POLICY INSIGHTS

CLIMATE CHANGE, SHORT LIVED CLIMATE POLLUTANTS, BLACK CARBON AND CLEAN DIESEL

Thanks to the introduction of ultra-low sulfur diesel fuel, more efficient engines and more effective emissions control technologies, diesel engines, vehicles and equipment are a small and declining contributor of black carbon emissions globally. Technology and policy opportunities exist for accelerating turnover from old to new technology diesel in the U.S. Globally, accelerating the introduction of low-sulfur diesel fuels enables similar progress to eliminating fine particulate emissions from all diesel engines.

Over the last few years there has been growing attention to black carbon and its potential contribution to global warming. The scientific and policymaking communities acknowledge that black carbon plays a role in climate change by heating our planet and altering precipitation patterns. Diesel engines are one of many sources of black carbon emissions and controlling diesel emissions is one of the most cost-effective and immediate term strategies to reduce emissions and help cool a warming planet.

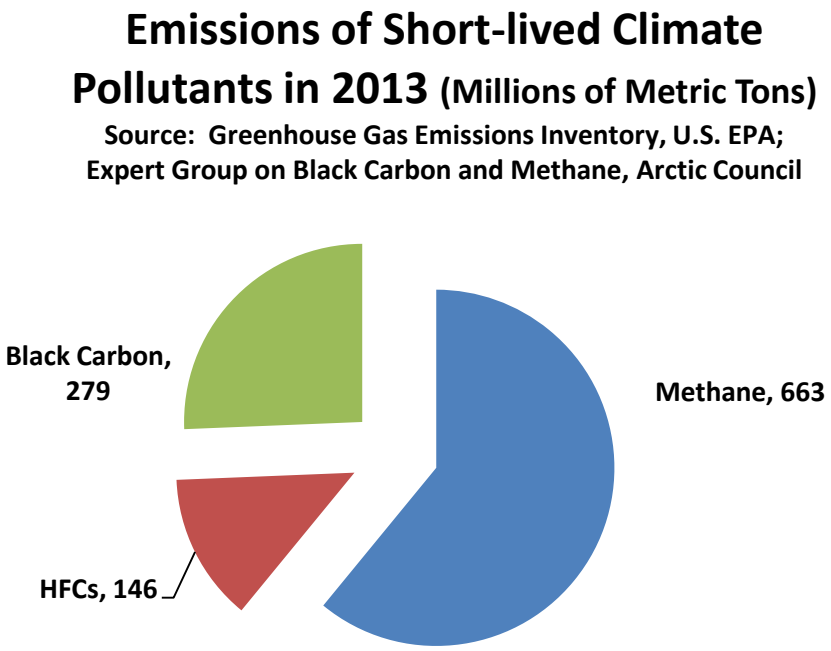
Thanks to changes in domestic fuel composition along with advances in engine design and emissions control technology, black carbon emissions have been virtually eliminated from tailpipe emissions from new diesel vehicles and equipment in the U.S. Regulations in place for heavy-duty truck engines beginning in model year 2007 and further tightened rules for model year 2010 engines have required a 98 percent reduction in particulate matter emissions – a leading contributor to black carbon. Similar standards have been in place since 2014 for the wide variety of off-road equipment types. Other countries have taken note of the advances made in the U.S. and are expanding the introduction of clean diesel technologies in part to reduce black carbon emissions.

These clean diesel advances are strongly supported by the United Nations Environment Programme which is advocating their adoption in countries around the world. The introduction of clean diesel technologies around the world can greatly help cool a warming planet by eliminating diesel sources of black carbon emissions.

We have compiled several definitions, statistics and facts about black carbon and clean diesel technology in order to promote greater understanding about the subject and the shrinking contribution of U.S. diesel emissions to the global black carbon inventory.

What is black carbon?

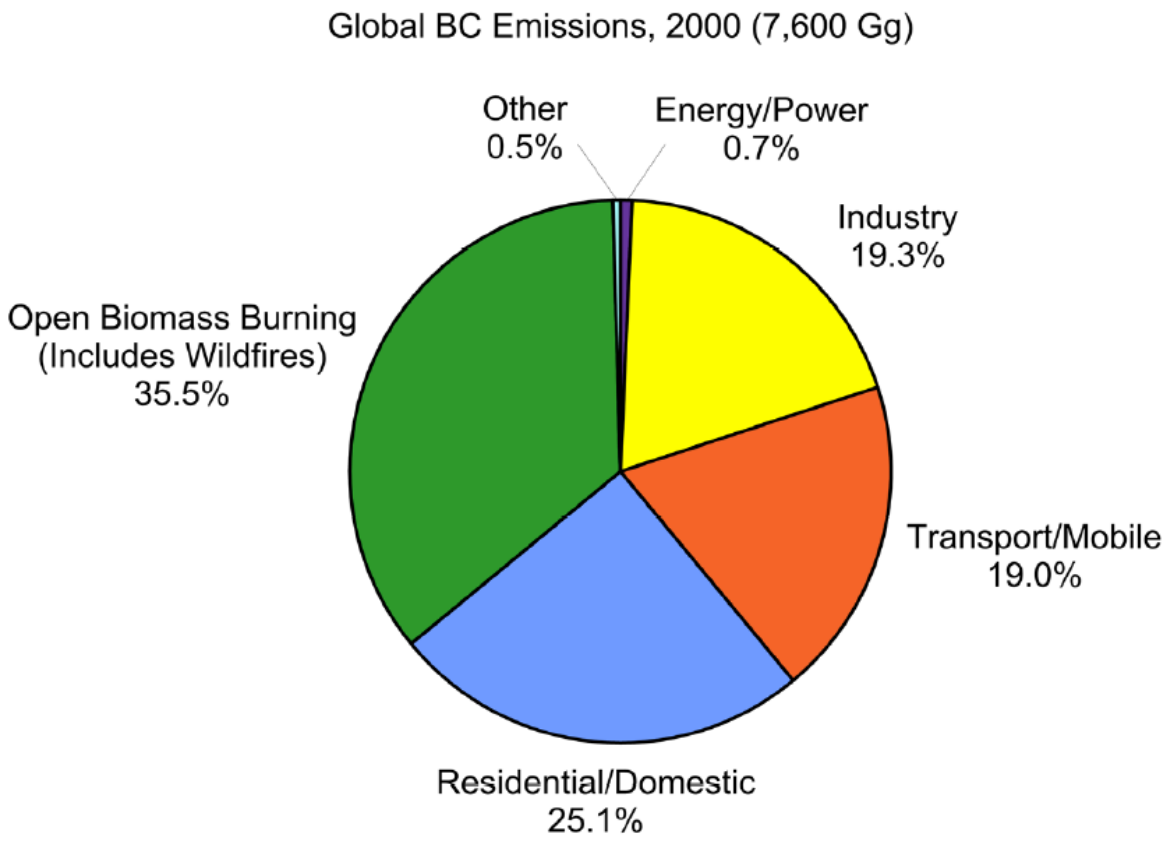
Black carbon is one of a variety of greenhouse gases known as short-lived climate pollutants (SLCP) that are much more potent but passing compared to carbon dioxide. Other SLCPs include methane and hydrofluorocarbons (HFC). Black carbon, often equated with elemental carbon, is a component of particulate matter, or soot, produced from the incomplete combustion of fuels including biomass that includes forest fires along with other emissions including brake and tire wear.



What are the primary sources of black carbon?

The main sources of black carbon are:

- forest fires
- open burning of biomass including residential burning of solid fuels such as coal, wood, dung and agricultural residue
- fossil fuel combustion for transportation
- industrial activities



SOURCE: EPA Report to Congress on Black Carbon

Globally, transportation sources account for 19 percent of all black carbon emissions and the majority of these emissions are from diesel engines. In the U.S, the transportation sector accounts for roughly 53 percent of black carbon emissions and diesel engines account for almost 90 percent of the transportation sector's share.

	Share of Transportation Sources of U.S. Black Carbon Emissions
Diesel: Trucks and Buses	48.6%
Diesel: Off-Road Equipment	35.5%
Diesel: Locomotives	1.6%
Diesel: Commercial Marine	6.9%
Gasoline Cars, Trucks & Equipment	6.3%
Ocean Going Vessels	0.5%
Tire Wear	0.4%
Brake Wear	0.2%
Aircraft Emissions	0.1%

SOURCE: EPA Report to Congress on Black Carbon

What is the geographic distribution of black carbon emissions on a global basis?

East Asia, predominantly China, are the largest emitters of black carbon, with the greatest amount of emissions coming from the residential and industrial sectors. The U.S. produces approximately eight percent of the world's fossil-fuel and biofuel soot.

What effect is black carbon believed to have on climate change?

Black carbon is thought by many scientists to have a net warming effect on the earth by absorbing light and turning that energy into heat. It also is believed to darken the surfaces of ice and snow when deposited on them, reducing their ability to reflect light while increasing heat absorption and melting. Black carbon is also understood to contribute to climate change by altering precipitation patterns and cloud formation.

How does black carbon compare to other greenhouse gases like carbon dioxide (CO2)?

Black carbon is estimated to be anywhere from 450 to 1,500 times a more potent as greenhouse gas than C02 emissions. Unlike CO2 which remains in the atmosphere for decades, black carbon remains in the atmosphere for days or weeks and washes out of the atmosphere within a few thousand kilometers of its emission source. Particular concern has been raised about the Arctic, where melting of ice and snow has been accelerated by deposition of wind-blown soot particles. While studies continue to determine the most likely sources affecting the Arctic, the latest research suggests that biomass burning, particularly from Eurasia, is the dominant source of black carbon in Arctic snow. Unlike C02, there are readily available and proven technologies to dramatically reduce or eliminate black carbon emissions from transportation and industrial sources, particularly those powered by diesel engines.

Are U.S. black carbon emissions rising or falling?

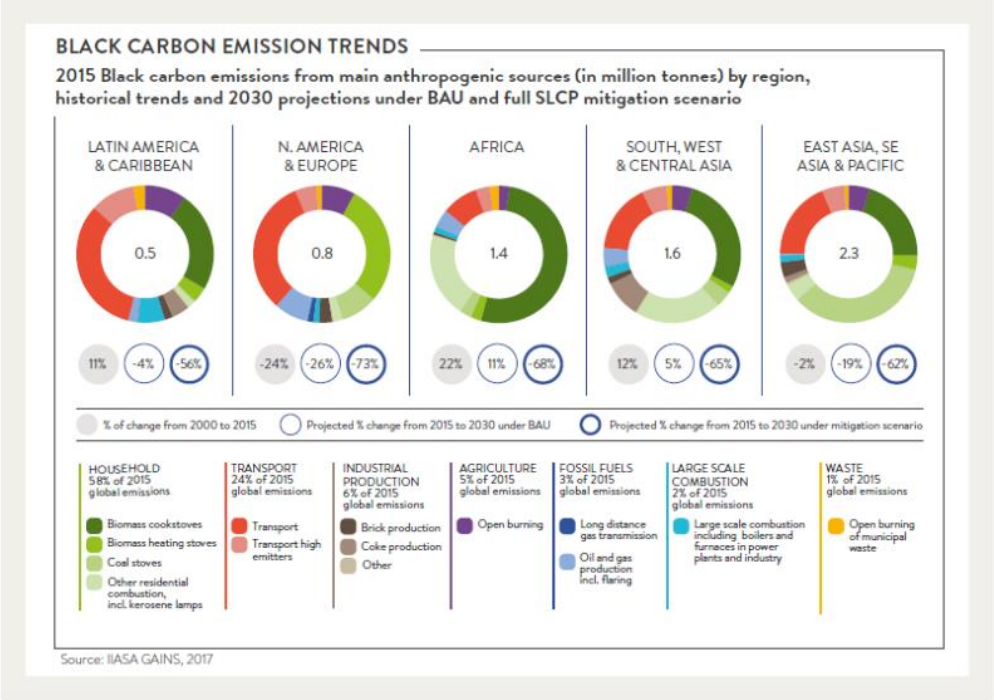
U.S. emissions of transportation related black carbon emissions are projected to decline 86 percent between 2005 and 2030, according to U.S. EPA. Diesel sources are expected to be the largest contributor to this reduction falling by 91 percent. This impressive emissions reduction from diesel sources is achieved by technologies designed to meet regulations already promulgated concerning particulate matter emissions on heavy-duty trucks and off-road equipment such as construction equipment, locomotives and commercial marine vessels, rail locomotives and stationary engines used for power generation and other industrial uses.

	Tons of Black Carbon Reduced: 2005-2030	Percent of Black Carbon Reduced: 2005-2030
Diesel: Trucks and Buses	-145,862	-95%
Diesel: Off Road Equipment	-102,702	-92%
Diesel: Locomotives	-16,811	-75%
Diesel: Commercial Marine	-16,212	-75%
Gasoline Cars, Trucks & Equipment	-4,753	-75%
Ocean Going Vessels	-375	-22%
Tire Wear	+522	44%
Brake Wear	+207	44%
Aircraft Emissions	+143	35%
Total Transportation Emissions	-285,843	-86%

SOURCE: EPA Report to Congress on Black Carbon

Are global black carbon emissions Increasing or decreasing?

The U.S. is experiencing a decline in black carbon emissions, owing largely to the introduction of new near-zero emissions diesel technology. Global emissions of black carbon are also falling due to various control strategies across individual countries and regions to reduce anthropogenic – or manmade – sources of black carbon emissions.

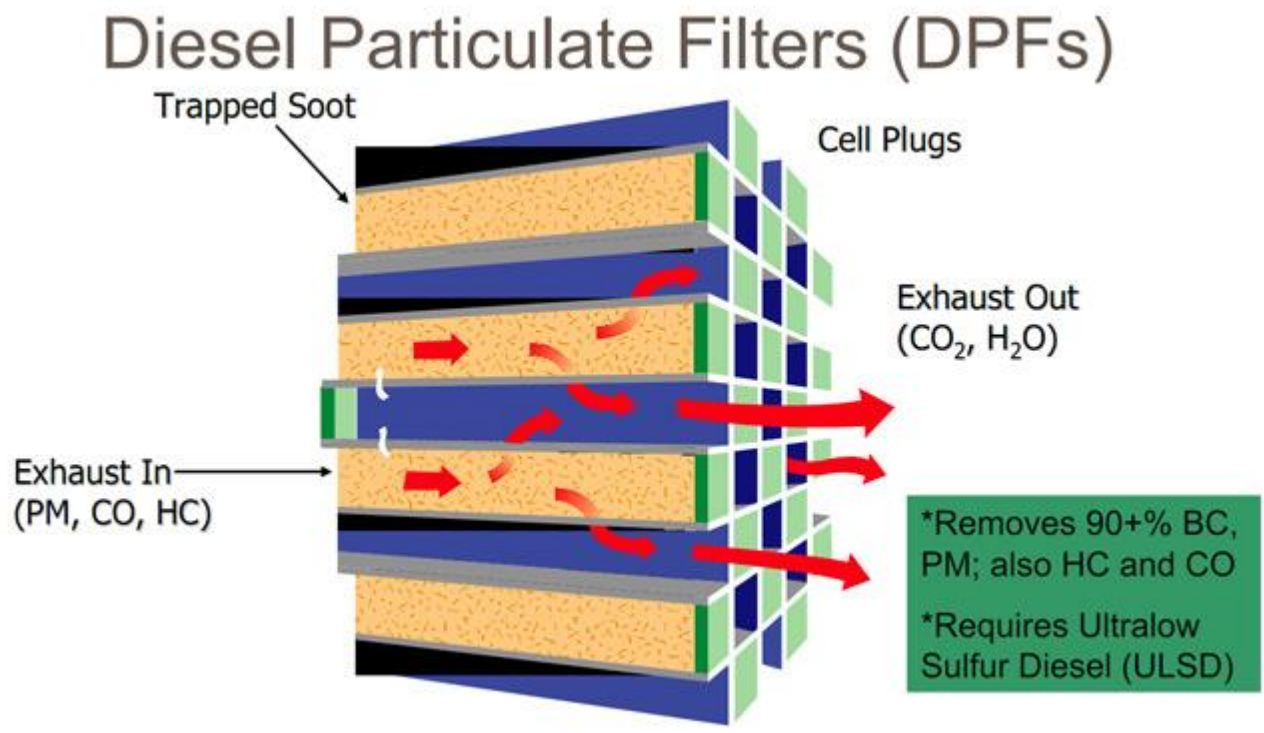


SOURCE: Climate and Clean Air Coalition

How does clean diesel technology reduce black carbon?

The clean diesel system that reduces fine particle emissions including black carbon relies on access to cleaner diesel fuel with near-zero levels of sulfur. With access to cleaner diesel fuels, modern engine designs and aftertreatment technologies are now fully integrated into vehicles and equipment to nearly eliminate black carbon emissions. Today's new diesel trucks and buses have advanced filters that trap particulate matter and reduce fine particle emissions by 90 percent relative to trucks manufactured before 2007.

The latest clean diesel technology is also standard in many off-road diesel vehicles and equipment such as construction equipment, locomotives and marine vessels designed to meet strict particulate matter and other emissions regulated by the Tier 4 standards established by the U.S. Environmental Protection Agency (EPA).



One of the most cost-effective control strategies to reduce fine particle emissions from diesel sources is the diesel particulate filter. This technology is found on all diesel commercial vehicles and buses manufactured since 2007 to meet the stringent near-zero emission fine particle emission standard. Many off-road equipment types also use particulate filters to meet similar emissions standards. With access to cleaner diesel fuel, these particulate filters are effective in trapping fine particles. Older generations of vehicles and equipment may also be retrofitted with diesel particulate filters to reduce fine particle emissions anywhere from 20 to 90 percent. The U.S. Department of Transportation finds

that retrofitting older diesel vehicles and equipment with diesel particulate filters is the most cost-effective strategy to reduce mobile source emissions of fine particles. Recent research conducted by the Health Effects Institute finds that these filters deployed on heavy-duty trucks are still effective in trapping fine particles years after their introduction.

What has the U.S. done to reduce its black carbon emissions form diesel sources?

The first step to introduce the clean diesel system that is fundamental to reduce transportation sources of black carbon emissions is to require the use of cleaner diesel fuel. Beginning in 2006, U.S. Environmental Protection Agency (EPA) established standards for diesel fuel quality that reduced the allowable sulfur content to 15 parts per million or less, known as Ultra Low Sulfur Diesel (ULSD). With access to cleaner diesel fuel, EPA issued stringent tailpipe emissions standards for trucks and buses manufactured beginning in 2007 that resulted in near zero fine particle emissions and more stringent standard set for 2010 that reduced emissions of oxides of nitrogen. A similar rule, known as the Tier 4 standards, was implemented for new engines that power off-road equipment beginning in 2014 and 2015.

While standards for new engines are in place, much of the fleet of diesel trucks and off-road equipment is still of a later generation of technology. According to the most recent vehicle in operation data commissioned by the Diesel Technology Forum, half of all diesel commercial vehicles and buses in the U.S. are of an older generation (pre-2007) without the benefit of the most advanced technologies that enable near-zero emissions of fine particles. Likewise, equipment sales and turnover rates suggest that a large proportion of off-road equipment currently in operation is of an older generation without the benefit of new technologies to virtually eliminate particulate matter, and are pre- Tier 4 standards emissions performance.

In the U.S., the state of California implemented measures to control black carbon emissions since the 1960s. Researchers estimate that diesel particulate matter emission reductions achieved in California since the 1980s is equivalent to reducing carbon emissions by 21 million metric tons and is roughly equivalent to five percent of all carbon dioxide emissions. According to the California Air Resources Board, brake and tire wear are expected to generate twice as much black carbon emissions as tailpipe emissions from the entire fleet of diesel trucks and buses in California by 2020.

Have other countries adopted similar measures to reduce black carbon emissions from diesel sources?

The impressive and dramatic reduction in black carbon from diesel sources in the U.S. has not gone unnoticed by other countries. Most developed economies including Europe, Canada and Japan adopted low sulfur diesel fuel standards along with progressively more stringent or U.S. equivalent diesel engine emission rules. The United Nations Environment Programme is encouraging developing economies to introduce clean diesel technologies, with an initial focus on increasing the availability of low sulfur diesel fuel (sulfur content of at most 50 parts per million) in many developing economies. According to the United Nations Environment Programme most nations across the globe are on course to adopt a clean diesel fuel standard by 2020 with a view to further tightening allowable sulfur standards by 2030.

Other nations with clean fuel standards have adopted modern engine emissions standards – either U.S. or European Union equivalent rules – including Argentina, Brazil, Mexico, Chile, Peru, India, Korea, Singapore, Thailand, Russia and Turkey. Yet, diesel emissions are a significantly smaller source of black carbon in these emerging economies than other sources including biomass burning for heat, cooking and industrial processes. The United Nations is working to introduce technologies and change practices to reduce these sources of black carbon through cleaner cookstoves and industrial kilns.

Can black carbon emission reductions mitigate climate change?

Black carbon is known to play a role in climate change and the reduction of black carbon can help reduce the impact of a warming planet. Because black carbon is a short-lived climate pollutant, reducing it is believed to forestall global warming impacts by slowing the rate of global temperature increases. The United Nations estimates that efforts to control all sources of black carbon emissions may ease the rise in global temperatures by 0.5 degrees Celsius. Global warming mitigation through black carbon reduction is regional with the largest temperature reduction occurring in the Artic, Antarctic and Himalayan regions. The World Bank estimates that roughly 30 million tons of crop losses each year can be reversed due to global controls on sources of black carbon.

Controlling diesel sources of black carbon emissions can be achieved with technologies that are readily available today. Recent research conducted by the International Council on Clean Transportation shows that climate targets may be achieved if more nations adopt a cleaner diesel fuel standard coupled with strict near-zero fine particle emissions standards similar to U.S. regulations for heavy-duty vehicles and equipment. With the introduction of clean diesel technology globally it may be possible to help cool a warming planet.

Policy solutions to help reduce U.S. sources of diesel emissions

Unlike CO2 emissions, eliminating diesel sources of black carbon emissions in the U.S. can be achieved with cost-effective and readily available technologies. Policies designed to promote the turnover of older and higher emitting on- and off-road vehicles and equipment can reduce emissions.

As noted earlier, one in every two diesel trucks and buses is of an older generation not equipped with the latest near-zero fine particle emissions technology. Recent research suggests that much larger off-road engines that power locomotives and marine vessels are twice as long-lived as assumed and may be in service for generations.

The U.S. Environmental Protection Agency provides grant funding through the National Clean Diesel Funding Assistance Program to help reduce emissions from existing diesel engines through a variety of strategies. Clean diesel funding appropriated between 2008 and 2016 retrofitted, repowered or replaced over 63,000 older engines found in a wide variety of applications from school buses, long haul trucks, construction equipment and even ferryboats. Over that period of time, 15,490 tons of particulate matter emissions was eliminated.

Other funds for replacing or repowering existing diesel vehicles are available through the U.S. Department of Transportation's Congestion Mitigation and Air Quality (CMAQ) program. Funding opportunities also include state supplemental environmental projects along with the Environmental Mitigation Trust established under the VW settlement and similar programs managed by states.

According to the U.S. Department of Transportation, replacing older diesel vehicles and equipment with new diesel models is the most cost-effective strategy to reduce fine particle emissions. In some heavy-duty vehicle types, alternatives to diesel technology exist. However, these alternatives are at a cost premium relative to diesel and may not generate significantly greater fine particle emission reductions. For a single dollar invested, older and higher emitting diesel trucks, buses and equipment may be replaced when choosing the new diesel option than choosing an alternative thereby maximizing black carbon reductions.

Summary

The introduction of cleaner diesel fuel and advanced engine and emissions control systems have dramatically reduced fine particle emissions - and in turn black carbon emissions - from new diesel engines in all categories. Today, the U.S. is estimated to account for about eight percent of all black carbon emissions, and is expected to account for only two percent of global on-road vehicle emissions by 2020 as a result of these technology improvements. Modernizing and upgrading existing diesel engines with particulate control technology has proven effective for many applications with the use of clean diesel fuel. A variety of programs managed by the states and federal agencies help replace older vehicles and equipment with new cleaner options, including new diesel, will go a long way to help cool a warming planet.

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