitted 60 percent more smog forming nitrogen oxides and 50 percent more particulates than similarly sized natural gas engines.[100]

A recent study comparing emissions from a new diesel engine running on older diesel fuel, and on a reformulated diesel fuel (required in California since 1993), revealed that the newer fuel only slightly reduces emissions of nitrogen oxides and particulates, and that more than 95 percent of the particle emissions are very fine (less than 1 micron in size). Dioxins were detected in diesel emissions, both with the older and newer fuel. Finally, levels of toxics such as benzene, toluene, 1,3-butadiene, and polycyclic aromatic hydrocarbons (PAHs) were essentially unchanged by use of the newer diesel fuel.[101]

MINIMAL REGULATION OF DIESEL EXHAUST

"HANDS-OFF" FEDERAL TREATMENT

U.S. EPA has been backpedaling on this program, each year further weakening its provisions. First, in 1994, the U.S. EPA weakened the heavy-duty vehicle emission standard in order to accommodate diesel technology.

While U.S. EPA has regulated the content of diesel fuel and has attempted to require diesel manufacturers to lower emissions from those engines, it has taken a "hands-off" policy toward forcing engine manufacturers to produce engines that run on cleaner fuels. Instead, each of U.S. EPA's federal rule makings has required the industry to push technology further to clean up diesel engines—while not mandating standards that would require a transition to alternative fuels.

An expeditious transition to alternative fuels is exactly what is needed to achieve national air quality goals. New heavy-duty engine standards, which were adopted by U.S. EPA in 1997 for implementation in 2004, reflect U.S. EPA's willingness to prolong the use of diesel engines. These standards are nearly 40 percent more stringent than the levels being achieved by diesel engines today for NO_x, but fail to require reduction of particulates. Diesel engines may have difficulty in meeting the 2004 standards but heavy-duty natural gas engines available today are already being certified at levels better than 2004 standards. U.S. EPA can and must do more to move heavy-duty transportation away from the current dependency on diesel. Their failure to address particulate emissions from diesel engines is especially troubling given the ample evidence that particulates are a major health threat.

Similarly, U.S. EPA must push other major sources of diesel exhaust such as construction and farm equipment to use alternative fuels. Currently proposed standards only moderately reduce emissions from these sources and certainly do not promise increased use of alternative-fuel technologies.

FEDERAL CLEAN FUEL FLEET PROGRAM UNLIKELY TO REALIZE FULL POTENTIAL

U.S. EPA's Clean Fuel Fleet program was implemented as part of the 1990 Clean Air Act Amendments.[102] The program applies to 22 metropolitan areas in non-attainment of the federal ozone or carbon monoxide air quality standards. The program requires the affected regions to mandate the purchase of clean-fuel fleet vehicles by public and private fleet owners operating more than ten vehicles which are centrally-fueled or have that fueling potential. Beginning with the model year 1999, 30 percent of all new purchases by fleets subject to this program are required to be clean-fuel vehicles. For the model year 2000, this clean fuel vehicle purchasing requirement increases to 50 percent, and to 70 percent for model year 2001.

Since 1993, though, the U.S. EPA has been backpedaling on this program, each year further weakening its provisions. First, in 1994, the U.S. EPA weakened the heavy-duty vehicle emission standard in order to accommodate diesel technology. The 1990 Clean Air Act Amendments established a Heavy-Duty Clean Fuel Vehicle Low-Emission Vehicle (combined nonmethane hydrocarbon (NMHC) plus NO_x) standard of 3.15 grams per brake horsepower-hour (g/Bhp-hr) to be implemented in the 1998 model year. In 1994, the U.S. EPA weakened this standard to 3.8 g/Bhp-hr because it determined that the "emission standard of 3.15 g/Bhp-hr is infeasible for clean diesel-fueled engines..." This weakening of the standard to further continued diesel use runs counter to the basic premise of the entire clean fuel program – to push the market toward clean fuel technologies. Indeed, several heavy-duty natural gas engines are currently certified below the more stringent standard.

Second, the U.S. EPA has allowed regions covered by the Clean Fuel Fleet program to "opt out" if they can demonstrate equivalent emission reductions through another program. Sixteen of twenty two regions have done just that. Again, this "opt out" allowance defeats the purpose of the program, which goes well beyond achieving equivalent emission reductions in the twenty two non-attainment regions. The Clean Fuel Fleet program provides an essential opportunity to push cleaner vehicle technology for the entire country. If implemented effectively, the program could take a major step toward commercializing and demonstrating on a large scale the viability of clean fuel technologies. The slight "nudge" generated by implementing this program in the six regions which remain in the program simply doesn't sufficiently advance cleaner vehicle technologies. And third, in another blow to the program, the U.S. EPA has delayed even the weakened standard so that it will first apply to the 1999 model year.

This weakening of the standard to further continued diesel use runs counter to the basic premise of the entire clean fuel program – to push the market toward clean fuel technologies.

• Table 2: Dirty Cities - Many Opt Out of Clean Fuel Fleet Program

Non attainment areas still in the Clean Fuel Fleet Program.	**Non attainment areas which have opted out of the Clean Fuel Fleet Program.**
Atlanta, GA	Baltimore, MD
Baton Rouge, LA	Beaumont-Port Arthur, TX
Chicago-Gary-Lake County, IL-IN-WI	Boston-Lawrence-Worcester, MA-NH
Denver-Boulder, CO	El Paso, TX
Milwaukee-Racine, WI	Greater Connecticut, CT
Washington, DC-MD-VA	Houston-Galveston-Brazoria, TX
	Los Angeles-Anaheim-Riverside, CA
	NYC-Long Island-Northern Jersey, NY-NJ
	Philadelphia-Wilmington-Trenton, PA-NJ-DE-MD
	Providence-Pawtucket-Fall River, RI-MA
	Sacramento, CA
	San Diego, CA
	San Joaquin Valley, CA
	Southeast Desert, CA
	Springfield, MA
	Ventura County, CA

CALIFORNIA ALSO UNWILLING TO PUSH

Unfortunately, the California Air Resources Board (CARB), which has a reputation for pushing cleaner technologies, has been unwilling to go further than the U.S. EPA in moving the heavy-duty diesel truck and equipment industry to cleaner alternatives. This is especially surprising in light of the fact that California needs every ounce of emission reductions which can be identified to achieve health-based air quality standards.

In 1983, the California Legislature enacted A.B. 1807, the Toxic Air Contaminants Hot Spots Law.[103] Under this law, the CARB must determine which substances are "air pollutant[s] which may cause or contribute to an increase in mortality or an increase in serious illness, or which may pose a present or potential hazard to human health".[104] There are a series of exposure and health effects-related criteria which must be satisfied before a substance can be declared a Toxic Air Contaminant (TAC). The process involves a careful review of the available science, public review and comment, and review by an independent panel of scientists. Once a substance is identified as a TAC, the CARB must evaluate the degree of risk and determine whether reductions in exposure are necessary. If such a determination is made, then exposure must be reduced to the lowest level achievable through the best available control technology.

Diesel exhaust entered the TAC designation process in 1989, and has undergone three draft review reports, three public comment periods, and five public workshops or scientific conferences.[105] Due to vigorous opposition from the trucking industry and the engine manufacturers, the process has been extensively delayed. At long last, diesel exhaust is nearing the end of the arduous process. The State of California's Scientific Review Panel unanimously endorsed the listing of diesel exhaust as a TAC on April 22, 1998. The Scientific Review Panel's unanimous decision could have national implications as the U.S. EPA pushes ahead with its own draft report. The listing will be finalized by the CARB early this summer. Listing as a TAC will only begin the long process of actually controlling diesel emissions under California law.

Proposition 65 prohibits exposing any person to carcinogens or reproductive toxicants without prior warning unless the polluter can show that the exposure poses no significant risk.

Focus #4: Proposition 65 - The People's Own Protection

On November 4, 1986, by a two to one margin, California voters approved the "Safe Drinking Water and Toxic Enforcement Act of 1986," more commonly known as Proposition 65. Proposition 65 is founded on two essential principles of good public health. First, the public has a right to know if they are being exposed to dangerous chemicals so they can take action to protect themselves. Second, once a chemical is identified as particularly dangerous, the burden to prove that a particular exposure is insignificant is shifted to the polluter.

The provisions of Proposition 65 are remarkably simple. The law prohibits the discharge of any chemical that is a carcinogen or reproductive toxicant into sources of drinking water except in amounts that the discharger can prove are insignificant.[106] Furthermore, Proposition 65 prohibits exposing any person to carcinogens or reproductive toxicants without prior warning unless the polluter can show that the exposure poses no significant risk.[107]

In order to be subject to Proposition 65, chemicals must first be listed by the Governor as "known to cause cancer" or reproductive harm. In recent years, the Governor has come under intense criticism from public health advocates for unjustifiably delaying listing of numerous reproductive toxicant and carcinogenic chemicals under Proposition 65.[108]

Under California regulations, a chemical poses a "significant risk" of cancer if it poses a risk of more than one additional cancer case out of 100,000 people exposed over their lifetime.[109] To determine a "no significant risk level" for reproductive toxicants it is necessary to first identify the highest dose that does not appear to cause adverse reproductive effects in animal studies, and then divide that dose by a safety factor of one thousand.[110]

The Governor of California listed diesel exhaust as known to cause cancer in 1990.[111] According to NRDC's monitoring, numerous Californians are being exposed to diesel exhaust by individual, identifiable companies at levels that are 10-100 fold higher than the level that would require warnings under Proposition 65. Yet, contrary to the law, these people are not being warned and do not know that they are being subjected to excessive cancer risks. NRDC, the Coalition, and the Environmental Law Foundation intend to target four of the worst diesel offenders in California – and nationwide – by filing the first in a series of lawsuits under Proposition 65 concurrently with release of this report.

• Figure 4: NRDC's Dump Dirty Diesel Campaign Hits the Streets in New York City

NRDC AND THE COALITION'S DUMP DIRTY DIESEL CAMPAIGN

The public typically envisions polluting industries occupying areas remote from where they live. Airborne diesel exhaust particles break through this complacency. In fact many people live near diesel "hot spots" and are impacted by dozens – or hundreds – of heavy-duty diesel trucks or buses passing through their neighborhoods each day. This scenario can be found in thousands of residential communities nationwide which are located near facilities with intensive diesel traffic, such as bus terminals, truck or bus maintenance facilities, and retail distribution centers. Residential communities near busy streets and highways face similar risks.

More than 800 trucks pass through this distribution center—and through local communities—each day.

DIESEL DETECTIVES: NRDC'S INVESTIGATION OF DIESEL "HOTSPOTS"

NRDC intensively investigated more than ten large retail and supermarket distribution centers in California. A closer look at the distribution center for one California supermarket chain, which is fairly typical of distribution centers around the country, will provide a better understanding of the impact this type of facility has on surrounding communities and workers. The distribution center operates seven days a week, 24 hours a day. Large tractor-trailers haul in foods and other goods from around the country; these shipments are unloaded into a warehouse, sorted, divided into smaller shipments, and then transported out of the center aboard company-owned heavy-duty diesel trucks to the local supermarket chains. More than 800 trucks pass through this distribution center—and through local communities—each day. The impact of this truck traffic is multiplied by the trucks' activities, including idling on the street in front of the facility, driving within the center's yard, delivering or picking up goods at the warehouse loading dock, and exiting the same day. The facility is surrounded on two sides by residential neighborhoods.

Workers at the distribution center—both inside and out—are likely to be exposed to diesel exhaust because the building is open to the yard to allow loading and unloading of trucks. Outside the warehouse, workers drive diesel yard tractors to maneuver the trailers filled with goods around the facility, while others direct traffic or serve as security guards. All of these employees are exposed to very high levels of diesel exhaust.

NRDC performed extensive monitoring at the distribution center, including surveillance of the truck traffic, captured on video cameras over a seven day period, 24 hours a day. During a portion of this period an expert on air pollution monitoring designed a protocol and established upwind and downwind air monitoring stations to collect samples of the diesel exhaust coming from truck movement at the facility. Analysis and modeling of the results reveal a plume of particulate pollution attributable to diesel emissions from this facility. The plume extends beyond the margins of the site itself and projects far into the adjoining residential community. Our expert estimates that local residents, like the family whose backyard we used for the monitoring, are exposed on average to 38 percent more diesel exhaust than typical residents in the area upwind from the facility—a highly significant impact. Exposures to the local residents pose an estimated excess risk of lung cancer ranging from 10 to 100 additional cancer cases out of 100,000 people exposed (depending on how close the residents live to the facility). These risks are 10-100 times greater than levels which require warnings under California's Proposition 65.

The workers at this facility and the local residents have a right to know about the health effects of diesel exhaust. Furthermore, there are ways that supermarket distribution centers can greatly reduce their impact on our air. For example, the yard tractors, which are subject to less regulation of emissions due to off-road classification (they are used in and around the facility to transport goods) can be run on alternative fuels such as propane, electricity, or natural gas. The tractor-trailer trucks that make short-range deliveries to the company's local supermarkets can also be switched to run on clean alternative fuels. Since these local delivery trucks contribute substantially to urban air pollution, switching them to clean fuels would benefit many more people than just those surrounding the distribution center. Changing heavy-duty fleets across the country to alternative fuels would greatly reduce the exposure of local communities to high levels of diesel exhaust pollution, particularly in urban areas.

Local residents, like the family whose backyard we used for the monitoring, are exposed on average to 38 percent more diesel exhaust than typical residents in the area upwind from the facility—a highly significant impact.

Focus #5: Environmental Justice: Communities of Color at Risk

While the sources of diesel exhaust differ from site to site, the most significant sources are often concentrated near low-income communities of color. After an intense year-long investigation of diesel exposures in California. NRDC investigators found in a majority of cases that the greatest concentrations of diesel vehicles - at bus depots, distribution centers, and industrial facilities - were typically located in low-income communities and communities of color. This pattern is consistent with numerous studies showing that a higher percentage of environmental hazards are concentrated in such areas.[112]

For example, NRDC has identified a residential community just north of Oakland, California, that is situated next to a large railroad switching yard. The switching yard is used to load and unload freight to and from local businesses and therefore requires many locomotives to run idle for long periods of time. Because of this idling and the concentration of diesel engines in one yard, high levels of diesel exhaust are released into the surrounding community.

The demographic data for this northern California community reveals that 85 percent of the impacted community is African-American, and the median household income is $18,315. Further, 25 percent of the impacted community live below the poverty line. When these demographics are compared to the city’s overall makeup, the difference is disheartening. The city’s population overall is 43.8 percent African-American and only 16.1 percent of the city’s residents live below the poverty line.

Note: Statistics based on 1998 data obtained from city records.

DUMP DIRTY DIESEL CAMPAIGN IN CALIFORNIA

The Natural Resources Defense Council and Coalition for Clean Air embarked last year on a collaborative anti-diesel campaign combining litigation, advocacy, and education about the hazards of diesel, along with information about cleaner alternatives. The initiative is designed to decrease the use of diesel-powered vehicles, with a resultant improvement in air quality. A shift toward cleaner fuels would mean cleaner air and, most importantly, reduced cancer and other health impacts on communities located near major sources of diesel emissions (for example, supermarket distribution centers), which are often located in low-income communities of color.

We are currently working on a multi-part campaign to decrease our dependence on diesel vehicles. This initiative includes:

• Air monitoring in communities near major sources of diesel exhaust to determine the risk posed by these sources to workers and local residents;

• Litigation against major companies that are violating California's Proposition 65 by exposing their workers and/or local communities to levels of diesel exhaust posing a significant risk;

• Education of private companies, public transit agencies and governmental entities about available clean fuel alternatives—and pressuring those entities to switch to cleaner fuels;

• Community outreach to residents near diesel “hot spots” to educate them as to the health problems associated with diesel exhaust and to assist them in taking steps to protect themselves from these serious health threats.

• Figure 5: A Liquified Natural Gas Truck - Cleaner Air for the Future

CHAPTER 6

LIFE AFTER DIESEL: THE ALTERNATIVES

While NRDC and the Coalition are not advocating any particular alternative fuel - we are advocating that public and private fleets reduce their use of diesel to help clean up our air. In addition to providing environmental benefits, switching to cleaner alternative fuels will also help reduce our nation's overwhelming reliance on imported petroleum. No diesel engine on the market can match the emissions reductions of the cleaner alternative fuels in real world conditions. Recent government-sponsored emissions tests of the newest, cleanest diesels have been unimpressive. Natural gas and stored electric power are currently the leading alternative fuel technologies for transit and school buses whereas natural gas technology has been used for most other heavy duty applications.

the CNG engine meets all of the federal and California State standards for the year 2004, whereas diesel engines only meet 1998 federal and State standards

CLEAN ALTERNATIVE FUEL OPTIONS

Natural gas appears to be the best option for heavy-duty applications due to the technology's wide range in horsepower ratings, moderate initial costs when compared with electric options, potential savings in maintenance and operating costs over diesel counterparts, as well as substantial emissions reductions. Based on the emissions calculations in Table 3, the lifetime emissions benefits of operating a compressed natural gas (CNG) transit bus instead of a new diesel transit bus is equal to 15,900 pounds of NO_x, 130 pounds of PM, and 370 pounds of Hydrocarbons (HC). Carbon monoxide emissions from a CNG bus, however, are 11,500 pounds greater when compared to the diesel engine[1], but well below the 2004 federal and California State standards.[113] In fact, the CNG engine meets all of the federal and California State standards for the year 2004, whereas diesel engines only meet 1998 federal and California State standards. The NO_x emissions savings from a bus using CNG rather than diesel would be equivalent to removing 55 passenger cars from the road; PM savings would be equivalent to removing 17 cars from the road.[2] Further, today's natural gas buses

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[1] Assuming a typical urban bus travels 630,000 miles over its 12-year lifetime (based on CARB's MVEI7G mobile source emissions model). These values include estimates of the higher emissions released in a vehicle's latter years because of deterioration. For all engine technologies, however, actual reductions will vary from case to case.

[2] Assuming a typical urban bus travels an average of 52,000 miles per year (CARB's MVEI7G model input), while a car travels roughly 10,600 miles per year (ORNL 1997). Emissions for the average passenger car in calendar year 1998 were calculated based on runs of MVEI7G for the South Coast Air Basin. These estimates are 1.026 g/mi (NO_x) and 0.027 g/mi (PM): CARB MVE17G Version 1.0. October 4, 1996.

are compatible with future hybrid buses, and could be a bridge to the longer-term solution of fuel cell powered buses that run on a renewable hydrogen energy source.

- Table 3. Emissions Comparison of Diesel and CNG Buses

Pollutant	**Certified Emissions[a] (g/bhp-hr)**		**Calculated Emissions[b] (g/mi)**	
	Diesel[c]	*CNG[d]*	*Diesel[c]*	*CNG[d]*
NO_x	4.0	1.4	17.2	5.74
Particulates	0.04	.02	.172	0.082
HC	0.09	0.03	0.387	0.123
CO[e]	0.26	4.1	1.118	9.43[f]
GHG (CO_2-eq)[g]			3,659	3,275

[a] Certified emissions data from CARB's *1998 Model Year Heavy-Duty On-Road Certification Listing*. Values are expressed in grams per brake-horsepower-hour (g/bhp-hr), a measure of the mass emissions released per unit energy consumed by the engine.
[b] Calculated from certified emissions data using CARB conversion factors of 4.3 bhp-hr/mi for diesel engines and 4.1 bhp-hr/mi for CNG (CARB 1996). Data from the US Environmental Protection Agency suggests that applying the same conversion factor for all pollutants is inappropriate and has identified empirically-derived estimates that would widen the gap between CNG and diesel for particulate emissions (U.S. EPA 1992).
[c] Data for a 330 horsepower Cummins M11-330E diesel engine.
[d] Data for a 300 horsepower Cummins L10-300G CNG engine.
[e] Engine certification data for the Cummins C series engine (which has a 15% smaller engine displacement) indicates CO emissions are 0.11 g/bhp-hr, or less than the diesel engine, due to improved oil control compared to the L10 engine shown in the table.
[f] Cummins L10-300G certifies at 4.1 g/bhp-hr which is the value at the end of its useful life (i.e., 290,000mi). The end of life value includes the deterioration factor of 8.54 which means a new engine only emits 0.48 g/bhp-hr. Thus the average emissions value over the engines useful life is 2.3 g/bhp-hr since a typical urban transit bus is rebuilt at the end of its useful life.
[g] Greenhouse gas (GHG) emissions over the entire fuel cycle (fuel production, transmission, and end-use), expressed as carbon-equivalents based on the relative radiative forcing (global warming potential) of key GHGs. Assumes 23.9 MMTC-eq/Quad for diesel fuel and 18.3 MMTC-eq/Quad of CNG (Delucchi 1995) and a fuel economy of 3.3 mpg for an average diesel bus and 2.7 mpg (diesel equivalent) for a CNG bus (CARB 1996). End-use emissions, including both carbon dioxide and methane, are from CARB (1996).

Hybrid-electric technology applications combine an internal combustion engine with electric battery power, resulting in a bus that has the potential to reduce emissions and increase fuel economy. While this technology shows promise in certain vehicle niches, it is still too soon to judge this technology in the transit bus world, and full-scale commercialization remains years away. Also, the environmental benefits will ultimately depend on the fuel and technology of the internal combustion engine. As Table 4 demonstrates, a diesel hybrid bus emits one third more NO_x and three times more particulates than a dedicated CNG bus, putting aside the issue of toxicity. Clearly, a hybrid-electric bus that relies on a CNG engine will be far cleaner than one that relies on a diesel engine.

• Table 4. Test Results for a Diesel Hybrid Prototype v. Dedicated CNG

	Diesel Hybrid Electric[h]	**Compressed Natural Gas**
Nitrogen Oxides (g/mi)	13.82	5.74
Particulates (g/mi)	0.372	0.082

[h] Mark, Jason, et al. *Shifting Gears: Advanced Technologies and Cleaner Fuels for Transit Buses*. Union of Concerned Scientists. April 1998. p. 25.

While battery-powered electric buses offer the greatest air quality benefits at the tailpipe, it seems they are best suited for light- or medium-duty vehicles such as shuttle vans. Electric buses are expensive, have associated power plant emissions, and their limited battery life means limited operating range. But battery technology is advancing rapidly and this technology is likely to play a significant role in the future of transportation. Furthermore, internal combustion engines deteriorate over time causing their emissions to increase, whereas electric vehicles do not experience any deterioration in emissions and in fact become cleaner over time as power plant emissions are reduced.

Fuel cell technologies for transit bus applications are also developing rapidly and may be a major energy source for heavy duty vehicles in the near future. Fuel cells, which are powered by air and hydrogen, would transform heavy duty vehicles to true zero emission vehicles. With its high efficiency and extremely low (and potentially zero) emissions, fuel cells offer enormous promise for use in vehicles, especially for buses and freight trucks. Fuel cell vehicles can rely on either hydrogen canisters or an on-board gas generation system (called a “reformer”) which produces hydrogen from CNG or another fuel. In either case the fuel cell operation produces only heat and pure water as by-products, but reformers do produce small emissions levels. In noise levels, too, the fuel cell is superior: fuel cells operate silently. Far greater efficiency can be achieved with a fuel cell than an internal combustion engine. Fuel cells are being developed for transit bus use, and three prototypes are currently being demonstrated by the Chicago Transit Authority.[114]

Many transit and school bus operators across the country are experiencing both lower emissions and *lower operating costs with natural gas buses.*

Although each of these alternatives deliver significantly lower emissions than the latest model diesel engines, these cleaner alternatives have been hampered by limited engine production, higher initial costs, a limited refueling infrastructure. Inconsistent public policy signals, in the form of either regulatory requirements or incentives, have also delayed the commercialization of these cleaner technologies. The interest level as well as the success of the alternative technologies has varied depending on the application and commitment of the operator but there have been wonderful successes. Many transit and school bus operators across the country are experiencing both lower emissions *and* lower operating costs with natural gas buses. In several regions of the country, transit operators are receiving high praise from the public for the use of quiet, zero-emission, battery-powered electric shuttle buses. And increasingly, heavy-duty truck owners are realizing the benefits of operating alternative fuel vehicles. In the remainder of this chapter, we highlight just a few of the success stories experienced by public and private heavy-duty fleet operations.

Focus #6: Using Incentives to Spur Cleaner Fuels

Many diesel operators are ready to make the move to alternative fuels but lack the funds to cover the incremental cost of alternative fueled vehicles and equipment. Incentive programs, including direct grants or tax credits, can play a significant role by helping to cover a portion of the incremental cost associated with purchasing cleaner vehicles and establishing the necessary fueling infrastructure.

In California, Assembly Member Antonio Villaraigosa and Senator Jim Brulte have introduced legislation to appropriate $50 million: 1) to assist operators of heavy-duty diesel vehicles and equipment to purchase new low-emission vehicles and technologies; 2) to help operators clean-up diesel vehicles and equipment already in use; and 3) to fund the development of a refueling infrastructure to support these cleaner alternative fueled vehicles and equipment.[115]

Separately, the Planning and Conservation League, Natural Resources Defense Council, and Union of Concerned Scientists are proposing a ballot initiative which would distribute some $200 million in tax credits per year for the next 12 years. The tax credits would be available to individuals, businesses and agencies to offset the incremental cost of purchasing new or retrofitting existing vehicles and equipment to achieve emission levels significantly below the levels required by regulation.

While not a replacement for strong regulatory action, incentive programs are an essential element of an expedited transition to cleaner, safer alternative fuel vehicles and equipment.

Lower emissions are attractive to operators because they often can improve employee relations and the company's public image.

ALTERNATIVE-FUEL HEAVY-DUTY TRUCKS MAKE A STRONG SHOWING

In the last few years, an increasing number of companies have started to manufacture natural gas engines with a wide variety of engine models. Heavy-duty truck operators have also shown an increased interest in alternatives to diesel. This change has resulted from a variety of factors, including the improved availability of alternative-fuel engines and trucks, less expensive fuel, lower maintenance costs, and lower emissions. Lower emissions are attractive to operators because they often can improve employee relations and the company's public image.

Currently, natural gas engines are available from most of the major heavy-duty engine manufacturers including: Caterpillar, Cummins, Deere, Mack, and Detroit Diesel. Similarly, natural gas-powered heavy-duty trucks are available from some of the leading truck manufacturers such as Freightliner, Kenworth, Peterbilt and Volvo.[116] Another option is to convert diesel engines to run on a combination of alternative fuels and diesel with a retrofit kit. Power Systems Associates located in Whittier, California, is currently selling a dual-fuel retrofit package, which can be used on Caterpillar heavy-duty engines. The completed conversion is a dual-fuel power train optimized to run simultaneously on both liquefied natural gas and a small percentage of diesel, but can "limp home" solely on diesel if necessary.[117]

CLEAN TRUCK SUCCESS STORIES

Raley's Groceries, Sacramento California

Raley's operates a chain of 87 supermarkets in northern California and northwest Nevada. In April 1997, Raley's purchased eight LNG trucks manufactured by Kenworth. The eight LNG trucks make up about 20% of Raley's total fleet. Each truck operates 16 hours per day, 5 or 6 days per week, with a range of up to 600 miles per fueling.[118] Operating the LNG trucks will reduce Raley's consumption of diesel fuel by approximately 100,000 gallons per year.[119] The Sacramento Metropolitan Air Quality Management District (SMAQMD) estimates that each Raley's LNG engine will produce approximately 60% less pollution than a typical diesel engine. This will result in a NO_x reduction up to 40 tons during the first seven years of operation. The SMAQMD provided $600,000 to fund the construction of the fueling station for Raley's and to help offset the higher cost of the trucks.

An August 1997 article in Fleet Equipment Magazine reported that the drivers who operate the LNG trucks seem satisfied with the rigs. Raley's LNG trucks are painted blue with white puffy clouds. "The intent of the blue trucks was to catch people's eye and let them know we're trying to improve the air quality," said Andreotti, Raley's transportation supervisor. "So far we're accomplishing that."[120]

HEB Grocery Company, Houston Texas[121]

HEB Grocery Company, which operates over 250 Class 8 heavy-duty trucks at three distribution centers in Texas, has been using LNG trucks in their fleet since January 1998. Specifically, the company operates ten LNG trucks at their Houston depot with the Caterpillar dual-fuel C-10 engine.[*] While HEB encountered some initial difficulties with venting of LNG on their trucks,[**] they are making significant progress with this issue. Seven of the trucks are now operating with no difficulties, while three of the vehicles are still venting some fuel. All ten vehicles are operating along normal HEB routes.

Once HEB has had the opportunity to evaluate the in-use performance of these vehicles for a sufficient time, the company intends to convert their entire Houston fleet of 54 trucks to LNG. Company officials have indicated their desire to purchase the additional 44 tractors by the end of 1998. HEB has proceeded with their LNG efforts with no public support to date, principally because public funding at the state level in Texas is available only to public fleets.

Raley's LNG trucks are painted blue with white puffy clouds. "The intent of the blue trucks was to catch people's eye and let them know we're trying to improve the air quality."

United Parcel Service

United Parcel Service (UPS) has been operating natural gas vehicles since 1989 and currently operates the largest private fleet of alternative fuel vehicles in the country. The current fleet includes more than 800 natural gas vehicles and continues to grow. UPS's natural gas vehicles are operating in cities all across the country including: Los Angeles, New York, Atlanta, Dallas, Oklahoma City, and Hartford. UPS also operates large propane fleets in Canada and Mexico.

Though UPS has clearly been a leader in the use of alternative fuels, the company has a large fleet and there is still room for improvement. For example, UPS operates more than 8,000 heavy-duty trucks running on diesel fuel. UPS needs to move aggressively to transition the heavy-duty portion of their fleet to alternative fuels.[122]

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[*] The Caterpillar dual fuel technology utilizes diesel and natural gas simultaneously, using diesel compression to ignite the natural gas. Using diesel ignition obviates the need for spark plugs, and allows these engines to take advantage of diesel efficiencies. While still only used in a few fleets nationally, early tests suggest that this dual fuel technology will allow alternative fuels to penetrate higher horsepower vehicles, and operate more efficiently than dedicated natural gas engines. Moreover, the Caterpillar C-10 was the first engine to be certified to the California Air Resources Board's optional 2.5g/bhp-hr low-NO_x standard, although Cummins has since certified three engine families to this standard (with the L10 actually be certified to the cleanest ever 2.0 g/bhp-hr NO_x).

[**] Since LNG has to be cooled to -260 degrees Fahrenheit, there is always an issue of the fuel increasing in temperature, despite its being stored on vehicles in double steel-lined cylinders. If the temperature does increase, the LNG expands and pressure increases in the cylinder, requiring the venting of the fuel. While natural gas is non-toxic and has a high ignition temperature (meaning low risk of flammability), venting fuel can reduce the cost-effectiveness of natural gas options.

New York City Trash Trucks

In the fall of 1992, six new CNG trash trucks appeared on the streets of New York City. Over the next four years, the trucks accumulated more than 60,000 miles each in regular service in the New York City fleet. The average range of a CNG refuse hauler is about 60 miles in between fueling, as compared to the diesel version which can go as far as 95 miles. In terms of maintenance, the CNG trucks performed above expectations and the Department of Sanitation was delighted with them. The maintenance and repair database accumulated on the CNG trucks showed that they had been only slightly more expensive to maintain that the diesel trucks. In terms of emissions, oxides of nitrogen and carbon monoxide were sometimes less for the CNG trucks and other times less from the diesel trucks (these results were expected given the early CNG engine models used in the pilot program). Particulate matter, however, was cut dramatically by use of CNG – the levels were too low to measure in 6 of 11 tests performed by the National Renewable Energy Laboratory.[123] According to New York City Department of Sanitation Manager Tim Harte, the Department has been pleased with its CNG experience. "Our drivers are satisfied with the horsepower and speed. And the vehicles are quieter and cleaner, there's no diesel knock, and there are no fumes."[124]

CITY BUSES: THE MOSTLY GOOD, THE BAD, AND THE UGLY

Over a dozen fleets have committed to purchase only natural gas buses, including Atlanta, Los Angeles, Cleveland, Toronto, Tacoma, Sacramento, Houston, and the N.Y.C. Department of Transportation.

One way local government can help protect the public from potential diesel exhaust exposures is to power their mass transit fleets with alternative fuels. Of the 3,406 buses built in 1996 for the US Market, 481 run on alternative fuels, and roughly one-fifth of the buses currently on order will be powered by natural gas, propane, electricity, or hydrogen.[125] Probably the greatest success in alternative fuel transit buses has come with compressed natural gas (CNG) and, to a lesser extent, liquefied natural gas (LNG). Nearly 1,000 natural gas buses now operate in cities around the United States.[126] Among the transit agencies that have reported major CNG successes are Pierce Transit in Tacoma, WA; RTD in Sacramento, CA; Los Angeles County Metropolitan Transportation Authority in Los Angeles, CA, and Sunline Transit in Palm Desert, CA.[127] NRDC's own "Dump Dirty Diesel" Campaign in New York has succeeded in convincing New York's transit agencies to significantly shift their bus purchases from diesel to CNG. In the next few years, nearly 1,000 CNG and other clean-fuel buses will replace New York City's dirty diesels.

As mentioned above, zero-emission fuel cell technology holds great promise for a variety of heavy-duty applications beyond municipal transit buses. Though these buses are not yet available on the market, the world's largest bus manufacturer, Daimler Benz, is poised to mass produce them near the turn of the century. Chicago Transit Authority already has three fuel cell buses in operation powered by hydrogen, and Vancouver will be starting a demonstration project with three fuel cell buses later this year.[128]

The promise of fuel cells should not stop transit officials from purchasing the cleanest buses available today. Buses purchased this year will likely be on the road for more than 12 years. Transit agencies need to move now to purchase low polluting natural gas buses instead of diesel. Fortunately, over a dozen fleets have committed to purchase only natural gas buses, including Atlanta, Los Angeles, Cleveland, Toronto, Tacoma, Sacramento, Houston, and the N.Y.C. Department of Transportation. Once in place, the natural gas infrastructure can provide a bridge to the zero-polluting hydrogen fuel cell buses of the future.

Focus # 7: Dumping Dirty Diesels in New York City

New York City is the nation's transit bus capital, with two of the nation's ten largest transit fleets - the Metropolitan Transportation Authority (MTA) operates a 3,500-bus fleet and the New York City Department of Transportation (NYC DOT) runs a 1,200-bus fleet. The New Jersey Transit shuttles, private tour buses, school buses, intercity buses, and trucks also add to the diesel mix. It is no wonder that New York City is the diesel emissions capital of the United States.

The New York State Department of Environmental Conservation estimates that 52.8 percent of the airborne particles found in Manhattan's street canyons come from diesel tailpipes.[129] With particle concentrations averaging roughly 50 $\mu g/m^3$ on an annualized basis, the diesel exhaust concentration may be as high as 26.4 $\mu g/m^3$ - far higher than most American cities. The health impacts of this concentration of diesel exhaust are potentially immense - over 4,000 premature deaths annually,[130] and approximately 6,100 cancer cases per million people exposed over a lifetime.[131] Low-income communities and communities of color in northern Manhattan bear the brunt of the MTA's diesel bus fleet. Six of the MTA's seven Manhattan depots are in communities like Harlem and Washington Heights which sustain asthma rates that are 3-5 times the City average and among the highest in the nation.[132]

Thankfully, New York has begun an effort to clean-up its fleet. In 1996-1997, MTA committed to converting three of its diesel bus depots to natural gas and to purchasing at least 500 clean-fuel buses over a five-year period. The NYC DOT fleet also added a bus order that could result in nearly 400 more natural gas buses with an option to buy an additional 176 buses. Each of these purchases will add to the approximately 100 natural gas buses that are already in service. But, while MTA's clean-fuel bus program is making an exciting turn-around, New Yorkers cannot breathe easy yet.

First, MTA has rejected calls to commit to clean fuels, and even proposed adding nearly 600 more diesel buses to its 5-year purchase plan. Second, despite significant progress in constructing natural gas programs for Brooklyn and the Bronx, MTA has dropped the ball on its commitment to build a Manhattan depot of approximately 200 natural gas buses. MTA's promised 1997 date for selecting the depot site has passed and its construction target of 1999 has been pushed back to 2001. To make matters worse, MTA recently closed one of its Bronx depots and plans to move those 200+ diesel buses to northern Manhattan, pushing those diesel emissions into the State's only PM_{10} nonattainment area.

Third, MTA continues to cling to the fantasy that "cleaner diesel" is a possible answer to their pollution problem. MTA is investing heavily in a diesel-fueled hybrid-electric bus program starting with 10 demonstration buses. While NRDC is encouraged by the improved efficiency and emissions reduction potential of hybrid-electric systems, we are concerned that a diesel hybrid-electric bus will only prolong New York's dependence on diesel.

MTA must build on the past two years of progress and fulfill its potential to become the clean-fuel bus capital. NRDC's Dump Dirty Diesel Campaign is committed to insuring that this happens. We urge MTA to take three immediate steps: First, MTA must commit fully to phase out its diesel buses in favor of cleaner alternatives. Second, MTA must re-commit to its original plan and timeline for converting a 200-bus depot in northern Manhattan to natural gas. Third, MTA must abandon its efforts to use so called "clean diesel" to meet the air quality and public health needs of New York City. These critical steps will help make New York City's air healthier.

Six of the MTA's seven Manhattan depots are in communities like Harlem and Washington Heights which sustain asthma rates that are 3-5 times the City average and among the highest in the nation

ALTERNATIVE-FUEL TRANSIT BUSES HIT THE ROAD

The market for alternative fuel transit buses has been developing for a decade and is very competitive. At least five manufacturers are selling the standard forty-foot transit buses configured to run on CNG or LNG. The manufacturers include New Flyer, Neoplan, Orion, North American Bus Industries (NABI) and NOVA. Most of the natural gas buses on the road or for sale today are powered by Cummins L10 or Detroit Diesel Series 50 engines, but recently John Deere has begun offering a CNG engine to compete in this growing market.

In the transit shuttle market, battery power is making the most progress among low-emission technologies. Santa Barbara, California and Chattanooga, Tennessee have had several years of success operating electric buses. Recently cities such as Santa Monica, CA have also begun operating electric shuttle buses. The Department of Energy's Heavy Vehicle and Engine Resource Guide (January 1998) lists more than 10 battery-powered electric bus models currently available for sale in the United States.

CLEAN TRANSIT SUCCESS STORIES

"We believe we're enhancing our community's quality of life with cleaner air. Environmentally, CNG is simply the right thing to do."

SunLine Transit Agency, Thousand Palms California

SunLine Transit Agency, a relatively small public transit property located in Thousand Palms, California, operated the second oldest fleet in the nation in 1992. The condition of the fleet was so bad, that SunLine management had a saying, "Old buses don't die –they come to SunLine!"[133] SunLine's breakdown reputation finally compelled the board of directors to order a replacement of SunLine's fleet, but this time with alternative fuel vehicles. After sending management to Canada, Washington, DC, and Sacramento to collect research and talk to experienced alternative fuel operators, SunLine chose to power its fleet with compressed natural gas. SunLine received over $2 million from the Federal Transit Administration's Section 3 money, was awarded a $12 million procurement from local funding, partnered up with the Southern California Gas Company to develop a refueling station, and convinced a local community college to train its mechanics. In under 2 years, Sunline became the first transit agency in the nation to convert 100% of its fleet to CNG. According to a 1995 source, SunLine Transit covers an area approximately 58 miles long by 7 miles wide, transports 8,000 passengers per week day, and has logged over 63,000 annual miles per bus.[134] Not only is SunLine's management happy with the fewer maintenance problems experienced with CNG in comparison to diesel and the lower fuel costs incurred, SunLine's general manager, Richard Cromwell III, concludes, "We believe we're enhancing our community's quality of life with cleaner air. Environmentally, CNG is simply the right thing to do."[135]

Sacramento Regional Transit District, Sacramento California

The Sacramento Regional Transit District has a long and extensive history using compressed natural gas transit buses in their operations. Their first CNG buses went into operation in 1993, and these buses have logged an average of 270,000 miles. While most of the agency's diesel fleet requires engine overhauls at 200,000 - 250,000 miles, the natural gas buses have not needed overhauls as yet and city officials hope to reach 300,000 (or more) miles before such overhauls are needed for their CNG buses. The RTD presently operates 136 Orion

CNG buses with Cummins L10 engines out of a total fleet of 210, and intends to purchase 18 new CNG buses (twelve full-size and six 22-foot shuttles) in their next fiscal cycle. Sacramento RTD intends to convert their entire fleet to run on natural gas as soon as funding is available.

Not only are these buses much cleaner than their diesel counterparts, but they are much cheaper to operate as well. During the period from July 1, 1997 through March 31, 1998, the agency's CNG buses logged 4,594,009 miles compared with 1,801,411 for their diesel fleet.[136] The agency estimates the total operational cost of their CNG buses for this period was approximately $.39 per mile, compared with $.47 for their diesel buses. Mark Lonergan, Assistant to the Chief Operating Officer, noted that the most telling thing about the agency's CNG buses is that they often go unnoticed, primarily because there is virtually no exhaust from these buses.

Pierce Transit, Tacoma Washington

Pierce Transit, based in Tacoma, Washington, began its CNG experience as far back in 1985 when it decided to test the alternative technology for its servicing needs. Ten years, a new facility and 58 CNG buses later, CNG is no longer a novelty; it's business as usual. Pierce Transit's operations cover an area of 450 square miles and a population of approximately 600,000 residents.[137] The agency serves both rural and urban areas, including an express route to Seattle which operates exclusively on CNG. Maintenance costs for Pierce's CNG fleets are only slightly higher for CNG over diesel – by about 8 percent. However, fuel costs for CNG are lower than diesel. Reliability of the CNG and diesel fleets were identical based on the number of road calls per 1,000 miles and usage comparisons. Currently Pierce reports that it pays $30,000 to $50,000 more for a CNG bus than for its diesel counterpart, but this incremental cost is likely to change as both technology and economies of scale improve, and as Federal and state environmental regulatory agencies place increasingly stringent environmental standards on diesel engines. Ron Shipley, Pierce Transit's Director of Maintenance, notes, "If you think you're going to be in business 10 years from now, you should be looking at some other way to do business (other than diesel) that provides fuel price stability and availability as well as environmental improvements."[138] By 2003, Pierce Transit plans to power all of its buses by CNG engines.

Los Angeles County and Orange County Transportation Authorities

The Los Angeles County Metropolitan Transportation Authority (LACMTA) is one of the country's leaders in operating alternative fuel buses. In 1993, the LACMTA Board adopted an Alternative Fuel Initiative policy, committing to purchase only clean alternative-fueled buses. Today, LACMTA is operating 420 CNG buses in a fleet of 2,160 buses. The transit agency has 400 CNG buses on order and is about to request bids for 215 more. LACMTA has four CNG refueling stations in operation and will have two more completed by early 1999.

Until recently, LACMTA had been operating approximately 320 buses on alcohol fuels -- ethanol and methanol. Unfortunately the agency's excellent record on purchasing new clean buses is tarnished by its recent decision to convert approximately 125 of its alcohol buses to diesel in response to some operational problems. LACMTA staff have indicated that the agency will probably continue to operate 100-150 buses on methanol and approximately 50 buses on ethanol.

In February 1998, neighboring Orange County Transportation Authority (OCTA) approved the purchase of 186 liquefied natural gas (LNG) buses to be delivered over the next three years. The OCTA plans to phase out diesel fuel buses from its fleet by the year 2010.[139]

Focus #8: Foggy Reasoning Plagues San Francisco Muni

Unfortunately, the San Francisco Municipal Railway (Muni), a transit authority that has a great opportunity to improve the Bay Area's air quality by replacing its aging diesel fleet with alternative fuels, has been sluggish to move away from diesel. Transit agencies are both a mobile and stationary source for diesel exhaust. For example, Muni maintains three diesel bus yards and a maintenance facility in and around low income residential areas. Muni defends its recent purchase of 280 new diesel buses by saying that it has done enough to provide environmentally cleaner public transportation by electric bus and rail, and that emission levels from the new "clean diesel" buses are "equal to that of compressed natural gas and meet 1998 U.S. EPA regulations."[140] However, as we note above, this view is mistaken and, in fact, so called "clean diesel" buses are more than twice as polluting as their CNG equivalents and pose high cancer risks. Although Muni's electric fleet does deserve praise, the transit authority has missed the bus on diesel emissions. Transit authorities, like Muni, need to use the alternative fuel options available and eliminate the use of diesel.

Although Muni's electric fleet does deserve praise, the transit authority has missed the bus on diesel emissions

CLEAN BUSES FOR KIDS

In light of children's heightened vulnerability to diesel exhaust pollution, the transition to cleaner alternative fuels seems especially appropriate for the legions of school buses providing daily transportation for millions of our children. Although the vast majority of school buses remain dependent on diesel engines, an increasing number of school bus fleet managers are discovering the benefits--both environmental and economic—of alternative fuels. Compressed natural gas seems to hold the greatest promise for alternative fuel school bus applications in the near term.

Natural gas school buses are currently available from major manufacturers including Blue Bird, Thomas and Navistar. Manufacturers of natural gas engines include Cummins, Detroit Diesel and John Deere. Blue Bird and Thomas also offer battery-powered electric school buses.

Antelope Valley Schools Transportation Agency, Lancaster California[141]

Located roughly 60 miles northeast of Los Angeles, the Antelope Valley Schools Transportation Agency (AVSTA) operates a fleet of school buses and special-education vans that transport students in four school districts covering 1,700 square miles. In the early 1990's, AVSTA accumulated several thousand dollars in fines for violating strict California vehicle emissions regulations. In 1992, Ken McCoy, AVSTA's Chief Executive Officer, found alternative fuels to offer a solution to this problem. McCoy combined grants from the California Energy Commission, the South Coast Air Quality Management District, SoCal Gas, and others to purchase an alternative fuel school bus fleet and build on-site fueling stations. AVSTA now operates 31 CNG buses and 16 methanol buses which have significantly reduced emissions from the fleet. McCoy vests the most confidence in his CNG buses, stating: "If I were choosing fuel, it would be CNG only, based on the bottom line."

Lower Marion School District, Ardmore Pennsylvania[142]

Michael Andre, Supervisor of Pupil Transportation for the Lower Marion School District (LMSD), located in Ardmore, PA (a Philadelphia suburb), reports that his CNG school buses are safe, clean, quiet, and dependable. LMSD operates a fleet of 81 school buses, 27 of which are powered by CNG. In 1993, LMSD decided to switch from diesel to CNG power in response to community concerns about the noise and pollution generated by the District's diesel school bus fleet, which is housed in a facility located in a quiet, residential neighborhood. After investigating several alternative fuels, LMSD determined that CNG offered the best combination of economic feasibility and pollution reduction. The District used State grants to purchase the CNG buses. The buses have demonstrated, through years of service, that they are dependable and safe. Mr. Andre emphasizes his CNG buses' emissions reductions compared to their diesel counterparts: NO_x reduced by 87 percent, PM virtually eliminated, carbon monoxide (CO) reduced by 69 percent; non-methane organic gases reduced by 87 percent; and carbon dioxide reduced by 20 percent.

LMSD decided to switch from diesel to CNG power in response to community concerns about the noise and pollution generated by the District's diesel school bus fleet

CONCLUSION AND RECOMMENDATIONS

Our nation's dependence on diesel must be reassessed in light of growing scientific evidence that diesel exhaust poses a major health hazard, particularly to children and the elderly. Diesel emissions are comprised of a witch's brew of potent carcinogens, reproductive toxicants, irritants, and other hazardous chemicals. This complex mixture of fine particles and toxic chemicals has been linked to cancer, asthma and other respiratory exacerbations, and premature death. Fortunately, alternatives such as electric, natural gas, and other less polluting fuels are technologically feasible and, in some cases, economically advantageous. The move away from diesel to clean alternatives will take a concerted effort by public and private operators and continued pressure from the people most affected by the health impacts of diesel exhaust.

Diesel emissions are comprised of a witch's brew of potent carcinogens, reproductive toxicants, irritants, and other hazardous chemicals.

We strongly recommend the following as an antidote to our nation's dependence on diesel:

- U.S. EPA and CARB must end their "hands off" diesel policy immediately and act quickly to set new stringent standards for heavy duty trucks, buses, trains, marine vessels, construction and agricultural equipment and other diesel vehicles and equipment to expedite the transition toward cleaner alternative fuel vehicles;
- U.S. EPA should apply the Clean Fuel Fleet purchasing requirements of 30, 50 and 70 percent to *all* centrally-fueled fleets with ten or more vehicles. In this effort, U.S. EPA must not be handcuffed by the inability of diesel technology to meet stringent emission standards and should not allow regions to opt out of this critical program;
- Legislative and municipal bodies should provide financial incentives to operators of diesel vehicles and equipment to encourage them to purchase new alternative fuel vehicles or to retrofit their existing diesel vehicles;
- Public transit agencies and governmental entities should lead the way toward clean fuel vehicles by committing to purchase only alternative fuel buses and other vehicles for their fleets; and
- Private fleet operators should take a major step to protect their workers and local communities by immediately beginning to purchase alternative fuel heavy duty trucks, buses and equipment as part of their fleet.

With a lot of determination, we can make the transition away from the toxic technology of diesel to cleaner fuels. Until then, the health of our urban communities lies in the balance.

ENDNOTES

[1] For a complete list, see Krieger, et al., Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Part A: Exposure Assessment. Technical Support Document, Public Comment And SRP Version [hereinafter referred to as ARB, Draft Diesel Exposure Assessment], February 1998, Appendix A; Health effects of diesel exhaust constituents discussed in eg. Rosenstock L, and Cullen M (eds.), Textbook of Clinical Occupational and Environmental Medicine, WB Saunders Co., Philadelphia, 1994. p. 778; Paul M (ed.), Occupational and Environmental Reproductive Hazards: A Guide for Clinicians, Williams and Wilkins, Philadelphia, 1993. pp. 234-248, 273-4; Birnbaum L, Developmental Effects of Dioxins and Related Endocrine Disrupting Chemicals, Toxicol Lett, 82/83: 743-750, 1995.

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[12] American Automobile Manufacturers Association. 1997. Motor Vehicles Facts & Figures 1997. Detroit, Michigan. p. 40.

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