Diesel and Health in America:
The Lingering Threat

CLEAN AIR TASK FORCE

February 2005

Find out about the risks
of breathing diesel exhaust
where you live:

www.catf.us/goto/dieselhealth

CLEAN AIR **TASK FORCE**

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Foreword

Scientists have been examining relationships between air pollution and death and disease for decades but only now are we beginning to understand the impacts of one of the most toxic sources of emissions today – the diesel engine. Diesels churn out a hazardous mix of gaseous and particle pollutants. What's more, diesel exhaust is emitted at ground level – where we breathe it – by trucks and buses around us in traffic, at school and transit bus stops, and by heavy construction or agricultural equipment. Diesel exhaust contains numerous dangerous compounds, ranging from respiratory irritants to carcinogens including a host of air toxics, particulate matter, carbon monoxide and nitrogen oxides.

While scientists have concluded that combustion-related particulate matter from all combustion sources is associated with premature death from heart attacks and cancer, we also are finding that carbon particles from mobile sources may be particularly unhealthy. These particles adsorb other metals and toxic gases produced by diesel engines – such as cancer causing-PAH (polycyclic aromatic hydrocarbons) – onto their surfaces making them even more dangerous. Furthermore, research on personal exposures demonstrates that these small particles easily penetrate our indoor environment where they may be trapped for days when ventilation is poor.

This report presents for the first time estimates of the health toll from diesel vehicle pollution. Using methodology approved by the U.S. Environmental Protection Agency's Science Advisory Board (SAB), the analysis finds that approximately 21,000 people die prematurely each year due to particulate matter pollution from diesels. Other serious adverse health impacts include tens of thousands of heart attacks, asthma attacks, and other respiratory ailments that can lead to days missed at work and at school.

Using more highly time-resolved studies we are increasingly able to understand the inflammation mechanism by which particles can lead to atherosclerosis, heart attacks, strokes and ultimately, untimely deaths. From all we know today, we can confidently say that reducing diesel exhaust in our environment will mean improving public health, and as this report demonstrates, reducing preventable premature deaths. We do not need to wait. Technology is available today that can reduce particulate matter emissions by up to 90 percent. Now is the time to clean up our old trucks, buses, heavy equipment and locomotives to provide a cleaner future for us and our children.

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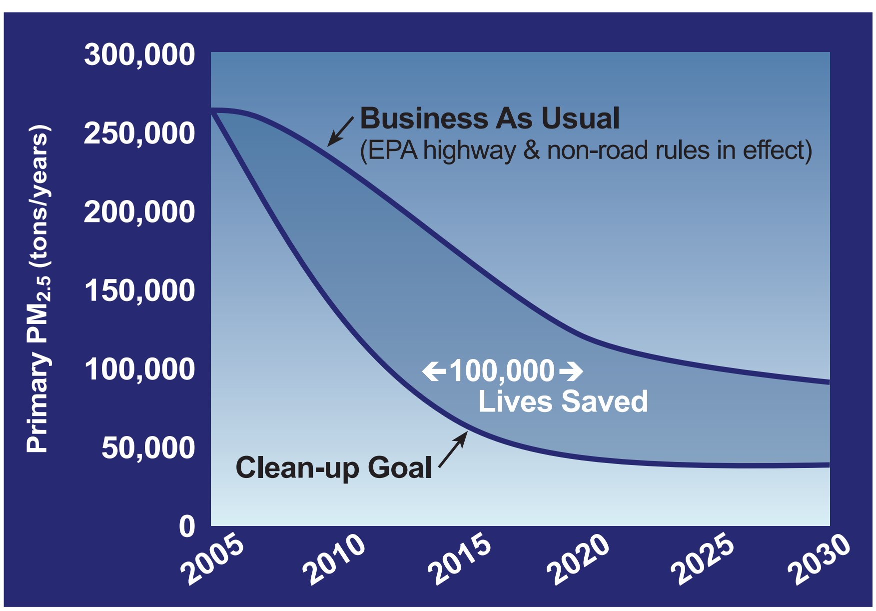
Executive Summary

Everyone has experienced it: getting hit right in the face by a cloud of acrid diesel smoke. Perhaps you were standing on a street corner when a bus or truck whizzed by. Or maybe you were standing at a bus stop or stuck behind a dump truck grinding up a hill. But breathing diesel exhaust isn't just unpleasant. It is hazardous to your health. In fact, health research indicates that the portion of the exhaust you can't see may be the most dangerous of all. Asthma attacks, respiratory disease, heart attacks, and even premature death – all of these are among the most serious public health problems linked to emissions from the nation's fleet of diesel vehicles. The good news is that the technology exists right now to clean up emissions from these engines, so that most of the adverse health impacts can be prevented.

Today in the U.S. more than 13 million diesel vehicles help to build our cities and towns, transport our food and goods, and take us to and from work. More than three quarters of all Americans live near intersections, bus stops, highways, bus and truck depots, or construction sites with heavy equipment – all of which are concentrated sources of diesel exhaust. In rural areas, those who live near heavy diesel agricultural equipment suffer their share of exposure to diesel as well.

The U.S. Environmental Protection Agency has issued important regulations that will require dramatic reductions in emissions from new diesel vehicles starting in 2007 – but only the new ones. These regulations, to be phased in over the next quarter century, apply only to ***new*** engines. What about the diesels on the road today? The lifespan of the average diesel vehicle is nearly 30 years. Many diesels are driven over a million miles. Because of this longevity, we will be left with the legacy of pollution from dirty diesel vehicles for decades to come. That is, ***unless*** we take action to reduce emissions from vehicles currently on the road. We don't have to wait. Control technologies exist right now that can significantly reduce deadly fine particle emissions from diesel vehicles, in some cases by upwards of 90 percent.

American know-how, witnessed by the success of the manufacturers of engines, control devices, and fuel refiners in developing innovative solutions for reducing diesel exhaust, provides a lifesaving opportunity we can seize today. Pollution from dirty diesels on the road now can be dramatically reduced using a combination of cleaner fuels, retrofit emission controls, rebuilt engines, engine repowerings, and accelerated purchase of new, cleaner vehicles. Unlike so many other vexing environmental issues, these affordable solutions present a highly unusual opportunity to actually address a major risk to public health and the environment. In fact, we could virtually eliminate this problem if diesel manufacturers, fleet owners, environmentalists, concerned citizens, and government regulators make the commitment to work together.



An Aggressive Program to Reduce Diesel Emissions Could Save About 100,000 Lives between Now and the Year 2030.

What are the health impacts of these dirty diesel vehicles? What benefits will we realize if we act now to clean them up? The Clean Air Task Force commissioned Abt Associates, an highly-respected consulting firm that U.S. EPA and other agencies rely upon to assess the benefits of national air quality policies, to quantify for the first time the health impacts of fine particle air pollution from America's diesel fleet. Using this information, we were able to estimate the expected benefits – in lives saved – from an aggressive but feasible program to clean up dirty diesel buses, trucks, and heavy equipment across the U.S.

This report summarizes the findings of the Abt Associates study. It then reviews the degree to which diesel vehicles increase the level of fine particle pollution in the air we breathe, and recommends reduction measures that will save thousands of lives each year.

Key findings include:

- Reducing diesel fine particle emissions 50 percent by 2010, 75 percent by 2015, and 85 percent by 2020 would save nearly 100,000 lives between now and 2030. These are additional lives saved above and beyond the projected impact of EPA's new engine regulations.
- Fine particle pollution from diesels shortens the lives of nearly 21,000 people each year. This includes almost 3,000 early deaths from lung cancer.
- Tens of thousands of Americans suffer each year from asthma attacks (over 400,000), heart attacks (27,000), and respiratory problems associated with fine particles from diesel vehicles. These illnesses result in thousands of emergency room visits, hospitalizations, and lost work days. Together with the toll of premature deaths, the health damages from diesel fine particles will total $139 billion in 2010.
- Nationally, diesel exhaust poses a cancer risk that is 7.5 times higher than the ***combined*** total cancer risk from all other air toxics.
- In the U.S., the average lifetime nationwide cancer risk due to diesel exhaust is over 350 times greater than the level U.S. EPA considers to be "acceptable" (i.e., one cancer per million persons over 70 years).
- Residents from more than two-thirds of all U.S. counties face a cancer risk from diesel exhaust greater than 100 deaths per million population. People living in eleven urban counties face diesel cancer risks greater than 1,000 in a million – one thousand times the level EPA says is acceptable.
- People who live in metropolitan areas with a high concentration of diesel vehicles and traffic feel their impacts most acutely. The risk of lung cancer from diesel exhaust for people living in urban areas is three times that for those living in rural areas.

The vast majority of the deaths due to dirty diesels could be avoided by an aggressive program over the next 15 years to require cleanup of the nation's existing diesel fleet. Practical, affordable solutions are available that can achieve substantial reductions in diesel risk. The only thing that stands between us and dramatically healthier air is the political will to require these reductions and the funding to make it a reality.

What We Must Do to Protect Public Health from Today's Dirty Diesels.

Although the EPA has mandated the phase-in of cleaner new engines and fuels beginning in 2007 for highway vehicles and heavy equipment, EPA has limited authority to mandate emissions controls on the fleet of existing diesel vehicles. To date, EPA has adopted a "voluntary" approach. Nevertheless, in order to meet the new ambient air quality standards for fine particles, states and cities must require controls to reduce diesel emissions. Diesel cleanup is also an important next step in areas that are having difficulty meeting existing and new ambient air quality standards for ozone such as Houston and Dallas, Texas.

States can enact legislation requiring diesel cleanup as some, such as California and Texas, have already begun to do. States should also consider measures to require early engine retirement and speed fleet turnover. For vehicles like long-haul trucks, ships, and locomotives that are engaged in interstate transport, federal regulations, federal legislation, or both may be needed. Funding for such initiatives may pose a challenge for public fleets (school buses, transit vehicles, garbage trucks, etc.), so support for expanded state and federal funding to help the cleanup of fleets owned by cash-strapped states and cities will be necessary. Local and state budget writers will need a strong commitment to come up with the necessary appropriations or bonds to fund the local share.

Particle filters combined with the use of Ultra Low Sulfur Diesel (ULSD) fuel have been found to reduce diesel particles and particle-bound toxics from diesel exhaust by up to 90 percent. Under the new engine rules, ULSD will be available for highway vehicles nationwide starting in 2006. It is already available in cities in 21 states. Not all vehicles can be retrofitted with a particle filter, but there are a variety of options available for the cleanup of every vehicle regardless of make or model year.

Cities and states should:

- Establish ambitious goals for reducing risk to their citizens by cleaning up existing diesels;
- Identify priority geographic areas and diesel "hotspots" for immediate attention;
- Adopt a package of options for reducing diesel exhaust including:
  - Retrofits accomplished by replacing mufflers with an optimal mix of filters or oxidation catalysts depending on vehicle age and type;
  - Requiring Ultra Low Sulfur Diesel and cleaner alternative fuels;
  - Closed crankcase ventilation systems to eliminate engine exhaust from penetrating the cabin of vehicles such as school and transit buses;
  - Engine rebuild and replacement requirements;
  - Truck stop electrification programs to give long-haul truckers a way to power their rigs overnight without running their engines;
  - Contract specifications requiring cleanup of trucks and construction equipment used in public works projects.
- Adopt diesel cleanup measures as federally-enforceable requirements in State Implementation Plans (SIPs) for the attainment of the fine particle and ozone air quality standards;
- Create and fund programs, such as California's "Carl Moyer" and the Texas Emission Reduction Plan (TERP) program, which provide funding for diesel equipment owners to replace or rebuild high-polluting diesel engines;
- Adopt and enforce anti-idling ordinances and legislation.

The Federal government should:

- Pass legislation providing funding for the cleanup of municipal and state fleet vehicles;
- Explore regulatory options for reducing emissions from existing interstate fleets such as long-haul trucks, shipping, and locomotives;
- Retain and enforce the tighter new engine and cleaner fuel standards for highway and non-road diesels.

NESCAUM

Retrofits are effective in reducing particle emissions from heavy equipment. The tractor on the left is retrofitted with a particle emissions control device.

New Findings

While numerous medical studies have linked diesel exhaust to a host of serious adverse health outcomes, no single study has yet quantified the death and disease attributable to diesel across America – until now. Researchers estimate that as many as 60,000 people in the U.S. die prematurely each year because of exposure to fine particles from all sources.[1] And some researchers believe that this figure may even underestimate the total number of particle-related deaths.[2] A reanalysis of the major particle mortality study in over 150 cities suggests that particles from motor vehicles may be more toxic than average.[3]

We know that diesel exhaust is a hazardous mixture of gases and particles including carcinogens, mutagens, respiratory irritants or inflammatory agents and other toxins that cause a range of diverse health effects. Diesel particles act like magnets for toxic organic chemicals and metals. The smallest of these particles (ultrafine particles) can penetrate deep into the lung and enter the blood-stream, carrying with them an array of toxins.[4] Diesel exhaust can contain 40 hazardous air pollutants as listed by EPA, 15 of which are listed by the International Agency for Research on cancer (IARC) as known, probable or possible human carcinogens.[5] Thousands of studies also have documented that fine particles are associated with respiratory and cardiovascular diseases and death. Additional studies have documented effects in infants and children such as Sudden Infant Death syndrome (SIDS) and retarded lung development.[6]

Now, for the first time, this report reveals the staggering toll of death and disease from diesel exhaust in our air – and the dramatic benefits of requiring the cleanup of the nation's existing diesel fleet. Abt Associates, using peer-reviewed, state-of-the-art research methodology employed by U.S. EPA in assessing the national benefits of proposed

National Annual Diesel Fine Particle Health Impacts[7]	
Annual Cases in the U.S., 2010	
Premature Deaths	21,000
Lung Cancer Deaths	3,000
Hospital Admissions	15,000
Emergency Room Visits for Asthma	15,000
Non-fatal Heart Attacks	27,000
Asthma Attacks	410,000
Chronic Bronchitis	12,000
Work Loss Days	2,400,000
Restricted Activity Days	14,000,000

rules and legislation, finds that nearly 21,000 people will die prematurely in 2010 in the U.S. as a result of exposure to fine particle emissions from mobile diesel sources (i.e., all on-and non-road engines such as highway, construction, rail, and marine engines). The average number of life-years lost by those who die prematurely from exposure to fine particles is 14 years.[8]

The deaths from diesel fine particle pollution equal or exceed the death toll from other causes commonly understood to be major public policy priorities. For instance, drunk driving causes more than 17,000 deaths per year.[9] There are more than 20,000 homicides in the U.S. each year.[10] Moreover, the approximately 15,000 premature deaths per year that could be avoided by achieving a 75 percent diesel-risk-reduction target exceed the 11,000 automobile fatalities avoided each year through the use of safety belts.[11]

The Abt Associates analysis further shows that hundreds of thousands of Americans suffer from asthma attacks, cardiac problems, and respiratory ailments associated with fine particles from diesels. These health damages result in thousands of respiratory and cardio-pulmonary related hospitalizations and emergency room visits annually as well as hundreds of thousands of lost work days each year. For instance, the study finds that diesel pollution leads to 27,000 heart attacks and 400,000 asthma attacks each year.[12]

You can find the adverse health impacts from diesel for your state, metropolitan area, and county on the web at: **www.catf.us/goto/dieselhealth**.

The risk from diesel exhaust can be virtually eliminated by the application of emissions control strategies available today. For example, an aggressive but feasible program to reduce diesel particle emissions nationwide 50 percent by 2010, 75 percent by 2015, and 85 percent by 2020 would save about 100,000 lives between now and 2030 – beyond those lives that will be saved under EPA's new engine regulations.[13] Indeed, in the year 2000, the State of California set a Diesel Risk Reduction goal of a 75 percent reduction in diesel risk by 2010 and 85 percent by 2020 and the California Air Resources Board over the past few years has begun to issue regulations to achieve it.[14]

Cancer Risk

CATF has calculated the national average lifetime excess cancer risk posed by diesel. We base these estimates on 1999 modeled directly-emitted diesel fine particle concentrations and by applying both the EPA range of individual risk estimates and the California Air Resources Board (CARB) diesel risk factor for lung cancer over the U.S. population.[15] Although EPA has found diesel exhaust to be a "likely" human carcinogen, EPA has not adopted a risk factor but has, instead, provided a range of lung cancer risk.[16] Based on the national average diesel particulate matter concentration, we find average lung cancer risk ranges from 12 to 1210 per million people over a 70-year lifetime using EPA's range of lung cancer risk.[17] Using the same methodology, CATF finds that, based on the single CARB risk factor, the nationwide average lifetime cancer risk posed by diesel exhaust is over 350 times greater than EPA's "acceptable" level of one cancer in a million.

For comparison, according to EPA's 1999 NATA assessment, the combined risk from all other air toxics is 48 per million.[18] Therefore, diesel exhaust presents a lung cancer risk that is 7.5 times higher than the cancer risk of all other air toxics – ***combined!***[19] In addition, CATF has calculated the cancer risk posed by diesel for residents of each U.S. county. Residents of over two-thirds of U.S. counties experience a cancer risk greater than 100 in a million from diesel exhaust. Moreover, residents of eleven urban U.S. counties face a diesel cancer risk equal to 1,000 new cases of cancer in a population of one million.

People who live in metropolitan areas with a high concentration of diesel vehicles and traffic feel their impacts most acutely. For example, the estimated risk of lung cancer from diesel in metropolitan areas is much higher than in areas with fewer diesels. In the rural counties we estimate a risk of 142 cancers per million based on the CARB unit risk, but three times that rate, 415 cancer per million, in urban counties. Therefore, the risk of lung cancer for people living in urban areas is three times that for those living in rural areas.[20]

You can find the community cancer risk from diesel for your state, metropolitan area, and county on the web at: **www.catf.us/goto/dieselhealth**. Personal risk varies with location and lifestyle. For example, if you live near a bus, truck, or train terminal, highway, construction site, or warehouse, or commute to work on congested roadways, your exposure may be higher than indicated by the county-wide average estimated here.

The Economic Toll of Health Effects

Respiratory distress severe enough to require a trip to the emergency room can be a terrifying experience for patients and their families. Victims of asthma attacks say that during an attack they wonder if and when their next breath will come. In addition to its serious physical and emotional costs, air pollution also takes a large monetary toll. Emergency room and hospital treatment costs can cripple a family financially, with the average stay for a respiratory ailment lasting about a week.[21] Bouts of respiratory illness and asthma attacks mean lost workdays and lost productivity. Although life is priceless, the government often monetizes loss of life when setting policies related to health and environmental protection. Using accepted valuation methodology employed by EPA in recent regulatory impact analyses, Abt Associates finds that the total monetized cost of the U.S. diesel fleet's fine particle pollution is a staggering $139 billion in 2010.

Pollution from motor vehicles, including diesels, can obscure city vistas such as illustrated in this split view of Dallas, Texas.

State and Metropolitan Area Findings

Using modeled concentrations of directly-emitted diesel fine particles throughout the lower 48 states, Abt Associates developed health impact estimates for every state and major metropolitan area in 1999, the latest year for which EPA's best emissions inventory for diesel fine particles is available.[22] Not surprisingly, heavily populated states with concentrated urban areas and significant diesel traffic fared the worst. Conversely, rural areas with a lower concentration of diesel vehicles fared much better. Similarly, metropolitan areas with large populations and heavy concentrations of diesel vehicles feel the impacts of diesel pollution most acutely.[23] In such large metropolitan areas, many hundreds of lives are shortened every year. However, because these state and metropolitan-area health estimates include only fine particles that are ***directly emitted*** from diesels – excluding any secondarily-formed particles from diesel emissions of nitrogen or sulfur oxides – they significantly understate the total adverse impact of diesel-related particles on public health.[24] Moreover, these estimates exclude any health impacts due to diesel's contribution to ozone smog.

States: Health Impacts from Diesel Fine Particles (1999)

Rank	State	Deaths	Cancer Deaths	Heart Attacks	Asthma Attacks	Chronic Bronchitis	Work Loss Days	Restricted Activity Days
1	New York	2,332	169	3,692	51,251	1,499	318,532	1,827,525
2	California	1,784	144	2,263	49,499	1,356	292,622	1,683,642
3	Pennsylvania	1,170	103	1,660	19,021	575	110,404	643,926
4	New Jersey	880	77	1,382	17,926	535	107,364	620,975
5	Texas	879	83	1,070	25,348	664	148,394	854,045
6	Illinois	878	76	1,193	19,162	539	112,205	649,445
7	Florida	805	77	980	13,926	438	81,462	474,601
8	Ohio	769	72	1,002	14,464	422	83,963	489,355
9	Michigan	484	43	667	10,511	299	61,109	355,260
10	Massachusetts	475	43	727	9,925	289	61,842	355,473
11	Maryland	409	39	454	8,418	246	50,275	291,675
12	Indiana	369	36	483	7,372	209	42,730	249,056
13	Georgia	329	29	377	8,514	235	51,808	298,317
14	Louisiana	324	32	339	7,131	188	40,740	236,444
15	Missouri	305	28	377	5,435	157	31,476	183,033
16	North Carolina	301	29	347	6,518	189	39,589	229,591
17	Tennessee	269	26	283	5,169	150	30,870	179,656
18	Washington	248	23	308	6,201	181	37,787	218,889
19	Virginia	248	24	303	5,991	174	36,963	214,083
20	Wisconsin	226	18	320	4,789	137	27,923	162,404
21	Arizona	214	19	268	5,215	144	30,053	173,721
22	Connecticut	206	18	340	4,091	125	24,097	140,140
23	Kentucky	198	22	213	3,764	110	22,385	130,403
24	Minnesota	193	15	291	4,713	134	27,979	161,954
25	Alabama	175	16	184	3,200	92	18,646	108,961

Metro Areas: Health Impacts from Diesel Fine Particles (1999)

Metropolitan Area	Rank	Deaths	Cancer Deaths	Heart Attacks
New York, NY	1	2,729	202	4,342
Los Angeles, CA	2	918	72	1,193
Chicago, IL	3	755	65	1,021
Philadelphia, PA	4	727	69	990
Boston, MA	5	391	36	602
Houston, TX	6	356	35	444
San Francisco, CA	7	291	23	358
Miami, FL	8	288	23	358
Baltimore, MD	9	285	28	290
Detroit, MI	10	279	25	378
Pittsburgh, PA	11	237	21	340
Washington, DC	12	226	19	302
St. Louis, MO	13	217	20	263
Dallas, TX	14	205	19	258
Atlanta, GA	15	199	17	239
Tampa, FL	16	185	18	210
Phoenix, AZ	17	183	16	230
Cleveland, OH	18	180	15	232
Cincinnati, OH	19	171	18	219
Seattle, WA	20	165	15	208

Metropolitan Area	Rank	Deaths	Cancer Deaths	Heart Attacks
San Diego, CA	21	150	13	191
Portland, OR	22	140	13	157
Minneapolis, MN	23	133	11	205
New Orleans, LA	24	128	13	131
Riverside, CA	25	123	10	142
Baton Rouge, LA	26	102	10	109
Milwaukee, WI	27	95	8	130
Columbus, OH	28	84	9	113
Indianapolis, IN	29	82	8	107
Louisville, KY	30	82	9	91
Memphis, TN	31	81	7	79
Kansas City, MO	32	79	8	109
Providence, RI	33	76	7	119
Bridgeport, CT	34	69	6	121
Beaumont, TX	35	65	7	65
Orlando, FL	36	65	7	85
Allentown, PA	37	65	5	101
Hartford, CT	38	63	5	100
Las Vegas, NV	39	62	7	71
Virginia Beach, VA	40	62	6	65

Metro Areas: Per Capita Impacts from Diesel Fine Particles (1999)

Rank Based on Mortality Risk	MSA	Deaths per 100,000 Adults	Heart Attacks per 100,000 Adults	Cancer Risk per Million
1	Beaumont, TX	29	29	865
2	Baton Rouge, LA	27	29	992
3	New York, NY	25	40	959
4	Philadelphia, PA	22	29	658
5	Trenton, NJ	20	31	699
6	Baltimore, MD	19	19	584
7	Huntington, WV	18	18	477
8	New Orleans, LA	17	18	889
9	Pittsburgh, PA	15	22	415
10	Cincinnati, OH	15	19	504
11	Boston, MA	15	23	563
12	Chicago, IL	15	20	539
13	Mobile, AL	14	15	435
14	Longview, WA	14	15	441
15	Houston, TX	14	18	691
16	Allentown, PA	14	22	450
17	Cleveland, OH	14	18	416
18	Toledo, OH	14	17	423
19	Los Angeles, CA	14	18	633
20	Lancaster, PA	14	22	463
21	Scranton, PA	14	18	319
22	St. Louis, MO	14	17	405
23	Reading, PA	14	21	428
24	Lake Charles, LA	14	14	437
25	Springfield, OH	13	16	356
26	Portland, OR	13	14	488
27	Bridgeport, CT	13	22	494
28	Harrisburg, PA	12.	19	412
29	York, PA	12	21	460
30	Wheeling, WV	12	14	309
31	Lebanon, PA	12	19	373
32	Evansville, IN	12	15	368
33	Memphis, TN	12	12	397
34	Savannah, GA	12	13	376
35	Dayton, OH	12	16	389
36	Vineland, NJ	12	17	365
37	Tampa, FL	12	14	365
38	Louisville, KY	12	13	384
39	Sandusky, OH	12	15	345
40	Kankakee, IL	12	14	336
41	San Francisco, CA	12	14	480
42	Muncie, IN	11	14	327
43	Duluth, MN	11	14	308
44	Michigan City, IN	11	15	370
45	Salt Lake City, UT	11	14	533
46	New Haven, CT	11	18	365
47	Steubenville, OH	11	13	279
48	Milwaukee, WI	11	15	376
49	South Bend, IN	11	15	342
50	Detroit, MI	11	15	381

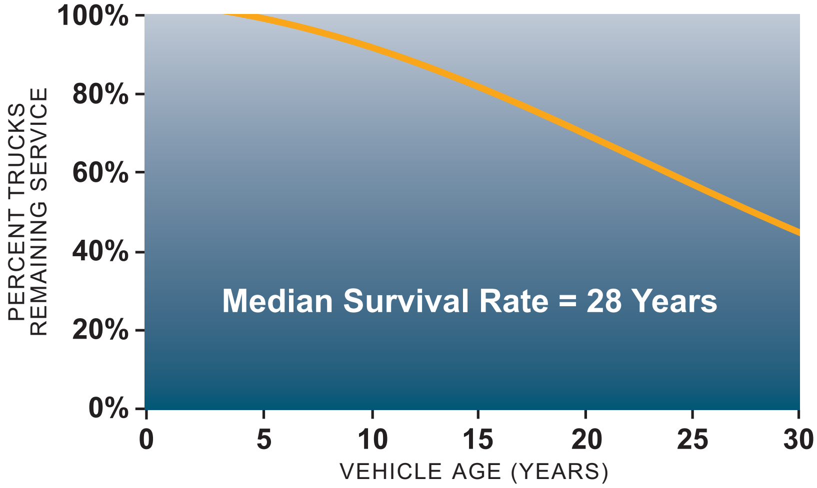
The Dirty Diesel Legacy

Since 1997, the U.S. EPA has promulgated major regulations that impose stringent emissions controls on new diesel vehicles, requiring tight emission standards and cleaner diesel fuel. These standards go into effect in 2007 and phase in over the next few decades. For example, the table below illustrates the progressively tighter standards for particulate matter and nitrogen oxides from trucks and buses over the next few years.

However, the emission rates of the diesel engines on the road and in use on construction sites and farms today are not affected by these rules. Considering that according to the U.S. Department of Energy the median lifetime for a heavy truck is nearly 30 years,[26] and a typical heavy duty diesel engine may power a truck for as long as one and a half million miles,[27] these vehicles will continue to pollute our air at unnecessarily high levels for years to come ***unless*** we act to clean them up now.

EPA Standards for New Trucks and Buses (g/bhphr)[25]

YEAR	NO_X	$PM_{2.5}$
1984	10.7	0.60
1991	5.0	0.25
1998	4.0	0.10
2004	2.0	0.10
2007	0.2	0.01



Median Heavy Truck Lifetime is Nearly 30 Years[28]

The Most Widespread Air Pollution Risk in the U.S.

There are few other sources of widespread pollution in our environment that rival diesel exhaust as an airborne toxin. America's 13 million diesel engines release a host of harmful substances including fine particles, ozone smog-forming nitrogen oxides, carbon monoxide, and a variety of toxic metals and organic gases such as formaldehyde, acrolein, and polycyclic aromatic hydrocarbons (PAH.)[29] In this report we focus on the respiratory, cardiovascular, and cancer effects of diesel fine particles only.[30]

Fine Particles are Linked to Heart Attacks, Asthma Attacks, and Stunted Lung Growth.

Fine particles have been linked to a wide variety of serious health impacts, from upper and lower respiratory ailments, such as asthma attacks and possible asthma onset, to heart attacks, stroke, and premature death, including crib death in children.[31] How risky is breathing air polluted with particles? A study published in the Journal of the American Medical Association found that living in the most polluted U.S. cities poses a risk similar to living with a smoker.[32] Based on thousands of studies compiled by EPA, federal health standards were established for fine particles in 1997.[34]

Health researchers have recently described serious health impacts of fine particles, including:

- Abnormal heart rhythms and heart attacks and atherosclerosis;[35]
- Increased incidence of stroke;[36]
- Permanent respiratory damage, characterized by fibrosis causing obstruction to airflow;[37]
- Chronic adverse effects on lung development resulting in deficits in lung function.[38]

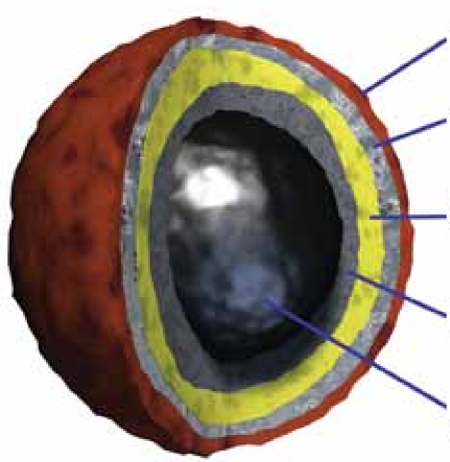
How Particulate Matter Kills

Fine particles, known as "$PM_{2.5}$", are particles less than 2.5 microns in diameter or 1/100th the width of a human hair, so small that they are often invisible. They can be deposited deep in the lung where they can affect both the respiratory and cardiovascular systems. Researchers believe that many deaths caused by particulate matter are related to cardiovascular illness. Fine particles aggravate cardiovascular disease and trigger heart attacks by invading the bloodstream and initiating an inflammatory response, disrupting heart rate and increasing blood clotting. In a recent experimental study, diesel particles caused blood clots providing "a plausible explanation for the increase in cardiovascular morbidity and mortality accompanying urban air pollution."[33]

Diesel Exhaust is a Likely Carcinogen that also Impairs Immune, Reproductive, and Nervous Systems.

In 1998, the Scientific Review Panel for the California Air Resources Board reviewed diesel exhaust as a toxic air contaminant and set a lifetime unit cancer risk from diesel particles at 3 in 10,000 persons for each microgram of annual average diesel exposure.[39] This is equivalent to 300 in a million excess lung cancers. In May 2002, EPA issued its Health Assessment for Diesel Exhaust which found diesel particulate matter to be a "likely" carcinogen. EPA did not settle on a unit risk factor but recommended a lifetime cancer risk range from 1 in 1,000 to 1 in 100,000.[40] The California unit risk falls within this range.[41]

> Diesel particles are carbon at their core with toxics and carcinogenic substances attached to their surfaces.



Applying California's cancer unit risk for diesel particulate matter to the national average concentration of directly-emitted diesel fine particles in 1999, results in a conservative estimate of 1,530 excess cases of lung cancer per year for 2005.[42] An American Cancer Society study of 150 metropolitan areas across the U.S published in 2002 supports the particulate matter cancer link.[43]

Other effects include:

- **Immune System Effects** – Diesel exposure is associated with numerous immune system responses in humans and animals culminating in increased allergic inflammatory responses and suppression of infection-fighting ability. These effects include disruption of chemical signals and production of antibodies, and an alteration in mobilization of infection-fighting cells.[44]
- **Reproductive, Developmental, and Endocrine Effects** – Diesel emissions have also been associated with reproductive, developmental and endocrine effects in animals. Specifically, diesel exposure has been associated in animals with decreased sperm production,[45] masculinization of rat fetuses,[46] changes in fetal development (thymus,[47] bone[48] and nervous system[49]) and endocrine disruption, i.e., production of adrenal and reproductive hormones.[50]
- **Nervous System Effects** – In addition to animal studies that have shown neurodevelopmental effects, a human study of railroad workers suggested that diesel exposure may have caused serious permanent impairment to the central nervous system.[51]

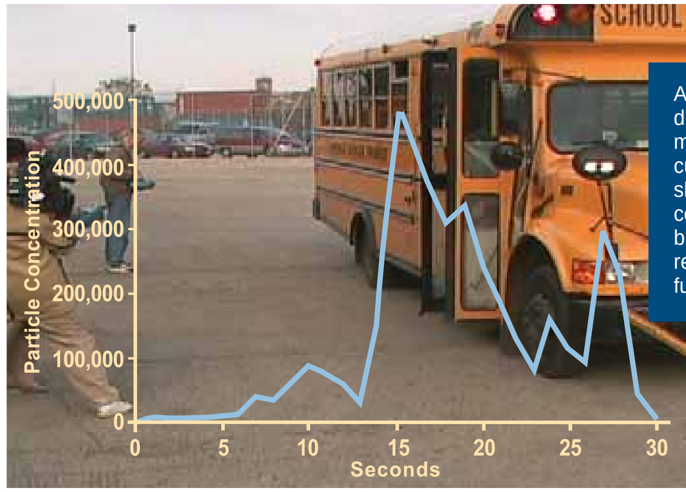
Cancer-causing Pollutants in Diesel Exhaust

Pollutant	Diesel Emissions % of all Mobile 1996[52]	EPA Carcinogen Status	Cancer Risk (per million/microgram in 70-yr life)
Formaldehyde	52%	probable	1 in a million
Acetaldehyde	59%	probable	1 in a million
Butadiene	8%	probable	2 in a million
Acrolein	50%	possible	n/a
Benzene	5%	known	2-8 in a million
Diesel Particulate Matter	77%	probable[53]	EPA: 12 to 1210 in a million; CARB: 300 in a million[54]

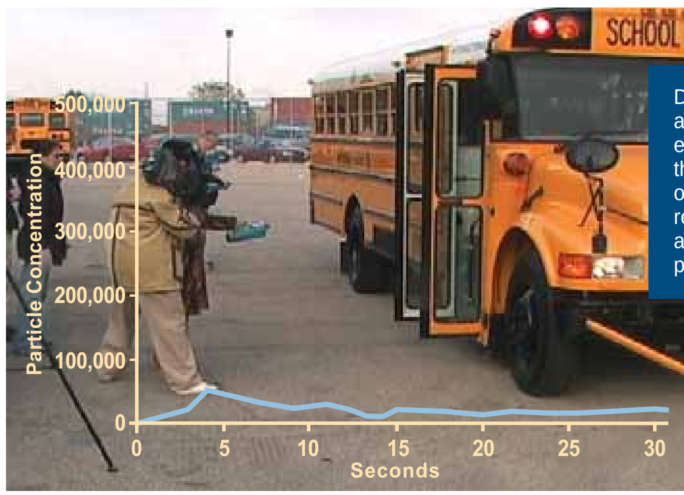
Children and Seniors are at Greatest Risk

Health researchers believe that children are more susceptible than adults to the adverse health effects of air pollution for a variety of reasons.[55] For example, children are more active than adults and therefore breathe more rapidly. Children also have more lung surface area compared to their body weight and therefore they inhale more air pound-for-pound than adults do. Compared to adults, children also have higher lung volume to body size, higher respiration rates, and spend more active time in the polluted outdoor environment. Fine particles have been linked in medical studies to serious health impacts in children such as slowed lung function growth, increased emergency room visits, increased incidences of asthma and bronchitis, and crib death. Furthermore, proximity to traffic has been linked to increased prevalence of asthma respiratory infections and allergic symptoms and asthma hospitalizations in children.[56]

Seniors are another important population at risk. Studies of the impacts of fine particles on seniors in Boston and Baltimore suggest that changes in their heart rhythms and control mechanisms occur when particle levels rise. In Phoenix, daily mortality increased in



At a bus stop, diesel particles measured at the curb spike sharply from a conventional bus running on regular diesel fuel.



Diesel particles are virtually eliminated when the bus is run on ULSD and retrofitted with a diesel particulate filter.

Children Exposed on School Buses

CATF Study: Cabin particulate matter eliminated with retrofit emissions controls.

Twenty four million students ride to school every day on yellow school buses that travel a total of four billion miles a year. While riding on a school bus is the safest way a student can travel to school,[57] children may be exposed to harmful pollutants, a concern since students spend an average of an hour and a half a day on school buses.[58] A recent study undertaken by Clean Air Task Force in cooperation with Purdue University investigated cabin air quality on school buses in three cities (Chicago, IL; Atlanta, GA; and Ann Arbor MI). The study found that particulate matter routinely entered the bus cabin from the tailpipe and the engine through the open front door. At some stops, particulate matter in the bus cabin exceeded levels in the outdoor air by as much as ten times. While idling or lined up in a schoolyard, rapid buildup of particulate matter in the buses also occurred. Most importantly, retrofit emissions controls worked: installation of a diesel particulate filter and the use of Ultra Low Sulfur Diesel (ULSD) fuel and a closed crankcase filtration device eliminated fine particles, ultrafine particles, black carbon and particle-bound PAH in the bus cabin. A closed crankcase filtration system by itself demonstrated major benefits and can provide immediate and low cost reductions in particulate matter levels on school buses. For a comprehensive report: **www.catf.us/goto/schoolbusreport** seniors with increased levels of elemental and organic carbon (typical of diesels and other motor vehicles) and fine particles. Collectively, these studies demonstrate that elevated fine particle levels put the elderly at risk and suggest a possible mechanistic link between fine particles and cardiovascular disease mortality.[59]

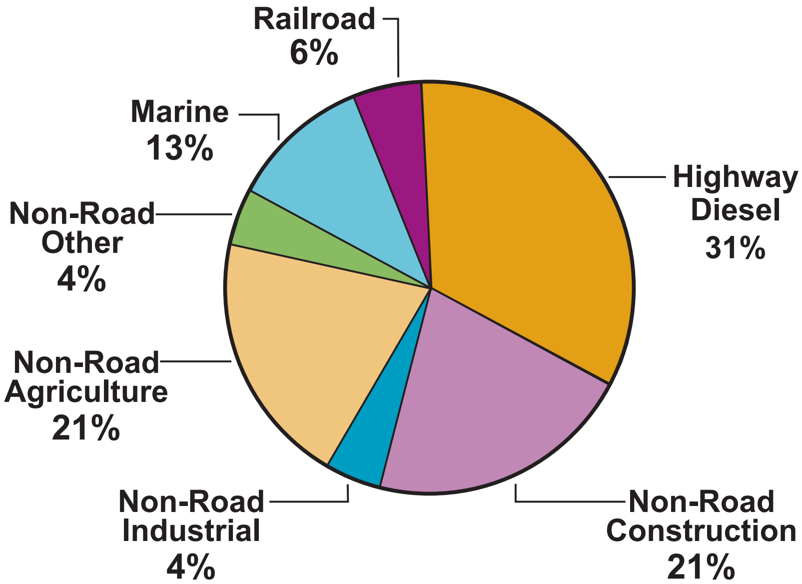
Today's Dirty Diesels

- **"On-road" or highway diesels** include many types of vehicles, such as municipal and commercial trucks and buses. Heavy duty highway diesels range from 8,500 lbs to those exceeding 60,000 lbs, such as 18-wheelers. Of the seven million diesels on the road today, 400,000 are school buses and 70,000 are transit buses. Highway diesels released 100,000 tons of directly-emitted fine particles in 2002, about one third of the total from diesels. Highway diesels also released 3.4 million tons of nitrogen oxides (NO_X) in 2002, which accounted for 16 percent of all NO_X emissions and half of all diesel NO_X emissions in the U.S. [60]

- **"Non-road" diesel engines and equipment** do not typically travel on roads or highways. There were approximately six million non-road diesel engines in service in 2003. Examples of these non-road diesels include construction equipment such as excavators, mining equipment and agricultural machinery. In 2002, 155,000 tons or half of all the fine particles directly emitted from diesels came from non-road engines. Non-road diesels also released 1.6 million tons of NO_X, 8 percent of all NO_X emissions and one quarter of all diesel NO_X emissions in the U.S. in 2002.[61]

- **Marine and river diesel** emissions are dominated by large commercial ships polluting our largest ocean and river port cities. Efforts to control pollution from shipping have focused on NO_X, although these engines also emit substantial quantities of fine particles. In 2002 marine diesel released 40,000 tons of directly-emitted fine particles, 13 percent of all diesel fine particles in the U.S. Marine diesels in the U.S. produced one million tons of diesel NO_X in 2002, 5 percent of all U.S. NO_X emissions and 14 percent of all diesel NO_X emissions.[62]

- **Locomotive diesels** account for a significant fraction of mobile source emissions in the U.S. today. In many areas, diesel trains travel through and pollute core urban and industrial areas. Diesel locomotives released 20,000 tons of directly-emitted diesel fine particles (six percent of all diesel fine particles) and 900,000 tons NO_X (13 percent of diesel NO_X). Diesel locomotives typically have a useful life of 40 years and are commonly rebuilt 5-10 times during their long service lives. For this reason, cleaning up today's locomotives is an important priority.[63]



Sources of Directly-Emitted Mobile Diesel Fine Particles

Source: EPA (2004)

Diesel "Hotspots"

Diesel Exhaust is Concentrated Near Roadways and Intersections.

Unlike industrial smokestack emissions, diesel typically is emitted at ground-level in places of concentrated population in our communities along busy streets and at our places of work. We often breathe diesel exhaust where it is fresh and most toxic. While air quality modeling, such as reported in our study, estimates average exposures in a community, your individual exposure may be much greater or smaller depending on a variety of factors. For example, the distance from where you live to major roadways and the nature of your commute to work may play a role.

Exposure to diesel exhaust is highest for those who:

- **Operate or work around diesel engines** – Occupational exposures to diesel are among the highest and have been associated with increased incidence of cancer. Furthermore, a study of diesel mechanics, train crewmen, and electricians working in a closed space near diesel generators suggests that diesel exposure may have caused both airway obstruction and serious impairment to the central nervous system. The report concludes that "impaired crews may be unable to operate trains safely."[64]
- **Live or work near areas where diesel emissions are concentrated** – Ambient diesel levels are highest near highways, busy roadways, bus depots, construction sites, railroad yards, ports and inland waterways with diesel boat traffic, major bridges, tunnels, or freight warehouses. People who live or work near these facilities face the greatest risk. Numerous recent medical studies have linked roadway proximity and traffic pollution to disease, asthma hospitalizations, and shortened life expectancy.[65] For example, a 2004 study in Ontario, Canada found increased risk of mortality from heart and lung disease in people living within 100 meters of a roadway.[66] New York City studies demonstrate that diesel trucks create air toxics hot spots at crossings, bus stops, and bus depots.[67] Rail yards can be diesel hotspots as well. For example, one study found elevated risk levels – up to 500 in a million – adjacent to a California rail yard.[68] Another study found elevated cancer risk for persons living near a ferry port.[69]

- **Regularly ride on school or transit buses, or commuter trains** – Children are exposed to elevated levels of diesel as a result of the buildup of diesel exhaust inside school buses – especially with windows closed.[70] Diesel exhaust levels on commuter trains and

People living and working near concentrated diesel emissions such as busy roadways have the greatest exposure to diesel exhaust.

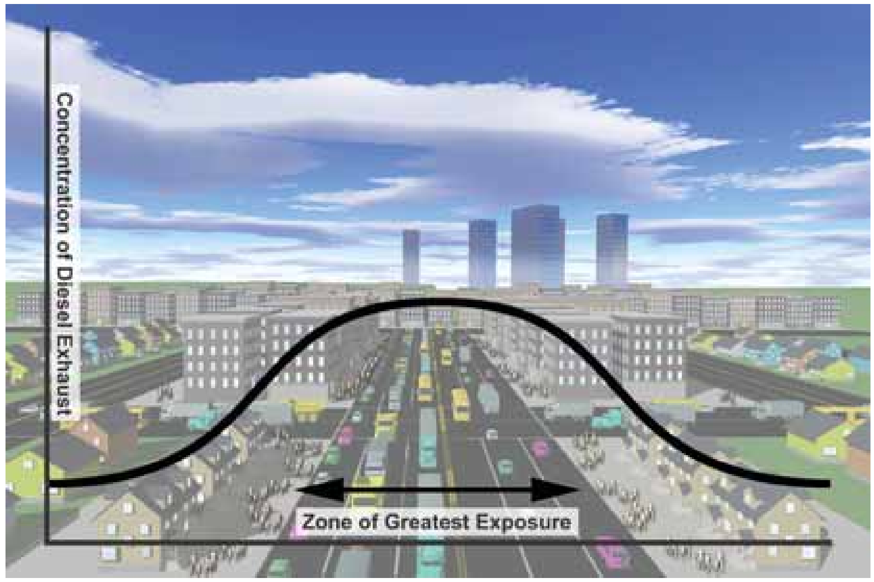


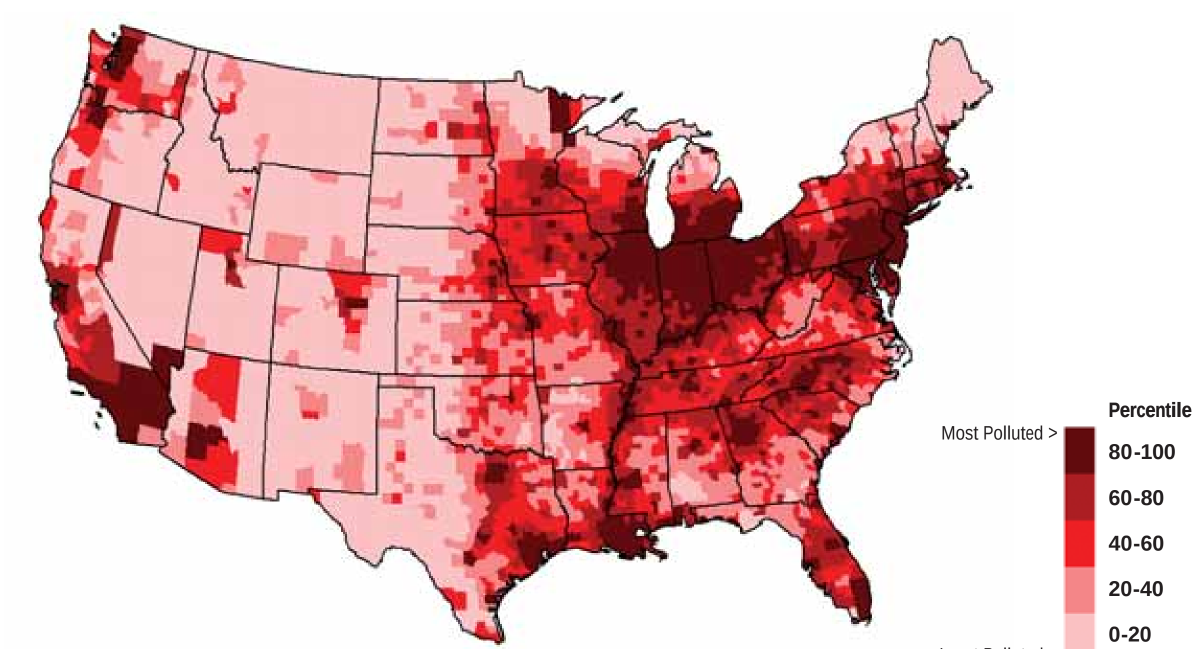
ILLUSTRATION BY ALAN MORIN

station platforms may also be high.[71]

- **Commute daily in heavy traffic** – Commuters are exposed to some of the highest diesel emissions in their cars due to pollutants released from trucks and buses on the road with them. Car occupants riding behind a diesel bus, for example, can experience extremely high levels of dangerous fine particles. Researchers in Los Angeles measured high fine particle levels (130 ug/m^3) behind an urban transit bus making numerous stops.[72] Exposures to drivers can have serious effects: a 2004 study suggests that young male state troopers experienced cardiac inflammation and heart rhythm changes from in-vehicle exposure to fine particles.[73]

Diesel exhaust from trucks and buses can be found in places we don't expect. For example it can be trapped in "urban canyons" and penetrate buildings through HVAC systems.

Exposure to diesel exhaust is also an Environmental Justice issue. Concentration of minority and low-income populations are more likely to be found in cities near diesel sources. Because these neighborhoods are exposed to some of the highest diesel exhaust levels, residents are certain to experience disproportionate health impacts.



Directly-Emitted Diesel Fine Particle Concentrations by County in the U.S. (1999)

A Solution Within Our Reach

Diesel Fine Particles Can Be Virtually Eliminated by Emission Controls Available Today.

Virtually all of the health risk posed by diesel exhaust can be eliminated through the application of emissions control strategies available today. For example, an aggressive but feasible program to reduce diesel particle emissions nationwide 50 percent by 2010, 75 percent by 2015, and 85 percent by 2020 would save about 100,000 lives between now and 2030 – beyond those lives that will be saved under EPA's new engine regulations.[74] Adopting this as a national goal would help states and municipalities set milestones for improvement and would be consistent with EPA's recently announced goal of retrofitting the entire U.S. fleet of diesel vehicles by 2015.[75] Indeed, California has already set a Diesel Risk Reduction goal of 75 percent 2010 and 85 percent by 2020. Over the last few years the California Air Resources Board has begun to issue regulations to achieve these goals.[76]

"Retrofit, Rebuild, Replace"

A variety of practical strategies exist to reduce diesel particle levels in America: tailpipe retrofits, clean fuels, closed crankcase filtration systems, engine rebuild and replacement requirements, emission specifications for vehicles used in public works contracts, anti-idling ordinances and legislation, truck stop electrification programs, aggressive fleet turnover policies, and more.

The most cost-effective approach to reducing diesel exhaust is likely in many cases to be the direct application of retrofit technology. Although the purchase of new, much cleaner vehicles will remain an important remedial strategy, the replacement of the entire diesel fleet is an expensive proposition that will have to be phased in over time. What's more, we can meet the challenge of reducing fine particles and related air toxics without replacing all vehicles right now. Current technology can easily remove particles from diesel exhaust. Retrofits that eliminate over 90 percent of fine particles from a heavy duty diesel bus engine typically cost $3,000-$7,500. This is a small expenditure when compared to the typical $60,000-75,000 price tag for a new school bus or $300,000 for a transit bus.[77]

Retrofits are available from many engine manufacturers. They generally are easy to install especially on highway vehicles. Nonetheless, it is important to point out that retrofits are not a "one size fits all" proposition. Retrofitting a fleet calls for careful planning and, often, a mix of strategies that will depend on the make and model year of the engines being retrofitted and funds available. For example, some heavy-duty engines lack modern electronic engine controls and are therefore are too old for some retrofit devices. Other diesel equipment simply does not have space for retrofit installation. Duty cycle is an important consideration too. Some engines do not run constantly which means that catalytic retrofit devices requiring consistent high engine temperatures do not operate as efficiently. Furthermore, some engines release

Installing a diesel particulate filter (DPF) in this Atlanta school bus simply required removal and replacement of the muffler and tailpipe.

pollution from crankcase ventilation in addition to the tailpipe. This calls for additional strategies. For some vehicles and model years, replacement may be the best option. As a result, fleets will need to develop individualized strategies that optimize emission reduction from their vehicles and equipment. Fortunately, this is not hard to do.

Catalyzed diesel particulate matter filters (DPF) can reduce emissions of fine particles and adsorbed air toxics by over 90 percent. DPFs have been used in thousands of on- and non-road diesel applications. Diesel oxidation catalysts (DOCs) represent a less expensive albeit less effective option. They are smaller and therefore easier to install. EPA has verified that they can reduce total particulate matter emissions by 10-30 percent. Like the DPF, the DOC is also attached to the exhaust system. Installing one on a diesel truck or bus costs about $1,000. DOCs may be appropriate for vehicles built before 1995 that lack electronic controls and for construction equipment where there is inadequate space for a DPF to be installed. DOCs have been installed in more than 1.5 million trucks in the U.S.[78]

Low Sulfur Diesel Fuels Are Requisite for Effective Retrofit Controls.

Diesel particulate filters require low sulfur fuels because sulfur in the fuel can foul the emission control device. Unfortunately, low sulfur fuels are not available everywhere in the U.S. today (see http://www.epa.gov/otaq/retrofit/fuelsmap.htm for the current fuel availability map). Where ULSD is available, decision makers should consider requiring installation of filters where possible. Federal regulations have established diesel fuel and additive formulation requirements for on-road vehicles, limiting fuel sulfur content to 15 ppm nationwide beginning in 2006 for use with 2007 highway vehicles. Starting in 2010, non-road equipment will be required to use ULSD.

Biodiesel is another potential low-sulfur fuel choice that can achieve modest reductions in emissions when used as a blend, or higher reductions when used at 100 percent. Biodiesel is an alternative diesel fuel made from either animal fats or plants such as soybeans.

Ultra low sulfur diesel fuel will be available nationwide mid-2006.

Cleaning up All School Buses Within a Decade

With today's emissions controls, students need not be exposed to diesel exhaust while riding to school. EPA in the summer of 2004 announced the goal of retrofitting all existing school buses with pollution controls within a decade.[79] Funding retrofits and cleaner fuel presents the greatest obstacle facing school districts. To achieve this goal, adequate funds must be appropriated by states and the federal government.

Recommendations

Cities and States Must Act to Reduce Diesel.

The fine particle pollution problem is so widespread in the U.S. about one quarter of the U.S. population resides in areas that violate the standard. EPA recently formally designated over 200 counties in "nonattainment" with the annual fine particle standard.[80] Countless additional commuters may also spend significant time in areas exceeding the standard where they work. But the rest of the country is not safe from the risk posed by diesel particles – science tells us that particle-related health impacts don't stop once the standard is achieved. Health research has shown that there are adverse health impacts from particles even at very low concentrations.[81]

Cities and states that have been designated as "nonattainment" must act now to achieve meaningful reductions in fine particles. For those areas, state implementation plans must be developed and presented to EPA for approval within three years. Controls must then be implemented and air quality standards achieved by 2010. For this reason, states and cites must start now to determine how to achieve substantial emissions reductions. With rules to reduce particles from power plants pending at EPA and expected to be finalized in the near future, diesel emissions will become the largest remaining share of the problem and the most cost-effective solution, one that largely is within the control of states and municipalities.

MA TURNPIKE AUTHORITY

Cities should adopt and enforce anti-idling ordinances.

Cities and states should:

- Establish ambitious goals for reducing risk to their citizens by cleaning up existing diesels;
- Identify priority geographic areas and diesel "hotspots" for immediate attention;
- Adopt a package of options for reducing diesel exhaust including:
  - Retrofits accomplished by replacing mufflers with an optimal mix of filters or oxidation catalysts depending on vehicle age and type;
  - Requiring Ultra Low Sulfur Diesel and cleaner alternative fuels;
  - Closed crankcase ventilation systems to eliminate engine exhaust from penetrating the cabins of school and transit buses;
  - Engine rebuild and replacement requirements;
  - Truck stop electrification programs to give long-haul truckers a way to power their rigs overnight without running their engines;
  - Contract specifications requiring cleanup of trucks and construction equipment used in public works projects.
- Adopt diesel cleanup measures as federally-enforceable requirements in State Implementation Plans (SIPs) for the attainment of the fine particle and ozone air quality standards;
- Create and fund programs to provide money for diesel equipment owners to replace or rebuild high-polluting diesel engines;
- Adopt and enforce anti-idling ordinances and legislation.

To meet this challenge, several states and cities have begun to take action. California continues to lead the way in reducing diesel emissions: adopting stricter fine particle air quality standards, developing a statewide diesel risk reduction plan, and establishing a state program to clean up on- and non-road diesel engines ranging from garbage trucks to stationary generators.[82] When completed, the California program will regulate emissions from all existing diesels within its jurisdiction.

Trucks parked at New York Thruway rest area shut off their engines and plug into IdleAire facility for heat and electricity.

In New York, over 120,000 kids now ride a school bus that has had a retrofit kit installed to reduce diesel emissions. Under city and state law all New York City-sponsored construction projects are required to use ULSD and all heavy equipment engines at the sites must be retrofitted. Likewise, Seattle, King County, and the State of Washington have made a solid start on diesel cleanup from on- and non-road vehicles, and ships including a commitment to retrofit up to 8,000 school buses using local, state, federal, and SEP monies and buy up to 250 new diesel/electric hybrid buses. Other cities also have made a start.[83]

California and Texas have created funds – the "Carl Moyer" program in California and the Texas Emission Reduction Program (TERP) – to provide funding for diesel equipment owners to replace or rebuild high-polluting diesel engines.

NEW FLYER

Some cities are choosing Diesel Electric Hybrid buses as an alternative to conventional diesel buses.

Washington Must Support States

States and cities cannot meet the challenge of diesel pollution alone. U.S. EPA has recognized the dangers and societal costs of diesel exhaust and set tighter emission standards for new highway and non-road diesel engines and mandated the availability beginning in 2006 of Ultra Low Sulfur Diesel (ULSD) fuel nationwide. These requirements must be retained with no backsliding. In addition, EPA has set a national goal of cleaning up all of America's existing diesels by 2015 and has established a voluntary retrofit program to begin to meet it.[84] However, this challenge will only be met with an aggressive set of policies and adequate funding to ensure the goal can be accomplished.

Many states do not have the resources to clean up state and municipally-owned vehicles. They will need the support of the federal government to achieve EPA's goal.

Federal action may also be needed to clean up transient diesel vehicles, including long-haul trucks, marine diesel shipping in U.S. ports, and locomotives that typically travel from city to city dispersing their emissions along travel corridors. Because the Clean Air Act contains limited authority for EPA to establish national diesel retrofit rules, federal legislation will ultimately be needed to establish federal requirements and funding for a national retrofit program for all diesel engines as well as these interstate diesels.

The Federal government should:

- Pass legislation providing funding for the cleanup of municipal and state fleet vehicles;
- Explore regulatory options for reducing emissions from existing interstate fleets such as long-haul trucks, shipping, and locomotives;
- Retain and enforce the tighter new engine and cleaner fuel standards for highway and non-road diesels.

Endnotes

1 Wilson, Richard and Spengler, John, eds. *Particles in Our Air: Concentrations and Health Effects* (1999) p. 212.

2 Schwartz, J.,"Air Pollution Deadlier than Previously Thought," Harvard School of Public Health, Press Release, March 2, 2000.

3 Laden, F., Neas, L., Dockery, D. and Schwartz, J., *Association of Fine Particulate Matter from Different Sources with Daily Mortality in Six U.S. Cities*, Environmental Health Perspectives, Vol. 108, No. 10, (2000) p. 941-947.

4 Nemmar, A. et al., *Passage of Inhaled Particles Into the Blood Circulation in Humans*. Circulation, Vol. 105, (2002), 411-414 ; Donaldson, Ken, et al., *Ambient Particle Inhalation and the Cardiovascular System: Potential Mechanisms,* Envir. Health Perspectives, Vol. 109, Supp. 4, Aug. 2001, p. 525.1

5 National Center for Environmental Assessment, Office of Research and Development, U.S. EPA. EPA/600/8-90/057F. May 2002. International Agency on Cancer, Monograph 46. See at: http://www-cie.iarc.fr/htdocs/monographs/vol46/46-01.htm; California Air Resources Board (1998) Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant; See also, California Environmental Protection Agency, Air Resources Board, Office of Environmental Health Hazard Assessment, April 22, 1998; CalEPA (2002). Health Assessment for Diesel Engine Exhaust;

6 American Academy of Pediatrics, Committee on Environmental Health, *Ambient Air Pollution: Health Hazards to Children,* Pediatrics, Vol 114, No. 6, (December 2004) pp. 1699-1707. Available at www.pediat rics.org. For a complete summary of studies of particulate matter and health see: EPA Air Quality Criteria for Particulate Matter, October 2004 avaialble at: http://cfpub.epa.gov/ncea/cfm/partmatt.cfm

7 Modeled health impacts of less severe acute health impacts (e.g. other than mortality, heart attacks) likely understate the full magnitude of the impacts because many cases go unreported (e.g. asthma, bronchitis self-treatment, or treatment in small clinics or private offices.) Furthermore, the U.S. does not manage a central database of national health records.

8 U.S. EPA, OAR, "Final Report to Congress on Benefits and Costs of the Clean Air Act,1970-1990," EPA 410-R-97-002, (1997) page I-23 at http://www.epa.gov/air/sect812/appen_i.pdf.

9 Mothers Against Drunk Driving online at: http://www.madd.org/stats/0,1056,1112,00.html

10 Arias, E. et al., "Deaths: Final Data for 2001," Centers for Disease Control, 52 National Vital Statistics Reports No. 3 (September 18, 2003). Available online at: http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_03.pdf

11 U.S. Department of Transportation, National Highway Traffic Safety Administration *Traffic Safety Facts 2000: Occupant Protection* (Washington, D.C. 2001). Available online at: http://www.bts.gov/publications/transportation_statistics_annual_report/2001/html/chapter_06_figure_01_152_table_.html

12 This analysis is based on methodology approved by U.S. EPA's Science Advisory Board and used by EPA in the Regulatory Impact Analysis (RIA) of the non-road rule. EPA Final Regulatory Impact Analysis, "Control of Emissions from Nonroad Diesel Engines," EPA420-R-04-007. (May 2004) http://www.epa.gov/nonroad-diesel/2004fr/420r 04007.pdf. It begins with EPA emissions inventory data, models the dispersion of those emissions using the Regional Emissions Modeling System for Acid Deposition (REMSAD) air quality model, and then applies a damage function model using concentration-response relationships to estimate adverse health endpoints from modeled changes in air quality. This analysis estimates the adverse health endpoints attributable to diesel PM2.5 in the year 2010. For a summary of CATF's methodology and FAQs please go to www.catf.us/goto/dieselhealth/ and click on "learn more." For Abt Associates' ASPEN and REMSAD reports please see: www.catf.us/goto/AbtASPEN/ and www.catf.us/goto/AbtREMSAD/.

13 Estimate is based on EPA methodology described in EPA Memorandum, Bryan Hubbell to Sam Napolitano, July 2, 2001. Estimated NO_X, SO_2 and PM emissions health damages for heavy duty vehicle emissions.

14 Through only those diesel regulations promulgated to date, California will reduce diesel fine particles by 30 percent from year 2000 levels. California has announced plans to promulgate additional critical regulations in the next few years to address significant sources such as construction, agriculture, and inland shipping. California Air Resources Board (CARB) 2004a. Air Quality Almanac Emission Projections. Online at http://www.arb.ca.gov/emisinv/emsmain/emsmain.htm; California Air Resources Board (CARB). 2003a. Staff Report: Initial Statement of Reasons: Proposed Diesel Particulate Matter Control Measure for On Road Heavy-Duty Residential and Commercial Solid Waste Collection Vehicles. Sacramento, CA: California Environmental Protection Agency. California Air Resources Board (CARB) 2003b Staff Report: Initial Statement of Reasons for Proposed Rulemaking: Airborne Toxic Control Measure for Stationary Compression Ignition Engines. Sacramento, CA: California Environmental Protection Agency, Stationary Source Division Emissions Assessment Branch;. California Air Resources Board (CARB) 2003c. REVISED – Staff Report: Initial Statement of Reasons for Proposed Rulemaking: Airborne Toxic Control Measure for In-use Diesel Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities Where TRUs Operate. Sacramento, CA: California Environmental Protection Agency, Stationary Source Division Emissions Assessment Branch. The Union of Concerned Scientists recently estimated the costs and benefits of achieving the CARB Diesel Risk Reduction goal. See Union of Concerned Scientists, *Sick of Soot: Reducing the Health Impacts of Diesel Pollution in California* (June 2004) available online at: http://www.ucsusa.org/clean_vehicles/trucks_ and_buses/page.cfm?pageID=1429

15 This analysis was performed by multiplying modeled ASPEN (Assessment System for Population Exposure Nationwide) 1999 county-level ambient diesel PM2.5 concentration data times: (1) the upper and lower bounds of EPA's possible diesel particulate matter cancer risk range; and (2) the California Air Resources Board diesel cancer unit risk factor. See: California Diesel Risk Reduction Plan: http://www.arb.ca.gov/diesel/documents/rrpapp.htm; EPA, Health Assessment Document for Diesel Exhaust, Office of Research and Development, EPA/600/8-90/057F (May 2002). The United States Public Interest Research Group previously used

a similar methodology i.e., multiplying the CARB unit risk factor by 1996 National Air Toxics Assessment fine particle concentration data to derive national, state, and local additional cancer risk (cancers per million people) from diesel fine particles. U.S. PIRG Education Fund, *Dangers of Diesel: How Diesel Soot and Other Air Toxics Increase Americans' Risk of Cancer* (October 2002).

16 "The estimated possible risk ranges (10^{-5} to 10^{-3} as well as lower and zero risk) provide a perspective of the potential significance of the lung cancer hazard." EPA, Health Assessment Document for Diesel Exhaust, Office of Research and Development, EPA/600/8-90/057F (May 2002) at p. 8-15. For CARB unit risk value, see: Findings of the Scientific Review Panel on *The Report on Diesel Exhaust* as adopted at the Panel's April 22, 1998, meeting. http://www.arb.ca.gov/toxics/dieseltac/de-fnds.pdf. See also, http://www.arb.ca.gov/regact/diesltac/diesltac.htm. The findings in this report based on the CARB unit risk factor are consistent with EPA's possible diesel risk range e.g., 3 X 10^{-4} is within EPA's range of 10^{-3} to 10^{-5}.

17 The number per million is the chance in a population of a million people who might be expected to get cancer over a 70-year lifetime. A potential cancer risk of 10 in a million means if one million people were exposed to a certain level of a pollutant or chemical there is a chance that 10 of them may develop cancer over their 70-year lifetime. This would be 10 new cases of cancer above the expected rate of cancer in the population. According to CARB the expected rate of cancer for all causes, including smoking, is about 200,000 to 250,000 chances in a million (one in four to five people).

18 For 1999 NATA national excess cancer risk from air toxics other than diesel see: Inside EPA, Inside Washington Publishers, (December 15, 2004) http://www.insideepa.com/

19 This finding is based on inhalation as the only exposure path and is limited to the thirty-three air toxics included in EPA's National Air Toxics Assessment (NATA). The relative cancer risk of diesel particulate matter is calculated as a ratio of the cancer risk of all air toxics tracked by EPA in the NATA divided by the risk of diesel particulate. We calculated the cancer risk for diesel PM in the U.S. based by applying the CARB cancer unit risk factor for diesel particulate matter to 1999 ASPEN model average national ambient concentration results for diesel PM. (Source for national toxic risk: Inside EPA, Inside Washington Publishers, December 15, 2004.)

20 According to the EPA's categorization of counties as urban or rural, the average ASPEN 1999 ambient diesel fine particle concentration is 1.3822 ug/m^3 for urban counties and 0.4730 ug/m^3 for rural counties. The overall national average is 1.2096 ug/m^3. These averages are population weighted. These averages convert (using the 0.0003 factor) to cancer risks of 415 per million urban, 142 per million rural, and 363 per million average.

21 U.S. Centers for Disease Control and Prevention, "National Hospital Discharge Summary 1998," Advance Data #316 (June 30, 2000). Available online at: http://www.cdc.gov.nchs.

22 This analysis was performed using 1999 county-level ambient diesel PM2.5 concentration data modeled using the Assessment System for Population Exposure Nationwide (ASPEN) air quality model, and then by applying a damage function model using concentration-response relationships to estimate adverse health endpoints from modeled changes in air quality. For a full discussion of the methodology used, please see: www.catf.us/goto/AbtASPEN/. For health impacts in your city and state see: http://www.catf.us/goto/dieselhealth.

23 The new health findings provided in this report by Abt Associates are derived from average modeled estimates of ambient concentrations of diesel particulate matter for entire counties. Many people experience higher diesel exposure situations depending upon where they live and work, for example, such as working near diesel engines, living near diesel sources or commuting regularly on roadways with diesel traffic. The quantitative estimates of death and disease we provide in this report are based on average exposures only and do not represent the risks associated with high diesel exposures. Furthermore, these health findings do not include the impacts from all toxic constituents in diesel exhaust, only directly-emitted particulate matter.

24 The state and metropolitan area health effects reported here exclude those associated with secondarily-formed fine particles, i.e., particles formed from gaseous emissions through post-emission atmospheric chemical reactions. Typically, these include nitrate from nitrogen oxide emissions and sulfate from sulfur dioxide emissions. Secondarily-formed fine particles may make up as much as one-third of diesel-related particles. See Lloyd, A. C., and Cackette, T.A. (2001). Diesel engines: Environmental Impact and Control. Journal of Air and Waste Management Association, v. 51, p. 809-847, June 2001.

25 Environmental Protection Agency fact sheet: Diesel Exhaust in the United States. EPA 420-F-02-048, September, 2002. Available at: http://www.epa.gov/otaq/retrofit/documents/420f03022.pdf. The unit of measure used by EPA for diesel emissions, g/bhp-hr = grams of pollutant released per brake horsepower hour.

26 1990 Truck Survival Rate, U.S. DOE, (2003) Available at: http://www-cta.ornl.gov/data/tedb23/Spreadsheets/Table3_11.xls

27 EPA Fact Sheet, "Proposal for Cleaner Heavy-duty Trucks and Buses and Cleaner Diesel Fuel," (May 17, 2000).

28 1990 Truck Survival Rate, U.S. DOE, (2003) Available at: http://www-cta.ornl.gov/data/tedb23/Spreadsheets/Table3_11.xls

29 California Air Resources Board, "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles," CARB Mobile Source Control Division, (October 2000).

30 For a more thorough discussion of the full panoply of diesel-related health effects please see CATF white paper at www.catf.us/goto/dieselwhitepaper/. For the two most comprehensive U.S. risk assessments for diesel exhaust, see the EPA health assessment document at: http:/cfpub. epa.gov/ncea/cfm/recor display.cfm?deid=29060 and the California health assessment at: http://www.arb.ca.gov/toxics/dieseltac/staffrpt.pdf.

31 Pope, C.A., Thun, M.J., Namboordiri, M.M. and Dockery, D.W., et al.; *Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults,.* 151 American Journal of Respiratory and Critical Care Medicine (1995). Available online at http://ajrccm.ats journals.org/search.shtml; Krewski, D., Burnett, R.T., Goldberg, M.S., Hoover, K., Siemiatycki, J., Jerrett, M., Abrahamowicz, A. and White, W.H., *Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Matter and Mortality*; Special Report to the Health Effects Institute, Cambridge, MA (July 2000); Samet, J.M., Dominici, F., Zeger, S.L., Schwartz, J. and Dockery, D.W. *National Morbidity, Mortality and Air Pollution Study, Part II: Morbidity, Mortality and Air Pollution in the United States*; Health Effects Institute Research Report No. 94, Cambridge MA (June 2000); Dockery, D.W., Pope, C.A., Xu, S. and Spengler, J.D., et al; *An Association Between Air Pollution and Mortality in Six U.S. Cities*, 329 New England J. Medicine 1753-59 (1993). Available online at http://nejm.org/content/1993/0329/0024/1753.asp; Woodruff, T., Grillo, J. and Schoendorf, K. 1997. *The relationship between selected causes of postneonatal infant mortality and particulate air pollution in the United States*. Environmental Health Perspectives, vol. 105, p. 608-612.

32 New York University, Press Release, "Most Definitive Study Yet Shows Tiny Particles in Air Are Linked to Lung Cancer," March 5, 2002; Pope. C.A., Burnett, R.T., Thun, M.J, Calle, E.E., Krewski, D., Ito, Kaz, and Thurston, G.D., *Lung Cancer, Cardiopulmonary Mortality, and Long Term Exposure to Fine Particulate Air Pollution,* Journal of the American Medical Association, Vol. 287, (2002), p. 1132-1141.

33 Peters, A., *Increased Particulate Air Pollution and the Triggering of Myocardial Infarction*, Circulation, Vol. 109, (June 12, 2001); Donaldson, K., et al. *Ambient Particle Inhalation and the Cardiovascular System: Potential Mechanisms*, Environmental Health Perspectives, Vol. 109, Supp. 4; Ghio, A.J., and Devlin, R.B., (2001). *Inflamatory Lung Injury After Bronchial Instillation of Air Pollution Particles,* American Journal of Respiratory Critical Care Medicine, Vol. 164, (2001) p. 704-708; Nemmar, A., Hoet, P., Dinsdale, D.,Vermylen, J., Hoylaerts,M., and Nemery, B., *Diesel Exhaust Particles in Lung Acutely Enhance Experimental Peripheral Thrombosis,* Circulation. Vol. 107, (2003), pp.1202-1208.

34 National Ambient Air Quality Standards for Particulate Matter, Final Rule. 40 CFR Part 50. EPA Federal Register, vol. 162, no. 138, Friday July 17, 1997 at page 38651. See at: http://www.epa.gov/ttn/oarpg/t1/fr_notices/pmnaaqs.pdf

35 Peters, A., and Pope, A.C., *Cardiopulmonary Mortality and Air Pollution,*

The Lancet, Vol. 360, (October 19, 2002), p.1184, http://cf pub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060; Brook, R.D., Brook, J.R., Urch, B., Rajagopalan, S., Silverman, P., *Inhalation of Fine Particulate Air Pollution and Ozone Causes Acute Arterial Vasoconstriction in Healthy Adults,* Circulation, Vol.105, (2002), pp. 1534-1536, http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060; Peters, A., Dockery, D.W., Muller, J.E., Mittleman, M.A., *Increased Particulate Air Pollution and the Triggering of Myocardial Infarction,* Circulation, Vol. 103, (2001), pp. 2810-2815; Peters, A., Liu, E., Verier, R.I. et al., *Air Pollution and Incidence of Cardiac Arrhythmia,* Epidemiology, Vol. 11, (2000), pp.11-17.

36 Hong, Y., Lee, J., Kim, H., Kwon, H., *Air Pollution. A New Risk Factor in Ischemic Stroke Mortality,* Stroke, Vol. 33, (2002), pp.2165-2169; Hong, Y., Lee, J., Kim, H., Ha, E., Schwartz, J. and Christiani, D.C., *Effects of Air Pollutants on Acute Stroke Mortality*, Environmental Health Perspectives, Vol. 110, No. 2, (February 2002).

37 Churg, A., Brauer, M., Avila-Casado, M., Fortoul, T.I., and Wright, J.L., *Chronic Exposure to High Levels of Particulate Air Pollution and Small Airway Remodeling*, Environmental Health Perspectives, Vol.111, No. 5, (2003), pp. 714-718.

38 American Academy of Pediatrics, Committee on Environmental Health, *Ambient Air Pollution: Health Hazards to Children,* Pediatrics, Vol. 114, No. 6, (December 2004).

39 California Air Resources Board (1998) Resolution 98-35. Identification of diesel exhaust as a toxic air contaminant.

40 EPA, Health Assessment Document for Diesel Exhaust, Office of Research and Development, EPA/600/8-90/057F (May 2002) at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060

41 Findings of the California Air Resources Board's Scientific Review Panel on *The Report on Diesel Exhaust* as adopted at the Panel's April 22, 1998, meeting. http://www.arb.ca.gov/toxics/dieseltac/de-fnds.pdf.

42 The national average ambient diesel particulate matter concentration from 1999 ASPEN modeling (1.21 ug/m^3) was multiplied times the CARB diesel particulate matter unit risk of 3 in 10,000 per 1.0 ug/m^3 and distributed over the 2005 U.S. population to get total of 107,000 lifetime cancers assuming a 70-year lifetime of exposure to the national average ambient concentration. The annual estimated impact is calculated by dividing the 107,000 lifetime cancers by 70 years, arriving at 1,530 annual cancers attributable to diesels per year. This estimate is likely very conservative (low) because urban areas where larger populations dwell, are characterized by concentrations that are much higher than the national average.

43 Pope. C.A., Burnett, R.T., Thun, M.J, Calle, E.E., Krewski, D., Ito, Kaz, Thurston, G.D., *Lung Cancer, Cardiopulmonary Mortality, and Long Term Exposure to Fine Particulate Air Pollution,* Journal of the American Medical Association, Vol. 287, (2002), pp. 1132-1141.

44 Diaz-Sanchez, D., et al., *Diesel Exhaust Particles Induce Local IgE Production in Vivo and Alter the Pattern of IgE Messenger RNA Isoforms*, J. Clin. Invest., 94:1417-1425 (1994); Diaz-Sanchez, D., *The Role of Diesel Exhaust Particles and Their Associated Polyaromatic Hydrocarbons in the Induction of Allergic Airway Disease*, Allergy 52 (Suppl. 38), 52-56, (1997); Castranova, Vincent, et al., *Effect of Exposure to Diesel Exhaust Particles on the Susceptibility of the Lung to Infection*, EHP, Vol. 109, Suppl. 4, (August 2001),609-612.

45 Watanabe and Oonuki, *Inhalation of Diesel Engine Exhaust Affects Spermatogenesis in Growing Male Rats*, Environmental Health Perspectives, Vol. 107, No. 7, (July 1999), 539-544.

46 Watanabe, N., and Kurita, M., *The Masculinization of the Fetus During Pregnancy Due to Inhalation of Diesel Exhaust*, Environmental Health Perspectives, Vol. 109, No.2, (Feb. 2001).

47 Id.

48 Callahan, J.F., et al. *The Subchronic Inhalation Toxicity of DF2 (diesel fuel) used in Vehicle Engine Exhaust Smoke Systems,* Maryland: Chemical Research and Development Center, (1986) pp. 1-152.

49 Laurie, R.D., and Boyes, W.K., *Neurophysiological Alterations Due to Diesel Exhaust During the Neonatal Life of the Rat*, Environ Int., (1981) b:5:363-8; Laurie, R.D., Boyes, W.K., and Wessendarp, T., *Behavioral Alterations Due to Diesel Exhaust Exposure*, Environ Int., (1981). a:5:357-61; Pepelko, W.E. and Peirano, W.B., *Health Effects of Exposure to Diesel Engine Emissions: a Summary of Animal Studies Conducted by the US EPA's Health Effects Research Laboratories at Cincinnati, Ohio,* J. Am. Coll. Toxicol. 1983:2(4):253-306.

50 Watanabe (1999); Watanabe (2001).

51 Kilburn, K.H., *Effects of Diesel Exhaust on Neurobehavioral and Pulmonary Functions*, Archives of Environmental Health, Vol. 55, No. 1, (2000), pp. 11-17.

52 Environmental Protection Agency, "The Projection of Mobile Source Air Toxics from 1996 to 2007: Emissions and Concentrations," August, 2001. (Totals do not reflect marine, rail, aircraft contributions)

53 EPA Health Assessment for Diesel Exhaust (2002) deemed diesel particulate matter a "likely" carcinogen, using yet-to-be-approved terminology. "Likely" under EPA's proposed terminology is equivalent to "probable" under EPA's approved terminology.

54 EPA Health Assessment for Diesel Exhaust (2002). EPA declined to assign a unit risk for diesel particulate matter in the diesel Health Assessment, however EPA has indicated a probable range of 10-3 to 10-5 which translates to 12 to 1210 cancers per million. Source for CARB Unit Risk: California Air Resources Board (1998): Staff Report for Rulemaking. Identification of diesel exhaust as a toxic air contaminant http://www.arb.ca.gov/regact/diesltac/diesltac.htm;

55 Wiley, J.A., Robinson, J.P., Cheng, Y.T, Piazza, T., Stork, L., and Pladsen, K., *Study of Children's Activity Patterns*, Final Report Contract No. A733-149, Survey Research Center, University of California, Berkeley, (September 1991); Snodgrass, W.R., *Physiological and Biochemical Differences Between Children and Adults and Determinants of Toxic Response to Environmental Pollutants,* in Guzlean, et al., *Similarities and Differences Between Children and Adults: Implications for Risk Assessment*, 1151 Press, Washington, DC. (year unknown); Thurston, G. D., "Particulate Matter and Sulfate: Evaluation of Current California Air Quality Standards with Respect to Protection of Children," California Air Resources Board, Office of Environmental Health Hazard Assessment, (September 1, 2000), http://www.arb.ca.gov/ch/ceh/airstandards.htm

56 Pope, C.A., and Dockery, D.W., *Acute Health Effects of PM10 Pollution Symptomatic and Asymptomatic Children,* American Review of Respiratory Disease, Vol. 145, (1992), pp. 1123-1128; Tolbert, P., et al. *Air Quality and Pediatric Emergency Room Visits for Asthma in Atlanta, Georgia,* American Journal of Epidemiology, Vol. 151, No. 8, (2000), pp. 798-810; Norris, G., Young Pong, N., Koenig, J., Larson, T., Sheppard, L. and Stout, J., *An Association Between Fine Particles and Asthma Emergency Department Visits for Children in Seattle,* Environmental Health Perspectives, Vol. 107, No. 6, (1999), pp. 489-493; Gauderman, W.J., McConnell, R., Gilliland, F., London, S., Thomas, D., Avol, E., Vora, H., Berhane, K., Rappaport, E., Lurmann, F., Margolis, H.G., and Peters, J., *Association Between Air Pollution and Lung Function Growth in Southern California Children,* American Journal of Respiratory and Critical Care Medicine, Vol. 162, No. 4, (2000), pp. 1-8; Brauer, M., Hoek, G., Van Vliet , P., et al., *Air Pollution from Traffic and the Development of Respiratory Infections and Asthmatic and Allergic Symptoms in Children*, American Journal of Respiratory and Critical Care Medicine, Vol.166 , (2002), pp. 1092-1098; Lin, S., Munsie, J., Hwang, S., Fitzgerald, E., and Cayo, M., *Childhood Asthma Hospitalization and Residential Exposure to State Route Traffic*, Environmental Research Section A 88, (2002), pp. 73-81; Kim, J., Smorodinsky, S., Lipsett, M., Singer, B., Hodgson, A., and Ostro, B., *Traffic-related Air Pollution near Busy Roads The East Bay Children's Respiratory Health Study*, American Journal of Respiratory and Critical Care Medicine, Vol. 170, (2004), pp. 520-526; Woodruff, T., Grillo, J. and Schoendorf, K., *The Relationship Between Selected Causes of Postneonatal Infant Mortality and Particulate Air Pollution in the United States*, Environmental Health Perspectives, Vol. 105, (1997). pp. 608-612.

57 Latest statistics from the U.S. Department of Transportation tell the story: school buses have the best safety record of any form of transportation. Last year, just six youngsters were killed as school bus occupants. Yet, 800 youngsters are killed every year getting to and from school by some other means than a school bus. Source: School Bus Information Council: http://www.schoolbusinfo.org/report.htm

58 See: http://www.epa.gov/cleanschoolbus/

59 Gold, D., Litonjua, A., Schwartz, J., Lovett, E., Larson, A., Nearing, B., Allen, G., Verrier, M., Cherry, R., and Verrier, R. *Ambient Pollution and Heart Rate Variability*, Vol. 101, No. 11, (21 March 2000), pp. 1267-

1273; Liao,D., Creason, J., Shy,C., Williams, R., Watts, R., and Zweidinger, R., *Daily Variation of Particulate Air Pollution and Poor Cardiac Autonomic Control in the Elderly*, Environmental Health Perspectives, Vol.107, No.7. (July 1999); Mar,T., Norris,G., Koenig, J. and Larson, T., *Associations Between Air Pollution and Mortality in Phoenix, 1995–1997*, Environmental Health Perspectives, Vol.108, No. 4, (April 2000).

60 For engine population data: EPA Diesel Engine Census, EPA Office of Transportation and Air Quality, 2004. For most recent highway diesel emissions see EPA Emissions Trends Report for 2002 at: http://www.epa.gov/ttn/chief/trends/trends02/trendsreportallpollut ants111504.xls

61 For descriptions of non-road engines see: EPA non-road rule: http://www.epa.gov/air/off-road/. For most recent non-road diesel emissions see: EPA Air Quality Trends for 2002 at: http://www.epa.gov/ttn/chief/trends/trends02/trends reportallpollutants111504.xls

62 For most recent marine diesel emissions see: EPA 2002 Emissions Trends Report at: http://www.epa.gov/ttn/chief/trends/trends02/trendsreportallpollutants111504.xls

63 For most recent locomotive diesel emissions, see: EPA 2002 Emissions Trends Report at: http://www.epa.gov/ttn/chief/trends/trends02/trendsreportallpollutants111504.xls

64 For summary of occupational studies: Cohen, A.J., and Higgins, M.W.P., *Health Effects of Diesel Exhaust: Epidemiology,* Diesel Exhaust : A Critical Analysis of emissions, Exposure and Health Effects, pp. 251-292, Health Effects Institute, Cambridge MA., (April 1995). For most comprehensive and recent U.S. study: Garshick, E., Laden, F., Hart, J., Rosner, B., Smith, T., Dockery, D. and Speizer, F., *Lung Cancer in Railroad Workers Exposed to Diesel Exhaust,* Environmental Health Perspectives, Vol. 122, No. 15, (November 2004), pp. 1539-1543. For nervous system effects: Kilburn, K.H., *Effects of Diesel Exhaust on Neurobehavioral and Pulmonary Functions,* Archives of Environmental Health, Vol. 55, No. 1, (2000), pp. 11-17.

65 Finkelstein, M., Jerrett, M., and Sears, M., *Traffic, Air Pollution and Mortality Rate Advancement Periods,* American Journal of Epidemiology, Vol. 160, (2004), pp. 173-177; Peters, A., Von Klot, S., Heier, A., Trentinaglia, I., Hormann, A., Wichmann, E., Lowel, H., *Exposure to Traffic and the Onset of Myocardial Infarction,* NEJM, Vol. 351, No 17, (October 15, 2004); Hoek, G., Brunekreef, B., Goldbohm, S., Fischer, P. and van den Brandt, P., *Association Between Mortality and Indicators of Traffic-Related Air Pollution in the Netherlands: a Cohort Study,* The Lancet, Vol. 360, December 19, 2002, pp.1203-1209; Brauer, M., Hoek, G., Van Vliet, P., et al., *Air Pollution from Traffic and the Development of Respiratory Infections and Asthmatic and Allergic Symptoms in Children*, American Journal of Respiratory and Critical Care Medicine, Vol.166, (2002). pp. 1092-1098; Lin, S., Munsie, J., Hwang, S., Fitzgerald, E., and Cayo, M., *Childhood Asthma Hospitalization and Residential Exposure to State Route Traffic*, Environmental Research Section A 88, (2002), pp. 73-81.

66 Finkelstein, M., et al. (2004).

67 Kinney, P., Aggarwal, M., Northridge, M., Janssen, N., and Shepard, P., *Airborne Concentrations of PM2.5 and Diesel Exhaust Particles on Harlem Sidewalks: A Community-Based Pilot Study*, Environmental Health Perspectives, Vol. 108, No.3, (2000); Lena, S., Ochieng, V., Carter, M., Holguín-Veras, J., and Kinney, P., *Elemental Carbon and PM2.5 Levels in an Urban Community Heavily Impacted by Truck Traffic,* Environmental Health Perspectives, Vol. 110, No.10 (2002).

68 California EPA (2004). Roseville Rail Yard Study. Available at: http://www.arb.ca.gov/diesel/documents/rrstudy/rrstudy101404.pdf

69 California Air Resources Board, staff report: initial statement of reasons for proposed rulemaking. "Proposed Regulatory Amendments Extending the California Standards for Motor Vehicle Diesel Fuel to Diesel Fuel Used in Harborcraft and Intrastate Locomotives," October 2004. Available at: http://www.arb.ca.gov/regact/carblohc/isor.pdf

70 Hill, L.B., Zimmerman, N.J., and Gooch, J., *A Multi-City Investigation of the Effectiveness of Retrofit Emissions Controls in Reducing Exposures to Particulate Matter in School Buses*, Clean Air Task Force Report, (2005). Available at: http://www.catf.us/publications/reports/CATF-Purdue_Multi_City_Bus_Study.php; Wargo, J., and Brown, D., *Children's Exposure to Diesel Exhaust on School Buses*. Environment and Human Health Inc., (February 2002), p. 76. http://www.ehhi.org/pubs/children_diesel.html; Natural Resources Defense Council, *No Breathing in the Aisles. Diesel Exhaust Inside School Buses* (2001). Available at: http://www.nrdc.org/air/transportation/schoolbus/sbusinx.asp; California Air Resources Board, "Characterizing the Range of Children's Pollutant Exposure During School Bus Commutes," (2003). Available at: http://www.arb.ca.gov/research/schoolbus/schoolbus.htm

71 Northeast States for Coordinated Air Use Management: Unpublished data, 2004.

72 Fruin, et al., *Fine Particle and Black Carbon Concentrations Inside Vehicles*, 10th Annual Conference of the International Society of Exposure Analysis, Oct. 2000.

73 Riediker, M., Cascio, W., Griggs, T., Herbst, M., Bromberg, P., Neas, L., Williams, R., and Devlin, R., *Particulate Matter Exposure in Cars Is Associated with Cardiovascular Effects in Healthy Young Men*, American Journal of Respiratory and Critical Care Medicine, Vol. 169, (2004), pp. 934-940; See also, Weinhold, B., *Pollutants Lurk Inside Vehicles: Don't Breathe and Drive?* Environmental Health Perspectives, Vol. 109, No. 9, (September 2001); Marr, L.C., Grogan, L.A., Wohrnschimmel, H., Molina, L., Molina, M., Smith, T., Garshick, E., *Vehicle Traffic as a Source of Particulate Polycyclic Aromatic Hydrocarbon Exposure in the Mexico City Metropolitan Area*, Environmental Science and Technology, Vol. 38, No. 9, (2004), pp. 2584-2592; Fruin et al., "Fine particle and black carbon concentrations inside vehicles," 10th Annual Conference of the International Society of Exposure Analysis, Oct., 2000.

74 Estimate is based on EPA methodology described in EPA Memorandum, Bryan Hubbell to Sam Napolitano, July 2, 2001. Estimated NO_X, SO_2 and PM emissions health damages for heavy duty vehicle emissions.

75 Motor Age, "EPA to Retrofit 11 Million Diesels," Advanstar Communications (August 2004). Available online at: http://www.motorage.com/motorage/article/articleDetail.jsp?id=141102

76 California Air Resources Board (CARB) 2004a. Air Quality Almanac Emission Projections. Online at *http://www.arb.ca.gov/emisinv/emsmain/emsmain.htm;* California Air Resources Board (CARB). 2003a. Staff Report: "Initial Statement of Reasons: Proposed Diesel Particulate Matter Control Measure for On-Road Heavy-Duty Residential and Commercial Solid Waste Collection Vehicles," California Environmental Protection Agency, Sacramento, CA; California Air Resources Board (CARB) 2003b Staff Report: "Initial Statement of Reasons for Proposed Rulemaking: Airborne Toxic Control Measure for Stationary Compression Ignition Engines," Sacramento, CA: California Environmental Protection Agency, Stationary Source Division Emissions Assessment Branch; California Air Resources Board (CARB) 2003c. REVISED – Staff Report: Initial Statement of Reasons for Proposed Rulemaking: Airborne Toxic Control Measure for In-use Diesel Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities Where TRUs Operate, Sacramento, CA: California Environmental Protection Agency, Stationary Source Division Emissions Assessment Branch.

77 MECA: http://www.epa.gov/otaq/retrofit/documents/meca1.pdf; CARB cost-effectiveness analysis: http://www.arb.ca.gov/regact/bus02/appf.pdf

78 MECA: http://www.meca.org/jahia/Jahia/engineName/filemanager/pid/229/dieselfact.PDF?actionreq=actionFileDownload&fileItem=213. A newly verified Diesel Oxidation Catalyst technology, called "a torturous path filter" achieves a 50 percent reduction in diesel particulate at about half the cost of a diesel particulate filter.

79 Motor Age, "EPA to Retrofit 11 Million Diesels," Advanstar Communications (August 2004). Available online at: http://www.motorage.com/motorage/article/articleDetail.jsp?id=141102. See also, http://www.epa.gov/cleanschoolbus/

80 See: http://www.epa.gov/air/oaqps/particles/designations/index.htm

81 Vedal, S., Brauer, M., White, R., and Petkau, R., (2003). Air Pollution and Daily Mortality in a City With Low Levels of Air Pollution, Environmental Health Perspectives Vol.111, No.1, (2003), pp. 45-51.

82 See: California Risk Reduction Plan at: http://www.arb.ca.gov/diesel/documents/rrpfinal.pdf

83 For more information about retrofit programs in your area see: http://www.epa.gov/otaq/retrofit/projectmap.htm

84 For more information on EPA's Voluntary Retrofit Program see: http://www.epa.gov/otaq/retrofit

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