Executive Summary

BREATHING FREE IN ILLINOIS:

REDUCING AIR POLLUTION AND IMPROVING HEALTH THROUGH CLEANER CARS

"Driving a private car is probably a typical citizen's most 'polluting' daily activity"
– US EPA, Automobile Emissions: Overview (1994)

Introduction. Millions of Illinois residents enjoy the convenience of driving cars. Unfortunately, the large and growing number of drivers enjoying the freedom of movement comes at a price: all those cars, going all those miles, are damaging our environment and worsening our public health.

Our cars, vans, SUVs, and pick-ups pollute the air by emitting volatile organic compounds (VOCs), air toxics, nitrogen oxides (NOx), and particulate matter (PM). Several of these "primary" pollutants react in the atmosphere to create harmful "secondary" pollutants like ground-level ozone and secondary PM. Our cars also are the transportation sector's biggest contributor—by far—of the carbon dioxide (CO_2) pollution that causes global warming.

People with respiratory and heart problems are particularly sensitive to vehicle pollutants, which are associated with symptoms ranging from aggravated asthma to premature death.

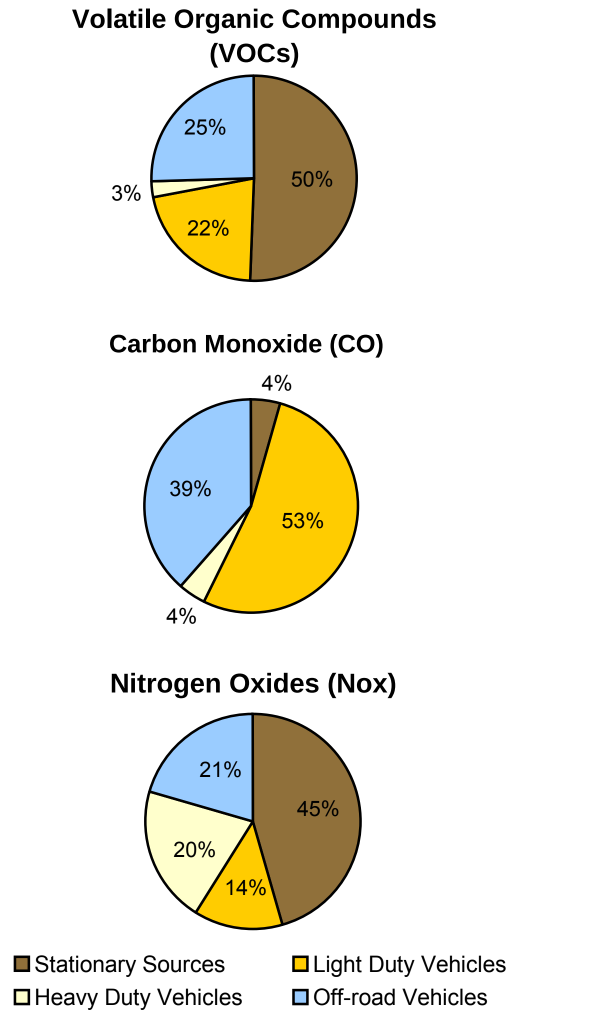
The good news is that car technologies exist—right now—to further reduce emissions and improve air quality and health. The bad news is that the vehicles boasting those technologies are not readily available to Illinois consumers. Bringing cleaner cars to Illinois – cars that Illinois consumers want and that are available in other parts of the country – will improve air quality and health for state residents, and reduce global warming pollution.

Vehicle Emissions. As shown in Figure 1[1] below, our vehicles produce 22% of the total VOCs 53% of the CO, and 14% of the NOx emitted by all human-generated pollution sources in the state, such as industrial facilities and coal plants.

Just as telling is how much our cars contribute to total statewide emissions from on-road vehicles: 89% of VOCs, 92% of CO, and 40%,of NOx.

Figure 1.

Air Pollutant Emissions in Illinois by Source



Source: 2002 Illinois Total Ozone Inventory Typical Summer Day Emissions, Illinois Environmental Protection Agency. Stationary sources consist of fixed emitters of pollutants, such as power plants and other industrial facilities with combustors.

More on Vehicle-Related Pollutants

Volatile Organic Compounds (VOCs). Carbon-based compounds present primarily in gaseous form that readily react to form other pollutants like ground-level ozone. ***Air toxics*** (below) are a subset of VOCs.

Nitrogen Oxides (NOx). A group of highly reactive gases containing nitrogen and oxygen that react to form ground-level ozone. Includes ***nitrogen dioxide (NO_2)***, a direct respiratory irritant.

Carbon monoxide. A highly poisonous gas formed by the partial combustion of carbon materials like gasoline.

Carbon dioxide. A gas formed by, among other things, the partial combustion of gasoline. Causes global warming. Other vehicle-related ***greenhouse gases (GHGs)*** include ***methane gas*** **(CH_4)** and ***nitrous oxide (N_2O)***.

Particulate Matter (PM). Particles found in the air, such as dust, soot, dirt, smoke, and liquid droplets. "Primary PM" results directly from processes such as burning fuel; "secondary PM" forms from interactions of other substances in the atmosphere. Identified in two sizes: ≤ 2.5 micrometers in diameter ($PM_{2.5}$) and < 10 micrometers in diameter (PM_{10}).

Ground-Level Ozone. A primary component of smog, ozone is a gas formed by atmospheric interactions between NOx and VOCs in the presence of sunlight.

Air Toxics. Substances that are known or suspected to cause cancer or other serious health problems, such as birth defects or reproductive effects. ***Acetaldehyde, acrolein, benzene, 1,3-butadiene and formaldehyde*** are five air toxics widely recognized as highly hazardous components of vehicle pollution.

How can we reduce pollution from our cars? Illinois can take a giant step forward in reducing vehicular pollution by adopting California's two-pronged emissions standards: Low Emissions Vehicles, Phase II (LEV II) and the Pavley Law. The latter regulates carbon dioxide emissions, while LEV II regulates all others. These are the standards that have been adopted by 12 other states, representing, with California, more than 35% of the U.S. car market.

To model the benefits of adopting California's standards, the Environmental Law & Policy Center engaged Cambridge Systematics, an independent national consulting firm specializing in transportation and air quality planning. Cambridge Systematics used various modeling techniques, including methods utilized by the U.S. EPA, to compare emissions in Illinois under the California program with those under the weaker default federal standards (called Tier 2). The analysis examined both standards under two sets of assumptions regarding how automakers would choose to comply.

Carbon dioxide reduction benefits are based on the California Air Resources Board's March 2008 comparison of the Pavley Law regulating greenhouse gas pollution with the revised 2007 CAFÉ standards. Only the California standards include a mandate for introduction of zero emission vehicles (ZEVs) and partial zero emission vehicles (PZEVs), such as conventional gasoline vehicles with high efficiency engines, hybrid gas-electric vehicles, and fuel cell vehicles. This requirement will result in substantial reductions in vehicle-related emissions.

Emissions Reduction Benefits

Given that our personal vehicles last more than 15 years, it takes some time for the fleet to completely turn over. Nonetheless, as shown in Table 1 below, Illinois would enjoy significant benefits even in 2020 from adopting the California standards. And by 2030, when all of our vehicles would meet the tougher standards, virtually all pollutants would drop by double-digit percentages, with air toxics down by as much as 21%.

Table 1. Summary of Emissions Benefits

	Benefit of California Emissions Standards for Illinois (% reduction from federal Tier 2 standards* except CO_2)	
Pollutant	2020	2030
VOCs	6.6%-8.9%	11.7%-15.5%
CO	3.0%-10.0%	4.8%-14.9%
NOx	5.7%-7.1%	10.1%-10.9%
Total air toxics	8.0%-12.6%	13.1%-20.7%
CO_2**	45% less total CO_2 by 2020	

* Range consists of estimates from Scenarios 1 and 2
**California Air Resources Board, Comparison of Greenhouse Gas Reductions for the United States and Canada Under U.S. CAFÉ Standards and California Air Resources Board Greenhouse Gas Regulations, 3/08, Table 16: Comparison of State-Specific Cumulative GHG Benefits, p. 19

Air Pollutants: Respiratory Irritants and Potential Killers

Ozone. Lung irritant associated with aggravation of asthma, allergies, bronchitis, and emphysema. Linked to premature death and cardiovascular problems, such as hospitalization for heart attacks and pulmonary heart disease.

PM. Strongly associated with premature death and other cardiovascular problems (e.g., reduced blood flow to the heart, irregular heart beat, and heart attack), as well as the respiratory effects seen with ozone. Also associated with low infant birth weight and infant mortality.

NOx. Eye, nose, throat, and lung irritant linked to respiratory problems. Also associated with the health effects from ozone and PM due to its role in their formation.

VOCs. Eye, nose, throat, and lung irritant linked to respiratory problems. Plus, four of the five air toxics in this study are known or thought to cause cancer; the fifth, acrolein, is a powerful respiratory irritant.

CO_2 and other GHGs. Linked to increased heat-related death and respiratory effects from ozone, because of their role as global warming pollutants.

Who, where, and how old we are also contribute to the severity of symptoms we experience from breathing polluted air.

- Vehicle pollutants are most concentrated near their sources and have localized effects, so persons who live, work, play, and exercise close to congested roads often bear the heaviest health burden from vehicle-related pollution.
- Children are particularly susceptible to air pollution because of the time they spend playing outdoors during the hours when pollution is at its worst.
- Aggravation of asthma caused by vehicular air pollution can cause children to miss school and adults to miss work.
- Due to evaporative emissions, drivers and passengers are exposed to some of the highest concentrations of certain pollutants while sitting in traffic congestion, as well as in their own garages and parking lots, and at gas stations.

Air pollution-related disease in Illinois

An estimated 11% of Illinois residents have been diagnosed with asthma[2] at some point in their lives.

In a 2004 study of childhood asthma in Chicago, 43% of children in the survey missed school or daycare over the previous year because of their asthma, with an average of more than three days lost.[3] The same survey reported that 27% of parents of children with asthma missed work in a one-year period due to their child's asthma.

Asthma-related hospitalizations in Illinois cost $268.6 million in 2005.[4] Total direct costs are significantly higher.

Illinois has one of the nation's highest death rates from asthma – an average of about 259 per year.[5]

Chicago's heat-related death toll has been identified as "high" by the federal agency with responsibility for studying the atmosphere.[6]

Illinois' heart disease death rate is above the national average[7], indicating the need to reduce risk from all sources.

Health Benefits. It's pretty simple. When our cars pollute less, we're healthier. To provide initial estimates of the health benefits from clean cars in Illinois, Jonathan Levy, an associate professor of Environmental Health and Risk Assessment at the Harvard School of Public Health, translated the above emissions reductions into health benefits. These estimates convey the range and magnitude of potential health benefits and can guide policy-makers in prioritizing future in-depth research. As is normal with these types of health analyses, the estimates are accompanied by various uncertainties, assumptions, and limitations, the details of which may be found in the full report and on-line appendices.

Health Benefits Results

Cleaner cars will make us healthier, as shown in the study's estimates below. In reviewing the data, particular attention should be paid to the relative difference in health-related symptoms under the two sets of standards, as well as the scale of the benefits.

Mortality. As noted above, various air pollutants are associated with premature death. The study found:

- ***Estimated decreases in annual premature deaths from vehicle-related ozone, PM, and air toxics of 7% in 2020 and 11% in 2030***. These figures include *a reduction in risk of death from cancer of 8-9% from baseline, and a 13-15% reduction in 2030.*
- That of the total mortality benefits, roughly 50% are associated with ozone, with most of the remaining 50% associated with secondary PM. Air toxics contribute to the annual mortality benefits to a much lesser extent.

Non-fatal outcomes, a.k.a. "Morbidity." As with mortality, **the Table 2 *estimates of morbidity health benefits from enhanced standards are in the range of 7-10%***. The table provides a summary of estimates for mortality and specific morbidity outcomes.

Conclusions. In sum, cleaner cars will mean less air pollution and improved health for Illinois residents. Given the high and ever-increasing costs of health care, enhanced clean car standards also will save Illinois health care dollars. The time is right to bring cleaner cars to Illinois.

Table 2. Summary of Health Benefits Estimates, 2020 and 2030.
(T*able 2 is shown for summary purposes only, as the underlying data for each outcome is based on different pollutants and sources. Full treatment of the pollutants and health benefits, including a discussion of limitations and uncertainties, are in the full report and appendices.*)

	Annual Estimated Benefits (# of reduced cases)*	
Health Outcome	2020	2030
Premature Deaths**	11-21	15-33
Cardiovascular hospital admissions***	2-4	3-7
Respiratory hospital admissions±±	58-170	93-270
ER visits for asthma±±	13-39	21-59
Lost days of school±	50,000-160,000	80,000-250,000
Minor restricted activity days±±	21,000-61,000	34,000-96,000
Reduction in respiratory symptoms±±±	59,000	100,000

*Ranges provided are in terms of central estimates for both intake fraction and linear rollback analyses.
** From all study pollutants except acrolein
*** From PM only
± From ozone only
±± From PM and ozone
±±± From acrolein, formaldehyde, and acetaldehyde

The Environmental Law and Policy Center is the Midwest's leading environmental legal advocacy and eco-business innovation organization. We believe that environmental progress and economic development can be achieved together, and we put that principle into practice through encouraging energy efficiency and other initiatives to protect natural resources and improve environmental quality. For more information, please contact the Environmental Law and Policy Center at 312-673-6500 or www.elpc.org.

Cambridge Systematics is a national firm with offices across the U.S., including Chicago. The firm has more than twenty years of experience providing transportation consulting services to federal, state and local government agencies, regional and local transportation authorities, and private industry. With respect to clean light-duty vehicles, Cambridge Systematics has conducted numerous studies measuring the air quality benefits for California, the Pacific Northwest, and several states in the Northeast.

Jonathan Levy is the Mark and Catherine Winkler Associate Professor of Environmental Health and Risk Assessment at the Harvard School of Public Health. Professor Levy is a well-respected and widely-published expert on air quality whose research centers on developing models to quantitatively assess the environmental and health impacts of air pollution from local to national scales. Professor Levy's studies on the health effects of power plant pollution have provided important information for debates over legislation in Massachusetts, New Hampshire, Connecticut, Illinois, and elsewhere.

The following people served as additional experts and reviewers on this study:

Vehicle Emissions: Tony Dutzik (Policy Analyst, State Public Interest Research Group), Louise Bedsworth (former Senior Vehicles Analyst, Union of Concerned Scientists), and Paul Hughes (Manager of LEV Implementation Section, California Air Resources Board).

Health: Stuart Batterman (Professor and Associate Chair of Environmental Health Sciences, University of Michigan School of Public Health), Serap Erdal, (Assistant Professor of Environmental & Occupational Health Sciences, University of Illinois School of Public Health).

Citations

1. IEPA Statewide Criteria Pollutants from Illinois' 2002 Inventory, Illinois Environmental Protection Agency
2. Illinois Department of Public Health, "Burden of Asthma in Illinois 1999-2006," (May 2007), available at http://www.idph.state.il.us/about/chronic/asthma.htm (last visited Mar. 12, 2008)
3. GlaxoSmithKline, "Children & Asthma in America: Chicago Survey Highlights," available at www.asthmainamerica.com/cities/child_chicago.html
4. Op. cit.
5. Id.
6. National Oceanic and Atmospheric Administration. Natural Disaster Survey Report: July 1995 Heat Wave. Washington: Department of Commerce, 1995.
7. National Center for Chronic Disease Prevention and Health Promotion, Heart Disease and Stroke Map for Illinois 1996-2000, available at http://apps.nccd.cdc.gov/giscvh/map.aspx

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ENVIRONMENTAL LAW & POLICY CENTER
Protecting the Midwest's Environment and Natural Heritage

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We would like to thank our panel of technical advisors for their input during the study process and review of pre-publication drafts. Our panel consisted of:

Vehicle Emissions: Tony Dutzik (Policy Analyst, State Public Interest Research Group), Louise Bedsworth (former Senior Vehicles Analyst, Union of Concerned Scientists), and Paul Hughes (Manager of LEV Implementation Section, California Air Resources Board).

Public Health: Stuart Batterman (Professor and Associate Chair of Environmental Health Sciences, University of Michigan School of Public Health) and Serap Erdal (Assistant Professor of Environmental & Occupational Health Sciences, University of Illinois School of Public Health).

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CHAPTER 1: INTRODUCTION

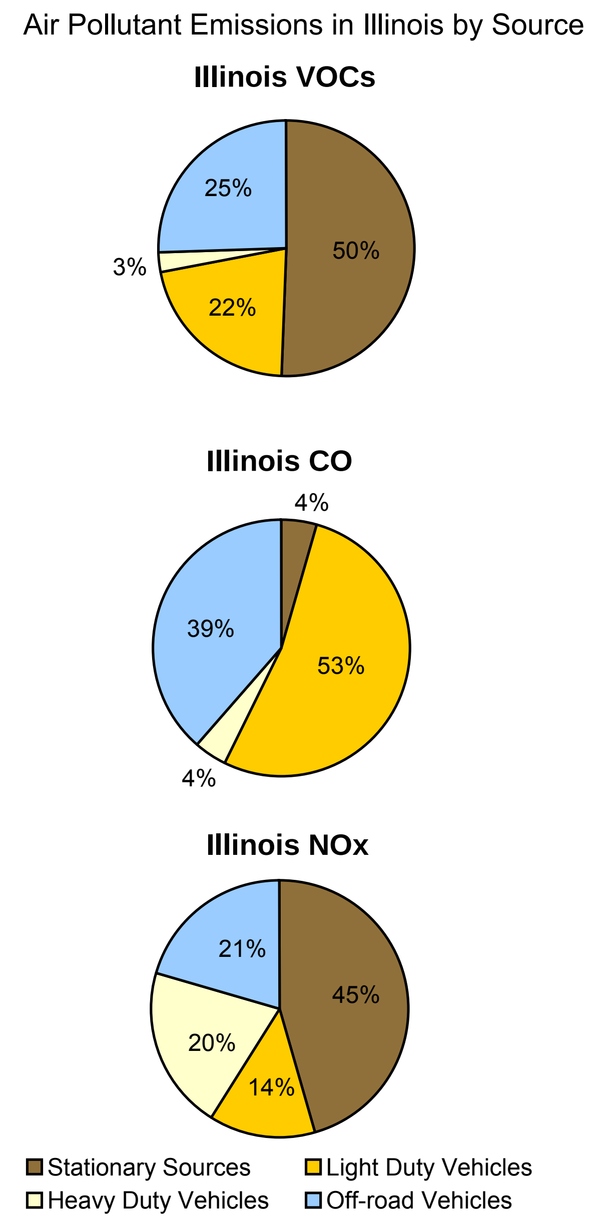
"Driving a private car is probably a typical citizen's most 'polluting' daily activity."
– US EPA, Automobile Emissions: Overview (1994)

Passenger vehicles provide convenience and freedom of movement to millions of Illinois residents. Unfortunately, these benefits come at a price. Cars and light duty trucks such as SUVs emit harmful air pollution, including air toxics, volatile organic compounds (VOCs), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO_2), and particulate matter (PM). Vehicle-related emissions are produced by the fuel production and distribution process, the engine's burning of fossil fuels, and from evaporation during refueling and driving. Once emitted, several of these "primary" pollutants react in the atmosphere to form "secondary" pollutants, like ground-level ozone and secondary PM, which themselves are harmful to health.

In Illinois, cars and light duty trucks (collectively "passenger vehicles" or "light-duty vehicles") account for a sizable portion of all emissions from human sources: 22% of VOCs, 53% of CO, and 14% of NOx (see Figure 1).[1] The numbers are even more staggering for light duty vehicles as a percentage of on-road sources. Here, light duty vehicles account for 89% of VOCs, 92% of CO, and 40% of NOx. Not surprisingly, SUVs alone are a major contributor to the problem, with SUVs being partially responsible for the 16% rise in national vehicle NOx emissions from 1970 to 1999.[i] Passenger vehicles also cause two-thirds of the U.S. transportation sector's total carbon dioxide pollution, which, in turn, represents 25% of our nation's total global warming pollution.[ii]

All this pollution occurs despite the fact that light duty vehicles are significantly cleaner than they were decades ago. How can this be? Americans are driving more than ever before because of longer commutes, family visits, and shopping at regional centers. Annual vehicle miles traveled by Illinois residents increased about 11% between 1996 and 2006, despite population growth of only about 8% for approximately the same time period.[iii]

Figure 1.



Source: 2002 Illinois Total Ozone Inventory Typical Summer Day Emissions, Illinois Environmental Protection Agency. Stationary sources consist of fixed emitters of pollutants, such as power plants and other industrial facilities with combustors.

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[1] The light duty vehicle contribution to on-road emissions was calculated for LDGV (passenger vehicles up to 6,000 pounds GVW), LDGT1 and LDGT 2 (light duty trucks up 6,000 pounds GVW), and LDGT 3 and LDGT 4 (light duty trucks from 6,001-8,500 pounds GVW). Other on-road sources include heavy-duty diesel trucks and heavy-duty gas vehicles. Anthropogenic sources include stationary sources such as coal plant stacktowers, area sources (collections of smaller stationary sources with large aggregate emissions), on-road mobile sources such as diesel trucks and passenger cars, and off-road mobile sources like construction equipment.

Air pollutants have been linked to numerous negative health outcomes, including aggravation of asthma symptoms and increased numbers of asthma attacks, lung disease (such as permanent lung damage), low birth weight and infant death, cancer, heart attacks, and premature death. As primary vehicle pollutants are most concentrated near their sources and have localized effects, persons who live, work, and exercise close to congested roads often bear the heaviest load from vehicular pollution. Children are disproportionately affected due to their greater susceptibility to air pollution and time spent playing outdoors during the hours in which air pollution is at its worst. Due to evaporative emissions, drivers and passengers are exposed to some of the highest concentrations of certain pollutants while sitting in traffic congestion, as well as in their own garages, at filling stations, and in parking lots.

In addition to having severe consequences for the global climate, greenhouse gases (GHGs) like carbon dioxide and methane gas also can negatively impact health. The contribution of GHGs to global warming may increase the number of heat-related illnesses during hot summer months, especially in urban areas where buildings and pavement trap heat close to the ground. Longer and hotter summers from global warming may result in more severe ozone seasons, leading to more respiratory problems. Numerous other health outcomes may result from global warming, as discussed below.

Light duty vehicles do not have to pollute the air as much as they do. Clean vehicle technologies ranging from air conditioning system modifications to hybrid engines currently are available to reduce emissions at a reasonable cost. However, cleaner versions of all models now are available only along the West and East Coasts. These models also carry extended warranties in participating states.

Recent polling data indicate that Americans nationwide—including here in the Midwest—also want full access to these clean cars. The reasons are many: less pollution, reduced dependency on foreign oil, and savings at the gas pump, as well as improved air quality and public health. This report focuses on these last two benefits, and how cleaner cars could help us leave a healthier heritage for our children. Our analysis consists of two primary steps: modeling the emissions reduction benefits from enhanced standards, and translating those air quality improvements into initial estimates of health benefits. These benefits can and should be considered by policy-makers; the estimates provided here can serve as guides for future in-depth analysis.

CHAPTER 2: VEHICLES & AIR POLLUTION

Pollutants. The federal Clean Air Act regulates "criteria pollutants," including nitrogen dioxide (NO_2, a component of NOx), PM, CO, and ground-level ozone, due to the high degree of danger they pose to the public's health and welfare.

> ***Vehicle-Related Pollutants***
>
> ***Volatile Organic Compounds (VOCs)***. Carbon-based compounds present primarily in gaseous form that readily react to form other pollutants like ground-level ozone.
>
> ***Nitrogen Oxides (NOx)***. A group of highly reactive gases containing nitrogen and oxygen that react to form ground-level ozone. Includes ***nitrogen dioxide (NO_2)***, a direct respiratory irritant.
>
> ***Carbon monoxide***. A highly poisonous gas at high concentrations, formed by the partial combustion of carbon materials like gasoline.
>
> ***Carbon dioxide***. A gas formed by, among other things, the partial combustion of gasoline. Contributes to global warming. Other vehicle-related ***greenhouse gases (GHGs)*** include ***methane gas (CH_4)*** and ***nitrous oxide (N_2O)***.
>
> ***Particulate Matter (PM)***. Particles found in the air, such as dust, soot, dirt, smoke, and liquid droplets. "Primary PM" results directly from processes such as burning fuel; "secondary PM" forms from interactions of other substances in the atmosphere. Identified in two sizes: ≤ 2.5 micrometers in diameter ($PM_{2.5}$) and < 10 μm micro-meters in diameter (PM_{10}).
>
> ***Ground-Level Ozone***. A primary component of smog, ozone is a gas formed by atmospheric interactions between NOx and VOCs in the presence of sunlight.
>
> ***Air Toxics***. Substances that are known or suspected to cause cancer or other serious health problems, such as birth defects or reproductive effects. ***Acetaldehyde, acrolein, benzene, 1,3-butadien, and formaldehyde*** are five air toxics widely recognized as highly hazardous components of vehicle pollution.

The U.S. EPA regulates air toxics by industry. In February 2007, the agency issued its first regulations for air toxics emitted by the operation of light-duty vehicles—although those regulations covered only one toxic, benzene.[2] Greenhouse gases (GHGs) also are a significant concern for the environment and human health because they are global warming pollutants. Examples of vehicle-related GHGs include carbon dioxide (CO_2), methane gas (CH_4), and nitrous oxide (N_2O, a component of NOx). The federal government does not limit emissions of GHGs in any way, although the U.S. Supreme Court essentially directed the U.S. EPA to do so in its 2007 *Massachusetts v. U.S. EPA* decision.[3]

Upstream Emission. "Upstream emissions" occur while fossil fuels are being extracted and processed to make gasoline. Another source of upstream emissions is the distribution of fuel from processor to wholesaler to retailer. This chain is a large source of vehicle-related criteria pollutant and air toxics emissions, as well as greenhouse gas pollution.[iv]

Tailpipe Emissions. Traditional gasoline vehicles run on the combustion of fossil fuels. Under ideal conditions, gasoline would be completely combusted to form carbon dioxide and water. But gasoline engines only partially burn fuel; as a result, operating an engine results in the release of combustion byproducts including hydrocarbons (essentially equivalent to VOCs in the vehicle context), NOx, PM, CO, and CO_2.

Evaporative Emissions. Pollution from vehicles also occurs through evaporation. Vehicles generate "evaporative emissions" in several different ways. "Diurnal emissions" occur as the temperature rises in the course of a day, heating a car's gas tank and causing it to vent gasoline vapors. A car's engine and exhaust system also can heat fuel while the engine is on, resulting in "running losses." Heat remaining in a car after it has been shut off likewise can produce vapors, known as "hot soak emissions." Finally, the act of refueling a vehicle forces out gasoline vapors that are always present in the fuel tank; hence the term "refueling emissions." Evaporative emissions can account for the majority of total hydrocarbon (and thus selected air toxics) pollution from vehicles on hot days.[v]

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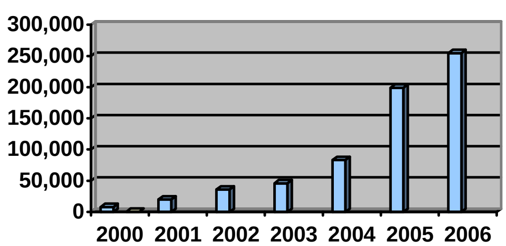
[2] 72 Fed. Reg. 8427 (Feb. 26, 2007).

[3] See 127 S.Ct. 1438 (2007).

Generation of Greenhouse Gases. Vehicles contribute to GHG levels through several primary routes. As stated above, the upstream production of gasoline produces greenhouse gases. The operation of vehicles also produces the GHGs carbon dioxide (CO_2), methane gas (CH_4), and nitrous oxide (N_2O). Air conditioning systems produce GHGs, both from their direct operation and from refrigerant emissions due to leakage, loss during recharge, or release upon disposal of a vehicle.

Clean Vehicle Technologies. The "clean" and "low emissions" labels can apply to a number of technologies. Emissions reductions from conventional gasoline-powered vehicles can occur through use of more efficient engines, although fuel economy from such engines is not proportional to emissions reductions. Innovative gas caps also can significantly reduce fuel tank evaporative emissions. Hybrid vehicles reduce emissions by only partially relying on fuel combustion, curtailing combustion, evaporative, and importantly, upstream emissions. In the future, if development is successful, fuel cell vehicles will produce only water from the tailpipe instead of air pollutants. GHG emissions can be reduced by using technologies such as cylinder deactivation, improved transmissions, turbo-charging, direct gasoline injection, and efficient, low-leak air conditioners.[vi] Vehicle manufacturers thus have a wide range of options for producing low emission vehicles. Plug-in hybrid technology, combining a gasoline engine with a longer-life battery system, is another promising innovation, particularly in states that do not rely on coal for a majority of their power.

Figure 2. New Hybrid Vehicle Registrations, 2000-2006



Source: U.S. Department of Energy/R.L. Polk & Co.

CHAPTER 3: POLLUTION BENEFITS FOR ILLINOIS FROM CLEANER CARS

Air Quality in Illinois

Criteria Pollutant Levels. All areas of the United States must comply with National Ambient Air Quality Standards (NAAQSs) for the criteria pollutants listed above. Failure to do so results in being designated as "nonattainment" by the U.S. EPA in violation of the federal Clean Air Act. As of the latest reporting period, numerous Illinois counties are in nonattainment for vehicle-related pollutants.

Illinois Nonattainment Areas

Ozone
Cook, DuPage, Grundy, Kane, Kendall, Lake, McHenry, Will,, Madison, St. Clair and Monroe Counties, and Aux Sable, Goose Lake, and Oswego Townships[4]

Particulate Matter
Same as above, also Randolph County and Baldwin Township[5]

Air Toxics Levels. The five air toxics in this report are emitted by vehicles and account for a disproportionate share of health risks from vehicle-related pollution. As seen in Table 1, estimated levels of air toxics in Illinois counties are among the highest in the United States. Cook County ranks in the top 5% of U.S. counties and equivalent areas for the five air toxics acetaldehyde, acrolein, benzene, 1,3-butadiene, and formaldehyde. Lake, DuPage and Will Counties likewise are in the top 5% for several air toxics, while Sangamon County and the St. Louis Metro East counties have excessive air toxics levels across the board. Reducing pollution from light duty vehicles is a step towards attainment and will lessen Illinois residents' inhalation of polluted air. Likewise, driving cleaner cars and light duty trucks will lower Illinois residents' exposure to damaging air toxics, which are regulated under separate Clean Air Act standards.

Pollutant Reduction Benefits for Illinois

In deciding whether and how to bring cleaner cars to the Midwest, policymakers should take into account the magnitude of air quality benefits to be achieved by various policies. Current methodologies can model vehicle emissions changes under different policy scenarios. One key policy for bringing clean cars to the Midwest is enhanced emissions standards; this chapter employs current methods, local data, and U.S. EPA and custom modeling assumptions to estimate the air quality benefits of Illinois adopting California's emissions standards.

The emissions modeling in this report was conducted by Cambridge Systematics, an independent consulting firm specializing in transportation and air quality planning. Cambridge Systematics is a national firm with offices across the U.S., including Chicago. The firm has more than twenty years of experience providing transportation consulting services to federal, state, and local government agencies; regional and local transportation authorities; and private industry. With respect to clean light-duty vehicles, Cambridge Systematics has conducted numerous studies measuring the air quality benefits for California, the Pacific Northwest, and several states in the Northeast.

The United States Environmental Protection Agency ("EPA") has developed a computer modeling package for estimating vehicle emissions. MOBILE 6.2 uses inputs such as the mix of vehicles sold, vehicle miles traveled (VMT) by different classes of vehicles, the age distribution of vehicles being driven, and various other assumptions to estimate the total pollution burden from highway vehicles. While the model includes several default and recommended assumptions, these assumptions can be changed to account for differences in market projections and technology development schedules. Inflexibility in the MOBILE 6.2 model limits comparison of evaporative emissions under different sets of standards.

[4] 8-hour ozone standard, U.S. EPA, 8-Hour Ozone Non-attainment State/Area/County Report, Dec. 2007.
[5] $PM_{2.5}$ standard, U.S. EPA, Particulate Matter ($PM_{2.5}$) Nonattainment State/Area/County Report, Dec. 2007.

Table 1. Concentration of Air Toxics: Illinois Counties vs. Other U.S. Counties, ≥ 75th Percentile

County		Illinois County Air Toxic Levels Ranked Nationwide*				
		Acetaldehyde	Acrolein	Benzene	1,3-Butadiene	Formaldehyde
Chicago Metro Area/Northern Illinois						
	Cook	Top 5%	Top 5%	Top 5%	Top 5%	Top 5%
	McHenry	75-90	75-90	75-90	--	75-90
	Lake	Top 5%	Top 5%	Top 5%	90-95	Top 5%
	Kane	75-90	75-90	75-90	--	90-95
	DuPage	Top 5%	Top 5%	Top 5%	90-95	Top 5
	Kendall	75-90	--	--	--	75-90
	Will	90-95	75-90	75-90	Top 5%	--
	LaSalle	--	--	--	75-90	--
	Boone	75-90	--	75-90	75-90	75-90
	Winnebago	90-95	75-90	75-90	90-95	90-95
	DeKalb	--	--	--	75-90	75-90
	Kankakee	--	--	---	75-90	75-90
Peoria/Springfield Central Region						
	Rock Island	75-90	75-90	75-90	75-90	75-90
	Knox	--	--	--	75-90	--
	Peoria	90-95	75-90	75-90	90-95	75-90
	Tazewell	75-90	--	75-90	75-90	75-90
	Mcclean	75-90	--	75-90	90-95	75-90
	Champaign	--	--	75-90	75-90	75-90
	Macon	--	--	75-90	75-90	75-90
	Adams	--	--	--	75-90	--
	Coles	--	--	--	--	75-90
	Sangamon	75-90	--	75-90	75-90	75-90
East St. Louis Area						
	St. Clair	Top 5%	75-90	90-95	75-90	90-95
	Madison	90-95	75-90	75-90	75-90	90-95
	Jersey	75-90	--	--	--	75-90
	Monroe	75-90	--	--	--	75-90
	Jefferson	--	--	75-90	--	--

*Illinois county median by U.S. county percentile, U.S. EPA, National-Scale Air Toxics Assessment 1999, available at http://www.epa.gov/ttn/atw/nata1999/nsata99.html. Analysis and data presented for 1999 are the most recent available, issued by U.S. EPA in February 2006

1. METHODOLOGY

To calculate the emissions benefits of Illinois adopting California's standards, Cambridge Systematics compared emissions in Illinois under two sets of vehicle emissions standards: the cleaner California standards (Low Emission Vehicles, Phase II and the Pavley greenhouse gas standard) and the default federal standards (Tier 2). Individual states can choose which standards – California or federal – they will adopt, but may do so only by adopting either set in its entirety. A discussion of modeling assumptions, input data, and sensitivity analysis can be found in Appendix A; more details are available in Appendix A2, available on-line at www.elpc.org.

Emissions Standards. Both the federal and California programs cover tailpipe and evaporative emissions from various weight classes of passenger cars and light-duty trucks. The two programs delineate different emissions standards, or "bins," into which manufacturers certify their cars. Each car manufacturer must comply with an overall fleet emissions average, calculated from the number of cars in each bin. The programs give manufacturers the flexibility to decide how to distribute their vehicles among the emissions bins to meet the mandated fleet average.

Only the California standards include an additional requirement for introduction of zero emission vehicles (ZEVs) and partial zero emission vehicles (PZEVs). Examples of such vehicles include conventional vehicles with enhanced engines, fuel cell vehicles, and hybrid gas-electric vehicles. The ZEV/PZEV requirement will result in substantial reductions in evaporative emissions.

In the U.S. EPA's view, automakers on their own will modify new vehicles to reduce evaporative emissions to the level required under the California standards. Nonetheless, as noted above, the U.S. EPA did issue a new Mobile Source Air Toxics Rule in February 2007 regulating the emissions of only benzene from light-duty vehicles. The new federal Rule, however, does not incorporate California's most stringent evaporative emissions provision – i.e., the zero-evaporative emissions requirement of the ZEV and PZEV mandate. In addition, only the California standards regulate greenhouse gas pollution from light duty vehicles, measured in terms of CO_2 equivalents.[6] Automakers are given full flexibility to achieve the standard's mandate of a 30% reduction in GHG emissions.

[6] California accounts for vehicle GHG emissions in terms of each pollutant's per unit contribution to global warming, with CO_2 acting as the baseline. Some pollutants, such as hydrofluorcarbons from air conditioners, are more potent contributors than CO_2. Small reductions in these pollutants mean a relatively large reduction in global warming potential.

Modeling Criteria Pollutants and Air Toxics. To compare the federal and California standards, Cambridge Systematics used MOBILE 6.2 to calculate reductions in the five vehicular air toxics listed above, VOCs, CO, and NO_x under two scenarios. The analysis did not include primary PM, as differences between the two standards were not expected to be significant using MOBILE.

Scenario 1 employs custom assumptions for "bin mix" (the fraction of vehicle sales in each bin in each model year) and "VMT mix" (the percent of vehicle miles traveled by vehicle type/weight).[vii] These assumptions are believed to better match future conditions than do the U.S. EPA's default assumptions, in that they (1) better reflect future sales trends of all relevant vehicles under each program, and (2) more accurately estimate the fraction of light-duty trucks in the light-duty vehicle mix, based on 2005 sales data showing a decline in light-duty truck sales. Scenario 2 serves as a baseline comparison by using U.S. EPA's default value for bin mix and a single year EPA default value for VMT mix. The two Scenarios are designed to bracket the range of likely emissions benefits.

In addition, the Scenario 1 and 2 analyses calculate evaporative emissions benefits of the California standards' ZEV and PZEV requirements for the above pollutants. The analyses apply further techniques to the MOBILE 6.2 output data to measure these benefits. These techniques are required due to the model's inflexibility in measuring relative levels of evaporative emissions under different sets of standards.

Modeling Greenhouse Gases. The Illinois analysis uses the GREET Model, Version 1.6, to estimate the greenhouse gas pollution reductions, in CO_2 equivalents, from low emissions vehicles under the California GHG standards.[viii] GREET estimates GHG emissions rates for different vehicle technology types; these rates in conjunction with the MOBILE 6.2 output yielded an estimate of fleet-average GHG emissions rates under each program.[ix]

Timing. California's standards provide a significant amount of time for manufacturers to redesign their fleets. Assuming the California standards were adopted in spring 2008, model year 2012 would be the first for Illinois under the new standards. The Pavley GHG standard is phased in over an eight-year period, which is anticipated to start in California with model year 2009. Model year 2012 is therefore the fourth year of implementation; the cars Illinois would see in model year 2012 also would be compliant with the fourth year of the standards.

This report's analyses were conducted in mid-2005, and assumed that 2010 would be the first model year of compliance in Illinois. The baseline year for the analysis thus is 2009, with data estimated for the subsequent years 2020 (partial turnover of Illinois cars to cleaner models) and 2030 (full turnover).

Sensitivity Analysis. Sensitivity analysis was conducted to investigate possible sources of difference between results from the present Illinois analysis and previous analyses in other states that have adopted the California standards, and to test the impacts of key inputs on results. Input factors considered in the sensitivity analysis were the existence and rigor of a state's inspection and maintenance (I/M) program and the age distribution of vehicles in the state.

2. RESULTS

Adoption of enhanced vehicle emissions standards in Illinois stands to provide the state sizable air pollution reductions. Table 2 provides a summary of benefits, reflecting the results from Scenarios 1 and 2.

Table 2. Summary of Emissions Benefits from Enhanced Light-Duty Vehicle Emissions Standards in Illinois

	Emissions Benefit (Except for CO_2, % reduction from Tier 2 standards; range based on values resulting from Scenarios 1 and 2)	
Pollutant	2020	2030
VOCs	6.6%-8.9%	11.7%-15.5%
CO	3.0%-10.0%	4.8%-14.9%
NOx	5.7%-7.1%	10.1%-10.9%
Air toxics	8.0%-12.6%	13.1%-20.7%
CO_2*	45% less total CO_2 by 2020	

* California Air Resources Board, Comparison of Greenhouse Gas Reductions for the United States and Canada Under U.S. CAFÉ Standards and California Air Resources Board Greenhouse Gas Regulations, 3/08, Table 16: Comparison of State-Specific Cumulative GHG Benefits, p. 19

As can be seen in Table 3, Scenario 1 estimates overall VOC benefits in 2020 and 2030, respectively, at 8.9% and 15.5%. Estimated NOx benefits are 5.6% and 9.9% for the same years. Carbon monoxide benefits also are evident, up to a 4.8% reduction in 2030. Even under the U.S. EPA's unmodified Scenario 2 assumptions, the benefits in criteria pollutants and precursors are substantial: an 11.7% reduction in VOCs, 14.9% in CO, and 10.9% in NOx (see Table 5).

The greatest emissions benefits are in reductions of air toxics and carbon dioxide. The Scenario 1 analysis shows benzene reductions of 19.5% by 2030 and 1,3-butadiene and acrolein reductions of 20.9% by the same year (see Table 4). Levels of acetaldehyde and formaldehyde stand to de-crease even more, up to 23.3% and 22.2%, re-spectively, by 2030. Air toxics benefits under Scenario 2 are lower, in the range of 12.7%-14.7% (see Table 6).

Table 3. Reduction of Criteria Pollutants and Precursors, Scenario 1 (2005 Updated Assumptions)

		Total Emissions (tons/day)		Benefit of higher standards for Illinois	
Pollutant	Year	Federal Default Standards	California Standards	Total	Percent
VOCs	2009	237.6	237.6	0.0	NA
	2020	144.5	131.4	13.1	8.9%
	2030	153.1	129.0	24.1	15.5%
CO	2009	2,668	2,668	0.0	NA
	2020	2,153	2,088	65.4	3.0%
	2030	2,457	2,339	118.0	4.8%
NOx	2009	220.4	220.4	0.0	NA
	2020	110.3	104.0	6.3	5.7%
	2030	111.7	100.4	11.3	10.1%

Comparing Scenario 1 and Scenario 2, the results differ in terms of the level of benefits seen for each pollutant. The Scenario 2 VOC and air toxics benefits for 2030 are somewhat lower than for Scenario 1, but the NOx benefits are higher (GHG benefits do not differ appreciably under the two scenarios). These differences are in part attributable to the bin mixes used in each Scenario.[x] Regardless of the source of the difference, estimates from the two Scenarios provide a reasonable range of expected emissions benefits

Table 4. Reduction of Air Toxics and Carbon Dioxide, Scenario 1 (2005 Updated Assumptions)

		Total Emissions (pounds per day)		Benefit of higher standards for Illinois	
Pollutant	Year	Federal Default Standards	California Standards	Total	Percent
Acetaldehyde	2009	2,262	2,262	0.0	NA
	2020	1,523	1,297	227	14.9%
	2030	1,669	1,279	390	23.3%
Acrolein	2009	1,898	1,898	0.0	NA
	2020	1,286	1,122	164	12.7%
	2030	1,401	1,108	293	20.9%
Benzene	2009	15,322	15,322	0.0	NA
	2020	10,417	9,195	1,222	11.7%
	2030	11,171	8,995	2,176	19.5%
1,3-Butadiene	2009	1,513	1,513	0.0	NA
	2020	1,035	905	130	12.6%
	2030	1,112	880	233	20.9%
Formaldehyde	2009	3,316	3,316	0.0	NA
	2020	2,277	1,955	322	14.1%
	2030	2,490	1,937	554	22.2%
Total, 5 Toxics	2009	24,251	24,251	0.0	NA
	2020	16,490	14,408	2,082	12.6%
	2030	17,807	14,122	3,684	20.7%

3. SENSITIVITY ANALYSIS

As stated above, sensitivity analysis was conducted on the existence of an inspection and maintenance program and the age distribution of vehicles in a state. Comparisons were made between the present Illinois analysis and the results of similar studies in New Jersey and Connecticut to investigate possible sources of difference between the estimated benefits for Illinois and for other states that have adopted the California standards. *The sensitivity analysis showed substantial benefits from I/M programs: VOC benefits of 10-12% in areas with I/M versus 8-10% in areas without; NOx benefits of 7-8% with I/M versus 4-5% without; and air toxics benefits of 15-20% with I/M versus 10-13% without*. Additional benefits arise because inspection and maintenance help to ensure the performance of clean technologies over the life of the vehicle.

Importance of Inspection and Maintenance

The existence of an I/M program corresponds with greater benefits from enhanced vehicle standards, in the range of 25-33% greater emissions reductions over no I/M program.

A newer vehicle age distribution, in turn, indicates that new emissions controls will be phased in more quickly, speeding the arrival of air quality benefits. The passenger car distribution in Chicago did not differ significantly from that in the U.S. EPA default model, Connecticut, or New Jersey. Chicago did show a newer distribution of light duty trucks relative to New Jersey and the U.S. EPA default. Air quality benefits to the Chicago area thus are likely to arrive faster than in New Jersey. With the downstate Illinois distribution factored in, the age distribution in Illinois is expected to be older than that in Connecticut, indicating that benefits across the state will accrue at a slower rate than in Connecticut.

Table 5. Reduction of Criteria Pollutants and Precursors, Scenario 2 (EPA Default Assumptions)

		Total Emissions (pounds per day)		Benefit of Higher Standards for Illinois	
Pollutant	Year	Federal Default Standards	California Standards	Total	Percent
VOCs	2009	236.8	236.8	0.0	NA
	2020	139.8	130.6	9.2	6.6%
	2030	146.7	129.6	17.1	11.7%
CO	2009	2,653	2,653	0.0	NA
	2020	2,143	1,928	214.8	10.0%
	2030	2,450	2,084	365.9	14.9%
NOx	2009	217.9	217.9	0.0	NA
	2020	108.5	100.8	7.7	7.1%
	2030	110.5	98.5	12.0	10.9%

Table 6. Reduction of Air Toxics and Carbon Dioxide, Scenario 2 (EPA Default Assumptions)

		Total Emissions (pounds per day)		Benefit of Higher Standards for Illinois	
Pollutant	Year	Federal Default Standards	California Standards	Total	Percent
Acetaldehyde	2009	2,239	2,239	0.0	NA
	2020	1,413	1,280	133	9.4%
	2030	1,518	1,296	223	14.7%
Acrolein	2009	1,884	1,884	0.0	NA
	2020	1,211	1,115	96	7.9%
	2030	1,295	1,126	169	13.0%
Benzene	2009	15,190	15,190	0.0	NA
	2020	9,828	9,075	753	7.7%
	2030	10,377	9,057	1,320	12.7%
1,3-Butadiene	2009	1,498	1,498	0.0	NA
	2020	969	891	77	8.0%
	2030	1,022	888	135	13.2%
Formaldehyde	2009	3,279	3,279	0.0	NA
	2020	2,120	1,930	191	9.0%
	2030	2,278	1,959	319	14.0%
Total, 5 Toxics	2009	24,089	24,089	0.0	NA
	2020	15,541	14,291	1,250	8.0%
	2030	16,491	14,326	2,165	13.1%

CHAPTER 4: HEALTH BENEFITS FOR ILLINOIS FROM CLEANER CARS

Air pollution harms people's health. Criteria pollutants and air toxics are associated with a long list of negative health effects. These impacts range in intensity from aggravation of asthma symptoms, which can reduce a person's activity levels and/or result in hospitalization, to low birth weight, infant mortality, increased risk of various cancers, heart attack and stroke, and heat-related mortality. While light-duty vehicles are not the sole source of these problems, they contribute significantly to Illinois' overall air pollution health burden.

Exposure to Vehicle Pollutants

Environmental health analyses measure levels of exposure to a pollutant and the health problems associated with those levels. Typically, exposure increases with the concentration of a pollutant in a given medium, such as air. Concentrations of vehicle air pollutants on the whole are greatest near their sources; exposure therefore is generally highest for people who spend significant time in or near polluting cars. People are exposed to vehicle pollutants in numerous places, some of which have pollutant concentrations far in excess of levels in the ambient air.

In-Vehicle. Individuals experience some of the highest concentrations of vehicular pollutants while driving. In-vehicle pollutant concentrations are especially high on traffic-congested roads, where idling engines put out large quantities of evaporative emissions. Compounding this problem is the high degree of road congestion in the Chicago urban area[xi], which increases both the level of pollutants in vehicles and the time spent inhaling those pollutants. As evaporative emissions account for the vast majority of air toxics released by cars, in-vehicle concentrations of air toxics are exceptionally high. For example, in-vehicle levels of benzene can be three to five times regional levels; levels of formaldehyde and other VOCs in vehicles similarly are above ambient levels.[xii]

Start-and-Stop, Refueling. Garages, parking lots, sidewalks, recreational paths along congested streets, and gas stations are all places where exposure to elevated levels of air toxics and VOCs can occur. Emissions are highly concentrated in garages because cars repeatedly start and stop, resulting in excessive exposure of the owner and others to air toxics. Evaporative emissions from attached garages enter homes where families are exposed to high levels of air toxics. Parking lots, sidewalks, and multi-use paths are prime locations for exposure to emissions from starting-and-stopping vehicles, as well as idling ones. Drivers also are exposed to evaporative emissions when they refuel. During refueling, blood levels of gasoline constituents such as benzene can rise as a result of exposure to gasoline and vehicle emissions.[xiii]

Highway Corridors, Roadside Concentrations. Traffic along highways and major roads creates marked corridors of elevated air pollution. The highest levels of vehicle-related air pollution are seen within 300 feet of a freeway.[xiv] Proximity to high traffic roads and highways has been found to be associated with reduced lung function in children, increased asthma hospitalizations, and increased asthma and bronchitis symptoms.[xv]

Health Impacts of Vehicle-Related Pollution

A wealth of public health studies documents the negative health implications of vehicle-related pollutants. Generally, children, the elderly, and adults with existing respiratory or cardiac conditions suffer the most from air pollution due to their greater susceptibility.

> ***Summary of Health Impacts from Air Pollutants***
>
> ***Ozone***. Lung irritant associated with aggravation of asthma, allergies, bronchitis, and emphysema. Linked to premature death and cardiovascular problems, such as hospitalization for heart attacks and pulmonary heart disease.
>
> ***PM***. Strongly associated with premature death and other cardiovascular problems (e.g., reduced blood flow to the heart, irregular heart beat, and heart attack), as well as the respiratory effects seen with ozone. Also associated with low infant birth weight and infant mortality.
>
> ***NOx***. Eye, nose, throat and lung irritant linked to respiratory problems. Also associated with the health effects from ozone and PM due to its role in their formation.
>
> ***VOCs***. Eye, nose, throat, and lung irritant linked to respiratory problems. In addition, four of the five air toxics in this report are known or thought to cause cancer, and the fifth is a powerful respiratory irritant.
>
> ***CO_2 and other GHGs***. Linked to increased heat-related death and respiratory effects from ozone through their role in global warming.

Ozone. Ground-level ozone ("ozone") is a powerful lung irritant that can permanently damage lung tissue and reduce lung function.[xvi] High levels of ozone can aggravate asthma and allergies, causing people to require medical attention and/or additional medication.[xvii] Numerous epidemiological studies have documented the effects of ozone on children, both those with and those without asthma. One recent study found that asthmatic children were vulnerable to pollution levels below the U.S. EPA's ozone standards.[xviii] A study of children in Chicago and seven other cities found increasing ozone levels to be associated with decreased peak respiratory flow rate, a measure of lung performance.[xix] Increased asthma symptoms and respiratory illness translate into direct health care costs from hospitalizations and emergency room visits.

Since ozone formation depends on sunlight, ozone levels are the highest in the summer and during the early afternoon. These times coincide with peak hours for children's outdoor play, increasing the risk of exposure to harmful levels of ozone. Children who play multiple sports outside in high ozone areas are significantly more likely to develop asthma than kids who do not play sports.[xx] The Illinois Department of Public Health warns asthmatics to limit their time spent outdoors on high ozone days.[xxi]

Persons suffering from chronic lung disease such as emphysema and bronchitis are particularly vulnerable to the respiratory effects of ozone.[xxii] Ozone-related lung damage in such people can lead to a compromised immune system, reducing the body's ability to fend off bacterial infection in the respiratory tract. More recently, researchers have documented associations between ozone and cardiovascular problems such as increased risk of hospitalization for heart attack and pulmonary (lung-related) heart disease, as well as premature death.[xxiii]

Particulate Matter. Numerous studies have linked PM to premature death.[xxiv] Like ozone, PM pollution is associated with increased respiratory symptoms, aggravated asthma, decreased lung function, and chronic bronchitis.[xxv] Increased levels of particulate matter have been linked to more emergency room visits by children, as well as increased risk of respiratory problems in persons with cystic fibrosis. [xxvi]

A large body of studies has documented associations between PM air pollution and various cardiovascular outcomes, including increased risk of hospitalization and death.[xxvii] After reviewing almost 200 scientific studies on air pollution and cardiovascular disease, the American Heart Association concluded that short-term exposure to elevated levels of PM significantly contributes to acute death from cardiovascular causes, especially in at-risk subsets of the population such as the elderly.[xxviii] A body of studies also has linked PM to low birth weight, pre-term birth, and infant mortality.[xxix]

Nitrogen Oxides. Exposure to low levels of nitrogen oxides can lead to irritation of the eyes, nose, throat, and lungs, and has been linked to respiratory symptoms and decreased lung function.[xxx] The main health effects of concern with nitrogen oxides, however, come from their role as precursors to ground-level ozone and secondary particulate matter. Health effects associated with nitrogen oxides therefore include the respiratory and cardiovascular problems seen with ozone and particulate matter.

Volatile Organic Compounds. Like nitrogen oxides, VOCs are direct eye, nose, throat, and lung irritants, and also negatively impact health through their role in ground-level ozone formation. The air toxic acrolein is an especially powerful respiratory irritant. Another health outcome of concern from vehicle-related VOCs is cancer: many VOCs are known or potential carcinogens. Several of the most studied VOCs from a cancer perspective are four of the air toxics included in this study, namely acetaldehyde, benzene, 1,3-butadiene, and formaldehyde.

Greenhouse Gases. Heat is the primary weather-related cause of death in the United States.[xxxi] With rising global mean temperatures, heat and heat waves are projected to increase in severity and frequency. Heat waves in urban areas in particular have been found to be associated with increases in mortality. In Chicago in 1995, a five-day heat wave was associated with 700 excess deaths.[xxxii] As with other pollutants that have cardiovascular and respiratory implications, the global warming pollution created by greenhouse gases is most threatening to susceptible populations like the elderly. Increased temperatures also may result in prolonged ozone seasons, as ozone formation is linked to sunlight and ozone levels are highest in the summer. Thus greenhouse gas pollution may contribute to increased respiratory problems from ozone exposure.

Other health problems associated with global warming pollution include increased numbers of allergy attacks from higher pollen and mold levels associated with warmer temperatures and extreme weather conditions; sunburn, skin cancer, and immuno-suppression from greater exposure to UV radiation; drowning, dehydration, gastro-intestinal illness, and psychological trauma from weather disasters; and increased exposure to infectious disease.[xxxiii]

Air Toxics

Acetaldehyde. The U.S. EPA categorizes acetaldehyde as a probable human carcinogen. In addition, acetaldehyde may aggravate asthma symptoms in persons with the disease.[xxxiv]

Acrolein. Described by the U.S. EPA as "extremely" toxic to humans, acrolein is a strong respiratory irritant that is associated with congestion and irritation of the eyes, nose, and throat.[xxxv]

Benzene. The U.S. EPA and the World Health Organization's International Agency for Research on Cancer (IARC) categorize benzene as a known human carcinogen. Specifically, long-term exposure to high levels of benzene can cause leukemia.[xxxvi] Benzene also can irritate the respiratory tract and is associated with disorders of the blood.[xxxvii]

1,3-Butadiene. Classified by the U.S. EPA as a known human carcinogen, 1,3-butadiene has been linked to negative reproductive effects.[xxxviii]

Formaldehyde. Classified as a probable human carcinogen by the U.S. EPA and a known carcinogen by IARC, formaldehyde is associated with irritation of the respiratory tract.[xxxix]

Illinois' Health Burden

Nationally, the number of people with asthma more than doubled between 1982-2002.[xl] In Illinois, asthma is one of the leading causes of missed school days for children.[xli] Illinois, like the rest of the nation, incurs large human health and associated monetary costs from asthma. Reducing air pollution that aggravates asthma and worsens lung health will help alleviate these costs for the state.

Asthma in Illinois

An estimated 11% of Illinois residents have ever been diagnosed with asthma.[xlii]

Illinois has one of the nation's highest death rates from asthma – at an average of about 259 per year.[xliii]

Asthma-related hospitalizations in Illinois cost $268.6 million in 2005.[4] Total direct costs are significantly higher..[xliv]

In a 2004 study of childhood asthma in Chicago, 43% of children in the survey missed school or daycare over the past year as a result of their asthma, with an average of more than three days lost.[xlv] The same survey reported that 27% of parents of children with asthma missed work in a one-year period due to their child's asthma.

Chicago's heat-related death toll has been identified as "high" by the federal agency with responsibility for studying the atmosphere.[xlvi]

Illinois' heart disease death rate is above the national average[xlvii], indicating the need to reduce risk from all sources.

Heat-related death. Asthma is not the only source of concern for Illinois. Extreme summer heat in combination with other factors, such as advanced age, other medical conditions, and/or use of certain medications, can lead to death in vulnerable populations. Chicago's heat-related death toll has been identified as "high" by the federal agency with responsibility for studying the atmosphere.[xlviii] Relative to other cities in the United States, Chicago is likely to experience increases in mortality from temperature increases due to the intensity and irregularity of heat waves in the city.[xlix] According to a Congressionally-mandated study of the impacts of global warming on the U.S., "Chicago, Illinois, must plan for heat waves" to prevent heat-related mortality.[l]

Cardiovascular disease and cancer. As detailed above, air pollution is linked to numerous cardiovascular problems. Illinois' heart disease death rate is above the national average, indicating the need to reduce all sources of increased cardiovascular risk.[li] Since vehicle air toxics are known or probable carcinogens, reductions in Illinois residents' exposures to these pollutants are likely to result in decreases in cancers.

Health Benefits for Illinois

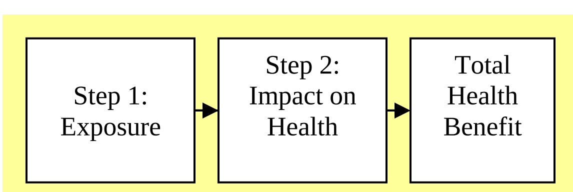
The previous chapter provided estimates of emissions reductions associated with enhanced vehicle emissions standards in Illinois. Policy decision-making would be greatly enhanced by the ability to consider the health benefits of these reductions in comparison to the costs of such standards. The objective of this chapter is to provide a logical basis for estimating health benefits and to provide initial estimates of the benefits associated with the emission reductions. The preliminary estimates can give policymakers an idea of the magnitude of potential health benefits. They also can be used to make relative comparisons among the pollutants and to determine where more refined modeling is warranted.

To emphasize, the calculations below are an initial step in an iterative risk assessment and should be viewed as such. A general discussion of limitations and uncertainties can be found in Appendix B. Policymakers and others interested in details on the methodologies employed in this analysis, including a discussion of uncertainties and limitations, should refer to Appendix B2, available on-line at www.elpc.org. A full analysis of the health benefits from reductions in these varied pollutants would require detailed modeling to determine the concentration and exposure influences of these emission changes, and then to subsequently link this exposure information with health evidence. Such modeling is beyond the scope of this report.

Health benefits estimations in this report were calculated by a research team led by Jonathan Levy, an associate professor of Environmental Health and Risk Assessment at the Harvard School of Public Health. Professor Levy is a well-respected and widely-published expert on air quality whose research centers on developing models to quantitatively assess the environmental and health impacts of air pollution from local to national scales. Professor Levy's studies on the health effects of power plant pollution have provided important information for debates over legislation in Massachusetts, New Hampshire, Connecticut, Illinois, and elsewhere.

1. METHODOLOGY

The health benefits analysis employed two primary steps to translate emissions data into health benefits. First, Step One took the emissions modeling data from Scenario 2, above (selected to match the U.S. EPA's recommended emissions modeling assumptions) and estimated the total population exposure to each pollutant under each set of emissions standards. Step Two converted these exposure estimates into estimates of health benefits by evaluating health response associated with different levels of exposure. While the objective was to model the effects of the pollutants considered most likely to contribute to health impacts, to the extent that other important mobile source pollutants were not included, the analysis could underestimate the health benefits of emission reductions.



Step One: Exposure

Exposure to Criteria Pollutants and Air Toxics. Two general approaches were used in Step One to estimate exposures for criteria pollutants and air toxics. The concept of an "intake fraction" was used to determine approximate relationships between emissions of each pollutant and ambient concentrations aggregated across the population. An intake fraction is essentially the amount of a pollutant (or its precursor) emitted that someone eventually inhales. Combining the intake fraction for each pollutant, which represents the population exposure per unit of emissions, with a given change in emissions yielded the total change in population exposure to that pollutant. Various models and databases, selected for their relevance, validity, and currency, served as the basis for individual pollutant intake fractions. Each model and database has its own set of uncertainties and limitations that carry over into the intake fractions.

To complement the intake fraction analyses, "linear rollback" methods were used to link changes in emissions with changes in concentrations within Illinois. Simply stated, a "linear rollback" model assumes that a 1% reduction in emissions would lead to a 1% reduction in concentrations. If the total emissions of a compound and its ambient concentrations are known, as are the reductions in emissions from a given policy change, it is possible to calculate the percentage reduction in emissions and apply that value to ambient concentrations. The linear rollback analyses provide direct concentration data for the study area of concern for assessment of a broader array of health impacts than under the intake fraction approach.

"Exposure" to Greenhouse Gases. The relevant question for assessing the health impacts of global warming pollution is not direct exposure to pollutants, but rather the health effects that come about due to global warming. Previous studies have attempted to quantify the incremental health damages associated with a ton of GHG emissions.[lii] Currently, there is considerable uncertainty regarding the magnitude of climate change associated with incremental changes in greenhouse gas pollution, the consequences of global warming on health outcomes, and the spatial distribution of those impacts. Due to these uncertainties, the current study does not attempt to quantify the health benefits of reductions in global warming pollution in Illinois. It should be noted, however, that Chicago may be especially prone to increased heat-related illness from global warming and that new methods for estimating such increases may become available in the near future.

Step Two: Health Effects

Step Two translated the above exposures into health effects using two different methods for criteria pollutants versus air toxics. For the criteria pollutants, this step consisted of identifying and/or constructing a "concentration-response function" for each pollutant, which conveys the relationship between the level of exposure and the level of health response. The changes in total population exposure to each pollutant from Step One were then linked with the appropriate concentration response function. This approach was used for criteria pollutants and for mortality estimates from air toxics. The concentration-response functions in this study were drawn from various sources, such as human epidemiological studies and laboratory animal tests.[liii] With respect to morbidity (i.e., non-fatal) outcomes related to air toxics, the proper approach was to compare exposures from Step One to the reference concentration (RfC) for each air toxic to determine if adverse health effects other than cancer are likely.[7]

Mortality. While numerous health outcomes are associated with the pollutants of interest, this study initially focused on premature mortality for two reasons. First, previous analyses have found that premature death dominates the health benefits of air pollution control when economic values are assigned to health effects.[liv] Second, an objective of the study is to help prioritize pollutants for future study, and it is possible to estimate mortality impacts for most pollutants of interest to aid in the creation of such a ranking.

To date, particulate matter (PM) is the criteria pollutant most closely linked to increased risk of premature death. The relationship between ozone exposure and premature mortality is more uncertain, but recent analyses have found a consistent association between short-term exposures to ozone and increased rates of premature death. Cancer is the specific contributor to premature mortality posed by four of the air toxics in this study. The fifth toxic, acrolein, is not included in the mortality analysis due to the current lack of data on its carcinogenicity. Since the health literature does not provide substantial evidence of mortality related to CO or NO_2 exposures at current ambient concentrations, these pollutants were not considered in the mortality estimates.

Non-fatal Health Effects, a.k.a. "Morbidity". To illustrate the range of severity in air pollution health effects, the health benefits analysis focused on a limited number of morbidity effects related to the modeled pollutants. Many other health problems have been linked to air pollution; however, the full number of outcomes that could be evaluated is substantial and beyond the scope of this study. As stated above, concentration-response functions were used for the criteria pollutants, while reference concentrations provided the touchstone for the air toxics.

The primary morbidity effects selected for ozone were respiratory hospital admissions, asthma-related emergency room visits, school loss days, and minor restricted activity days.[lv] Other health problems have been associated with ozone exposure in past epidemiological studies (like respiratory symptoms, asthma attacks, or hospital admissions for cardiovascular disease). The subset of morbidity effects included in this study were selected from previous studies with the most robust data for the construction of concentration-response functions. A similar approach was taken for PM, with the selected outcomes consisting of hospital admissions for both cardiovascular and respiratory disease, asthma-

[7] A reference concentration is an estimate of a daily continuous inhalation (concentration) exposure for a given duration to the human population, including susceptible subgroups, that is likely to be without an appreciable risk of adverse health effects over a lifetime. U.S. EPA, Glossary of IRIS Terms (revised July 2005).

related emergency room visits, and minor restricted activity days.

Due to lack of robust data on the morbidity effects of low-level exposures to carbon monoxide or nitrogen dioxide, and a desire to avoid possible double-counting arising from the correlation between these two pollutants and traffic-related particulate matter, morbidity impacts related to these pollutants are omitted. This may potentially underestimate the benefits of clean car standards, as some evidence supports a relationship between carbon monoxide exposures and cardiovascular or respiratory hospital admissions, and between nitrogen dioxide and respiratory symptoms and decreased lung function.

As noted above, a proper approach to estimating health effects from air toxics other than cancer is to compare the concentration of a toxic with a reference concentration (RfC). If the concentration exceeds the RfC, the concentration is considered likely to contribute to adverse health effects. Here, the ratio of the concentration to the RfC is used: a ratio value greater than one indicates the potential for health effects. An RfC is calculated with a margin of safety, unlike the concentration-response functions described above. As a result, uncertainty in an RfC can span an order of magnitude or more. The ratio comparison therefore should not be considered a strict boundary delineating health effects from no health effects, but rather a general guideline on the likelihood of health effects.

In addition, while this comparison can be made for individual air toxics (where the ratio is termed the "hazard quotient"), it is more appropriate to create a cumulative "hazard index" (HI) by summing the hazard quotients for all air toxics with similar health effects. Typically, a hazard index of greater than 1.0 is considered a threshold of concern for health effects. The presumptions in this approach are that people are exposed to multiple air toxics in their daily lives and that each air toxic might contribute linearly to increased risk of health effects. Isolating each air toxic for analysis would misrepresent real-world exposure conditions, and would fail to account for important cumulative effects.

For respiratory health effects, a hazard index including formaldehyde, acetaldehyde, and acrolein was considered. Additional respiratory air toxics in this HI, selected based on U.S. EPA data, include acrylonitrile, chromium, 1,3-dichloropropene, nickel, and 1,2-dichloropropane.[lvi] These air toxics are primarily emitted by sources other than vehicles, such as industrial metals processing, and make up the background for vehicle-related respiratory toxics. Benzene and 1,3-butadiene have been linked to negative effects on the blood and reproductive system, respectively. These two air toxics were considered individually in comparison to their RfCs, as other major air toxics with calculated RfCs do not have similar health effects.

2. RESULTS

The preliminary estimates show significant health benefits for Illinois from California standards. Tables 7-11 provide summaries of the results, focusing on the estimated annual health benefits in 2020 and 2030. In each case, estimates are provided for the baseline conditions under the federal Tier 2 standards, modified conditions under enhanced standards, and the difference between these values, unless noted.

Table 7. Summary of Health Benefits Estimates

(*Provided for summary purposes only, as underlying data for each outcome are based on different pollutants & sources.*)

	Annual Estimated Benefits (# of reduced cases)*	
Health Outcome	2020	2030
Premature Deaths**	11-21	15-33
Cardiovascular hospital admissions***	2-4	3-7
Respiratory hospital admissions±±	58-170	93-270
ER visits for asthma±±	13-39	21-59
Lost days of school±	50,000-160,000	80,000-250,000
Minor restricted activity days±±	21,000-61,000	34,000-96,000
Reduction in respiratory symptoms±±±	59,000	100,000

* Ranges provided are in terms of central estimates for both intake fraction and linear rollback analyses. Note that results are rounded to two significant digits when summed across pollutants, and thus may differ from individual results in the following tables.
** From all study pollutants except acrolein
*** From PM only
± From ozone only
±± From PM and ozone
±±± From acrolein, formaldehyde, and acetaldehyde

At this stage, the focus should be on the magnitude of the estimates and on the relative differences between the two sets of emissions standards (i.e., percent reduction attributable to the California standards). The latter provides a sense for benefits with some control for uncertainties and limitations in the calculations, as each emissions standard was analyzed using the same methodology and hence the results are accompanied by similar uncertainties and limitations.

Mortality. In sum, ***estimated reductions in premature mortality represent an approximate 7% reduction from baseline Tier 2 conditions in 2020 and a 10% reduction in 2030***. **These figures include *a reduction in risk of death from cancer of 8-9% from baseline, and a 13-15% reduction in 2030***. Tables 8 to 11 summarize the estimated annual mortality benefits for each pollutant. Results using both intake fraction and linear rollback methods are presented separately for comparison.

A few key observations can be made from these tables. First, a comparison of the intake fraction and linear rollback calculations shows that the estimates are generally similar to one another in most cases (i.e., well within an order of magnitude). Where the two sets of estimates diverge to a greater degree for a given pollutant, as with secondary organic aero-sol and ozone from NOx, uncertainties in the approaches and limitations of the assumptions sufficiently explain the differences. Pollutants with the greatest divergence, such as the aldehydes, are unlikely to be significant contributors to mortality based on the miniscule estimates; thus any differences between the linear rollback and intake fraction estimates are of limited significance.

Looking at the mortality values themselves, and considering both uncertainties in the exposure assessment approach (intake fraction versus linear rollback) and in the concentration-response functions for particulate matter and ozone as described in Appendix B2, estimated *annual mortality benefits in 2020 from enhanced emissions standards are approximately 11-21 fewer premature deaths per year, with benefits in 2030 of 15-33 fewer premature deaths per year. The inclusion of GHG standards increases the benefits by about 1 fewer death per year in 2020 and 2 fewer deaths per year in 2030.*

Finally, the relative values allow us to draw some conclusions about the compounds that contribute most to public health benefits. Of the total mortality benefits, roughly half are associated with ozone, with most of the other half associated with secondary particulate matter. The air toxics contribute much less to the annual mortality benefits.

Table 8. Annual Mortality Benefits: central estimates from reductions in NOx and VOC emissions associated with California vehicle emissions standards in Illinois, 2020.*

	Avoided Deaths Per Year (Intake Fraction)				Avoided Deaths Per Year (Linear Rollback)			
	Baseline	Enhanced Standards	Reduction		Baseline	Enhanced Standards	Reduction	
			No.	%			No.	%
NOx/ozone	71	66	5	7%	212	197	15	7%
NOx/nitrate	49	46	3	7%	51	48	4	7%
VOC/SOA	15	14	1	7%	33	31	2	7%
TOTAL	136	127	10	7%	297	276	21	7%

* In all cases, note that more significant digits are presented than would be warranted given the methods to better express the differences between the scenarios, and that some of the sums and differences may not appear to match due to rounding.

Table 9. Annual Cancer Mortality Benefits: central estimates from reductions in emissions of four air toxics associated with California vehicle emissions standards in Illinois, 2020.*

	Avoided Deaths Per Year (Intake Fraction)				Avoided Deaths Per Year (Linear Rollback)			
	Baseline	Enhanced Standard	Reduction		Baseline	Enhanced Standards	Reduction	
			No.	%			No.	%
Benzene	0.21	0.19	0.016	8%	0.17	0.16	0.01	8%
1,3-butadiene	0.030	0.028	0.002	8%	0.061	0.056	0.005	8%
Formaldehyde	0.0048	0.0044	0.0004	9%	0.13	0.12	0.01	9%
Acetaldehyde	0.0006	0.0005	0.0001	9%	0.04	0.037	0.004	9%
TOTAL	0.246	0.227	0.019	8%	0.409	0.375	0.034	8%

*In all cases, note that more significant digits are presented than would be warranted given the methods to better express the differences between the scenarios, and that some of the sums and differences may not appear to match due to rounding.

Table 10. Annual mortality benefits: central estimates from reductions in NOx and VOC emissions associated with California vehicle emissions standards in Illinois, 2030.*

	Deaths Per Year (Intake Fraction)				Deaths Per Year (Linear Rollback)			
	Baseline	Enhanced Standards	Reduction		Baseline	Enhanced Standards	Reduction	
			No.	%			No.	%
NOx/ozone	73	65	8	11%	215	192	23	11%
NOx/nitrate	50	45	5	11%	52	47	6	11%
VOC/SOA	16	14	2	12%	35	31	4	12%
TOTAL	139	124	15	11%	303	270	33	11%

*In all cases, note that more significant digits are presented than would be warranted given the methods to better express the differences between the scenarios, and that some of the sums and differences may not appear to match due to rounding.

Table 11. Annual cancer mortality benefits: central estimates from reductions in emissions of four air toxics associated with California vehicle emissions standards in Illinois, 2030.*

	Deaths Per Year (Intake Fraction)				Deaths Per Year (Linear Rollback)			
	Baseline	Enhanced Standards	Reduction		Baseline	Enhanced Standards	Reduction	
			No.	%			No.	%
Benzene	0.22	0.19	0.03	13%	0.18	0.16	0.02	13%
1,3-butadiene	0.032	0.028	0.004	13%	0.065	0.056	0.009	13%
Formaldehyde	0.0052	0.0045	0.0007	14%	0.14	0.12	0.02	14%
Acetaldehyde	0.0006	0.0005	0.0001	15%	0.043	0.037	0.006	15%
TOTAL	0.260	0.226	0.033	13%	0.435	0.376	0.058	13%

*In all cases, note that more significant digits are presented than would be warranted given the methods to better express the differences between the scenarios, and that some of the sums and differences may not appear to match due to rounding.

Table 12. Annual morbidity benefits: central estimates of emission reductions in criteria pollutants associated with California vehicle emissions standards in Illinois, 2020 and 2030.

	Reductions in Health Problems			
	2020		2030	
	Intake Fraction	Linear rollback	Intake fraction	Linear rollback
Ozone				
Respiratory hospital admissions	50	150	80	240
ER visits for asthma	9	30	14	43
School loss days	50,000	160,000	80,000	250,000
Minor restricted activity days	18,000	55,000	29,000	86,000
Particulate matter				
Cardiovascular hospital admissions	2	4	3	7
Respiratory hospital admissions	8	17	13	29
ER visits for asthma	4	9	7	16
Minor restricted activity days	2,700	5,900	4,500	9,900

Morbidity, criteria air pollutants. Table 12 summarizes the morbidity reduction estimates for the criteria air pollutants, focusing on ozone and secondary particulate matter. *Morbidity benefits over Tier 2* are not presented for brevity's sake, but *are essentially proportional to the mortality estimates: an approximate 7% reduction in 2020 and 10% in 2030*.

This table shows that ozone-related morbidity benefits tend to be greater than PM-related morbidity benefits.[lvii] In addition, the values in this table demonstrate that the *benefits are on the order of tens of thousands of reduced cases for mild outcomes like minor restricted activity days or school loss days, versus values of a factor of 1,000 lower for more severe health outcomes*.

Morbidity, air toxics. Based on the estimated hazard indices (see page 19), a majority of individuals in Illinois currently live with a respiratory hazard index (HI) greater than 1, driven largely by acrolein exposure.[lviii] Linear rollback estimates are used to estimate the number of people who would move from a respiratory hazard index of 1 to below a respiratory hazard index of 1, based on reduced concentrations of formaldehyde, acetaldehyde, and acrolein.

Following this approach, California standards would result in approximately 59,000 additional people in Illinois moving below a respiratory hazard index of 1 by 2020. Similarly, by 2030, about 100,000 more people in Illinois would have moved below a respiratory HI of 1 as compared with Tier 2 conditions. These shifts are largely due to acrolein concentration changes, although the reductions resulting from reduced concentrations in formaldehyde and acetaldehyde are also significant: 600 and 1,000 in 2020 and 2030, respectively. The findings show that California standards would result in slight shifts in the degree of exposure to air toxics that act as respiratory irritants, thereby lowering the likelihood of respiratory problems for multiple thousands of people.[lix]

Considering health effects other than respiratory effects, both 1,3-butadiene and benzene are well below the reference concentrations in all census tracts in Illinois, so non-cancer health benefits are not anticipated for these pollutants.[lx]

3. DISCUSSION

The analysis presented above is based on many significant assumptions. This is by necessity, given the prospective nature and scope of this analysis. While the precise quantitative estimates are uncertain, the qualitative conclusions and rank-ordering of compounds provide useful insights. The following conclusions can be reasonably drawn from the data:

Total Benefits

Estimated public health benefits in Illinois are on the order of tens of reduced deaths per year, and tens of thousands of minor restricted activity days averted per year, with other intermediate health benefits as well. Overall, benefits are estimated at 7-15% fewer health problems attributable to specific air pollutants under enhanced standards versus the federal Tier 2 standards.

Benefits from Reductions in Criteria Pollutants and Precursors

From the perspective of premature mortality, public health benefits from particulate matter and ozone concentration reductions are most important and likely outweigh the public health benefits from air toxics reductions.

Ozone appears to be the single largest contributor to public health benefits, both for premature mortality and morbidity.

Secondary particulate matter contributes significantly to public health benefits as well, especially for premature mortality, and may outweigh ozone in terms of importance under more in-depth atmospheric modeling of pollutant concentrations.

Benefits from Reductions in Air Toxics

While the benefits from emissions reductions in the five air toxics covered by this study are not as large as those from ozone and secondary particulate matter, there is evidence of non-cancer morbidity benefits as well as cancer mortality benefits. This evidence is sufficient to warrant tracking air toxics in a comprehensive assessment of benefits.

Non-cancer benefits are driven by reductions in acrolein as well as formaldehyde and acetaldehyde, under the assumptions that these air toxics are respiratory irritants, and that exposure to these substances places many individuals above a respiratory health effect threshold.

Due to the large difference in air toxics emissions results between Scenarios 1 and 2, and the use of the lower Scenario 2 results for the health benefits modeling, the analysis would have yielded somewhat larger health benefits under Scenario 1.

Avoided health care costs. Applying standard economic valuation of health outcomes to the results of this study would show that the public health benefits of enhanced vehicle emissions standards could save Illinois millions of dollars per year. These potential cost savings represent a significant benefit that should be considered more formally in decision-making about enhanced vehicle emissions standards being adopted in Illinois.

Recommendations for Future Research

Detailed atmospheric modeling. Modeling the impacts of simultaneous NOx and VOC reductions on ozone concentrations is complex and well beyond the scope of this report. As it is possible for precursor controls to lead to benefits in some settings and impairments in other settings, more detailed atmospheric modeling is needed to draw definitive conclusions about the magnitude and direction of these impacts. Models such as CAMx (Comprehensive Air quality Model with Extensions) or Models-3/CMAQ should be used.

Modeling of "hot spot" local impacts. As discussed above, many people are exposed to very high levels of pollutants in traffic and garages and along roads, thereby increasing their risk of disease. This analysis estimated average exposures over large geographic areas, thus potentially underestimating the health benefits. More detailed modeling of local impacts should be completed in the future. It is worth noting that Models-3/CMAQ would capture secondary particulate matter and air toxics at a variety of spatial scales, and would be a preferred approach for refined health benefits estimates.

GHGs and mortality. More refined methods for measuring the mortality benefits of global warming pollution reductions, especially with respect to local impacts, are warranted as evidence becomes available.

CO and NOx. As noted above, the health literature provides some support for a relationship between carbon monoxide exposures and cardiovascular or respiratory hospital admissions, and between nitrogen dioxide and respiratory symptoms and decreased lung function. As future studies confirm these relationships, estimates of the direct health impacts of CO and NOx should be added to the health benefits analysis.

Health care cost savings. Research on quantifying cost savings from reductions in air pollution-related health outcomes is ongoing. As data and methods improve, they should be employed to compare cost savings to the costs of pollution control.

CHAPTER 5: CONCLUSION

Cleaner cars mean cleaner air and fewer health problems for the people of Illinois. The magnitude of these benefits brought about by only one clean car policy – the adoption of California's emissions standards – is significant. Other clean car policies, such as incentives to purchase the cleanest vehicles, may similarly improve Illinois' health and environment.

As described in this report, no significant obstacles exist on the path to cleaner cars in Illinois: proven, reliable technologies that reduce emissions are currently available in other states. Just as important, some of the technologies needed to reduce emissions and improve public health can significantly improve fuel efficiency. Reduced fuel needs from improved efficiency can offset the cost of emissions controls, put more money in people's pockets, and reduce our dependence on foreign oil. The public recognizes these benefits, as seen in recent polls and vehicle sales.

What is missing in Illinois, at least so far, is the "drive" to get new emissions technologies installed in our light-duty vehicles as soon as possible. The air quality and public health benefits described in this study are sizable, and the accompanying economic savings from reducing health care needs rate in the millions of dollars. It is our hope that these benefits – combined with concerns about oil imports and national security, tight household budgets, and our responsibility to the planet – will coalesce into policies that encourage more widespread availability and use of clean cars. For the sake of our health—and our children's—Illinois should adopt California's LEV II and Pavley standards.

APPENDIX A.
Emissions Modeling
Methodology and Assumptions

Modeling Methodology Overview

The federal default standards are known as "Tier 2," while the California standards are known as "LEV II." Tier 2 focuses on vehicle fleet averages of NOx; more information on Tier 2 can be found on the U.S. EPA's website at www.epa.gov/tier2/index.htm. The California Air Resources Board (CARB) provides information on LEV II, which regulates vehicle fleet averages of non-methane organic gas (NMOG), at www.arb.ca.gov/msprog/levprog/levii/levii.htm; a summary of main elements may be found in the on-line appendix to this report at www.elpc.org. The present study did not include primary PM, as differences between the two standards were not expected to be significant using the MOBILE model.

Regulation of greenhouse gases from vehicles is required in California under state legislation sponsored by Assemblymember Fran Pavley (AB1493). A report on GHG control technologies and costs of regulation can be found at www.arb.ca.gov/cc/ 042004workshop/final-draft-4-17-04.pdf. GREET Model Version 1.6, used to estimate GHG emission rates for different vehicle standards, was developed by the Argonne National Laboratory; more information on GREET is available at www.transporation.anl.gov/software/GREET/download.html.

Policy Program Assumptions

Start year – Implementation of California standards in Illinois was assumed to start in model year 2010, which took into account the two-year lead time required by the California standards, and the model year schedule of car manufacturers. See footnote 6 for rules governing the implementation timetable.

ZEV implementation – The analysis assumed that manufacturers would follow California's "Alternative Compliance Path" (ACP). The ACP allows manufacturers to sell a small number of hydrogen fuel cell vehicles (H2FCV) in model years prior to 2018, in lieu of meeting LEV II's default minimum ZEV credit requirement. More information on the ACP, including percent sales by vehicle technology group, can be found in Appendix A2, available on-line at www.elpc.org and at CARB's website.

Banking/trading – No credit banking or trading of credits between model years was assumed.

MOBILE6.2 Modeling Assumptions

Cambridge Systematics obtained current MOBILE 6.2 input files in May 2005 from the Illinois Environmental Protection Agency (IEPA). To the extent possible, Illinois-specific inputs were utilized. Modifications of the IEPA input files and/or modeling assumptions are noted below; otherwise, the study used the data and approach taken by IEPA.

Basic MOBILE inputs. IEPA models emissions for three geographic areas (Chicago metro, downstate, and St. Louis metro east), and for vehicles subject and not subject to inspection and maintenance (I/M) programs in the two metro areas, for a total of five geographic area/IM program groups (downstate vehicles are not subject to I/M). Emission factors were computed for each group and applied to total VMT for that group.

Fuels inputs. Fuels inputs (for VOC and air toxics modeling) were modified to account for area-specific fuel parameters, based on data provided by IEPA.

Vehicle registration (age) distributions. The MOBILE6 default distribution was used for the "downstate" area.

VMT mix. In lieu of IEPA's assumption regarding VMT mix, Scenarios 1 and 2 of this study use the EPA default VMT mix for 2009, which is consistent with the EPA-recommended bin mix for the Tier 2 program. The alternative VMT assumption was made for two reasons. First, it was felt that the MOBILE6 default VMT mix for later years, developed several years ago, is likely to overestimate the fraction of light-duty trucks in the light-duty vehicle fleet, based on current sales trends showing decreased sales of light-duty trucks. Second, use of a constant VMT mix allows consistency with the methodology for developing a "bin mix" for the federal default and California programs, which requires assumptions about the sales fractions in each future model year by vehicle class. As noted, use of the MOBILE6 2009 default VMT mix for developing the bin mix produces a fleet-average NOx standard for EPA's bin mix (Scenario 2) that meets EPA's standard of 0.07 g/mi. A table of the VMT mixes used in this analysis can be found in Appendix A2, available on-line at www.elpc.org.

Bin mix (sales fractions). The "bin mix" refers to the fraction of vehicle sales in each model year by federal default bin, or alternatively, by class under the California program. Scenario 1 of the current study used custom bin mixes believed to be more likely to reflect future sales trends under each program, as with VMT mix. The custom mixes also provide an alternative "sensitivity test" to comparing the California and federal default programs using EPA modeling guidelines. The custom bin mix known as Scenario 1 includes 70-75% of vehicle sales in the bin 5 category under the Tier 2 program. EPA's bin mix (Scenario 2), in contrast, distributes vehicles more widely across bins, with cleaner vehicles (under the Tier 2 NOx standard) in the passenger car category and less clean vehicles (higher than the Tier 2 NOx standard) in the light truck categories. A corresponding Scenario 1 bin mix was created for the California scenario which meets ZEV credit requirements as well as California fleet-average NMOG requirements. The bin mixes used under Scenario 1 and Scenario 2 are available upon request from the Environmental Law & Policy Center. For model years 2004-2009, the federal default bin mix under Scenario 1 was used for both the federal default and California programs.

California Data Files – To analyze the custom bin mixes, custom files for both the California and federal default programs were developed.

Total VMT – Cambridge Systematics used average daily VMT projections obtained from IEPA to compute total emissions from the gram/mile emission rates. The data provided were total VMT from all vehicle types for each of the three geographic areas noted. More details on this step, as well as a table of VMT projections, can be found in the on-line Appendix A2 at www.elpc.org. Light-duty diesel vehicles make up a small fraction of the current overall vehicle fleet and thus were not included in this analysis. Projections were not made regarding future penetration of diesel vehicles in the light duty market, due to uncertainty regarding diesel development and future regulations.

Notes on Sensitivity Analysis

In the case of inspection/maintenance (I/M) programs, Illinois today only inspects light-duty vehicles in the seven-county Chicago area and in three counties east of St. Louis. Legislation signed by the governor in August 2005 reduced these limited inspections even further by exempting all vehicles built before 1996 and requiring only on-board diagnostic system inspections of vehicles built since then. This legislation was passed to save the state tens of millions of dollars in inspection costs as older cars begin to disappear from Illinois roads—although pre-'96 cars will continue to be a significant presence in Illinois until approximately 2009.

Notes on Results

The Scenario VOC and air toxics benefits for 2030 are somewhat lower than for Scenario 1, but the NOx benefits are higher. Differences are attributable to the following:

- The EPA bin mix includes a greater distribution of vehicles across bins under Tier 2, which reduces average VOC levels. Air toxics emissions are reduced in relationship to VOC.
- A different California LEV II mix is used along with the different EPA Tier 2 bin mix. The California LEV II mix is based on an ARB-developed implementation schedule that is meant to provide consistent comparison with EPA's default Tier 2 bin mix. This LEV II phase in schedule shows higher NOx benefits compared to the Scenario 1 phase in schedule.

APPENDIX B.
Health Benefits Analysis
Limitations and Uncertainties

The estimates in this study are based on current data and methodologies. They provide reasonable initial approximations of the magnitude of health benefits from enhanced vehicle emissions standards, as well as the relative contribution of each pollutant to the overall health burden from air pollution. Nevertheless, substantial uncertainties and limitations exist at each step of the health benefits analysis. In addition, risk estimates for the analyzed pollutants are population-based figures, and thus should not be interpreted as a prediction of any individual's health outcome. The results should be read in keeping with these two points. A general discussion of limitations and uncertainties is provided below. For a detailed discussion of methodology, including uncertainty and limitations, see Appendix B2, available on-line at www.elpc.org.

Data

Due to limitations in data availability and the preliminary nature of the analysis, several of the calculations rely on non-Illinois-specific data and/or extrapolate data seasonally or geographically. To the extent that local, yearly conditions differ significantly from these data, the analysis provides a less accurate estimate of local annual impacts. The U.S. EPA was in the process of developing 1999 NATA modeling data at the time of this writing; 1996 data thus was used in this report and may not represent the most current modeled conditions.

Exposure

The U.S. EPA has found that direct measurements of ambient concentrations typically exceed modeled ambient air concentrations from NATA. As this analysis relies on modeled concentrations, it may underestimate actual health benefits. More information on the uncertainties and limitations in NATA can be found on the U.S. EPA's website at www.epa.gov/ttn/atw /nata. A comparison of NATA data and monitoring data from Illinois sites confirmed underestimation by NATA of concentrations of several air toxics (see Appendix B2).

People are exposed to the studied pollutants through multiple biological pathways and in multiple settings. This study considers only inhalation exposures to outdoor air. Since indoor or microenvironmental concentrations of many important air toxics are higher than ambient levels, the present analysis may underestimate health benefits from reductions of such pollutants. Furthermore, the current study does not assess pockets of high pollutant concentrations, and thus may underestimate health benefits for people living in such pockets and/or overestimate health benefits for people living in areas where pollutant concentrations are lower than annual ambient averages.

The intake fraction and linear rollback methodologies both are accompanied by limitations. An intake fraction is not an inherent property of a pollutant or a location, but is dependent on context-specific factors. If an intake fraction has been published for a location other than the location of interest, it will be somewhat uncertain and will need to be interpreted with care. In addition, an intake fraction (as defined in the on-line appendix) implicitly assumes that an incremental change in exposure has the same health effect regardless of the current level of exposure, i.e., the ambient concentration of the pollutant. More formally, this means that the health effect is assumed to have a linear dose-response function with no threshold. If there are non-linearities in the dose-response function, the intake fraction would not necessarily be a health-relevant exposure metric.

The linear rollback analysis assumes that any emissions in Illinois only influence concentrations in Illinois, and that sources outside of Illinois do not affect concentrations in Illinois. This is a reasonable assumption for some pollutants (e.g., coarse particulate matter and other primary air pollutants that do not travel far in the atmosphere), but is a less valid assumption for others (e.g., ozone and secondary particulate matter). Regardless, linear rollback methods are used for all pollutants to allow for comparisons with intake fraction estimates, and not solely for their individual validity.

Health Effects

The concentration-response functions draw upon a number of different sources, including occupational studies, animal studies, and various types of general population epidemiological studies. Thus, although the present study quantifies mortality and morbidity risks for each pollutant, direct comparisons or addition across pollutants may be less meaningful than a simple summation might indicate. In addition, the bodies of evidence supporting calculations for each pollutant vary in terms of their quality, direct relevance, and conclusiveness. Higher levels of uncertainty in the present study attach to certain pollutants based on the state of the existing literature and whether significant extrapolation was required from the studies to the current analysis. For example, more uncertainty accompanies the ozone calculations than the PM figures.

Reference concentrations, used here to assess air toxics, are constructed taking into account margins of safety. The uncertainty involved in calculating an individual reference concentration, or "RfC" can span an order of magnitude. RfCs thus should not be interpreted as bright-line measures of when health effects will happen, but rather as general guidance on the likelihood of changes in health effects. Information on reference concentrations can be found in the U.S. EPA publication "A Review of the Reference Dose and Reference Concentration Processes," available at www.epa.gov.

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