Smokestacks on Rails

GETTING CLEAN AIR SOLUTIONS FOR LOCOMOTIVES ON TRACK

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ENVIRONMENTAL DEFENSE

finding the ways that work

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Environmental Defense does not endorse any particular air pollution control technology or method. This report factually describes air pollution control technologies and methods based on published reports.

Our mission
Environmental Defense is dedicated to protecting the environmental rights of all people, including the right to clean air, clean water, healthy food and flourishing ecosystems. Guided by science, we work to create practical solutions that win lasting political, economic and social support because they are nonpartisan, cost-effective and fair.

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Contents

Executive summary

Trains play a vital role in American commerce. Every year, they move billions of tons of freight and millions of people throughout the nation. However, they also deliver pollution, contributing significantly to air quality problems across the country. Many of today's locomotives are powered by high-polluting diesel engines. Diesel exhaust is made up of:

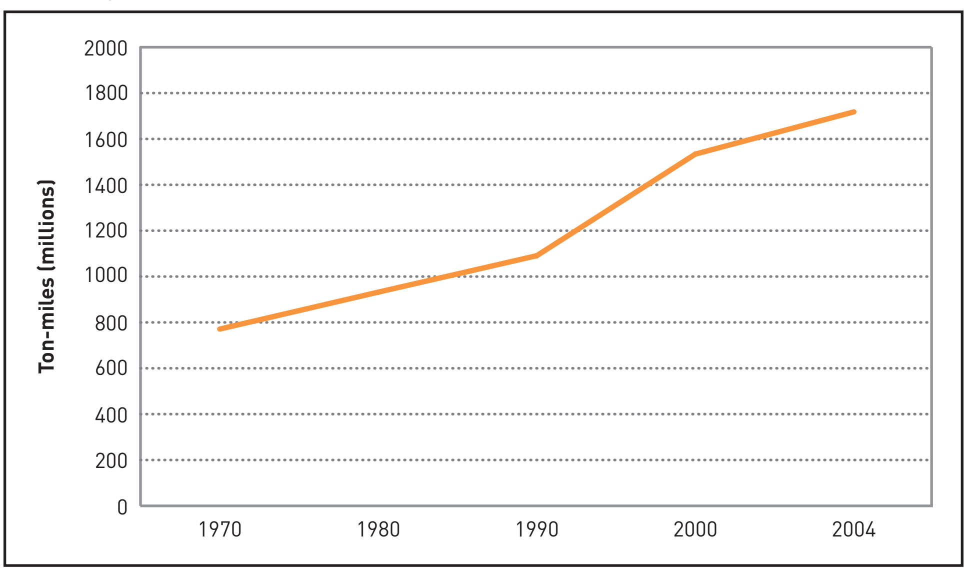
- particulate matter (PM), implicated in a host of respiratory problems and tens of thousands of premature deaths every year;
- smog-forming oxides of nitrogen (NO_x);
- sulfur dioxide (SO_2), which forms harmful particulate pollution and falls back to earth as acid rain;
- a noxious brew of toxic chemicals that together pose a cancer risk greater than that of any other air pollutant; and
- greenhouse gases that contribute to global warming.

In 2004, the U.S. Environmental Protection Agency (EPA) repeatedly committed to strengthen federal clean air standards for locomotives. Indeed, EPA publicly announced plans to issue proposed national emission standards in 2005 and to finalize those standards by mid-2006. But EPA has failed to act. This report documents the serious health impacts associated with each year of delay in federal action to clean up these smokestacks on rails.

Diesel locomotive emissions pollute our air and harm public health

The use of these dirty diesel locomotive engines to transport freight has risen dramatically in the past 35 years from nearly 800 million ton-miles in 1970 to more than 1.6 billion ton-miles in 2004 (see Figure 1), and is projected to continue at a brisk pace. In fact, the

FIGURE 1
U.S. freight rail in ton-miles 1970–2004



Source: Bureau of Transportation Statistics, Table 1-46a: U.S. Ton-Miles of Freight. http://www.bts.gov/publications/national_transportation_statistics/html/table_01_46a.html.

TABLE 1
Smog-forming emissions from locomotives in six major cities and comparable number of today's new automobiles[a]

Urban area	Locomotive NO_x emissions (tons/year)	Equivalent number of automobiles[b]
Los Angeles[c]	12,000	13,000,000
Dallas-Fort Worth	4,500	4,900,000
Houston-Galveston	6,500	7,000,000
Chicago	23,000	25,000,000
Detroit	2,100	2,300,000
Baltimore	2,600	2,800,000

[a] Emissions data for Houston and Dallas is from 2002. Emissions data from the other cities is from 2003.

[b] Calculations based on Tier 2 NO_x emissions standard (0.07gNO_x/mile) for highway vehicles and 12,000 vehicle miles/year. Bureau of Automotive Repair, Engineering and Research Branch, State of California, "Methodology for Calculating Vehicle Miles Traveled (VMT)", September 30, 2000, Report 2000-06, available at http://www.epa.gov/otaq/regs/im/vmt.pdf

[c] Emissions data is for the South Coast Air Quality Management District

EPA estimates that locomotives will release 930,000 tons of smog-forming NO_x this year, comparable to 120 coal-fired power plants.

amount of freight carried by rail is expected to increase by another 50% by 2030. Currently, locomotives move about 42% of our nation's freight as measured in ton-miles.

As a result, these diesel engines contribute significantly to national air pollution. EPA estimates that in 2006 locomotives will emit 930,000 tons of ozone-forming oxides of nitrogen (NO_x)—as much as 120 coal-fired power plants. Locomotives are also responsible for more than 32,000 tons of particulate pollution; these particles, which can be inhaled deep into the lungs, are probable carcinogens. The particulate pollution from locomotives is comparable to the emissions from more than 70 coal-fired power plants.[1]

Table 1 takes a closer look at the smog-forming pollution from locomotive engines in six major U.S. cities hard hit by ground-level ozone. The extensive locomotive NO_x pollution levels in these communities are compared with automobiles, based on the smog limits in effect for today's new motor vehicles.

Using EPA's methodology, Environmental Defense estimates that the 2006 particulate and NO_x emissions from locomotives will be associated with more than 3,000 premature deaths this year (Table 2).[2] Exposure to this pollution may also contribute to, among other health effects, more than 4,000 non-fatal heart attacks, approximately 61,000 cases of acute bronchitis and exacerbated asthma in children, and nearly 290,000 lost workdays. The economic impact of these adverse health effects will total over $23 billion this year.

TABLE 2
Adverse health effects associated with 2006 locomotive pollution

Premature deaths	3,400
Non-fatal heart attacks	4,400
Acute bronchitis and asthma exacerbations in children	61,000
Lost work days	290,000
Total economic impact of adverse health effects	$23.2 billion

Delays in EPA action or weak standards will impose a heavy burden on human health.

Each year of EPA delay has serious health effects

EPA has found that locomotive diesel engines can be designed to use the same high-efficiency exhaust emission controls now being developed for large highway and nonroad diesel engines. These technologies will allow locomotive engines to reduce NO_x and particulate matter emissions by 90%. In 2004, when EPA publicly announced a new initiative to strengthen pollution controls for locomotives, EPA also indicated new clean air standards could be implemented beginning in 2011.

Table 3 shows the estimated health benefits in the year 2030 associated with implementing new locomotive emission standards that are 90%, 75% or 50% more protective than today's tightest standard (Tier 2).[3] Our analysis indicates a 90% reduction implemented in a 2011 compliance schedule would annually prevent over 2,000 premature deaths, approximately 2,600 non-fatal heart attacks, 36,000 bronchitis and asthma exacerbations, and nearly 170,000 lost work days and would realize more than $13 billion in health benefits by 2030.[4]

By comparison, Table 3 also shows that considerably lower health protections are realized from slower and less protective federal standards. For example, standards to limit locomotive pollution from new engines by 50% beginning in 2013 would, upon advanced implementation in 2030, allow an estimated 900 more deaths, 1,200 more non-fatal heart attacks, 16,000 more cases of bronchitis and asthma exacerbations, and about 75,000 lost work days over rigorous standards that take effect in 2011. They would forego some $6 billion in health benefits annually. In short, our analysis demonstrates that delays in EPA action or weak standards will impose a heavy burden on human health.

Clean air solutions are on track today

States and localities across the United States are working to meet national health-based air quality standards for ozone and particulates—a problem to which locomotive pollution is a major contributor. And science points overwhelmingly to the need for more protective national standards for particulates and

TABLE 3

Projected health benefits in 2030 with stricter NO_x and $PM_{2.5}$ locomotive emissions standards

Percentage cleaner than current Tier 2 standards	Year new standards would take effect	Annual health benefits in billions of dollars	Premature deaths avoided annually	Non-fatal heart attacks avoided annually	Respiratory hospital visits avoided annually	Children's bronchitis and asthma exacerbations avoided annually	Work loss days avoided annually
90%	2011	13.7	2,000	2,600	870	36,000	170,000
	2013	12.5	1,800	2,400	800	33,000	150,000
	2015	11.3	1,700	2,100	720	30,000	140,000
75%	2011	11.7	1,700	2,200	750	31,000	140,000
	2013	10.7	1,600	2,000	680	28,000	130,000
	2015	9.7	1,400	1,800	620	25,000	120,000
50%	2011	8.3	1,200	1,600	530	22,000	100,000
	2013	7.7	1,100	1,400	490	20,000	95,000
	2015	7.0	1,000	1,300	450	18,000	87,000

ozone and the imperative for greater progress in communities across the country in safeguarding human health.

The good news is the foundation for cleaner locomotives is at hand. Ultra low sulfur diesel fuel is being delivered to pumps across America today. Lower sulfur levels enable the state of the art technologies that can significantly reduce the level of pollution coming from these engines. Indeed, manufacturers have been developing technologies to reduce locomotive emissions. For example, hybrid switcher engines, called Green Goats, use a combination of rechargeable batteries and a low-emissions diesel engine to cut emissions by 80–90% and reduce fuel use by 40–70%. And to reduce idling, various technologies have been introduced, including auxiliary power units, which keep engines warm while they are turned off.

Furthermore, communities across the country have set up pilot projects to curb locomotive emissions and reduce fuel consumption. For example, in Chicago an anti-idling project saved over 14,000 gallons of fuel and in Texas, more than a dozen hybrid-diesel Green Goat trains have been deployed. While these voluntary pilot programs play an important role in incubating new technologies, they are often limited in scope.

National leadership is essential to clean up the smokestacks on rails

Environmental Defense calls on EPA to fulfill its public commitment to strengthen the nation's clean air standards for these smokestacks on rails. The demands on the nation's freight system have steadily risen over the past 35 years. At the same time, hauling freight by rail is more efficient than truck transport. Timely cleanup of the nation's fleet of locomotive engines could help clear the way for extensive human health and environmental benefits by lowering soot, smog and global warming pollution while also reducing highway and roadway congestion. Federal leadership is essential to keep these far-reaching clean air solutions for locomotive engines on the right track.

Introduction

Locomotives perform many vital tasks in our busy society. Passenger trains, such as Amtrak, usher people from city to city and coast to coast. Freight carriers, like Union Pacific and Burlington Northern Santa Fe, haul cargo long distances. Line-haul freight trains transport containers full of merchandise, food and other cargo between ports and inland cities. Specialized trains called switchers assemble and disassemble other trains and transfer freight between ships, line-haul trains and trucks. However, as crucial as locomotives are to our economic health, they also present a significant threat to public health and the environment.

While some commuter rail is electric, many locomotives are powered by diesel engines. Exposure to diesel pollution is associated with a wide range of adverse health effects including cancer, neurological damage, a weakened immune system, respiratory disease and cardiovascular disease.[5] Diesel particulate matter (PM) is especially harmful and can lead to premature death. In addition, diesel engines emit smog-forming oxides of nitrogen (NO_x) that contribute to unhealthy ozone levels and more than 40 toxic compounds, and large quantities of global warming pollutants.

Many cities already suffering from unhealthy levels of air pollution are finding that locomotives are a significant contributor to that pollution. A few, including Chicago and Houston, have taken steps to reduce those emissions in the absence of protective federal standards. Successful programs help fund the implementation of new technologies like hybrid "Green Goat" engines and anti-idling devices. While voluntary programs play an important role in incubating new technologies and demonstrating the feasibility and effectiveness of emissions controls, they are often limited in scope. These types of programs are too beneficial and important not to implement nationally.

Diesel freight locomotives.

Without comprehensive federal emission standards for locomotives, state and local leaders have limited means to achieve needed pollution reductions in their communities. In fact, while many other diesel powered motor vehicles, including heavy duty trucks and buses, farm, construction, mining and industrial equipment are subject to advanced federal emissions standards that help protect public health from the deleterious effects of diesel exhaust, locomotives are not yet subject to today's rigorous standards and continue to be a threat to public health across the nation.

Because of the long life of a train engine, often up to 40 years, any delay in establishing strengthened standards prolongs adverse human health and environmental impacts. A meaningful program must address new and existing locomotives to help relieve the burden imposed on millions of people exposed to unhealthy locomotive exhaust. And EPA can maximize the human health benefits by acting swiftly to put a new rule in place.

The technical foundation for cleaning up locomotives is at hand. Cleaner ultra low sulfur diesel fuel (15 parts per million of sulfur or less) is available for highway vehicles and will be mandatory for locomotives by 2012. Meanwhile, the same technologies designed to reduce diesel emissions from highway and nonroad diesel engines are being redesigned for application on locomotives.[6] Similarly, new technologies, like the Green Goat hybrid train designed especially for locomotives, are in use, have been tested, and show significant emissions reductions.

In this report, we review the serious health and environmental threats posed by diesel exhaust. We examine the public health consequences of failure to implement strong federal standards for diesel locomotives as well as the health impacts resulting from further delays in federal action. We also evaluate the health effects specific to particular cities and regions across the nation; we describe available technologies that significantly reduce locomotive emissions; and, finally, we highlight promising and successful programs that currently use these technologies—programs that are the proving ground for decisive federal action.

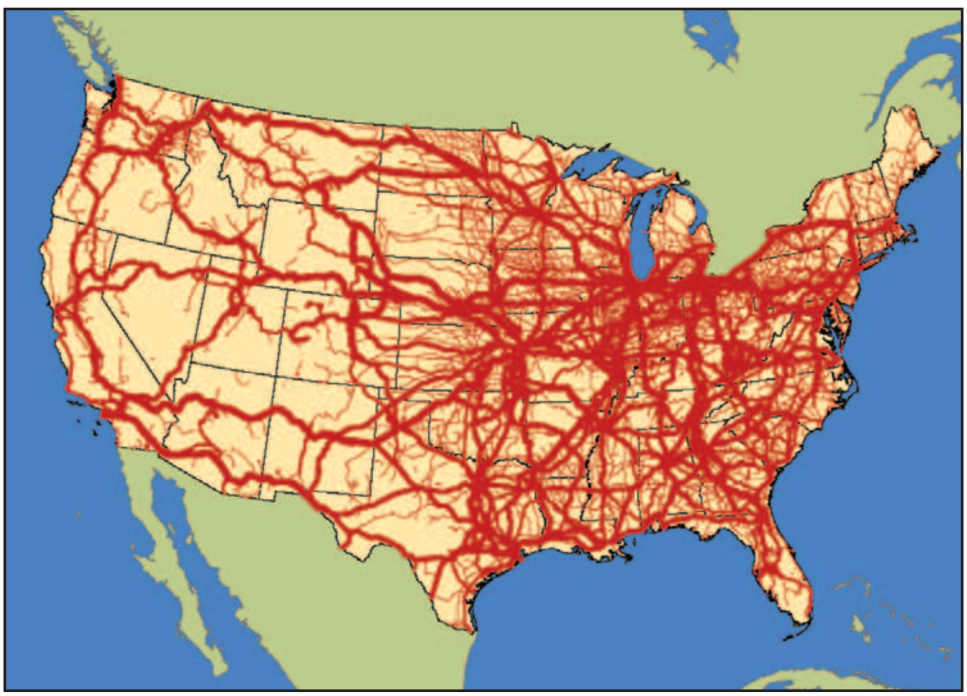
CHAPTER 1
All aboard—trains carry freight and people across the United States

Locomotives were invented in the 1820s.[7] Since then, five major types—including the steam engine—have hauled people and freight. Today's most prevalent locomotive type is the *diesel-electric locomotive*. Unlike the gasoline-powered car, which uses a transmission to change gears, a train's large diesel engine runs at a constant speed. Its engine drives an electric generator that sends power to motors at each axle, which, in turn, drive the wheels. Typical diesel locomotive engines are more than 20 times larger than the V-8 engines in pickup trucks and SUVs. However, because train engines run at a relatively constant speed, they only have about 10 times the horsepower of a typical light truck.[8]

Currently, more than 22,000 freight and 270 passenger locomotives operate in the United States and approximately 100,000 miles of track crisscross the country.[9] As illustrated in Figure 2, trains run through every state in the nation, although the density of the rail network is far from uniform. Rail lines and yards tend to cluster around city centers where populations are the densest, as do the nation's 3,300 passenger train stations.[10]

Two types of locomotives move freight: *line-haul* and *switcher* engines. Line-haul engines carry freight across

FIGURE 2
Map of U.S. rail crossings

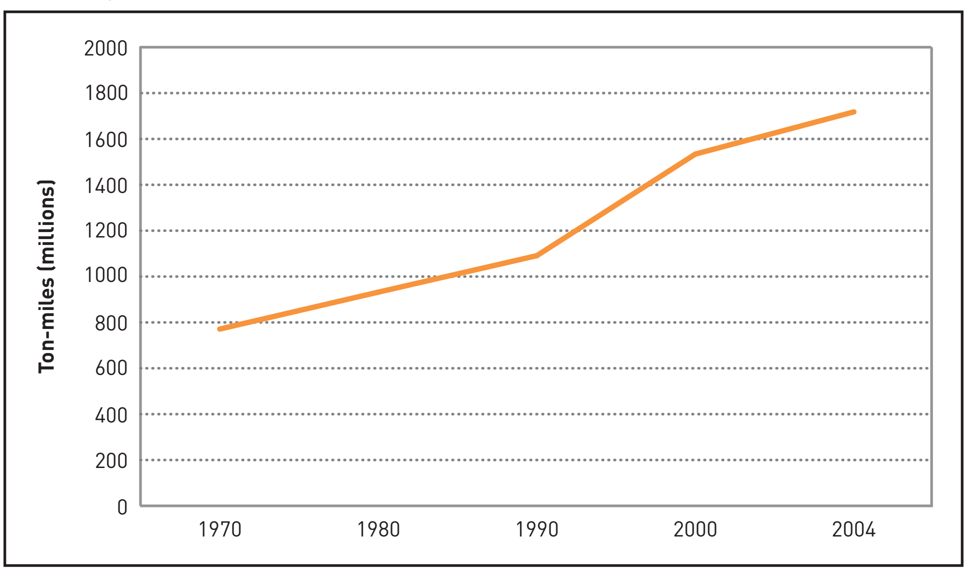


The U.S. national rail system serves both freight and passenger carriers. A map of rail crossings—points where roads and highways cross the rail lines—creates a nearly identical image of the overall rail system. Intense clusters of rail lines are apparent surrounding the nation's larger cities. Many such clusters coincide with areas that have poor air quality, such as Baltimore on the east coast; Chicago, IL and Detroit, MI in the Midwest; Houston and Dallas, TX in the south; and Los Angeles in the far west. Source: U.S. Department of Transportation

Long haul trains move millions of tons of cargo across the nation each year

the country. Switcher engines stay in rail yards and ports, assembling and disassembling the train cars that line-haul engines pull. Together, these locomotives move 42% of our nation's freight, as measured in ton-miles. However, many of the heaviest goods are shipped by train, so measurements in ton-miles are somewhat biased towards trains. Locomotives haul everything from gravel to automobiles, lumber to vegetables and paper to grain. In 2004, coal accounted for 42% of all tonnage and 20% of revenue for Class 1 railroads,

FIGURE 3
U.S. freight rail in ton-miles 1970–2004



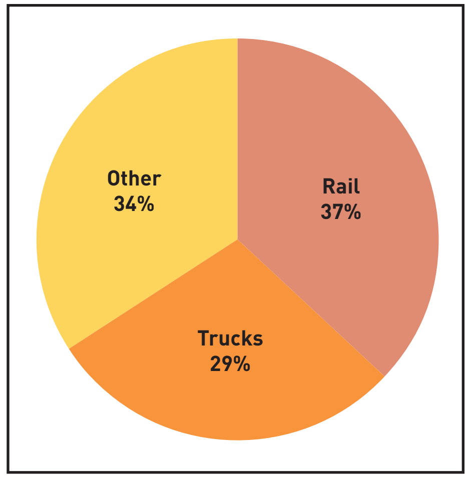
Source: Bureau of Transportation Statistics, Table 1-46a: U.S. Ton-Miles of Freight. http://www.bts.gov/publications/national_transportation_statistics/html/table_01_46a.html.

making it one of the most significant commodities for railroads. And rail transport represents the largest portion of the intercity freight market at 47%—more than trucks or marine vessels.[11]

The use of locomotives as freight transport is on the rise. The United States Department of Transportation (DOT) estimates that rail carried 1.95 billion tons of freight in 1998 and that by 2030 the industry will transport nearly 3 million tons, an increase of about 50%.[12] In California alone, freight shipments by rail are expected to double in the same timeframe.[13] As Figure 3 illustrates, railroad transport, in terms of ton-miles, has more than doubled in the last 35 years from nearly 800 million in 1970 to more than 1.6 billion in 2004.

Over the last decade, intermodal traffic (the movement of trailers or containers by rail and at least one other mode of transportation, usually trucks and/or marine vessels) has been the fastest growing rail traffic segment. In just over 20 years, rail intermodal traffic has more than tripled from 3.1 million containers in 1980 to 11.7 million containers in 2005. In 2003, intermodal surpassed coal as the leading revenue source for Class 1 railroads.[14]

FIGURE 4
Transportation freight ton-miles, 2003



Source: Bureau of Transportation, *National Transportation Statistics* (2003), Table I-46b, available at www.bts.gov/publications/national_transportation_statistics/html/table_01_46b.html.

Trains versus trucks: finding the most efficient long-haul

Locomotives currently present a window of opportunity for national and regional reductions in NO_x, particulates and global warming-causing pollutants like CO_2. Making these reductions will not only improve our air quality but could also make rail one of the cleanest modes of freight transport.

Trucks produce about 4–9 times more pollution than trains, and they are responsible for fewer ton-miles of freight transportation: in 2003, locomotives accounted for 36.8% of freight ton-miles, while trucks accounted for 29% (see Figure 4). Locomotives are the most energy efficient transporters of freight.[15] This is because trains are three times more fuel efficient than trucks based on the number of miles a ton of freight can be hauled on one gallon of fuel. Trains are inherently more efficient because they move with less rolling and wind resistance on smooth steel rails, with each train carrying an average of over 3,000 tons of cargo—equivalent to approximately 280 to 500 trucks, depending on the type of cargo.[16]

There are important opportunities to further increase the fuel efficiency of rail and reduce locomotive contributions to global warming pollution. Freight transport accounts for 25% of transportation-related carbon emissions[17] and for 6.3% of total heat-trapping carbon dioxide emissions in the United States.[18] Freight transportation uses 36 billion gallons of fuel each year, with freight trucks consuming the majority of fuel.[19] Freight rail is three times more fuel efficient than freight trucks,[20] so increased investment in intermodal freight infrastructure can produce sizeable cuts in fuel use and carbon dioxide emissions. Shifting 10% of the intercity freight moved by highway to rail would save the U.S. approximately 1 billion gallons of fuel per year,[21] a 3% annual reduction in fuel use, and would lower overall carbon dioxide by freight transportation.[22]

With superior ton-miles per gallon and energy efficiency, and equally stringent emissions standards, the more freight that is shifted off of trucks and onto trains the greater the environmental and economic savings. According to the Union Pacific Railroad, if 25% of truck freight were diverted to rail by 2025 it would lead to: almost 800,000 fewer tons of air pollution, 16 billion gallons of fuel saved, and 2.8 billion fewer traveler-hours lost in congested traffic.[23] Although these numbers do not include additional congestion that may be caused at rail crossings while longer trains go by, they do demonstrate the potential for moving freight more efficiently. Boosting the fuel efficiency of locomotives could thus form part of a national strategy to reduce overall greenhouse gas emissions in transportation.

Furthermore, the timely cleanup of U.S. freight railroad vehicles could not only protect public health, but also open the door to important opportunities for addressing other transportation and environmental problems. For example, in Switzerland, Austria, and Germany, truck tolls have recently been introduced to help pay for investments in improved freight mobility systems, including better railways, thereby curbing pollution and global warming, and also reducing highway congestion. Similar strategies might help states and metropolitan areas accomplish the objectives of supporting the mobility of people and goods and encouraging economic development, while minimizing fuel use and emissions, as required by the new 2005 federal transportation law, SAFETEA-LU.

Therefore, if EPA adopts a rigorous and comprehensive pollution plan for locomotives to reduce PM and NO_x emissions, a move away from trucks toward rail freight may result in public health benefits, less traffic congestion and reduced impacts on global warming. A smarter, cleaner and faster freight transportation system is possible, and cleaner locomotives have a significant role to play in its realization.

CHAPTER 2

Smokestacks on rails—locomotives' impact on public health and the environment

Locomotives and air pollution in the United States

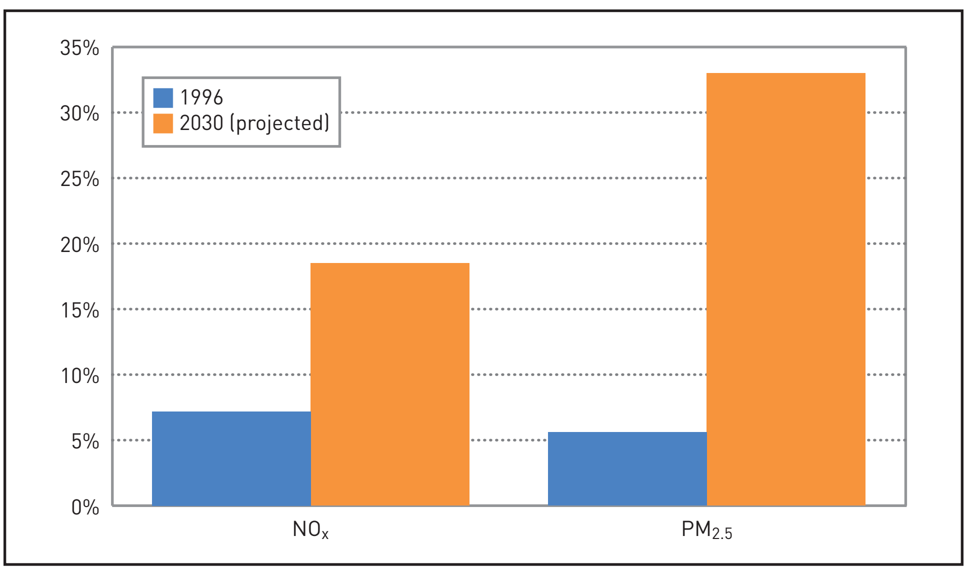
Locomotives crisscross the country, pausing to load and unload cargo in urban and industrial centers. They contribute significantly to the national emissions inventory for the transportation sector and pollute densely populated areas already suffering from unhealthy air. EPA estimates that, in 2006, locomotives will emit about 930,000 tons of ozone-forming oxides of nitrogen (NO_x)—the same amount as emitted from more than 120 coal-fired power plants. Locomotives will also be responsible for more than 32,000 tons of harmful particulate pollution ($PM_{2.5}$)—comparable to the emissions from more than 70 coal-fired power plants.[24]

Rail also contributes to global warming: EPA estimates that it was responsible for 2% of total transportation greenhouse gas emissions in 2003, which is an increase of 18% from 1990 levels.[25] Rising global temperatures are expected to raise sea levels and change precipitation and other local climate conditions. Changing regional conditions will alter forests, crop yields and water supplies, threatening human health, animals and diverse ecosystems.[26]

There are several reasons why locomotives are currently such significant polluters. First, locomotive engines are incredibly large. Their engines can be 20 times larger than the V-8 engines in pickup trucks and SUVs.[27] Second, these engines use an older, more antiquated engine design. Many locomotives are two-cycle engines which have greater power density and are less costly to manufacture, but have considerably higher emissions than their 4-cycle counterparts. Third, because these engines represent major monetary investments, operators tend to

FIGURE 5

Growing locomotive contribution to national mobile source NO_x and $PM_{2.5}$ emission inventories, 1996 and 2030



Source: 69 Fed. Reg. 39,276 (June 29, 2004). EPA PowerPoint presentation by Don Kopinski presented to California Air Resources Board Locomotive Emissions Meeting, "EPA's Rulemaking for Clean Diesel Locomotives," July 13, 2006.

"remanufacture," or rebuild diesel locomotive engines every five to seven years, often keeping heavy emitters in operation for 40 years or more. Lastly, they run for a great portion of their lives—locomotive engines do not use anti-freeze and must idle whenever the temperature approaches 40 degrees Fahrenheit or below to keep them from freezing. Indeed, a switcher engine may spend up to 75% of its time idling. Nationwide, switcher idling wastes about 60 million gallons of diesel fuel annually and emits 12,000 tons of NO_x, 500 tons of particulate matter and 750,000 tons of carbon dioxide.[28]

Locomotives' share of national mobile source emissions is on the rise. EPA estimated that in 1996, locomotives were responsible for 7.2% of NO_x and 5.6% of $PM_{2.5}$ emissions from the transportation sector.[29] By 2030, EPA estimates that, if more stringent standards are not put in place, those numbers will climb to 18.5% and 33% of NO_x and $PM_{2.5}$ mobile emissions respectively (Figure 5).[30] Locomotives' growing share of total mobile-source emissions is a result of the combined effects of weak emissions standards and the projected increase in rail-hauled freight.

Diesel pollution harms public health and the environment

Many trains in the United States are powered by diesel engines. Diesel

Railroad workers: a vulnerable subpopulation

An evaluation of lung cancer mortality in approximately 55,000 railroad workers between 1959 and 1996 revealed that those regularly exposed to diesel exhaust, defined as working as either engineers or conductors, had a higher risk of dying from lung cancer than unexposed workers (clerks and signal maintainers). Lung cancer mortality was significantly associated with being a member of a diesel exhaust-exposed job group, although risk did not increase with years of exposure.[31] These findings are being studied further by the National Institute for Occupational Safety and Health (NIOSH).

Railroad workers are exposed to the harmful diesel emissions from locomotives.

exhaust occurs as a mix of gas, liquids and solids resulting from diesel fuel combustion in a compression-ignition engine, and it is one of the nation's most dangerous and pervasive sources of air pollution. Its components include:

- Fine particulate matter ($PM_{2.5}$). Particulate matter can aggravate respiratory conditions such as asthma and chronic bronchitis and has been associated with cardiac arrhythmias (heartbeat irregularities), heart attacks and premature deaths. People with heart or lung disease, the elderly and children are at highest risk from exposure to particulate pollution.[32]

- Smog-forming nitrogen oxides (NO_x). In warm weather, NO_x combines with volatile organic compounds under certain atmospheric conditions to create ozone. Ozone causes coughing, throat irritation and congestion in healthy adults, and the severity and frequency of asthma cases are exacerbated by ozone smog, especially in children.[33] Ozone is also associated with premature death.[34] In addition, NO_x contributes to the formation of fine particulate matter, acid rain and eutrophication.

- Sulfur dioxide (SO_2), which forms harmful particulate pollution and falls back to earth as acid rain;

- A noxious brew of toxic chemicals that together with diesel particulate pollution pose a cancer risk greater than that of any other air pollutant.

Exposure to diesel exhaust has been associated with a wide range of health effects including cancer, neurological damage, a weakened immune system, respiratory disease and cardiovascular disease.[35]

To examine the current impact diesel exhaust from locomotives is having on public health, Environmental Defense conducted an analysis to quantify adverse health instances and corresponding economic effects resulting from locomotive NO_x and $PM_{2.5}$ emissions (Table 4). We estimate that $PM_{2.5}$ emissions, together with the contribution of NO_x emissions to $PM_{2.5}$, will cause more than 3,000 premature deaths in 2006.[36] Exposure to these emissions will also lead to, among other things, more than 4,000 non-fatal heart attacks, over 60,000 cases of acute bronchitis and exacerbated asthma in children, and nearly 290,000 lost workdays. Based on the methodology EPA used in the nonroad rule, the economic impact of these adverse health effects totals over $23 billion. Appendix A describes the methodology used to derive these estimates.

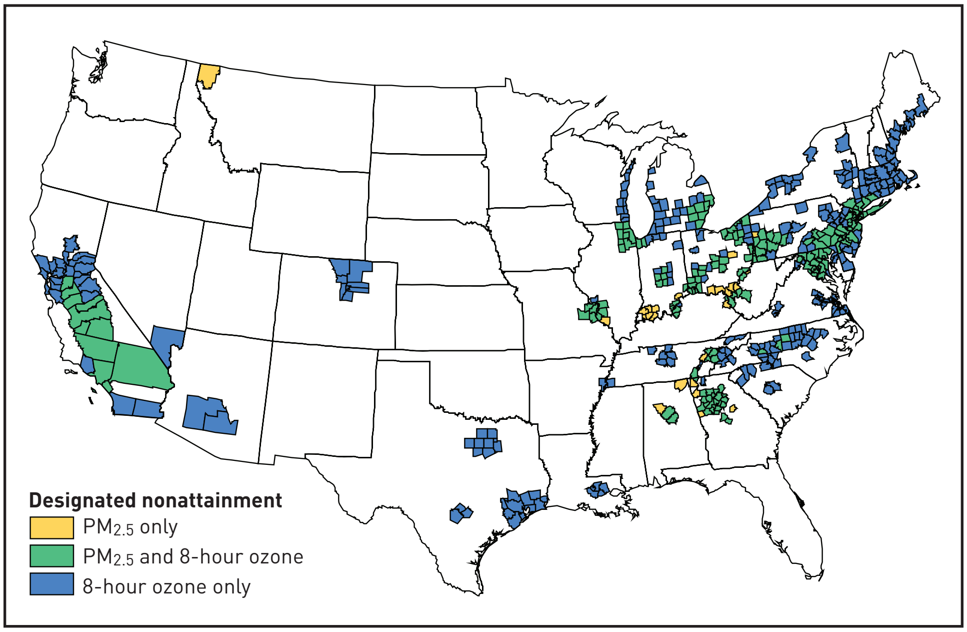
In sum, our analysis highlights how crucial it is to address the harmful emissions from locomotives. We can protect public health and the environment by aggressively reducing diesel locomotive pollution as much and as soon as possible.

TABLE 4
Adverse health effects associated with 2006 locomotive pollution

Adverse health effect	Instances
Premature death	3,400
Chronic bronchitis	1,600
Non-fatal heart attacks	4,400
Hospital admissions	1,500
Acute bronchitis in children	4,000
Asthma exacerbations in children	57,000
Lower respiratory symptoms	47,000
Upper respiratory symptoms in children	35,000
Lost work days	290,000
Minor restricted activity days	1,700,000
Total economic impact of adverse health effects	**$23.2 billion**

FIGURE 6

Communities out of compliance with 1997 national health-based standards for particulate pollution and ozone



Several counties have only a portion of their county designated nonattainment. These counties are represented as whole counties on this map. Source: EPA Greenbook website at: http://www.epa.gov/oar/oaqps/greenbk/mappm25o3.html

Reducing pollution from locomotive engines can help communities restore healthy air

Locomotives are significant contributors to both the NO_x and $PM_{2.5}$ emission inventories. More than half of the American population live in communities out of compliance with the nation's health-based ambient air quality standards for ozone and particulate pollution.[37] States and localities across the United States are working to clean the air and protect the health of their citizens. Cleaning up the pollution from locomotive engines will help states and local governments restore healthy air.

Additionally, the science points overwhelmingly to the need for tighter national health standards for particulate pollution and ozone. As the proportion of locomotive emissions grows compared to other sources in the transportation sector, communities working to achieve and maintain healthy air will increasingly look to locomotives for cost-effective reductions.

CHAPTER 3

Federal delays in strengthening standards impose a heavy burden on human health

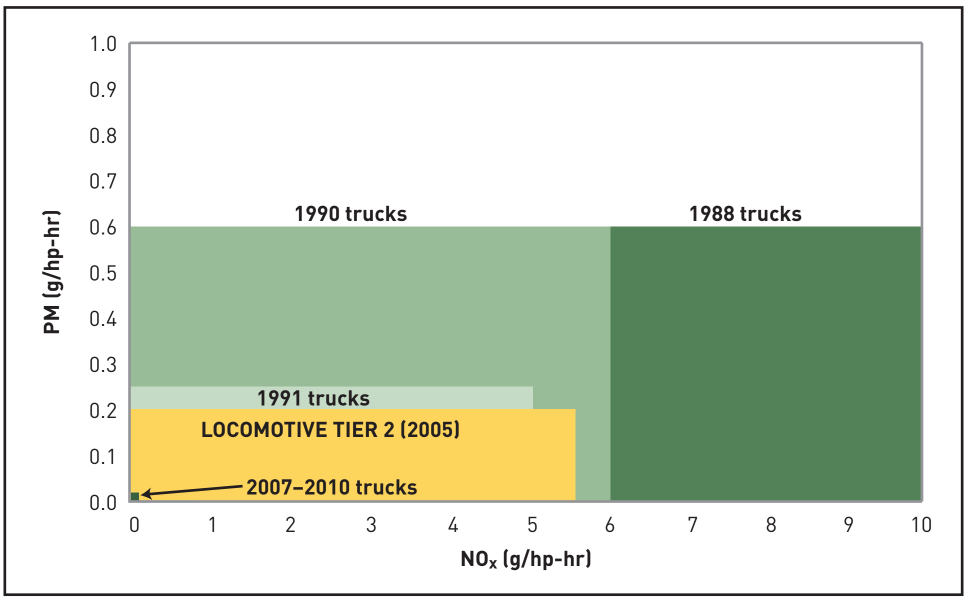
The United States needs strong new emissions standards to address the significant problem of locomotive pollution. Recognizing this urgent need, in June 2004, EPA published a notice of intent to propose new emissions standards for locomotives and ships by the middle of 2005, with final rules set for the middle of 2006.[38] However, at the time of this report's writing, EPA had still not issued new standards—either proposed or final. In order to protect public health and reduce local air pollution in communities across the country, it is imperative that EPA promptly fulfill its commitment to strengthen the nation's clean air standards for locomotives.

Despite the high levels of pollution emitted from these powerhouses, only modest national standards are currently in place to protect the public from their harmful diesel exhaust. Federal emission limits to curb locomotive emissions have lagged far behind those of other mobile sources (see Figure 7), including highway vehicles, diesel freight trucks and nonroad diesel vehicles like farm and construction equipment. Rules for locomotives issued by EPA in 1998, and phased in from 2001 to 2005 do not reflect the capacity of available modern exhaust emission control devices to dramatically lower particulate and smog-forming pollution.[39]

In contrast, EPA adopted a comprehensive clean-up strategy for other new diesel engines, including trucks, buses and nonroad engines, such as construction and farming equipment, that calls for approximately a 95-percent reduction in PM emissions and a 90-percent reduction in emissions of NO_x over previous standards. There is no reason to delay implementing similar protective standards for locomotives. In fact, EPA expects "that similar levels of NO_x and PM reductions could be achieved by applying

FIGURE 7

Comparison of established standards for locomotives and diesel trucks



Source: Slide 4, http://www.arb.ca.gov/railyard/ryagreement/071306epa.pdf these technologies to locomotives" and initially suggested an implementation date of 2011 for these reductions.[40]

New standards for locomotives can be modeled after the same advanced emissions control technologies on which the recent "Tier 4" standards for land-based nonroad diesel engines are based.[41] Many of these technologies have already been redesigned for locomotive engines and show emissions reductions of up to 90% (see Chapter 5). These technologies are enabled by ultra-low sulfur diesel (ULSD), which is already available for highway vehicles, and which will be required in all off road engines, including locomotives, by 2012.

The slow turnover of diesel locomotive engines makes it even more urgent that EPA not hesitate in implementing tougher emissions standards. Like many other nonroad engines, diesel locomotive engines can run for 40 years or more. Every five to seven years locomotive engines are typically remanufactured to "as new" condition, resulting in a slow turnover of dirty engines.[42] Therefore, any new EPA emission standards should address the heavy pollution burden from existing engines by requiring rebuilt/remanufactured engines to meet the same rigorous standards as "new" engines and applying clean air protections to all existing engines.

Environmental Defense recently conducted an analysis to assess the health benefits that would result from timely implementation of emissions standards for new locomotive engines that are 90% more stringent than existing standards. We also looked at the health impacts of emissions standards that would achieve only 75% or 50% reductions from today's standards, as well as the effect of delaying meaningful standards by an additional 2 or 4 years. Our analysis is based on an emissions reduction scenario that assumes (1) a new Tier 3 standard that is 90%, 75% or 50% lower than Tier 2, and (2) Tier 0 and Tier 1 standards that are raised to Tier 2 levels. See Table 5 for more detail on the Tier 0, 1, and 2 emission standards.

Our analysis clearly illustrates the significant benefit in avoiding serious health instances as a result of more protective emission standards. For example, Table 6 shows that implementing a Tier 3 standard that is 90% more protective than the existing Tier 2 standard, and raising emission standards for Tier 0 and Tier 1 engines to Tier 2 levels, would result in more than $13 billion in health benefits annually beginning in 2030, and would prevent over 2,000 premature deaths, about 2,600 non-fatal heart attacks, 36,000 bronchitis and asthma exacerbations, and nearly 170,000 lost work days each year.

On the other hand, implementing a somewhat less protective Tier 3 standard—50% lower than Tier 2 in 2013—

TABLE 5
Current federal exhaust emission standards for line-haul locomotives

Current locomotive emission standards	Age of locomotive fleet	CURRENT EMISSION STANDARDS FOR LINE-HAUL LOCOMOTIVES: PM (g/br-hpr)	NO_x (g/br-hpr)
Tier 3	Originally proposed for 2011	—	—
Tier 2	2005 and after	0.20	5.5
Tier 1	2002–2004	0.45	7.4
Tier 0	1973–2001	0.60	9.5
Uncontrolled	Pre-1973	—	—

Source: 40 CFR 92, July 1 2000 as reported in 2005 Bureau of Transportation Statistics, Table 4.35

TABLE 6
Projected health benefits in 2030 with stricter NO_x and $PM_{2.5}$ locomotive emissions standards

Percentage cleaner than current Tier 2 standards	Year new standards would take effect	Annual health benefits in billions of dollars	Premature deaths avoided annually	Non-fatal heart attacks avoided annually	Respiratory hospital visits avoided annually	Children's bronchitis and asthma exacerbations avoided annually	Work loss days avoided annually
90%	2011	13.7	2,000	2,600	870	36,000	170,000
	2013	12.5	1,800	2,400	800	33,000	150,000
	2015	11.3	1,700	2,100	720	30,000	140,000
75%	2011	11.7	1,700	2,200	750	31,000	140,000
	2013	10.7	1,600	2,000	680	28,000	130,000
	2015	9.7	1,400	1,800	620	25,000	120,000
50%	2011	8.3	1,200	1,600	530	22,000	100,000
	2013	7.7	1,100	1,400	490	20,000	95,000
	2015	7.0	1,000	1,300	450	18,000	87,000

would realize less than $8 billion in health benefits each year, annually preventing 1,100 premature deaths, 1,400 non-fatal heart attacks, 20,000 bronchitis and asthma exacerbations in children, and about 95,000 lost work days. While these benefits are still significant, they fail to capture the full potential of human health benefits that could be achieved by federal adoption of rigorous and timely standards. These numbers show that delays in implementation impose a heavy burden on human health and that interim standards are crucial to "making up" missed health benefits.

Timely and meaningful federal emission standards are essential to protect public health from the harmful effects of diesel locomotive emissions. States, environmental groups and public health agencies have already called on the EPA to adopt more protective standards.[43] Moreover, stringent emission standards would finally put clean air standards for diesel locomotive engines on par with requirements for other onroad and nonroad diesel engines—truly helping to eliminate that puff of black smoke associated with dirtier diesel engines.

CHAPTER 4

Locomotives impose a heavy pollution burden on urban and rural areas across the nation

Locomotives travel all over the nation, but the pollution from trains tends to be concentrated in rail yards, trains stations, and ports where trains gather and wait to load and unload cargo. These concentrated emissions impose a heavy pollution burden on urban and rural areas. This chapter examines some of the communities and rail yards around the country that are hard hit by locomotive emissions.

Instead of relying on EPA's national emissions inventory for locomotives, the cities and rail yards outlined in this chapter conducted their own local emissions inventories and studies to further investigate the health and environmental impacts of nearby locomotive emissions. Table 7 takes a closer look at the smog-forming pollution from locomotive engines in some of these cities compared to today's automobiles.

Southern California

Air quality in southern California far exceeds the federal, health-based ambient air quality standards for ozone and particulates.[44] Diesel air pollution is a major contributor to the region's high ozone and particulate pollution, and is responsible for more cancer risk in southern California than any other single airborne contaminant.

Diesel locomotives have a significant role in these serious pollution problems. Further, the number of locomotives moving through the areas near the ports of Los Angeles and Long Beach is expected to double or triple by 2025 to accommodate an increased number of imported cargo containers.[45] In the South Coast Air Basin, home to both of these ports, diesel locomotives emit about 33 tons of NO_x pollution per day. That exceeds the combined emissions from the area's 350 largest oil refineries, power plants, chemical plants and other industrial facilities.[46]

The Port of Los Angeles recently completed its own emissions inventory. Not only are locomotive emissions prevalent within the Port boundaries, but emissions from trains going to and

TABLE 7

Smog-forming emissions from locomotives in six major cities and comparable number of today's new automobiles[a]

Urban area	Locomotive NO_x emissions (tons/year)	Equivalent number of automobiles[b]
Los Angeles[c]	12,000	13,000,000
Dallas-Fort Worth	4,500	4,900,000
Houston-Galveston	6,500	7,000,000
Chicago	23,000	25,000,000
Detroit	2,100	2,300,000
Baltimore	2,600	2,800,000

[a] Emissions data for Houston and Dallas is from 2002. Emissions data from the other cities is from 2003.

[b] Calculations based on Tier 2 NO_x emissions standard (0.07gNO_x/mile) for highway vehicles and 12,000 vehicle miles/year. Bureau of Automotive Repair, Engineering and Research Branch, State of California, "Methodology for Calculating Vehicle Miles Traveled (VMT)," September 30, 2000, Report 2000-06, available at http://www.epa.gov/otaq/regs/im/vmt.pdf

[c] Emissions data is for the South Coast Air Quality Management District.

from the Port pollute surrounding neighborhoods. The study found that, in 2001, locomotives within the port emitted nearly 450 tons of NO_x.[47] Those emissions are equivalent to the pollution from more than 480,000 of today's cleanest cars, more than all the cars registered in the state of Delaware.[48] Locomotives are responsible for 13% of all NO_x pollution at the Port and 7% of the Port's $PM_{2.5}$ emissions.[49]

The California Air Resources Board (CARB) conducted a further study of the diesel particulate exposure at the Ports of Los Angeles and Long Beach. The study found that locomotives at the two Ports were responsible for 18 tons per year of particulate matter and contribute to elevated risks of cancer in nearby neighborhoods.[50]

The J.R. Davis Yard in Roseville, California

DAVE HENRY

Roseville, California

Central California also suffers from some of the worst air quality in the country. Locomotives are a significant contributor to this pollution problem, especially near rail yards. In 2004, CARB completed a health risk assessment of PM emissions from locomotives at the Union Pacific J.R. Davis Yard, a busy hub for railcar switching in Roseville, California. Roseville, located in the Central Valley near Sacramento, is a fast-growing suburb and the past several years have brought increased residential development in close proximity to the rail yard. The yard is situated near the heart of Roseville and is the largest service and maintenance rail yard in the West, with over 30,000 locomotives visiting annually.

The Roseville study concluded that dangerous concentrations of ultra-fine particulates from the rail yard extend out over a now-populated landscape and effect residents for miles around. Specifically, diesel exhaust from the rail yard increases the estimated cancer risk at a rate of 100–500 cases per million residents across an area in which between 14,000 and 26,000 people live, and at a rate of 10–100 cases per million people across a larger region with a current population of 140,000–155,000. Cancer risks posed to workers in the immediate area of the switching yard are even higher. The study concluded that the cancer risk associated with diesel emissions at the rail yard were substantially higher than the risk posed by diesel emissions on the adjacent interstate highway, I-80, which is itself a significant source of harmful pollutants.[51]

Houston and Dallas

Twenty-three counties in Texas currently do not meet health-based air quality standards for ozone established by EPA, and several more are on the verge of violating these standards.[52] Houston is the tenth largest city in the United States,[53] has some of the most unhealthy ozone concentrations in the country and is located in one of the most populated regions in the nation.

Texas is also home to significant national rail hubs, as ships deliver cargo to the many ports and harbors scattered along the state's long coastline to be further transported inland by truck and rail. And the freight carried by trains in Texas is expected to grow from 282 million tons in 1998 to 473 million tons by 2020—a nearly 68% increase.[54]

In June 2005, the Texas Commission on Environmental Quality (TCEQ) finalized a locomotive emissions inventory for Houston-Galveston and Dallas–Fort Worth, the two metropolitan areas with the state's heaviest railway traffic, and both out of compliance with EPA's health-based air quality standards for ozone.[55] The study estimated that in 2003, locomotives in Texas emitted approximately 51,400 tons of NO_x and 2,000 tons of particulate pollution. Collectively, the Dallas–Fort Worth and Houston–Galveston counties accounted for approximately 20% of Texas locomotive emissions.[56] Moreover, the TCEQ concluded that the inventory likely *underestimated* the state's actual total locomotive emissions.[57]

Chicago

Chicago is the busiest rail freight gateway in the United States, and the only city where six of the seven major U.S. and Canadian Class I railroads come together to interchange freight. This includes the two major western U.S. railroads, Burlington Northern and Union Pacific, the two major eastern U.S. railroads, CSX and Norfolk Southern, and the two major Canadian railroads, Canadian National and Canadian Pacific. A remarkable one-third of all long-haul rail traffic in the country passes through Chicago, and the largest U.S. rail yard, the Belt Rail Yard, is located there.

Chicago handles more than 37,500 rail freight cars each day and 20 years from now, that number is expected to nearly double to 67,000 freight cars per day.[58] More freight carried by locomotives passes in and out of Illinois than any other state. In 1998, 371 million tons of cargo was transported by freight in Illinois. By 2020, the U.S. Department of Transportation estimates that number will rise dramatically to about 600 million tons.[59] Meanwhile, Cook County, the home of Chicago, violates the federal health-based standards for both ozone and particulate pollution. [60]

Due to the high volume of rail freight, Chicago has more NO_x and PM emissions from locomotives than any other city in the United States. In 2002, trains emitted some 23,212 tons of NO_x and 792 tons of particulates into Chicago's air. Of that, 18% of the NO_x and 32% of the particulates was from switchyard locomotive activity alone. [61] The NO_x emissions from locomotives in Chicago are equal to the emissions of more than 25 million of today's new cars, more than 5 times the number of cars registered in the entire state of Illinois.[62]

Detroit

The Detroit metropolitan area, which includes seven Michigan counties, is also out of compliance with the federal health-based ozone standard. Detroit has a regional economy dominated by automobile manufacturing and rail-truck intermodal transfer facilities are critical to the automobile industry's inventory processing. Detroit also serves as an important freight gateway to Canada, Chicago and the Midwest.

Approximately 4.2 million tons of rail freight are imported through the Detroit region annually—17% of total interregional freight tonnage. Based on commodity flow data, an estimated 300,000 loaded rail cars cross between Canada and southeast Michigan annually, or more than 800 loaded rail cars per day. The locomotives that pull this freight emit some 2,106 tons of NO_x and 58 tons of PM each year.[63]

Baltimore

More than a dozen counties in Maryland, including the counties surrounding Baltimore, violate the federal health-based ozone standard, and nearly a dozen of those same counties fail to meet the national $PM_{2.5}$ ambient air quality standard.[64] In 2002, locomotives were responsible for more than 2,600 tons of NO_x and over 70 tons of coarse particulate matter in Baltimore. Of those emissions, more than half were from switcher engines in rail yards. The contribution of switcher engines to regional locomotive emissions is higher in Baltimore than any of the other localities examined here.[65] Addressing locomotive emissions from Baltimore's urban rail yards would have a significant benefit for public health and help the state come in line with federal air quality standards.

Powder River Basin, Wyoming

While most locomotive rail yards and hubs are located in densely populated cities, there are important exceptions, such as Wyoming's Powder River Basin (PRB). The Powder River Basin experiences a tremendous amount of rail traffic because of regional low-sulfur coal deposits, which are mined and transported by train to eastern utilities across the nation. The largest coal shipments are from the PRB to power plants in Illinois, Texas and Missouri.[66]

Because the Powder River Basin is the nation's largest supplier of coal, Wyoming experiences the second largest quantity of cross-border rail

ERNEST H. ROBL

An inbound empty coal train meets a loaded outbound coal train at Logan Hill, Wyoming, in the Powder River Basin.

freight of any state, following only Illinois.[67] Recent studies show that PRB coal production has degraded the air quality and visibility at Badlands National Park. After release from locomotives and other sources, sulfur dioxide (SO_2) and NO_x typically react to form haze-causing sulfate and nitrate particles. A study of Badlands from 1989 to 1998 found that nitrate concentrations had increased by 20%, resulting in decreased visibility. The study also determined that transport of coal by rail was responsible for as much as 18% of the overall nitrate increases. The study determined that the most effective means of improving the Park' sair quality would be to control diesel emissions from mine equipment and locomotives.[68]

CHAPTER 5

Technology is on hand to curb locomotive emissions today

As illustrated above, locomotive pollution has far-reaching impacts on human health and the environment. And locomotives, like many other nonroad engines, can last for 40 years or more, resulting in slow turnover of dirty engines.[69] The good news is that available technology can significantly reduce emissions from existing locomotives and help power newer, cleaner ones. Moreover, the ultra low sulfur diesel fuel (15 parts per million of sulfur or less) that enables these technologies is widely available today and will be mandatory for all locomotives in 2012.

Some advanced emissions control technologies currently in use in highway and nonroad engines have already been successfully redesigned for application to locomotive engines, and new technologies are being designed specifically for locomotives. The implementation of these technologies can help make strict federal emissions standards, as well as local and regional emissions reduction programs, successful in cost-effectively controlling pollution.

Hybrids

Railpower Technologies of Vancouver, British Columbia manufactures hybrid locomotive switcher engines called "Green Goats" to help reduce emissions in urban switching yards. Green Goats are powered with large banks of long-life recyclable batteries. When energy stored in the batteries is depleted to a pre-set level, a low-emissions diesel engine automatically starts to power a generator that recharges the batteries. These new hybrid switcher engines are designed to cut air emissions by 80–90% and reduce diesel fuel use by 40–70% compared to the 500–2,000 horsepower engine that runs a conventional switcher.[70]

Green Goat reductions	
Emissions	80-90%
Fuel	40-70%

COURTESY OF RAILPOWER TECHNOLOGIES CORP

Green Goat, hybrid locomotive

In addition, General Electric is developing the GE Transportation Rail, a hybrid technology to be used in line-haul locomotives. The GE locomotive is designed to capture energy dissipated during braking and store it in a series of sophisticated batteries. That stored energy could then be used on demand by the crew, reducing fuel consumption and emissions by up to 15% when compared to GE's current series of locomotives.[71]

Gen-set

With funding from Union Pacific, the National Railway Equipment Corporation has developed another type of cleaner switcher engine. Their new Gen-Set Switcher (GSS) technology replaces the traditional switcher engine with three 700 horsepower generator sets that meet EPA Tier 3 standards for nonroad engines. The combination of smaller engines meets the energy needs of the switcher locomotives while meeting emissions standards more protective than the ones currently in place for locomotives. The multi-engine approach allows the switcher to reduce emissions of NO_x and particulate matter by up to 80% and achieve a 40% reduction in fuel consumption over existing, unregulated switchers. It is the first emissions reducing rail technology being developed by a rail company itself, with funding from the Texas Emissions Reduction Plan's new technology and research development program, and signals that the industry is starting to recognize the benefits of improving efficiency and reducing emissions.[72]

Gen-set reductions	
NO_x and PM	80%
Fuel	40%

Anti-idling technology

Engine idling is one of the top factors contributing to high locomotive

The dual fuel consumption and pollution impacts from idling

Moving freight accounts for 20% of all energy consumed in the transportation sector. As the carrier of more than 40% of all US freight,[73] locomotives consumed nearly 5 billion gallons of diesel fuel in 2001.[74] A large portion of fuel burned by locomotives occurs during idling. Train operators idle their engines to protect them during cold weather since most locomotive engines do not use antifreeze. They also idle to maintain the fuel, oil and water warmth as well as the battery charge and the temperature inside the cab.[75]

Switcher engines spend almost 60% of their time idling while long-haul engines idle approximately one-third of the time.[76] While idling is most prevalent in urban rail yards where switchers sort out rail cars from inbound trains and assemble outbound trains, it is also a significant source of pollution from long-haul freight transport. EPA estimates that truck and locomotive idling consumes over 1 billion gallons of diesel fuel annually.

Engine idling is one of the top contributing factors to high locomotive emissions. EPA estimates that idling of switchyard locomotives produces 13,000 tons of NO_x, 430 tons of PM, and 750,000 tons of CO_2 *each year*.[77]

Fortunately, idling is something that can be addressed through new technology and well-designed policy. Anti-idling technology has been successful in a Chicago pilot project (see Chapter 6). A rigorous national program to require such technology on all new and existing locomotives would not only reduce harmful emissions but also realize significant reductions in fuel consumption.

emissions. There are at least three technologies on the market that successfully reduce idling time and emissions. Auxiliary power units (APUs) use a small fuel-saving auxiliary diesel engine and generator set to power on-board electrical and environmental systems instead of idling the locomotive's main engine continuously. The Southwest Research Institute (SwRI) tested this technology and determined that APUs can achieve a 91% reduction in NO_x and an 84% reduction in PM compared to main-engine idling emissions.[78] SwRI also found APUs reduce fuel consumption during idling by 83%, which translates into a savings of approximately 22,000 gallons of fuel per year for each switcher locomotive. At today's diesel prices, that translates into an annual savings of over $65,000 for the operator.[79]

APU reductions	
NO_x	91%
PM	84%
Fuel	83%

Another technology automatically monitors a locomotive's battery, engine temperature and other important gauges during idling operation and safely stops and restarts the engine to conserve fuel and reduce air and noise pollution. Tests have shown that these stop/start technologies can reduce emissions by 50%.[80] Additionally, Kim Hotstart idling reduction systems use electric and small diesel-powered heating units to maintain desired engine temperatures in both coolant and lube oil while the locomotive is shut down.[81]

Advanced exhaust emission control technologies

Proven emissions-reducing technologies have been and are being further adapted

Adapting highway and nonroad diesel pollution control technologies to locomotives

While some technologies, like the Green Goat, have been designed specifically to reduce locomotive emissions, other technologies are being adapted from highway and nonroad diesel engine applications. Locomotive engines share some important design features with highway and land-based nonroad vehicle engines, making it feasible to adapt these technologies, which include exhaust emission-control devices typically retrofitted onto existing locomotives to reduce emissions and advanced exhaust emission control technologies like diesel oxidation catalysts and active particulate filters.

Manufacturers have faced challenges in adapting highway and nonroad technologies to locomotives and are continuing to refine technologies for broader deployment. These challenges include scaling technologies up to fit the large size of locomotive engines; scaling up the advanced exhaust emission control systems to large horsepower sizes; and retooling to maintaining high exhaust temperatures. For example, low exhaust gas temperatures may compromise diesel particulate filters (DPF) and diesel oxidation catalysts (DOC) performance. In addition, the engine compartments on a train are very compact because trains need to be able to fit through tunnels and other small spaces, requiring cab redesign to fit DPFs and DOCs. EPA has found that these challenges to not "pose a barrier to setting standards based on implementing these technologies…"[82] Moreover, as described in this chapter, many of these technologies have already been successfully implemented on locomotives in the U.S.A. and in Europe. New federal emissions standards for locomotives would not only help protect public health but would also drive the advancement of new, important technologies.

from highway, nonroad and stationary diesel engines for use on locomotive engines. These exhaust control technologies can be applied to new engines or retrofitted onto existing engines to achieve immediate reductions in NO_x and PM emissions.

Some of these technologies include diesel oxidation catalysts (DOCs) and actively regenerating diesel particulate filters (DPFs) for particulate emissions reductions, and engine rebuild kits and selective catalytic reduction (SCR) catalysts for reducing NO_x emissions. These technologies have been successful in reducing up to 90% of NO_x and $PM_{2.5}$ emissions from highway, nonroad and stationary engines and these types of technologies are already being successfully tested and applied to locomotive engines. [83] In October 2006, the Manufacturers of Emission Controls Association (MECA) released a report pointing to the numerous test programs across the nation that have successfully applied these technologies to new and existing locomotive engines.[84]

For example, in 2006 Union Pacific, with the help of U.S. EPA, is testing the use of a DOC and a DPF on two of their existing engines. The Southwest Research Institute will perform EPA locomotive emissions tests to verify how much particulate matter is removed from the locomotive's exhaust.[85] And beginning in 2004, as part of the Locomotive Demonstration Project, the Massachusetts Bay Transportation Authority began testing a diesel oxidation catalyst (DOC) on a diesel powered commuter rail locomotive.

In addition, of the 113 diesel powered locomotives used to move freight in Switzerland, 73 new, low horsepower units have been fitted with DPFs, while 6 of the 40 existing units have been retrofitted with DPFs. And in California, the Placer County Air Pollution Control District, which encompasses the Roseville rail yard near Sacramento, has initiated a project to employ selective catalytic reduction (SCR) technology on locomotives operating at the Roseville rail yard. As confirmed by MECA, the growing experience base with DOCs, DPFs, and SCR on locomotive engines indicates that these technologies are feasible for use on new locomotive engines to comply with stringent national emission standards.[86]

CHAPTER 6

"I think I can, I think I can"—successful emissions reduction programs

Chapter 4 examined cities and rail yards where locomotive emissions are concentrated and contribute significantly to local air pollution problems. Chapter 5 reviewed new and redesigned technologies available today that can reduce harmful diesel locomotive emissions. This chapter takes a look at programs that leverage technology to reduce pollution. These initiatives, and others, are a proving ground for a comprehensive national emissions reduction program.

The EPA SmartWay Transport Partnership

The SmartWay Transport Partnership is a voluntary collaboration between the freight industry and EPA designed to increase energy efficiency while reducing air pollution. Launched in February 2004, the Partnership includes major freight shippers, trucking companies, railroads and logistics companies. These groups work together to implement efficiency measures that reduce emissions and bring cost savings to freight operators. All seven major freight railroads have joined the Partnership, and each has committed to develop a plan to identify fuel savings and emissions reduction strategies that include reducing idling, improving aerodynamics, applying new fuel-saving technologies and installing emissions control devices.[87]

Because ton-mile for ton-mile, rail is an efficient mode of transportation, the SmartWay Program also encourages technical innovation to increase rail efficiency and highlight opportunities where rail could be better utilized. By 2012, the initiative aims to reduce between 33 and 66 million metric tons of CO_2 emissions per year, as many as 200,000 tons of NO_x emissions per year, and to achieve fuel savings of up to 150 million barrels of fuel per year.[88] Recent reports show that, since its inception in February 2004, SmartWay projects, including truck and rail, have saved 283.6 million gallons of fuel per year. EPA estimates that, by 2007, the fuel savings will have yielded annual reductions of 3.1 million tons of CO_2, 22,000 tons of NO_x, and 800 tons of PM emissions. The emissions reductions and fuel savings achieved in the two years of SmartWay's existence translate into the equivalent of emissions from nearly 550,000 cars or about 390,000 homes heated in the United States.[89]

Chicago's Anti-idling Program

In order to address the growing impact of locomotives in Chicago, EPA and the City of Chicago sponsored a locomotive idling reduction demonstration project in 2002 and 2003. The governments recruited Burlington Northern Railway Company, the Wisconsin Southern Railroad Company and the Kim Hotstart Company, a manufacturer of idling reduction systems, as partners in the project. Seven locomotives were outfitted to reduce idling in the winter, when engines are typically left running to keep the engine and cab warm. The start/stop systems were also useful in the summer to shut down idling engines left on by conductors who idle out of habit.[90]

The project resulted in an 80% reduction in idling time, an annual fuel savings of over 14,000 gallons and an annual NO_x reduction of 2.4 tons.[91] Based on the successful performance of idling reduction systems in Chicago, EPA estimates that anti-idling retrofits at a typically sized rail yard with five switching engines would eliminate 12.5 tons of NO_x at a cost of $1,420 per ton of NO_x reduced.[92] This is equivalent to taking 13,500 of today's cars off the road in the areas surrounding each switching yard.

Because of the success of the Chicago project, and the fuel savings from the various anti-idling technologies, railroad companies have begun to retrofit some of their older locomotives with stop/start mechanisms and APUs. Union Pacific has now equipped 20% of its fleet with automatic stop/start idling reduction technology.[93] As of July 2004, the Burlington Northern Santa Fe Railroad had retrofitted 38 of the approximately 400 switching engines it operates in 28 states and two Canadian provinces with Kim Hotstart systems.

Chicago's successful idling reduction program shows how technology and policy innovation can be used to reduce harmful diesel emissions from locomotives.

Texas Emissions Reduction Plan

In response to the large number of Texas counties out of compliance with the federal health-based ozone standard, the Texas Emissions Reduction Plan (TERP) was established to reduce ozone-forming NO_x emissions. TERP has committed almost $20 million to reduce locomotive emissions in the Houston–Galveston area, which suffers from the highest ozone levels and the most locomotive emissions in the state.[94]

The TERP program funds projects in nonattainment counties for purchase of new locomotives; replacement of old locomotives; repowering or replacement of engines; and retrofitting or adding emissions control technology. In each case, the repowered, retrofitted or replaced locomotive must be certified to emit 25% less NO_x than the engine it replaces, or if new, 25% less NO_x than the current federal standard for that engine.[95] The Houston locomotive projects include replacement of old switching engines and repowering locomotives with cleaner hybrid technology.

TERP officials expect these projects to reduce NOx emissions by more than 3,300 tons, at an average cost of about $5,900 per ton. TERP has funded four Green Goats for Burlington Northern Santa Fe (BNSF), two for Kansas City Southern (KCS) and ten for Union Pacific Railways, and it continues to process applications.[96]

California Clean Air Initiatives

California suffers from some of the most unhealthy and far-reaching air pollution problems in the nation. One of its campaigns to address harmful air pollution levels aims to reduce emissions from the movement of goods. Intermodal transport of goods includes trains, trucks and marine vessels, and is on the rise in California and around the nation.

As part of this broad strategy, the California Air Resources Board (CARB) established the California Rail Yard Emission Reduction Project. In 1998, CARB reached an agreement with Union Pacific and Burlington Northern Railways, the two Class 1 operators in California, to reduce NO_x emissions from locomotives. The agreement also provides for all intrastate locomotives to use ultra-low sulfur diesel, with a sulfur content of 15ppm or less, by 2007—a full five years before ULSD is federally mandated to be in national circulation for locomotives.

On June 30, 2005, CARB and Union Pacific Railroad Company and BNSF Railway Company entered into a second voluntary agreement providing for UPRR and BNSF to reduce locomotive and associated diesel particulate emissions in and around California's rail yards.[97] In addition, the railroads have committed to studying and reducing pollution risks at 17 designated rail yards. The Roseville risk assessment mentioned in Chapter 4 is the first of those studies.

The agreements encourage these railways to implement new emissions reducing technologies. Union Pacific and BNSF have agreed to phase out non-essential idling and install idling reduction devices on all California-based locomotives, identify and repair locomotives with excessive smoke, maximize the use of ULSD by 2007, and prepare a progress report on plans to implement feasible mitigation measures at the 17 major rail yards in California. The program is expected to achieve a 20% reduction in locomotive diesel particulate matter emissions near rail yards by 2008, when all the program elements are fully phased in.[98]

Currently, more than a third of the 430 intrastate locomotives (switchers and local locomotives) in California have been equipped with idling reduction devices, which is more than twice the rate of installations that have occurred to date in the rest of the country.[99] In addition, Union Pacific recently spent $8.2 million on ten new Green Goat locomotives for its Southern California rail operations to help meet the agreement. The first two have been received and have been put into service at the UP rail yard in Mira Loma. The remaining Green Goats are expected to arrive and be put into service in 2006.[100] Union Pacific expects to spend a total of $20 million implementing the program. BNSF has one Green Goat switcher in the Los Angeles area and four liquefied natural gas (LNG) locomotives in service elsewhere in the area.[101]

The Health Risk Assessments will evaluate emissions of toxic air contaminants and criteria pollutants from emissions sources at each Designated Rail Yard including resident and transient locomotives, on- and off-road equipment, and stationary equipment, and will identify the associated health risk from on-site activities. The HRAs will estimate potential cancer and non-cancer risks to the public from exposure to airborne contaminants inventoried from the Designated Rail Yards. Completion of nine of these HRAs is expected by the end of 2006, with the final seven concluding in 2007.[102]

The South Coast Air Quality Management District (SCAQMD), which includes the counties of Los Angeles, Orange, San Bernardino and Riverside, is deploying additional measures to address locomotive emissions in and around the Los Angeles air basin. The SCAQMD recently adopted two rules requiring railroads in the region to eliminate unnecessary locomotive idling. Under Rule 3501, railroads will be required to keep records of all idling over 30 minutes. The information will be used to identify ways to reduce idling and associated pollution. Rule 3502 prohibits unattended locomotives from idling for more than 30 minutes under certain circumstances. This goes farther than the CARB agreement, which targets idling over 60 minutes. In addition, these rules are mandatory in contrast to the CARB agreement, which is voluntary. A SCAQMD analysis predicts the railroads will realize a net savings of more than $3 million over the next four years as a result of the two combined rules.[103]

California's Carl Moyer Program

Because many of the dirtiest diesel engines on the road today can be in use for decades, and federal regulations often do not apply to them, the Carl Moyer Program was started in California to provide incentive funds to retrofit old engines or to retire them for newer, cleaner engines. The Program covers the incremental costs of obtaining cleaner-than-required engines and equipment. Eligible projects include cleaner on-road, off-road, marine, locomotive and stationary agricultural pump engines, as well as engines in forklifts, airport ground support equipment and auxiliary power units. Each air district in the state is allotted a portion of the Moyer Funds and disperses them to the projects that can make the greatest reductions.

With support from the Carl Moyer Program, the San Joaquin Valley Air Pollution Control District (SJVAPCD) has created the Heavy-Duty Engine Emission Reduction Incentive Program, which provides funds to help public agencies, companies and individuals retrofit their locomotive engines or replace them with new, cleaner engines that run on diesel or alternative fuels.[104]

Provisions for the SJV program state that retrofits must reduce emissions by 15% compared to applicable EPA standards for a similar engine. This program has provided funding to aid BNSF in the purchase of one Green Goat and is under contract to help with an additional five.[105] The San Joaquin program has also helped fund the installation of anti-idling technology in four BNSF trains. SJVAPCD estimates that the Green Goat will reduce 120 tons of NO_x over the next eight years, at a cost of $700,000, resulting in a cost-benefit ratio of only about $5,800 per ton reduced. The anti-idling technology is estimated to reduce annual NO_x emissions in the Valley by 1.53 tons and reduce fuel consumption by 38 gallons per day.[106] Combined, these reductions will be the equivalent of removing more than 140,000 of today's cars from the San Joaquin Valley's roads.

The Carl Moyer Program has also helped fund projects in the South Coast Air Quality Management District (SCAQMD), the Port of Los Angeles, and other areas around the state of California.

Rail yard at the Port of Los Angeles

COURTESY OF THE PORT OF LOS ANGELES

Pollution reduction strategies for the Ports of Los Angeles and Long Beach

With well-designed policies and the use of advanced technologies, trains can become a cleaner mode of transportation, replacing trucks and thereby reducing traffic congestion and regional air pollution.

The Ports of Los Angeles and Long Beach recently reached a voluntary agreement with Pacific Harbor Lines (PHL), a private company that since 1998 has provided railroad-switching services to both Ports, to replace all 18 of its existing switcher locomotives—some more than 50 years old. The agreement, which was signed in August 2005, specifies that 16 of the replacement locomotives will be equipped with new diesel engines that exceed EPA Tier 2 standards. The additional two will be alternative-fuel locomotives—one using liquefied natural gas and the other a Green Goat hybrid engine from Railpower Technologies. Each of the two ports will contribute $5 million toward the estimated $23 million cost to replace the PHL locomotive fleet, with the balance coming from PHL and a $3.2 million Carl Moyer grant. The use of these replacement locomotives will result in a 53% reduction in NO_x emissions and a 45% reduction in PM emissions per locomotive, and the removal of an estimated 163 tons of NO_x per year and 3 tons of annual PM from the two ports.[107] These NO_x reductions are equivalent to eliminating more than 175,000 of today's cleanest cars from the streets of Los Angeles and Long Beach.

In addition to buying new locomotives, the ports are taking further steps to reduce emissions. The agreement provides incentives to PHL to block street crossings for fewer than 10 minutes so as to reduce road congestion and motor vehicle idling. It also requires that all locomotives be equipped with automatic shut-down devices that will kick in if a locomotive idles for more than 15 minutes. In addition, PHL will use cleaner-burning emulsified diesel fuel in all of its new locomotives. And because the turnover of all 18 locomotives will take some time, PHL has also agreed to use the emulsified diesel in the existing fleet, which will result in immediate air quality benefits.[108]

CHAPTER 7

National clean air solutions for locomotives

As described in Chapter 6, local officials are taking steps to reduce emissions from locomotives. While these programs have an important role in incubating new technologies and demonstrating the efficacy of emissions controls, they are limited in scope. EPA leadership is essential to put comprehensive national clean air solutions in place for diesel locomotives. This will help communities across the country achieve the health-based national ambient air quality standards (NAAQS) for particulate pollution and ozone, and address the serious cancer risk of diesel emissions.

Environmental Defense respectfully recommends the following essential steps to cut the harmful air pollution from diesel locomotives.

1. We call on EPA to issue, without further delay, new protective locomotive emission standards. To protect human health and the environment nationwide, Environmental Defense calls for EPA to fulfill its public commitment to strengthen the nation's clean air standards for these harmful smokestacks on rails. EPA's failure to finalize new standards in mid-2006, as the Agency had publicly committed, will likely delay compliance deadlines when EPA does take action. Each year of delay risks lives and imposes a cascade of health effects that could be prevented with solutions available today. Environmental Defense strongly recommends that this new policy adopt the following standards:

- Require, by 2013, a 90% reduction in current particulate pollution and NO_x emissions from all new and remanufactured locomotive engines, consistent with EPA's 2004 emission standards for heavy-duty nonroad diesel engines.
- Establish protective PM and NO_x emissions standards for the existing locomotive fleet to be achieved immediately to secure important near-term pollution reductions.
- Provide for widespread utilization of anti-idling technologies to help reduce locomotive emissions, noise, and fuel waste while saving operators money.

2. Update national locomotive emissions inventories. EPA should review and update the emissions inventory for locomotives. Diesel pollution from locomotives imposes a heavy burden on public health and the environment. Local and national policy leaders need up-to-date, comprehensive data regarding the number of locomotives, their emissions and projected growth trends. The current EPA emissions inventory has many shortfalls: it does not account for the effect of grade or elevation on locomotive emissions; it uses only railroad distillate fuel consumption data as an indicator of locomotive growth;[109] and it cites only national estimates, neglecting geographic allocation. It is important that EPA work with local air pollution control agencies, other technical experts and the rail companies to develop a more comprehensive set of emissions factors for locomotives and gather data on a county level so that policymakers are aware of local and regional locomotive emissions hotspots.

3. Establish incentive programs designed to encourage faster turnover of dirty switcher engines. The turnover for switcher engines tends to be more sluggish than for long-haul engines. Because long-haul trains cover such long distances each year, owners have a business incentive to buy newer, more fuel-efficient trains that will not break down and are less expensive to operate. Switcher engines, by contrast, never leave the rail yard, and there are few operational incentives for replacing or updating these engines. This leaves the oldest, dirtiest engines operating in busy urban centers where many people can be exposed to their pollution. Therefore, a protective national program must include emission standards for existing switcher engines together with well-designed economic incentives to encourage faster turnover of switcher engines. Tailored incentives could have economic benefits for operators and speed the transition to cleaner locomotive engines, rail yards, and healthier communities.

4. Full funding of existing federal programs will help lower harmful pollution from diesel engines on the road today. Programs like the Texas Emission Reduction Program, California's Carl Moyer program, the Congestion Mitigation Funds under federal transportation legislation (SAFETEA-LU), and the federal Diesel Emissions Reduction Act exist to hasten the transition to new, cleaner engines. Retrofitting diesel engines with pollution control technology is a cost-effective way of reducing NO_x and particulate pollution and protecting human health—in fact every dollar spent can reap at least $12 in health benefits. The Diesel Emissions Reduction Act was adopted with overwhelming bipartisan support but has received only meager appropriations. The federal government can help address the health burden from diesel engines on the road today by fully funding diesel clean-up programs without taking money away from other clean air programs. State and local governments can leverage federal funds by setting up their own incentive programs.

APPENDIX A

Methodology for estimating health benefits of locomotive emission reductions

This report presents technical analysis of the estimated health benefits associated with reducing emissions of $PM_{2.5}$ and NO_x by adopting new national emissions standards for diesel locomotives. In 2004 the EPA issued an Advance Notice of Proposed Rulemaking (ANPRM) that announced the agency's intent to propose new standards for diesel locomotives modeled after the 2007/2010 highway and Tier 4 nonroad diesel engine programs.[110] Although the EPA stated that it would issue a Final Rule by mid-2006, it has not yet proposed new standards for diesel locomotives.

This analysis estimates the benefits of $PM_{2.5}$ and NOx reductions over a range of scenarios that consider different emissions standards for new diesel locomotives (expressed in grams per brake horsepower-hour or g/bhp-hr) and different years in which the new standards would become effective. The estimated health and monetary benefits are based on EPA estimated benefits of the Nonroad Diesel Engine Rule.[111]

Estimating diesel locomotive $PM_{2.5}$ and NO_x emissions

EPA is revising its estimates of $PM_{2.5}$ and NO_x emissions from diesel locomotives. The revised estimates are expected to be significantly higher than the emissions considered in the ANPRM. Accordingly, the estimated $PM_{2.5}$ and NO_x emissions used in this analysis are based on EPA draft model results as illustrated in the agency's July 13, 2006 presentation to the California Air Resources Board (CARB) and shown in Table A1.[112] To maintain consistency with the EPA benefits analysis for the Nonroad Diesel Engine Rule, the current analysis focuses on $PM_{2.5}$ and NO_x reductions in the year 2030.

Due to data constraints within the presentation of EPA draft model results and the Association of American Railroads' (AAR) estimates of in-service locomotives, this analysis considers emissions from Class 1 railroad locomotives only, and excludes emissions from switcher, passenger and Class 2 and 3 locomotives.[113] Therefore, the analysis produces a conservative estimate of the health benefits of tighter emissions standards for diesel locomotives.

Existing emissions standards for diesel locomotives are shown in Table A2. Because EPA has not yet announced Tier 3 emissions standards for new diesel locomotives, this analysis assumes alternative Tier 3 standards that represent 50%, 75%

TABLE A1

Estimated annual $PM_{2.5}$ and NO_x emissions from diesel locomotives in 2030 (tons per year)

Locomotive category	$PM_{2.5}$	NO_x
Switchers, passenger, Class 1 & 2	3,500	140,000
Uncontrolled (pre-1973 fleet)	100	5,000
Tier 0 (1973–2001 fleet)	2,800	50,000
Tier 1 (2002–2004 fleet)	2,000	20,000
Tier 2 (2005 and after fleet)	18,000	625,000
Total	26,400	840,000

Source: USEPA, EPA Rulemaking for Clean Diesel Locomotives, CARB presentation, July 2006

TABLE A2

Emissions standards for diesel locomotives

Emissions standard	PM emissions standard (g/bhp-hr)		NO_x emissions standard (g/bhp-hr)	
	Current[a]	Assumed	Current[a]	Assumed
Uncontrolled (pre-1973 fleet)				
Tier 0 (1973–2001 fleet)	0.60	0.20	9.50	5.50
Tier 1 (2002–2004 fleet)	0.45	0.20	7.40	5.50
Tier 2 (2005 and after fleet)	0.20	0.20	5.50	5.50
Tier 3 (2011 and after fleet)				
90% reduction from Tier 2	-	0.02		0.55
75% reduction from Tier 2	-	0.05		1.38
50% reduction from Tier 2	-	0.10		2.75

Source: 40 CFR 92, July 1, 2000 as reported in Bureau of Transportation Statistics, Table 4-35: Federal Exhaust Emission Standards for Diesel Locomotives.

[a] Current emissions standards for line-haul locomotives.

and 90% emissions reductions from existing Tier 2 standards. The analysis assumes that the new Tier 3 standards will become effective in 2011, 2013 or 2015 and that Tier 0 and Tier 1 standards will conform with Tier 2 levels when the new Tier 3 standards become effective.

Under existing emissions standards, all locomotives built or rebuilt between 2005 and 2030 must comply with Tier 2 standards. Under the proposed standards discussed in the ANPRM, locomotives built after 2011 would be required to meet new Tier 3 standards, while locomotives built between 2005 and 2010 would remain subject to Tier 2 standards.

The health benefits of new emissions standards for diesel locomotives are based on reductions in $PM_{2.5}$ and NO_x emissions under the new standards from the emissions that would occur under the existing standards. Within this analysis, emissions reductions for Tier 3 locomotives were estimated by applying a 90%, 75% or 50% reduction to the emissions that would have been emitted under Tier 2 standards. The analysis also assumed that unit-level emissions from Tier 2 locomotives would not change under the new standards but overall levels of $PM_{2.5}$ and NO_x (tons per year) emitted by Tier 2 locomotives would fall because fewer locomotives are included in this category. Emission reductions for Tier 1 and Tier 0 locomotives were estimated by applying

TABLE A3

Estimated emissions reductions (tons per year) achieved by new diesel locomotive emissions standards—alternative Tier 3 standards and implementation years

Reduction in Tier 3 standards from Tier 2 standards	Year new Tier 3 standard become effective					
	$PM_{2.5}$			NO_x		
	2011	2013	2015	2011	2013	2015
90%	15,439	14,193	12,947	458,880	415,611	372,342
75%	13,362	12,324	11,285	386,765	350,707	314,649
25%	9,901	9,209	8,516	266,572	242,534	218,495

the lower emissions standards, also expressed as a percent reduction from the existing standard, to the emissions that would otherwise be emitted.

Emissions reductions within each tier were summed to estimate total $PM_{2.5}$ and NO_x reductions under alternative Tier 3 standards and implementation dates. The results of this analysis are summarized in Table A3.

Benefit estimates

Estimation of the health benefits associated with new diesel locomotive emissions standards is based on $PM_{2.5}$ and NO_x emissions reductions, health benefits and monetary benefits associated with the Nonroad Diesel Engine Rule as reported in Chapter 9 of the Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines. As part of this RIA, EPA conducted a rigorous analysis of the emissions reductions and benefits associated with the proposed rule (preliminary scenario), which included deeper emissions reductions than the final rule. In order to avoid the scaling adjustments EPA applied to the final Nonroad Diesel Engine Rule, this analysis is based on the preliminary EPA scenario.

Our analysis of the health benefits associated with new locomotive emissions standards applies the ratio of $PM_{2.5}$ and NO_x emissions reductions under each scenario illustrated in Table A2 to the emissions reductions and health benefits achieved under the Nonroad Diesel Engine Rule. The analysis applies several simplifying assumptions. Although the health benefits associated with lower emissions from diesel locomotives span several years, future benefits that occur in later years are not discounted. Although there is a time lag between reductions in $PM_{2.5}$ concentrations and decreases in the occurrence of adverse health effects, this analysis assumes full realization of reductions in $PM_{2.5}$ concentrations and reductions in adverse health impacts. Our analysis further assumes that the dispersion modeling conducted to support the non-road rule applies to locomotives.

The current analysis estimates the monetary value of the health benefits associated with tighter emissions standards for diesel locomotives by applying the unit values used for economic valuation of the PM-related health endpoints reported in the Nonroad Diesel Engine Rule RIA to the (health) incidence reductions associated with each Tier 3 standard/implementation year scenario. All monetary values are expressed in 2000 dollars. PM-related health endpoints include premature mortality, chronic bronchitis, non-fatal heart attacks, respiratory hospital admissions, acute bronchitis, asthma exacerbations, upper and lower respiratory symptoms, work loss days and minor restricted activity days.

With the exception of non-fatal heart attacks, the Nonroad Diesel Engine Rule RIA expresses the monetary values of health-related benefits associated with reduced ambient $PM_{2.5}$ concentrations as point estimates. The monetary benefits of reduced non-fatal heart attacks assume avoided illness costs and lost earnings in later years and are discounted at a 3% and 7% discount rate. The current analysis applies the 7% discount rate as it more closely reflects the social cost of capital. The economic value of reduced work loss days was estimated using July 2006 average national earnings data from the Bureau of Labor Statistics.

Glossary

Class 1 railroad: Class 1 railroads are the largest freight railroads, as classified by operating revenue. There are seven Class 1 railroads that operate in the United States: Burlington Northern Santa Fe Railway (BNSF), CSX Transportation, Kansas City Southern (KCS), Union Pacific (UP), Norfolk Southern, Canadian Pacific (CP) and Canadian National (CN). Class 1 railroads typically operate in many different states and concentrate largely on long-haul, high-density intercity transport.

Class 2 railroad: Class 2 railroads are line-haul railroads with at least 350 route miles and/or revenue between $40 million and the Class 1 threshold. They typically operate 400 to 650 miles in two to four states.

Class 3 railroad: Class 3 railroads, or local line-haul railroads, operate less than 350 route miles and earn less than $40 million. They generally perform point-to-point services over short distances. Most operate less than 50 miles of track and serve a single state.

Freight transport vs. passenger transport: Freight transport involves moving goods or produce, while passenger transport involves the movement of people. All Class 1 railroads are used for freight transport.

Idling: An engine is idling when it is running while the train is stationary.

Intermodal: Intermodal transport involves more than one mode of transport. For example, moving goods by ship then by train is described as intermodal.

Line-haul trains: Locomotives can perform two different types of operations: line haul (or long haul) and switch (or yard). In the line-haul operations, locomotives generally travel between distant locations. In the switch operations, locomotives are primarily responsible for moving railcars within a particular railway yard.

National Ambient Air Quality Standards (NAAQS): The Clean Air Act provides for two types of national ambient air quality standards. *Primary standards* are requisite to protect public health with an adequate margin on safety. *Secondary standards* are requisite to protect public welfare from any known or anticipated adverse effects including effects on climate, soils, water, crops, vegetation, wildlife and visibility.

Nonattainment Area: Any area of the country that does not meet, or that contributes to ambient air quality in a nearby area that does not meet, the national primary or secondary ambient air quality standard for a pollutant.

Oxides of nitrogen (NO_x): The generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. NO_x combines with volatile organic compounds to create ground-level ozone, or smog. It also can combine with ammonia to create particulate matter. In addition, NO_x contributes to acid rain and eutrophication of water bodies.

Ozone: Ground-level ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOC) in the presence of sunlight.

PM: Particulate matter is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. $PM_{2.5}$, or fine particles, refers to tiny particles or droplets in the air that are two and one half microns or less in width. Fine particles, such as those found in smoke and haze, can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.

Switcher trains: Rather than traveling long distances like long-haul trains, switcher locomotives perform pick-up and delivery services within a rail yard, or switchyard. They are used to assemble and disassemble trains, move railroad cars around the yard, and transfer cargo to and from long-haul trains.

Switchyard: An area where railroad cars are switched and trains assembled.

Ton-mile: A unit of freight transportation equivalent to a ton of freight moved one mile.

Notes

1 Power plant comparisons are based on 0.25 lb/MWh of $PM_{2.5}$ and 4.22 lb/MWh of NOx for power plants, which are the averages for existing coal plants in the western U.S.

2 Estimated health impacts combine 2006 Census population estimates and EPA's estimated 2006 diesel locomotive emissions with EPA's methodology for estimating the health benefits of the non-road diesel rule, which is described in EPA's Regulatory Impact Analysis for the Clean Air Nonroad Diesel—Tier 4 Final Rule, May 2004, and available at www.epa.gov/nonroad-diesel/2004fr.htm

3 Our analysis assumes that these new standards (Tier 3) would apply to any new locomotive manufactured after the start date of the program. We also assume that under any new program, regardless of the strength of the new standard, all locomotives currently subject to Tier 0 and Tier 1 standards, would be required to meet Tier 2 standards when remanufactured.

4 Our analysis produced conservative results for a number of reasons. Due to data constraints, this analysis excludes the significant emissions from switcher locomotives. Also, our analysis focused on the health effects of particulates and NO_x's contribution to particulates. Therefore, we did not include the important and significant ozone-related health benefits from NO_x reductions and the new science linking mortality to ozone. Finally, we did not include ecological benefits from particulate and NO_x reductions.

5 U.S. Department of Health and Human Services, "Tenth Report on Carcinogens," National Toxicology Program, Research Triangle Park, NC, 2002. California Office of Environmental Health Hazard Assessment and Air Resources Board, "Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant."

6 Manufacturers of Emission Controls Association, "Case Studies of the Use of Exhaust Emission Controls on Locomotives and Large Marine Diesel Engines," October 2006.

7 See www.fatbadgers.co.uk/Britain/inventors.htm.

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20 American Association of Railroads, January 2006. "Railroads: Building a Cleaner Environment." Available at: http://www.aar.org/getFile.asp?File_id=364

21 American Association of Railroads, January 2006. "Railroads: Building a Cleaner Environment." Available at: http://www.aar.org/getFile.asp?File_id=364

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"Freight-Rail Bottom Line Report," pg. 29. Available at http://freight.transportation.org/doc/FreightRailReport.pdf

[23] Union Pacific factsheet, "Union Pacific and the Environment." Available at: http://www.uprr.com/she/emg/attachments/whitepaper.pdf

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[30] EPA PowerPoint presentation by Don Kopinski presented to California Air Resources Board Locomotive Emissions Meeting, "EPA's Rulemaking for Clean Diesel Locomotives," July 13, 2006.

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[36] Estimated health impacts combine 2006 Census population estimates and EPA's estimated 2006 diesel locomotive emissions with the EAP's methodology for estimating the health benefits of the non-road diesel rule.

[37] EPA Office of Air Quality, Planning and Standards, *Welcome to the Green Book—Nonattainment Areas for Criteria Pollutants.* http://www.epa.gov/oar/oaqps/greenbk/

[38] 69 Fed. Reg. 39,276 (June 29, 2004).

[39] 63 Fed. Reg. 18,977 (April 16, 1998).

[40] 69 Fed. Reg. 39,276 (June 29, 2004). "[EPA is considering emission standards for new locomotives built as early as 2011, based on the application of advanced emission control technologies. These technologies are currently being developed for use in highway and nonroad applications and will begin to see widespread use in these applications starting in 2007. In those programs, we estimated that NO_x and PM emissions could be reduced by 90 percent or more from emission levels in the exhaust leaving the engine through the use of NO_x aftertreatment and PM filter technologies. We would expect that similar levels of NO_x and PM reductions could be achieved by applying these technologies to locomotives as well." Page 39281–39282

[41] "We believe that, given adequate development lead time and appropriate structuring of phase-in provisions, locomotive and marine diesel engines could be designed to successfully employ the same high-efficiency exhaust emission control technologies now being developed for highway and nonroad engine use." 69 Fed. Reg. 39,276, 39280 (June 29, 2004)

[42] 69 Fed. Reg. 39,276 (June 29, 2004).

[43] 69 Fed. Reg. 39,276 (June 29, 2004).

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[53] U.S. Census Bureau, 2000.

[54] U.S. DOT Federal Highway Administration's Freight Analysis Framework, State Profile-Texas. Available at: ops.fhwa.dot.gov/freight/freight_analysis/state_info/texas/profile_tx.htm.

[55] EPA website, "8-hour ground level ozone designations." Available at: http://www.epa.gov/ozonedesignations/regions/region6desig.htm

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