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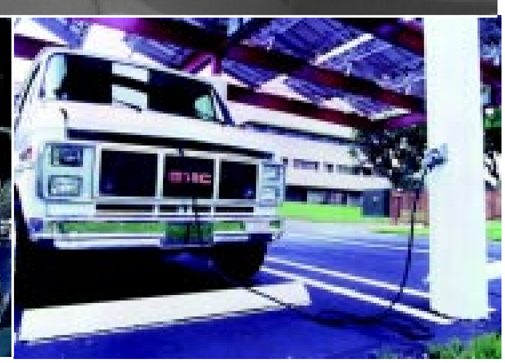

HOW STRICT LOW-EMISSION AND ZERO-EMISSION VEHICLE STANDARDS CAN CUT AIRBORNE TOXIC POLLUTION IN NEW HAMPSHIRE

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TONY DUTZIK

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APRIL 2002

ACKNOWLEDGMENTS

We express our gratitude to the Energy Foundation and the Orchard Foundation for their financial support of this project and the NHPIRG Education Fund.

We also thank the following individuals who provided insight or information relevant to this report: Paul Hughes of the California Air Resources Board, Roland Hwang of the Natural Resources Defense Council, Peter Iwanowicz of the American Lung Association of New York State, Coralee Cooper of Northeast States for Coordinated Air Use Management (NESCAUM), Rick Rumba of the New Hampshire Department of Environmental Services, Dave Gwinnup of the U.S. EPA and Rob Sargent, Rebecca Stanfield, Alison Cassady, Jasmine Vasavada and Travis Madsen of the state PIRGs. Special thanks to Steve Blackledge of NHPIRG Education Fund for his direction of this project, to Susan Rakov and Brad Heavner for their editorial assistance and guidance, and to Will Coyne for accessing and assembling the air toxics data from the EPA's National-Scale Air Toxics Assessment.

Cover photos: Traffic congestion on Interstate 93 in Salem, N.H. courtesy the *Eagle-Tribune*. Hybrid-electric and battery-electric vehicles from U.S. Department of Energy, National Renewable Energy Laboratory.

The author alone bears responsibility for any factual errors. The recommendations are those of the NHPIRG Education Fund and do not necessarily reflect the views of our funders.

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CLEAN CARS, CLEANER AIR

How Strict Low-Emission and Zero-Emission Vehicle Standards Can Cut Airborne Toxic Pollution in New Hampshire

Executive Summary

Toxic air pollutants – including those from light-duty cars and trucks – pose a significant public health threat in New Hampshire. New Hampshire could enjoy significant reductions in emissions of those pollutants, as well as emissions of smog-forming chemicals, were it to adopt Low-Emission Vehicle II (LEV II) emission standards in place in California and several other New England states.

Mobile sources – defined as cars, trucks and other non-stationary machinery – are major contributors to the toxic air pollution problem. The U.S. Environmental Protection Agency estimates that mobile sources emit 41 percent of all air toxics by weight and that on-road vehicles are responsible for approximately half that amount. Mobile sources are responsible for the vast majority of emissions of certain air toxics, such as benzene.

Analysis of 1996 data from the EPA's National-Scale Air Toxics Assessment, the most recent available, shows that residents of all 10 New Hampshire counties suffer from levels of toxic air pollution that pose excessive cancer risks to the population and may jeopardize the respiratory, reproductive and developmental health of residents as well.

Specifically:

- Ambient concentrations of 1,3-butadiene, formaldehyde and benzene exceed EPA standards for cancer risk in all 10 New Hampshire counties. Concentrations of acetaldehyde exceed the benchmark in two counties – Hillsborough and Rockingham – that contain more than half the state's population. All four chemicals are known or probable human carcinogens.
- Ambient concentrations of 1,3-butadiene in Hillsborough County were nearly 20 times higher than the EPA's cancer risk benchmark, and concentrations of formaldehyde and benzene exceeded the benchmark by factors of 14 and 10, respectively.
- Hillsborough County ranked first in ambient concentrations from on-road mobile sources for all four air toxics. Rockingham County ranked second and Strafford County ranked third.

While the past several decades have seen increasingly stringent limits on air pollution from automobiles, the effect of those tighter standards has been muted by dramatic increases in vehicle miles traveled. In New Hampshire, the annual number of vehicle miles traveled has nearly tripled since 1970.

In 1999, the EPA and the state of California adopted separate standards to further limit emissions from cars and light-duty trucks. Those standards were intended to address a variety of air pollution problems, including the emission of toxic chemicals into the air.

The California standards, known as LEV II, are much stronger than those of the EPA, known as Tier 2. LEV II includes tight limits on tailpipe and evaporative emissions of several air pollutants, including air toxics. It also includes a provision that ensures that a certain percentage of cars sold in future years will be zero-emission or near-zero-emission vehicles.

The LEV II program holds the potential for substantial environmental and public health benefits for New Hampshire – over and above the benefits gained through Tier 2. Specifically:

- LEV II would result in significant reductions in emissions of air toxics.

  Should New Hampshire adopt the LEV II program beginning in model year 2006, light-duty vehicles would annually release about 23 percent less toxic pollution by 2020 than vehicles certified to Tier 2 standards.

  Those emission reductions are the equivalent of taking approximately 86,000 of today's cars off the state's roads.
- LEV II would result in lower emissions of other important pollutants.

Emissions of smog-forming nitrogen oxides and volatile organic compounds (VOCs) would both decline in the long run under LEV II. By 2020, VOC emissions from light-duty vehicles would be approximately 19 percent less under LEV II than under Tier 2.

Unlike Tier 2, LEV II does not "make room" for the expanded use of diesel in the light-duty vehicle fleet. Diesel is responsible for a significant portion of the toxic particulate matter in the nation's air.

- The zero-emission vehicle (ZEV) requirement is an integral feature of the LEV II program.

  The ZEV requirement in LEV II makes the pollution reduction goals of the program more attainable. More than half of the projected reductions in air toxics emissions attained from LEV II can be attributed to vehicles covered by the ZEV requirement.

  The ZEV requirement would also fuel the development of even cleaner technologies such as electric, fuel cell and hybrid-electric vehicles. ZEV technologies are the only ones that offer the potential of a permanent solution to the state's mobile source air toxics and smog problems and are the only ones that couple those benefits with significant reductions in global warming emissions.

The LEV II and ZEV programs will come at some additional cost to automakers and consumers. However, those costs are minor when compared to those of other air pollution reduction programs and average vehicle costs. The ZEV program has the additional benefit of reducing automobile emissions of greenhouse gases – an important step in New Hampshire's efforts to meet its commitments under the regional Climate Change Action Plan signed by Gov. Jeanne Shaheen last year. Moreover, the LEV II and ZEV rules will result in a net economic gain for the state over the long term by reducing public health costs and enhancing the state's energy security.

We recommend that the state of New Hampshire adopt the LEV II program and ZEV requirement at the earliest opportunity. Further, we recommend that the state take additional actions to encourage the deployment of ZEVs and other ultra-clean vehicles and to reduce air toxic health threats from other sources in the state.

1. INTRODUCTION

Despite its image as a place of abundant forests, breathtaking mountains and pristine lakes, New Hampshire faces significant environmental problems, among them, air pollution.

Levels of smog in New Hampshire's air exceeded EPA health standards on ten occasions during the summer of 2001, up from just once during the summer of 2000.[1] Among the biggest contributors to the problem are cars and light trucks. While tailpipe emissions from these vehicles have been reduced over the last three decades, those gains have been compromised by the dramatic increase in the number of miles traveled on the state's highways. Between 1970 and 1999, the annual number of miles traveled on New Hampshire's roads nearly tripled – from 12 million miles to 32.5 million miles.[2] With rapid residential growth continuing to occur in the state's southern tier, this trend can be expected to continue.

But smog isn't the only vehicle-related air pollution problem. Airborne toxic pollutants – such as benzene, particulate matter and formaldehyde – also pose a significant public health threat, putting hundreds of thousands of New Hampshire residents at increased risk of contracting cancer and respiratory ailments, and possibly leading to reproductive and developmental health effects as well.

Residents of every New Hampshire county – from Coos to Rockingham – breathe levels of airborne toxic contaminants that pose an excessive cancer risk under the guidelines set by federal law. Mobile sources, and especially highway vehicles like cars and trucks, are a major source of that pollution.

Over the past three decades, the federal government has adopted increasingly stringent standards to regulate emissions from motor vehicles. In 1999, it did so again, adopting "Tier 2" standards that will dramatically reduce emissions of a range of air pollutants.

But while the new standards will likely go far to address the region's smog problem, they may not be sufficient to protect New Hampshire residents from exposure to air toxics.

Thankfully, there is an alternative. The state of California – long a leader in automobile emissions reductions – has adopted a different set of emission standards that take an aggressive posture toward air toxics while also helping to combat the state's smog problem. Those standards, called the Low-Emission Vehicle II (LEV II) rule, also include a cutting-edge requirement that automakers sell significant numbers of zero-emission or near-zero emission vehicles in the near future. Recognizing the benefits of the California approach, four states – New York, Massachusetts, Maine and Vermont – have adopted some or all of the LEV II standards for themselves – leaving New Hampshire the only northern New England state without the tougher standards.

Adopting the LEV II standards in New Hampshire would lead to a significant reduction in air toxics emissions in the state over the next two decades while helping to encourage the development of technologies that could someday eliminate toxic emissions from automobiles altogether.

This approach will not be without short-term costs. But the long-term benefits – in improved public health, reduced environmental pollution and enhanced economic and energy security – are well worth the investment.

2. Air Toxics in New Hampshire

The Environmental Protection Agency lists 188 chemicals as hazardous air pollutants (HAPs). Of those, EPA has identified 21 as coming primarily from "mobile sources" – cars, trucks and other non-stationary machinery. At least 10 of those are produced in significant quantities by light-duty cars and trucks:

- **Benzene**, which can cause leukemia and a variety of other cancers, as well as central nervous system depression at high levels of exposure. On-road vehicles produced an estimated 32 percent of all benzene emitted into New Hampshire's air in 1996.[3]
- **1,3-Butadiene**, a probable human carcinogen, which is suspected of causing respiratory problems. On-road vehicles are responsible for 35 percent of emissions in New Hampshire.
- **n-Hexane**, which is associated with neurotoxicity and whose links to cancer are unknown.
- **Formaldehyde**, a probable human carcinogen with respiratory effects. On-road vehicles are responsible for 29 percent of emissions in New Hampshire.
- **Acetaldehyde**, a probable human carcinogen that has caused reproductive health effects in animal studies. On-road vehicles are responsible for 28 percent of emissions in New Hampshire.
- **Acrolein**, a possible human carcinogen that can cause eye, nose and throat irritation.
- **Toluene**, a central nervous system depressant suspected of causing developmental problems in children whose mothers were exposed while pregnant. Its cancer links are unknown.
- **Ethylbenzene**, which has caused adverse fetal development effects in animal studies. Its cancer links are unknown.
- **Xylene**, a central nervous system depressant that has caused developmental and reproductive problems in animal studies.
- **Styrene**, a central nervous system depressant that is a possible human carcinogen.[4]

In addition, airborne **particulate matter** – the motor vehicle component of which comes largely from diesel-fueled vehicles – has also been recognized as a cause of lung cancer and respiratory problems, and is classified by California as a toxic air contaminant.

Mobile sources – which include cars, trucks and other highway and non-road motorized machinery – are major emitters of air toxics. EPA estimates that mobile sources emit 41 percent of all air toxics by weight and that on-road vehicles are responsible for approximately half that amount.[5] Several air toxics – such as benzene and toluene – are also hydrocarbons, which play an important role in the chemical reaction that creates smog.

Emissions only tell part of the air toxics story. On-road mobile source air toxics tend to achieve higher concentrations in the most populated areas of the state, where the density of vehicle emissions tends to be highest. In Hillsborough County, for instance, on-road mobile sources are responsible for 42 percent of ambient formaldehyde concentrations, 43 percent of benzene concentrations, 70 percent of 1,3-butadiene concentrations, and 69 percent of formaldehyde concentrations.[6]

In 1990, the U.S. Congress mandated that the EPA take steps to address emissions of airborne toxic chemicals. In the Clean Air Act amendments of that year, Congress set as a goal reducing the cancer risk from airborne toxins to one case of cancer for every one million residents. But twelve years later, New Hampshire residents still face cancer risks from these and other air toxics that are well above the Clean Air Act goal.

Specifically:

- Ambient concentrations of 1,3-butadiene, formaldehyde and benzene exceed EPA standards for cancer risk in all 10 New Hampshire counties. Concentrations of acetaldehyde exceed the benchmark in two counties – Hillsborough and Rockingham – that contain more than half the state's population. All four chemicals are known or probable human carcinogens. (See Table 1.)
- Ambient concentrations of 1,3-butadiene in Hillsborough County were nearly 20 times higher than the EPA's cancer risk benchmark, and concentrations of formaldehyde and benzene exceeded the benchmark by factors of 14 and 10, respectively.
- In terms of concentrations from on-road mobile sources, Hillsborough County ranked first in ambient concentrations of all four air toxics. Rockingham County ranked second and Strafford County ranked third. (See Appendix C for additional information.)

Air toxics are clearly a significant public health problem for New Hampshire. But while that threat has gained increasing recognition in recent years, it has not been adequately addressed at the federal level.

The 1970 Clean Air Act directed EPA to set health-based ambient air quality standards for six "criteria" pollutants – carbon monoxide, ground level ozone, lead, nitrogen oxide, particulate matter and sulfur dioxide. With the Clean Air Act amendments of 1990, Congress established the one-in-a-million cancer risk goal for toxic air contaminants and directed EPA to address emissions of three specific mobile source air toxics: benzene, formaldehyde and 1,3-butadiene.[7]

Despite a 54-month timeframe for developing regulations for those chemicals, it took the agency until 2001 to issue a mobile source air toxics rule – and even that rule did not take additional action to limit air toxic emissions from mobile sources. A group of environmentalists and states filed suit against the EPA in May 2001 to get the agency to fulfill the congressional mandate.[8]

Northeast States for Coordinated Air Use Management – a group representing the six New England states, New York and New Jersey – contends that the implementation of all current and proposed federal regulations, including the Tier 2 standards discussed in this report, will not achieve the

Table 1: County Rankings for Ambient Concentrations of Selected Air Toxics ($\mu g/m^3$)

	1,3 Butadiene		Formaldehyde		Benzene		Acetaldehyde		
County	Ambient Concentration	State Rank	Ambient Concentration	State Rank	Ambient Concentration	State Rank	Ambient Concentration	State Rank	Average Rank
Hillsborough	***0.071***	***1***	***1.089***	***1***	***1.343***	***1***	***0.581***	***1***	1.0
Rockingham	***0.043***	***3***	***0.893***	***2***	***1.163***	***3***	***0.481***	***2***	2.5
Belknap	***0.064***	***2***	***0.625***	***5***	***1.265***	***2***	0.200	5	3.5
Strafford	***0.031***	***6***	***0.638***	***4***	***0.896***	***6***	0.263	3	4.8
Merrimack	***0.029***	***9***	***0.652***	***3***	***0.912***	***4***	0.250	4	5.0
Carroll	***0.032***	***4***	***0.458***	***10***	***0.911***	***5***	0.095	9	7.0
Cheshire	***0.029***	***8***	***0.573***	***6***	***0.735***	***9***	0.166	6	7.3
Grafton	***0.031***	***7***	***0.492***	***9***	***0.835***	***7***	0.104	8	7.8
Sullivan	***0.026***	***10***	***0.526***	***7***	***0.769***	***8***	0.135	7	8.0
Coos	***0.032***	***5***	***0.520***	***8***	***0.651***	***10***	0.068	10	8.3

***Bolded and italacized exceed cancer risk benchmarks.**

cancer risk reductions called for by the Clean Air Act.[9]

Achieving that goal – and protecting the health of New Hampshire residents – will require additional action. The LEV II standards are the best option available to New Hampshire to meet this threat.

3. Auto Emissions Standards

A common theme runs through the history of automobile emissions standards in the United States. Whenever the time has come to take action to protect the environment and public health from vehicle emissions, California has led the rest of the nation.

That should be no surprise. With its automobile-centered culture and smog-conducive climate, California has typically felt the negative effects of vehicle emissions earlier and with greater severity than elsewhere in the country.

In 1961, California required installation of the first automobile emissions control device in the country. In 1966, it was the first state to adopt tailpipe emissions standards for specific pollutants. Three years later, the state issued the first set of pollutant-specific air quality standards. In the latter two cases, the federal government followed suit within two years with similar regulations.

In 1970, the federal government took a major step forward with the passage of the original Clean Air Act, which called for the first national tailpipe emissions standards and set the overall framework that has governed automobile emission regulation since.[10] The 1970s and 1980s saw the progressive tightening of existing air quality standards, the installation of new pollution control equipment, and the elimination of leaded gasoline – all of which led to significant reductions in automobile emissions.

But even as federal air pollution rules grew more stringent, federal law preserved a special place for California. From the very early days of air pollution regulation, California has been empowered to issue its own vehicle emissions standards because of the state's urgent air pollution problems.

With the Clean Air Act of 1990, the federal government further tightened emissions standards at the federal level. The law also required the EPA to reassess the need for even tighter standards for the 2004 model year and beyond.

The 1990 act also preserved the right of states to adopt more protective emission standards based on those adopted in California. By the mid-1990s, New York and Massachusetts had adopted the California rules, with Vermont and Maine following suit later. States were barred from issuing standards that differed from the federal or California rules – a provision intended to prevent automakers from being forced to market 50 different cars in 50 states.

While Congress was acting to tighten air pollution standards at the national level, California was not sitting still. In 1990, the state adopted its low-emission vehicle (LEV) and zero-emission vehicle (ZEV) standards. The LEV standards, which were far tighter than the prevailing federal standards at the time, allowed manufacturers to certify vehicles to a series of emissions "bins," provided that their fleets met an overall average standard for non-methane organic gas (NMOG) – a class of pollutants that includes many air toxics and smog precursors – that declined over time. The law also required automakers to manufacture a certain percentage of ZEVs, beginning with 2 percent in 1998 and increasing to 10 percent by 2003.[11]

In 1994, following up on the 1990 Clean Air Act Amendments, the U.S. EPA issued its Tier 1 rule, which phased in tighter emissions standards for cars and some light trucks. Several years later, in an effort to stave off the implementation of the ZEV requirement by other states, the auto industry and federal government agreed to a new National Low Emission Vehicle (NLEV) program that went into effect in the northeastern states in 1999 and nationwide in 2001. The NLEV standards include further reductions in tailpipe emissions, mirroring the reductions included in California's original LEV standards.

In 1999, both California and the federal government adopted tough new standards designed to limit air pollution emissions from a wide range of motor vehicles beginning in the 2004 model year. The California program was called LEV II; the federal program, Tier 2.

There are many similarities between the two programs. In fact, they have more in common than not.

Both adopted the "bin" system pioneered in California's 1990 LEV I standards. The system gives manufacturers the flexibility to produce a mix of higher- and lower-polluting vehicles as long as their entire fleet meets overall emission reduction targets. Both programs also eliminated the "SUV loophole" that exempted many light trucks from the tough emissions standards in place for passenger cars (although a similar loophole still exists in federal fuel efficiency standards). And both established tighter emission levels for vehicles regardless of the type of fuel they use.[12]

But there are several key differences between the two programs. Among these are:

- The two programs measure compliance against different benchmark pollutants.
- There is significant difference in the reductions required for "evaporative emissions" – those emissions that come from sources other than vehicle exhaust.
- The federal standards do not require the production and sale of technology-stimulating zero-emission vehicles.

How Standards Are Enforced

For both the California LEV II and the federal Tier 2 programs, the amount of emissions permitted for a vehicle depends on its vehicle class and weight. With the 1999 changes, the Tier 2 and LEV II programs have adopted a generally similar set of classifications for passenger cars (known as PCs or LDVs) and light trucks (LDTs). (See Table 2.)

To determine if vehicles are in compliance with clean air standards, vehicles are tested according to standardized test procedures, with their engines aged to simulate conditions at their "full useful life," which is currently defined as 120,000 miles under both California and federal standards. In certain cases, regulations also stipulate "intermediate life" standards, which are measured at 50,000 miles.

For the sake of clarity, this report will refer to vehicles by their federal classifications. Occasionally, we will refer to "heavy" and "light" light-duty trucks. Heavy light-duty trucks (or HLDTs) comprise the LDT3 and LDT4 categories in the federal classifications, while light light-duty trucks (LLDTs) represent the LDT1 and LDT2 categories. Further, whenever standards are mentioned, they should be assumed to be for the full (120,000 mile) useful life, unless otherwise stated.

Table 2: Federal and California Light-Duty Vehicle Classes[13]

CA Vehicle Class	Weight	US Vehicle Class	Weight
PC	All passenger cars	LDV	All passenger cars
LDT1	0-3,750 lbs. LVW	LDT1	0-6,000 lbs. GVW 0-3,750 lbs. LVW
LDT2	3,751 lbs. LVW- 8,500 lbs. GVW	LDT2	0-6,000 lbs. GVW 3,751-5,750 lbs. LVW
		LDT3	6,001-8,500 lbs. GVW 0-5,750 lbs. ALVW
		LDT4	6,001-8,500 lbs. GVW 5,751-8,500 lbs. ALVW

LVW: Loaded Vehicle Weight=actual vehicle weight plus 300 lbs.

GVW: Gross Vehicle Weight=maximum design loaded weight

ALVW: Adjusted Loaded Vehicle Weight=average of GVW and actual vehicle weight

While many think of pollution as primarily coming from a vehicle's tailpipe, there are other sources as well. Approximately half of all hydrocarbon emissions from vehicles come from evaporative emissions – those emissions that emanate from engines, fuel systems and other parts of the vehicle both while it is running and while it is sitting still.[14]

Those emissions include:

- **Running losses** (about 47 percent of evaporative emissions) – Running losses include leakage from the fuel and exhaust systems as the car is being driven.
- **Hot soak emissions** (about 38 percent) – Hot soak emissions include releases from the carburetor or fuel injector that occur when a car is cooling off following a trip.
- **Diurnal emissions** (about 10 percent) – Emissions that take place due to "breathing" of the gas tank caused by changes in ambient temperature (i.e. the car being heated and cooled by the sun).
- **Resting losses** (about 4 percent) – Leakage from a car while it is resting.[15]

Both the California and federal programs include new limits on evaporative emissions, although the federal standards are much weaker than the California standards. Compliance with evaporative emission standards is determined by putting a vehicle through a set testing procedure that simulates changing ambient temperatures and the effects of engine cooling following a drive.

NMOG, NMHC and VOCs

Historically, federal and California regulations have used a variety of measures to gauge the release of toxic and smog-forming pollutants from motor vehicles. The Tier 2 and LEV II rules both measure tailpipe emissions of non-methane organic gases (NMOG), a class of pollutants that includes hydrocarbons (except methane) and various other reactive organic substances such as alcohols, ketones, aldehydes and ethers. Some previous standards have been communicated in terms of non-methane hydrocarbons (NMHC), which do not include non-hydrocarbon reactive gases. Still other standards are communicated in terms of volatile organic compounds (VOCs), which include all the components of NMOG but exempt some non-reactive hydrocarbons. All three measures include a variety of air toxics, but not necessarily the same ones.

The three measures yield roughly equivalent amounts of motor vehicle emissions and are often used interchangeably. In this report, overall tailpipe and evaporative emissions reductions are presented in terms of NMHC. These values were then converted to NMOG to analyze emissions of specific air toxics and VOCs. For a more detailed discussion of this topic, see Appendix A.

Tailpipe Emission Standards

Federal Tier 2 Rule

The foundation of the Tier 2 rule is a fleet average emission standard for nitrogen oxides (NOx) – a key precursor of smog – of 0.07 grams/mile, a significant reduction from earlier federal standards. The NOx standard is to be phased in for cars and LLDTs beginning in 2004, with the standards to be fully phased in for the 2007 model year. HLDTs and medium-duty passenger vehicles (MDPVs, a class of larger passenger vehicles that includes conversion vans) will be subject to interim standards, which will be phased in beginning in 2004, and the full Tier 2 standards, which will be phased in beginning in 2008. All vehicles will comply with the new standards beginning in 2009.[16]

The new rules also give manufacturers an incentive to certify their vehicles to Tier 2 standards ahead of schedule, by allowing them to bank credits toward future compliance with the rules.

Manufacturers will have the flexibility to certify their vehicles to one of a number of "bins," provided that their fleets meet the

Table 3: Tier 2 Tailpipe Emission Standards (grams/mile)[17]

Bin No.	NOx	NMOG	CO	Formaldehyde	PM	Notes
11	0.9	0.280	7.3	0.032	0.12	a,c
10	0.6	0.156/0.230	4.2/6.4	0.018/0.027	0.08	a,b,d
9	0.3	0.09/0.18	4.2	0.018	0.06	a,b,e
8	0.2	0.125/0.156	4.2	0.018	0.02	b,f
7	0.15	0.09	4.2	0.018	0.02	
6	0.1	0.09	4.2	0.018	0.01	
5	0.07	0.09	4.2	0.018	0.01	
4	0.04	0.07	2.1	0.011	0.01	
3	0.03	0.055	2.1	0.011	0.01	
2	0.02	0.01	2.1	0.004	0.01	
1	0	0	0	0	0	

Notes:

a) This bin is deleted at the end of the 2006 model year (end of 2008 model year for LDT3-4 and MDPVs).
b) Higher NMOG, CO and formaldehyde values apply for LDT3-4 and MDPVs only.
c) This bin is only for MDPVs.
d) Optional NMOG standard of 0.280 g/mi applies for qualifying LDT4s and qualifying MDPVs only.
e) Optional NMOG standard of 0.130 g/mi applies for qualifying LDT2s only.
f) Higher NMOG standard deleted at end of 2008 model year.

0.07 g/mi average NOx requirement. In practice, the bins will allow manufacturers to produce some vehicles that emit more than 0.07 g/mi of NOx, as long as they also manufacture vehicles certified to bins with tighter NOx requirements.

The bins are structured to ensure that emissions of other air pollutants – including NMOG (which includes many air toxics), carbon monoxide (CO), formaldehyde, and particulate matter for diesel vehicles (PM) – are reduced along with NOx.

The Tier 2 standards guarantee that, at full phase-in, light-duty cars and trucks will emit no more than 0.09 g/mi of NMOG – the highest level allowed in any permanent bin. In fact, emissions will likely be less, as automakers certify some vehicles to bins 1 through 4 in an effort to balance out higher NOx-emitting vehicles in their fleets.

California LEV II Rule

In contrast to the federal rules based on NOx, the California LEV II standards are based on fleet average emissions of non-methane organic gases (NMOG) – which include some smog precursors as well as many air toxics.

The LEV II standards require all cars and light-duty trucks to meet a steadily declining fleet average NMOG requirement beginning in 2004. In the first year, cars and light light-duty trucks (LLDTs) must meet a fleet average of 0.053 g/mi NMOG when tested at 50,000 miles intermediate life, while heavy light-duty trucks (HLDTs) must meet a fleet average of 0.085 g/mi. Those averages gradually decline to 0.035 g/mi. for cars and LLDTs and 0.043 for HLDTs by 2010. (See Table 4.)

As is the case in Tier 2, manufacturers can certify their cars to any one of a number of

Table 4: LEV II Fleet Average NMOG Standards for Light-Duty Vehicle Classes (grams/mile)[18]

Model Year	All PCs; LDTs 0-3,750 lbs. LVW	LDTs 3,751 lbs. LVW-8,500 lbs. GVW
2004	0.053	0.085
2005	0.049	0.076
2006	0.046	0.062
2007	0.043	0.055
2008	0.040	0.050
2009	0.038	0.047
2010+	0.035	0.043

Table 5: LEV II Light-Duty Emission Bins at Intermediate and Full Useful Life (grams/mile)[19]

Bin	NMOG	CO	NOx	Formaldehyde	PM
LEV[20]	0.075/0.09	3.4/4.2	0.05/0.07	0.015/0.018	NA/0.01
ULEV	0.04/0.055	1.7/2.1	0.05/0.07	0.008/0.011	NA/0.01
SULEV	NA/0.01	NA/1.0	NA/0.02	NA/0.004	NA/0.01
ZEV	0	0	0	0	0

LEV=low-emission vehicle, ULEV=ultra low-emission vehicle, SULEV=super low-emission vehicle

emissions "bins"– as long as their fleet average emissions of NMOG meet the standards. The declining NMOG fleet averages will result in manufacturers certifying a greater proportion of their cars to cleaner bins as the years go by.

In the early years of LEV II, manufacturers can still certify a portion of their vehicles to the earlier LEV I standards, but the fleet averages in LEV II still apply. After 2006, the following emissions bins apply. (See Table 5)

It must also be noted both federal and California standards impose new limits on emissions from medium-duty passenger vehicles (e.g. large passenger vans). Because medium-duty vehicles make up only a small portion of the U.S. vehicle fleet, this analysis focuses primarily on light-duty vehicles, which make up 90 percent of all vehicle miles traveled in the U.S.[21]

Evaporative Emission Standards

In addition to limiting tailpipe emissions, both the Tier 2 and LEV II standards include new rules to limit evaporative emissions. Both rules keep in place limits on running loss emissions that are the same for California and the rest of the nation. The main difference is in limits on diurnal and hot-soak emissions. Those emissions are measured by two sets of tests. The three-day diurnal-plus-hot-soak test measures the evaporative emissions produced during a set of vehicle operations. The two-day test is a supplemental testing procedure designed to ensure adequate purging of the emission control canister during vehicle operation.[22] (See Table 6.)

How They Stack Up

Although both the LEV II and Tier 2 programs will result in substantial reductions in emissions, a direct comparison between the programs shows that LEV II is much stronger:

- **The LEV II program will lead to greater tailpipe emissions reductions upon full phase-in.** As noted above, the federal Tier 2 program will result in maximum fleet-average NMOG emissions of 0.09 grams/mile. Vehicles certified to Tier 2 standards will likely have somewhat lower emissions of NMOG than the 0.09 g/mi upper limit, as manufacturers certify their vehicles to cleaner bins in order to meet the fleet-average NOx requirement. The declining fleet average NMOG standard in LEV II, however, ensures that California cars will eventually release significantly less NMOG – and, therefore,

Table 6: Evaporative Emission Standards for Three-Day Diurnal Plus Hot Soak Test (in grams/test)

Class	California	Federal
Passenger cars	0.5	0.95
Light-duty trucks <6,000 lbs. GVW	0.65	0.95
Light-duty trucks 6,000-8,500 lbs. GVW	0.9	1.2

fewer air toxics – than cars certified under Tier 2. An analysis of the potential reduction in air toxics in New Hampshire that would result from adoption of LEV II follows in the next chapter.

A similar situation is likely to occur for the two chemical precursors of smog: volatile organic compounds and nitrogen oxides. Because VOC emissions are closely tied to emissions of NMOG, New Hampshire will experience a significant decline in VOC releases as the LEV II program progresses. (See next chapter for a more detailed analysis.)

Reductions in NOx emissions are expected to be similar for the early years of both the Tier 2 and LEV II programs. However, as California's fleet-average standard for NMOG tightens, more super-low-emission and zero-emission vehicles will be required to meet the standards, driving down NOx emissions significantly.

Detailed analysis conducted by the Massachusetts Department of Environmental Protection and the New York State Department of Environmental Conservation confirms the long-term NOx reduction benefits of LEV II. The Massachusetts DEP estimated that adoption of LEV II would result in a 19 percent reduction in NOx emissions compared to Tier 2 levels by 2020.[23] New York's DEC estimated that LEV II would attain a fleet average for NOx that is nearly 29 percent lower than the final fleet average attained by Tier 2 upon full implementation of both programs.[24]

- **Tier 2 could allow for continued use of dirtier vehicles**. Even at full phase-in, the Tier 2 program preserves the use of two bins – Bin 6 and Bin 7 – that permit greater emissions of certain pollutants than the LEV II standards.

  Use of the higher NOx emission levels in Bins 6 and 7 would require manufacturers to also certify some vehicles to cleaner bins in order to meet the federal fleet average requirement for NOx.

  The more significant difference, however, is in Bin 7's standard for particulate matter, which is double that of the highest LEV II bin. Some analysts suggest that such an approach would open the door for greater sales of diesel vehicles, which are a major source of particulate pollution.[25]

- **LEV II will generate greater reductions in evaporative emissions than Tier 2.** The California standards represent a nearly 80 percent reduction in evaporative emissions from previous standards, while the federal Tier 2 standards represent only a 50 percent reduction.[26]

4. Emissions Reductions in New Hampshire

Air Toxics Reductions Under LEV II

Adoption of the LEV II standards would result in a 23 percent reduction in light-duty emissions of air toxics by 2020 compared with Tier 2 emission standards, according to an analysis of models and data compiled by EPA, the Massachusetts Department of Environmental Protection and other agencies.

Tailpipe NMHC Emission Benefits

By 2020, state adoption of LEV II would result in a reduction of about 1 million pounds – or 28 percent – of annual tailpipe non-methane hydrocarbon (NMHC) emissions in New Hampshire when compared to Tier 2 standards. (See Table 7.) NMHC emissions are closely related to emissions of NMOG, which includes the bulk of EPA-regulated mobile source air toxics present in light-duty exhaust.

Most of the difference between the two standards comes from passenger cars and light light-duty trucks. These vehicles were already subject to stringent emissions limits before Tier 2 and LEV II, meaning that older LDVs and LLDTs still on the road in 2020 will make up a smaller percentage of the pollution from vehicles in those weight classes than will older HLDTs. Moreover, the high percentage reduction under LEV II reflects the program's phase-in of more stringent limits on NMOG releases from LDVs and LDT1s over time – an aggressive posture not found in Tier 2.

Evaporative NMHC Emission Benefits

The LEV II program would also bring about significant reductions in evaporative NMHC emissions – the source of about half of all NMHC released into the air from motor vehicles.

By 2020, light-duty vehicles in New Hampshire would release about 401,000 fewer pounds of NMHC – or about 11 percent – under LEV II evaporative emission standards as opposed to those in Tier 2. (See Table 8.)

Total NMHC Reductions

Combining the tailpipe and evaporative emission benefits of LEV II leads to the conclusion that total light-duty NMHC emissions would be about 1.4 million pounds per year less in New Hampshire by 2020 – or 20 percent – under LEV II as opposed to Tier 2. (See Table 9.)

Reductions in Air Toxics

The EPA regulates 21 mobile source air toxics (see Appendix D), of which a smaller number, approximately 10, are present in detectable levels in light-duty vehicle exhaust and evaporative emissions. With the exception of diesel particulate matter, which is addressed in the next section, the NMOG category of emissions includes the bulk of EPA-regulated mobile source air toxics from light-duty vehicles.

These specific chemicals are not measured individually. But chemical speciation pro-

Table 7: Estimated New Hampshire Tailpipe NMHC Emissions in 2020 Under Tier 2 and LEV II (in thousand pounds)

Vehicle Class	Tier 2	LEV II	Difference	Pct. Difference
LDV	996	606	390	39%
LDT 1/2	1,662	1,180	481	29%
LDT 3/4	1,071	914	157	15%
TOTAL	**3,729**	**2,700**	**1,029**	**28%**

Table 8: Light-Duty Evaporative NMHC Emissions in 2020 Under Tier 2/LEV II (in thousand pounds)

Vehicle Class	Tier 2	LEV II	Difference	Pct. Difference
LDV	1,222	1,047	175	14%
LDT 1/2	1,708	1,537	171	10%
LDT 3/4	668	612	56	8%
TOTAL	**3,598**	**3,197**	**401**	**11%**

Table 9: Total NMHC Emissions from Light-Duty Vehicles in 2020 under Tier 2/LEV II (in thousand pounds)

	NMHC Emissions
LEV II	5,897
Tier 2	7,327
Total Reduction	**1,430**
Pct. Reduction	**20%**

files, which detail the chemical composition of NMOG, allow us to determine the potential reductions in emissions of particular air toxics.

Applying EPA-generated speciation profiles to the LEV II-generated NMHC emission reductions detailed above yields a projected annual reduction under LEV II of 354,000 pounds – or approximately 23 percent – of the 10 air toxics listed in Table 10.[27]

Estimating that the average car on the road today in New Hampshire produces approximately 4.1 pounds of air toxics per year, the additional emissions reductions under LEV II compared with Tier 2 will be equivalent to taking approximately 86,000 of today's cars off the road by 2020.[28]

Table 10: Air Toxics Emissions by Light-Duty Fleet Under Tier 2/LEV II, 2020 (in thousand pounds)

	Tier 2	LEV II	Difference
1,3- BUTADIENE	22	16	6
N-HEXANE	118	100	18
FORMALDEHYDE	49	35	13
ACETALDEHYDE	22	16	6
ACROLEIN	2.7	1.9	0.7
BENZENE	255	196	58
TOLUENE	615	471	145
ETHYLBENZENE	94	73	21
XYLENE	343	262	81
STYRENE	15	11	4
TOTAL AIR TOXICS	**1,536**	**1,182**	**354**
PCT. REDUCTION			**23%**

Reductions in Volatile Organic Compounds

As noted above, the declining NMOG certification standards in LEV II will eventually force automakers to certify increasing numbers of cars to cleaner emission "bins" – a move that will lead to long-term reductions in emissions of NOx, an important ozone precursor.

However, those declining standards will also lead to reductions in the other main precursor of smog: volatile organic compounds, or VOCs.

In addition to containing a variety of toxic substances, the NMOG category of emissions also includes many volatile compounds that react with NOx in the atmosphere and sunlight to form smog. By reducing NMOG emissions through LEV II, New Hampshire can enjoy commensurate reductions in VOCs. By 2020, adoption of the LEV II standards would result in a reduction of 1.4 million pounds of VOC emissions – or 19 percent – when compared to Tier 2. (See Table 11.)

The Impact of Diesel

No discussion of mobile-source air toxics would be complete without referencing one of the most dangerous pollutants: diesel particulate matter (PM).

Currently, light-duty vehicles are responsible for only a small portion of the particulate matter emitted into the nation's air. The EPA estimates that even without the Tier 2 standards, emissions from light-duty vehicles would make up only 1.4 percent of all emissions of PM by 2007.

However, there is little certainty as to what portion of light-duty vehicles will run on diesel fuel in the years to come. In making its Tier 2 rule, the EPA posited a scenario in which as many as 9 percent of all passenger cars and 24 percent of light trucks sold in 2020 are running on diesel.[29]

As noted above, the Tier 2 rule allows some greater flexibility for manufacturers to produce diesel-fueled vehicles because of more lenient particulate matter standards. In one bin, PM standards are double the maximum level allowed in any bin under LEV II. Manufacturers might be tempted to take advantage of that leniency due to the greater fuel efficiency of diesel engines.

The EPA projects that tighter limits on sulfur in gasoline (enacted at the same time as Tier 2) will offset the increased production of light-duty diesel vehicles, such that its Tier 2 standards will result in total light-duty PM emissions remaining roughly the same in 2020 as today.[30]

In contrast, California's LEV II emissions standards would not make room for the widespread introduction of light-duty diesel vehicles to the marketplace. Combined with standards that reduce the sulfur content of gasoline, California's standards will lead to steep reductions in light-duty PM emissions.

Cost

Adopting the LEV II standards will not be without costs to automakers or consumers. However, those costs appear minor when compared to the price of an average vehicle or to the economic benefits that will result from improved public health.

The best gauge of the added cost of LEV II versus Tier 2 comes from a cost analysis by the California Air Resources Board (CARB). This analysis projected the additional cost of upgrading a 2003 model year vehicle certified to the ULEV bin in the original LEV I standards to a ULEV or SULEV under LEV II. The LEV I ULEV bin includes NMOG emission levels that are roughly comparable to the final Tier 2 standards, but NOx levels that are between four and twelve times higher than Tier 2. Thus, CARB's estimate – while the best available – likely overstates the additional cost of upgrading Tier 2 vehicles to meet the LEV II standards.[31]

Table 11: VOC Emissions Under LEV II vs. Tier 2, 2020 (thousand pounds)

	Tier 2	LEV II	Difference	Pct. Difference
Tailpipe	3,718	2,692	1,026	28%
Evaporative	3,705	3,292	413	11%
Total VOC	**7,423**	**5,984**	**1,439**	**19%**

CARB estimated that the incremental per-vehicle cost of LEV II would range from as little as $71 to upgrade an LDT1 to meet the LEV II ULEV standard to $304 to upgrade a heavy light-duty truck to meet the LEV II SULEV standard.[32] These figures include CARB's $25 per vehicle estimated cost of complying with LEV II's evaporative emission standards. (See Table 12.)

The LEV II standards also appear to be cost-effective when compared to other means of reducing pollution from mobile sources. CARB estimated that the additional cost would translate to approximately $1.00 for every pound of pollution reduced, compared to $5.00 per pound for other mobile source reduction programs and $10.00 per pound for many stationary source programs.[33]

The increase in cost under LEV II also appears small when compared to the average cost of a new motor vehicle, currently about $24,800.[34] The cost of adopting the program, then, translates to less than one percent of vehicle price in almost all cases.

Unfortunately, CARB did not go on to estimate the societal benefits – in reduced public health costs, averted sick days, and the like – that would result from adoption of LEV II. However, EPA did conduct such an analysis for its adoption of Tier 2 standards. EPA estimated that its Tier 2 standards will lead

Table 12: Incremental Per Vehicle Cost of LEV II ULEVs and SULEVs Versus LEV I ULEVs

	LEV II ULEV	LEV II SULEV
LDV	$96	$156
LDT1	$71	$130
LDT2-4	$209	$304

to the annual avoidance of 4,300 premature deaths nationwide, 2,300 cases of bronchitis, and numerous lost work days, hospital visits and other costs.[35] The net economic benefit of the policy to society at full implementation in 2030, EPA estimated, would be between $8.5 billion and $20 billion.[36]

Because the marginal cost of eliminating pollution increases as pollution controls tighten, it would be improper to extrapolate the potential societal benefit of the LEV II program from the EPA analysis. Since LEV II will reduce air toxics concentrations in New Hampshire – and the risks of cancer and other health problems that they pose – it is reasonable to assume that the program would result in a significant additional net economic benefit to the state.

5. The Zero Emission Vehicle Requirement

The zero-emission vehicle (ZEV) requirement in the LEV II standards makes possible much of the emission reductions gained through the program, while promoting the development and use of advanced technology cars that could lead to further emission reductions in the future.

The ZEV requirement – as it has developed in California and been adopted by other states – is a complicated program. It has also had a tortuous history, thanks in large part to the consistent and vehement opposition of the automobile and oil industries, which have employed litigation, lobbying and public relations strategies to undo the program and prevent its spread.

Yet California's experience with the ZEV program to date has already spurred innovation in a wide range of zero-emission and low-emission vehicle technologies, from traditional electric cars to new options such as fuel-cell and hybrid-electric vehicles.

The History of ZEV

The original zero-emission vehicle program was unveiled as part of California's Low-Emission Vehicle program in 1990. As originally constructed, the plan was to have required that two percent of cars sold in California would be ZEVs by 1998, five percent by 2001, and ten percent by 2003.

In 1996, the California Air Resources Board amended the ZEV regulations in keeping with a memorandum of agreement it negotiated with seven major auto manufacturers. The agreement called for the lifting of all ZEV requirements prior to 2003 in exchange for automakers' pledge to produce for sale between 1,250 and 3,750 advanced battery electric vehicles between 1998 and 2000.[37]

In 1998, the board again amended the ZEV program, creating partial ZEV (PZEV) credits for vehicles that achieve near-zero emissions (commensurate with the SULEV emission standard) and have zero evaporative emissions. The credits served to reduce the number of "pure ZEVs" that would have to be sold by manufacturers in 2003, while increasing the overall number of cleaner vehicles on the road.

As California was adjusting its ZEV rules, a set of eastern states were positioning themselves to adopt the LEV standards and the ZEV rules that come with them. By 1996, four eastern states – New York, Massachusetts, Maine and Vermont – had adopted some or all of the LEV/ZEV program.

In the early 1990s, it looked for a time as though the LEV and ZEV programs would take hold throughout the northeast. Acting as the Ozone Transport Commission (OTC – a body created under the 1990 Clean Air Act), the northeastern states petitioned EPA to mandate adoption of the LEV program from Maine to Virginia.

The OTC's petition was later thrown out in one of many legal actions filed by automakers against the LEV program in the northeast. However, the EPA and automakers negotiated to develop a voluntary program that could supplant LEV/ZEV in the northeastern states that hadn't already adopted it.

In 1998, that voluntary program – the National Low-Emission Vehicle (NLEV) program – took effect, requiring automakers to sell cars meeting roughly the same standards as the original LEV program in New Hampshire and other northeastern states by 1999 and across the country by 2001. However, the program did not include the ZEV requirement. And it came with a promise from the northeastern states that hadn't already adopted LEV that they would not adopt California standards that would take effect before the 2006 model year.

In 2001, CARB again altered the ZEV program, reducing the percentage of pure ZEVs required in the initial years of the program to two percent and allowing manufacturers to claim additional ZEV credits. Those changes are now making their way through the regulatory process.

In the northeastern states that had adopted the ZEV program, meanwhile, state officials have proposed an alternative compliance strategy that would delay the introduction of pure ZEVs, while encouraging the early introduction of vehicles meeting PZEV criteria.[38] The plan is currently in the process of being finalized as this report goes to press.

In its short history, then, the ZEV program has been through several incarnations, weathered many political and legal battles, and remains in flux even now.

For the purpose of this report, we will assume that the version of the ZEV program that would be considered for adoption by New Hampshire is the version that was adopted by CARB in 2001, for which detailed regulations are currently being written.

How It Works

The percentages of ZEV and near-ZEV vehicles called for under California's ZEV program do not represent actual percentages of cars sold. Rather, automakers have many opportunities to earn credits toward the ZEV requirements that reduce the actual number of ZEVs they must produce.

In recent years, CARB has moved toward policies that reduce the number of pure ZEVs required of automakers, while increasing the number of extremely clean vehicles eligible for partial ZEV (or PZEV) credits.

The complexity of California's credit scheme makes it impossible to predict how many of each type of ZEV or PZEV vehicle will be on the road by 2020. Moreover, rapid changes in technology could render even CARB's initial assumptions invalid.

The key elements of the program are as follows:

- **Pure ZEVs** – The California rules require that two percent of the cars sold by large volume manufacturers by 2003 be "pure ZEVs"; those with no tailpipe or fuel-related evaporative emissions. Currently, that means electric cars, but it is expected that this will soon lead to commercial introduction of hydrogen fuel cells. In early years of the program, manufacturers can meet the requirement either with "full function" ZEVs, or with "city" or "neighborhood" electric vehicles that have a smaller range and travel at lower speeds. Credits for neighborhood electric vehicles are scheduled to decrease over time, so that by 2006 they will count for only 0.15 of a full-function ZEV.[39]
- **Advanced technology PZEVs (AT-PZEVs)** – Manufacturers will be allowed to satisfy up to two percent of the 10 percent ZEV requirement by marketing AT-PZEVs powered by compressed natural gas, hybrid-electric motors, methanol fuel cells, or other very clean means. Such vehicles must meet the strict SULEV emissions standards, have "zero" evaporative emissions, and have their emissions control systems under warranty for 150,000 miles.[40] Current hybrid-electric vehicles such as the Toyota Prius do not yet meet those standards. If manufacturers fail to fulfill the two percent allocated to AT-PZEVs, they must sell pure ZEVs instead.
- **Partial ZEV (PZEV) credits** – The California law also allows manufacturers to meet up to 6 percent of the 10 percent ZEV requirement by marketing cars that meet 150,000 mile SULEV emissions standards, the state's zero evaporative emissions standards, and other criteria. These cars, which can be powered by internal combustion engines, are eligible for partial credit toward the ZEV mandate. Under the 2001 rules, their introduction will be phased in between 2003 and 2006.
- **Other credits** – Automakers can also receive additional credits for early introduction of ZEVs or for including technologies that enhance vehicle performance, such as fast recharging, extended range, and extended warranties on batteries or fuel cells.
- **Scope** – In the initial years of the program, the ZEV requirement applies only to passenger cars and light trucks in the LDT1

category. Beginning in 2007, heavier sport utility vehicles, pickup trucks and vans will be phased into the sales figures used to calculate the ZEV requirement.

Another important change adopted by CARB in 2001 is a gradual ratcheting up of the ZEV requirement from 10 percent to 16 percent over the next two decades as shown in Table 13.

However, the ample opportunities for additional credits and multipliers available to manufacturers will significantly reduce the amount of vehicles that must be sold – particularly in the early years of the program.

Assuming that New Hampshire implements the ZEV requirement beginning in 2006 – and that implementation takes place in a similar fashion as it is expected to in California – approximately 8,000 pure ZEVs would be on the road in New Hampshire in 2020, along with approximately 44,000 AT-PZEVs and 316,000 PZEVs, based on a CARB projection of how automakers will satisfy the ZEV requirement over the next 20 years.[42] (See Table 14.)

Were New Hampshire to adopt the alternative compliance plan under consideration in other northeastern states, the number of pure ZEVs and AT-PZEVs required in the first two years of the program would be reduced, while the number of PZEVs would remain roughly the same. Because the number of pure ZEVs and AT-PZEVs required in the early years of the program is already low, the alternative plan would not have a significant impact on the number of clean cars on the road in New Hampshire by 2020.

Even with the small number of pure ZEVs required by the new version of the California standards, the overall ZEV program has the potential to bring two major benefits to New Hampshire. It makes possible the impressive reductions in air toxics and other pollutants called for by LEV II and it fosters the development of new technologies that can make automobiles much cleaner in the years to come.

Table 13: ZEV Percentage Requirement[41]

Model Years	Minimum ZEV Requirement
2003-2008	10 percent
2009-2011	11 percent
2012-2014	12 percent
2015-2017	14 percent
2018+	16 percent

Emissions Benefits

As noted above, the ZEV requirement is separate from the overall fleet-average emissions goals set out by the LEV II standards. In other words, automakers must meet the LEV II emission targets, regardless of how many, or what type, of ZEVs they put on the road. On the other hand, it can be argued that meeting LEV II's increasingly stringent emissions requirements will only be possible with the significant number of ultra-clean cars required under the ZEV program. Between the 2004 and 2010 model years, California's fleet-average standard for non-methane organic gases is scheduled to be reduced by 34 percent for cars and LDT1s and 50 percent for LDT2-4s. Coincidentally, these are the same years when the ZEV requirement is in the process of phase-in.

Using CARB's predictions of how automakers will comply with the ZEV rule, and applying them to New Hampshire, the tailpipe NMOG emissions of ZEV, PZEV and AT-PZEV vehicles on the road in the state in 2020 would be approximately 112,000 pounds, provided that all ZEV and PZEV vehicles adhere to applicable emis-

Table 14: Estimated ZEVs and PZEVs in Use in Hampshire: 2020

	Cars	Percentage of light-duty fleet
ZEVs	8,000	0.7%
AT-PZEVs	43,700	3.9%
PZEVs	315,600	27.9%

Table 15: NMHC Emissions of Vehicles Used to Comply with ZEV Requirement vs. Comparable Tier 2 Vehicles, 2020 (in thousand pounds)[44]

	NMHC (thousand lbs.)
ZEV, PZEV, AT-PZEV emissions	112
Tier 2 vehicle emissions	919
Difference	**807**
Total emissions savings LEV II vs. Tier 2	**1,430**
Pct. of savings due to vehicles covered by ZEV requirement	**56%**

sion standards for their entire lives. The same number of vehicles meeting the anticipated fleet average for NMOG under Tier 2 would emit 919,000 pounds.[43]

As stated in the previous section, the LEV II standards would result in a reduction of 1.4 million pounds of NMHC in 2020 when compared to Tier 2. ***Thus, more than half of the NMHC emissions savings gained under LEV II versus Tier 2 can be attributed to vehicles manufactured to fulfill the ZEV requirement.*** (See Table 15.)

The above analysis underestimates the impact of the ZEV requirement on air quality. First, the ZEV program's requirements for PZEVs and AT-PZEVs require that automakers certify those vehicles to the ultra-low SULEV emissions bin for 150,000 miles useful life, not 120,000. Because emission control systems degrade over time and with wear, the emission reductions generated by vehicles covered by the ZEV mandate will persist for a longer period of time than even conventional LEV II cars.

Second, those rules also require PZEVs and AT-PZEVs to have zero fuel-related evaporative emissions, reducing diurnal-plus-hot-soak NMOG emissions by a further 30 percent for passenger cars and 17 to 23 percent for light-duty trucks from LEV II levels.[45]

In sum, the ZEV requirement, by mandating the sale of significant numbers of ultra-clean vehicles, brings the aggressive emission-reduction goals of the LEV II program within closer technological reach for the rest of the vehicle fleet. And its own particular rules for useful life and evaporative emissions result in additional emission reductions that would not occur were it not for the ZEV requirement.

Toxic Air Pollution Associated With Zero-Emission Vehicles

One argument often lodged against ZEVs – and electric vehicles in particular – is that the pollution caused by power plants that use coal, oil, natural gas or nuclear fuel to generate electricity for vehicles reduces or outweighs the environmental benefits of eliminating emissions from the vehicles themselves.

This argument sets up an unfair comparison with conventional vehicles. The "upstream" pollution caused by petroleum extraction, refining, storage and distribution is rarely factored into the analysis of emissions from internal combustion vehicles. Including oil spills, leaking underground storage tanks, and air emissions from refineries into a calculation of the environmental impacts of internal combustion engines would only serve to underscore the urgency of moving away from fossil fuels for transportation.

Because ZEVs use energy more efficiently than internal combustion engines, their upstream environmental impacts are generally less than those of conventional vehicles. However, in the case of electric vehicles, much depends on the source of electricity in the area in which the vehicles will operate. The approximately 8,000 zero-emission vehicles anticipated to be on the state's roads in 2020 would result in a 0.4 percent increase in demand for electricity in New Hampshire compared to 1999 utility sales figures, should all of them be exclusively powered by electricity.[46]

At present, New Hampshire generates more than 20 percent of its electricity from coal – a notoriously dirty source of power that is responsible for emissions of sulfur dioxide, nitrogen oxides, carbon dioxide and a slew of toxic substances, such as particulate matter and mercury – and 18 percent of its electricity from petroleum.[47] In addition, three power plants – located in Bow, Newington and Portsmouth and owned by Public Service of New Hampshire (PSNH) – rank as the dirtiest in New England and are exempt from meeting modern air pollution standards under the Clean Air Act.[48]

There is reason to believe, however, that electric generation in New Hampshire will be significantly cleaner in 2020 than it is today.

The imposition of tougher air pollution standards and the continued shift toward natural gas for electric generation promise to make electric power plants cleaner on a per-kilowatt-hour basis. There is also the potential for widespread adoption of renewable energy sources – such as solar and wind – for electricity generation.

Moreover, significant public pressure has mounted in recent years to clean up the state's old, dirty fossil fuel-fired power plants, which are exempt from modern pollution controls. These plants pose significant environmental and public health risks and must be required to meet the same clean air standards as modern power plants – regardless of the potential for increased future demand from ZEVs.

The upstream impact of the ZEV requirement will be limited by other factors as well. First, only a small percentage of cars on the road in 2020 will be required to be "pure ZEVs." Should automakers choose to fill the ZEV requirement with PZEVs and AT-PZEVs, they will be able to use a variety of fuels to power them – including compressed natural gas, hybrid-electric motors, and methanol fuel cells – whose emissions would be regulated under LEV II.

Second, there is growing belief that hydrogen fuel cell vehicles – not electric vehicles – will become the "pure" ZEVs of choice within the next two decades. If that were to be the case, the need for off-site generation of electricity to power vehicles would be eliminated entirely, except for any electricity used to extract hydrogen for use as a fuel.

All of these factors serve to minimize the potential long-term pollution displacement effects that would result from the widespread adoption of ZEVs.

Stimulating Technology

The most important benefit of the ZEV program has little to do with reducing emissions in the near term. In its 12 years in existence in California, the ZEV program has proven to be a catalyst for the development of new technologies that could make automobiles even cleaner in the years to come.

The enactment of the original ZEV program in California in 1990 led to an almost immediate spike in interest among automakers in advancing electric vehicle technology. A study conducted for CARB by researchers from the University of California-Davis found that patent applications for electric vehicle-related technologies skyrocketed beginning in 1993 after a long decline during the 1980s and early 1990s.[49] The researchers also found that spending on joint federal government/industry electric vehicle programs increased from $18 million in 1990 to $100 million in 2000.[50]

The renewed research effort had a major impact on the state of electric vehicle technology. Between 1996 and 2000, as a result of California's memorandum of agreement with the automakers, approximately 2,300 electric vehicles of seven different models took the road in California, demonstrating their viability as a transportation alternative.[51]

Other alternative technologies advanced as well. In 1999, Honda offered the first hybrid-electric vehicle, the Insight, for sale in the U.S. The "Big 3" American automakers have been working in conjunction with the federal government on a research effort to develop their own market-ready hybrids by 2003.[52] In 2001, the gasoline-powered California version of the Nissan Sentra became the first vehicle to qualify for PZEV credit. Other vehicles – such as the Honda Accord, Honda Civic GX and Toyota Prius, have achieved SULEV status, one of the main criteria for qualifying as a PZEV.

Hydrogen fuel cells are another technology that has recently made significant advances. Fuel cells use hydrogen to create a chemical reaction that generates electricity to power a vehicle. Fuels such as gasoline and methanol can be used to generate the hydrogen needed, or hydrogen itself can be used as a fuel. When hydrogen is used, the only "emissions" from the fuel cell are water and heat. Other base fuels generate small amounts of hydrocarbon emissions, but produce far less pollution than conventional vehicles because of their superior efficiency.

Until recent years, fuel cells have been mainly used in specialized applications such as space travel. But over the last several years, public-private partnerships at the federal level and in California have worked to bring fuel-cell vehicles to the demonstration stage. The California program, the California Fuel Cell Partnership, aims to put more than 60 fuel cell-powered cars and buses in the state by 2003.[53]

Automakers are already working toward the introduction of fuel-cell vehicles into their fleets, with Ford planning to market such a vehicle beginning in 2004, and other manufacturers planning to follow suit.[54]

The technological state of the art with regard to ZEVs and near-ZEVs is clearly far advanced from where it was when California adopted the ZEV requirement in 1990. Electric vehicles have moved from car-show concepts to daily reality for more than 2,000 Californians. Hybrid and fuel-cell vehicles have gone from the drawing board to concept development to, in the case of hybrids, mass production. California's ZEV requirement has clearly played a role in driving those technological developments.

However the California experience has not only demonstrated the effectiveness of the ZEV requirement in spurring technological innovation, it has also proven the reverse – that without a specific requirement in effect, progress toward advanced technology vehicles will languish.

In 1996, California and the seven major automakers reached an agreement that would lift the ZEV percentage requirement until 2003 in exchange for a commitment by manufacturers to produce a certain number of electric vehicles. The agreement was billed as a way to guarantee that electric cars would make their way onto California's roadways quickly, with the hope that, once established, the vehicles would gain a foothold.

What state officials did not anticipate, however, is that once the agreement expired, automakers would quickly cease producing electric cars – despite evidence of continuing consumer demand.

The decision of the automakers to stop manufacturing electric cars in the absence of a specific government mandate was a setback to the long-term success of the ZEV program. "(C)ontinuity of ZEV production is critical. Market acceptance cannot build, and volume production cannot be achieved, if ZEVs continue to be available only in boom and bust cycles," wrote CARB in a 2000 report.[55] Had CARB maintained some form of ZEV requirement for 1998 through 2003, instead of reaching a voluntary agreement with the automakers, chances are that such a "boom and bust" cycle could have been avoided.

Whether the issue is safety, the adoption of emission control technologies, or the development of advanced technology vehicles, the automobile industry has proven time and time again that it requires a strong push from state and federal agencies before it adopts practices to protect public health and safety. The ZEV requirement, then, is a necessary step to hasten the development of technologies that will make New Hampshire's air cleaner for decades to come.

An Investment Worth Making

The primary argument against the ZEV requirement is that it costs too much. Automakers must spend millions to develop new technologies. And the cars that result are much more expensive than the average consumer can afford.

Because few ZEV or near-ZEV cars have yet made it into general production, there is some truth to this argument. CARB estimates that incremental costs for ZEVs in 2003 will range from $7,500 for city electric vehicles to more than $20,000 for freeway-capable vehicles with advanced batteries.[56] However, CARB noted that if existing electric vehicles were to be produced in volume and if gasoline prices should increase significantly (to $1.75 per gallon), the life-cycle cost of a freeway-capable electric car would begin to approach that of a conventional car.[57] CARB's study also found that hybrid-electric vehicles and PZEV vehicles have significantly lower incremental costs than electric vehicles – approximately $3,200 for hybrids and $200 for PZEVs.[58]

To help with the purchase of ZEVs during the term of the memorandum of agreement, California provided $5,000 per car subsidies to automakers, which then applied the subsidy to their ZEV lease or deducted it from the sticker price.[59] In 2000, California passed a new law under which consumers will be eligible for grants of up to $9,000 toward the purchase of a new ZEV.[60]

There are other costs associated with ZEVs as well. Widespread use of electric vehicles will require some public charging infrastructure to augment charging stations in homes and in offices. Fuel cells that rely on hydrogen as a base fuel will require the availability of hydrogen fueling stations.

But the infrastructure costs – and vehicle costs as well – are offset by the profound environmental and economic benefits that come from a reduced dependence on fossil fuels for transportation use. Subsidizing the development and deployment of advanced technology vehicles is a sound long-term investment to reduce future costs from public health and environmental damage.

Environmentally, in addition to the reductions in emissions noted above, ZEV and near-ZEV vehicles can play a major role in reducing the incentive to drill for oil in sensitive natural areas and eliminate many of the negative "upstream" impacts of oil production, from oil spills to pollution from refineries to leaking underground storage tanks. In addition, the ZEV requirement provides incentives for manufacturers to meet higher energy-efficiency standards for zero-emission vehicles and AT-PZEVs, which can not only ease demand for oil or electricity but can also reduce emissions of greenhouse gases responsible for global warming.

The global warming benefits of the ZEV program alone make it worth consideration. In 2001, Gov. Jeanne Shaheen, along with other New England governors and eastern Canadian premiers, committed to a Climate Change Action Plan that seeks to reduce regional greenhouse gas emissions to 1990 levels by 2010. The plan included a recommendation to "promote the shift to higher-efficiency vehicles, lower carbon fuels and advanced technologies."[61]

An analysis produced for CARB's 2000 biennial review of the ZEV program found that electric and hybrid-electric vehicles produced the lowest emissions of carbon dioxide among seven vehicle-fuel combinations studied.[62] Another analysis, by Argonne National Laboratory, found that battery-electric passenger cars receiving their power from Northeastern power sources have 43 percent lower greenhouse gas emissions over the entire fuel cycle than conventional cars. Hybrid-electric vehicles have 46 percent lower greenhouse gas emissions and compressed natural gas vehicles 11 percent lower emissions over their fuel cycles than conventional cars.[63] With the number of vehicle miles traveled expected to increase in New Hampshire and elsewhere, the introduction of significant numbers of alternative vehicles will be needed to prevent further increases in carbon emissions from the light-duty fleet – let alone meet the regional greenhouse gas reduction goals set in the Climate Change Action Plan.

Economically, the introduction of ZEVs would cushion the economy from the impact of intermittent oil-price shocks, reduce dependence on foreign oil, and safeguard New Hampshire from severe social disruption should the oil supply become significantly strained within the next two decades, as some experts predict. The development and production of ZEVs can also help spur the economy, provided that the United States acts aggressively to take leadership in this emerging market. New Hampshire, with its growing concentration of high-tech industries, is well-suited to enjoy the benefits of this technological shift.

Finally, the adoption of the ZEV requirement can help hasten the development of alternative fuel sources for other uses – from home heating to manufacturing – bringing added stability and efficiency to those sectors as well.

These benefits more than justify the financial and regulatory investment that would be made by adoption of the ZEV requirement in New Hampshire.

A Role for New Hampshire

New Hampshire's adoption of LEV II and the ZEV requirement would not, in and of itself, bring about the massive technological shift described above. However, the state has a key role to play in making such a shift happen.

While New Hampshire makes up only a small percentage of the light-duty cars and trucks registered in the United States, it is also the only northern New England state not to have adopted at least part of the LEV II program. With New York, Massachusetts and Vermont already planning to require the sale of ZEVs within the next five years, New Hampshire could help form a core northeastern block of states committed to the program. That could create a powerful incentive for other nearby states to join the program and establish New England as a center for the development of ZEV technology. It would also guarantee New Hampshire residents access to the cleanest cars available – cars that will already be on sale to residents of neighboring states.

In short, despite its small size, New Hampshire is uniquely situated to adopt a policy that would not only reap major benefits for its own citizens, but help build the solid, sustainable base of demand that will be required for ZEVs to become an economically viable alternative in the years to come.

6. Policy Recommendations

New Hampshire should join Massachusetts, New York and Vermont in adopting the California Low-Emission Vehicle II standards.

Adoption of the California LEV II standards and the ZEV requirement is one of the most effective steps New Hampshire can take to protect citizens from the health dangers posed by air toxics, reduce the emission of smog-forming pollutants, attain the state's goals for reducing greenhouse gas emissions, and strengthen the state's long-term economic and environmental security.

Northeast States for Coordinated Air Use Management (NESCAUM) has estimated the changes in ambient air toxics concentrations for the northeastern states that would take place under all current and proposed federal mobile source regulations – including Tier 2. NESCAUM concluded that all those regulations, combined, would fail to meet standards for cancer risk set out by the Clean Air Act by 2030.

Adoption of the LEV II standards is a straightforward and effective way that New Hampshire can move itself closer to the goal of reducing the cancer threats posed by air toxics.

New Hampshire should consider other incentives for ZEV development and use.

Even under the LEV II program, it will be several years before New Hampshire residents have the opportunity to purchase or own a ZEV or near-ZEV vehicle. There are several ways the state can encourage the speedy introduction of ultra-clean vehicles.

- **Direct subsidies or tax credits for consumers.** These should be carefully targeted to encourage only the purchase of vehicles with true environmental benefits: electric and fuel-cell vehicles, vehicles dedicated to run on natural gas or other clean fuels, and hybrid electric vehicles with high fuel efficiency. Tax credits that are combined with increased taxes on gas guzzlers would be a revenue-neutral way to encourage purchase of cleaner cars.
- **Requirements that government or public agencies purchase zero emission and alternative fuel vehicles for appropriate uses.** The state of New Hampshire deserves credit for purchasing a small number of electric, compressed natural gas and hybrid-electric vehicles for government use. These procurement efforts should continue at the state level and the state should identify ways to assist local and county governments in making similar purchases. Public-private efforts such as the Granite State Clean Cities Coalition can also play a useful role in expanding the use of alternative-fuel vehicles.
- **Encouragement of voluntary labeling systems that can help environmentally conscious consumers identify the cleanest cars.** The recently announced Granite State Clean Cars initiative, while laudable in its intent, sets the bar too low for inclusion, allowing vehicles certified to NLEV standards to bear the Granite State Clean Cars sticker. Limiting inclusion to the program to vehicles that qualify as California ULEVs and SULEVs and obtain truly exceptional fuel economy – or providing more detailed emissions information on all vehicles to consumers at the point of sale – could help New Hampshire consumers better identify which vehicle purchases will result in truly substantial benefits to air quality.
- **Providing assistance for the development of charging infrastructure for electric vehicles or other infrastructure improvements.**

We acknowledge that it may be politically difficult with the recent economic downturn to create new incentives such as direct subsidies. But it is important for state officials to realize that a thoughtful and effective approach to the introduction of ZEVs will require carrots as well as sticks. The experience of California and other states should help state officials decide what works and what doesn't in encouraging ZEV use.

Adopt Other Policies to Reduce Emissions of Toxic Substances into New Hampshire's Air

Light-duty cars and trucks make up a significant portion of air toxics releases in New Hampshire. But other state and federal policies will likely also be needed to fully protect state residents from the dangers posed by air toxics. Strengthening the U.S. EPA's Mobile Source Air Toxics rule and moving to require the state's old, fossil fuel-fired power plants to meet modern air pollution standards are among the steps that can be taken to complement the reductions in air toxics emissions that would result from adoption of the LEV II standards.

Appendix A: Methodology and Sources

Assumptions

This report is intended to calculate an estimate of anticipated reductions in toxic air pollution that would take place annually in New Hampshire beginning in 2020 under the LEV II standards as opposed to federal Tier 2 emission controls. Estimates of these relative benefits – as well as other conclusions reached by this report – were derived using a simplified methodology that does not reflect all local factors that can influence vehicle emissions. It is intended as a measure of the relative policy implications of the LEV II and Tier 2 standards, not a projection of future toxic pollution in New Hampshire.

Two assumptions underlie this analysis:

- **This study focused on emissions from light-duty vehicles only.** New standards for medium-duty passenger vehicles are part of the updated Tier 2 and LEV II rules. However, the rules still primarily focus on light-duty vehicles, which make up the vast majority of vehicle miles traveled in the U.S. As a result, this analysis understates the relative emissions benefits of both the Tier 2 and LEV II programs.
- **This study assumes that no light-duty vehicles are powered by diesel.** This assumption is largely true at present, because diesel-powered vehicles make up less than one percent of overall car and light truck sales. However, as noted earlier, the EPA projects that light-duty diesel vehicles could increase to as much as 9 percent of all new car sales and 24 percent of all light truck sales by 2015 under one scenario.

  Because these projections of future diesel penetration of the light-duty fleet are highly speculative – and because the use of diesel fuel results in a different mix of air toxics emissions than gasoline, introducing a complicating factor to the analysis – this study assumed that the light-duty fleet on the road in 2020 will continue to be gasoline-powered vehicles.

Emissions Estimation

Overall NMHC Emissions

Estimates of relative reductions in non-methane hydrocarbon (NMHC) emissions are based on emissions factors calculated by Cambridge Systematics in their analysis for the Massachusetts DEP, which were in turn derived from EPA's Tier 2 and MOBILE5b models. These emission factors have the limitation of being based on climactic and driving patterns that differ slightly from those in New Hampshire. It is also based on the assumptions (true in Massachusetts) a) that LEV II standards will be implemented beginning in 2004, not 2006 as would be the case in New Hampshire, and b) that the LEV I program, rather than the NLEV and Tier 1 programs, was in effect for vehicles sold prior to the 2004 model year. As a result, the Mass. Emissions Factor model will tend to slightly exaggerate the differences between LEV II and Tier 2 when applied to New Hampshire. Finally, the EPA has recently issued a new emissions modeling program – MOBILE6 – that supersedes MOBILE5b and the Tier 2 model. MOBILE6 was made public in late January, just as this analysis was being completed, and there was not time to revisit the analysis based on the new model.

Overall emissions were calculated by multiplying the total light-duty VMT projected for 2020 for each vehicle class (as derived below) by the applicable emission factor for that class.

Air Toxics

Estimated emissions of individual air toxics were calculated by converting total estimated NMHC emissions into estimated NMOG emissions, then multiplying by speciation percentages in EPA's Speciate database. The speciation profiles chosen were profile #1313 for tailpipe emissions and profile #1305 for evaporative emissions. Both profiles are based on 1990 baseline gasoline. No attempt was made to account for differences in speciation profiles based on the use of oxygenated or reformulated gasoline.

In both profiles, the total organic gas (TOG) percentages in the EPA's speciation model were converted to NMOG by eliminating the methane portion of the profile. In addition, the profiles were used to estimate an NMHC to NMOG conversion factor based on the percentage of TOG represented by non-hydrocarbon organic gases (alcohols, ethers, ketones and aldehydes). This factor was 1.027 for exhaust and 1.030 for evaporative emissions. NMHC emissions were multiplied by the conversion factor, and then by the percentages in the NMOG portion of the speciation profile to derive individual air toxics emissions.

Volatile Organic Chemicals

Speciation profiles were also employed to derive a NMOG to VOC conversion factor, by calculating the percentage of NMOG represented by compounds exempted by the EPA from its definition of VOCs per Code of Federal Regulations 40 CFR 51.100(s)(1). This factor was found to be 0.971 for exhaust and 1.0 for evaporative emissions. The factor was then multiplied by total NMOG emissions to derive total VOC emissions.

Number of Cars Taken Off the Road

An estimate was made of the number of 2000 model year cars that would be taken off the road to equal the additional air toxics pollution reductions in LEV II over Tier 2.The "car" used for this comparison is an average passenger car on the road in 2000 per the emission factors in Cambridge Systematics' analysis. The per-mile emission levels were then multiplied by the estimated number of vehicle-miles traveled by a light-duty car in 2020 per the methodology below, and then the chemical speciation profiles listed above, to arrive at a per-car amount of air toxics emissions. The total air toxics reductions under LEV II were then divided by this per-car amount to arrive at the number of cars that would be taken off the road.

Fleet Characteristics and Vehicle Miles Traveled

Unless otherwise noted, fleet and vehicle miles traveled data attributed to the EPA are from "Fleet Characterization Data for MOBILE6: Development and Use of Age Distributions, Average Annual Mileage Accumulation Rates and Projected Vehicle Counts for Use in MOBILE6," published April 1999.

The total number of light-duty vehicles in use in 2020 in the state was determined by taking the national in-use vehicle fleet estimates from EPA and multiplying them by the percentage of car and truck registrations for the state in 2000 per Ward's Automotive Yearbook 2001. The number of light-duty trucks in each class was determined by multiplying the total number of light-duty trucks by ratios of truck classes established by EPA for MOBILE6.

Vehicle counts were further broken down by model year using age distribution percentages for each vehicle class established by EPA.

Vehicle miles traveled data are based on the estimate of 47-state VMT for 2020 prepared by EPA corrected to take account for VMT in Alaska, California and Hawaii. Total VMT was then disaggregated into national VMT by vehicle subgroupings (LDV, LDT1/2 and LDT3/4) using ratios in worksheet T2MODAQA of EPA's Tier 2 model, and further broken down into individual vehicle classes using the vehicle stock splits in EPA's MOBILE6 fleet characterization data.

Two correction factors were applied to determine what portion of VMT should be applied to vehicles of each model year and to account for different driving habits at the state versus national level.

A vehicle age factor was applied consisting of the vehicle mileage accumulation rates developed by EPA divided by the average VMT per vehicle for 1996 per Ward's Automotive Yearbook 2001.

A state correction factor was applied consisting of the average VMT per vehicle for the state in 1999 divided by the national average VMT for 1999 (per Ward's and the "Highway Statistics 1999" published by the U.S. Department of Transportation).

The result was a state-specific estimate of the number of miles traveled per vehicle by vehicles in each class and each model year for the year 2020. This number was then multiplied by the estimated fleet composition numbers to arrive at the total number of VMT traveled by vehicles in each class and each model year during 2020.

ZEV Program Analysis

Because the emission factors generated from the Massachusetts DEP modeling encompass the overall impact of the LEV II rules, a separate model was constructed to estimate the relative impact of the ZEV requirement within the LEV II program. This model was used to project the contribution made by the ZEV program to overall LEV II emissions reductions, the amount of air toxics released by power plants to fuel ZEVs, and the additional evaporative emissions benefits of the "zero" evaporative emission standard in the ZEV program.

Estimates of tailpipe emissions for ZEV-compliant vehicles were obtained by multiplying the estimated VMT of vehicles in each model year and class in 2020 by the applicable emission standard. A similar calculation was performed for Tier 2 vehicles, multiplying VMT by Cambridge Systematics' inference of grams/mile NMOG emissions based on 120,000 miles useful life, in its analysis for the Massachusetts DEP. This method will tend to underestimate emissions from both ZEV-compliant and Tier 2 vehicles.

Estimates of the amount of electric power needed to operate ZEVs were derived by multiplying the average VMT per LDV in 2020 by the number of ZEVs on the road that year (as calculated based on CARB's projection of how automakers will implement the ZEV requirement) and an estimated average energy efficiency of 0.5 kW per mile per CARB's 2000 ZEV biennial review. Per-kilowatt-hour toxic emissions levels were derived by taking the total toxic emissions for electric power plants in the state from the 1999 EPA Toxics Release Inventory and dividing that number by the number of kilowatt-hours of electricity sold in the state in 1999 per the Energy Information Administration's Annual Electric Utility Report. Total electricity consumption of ZEVs on the road in the state in 2020 was then multiplied by the per-kilowatt-hour toxic emissions data to arrive at the amount of toxic pollution from power plants resulting from ZEVs.

APPENDIX B: GLOSSARY OF ABBREVIATIONS

ALVW – Adjusted loaded vehicle weight (average of gross vehicle weight and actual vehicle weight).

AT-PZEV – Advanced technology partial zero-emission vehicle. Class of ultra-clean vehicles under California standards that run on alternative fuels.

CARB – California Air Resources Board.

CO – Carbon monoxide.

DEP – Massachusetts Department of Environmental Protection.

GVW – Gross vehicle weight (maximum design loaded weight).

HAP – Hazardous air pollutant. Also known as air toxics.

HLDT – Heavy light-duty truck.

I/M – Inspection and maintenance programs.

LDV – Light-duty vehicle (i.e. passenger car).

LDT – Light-duty truck.

LEV – Low-Emission Vehicle program adopted in California in 1990. Also, the dirtiest bin to which vehicles may be certified under the LEV II standards.

LEV II – Low-Emission Vehicle program adopted in California in 1999.

LLDT – Light light-duty truck.

LVW – Loaded vehicle weight (vehicle weight plus 300 pounds).

MDPV – Medium-duty passenger vehicle.

NLEV – National Low-Emission Vehicle program adopted as a result of voluntary agreement between automakers, state governments and the EPA.

NMHC – Non-methane hydrocarbons. Category of emissions that includes many air toxics. Includes most of the NMOG category, but not aldehydes, ketones, alcohols and ethers

NMOG – Non-methane organic gas. Category of emissions that includes many air toxics. Includes non-methane hydrocarbons and other organic gases such as aldehydes, ketones alcohols and ethers.

NOx – Nitrogen oxides, a major precursor of smog.

OTC – Ozone Transport Commission. A group of northeastern states formed by Clean Air Act of 1990 to promote coordinated smog-reduction policies.

PC – Passenger car.

PM – Particulate matter, a toxic air pollutant.

PZEV – Partial zero-emission vehicle. Class of ultra-clean vehicles under California standards that may include vehicles run by internal combustion or other engines.

SULEV – Super low-emission vehicle. A certification bin under the LEV II standards that is cleaner than ULEV but not as clean as ZEV. AT-PZEVs and PZEVs must meet SULEV emission standards.

ULEV – Ultra-low-emission vehicle. A certification bin under the LEV II standards that is cleaner than LEV but not as clean as SULEV.

VOC – Volatile organic compounds. Organic compounds that evaporate into the air. Includes many air toxics.

VMT – Vehicle miles traveled.

ZEV – Zero-emission vehicle.

APPENDIX C: CONCENTRATIONS OF AIR TOXICS IN NEW HAMPSHIRE

Table C-1: County Rankings for Ambient Concentrations of Selected Air Toxics from On-Road Mobile Sources

	1,3 Butadiene		Formaldehyde		Benzene		Acetaldehyde		
County	Ambient Concentration	State Rank	Ambient Concentration	State Rank	Ambient Concentration	State Rank	Ambient Concentration	State Rank	Average Rank
Hillsborough	0.050	1	0.453	1	0.577	1	0.399	1	1.0
Rockingham	0.025	2	0.319	2	0.359	2	0.306	2	2.0
Strafford	0.021	3	0.191	3	0.240	3	0.177	3	3.0
Merrimack	0.012	6	0.163	4	0.168	4	0.160	4	4.5
Belknap	0.014	5	0.102	5	0.140	5	0.096	5	5.0
Cheshire	0.014	4	0.100	6	0.138	6	0.091	6	5.5
Sullivan	0.008	7	0.068	7	0.088	7	0.069	7	7.0
Grafton	0.006	8	0.049	8	0.065	8	0.047	8	8.0
Carroll	0.004	10	0.042	9	0.049	9	0.042	9	9.3
Coos	0.005	9	0.026	10	0.043	10	0.021	10	9.8

Table C-2: Formaldehyde: Ambient Concentrations in New Hampshire Counties

County	Total Ambient Concentration (μg/m³)	Ambient Concentration from On-Road Mobile Sources (μg/m³)	% from On-Road Mobile Sources	Factor by which Total Ambient Concentration Exceeds EPA Health Standards	Rank for Total Ambient Concentration
Belknap	0.63	0.102	16%	8.1	5
Carroll	0.46	0.042	9%	6.0	10
Cheshire	0.57	0.100	18%	7.4	6
Coos	0.52	0.026	5%	6.8	8
Grafton	0.49	0.049	10%	6.4	9
Hillsborough	1.09	0.453	42%	14.1	1
Merrimack	0.65	0.163	25%	8.5	3
Rockingham	0.89	0.319	36%	11.6	2
Strafford	0.64	0.191	30%	8.3	4
Sullivan	0.53	0.068	13%	6.8	7

Table C-3: Benzene: Ambient Concentrations in New Hampshire Counties

County	Total Ambient Concentration (μg/m³)	Ambient Concentration from On-Road Mobile Sources (μg/m³)	% from On-Road Mobile Sources	Factor by which Total Ambient Concentration Exceeds EPA Health Standards	Rank for Total Ambient Concentration
Belknap	1.26	0.140	11%	9.7	2
Carroll	0.91	0.049	5%	7.0	5
Cheshire	0.73	0.138	19%	5.7	9
Coos	0.65	0.043	7%	5.0	10
Grafton	0.84	0.065	8%	6.4	7
Hillsborough	1.34	0.577	43%	10.3	1
Merrimack	0.91	0.168	18%	7.0	4
Rockingham	1.16	0.359	31%	8.9	3
Strafford	0.90	0.240	27%	6.9	6
Sullivan	0.77	0.088	11%	5.9	8

Table C-4: 1,3-Butadiene: Ambient Concentrations in New Hampshire Counties

County	Total Ambient Concentration (μg/m³)	Ambient Concentration from On-Road Mobile Sources (μg/m³)	% from On-Road Mobile Sources	Factor by which Total Ambient Concentration Exceeds EPA Health Standards	Rank for Total Ambient Concentration
Belknap	0.064	0.014	22%	17.7	2
Carroll	0.032	0.004	13%	8.9	4
Cheshire	0.029	0.014	49%	8.1	8
Coos	0.032	0.005	17%	8.8	5
Grafton	0.031	0.006	21%	8.5	7
Hillsborough	0.071	0.050	70%	19.8	1
Merrimack	0.029	0.012	41%	7.9	9
Rockingham	0.043	0.025	58%	12.0	3
Strafford	0.031	0.021	66%	8.7	6
Sullivan	0.026	0.008	30%	7.3	10

Table C-5: Acetaldehyde: Ambient Concentrations in New Hampshire Counties

County	Total Ambient Concentration (μg/m³)	Ambient Concentration from On-Road Mobile Sources (μg/m³)	% from On-Road Mobile Sources	Factor by which Total Ambient Concentration Exceeds EPA Health Standards	Rank for Total Ambient Concentration
Belknap	0.200	0.096	48%	0.4	5
Carroll	0.095	0.042	44%	0.2	9
Cheshire	0.166	0.091	55%	0.4	6
Coos	0.068	0.021	31%	0.2	10
Grafton	0.104	0.047	45%	0.2	8
Hillsborough	0.581	0.399	69%	1.3	1
Merrimack	0.250	0.160	64%	0.6	4
Rockingham	0.481	0.306	64%	1.1	2
Strafford	0.263	0.177	67%	0.6	3
Sullivan	0.135	0.069	51%	0.3	7

APPENDIX D: EPA LIST OF REGULATED MOBILE SOURCE AIR TOXICS

Acetaldehyde
MTBE
Acrolein
Ethylbenzene
Naphthalene
Arsenic Compounds
Formaldehyde
Nickel Compounds
Benzene
n-Hexane
Polycyclic Organic Matter[i]
1,3-Butadiene
Lead Compounds
Styrene
Chromium Compounds
Manganese Compounds
Toluene
Dioxin/Furans
Mercury Compounds
Xylene

[i] Polycyclic Organic Matter includes organic compounds with more than one benzene ring, and which have a boiling point greater than or equal to 100 degrees centigrade. A group of seven polynuclear aromatic hydrocarbons, which have been identified by EPA as probable human carcinogens.

Source: Federal Register: March 29, 2001 (Volume 66, Number 61), pages 17229-17273.

APPENDIX E: EMISSION FACTORS FOR TAILPIPE AND EVAPORATIVE NMHC EMISSIONS

Cumulative fleet emission factors for tailpipe and evaporative NMHC emissions in 2020 in grams/mile.

	Tier 2		LEV II	
	Tailpipe	Evaporative	Tailpipe	Evaporative
LDV	0.097	0.119	0.059	0.102
LDT 1/2	0.107	0.110	0.076	0.099
LDT 3/4	0.211	0.132	0.180	0.121

Source: "Background Document and Technical Support for Public Hearings on the Proposed Amendments to the State Implementation Plan for Ozone and Public Hearing and Findings Under the Massachusetts Low Emission Vehicle Statute," Massachusetts Department of Environmental Protection, October 1999.

NOTES

1. New Hampshire Department of Environmental Services, "Hotter Summer Brings More Air Pollution," Press Release, 3 October 2001.
2. New Hampshire Department of Environmental Services, Air Resources Division, "Mobile Sources: General Information," downloaded from http://www.des.state.nh.us/ard/mobilesources, 21 February 2002.
3. Emissions data based on draft 1996 data from U.S. Environmental Protection Agency, National Air Toxics Assessment, downloaded from http://www.epa.gov/ttn/atw/nata.
4. All health data from California Air Resources Board Toxic Air Contaminant Fact Sheets, downloaded from http://arbis.arb.ca.gov/toxics/tac/toctbl.htm, 16 November 2001.
5. Travis Madsen and Jasmine Vasavada, "Invisible Threats: Hazardous Air Pollutants and Cancer in New Jersey," NJPIRG Law and Policy Center, 28 November 2001, 16.
6. Ambient concentrations for all New Hampshire counties are presented in Appendix C. Modeling of ambient concentrations for the National-Scale Air Toxics Assessment is weighted based on population and is not a straight average of concentrations across a given county. Source: Personal communication with Dave Gwinnup, U.S. EPA, 28 February 2002.
7. Michelle Toering, Rob Sargent, "Every Breath We Take: How Motor Vehicles Contribute to High Levels of Toxic Air Pollution in Massachusetts," MASSPIRG Education Fund, 8 July 1999.
8. "Coalition of Environmental Organizations and States Sue EPA on Inadequate Mobile Source Toxics Rule," press release, 24 May 2001. Downloaded from www.nescaum.org.
9. Travis Madsen and Jasmine Vasavada, "Invisible Threats: Hazardous Air Pollutants and Cancer in New Jersey," NJPIRG Law and Policy Center, 28 November 2001, 32.
10. U.S. Environmental Protection Agency , "Milestones in Auto Emissions Control," Fact Sheet OMS-12, August 1994; U.S. Environmental Protection Agency, "The History of Reducing Tailpipe Emissions," publication EPA420-F-99-017, May 1999; California Air Resources Board, "California's Air Quality History – Key Events," downloaded from http://www.arb.ca.gov/html/brochure/history.htm, updated 21 April 2000.
11. Michael Walsh, "California's Low Emission Vehicle Program Compared to U.S. EPA's Tier 2 Program," 20 January 2000, 1.
12. Anne G. Dillenbeck, "Driving Clean Transportation: LEVII: A Policy that Works," INFORM, 2000, 8.
13. U.S. Environmental Protection Agency, "Tier 2 Study White Paper," April 1997, downloaded from http://www.epa.gov/oms/t2paper.htm; Michael P. Walsh, "California's Low Emission Vehicle Program Compared to U.S. EPA's Tier 2 Program," 20 January 2000, 4, downloaded from http://www.walshcarlines.com/pdf/l2vst2.pdf.
14. New York State Department of Environmental Conservation, "Federally Mandated Emissions Tests Begins Jan. 2 Upstate," press release, 11 December 1997.
15. Dr. John Holtzclaw, "Traffic Calming Cleans," Sierra Club, downloaded from http://www.sierraclub.org/sprawl/articles/hwyemis.asp, 6 September 2001. Based on CARB data. Great Lakes Commission, "Scope Study for Expanding the Great Lakes Toxic Emission Regional Inventory to Include Estimated Emissions from Mobile Sources," Chapter 4-1, downloaded from http://www.glc.org/air/scope/scope006.htm, 5 September 2001.
16. Walsh, pages 28-29.
17. Federal Register, Vol. 65, No. 28, 10 February 2000, page 6855.
18. Walsh, page 9. The LEV II NMOG fleet averages are measured at 50,000 miles rather than 120,000 miles useful life.
19. Walsh, page 7.
20. LEV II allows manufacturers to certify up to four percent of their heavy (California LDT2) fleet to a higher NOx standard of 0.10 g/mi.
21. From VMT fractions included in EPA's Tier 2 model, spreadsheet T2MODAQA.XLS.
22. Walsh, page 18.

23. Massachusetts Department of Environmental Protection, “Background Document and Technical Support for Public Hearings on the Proposed Amendments to the State Implementation Plan for Ozone and Public Hearing and Findings Under the Massachusetts Low Emission Vehicle Statute,” October 1999.

24. New York State Department of Environmental Conservation, “Regulatory Impact Statement Summary,” Amendments to 6 NYCRR Part 218 , 2000, page 4.

25. Walsh, page 37.

26. Walsh, page 18, 31.

27. The chemical composition of vehicle exhaust varies greatly depending on the vehicle and the type of fuel used. The speciation profiles used in this analysis are based on 1990 baseline gasoline and do not account for the use of oxygenated or reformulated gasoline. The results presented here are intended to be suggestive of the air toxics reductions that could be expected under LEV II.

28. Estimate of “average car” toxic emissions based on applying speciation profile to a typical light-duty vehicle on the road in 2000 whose emissions were calculated using 2020 vehicle-miles traveled estimates.

29. U.S. Environmental Protection Agency, “Tier 2/Sulfur Regulatory Impact Analysis,” December 1999, page III-36.

30. U.S. Environmental Protection Agency, “Tier 2/Sulfur Regulatory Impact Analysis,” December 1999, page III-39.

31. The NMOG standards for the ULEV bin under LEV I are 0.055 g/mi for LDVs and LDT1s; 0.07 for LDT2s; 0.143 for LDT3s; and 0.167 for LDT4s, compared to an anticipated fleet average under Tier 2 of 0.09 g/mi. The NOx standards are 0.3 g/mi for LDVs and LDT1s; 0.5 for LDT2s; 0.6 for LDT3s; and 0.9 for LDT4s, compared with the 0.07 g/mi fleet average standard under Tier 2. From Walsh, 5-6.

32. California Air Resources Board, “Staff Report: Initial Statement of Reasons: Proposed Amendments to California Exhaust and Evaporative Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles,” 18 September 2001, II-55.

33. California Air Resources Board, “Staff Report: Initial Statement of Reasons: Proposed Amendments to California Exhaust and Evaporative Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles,” 18 September 2001, II-54.

34. Csaba Csere, “10 Best Cars,” *Car and Driver*, January 2001.

35. U.S. Environmental Protection Agency, “Tier 2/Sulfur Regulatory Impact Analysis,” December 1999, Executive Summary, v.

36. U.S. Environmental Protection Agency, “Tier 2/Sulfur Regulatory Impact Analysis,” December 1999, Executive Summary, vii.

37. Walsh, 13.

38. State of New York, “Governor: Regulation to Reduce Harmful Vehicle Emissions,” press release, 4 January 2002.

39. California Air Resources Board, “Zero Emission Vehicle Program Changes,” Fact Sheet, 23 February 2001.

40. In this case, “zero” evaporative emissions refers to emissions from fuel. Hydrocarbon evaporative emissions also come from other sources, including paint, adhesives, air conditioning refrigerants, vinyl, tires, etc. Passenger cars releasing less than 0.35 grams/test, LLDTs releasing less than 0.65 grams/test, and HLDTs releasing less than 0.9 grams/test in evaporative emissions meet the “zero” evaporative emission requirement under California standards. Sources: California Air Resources Board, “California Evaporative Emission Test Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles,” I.E.1(2), adopted 5 August 1999. Harold M. Haskew et al, “Running Loss Emissions from In-Use Vehicles,” Coordinating Research Council, February 1999, 3.

41. California Air Resources Board , “Zero Emission Vehicle Program Changes,” Fact Sheet, 23 February 2001.

42. Based on California Air Resources Board, “Fleet Implementation Schedule,” downloaded from http://www.arb.ca.gov/regact/zev2001/zev2001.htm, 27 December 2001. Percentages of ZEV, AT-PZEV and PZEV vehicles in use for each model year based on CARB’s estimate of total number of ZEV-compliant vehicles

sold in each model year divided by total sales base covered by the ZEV requirement in each model year. This percentage is then applied to the fleet composition projection derived from the methodology outlined in Appendix A. Note: CARB assumes that even though LDT2-4s are counted toward the ZEV requirement beginning in 2007, manufacturers will choose to comply with the requirement by selling additional numbers of ZEV-compliant LDVs and LDT1s. The remainder of this section assumes that this assumption is true.

43. The model used to calculate emissions from ZEV program-compliant and Tier 2 vehicles differs from the model used in the rest of this report in that it is based on compliance with emission standards and not the results of emission factor modeling. Because a large proportion of real-world hydrocarbon emissions come from vehicles that, due to age or malfunction, do not meet established standards, this method will tend to significantly underestimate actual emissions from both ZEV-compliant and Tier 2 vehicles. However, because ZEV-compliant vehicles must have their emissions certified for a longer useful life (150,000 miles as opposed to 120,000 miles under Tier 2), and because a significant number of those vehicles will likely be powered by fuel sources (such as electricity and fuel cells) that are not subject to the effects of fuel or emission system degradation, it is more likely that ZEV-compliant vehicles will comply with emission standards over the long haul. Thus, this method – while not an accurate representation of real-world conditions – likely provides a fair portrayal of the role of the ZEV program in overall emission reductions under LEV II, and may even underestimate that role. Note: because this analysis is based on certification standards communicated in NMOG, that measure is used here and subsequently in this section of the report.

44. Values of ZEV and Tier 2 emissions calculated in terms of NMOG.

45. Based on maximum non-fuel evaporative emissions of 0.35 grams per test for passenger cars, 0.50 grams per test for light-duty trucks 6,000 lbs. GVW and under, and 0.75 grams per test for light-duty trucks from 6,001 to 8,500 lbs. Source: California Code of Regulations, title 13, section 1976(b)(1)(E).

46. Based on an estimated average energy efficiency of 0.5 kW per mile per CARB's 2000 ZEV program biennial review and 1999 electric utility sales figures from Energy Information Administration, U.S. Department of Energy, "State Electricity Profiles 2001-New Hampshire."

47. Based on 1999 figures. From Energy Information Administration, "State Electricity Profiles 2001-New Hampshire."

48. Steve Blackledge, "PSNH: Generating the Dirtiest Power in New England," NHPIRG Education Fund, November 2001.

49. A.F. Burke, K.S. Kurani, E.J. Kenney, "Study of the Secondary Benefits of the ZEV Mandate," August 2000, 17.

50. Burke, et al, 6.

51. California Air Resources Board, "Executive Summary to the Staff Report: 2000 Zero Emission Vehicle Program Biennial Review," 7 August 2000.

52. Hybrid Electric Vehicle Program, "HEV Program Background," downloaded from http://www.ott.doe.gov/hev/background.html, 15 November 2001.

53. California Fuel Cell Partnership, "California Fuel Cell Partnership Agrees: Hydrogen Will Power Earliest Fuel Cell Cars, While Industry Examines Other Options for Future Models," press release, 25 October 2001.

54. S. Stephenson, "Emission-Free Fuel Cells on the Horizon," *Motor Age*, downloaded from http://www.motorage.com/techfocus/092201.htm, 15 November 2001.

55. California Air Resources Board, "Executive Summary to the Staff Report: 2000 Zero Emission Vehicle Program Biennial Review," 7 August 2000.

56. California Air Resources Board, "Executive Summary to the Staff Report: 2000 Zero Emission Vehicle Program Biennial Review," 7 August 2000.

57. California Air Resources Board, "Staff Report: 2000 Zero Emission Vehicle Program Biennial Review," 7 August 2000, 128.

58. California Environmental Protection Agency, Air Resources Board, "ARB Staff Review of Report Entitled 'Impacts of Alternative ZEV Sales Mandates on California Motor Vehicle Emissions: A Comprehensive Study," 31 October 2001.

59. California Air Resources Board, "Executive Summary to the Staff Report: 2000 Zero Emission Vehicle Program Biennial Review," 7 August 2000.

60. California Air Resources Board, "AB 2061 (Lowenthal): A New Zero Emission Vehicle Incentive Program," downloaded from http://www.arb.ca.gov/msprog/zevprog/zip/zip.htm, 15 November 2001.

61. The Conference of New England Governors and Eastern Canadian Premiers, "Climate Change Action Plan," 28 August 2001, 7, 17.

62. California Air Resources Board, "Staff Report: 2000 Zero Emission Vehicle Program Biennial Review," 7 August 2000.

63. M.Q. Wang, "GREET 1.5 – Transportation Fuel-Cycle Model," Center for Transportation Research, Energy Systems Division, Argonne National Laboratory, August 1999, Vol. 2, 166-167.