TAILPIPE EMISSIONS: HOW THEY EFFECT HUMAN HEALTH

INTRODUCTION

Tailpipe emissions are a serious threat to human and environmental health. The combustion of petroleum-based fuels results in the release of noxious chemicals into the air. Before the Clean Air Act of 1970, tailpipe emissions were not regulated by the U.S. government. In the time since, great strides have been made, yet the use of automobiles inherently retains serious side effects. In this lesson plan, students will focus on the consequences exposure to tailpipe emissions has for human health. They will learn how combustion creates these emissions, and what they can do to reduce them.

LESSON OVERVIEW

Grade Level & Subject: 9-12, Chemistry, History, Environmental Studies

Length: 1-2 class periods

Objectives:
After completing this lesson, students will be able to:

- Identify components of tailpipe emissions
- Understand the effect of tailpipe emissions on human health
- Recognize problems and begin to identify solutions associated with automobile exhaust

National Standards Addressed:
This lesson addresses the following National Education Standards:[1]

- **Content Standard:** **NS.9-12.6** PERSONAL AND SOCIAL PERSPECTIVES
  As a result of activities in grades 9-12, all students should develop understanding of:
    - Personal and community health
    - Environmental quality
    - Natural and human-induced hazards
    - Science and technology in local, national, and global challenges
- **Content Standard:** NS.9-12.7 HISTORY AND NATURE OF SCIENCE
  As a result of activities in grades 9-12, all students should develop understanding of:
    - Science as a human endeavor
    - Nature of scientific knowledge
    - Historical perspectives

[1] http://www.education-world.com/standards/

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Materials Needed:

- **Reproducible #1: EPA History of Reducing Tailpipe Emissions**
- **Reproducible #2: Air Pollution from Motor Vehicles in Vermont**
- **Reproducible #3: South Carolina: Vehicle Maintenance and Air Quality**
- **Reproducible #4: New Hampshire: Motor Vehicles and Toxic Air Pollutants**

Assessment:

Students will be assessed through the following activities:

- Participation in class discussion
- Demonstrated thought and research in small group presentations

LESSON BACKGROUND

Relevant Vocabulary:

- **Emissions:** Releases of pollutants into the air from a source, such as a motor vehicle or a factory.[2]
- **Hydrocarbons:** Chemical compounds that contain hydrogen and carbon. Most motor vehicles and engines are powered by hydrocarbon-based fuels such as gasoline and diesel. Hydrocarbon pollution results when unburned or partially burned fuel is emitted from the engine as exhaust, and also when fuel evaporates directly into the atmosphere. Hydrocarbons include many toxic compounds that cause cancer and other adverse health effects. Hydrocarbons also react with nitrogen oxides in the presence of sunlight to form ozone. Hydrocarbons, which may take the form of gases, tiny particles, or droplets, come from a great variety of industrial and natural processes. In typical urban areas, a very significant fraction comes from cars, buses, trucks, and nonroad mobile sources such as construction vehicles and boats.[3]
- **Nitrogen Oxides:** A group of highly reactive gases that contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless. The common pollutant nitrogen dioxide (NO2) can often be seen combined with particles in the air as a reddish-brown layer over many urban areas. Nitrogen oxides are formed when the oxygen and nitrogen in the air react with each other during combustion. The formation of nitrogen oxides is favored by high temperatures and excess oxygen (more than is needed to burn the fuel). The primary sources of nitrogen oxides are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels.[4]
- **Ozone:** A gaseous molecule that contains three oxygen atoms (O3). Ozone can exist either high in the atmosphere, where it shields the Earth against harmful ultraviolet rays from the sun, or close to the ground, where it is the main component of smog. Ground-level ozone is

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[2] " Emissions Entry." *U.S. Environmental Protection Agency*. Retrieved July 11, 2011 from http://www.epa.gov/otaq/invntory/overview/definitions.htm.

[3] " Hydrocarbons Entry." *U.S. Environmental Protection Agency*. Retrieved July 11, 2011 from http://www.epa.gov/otaq/invntory/overview/definitions.htm.

[4] " Nitrogen Oxide." *U.S. Environmental Protection Agency*. Retrieved July 11, 2011 from http://www.epa.gov/otaq/invntory/overview/definitions.htm.

a product of reactions involving hydrocarbons and nitrogen oxides in the presence of sunlight. Ozone is a potent irritant that causes lung damage and a variety of respiratory problems.[5]

- **Smog:** A commonly used term for pollution caused by complex chemical reactions involving nitrogen oxides and hydrocarbons in the presence of sunlight. Ozone is a key component of smog. Smog-forming chemicals come from a wide variety of combustion sources and are also found in products such as paints and solvents. Smog can harm human health, damage the environment, and cause poor visibility. Major smog occurrences are often linked to heavy motor vehicle traffic.[6]
- **Particulate Matter:** Tiny particles or liquid droplets suspended in the air that can contain a variety of chemical components. Larger particles are visible as smoke or dust and settle out relatively rapidly. The tiniest particles can be suspended in the air for long periods of time and are the most harmful to human health because they can penetrate deep into the lungs. Some particles are directly emitted into the air. They come from a variety of sources such as cars, trucks, buses, factories, construction sites, tilled fields, unpaved roads, stone crushing, and wood burning. Other particles are formed in the atmosphere by chemical reactions.[7]
- **Carbon Monoxide:** A colorless, odorless gas that forms when carbon in fuel is not burned completely. Carbon monoxide is a component of exhaust from motor vehicles and engines. Carbon monoxide emissions increase when conditions are poor for combustion; thus, the highest carbon monoxide levels tend to occur when the weather is very cold or at high elevations where there is less oxygen in the air to burn the fuel.[8]
- **Benzene:** A cancer-causing hydrocarbon (C6H6) derived from petroleum. Benzene is a component of gasoline. Benzene emissions occur in exhaust as a byproduct of fuel combustion and also occur when gasoline evaporates.[9]
- **Carbon Dioxide:** A colorless, odorless, non-poisonous gas that exists in trace quantities (less than 400 parts per million) within ambient air. Carbon dioxide is a product of fossil fuel combustion. Although carbon dioxide does not directly impair human health, it is a greenhouse gas that traps terrestrial (i.e., infrared) radiation and contributes to the potential for global warming.[10]
- **Volatile Organic Compounds:** Emitted as gases from certain solids or liquids, VOCs include substances—some of which may have short- and long-term adverse health effects—such as benzene, toluene, methylene chloride, and methyl chloroform.[11]

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[5] " Ozone Entry." *U.S. Environmental Protection Agency.* Retrieved July 11, 2011 from http://www.epa.gov/otaq/invntory/overview/definitions.htm

[6] " Smog Entry." *U.S. Environmental Protection Agency.* Retrieved July 11, 2011 from http://www.epa.gov/otaq/invntory/overview/definitions.htm

[7] " Particulate Matter Entry." *U.S. Environmental Protection Agency.* Retrieved July 11, 2011 from http://www.epa.gov/otaq/invntory/overview/definitions.htm

[8] " Carbon Monoxide Entry." *U.S. Environmental Protection Agency.* Retrieved July 11, 2011 from http://www.epa.gov/otaq/invntory/overview/definitions.htm

[9]" Benzene Entry." *U.S. Environmental Protection Agency.* Retrieved July 11, 2011 from http://www.epa.gov/otaq/invntory/overview/definitions.htm

[10] " Carbon Dioxide Entry." *U.S. Environmental Protection Agency.* Retrieved July 11, 2011 from http://www.epa.gov/otaq/invntory/overview/definitions.htm

[11]" Volatile Organic Compounds Entry." *U.S. Environmental Protection Agency.* Retrieved July 11, 2011 from http://www.epa.gov/otaq/invntory/overview/definitions.htm

Background Information:

Automobiles typically run on gasoline or diesel fuel, both of which are a composite of different chemicals collectively known as hydrocarbons. Mainly carbon and hydrogen, hydrocarbons are Volatile Organic Compounds (VOCs), meaning that they readily evaporate at normal temperatures. According to the Environmental Protection Agency, they are a precursor to ground-level ozone and smog. Hydrocarbons result in dangerous emissions because our vehicles do not operate in a vacuum. In a "perfect" combustion engine, all the hydrogen in the fuel would be converted to water by the oxygen in the air. Meanwhile the carbon in the fuel would be converted to carbon dioxide, and the nitrogen already in the air would remain unaltered. However, as is clearly the case, we do not operate in a vacuum, and none of our vehicles are equipped with a perfect engine. Instead, incomplete combustion, combined with high pressure and temperature, results in several toxic exhaust pollutants:

- Carbon Monoxide
- Nitrogen Oxides
- Sulfur Oxides
- Carbon Dioxide

In addition to exhaust pollutants, petroleum-based fuels also emit dangerous compounds due to evaporation. Typically, these emissions stem from storage tanks and fueling lines. As has been stated, hydrocarbons are VOCs which means that, especially on hot days, they contribute significantly to ground level ozone as they are released from vehicles (both parked and driving), gas stations, and anywhere gas or diesel is stored. A key component of smog, ground-level ozone is formed by reactions involving hydrocarbons and nitrogen oxides in the presence of sunlight. Particulate matter as well, though not a chemical compound, is nevertheless a serious health concern as an auto emission.

Resources:

- **Health Impacts of Air Pollution in Los Angeles County Powerpoint**
  http://publichealth.lacounty.gov/plan/docs/Smart%20Commuting%20presentation.ppt
- **LA Times: Standards will limit tailpipe emissions**
  http://articles.latimes.com/2010/apr/02/nation/la-na-fuel-efficiency2-2010apr02
- **NREL Newsroom**
  http://www.nrel.gov/news/press/2011/941.html
- **UMN Vehicular Exhaust and Air Pollution**
  http://enhs.umn.edu/current/5103/vehicular/emissions.html
- **Consumer Product Safety Commission: Carbon Monoxide Questions and Answers**
  http://www.cpsc.gov/cpscpub/pubs/466.html
- **EPA: Particulate Matter**
  http://www.epa.gov/pm/
- **EPA: Nitrogen Dioxide**
  http://www.epa.gov/oaqps001/nitrogenoxides/
- **EPA: Sulfur Dioxide**

http://www.epa.gov/oaqps001/sulfurdioxide/

- **UCLA Institute on Environment and Sustainability: Air Pollution Impacts on Infants and Children**
- http://www.environment.ucla.edu/reportcard/article.asp?parentid=1700

LESSON STEPS

Warm-up: *What is released from your car's tailpipe?*

1. Write the names of the emissions listed below on the board, and ask the class if they can guess what all of them have in common. *Answers may vary.* Explain to them that one trait that all the words on the board share is that they are all hazardous to human health. Proceed to detail the health effects of each item.
    - Carbon Monoxide: reduces the amount of oxygen reaching the body's organs and tissues, aggravates heart disease.
    - Nitrogen Oxides: aggravates lung diseases, can contribute to asthma and other respiratory problems.
    - Sulfur Oxides: aggravates asthma
    - Carbon Dioxide: headaches and dizziness when exposed to an abundance of the compound.
    - Benzene: is a known carcinogen.
    - Ozone: causes lung damage and a variety of respiratory problems.
    - Particulate Matter: decreased lung function, asthma, development of chronic bronchitis, nonfatal heart attacks, and premature death in people with heart or lung disease.

2. Ask the class if they can guess another commonality shared by all of the items on the board. *Answers may vary.* They may be surprised to learn that all of these items are released as emissions from the cars that they most likely drive in everyday. Feel free to reference the information section if you choose to explain why the emissions exist.

    - "Perfect" Combustion:
      Fuel (hydrocarbons) + air (oxygen and nitrogen) = carbon dioxide + water + unaffected nitrogen
    - Typical Engine Combustion:
      Fuel + air = unburned hydrocarbons + nitrogen oxides + carbon monoxide + carbon dioxide + water[12]

3. Explain to the class that the current level of emissions per vehicle are today much lower than

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[12] "The Environmental Impact of Vehicle Emissions." *University of Connecticut – School of Engineering.* Retrieved July 11, 2011 from http://www.engr.uconn.edu/~garrick/ce320/2007/Lecture%207%20-%20The%20Environmental%20Impact%20of%20Vehicle%20Emissions.doc.

in the past. Ask them if they can imagine, given their new knowledge of the health effects of tailpipe emissions, how hazardous things were 40 years ago. Do they have any idea how many cars and trucks there were on the road in 1970? *108,418,197*[13]. The year 2000? *221,475,173.*2008? *Over 250 million.*[14] How dangerous would the environment be if regulation had never been adopted? *Answers may vary.* And what exactly are these regulations? Take the class through **Reproducible #1**. Feel free to split up the text, and have students read individual paragraphs.

Activity One: *Real World Ramifications*
Activity one will give a couple real world examples of the problem with auto emissions, and ask students to research solutions to those problems.

1. Now that they have an idea of how vehicle regulations came into being, have the class examine contemporary issues and research solutions. Depending upon the size of your class, break students into "solution-finding small groups." Each group will be responsible for researching a different manner of reducing emissions. They should complete their research as homework, and be ready to present during the next class period.
2. Break the class up into groups based on potential emission reducing strategies. These could include: hybrid cars, electric cars, ways to increase gas mileage, MTBE and other gasoline additives, ethanol, biodiesel etc. They should structure their research and strategies as if they were governing a particular state. Allow groups to choose their state, and make them aware that they should be prepared during the next class period to present the pertinent data for their respective states (i.e. how many vehicles are currently on the road, and how much driving is done – this information can typically be found on the state's DOT website.), as well as their group's plan to mitigate emissions.
3. Before they dive into the research, students should become more aware of the current problem. In order to facilitate this, present **Reproducibles #2 – 4** to the class either on an Overhead Projector or Smart Board. Also, consider showing the Los Angeles Powerpoint (listed first in the reference section) in order to give students an idea of some mitigating strategies.

Wrap Up: *The Future*

1. During the next class period, have state groups present their findings and subsequent strategies they researched in order to mitigate harmful tailpipe emissions. Steer this into a conversation centered on what must be achieved for a cleaner future versus what is actually possible. Your students are the future leaders of this country. What limits are they willing to tolerate when it comes to clean air and human health? Where will they sacrifice for convenience? How much pushback to they think will come from the automotive industry?

Extension: *Environmental Effects*

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[13] "Highway Finance Data & Information." *U.S. Department of Transportation.* Retrieved July 11, 2011 from http://www.fhwa.dot.gov/policyinformation/pubs/pl08021/fig3_1.cfm.
[14] "Number of U.S. Air Craft, Vehicles, Vessels, and Other Conveyances." *Bureau of Transportation Statistics.*http://www.bts.gov/publications/national_transportation_statistics/html/table_01_11.html.

1. The toxicity of tailpipe emissions affects much more than human health. The environment, animals, bodies of water, and the Earth as a whole suffer because these compounds are emitted into the air. Encourage interested students to pursue extra inquiry into its effects.

CONCLUSION

Students have examined the history of the automobile in films as a catalyst for advertising. They now have an understanding of how the "car culture" came to be in America, and they have done their best to guess at its future. They' also touched on the role of technology in determining driving habits.

LESSON PLAN CREDITS

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EPA Emission Facts[15]

United States Environmental Protection Agency | Air and Radiation | EPA420-F-99-017 May 1999

Office of Mobile Sources

EPA

Emission Facts

The History of Reducing Tailpipe Emissions

1970-1975: The First Standards

In 1970, Congress passes the Clean Air Act, which called for the first tailpipe emissions standards. The pollutants controlled are carbon monoxide (CO), volatile organic compounds (VOC), and oxides of nitrogen (NOx). The new standards go into effect in 1975 with a NOx standard for cars and light-duty trucks of 3.1 grams per mile (gpm).

1977-1988: Tightening Standards for the First Time

In 1977, Congress amends the Clean Air Act and tightens emission standards again in two steps. First, between 1977 and 1979, the NOx standard becomes 2.0 gpm for cars. Then in 1981, the NOx standard for cars is reduced to 1.0 gpm. Effective in 1979, pursuant to the Clean Air Act requirements, EPA tightens standards for light-duty trucks to 2.3 gpm. Effective in 1988, EPA then sets the first tailpipe standards for heavier trucks at 1.7 gpm and revises the standard for lighter trucks to 1.2 gpm.

1990-1994: Tier 1

In 1990, Congress again amends the Clean Air Act, further tightening emission standards. The NOx standard is set at 0.6 gpm for cars, effective in 1994. The new standard — called "Tier 1"—is a 40 percent reduction from the 1981 standard. For trucks, the new standard ranges from 0.6 to 1.53 gpm, depending on the weight of the vehicle.

[15] "The History of Reducing Tailpipe Emissions." *United States Environmental Protection Agency*. Retrieved July 13, 2011 from http://www.epa.gov/oms/consumer/f99017.pdf.

The Clean Air Act Amendments of 1990 also require EPA to assess the air quality need, cost effectiveness, and feasibility of tighter emission standards for the 2004 model year and beyond.

1998: Voluntary Agreement For Cleaner Cars

In 1998, the Clinton Administration with the auto industry and the Northeast states strike an innovative, voluntary agreement to put cleaner cars on the road before they could be mandated under the Clean Air Act. The new cars are called National Low Emission Vehicles (NLEV). The first NLEV cars under the agreement reach consumers in New England in 1999 and will reach the rest of the country in 2001. NLEV cars operate with a NOx standard of 0.3 gpm, a 50 percent reduction from Tier 1 standards. The NLEV agreement also calls for a 0.5 gpm NOx standard for lighter trucks only, a 17 percent reduction from Tier 1 requirements for these vehicles.

In 1998, as required by the Clean Air Act Amendments of 1990, EPA issues the Tier 2 Report to Congress. The report contains strong evidence of the need, cost-effectiveness and feasibility for tighter tailpipe emission standards in the future beginning in 2004. Three main factors support EPA's decision:

1) currently vehicles make up 30 percent of smog-forming emissions nationally, and because the number of miles driven is increasing (up 127 percent since 1970) they will continue to be a significant contributor to pollution;
2) larger vehicles like SUVs, that currently do not meet the same standards as cars, pollute 3-5 times as much and make up 50 percent of the vehicles sold today; and
3) the technology to meet tighter standards is available and cost-effective.

In 1998, EPA also determines that sulfur reductions in gasoline are needed to enable the full performance of low emission-control devices.

1999: Tier 2

In 1999, EPA proposes Tier 2 tailpipe emissions standards beginning in 2004—the first time both cars and light-duty trucks are subject to the same national pollution control system. The new standard is 0.07 gpm for NOx, a 77-86 percent reduction for cars and a 92-95 percent reduc-

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tion for trucks beyond the NLEV agreement. EPA also proposes a reduction in average sulfur levels to 30 parts per million (ppm) (maximum of 80 ppm) to achieve the full performance of vehicle emission control technologies.

As part of these new standards, EPA has included several measures to ensure maximum flexibility and cost-effectiveness. These flexibilities include:

- allowing averaging to meet both the car emission and gasoline sulfur standards;
- allowing extra time for larger vehicles between 6000 and 8500 pounds and smaller refiners to meet their respective standards; and
- allowing for a market-based credit trading-and-banking system for both industries to reward those who lead the way in reducing pollution.

Cars

Year	1975	1977	1981	1994	1999	2004-2009
NOx Standard (gpm)	3.1	2.0	1.0	0.6	0.3	0.07
NOx Reduced (from previous standard)		35%	50%	40%	50%	77%

Smaller SUVs, Minivans, and Light Trucks (Less that 6000 lbs)

Year	1975	1979	1988	1994	1999	2004-2009
NOx Standard (gpm)	3.1	2.3	1.2	0.6	0.5	0.07
NOx Reduced (from previous standard)		26%	48%	50%	17%	86%

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Larger SUVs, Vans, and Heavier Trucks (Between 6000 and 8500 lbs)

Year	1988	1994	2004-2007	2008-2009
NOx Standard (gpm)	1.7	1.53	0.2	0.07
NOx Reduced (from previous standard)		10%	87%	65% or 95% from 1994 standard

For More Information

Additional documents on emission standards for cars and light trucks are available electronically from the EPA Internet server at:

http://www.epa.gov/oms/ld-hwy.htm

Information on the Tier 2 standards is available on the Tier 2 home page at:

http://www.epa.gov/oms/tr2home.htm

Document information is also available by writing to:

Tier 2 Team
U.S. Environmental Protection Agency
Office of Mobile Sources
2000 Traverwood Drive
Ann Arbor, MI 48105

Air Pollution from Motor Vehicles in Vermont[16]

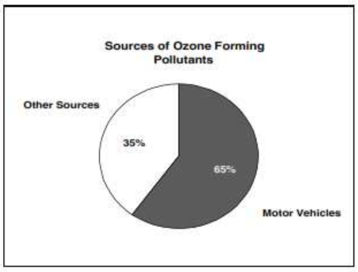
How Much of Vermont's Air Pollution Comes From Motor Vehicles?

Motor vehicles are the largest source of toxic and carcinogenic air pollutants in Vermont. Each year, motor vehicles emit about 2 million pounds of toxic and carcinogenic compounds like benzene, formaldehyde, and 1,3-Butadiene.

Motor vehicles are the largest source (about 65%) of ozone-forming pollutants in Vermont. Each year vehicles emit over:

- 234 million pounds of carbon monoxide,
- 20 million pounds of hydro-carbons,
- and 28 million pounds of nitrogen oxides.

As industries have reduced their emissions, motor vehicles have become an increasing portion of the air pollution created in Vermont.

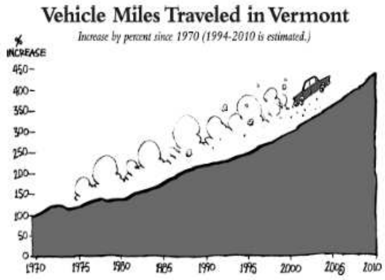


The number of vehicles and the miles they travel are ncreasing. Motor vehicles now travel over 6 billion miles nnually in Vermont, double the amount traveled in 1972.

How Much Air Pollution Does an Average Motor Vehicle Emit?

The average Vermont driver puts 17,000 miles a year on his/her car. This equals 935 pounds of carbon monoxide, 13,600 pounds of carbon dioxide, 114 pounds of hydrocarbons, and 68 pounds of nitrogen oxides emitted every year. That's nearly 7.5 tons of air pollution each year, from just one vehicle!

A vehicle with a malfunctioning or faulty emission control system can emit over 800% more air pollution than a properly operating vehicle!



What are the Health and Environmental Effects of Motor Vehicle Emissions?

Because motor vehicles are so common and so widely used, humans are continuously exposed to air pollution from motor vehicles.

We all breath air, all day, every day.

Toxic and carcinogenic air pollutants from motor vehicles are of concern because they are known or suspected of causing cancer in humans, and pose a threat even at very low levels.

Hydrocarbons and nitrogen oxides from motor vehicles form smog (ground-level ozone), which damages lung tissue and aggravates respiratory disease.

Children and the elderly are especially vulnerable to smog. According to the American Lung Association of Vermont, nearly 200,000 children and elderly Vermonters are frequently exposed to unhealthy levels of smog.

Smog from motor vehicles inhibits plant growth and can cause widespread damage to crops and forests.

Air pollution from motor vehicles contributes to the formation of acid rain and global warming.

[16] "Air Pollution from Motor Vehicles in Vermont." Vermont Department of Environmental Conservation. Retrieved July 12, 2011 from http://www.anr.state.vt.us/air/mobilesources/docs/pollution.pdf.

What Can Be Done to Reduce Motor Vehicle Emissions?

ALTERNATE TRANSPORTATION
The most effective way to reduce emissions from motor vehicles is to use them less. The trend of more cars driving more miles is starting to outpace the progress in vehicle emission control technology. Carpool, take a bus or train, ride a bike, walk- every effort helps.

MAINTENANCE Proper maintenance of motor vehicles is critical to pollution prevention. Following maintenance guidelines can reduce vehicle emissions and enhance vehicle performance and reliability.

INSPECTIONS A well designed vehicle emissions inspection and maintenance program is a practical and cost-effective way to reduce air pollution from vehicles currently in use.

CLEAN CARS Advances in vehicle emission control technology are making it possible to produce new vehicles with lower emissions. Electric vehicles, sometimes referred to as "zero-emission vehicles," are gaining attention as an option for improving air quality.

CLEAN FUELS New fuel blends and alternative fuels have the potential to produce less air pollution and greenhouse gases than conventional fuels.

Carpool!

Doing your part

If you have to drive, these simple rules will help you minimize emissions:

- Keep tires inflated to required pressure and front end aligned.
- Follow manufacturers maintenance schedule - especially regarding tune ups and oil changes.
- Drive sensibly. Avoid jack rabbit starts and stops.
- Warm up your car - even in cold weather - by driving it. Idling for long periods in cold weather can actually damage your engine.
- Don't let your car idle unnecessarily (30 seconds or less). Avoid drive up service windows!
- Avoid high speeds. You will get 15% better mileage driving 55 mph versus 65 mph.

Higher emissions means lower engine efficiency and lower miles per gallon, which costs you $$$.

Thank you for your cooperation and helping do your part to clean up the air.

For more information call the Air Pollution Control Division at (802) 241-3840

State of Vermont Agency of Natural Resources
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Air Pollution Control Division
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Air Pollution Control In Vermont

Air Pollution from Motor Vehicles in Vermont

Your Car and Clean Air

South Carolina: Vehicle Maintenance and Air Quality[17]

Fact Sheet

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Vehicle Maintenance and Air Quality

Why should I be concerned about my vehicle's impact on the environment?

Your car or truck emits pollutants that form harmful ground-level ozone and particle pollution. Ground-level ozone can cause or worsen breathing problems. Particle pollution can irritate or damage your lungs.

Nitrogen oxides (NO_x) and volatile organic compounds (VOCs) are some of the tailpipe emissions that help form ground-level ozone. NO_x is formed when fuel is burned at high temperatures. Sunlight causes NO_x to react with VOCs. When NO_x and VOCs react together in the presence of sunlight, the result is ground-level ozone.

Your vehicle also emits particle pollution, which can be formed from solid or liquid particles called particulate matter (PM). Sources of particle pollution include vehicle exhaust, tires and unpaved roads. Vehicle exhaust contains NO_x, VOCs, sulfur oxides and ammonia, and these react in the atmosphere to form PM.

The U.S. Environmental Protection Agency (EPA) regulates ground-level ozone and PM in South Carolina.

Which vehicle systems and parts help reduce air pollution?

Your vehicle's **emissions control system** reduces NO_x and VOCs and improves gas mileage.

Your vehicle's **on-board diagnostic monitoring (OBD) system** also plays a big role. If it finds a problem in the engine, the "check engine" light comes on. Often, the problem is actually related to the transmission or your tailpipe emissions. Making repairs quickly can reduce emissions and improve air quality. A flashing light means the computer has found a serious problem and you shouldn't drive your car at all until it is fixed.

These vehicle parts also help reduce pollution:

- The **catalytic converter** oxidizes VOCs and carbon monoxide (CO) and reduces NO_x.
- The **oxygen sensor** ensures the best possible mix of fuel and oxygen. If there is too much of one or the other, your emissions increase. When the oxygen sensor isn't working properly, your car uses more gasoline. In fact, replacing a worn oxygen sensor with a new one may boost gas mileage by 10 to 15 percent.
- The **exhaust gas recirculation (EGR) system** returns part of the exhaust gas to the combustion chamber. This lowers NO_x emissions and improves gas mileage.
- The **air injection pump** pushes air into the exhaust manifold. This burns off VOCs and CO and helps fuel burn more completely.

[17] "Vehicle Maintenance and Air Quality." *South Carolina Department of Health and Environmental Control.* Retrieved July 11, 2011 from http://www.scdhec.gov/environment/baq/docs/factsheets/AQVAMP.pdf.

- The **positive crankcase ventilation valve** redirects vapors into the intake manifold, reducing VOC emissions. This helps prevent engine corrosion, oil dilution and engine deposits.
- The **misfire monitor** causes the "check engine" light to come on when the engine misfires. Engine misfires can very quickly damage the catalyst.

What can I do to keep my car running efficiently and reduce greenhouse gas emissions?

Greenhouse gas emissions contribute to global warming, or climate change. While some greenhouse gases occur naturally in the atmosphere, others result from human activities. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane, nitrous oxide and ozone. Energy-related CO_2 emissions, such as those that come from burning fuel, make up 82 percent of U.S. greenhouse gas emissions. CO_2 emissions are always linked to fuel consumption because CO_2 is the end product of burning gasoline. The more fuel a car burns, the more CO_2 it emits. Efficient vehicles that burn less fuel also emit fewer greenhouse gases.

If you want to reduce your car's greenhouse gas emissions, follow these tips:

- Replace clogged **air filters.** This will improve gas mileage by as much as 10 percent and protect the engine.
- Use the recommended grade of **motor oil**. Using a different motor oil grade than the one recommended for your vehicle can lower gas mileage by 1 to 2 percent.
- Properly inflate and align your **tires.** This can improve gas mileage by around 3.3 percent.
- Get regular **tune-ups.** They can improve gas mileage by 4 to 12 percent. Regular engine tune-ups and car maintenance checks help avoid problems due to worn spark plugs, dragging brakes, low transmission fluid or transmission problems. When your average gas mileage falls by 10 to 15 percent, you're ready for a tune-up. Check your owner's manual for tune-up guidance.

Your driving habits can also affect fuel efficiency and greenhouse gas emissions. To save gas and reduce pollution, follow these tips:

- Don't warm up the engine before driving. It's unnecessary, even in winter.
- Accelerate smoothly.
- Remove extra weight from your vehicle.
- Drive the speed limit. At speeds over 60 mph, greenhouse gas emissions increase and fuel economy drops.

New Hampshire: Motor Vehicles and Toxic Air Pollutants[18]

ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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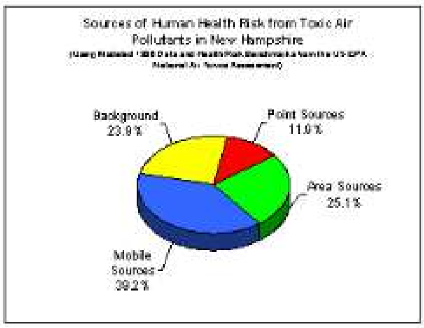
Motor Vehicles and Toxic Air Pollutants

What are Toxic Air Pollutants?

Toxic air pollutants (TAPS), or hazardous air pollutants (HAPS), are those pollutants that have the potential to cause serious adverse health effects in humans; for example, neurological, cardiovascular, liver, kidney, and respiratory effects or effects on the immune and reproductive systems. The U.S. Environmental Protection Agency (EPA) classifies these pollutants based on their potential cancer risk due to inhalation as either ***possible, probable***, or ***known human carcinogens***. Motor vehicle exhaust contains numerous toxic air pollutants, such as benzene, formaldehyde, 1,3-butadiene, and diesel particulate matter. Some additional toxic air pollutants emitted by motor vehicles include acrolein, cadmium, chromium and lead.

Air Toxics and Public Health

Motor vehicles are such an integral part of our society that everyone is exposed to their emissions. Using 1996 data, EPA estimates that on-road mobile sources (cars, trucks, and buses) are responsible for over 3,000 cases of cancer; and non-road mobile sources (construction equipment, recreational vehicles, boats, trains, aircraft) are responsible for an additional 1,850 cases of cancer each year in the U.S. Using this data for New Hampshire, almost 40 percent of all human health risk from toxic air pollutants comes from on-road and non-road mobile sources.



How are Toxic Air Pollutants from Motor Vehicles Formed?

Toxic air pollutants are typically emitted from cars and trucks through four mechanisms. First, some toxic air pollutants, such as benzene, toluene and xylenes, are components of gasoline that can be emitted into the air when gasoline evaporates during refueling or when gasoline remains in a hot engine after it is shut off. Second, these same compounds can also be emitted through the tailpipe and crankcase when the fuel is not completely burned in the engine, or as engine "blow-by." Third, a significant amount of benzene, formaldehyde, and acetaldehyde emissions from automobiles is formed in the exhaust as a result of the chemical reactions that occur when other components of gasoline are not completely burned in the engine. Finally, some toxic air

[18] "Motor Vehicle and Toxic Air Pollutants." *New Hampshire Department of Environmental Services, 2008*. Retrieved July 13, 2011 from http://des.nh.gov/organization/commissioner/pip/factsheets/ard/documents/ard-5.pdf.

pollutants, such as formaldehyde and acetaldehyde, can also be formed through a secondary process when other toxic pollutants from car and truck engines undergo chemical reactions in the atmosphere.

What's Been Done to Control Toxic Air Pollutant Emissions?

The control of air toxics emissions from motor vehicles has been addressed at the federal level through mandates for cleaner burning fuels and technological controls on motor vehicles such as catalytic converters. Pre-1975 vehicles without catalytic converters (and even pre-1981 vehicles with simple catalysts) emit far more air toxics than newer vehicles.

The removal of lead from gasoline, which began in the mid-1970s, has essentially eliminated mobile source emissions of this highly toxic substance. The federal government also has placed limits on gasoline volatility to control evaporative emissions of both hydrocarbon and toxic compounds. The 1990 Clean Air Act Amendments included provisions to require the use of reformulated gasoline (RFG) in the nation's most polluted cities. Federal requirements to reduce the benzene content of gasoline and to limit the amount of sulfur in diesel fuels achieved additional reductions in air toxics beginning in the mid-1990s.

At the state level, motor vehicles are currently exempt from New Hampshire's Air Toxic Control Program. To reduce emissions of air pollution and air toxics from motor vehicles, New Hampshire has creatively initiated voluntary programs that reduce unnecessary idling of heavy-duty diesel vehicles like school buses, construction vehicles, and delivery trucks, and that encourage the use of bio-diesel as an alternative cleaner-burning fuel. Emissions inspections and smoke "opacity" testing of diesel trucks have increased.

What Else Can Be Done?

Additional federal mandates for cleaner fuels and additional federal or state incentives to encourage measures like fuel economy, alternative fuels, carpooling, public transit and personal responsibility will all help reduce toxic air pollution from motor vehicles. More stringent tailpipe emission standards and test procedures for air toxics from motor vehicles are needed. The 1990 Clean Air Act Amendments do set specific emission standards for hydrocarbons (VOCs) and for diesel particulate matter, and vehicle manufacturers continue to develop technologies to comply with these standards.

Actual emissions from all mobile sources, from cars to garden equipment, are over 50 percent of total emissions of hazardous air pollutants in New Hampshire.

The Clean Air Act requires periodic emission inspections and computerized diagnostic systems to ensure that vehicle emission controls are functioning properly.

The good news is that today's new cars, trucks, and buses emit 90 percent less hydrocarbons and 50 percent less toxic air pollutants over their lifetimes than earlier uncontrolled models. Despite improvements in individual vehicle emissions, as "dirtier" vehicles are phased out of fleets and become replaced by newer clearer burning models, it is still likely that, with more cars driving more miles every year, overall emissions of air toxics may again begin to increase.

Changing to cleaner alternative non-petroleum fuels is one strategy for reducing air toxics. Choices include natural gas, propane, and electricity. These fuels are inherently cleaner than conventional gasoline and diesel because they do not contain toxics like benzene.

For more information on air toxics from automobiles, contact the N.H. Department of Environmental Services Air Resources Division at (603) 271-1370 or visit the EPA's Office of Transportation and Air Quality website at www.epa.gov/otaq/toxics.htm.

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