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Reducing black carbon emissions from diesel vehicles in Russia: An assessment and policy recommendations

Nazar Kholod *, Meredydd Evans

Joint Global Change Research Institute, Pacific Northwest National Laboratory, 5825 University Research Court, Suite 3500, College Park, MD 20742, USA

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ABSTRACT

The paper assesses options and challenges of reducing black carbon emissions from diesel vehicles in Russia. Black carbon is a product of incomplete diesel combustion and is a component of fine particulate matter. Particulate matter emissions have adverse health impacts, causing cardiopulmonary disease and lung cancer; black carbon is also a large climate forcer. Black carbon emissions from Russian diesel sources affect not only the Russian territory but also contribute to overall pollution. This paper analyzes current ecological standards for vehicles and fuel, evaluates policies for emission reductions from existing diesel vehicle fleet, and assesses Russia's attempts to encourage the use of natural gas as a vehicle fuel. Based on best practices of black carbon emission reductions, this paper provides a number of policy recommendations for Russia.

1. Introduction

Diesel is growing as a fuel for on-road transport and off-road vehicles and equipment. Diesel vehicles are a source of black carbon (BC) emissions, a light-absorbing component of particulate matter (PM). Chronic exposure to particulate matter is associated with a range of diseases, as well as premature death from cardiopulmonary disease and lung cancer. According to a World Health Organization study, exposure to $PM_{2.5}$ reduces the life expectancy of the population in Eastern Europe by about 8.6 months on average (WHO, 2013).

The Intergovernmental Panel on Climate Change defined BC as a major contributor to global warming, with the third largest global warming potential after carbon dioxide and methane (Stocker et al., 2013). A recent study indicates that BC might be the second most powerful climate forcer after carbon dioxide (Bond et al., 2013).

BC has a particularly pronounced impact as a climate forcer in the Arctic. By darkening the surface of snow and ice and reducing its albedo, BC facilitates the absorption of solar radiation, increases air temperatures and accelerates snow and ice melting (EPA, 2012b; Flanner and Zender, 2006; Flanner et al., 2007). These effects make the Arctic an exceptionally vulnerable region for BC emissions (Hirdman et al., 2010); the Arctic is warming considerably faster than other regions of the globe.

Russia makes up a large part of the Arctic. While some BC is produced in the Arctic region by local diesel sources, most emissions are transported to the region from other parts of the country. Thus, it is important to analyze nation-wide policies and mechanisms for BC emission reductions.

The first detailed BC emission inventory from diesel sources for the most populous Arctic region of the Russian Federation was completed only recently (Evans et al., 2015). This study examines the main sources of BC emissions including on-road and off-road vehicles, fishing vessels and diesel generators. The study laid a foundation for developing policy recommendations to reduce BC emissions from diesel sources in Russia.

Diesel transport is a significant source of BC emissions in Russia. In 2000, 9% of total BC emissions in Russia came from transport. Transport is the fourth biggest source of BC emissions after residential/domestic sources, forest fires and industry (EPA, 2012b; Lamarque et al., 2010). Policymakers often focus on emission reductions from on-road transport because transport is one of the largest sources of emissions in cities. Off-road vehicles are also an important source of diesel emissions, but in Russia they represent only about 13% of total diesel-related BC emissions, compared to 49% that come from on-road vehicles. This is despite the fact that Russia currently has no regulations limiting off-road emissions, while the majority of the on-road fleet has some level of controls today.

The United States and the EU used a system approach to reduce diesel BC emissions (ICCT, 2009; NRDC, 2014; World Bank, 2014). This approach for transport-emission reductions focuses on three

* Corresponding author.
E-mail address: Nazar.kholod@pnnl.gov (N. Kholod).

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areas. First, low-sulfur fuel must be available to enable the use of retrofit technologies. Second, vehicle emission standards must be adopted and enforced for new vehicles entering the market. Third, the government should develop complementary strategies focusing on retrofits of older engines, inspections to identify and address super-emitters, procurement of new diesel vehicles and other programs aimed at reducing emissions from the existing diesel fleet.

While Russia faces many challenges in reducing vehicular emissions due to political, economic, and technological constraints, the country has a significant potential for BC reductions which would bring benefits to Russian people and the environment, both locally and globally. In fact, Russia has already shown much progress in reducing emissions because of vehicle and fuel standards.

This paper analyzes current Russian efforts aimed at reducing emissions from diesel vehicles. Russia, like other nations, does not directly regulate BC emissions but policies and programs aimed at reducing diesel exhaust emissions would also reduce BC.

2. BC emissions from diesel sources in Russia

2.1. Current ecological standards for vehicles and diesel fuel quality in Russia

On-road transport is traditionally the largest contributor to diesel particulate emissions around the world. Organisation for Economic Co-operation and Development (OECD) countries first implemented vehicle-emission standards in the early 1990s. The European countries initially introduced emission standards for on-road vehicles developed by the United Nations Economic Commission for Europe (UNECE) and then the EU developed its own standards. The main reason for introducing emissions standards were health concerns because vehicular emissions have adverse health impacts. Implementing emission standards is the most effective way to reduce emissions.

Russia adopted UNECE emission standards in 2006, which now apply to both domestically produced and imported cars. Before that, Russia did not have any emission regulations for on-road vehicles and leapfrogged to Euro 2/II standards (Table 1). (According to the common approach, standards for light-duty vehicles are expressed by using Arabic numerals while Roman numerals are used for heavy-duty vehicles.)

The availability and widespread use of ultra-low-sulfur fuel is a critical prerequisite to control BC emissions. Emission reductions require high-quality fuel that enables advanced emission-control technologies.

Recently, Russia has rapidly increased production of ultra-low-sulfur diesel (Euro 5). Euro 5 diesel (with sulfur content of 10 ppm) accounted for 17% of Russia's total domestic diesel market production in 2011, compared to 29% in 2012, and 52% in 2013 (Novak, 2014). This progress was a result of regulation, bolstered by well-targeted fiscal policy. Russia introduced an excise tax on diesel fuel in 2011 to force diesel producers to move from low-quality to high-quality fuel.

Table 1
Introduction of emission standards for on-road vehicles in Russia.

	Euro 2/II	Euro 3/III	Euro 4/IV	Euro 5/V
Light-duty vehicle	April 2006	January 2008	January 2014	January 2016
Heavy-duty engines	January 2006	January 2008	January 2013	January 2016

Compliance and enforcement measures aimed at ensuring the use of high-quality diesel are fundamental for emission reductions. Though Russia made significant progress in modernizing its major refineries, some small refineries still can produce low-quality diesel. Rostekhnadzor, the supervisory body of the Government of Russia on ecological, technological, and nuclear issues, is responsible for fuel quality control. All small refineries checked by Rostekhnadzor in 2011–2012, produced diesel which did not meet the minimum standards. In 2013, 33.7% of fueling stations sold diesel that did not meet the Euro 3 requirements. One of the reasons why poor quality diesel is still available at fueling stations is because technical regulation does not regulate all stages of production and distribution. Rostekhnadzor can inspect refineries only once in three years and is required to inform about inspections in advance. Any unplanned inspection must be approved by local law enforcement. The government should introduce rigorous control over fuel quality at fueling stations and use financial penalties to those who sell diesel that does not meet minimum standards.

2.2. Russia's on-road diesel fleet

There are three distinct trends in the development of on-road transport in Russia. First, the total number of vehicles on the roads is growing rapidly. Between 2000 and 2013, the number of passenger cars doubled, while truck and bus fleets increased by about 40% (Table 2). There were about 48 million vehicles in Russia in 2013. Private-car ownership will likely continue to grow as personal car ownership remains far below levels in most developed countries. There were 273 cars per 1000 people in Russia in 2013, while there are 500–700 vehicles per 1000 people in OECD countries.

Second, diesel vehicles have become more popular in Russia (Table 3). The growing diesel fleet means that more sources of BC emissions are on the roads now. In 2012, the share of diesel cars in the existing fleet was 4%, while it was 6% in new vehicle sales (Avtostat, 2013). However, the share of diesel cars might be much higher in some regions; for example Evans et al. found that the share of diesel cars in city of Murmansk in the Arctic was 12% (2015). Increasing popularity of diesel engines in Russia is in line with the same trend in Europe, where the car fleet has been persistently transformed from being petrol-driven to diesel-driven over the last 20 years (Cames and Helmers, 2013).

Finally, while the share of newer vehicles is growing, the share of vehicles older than 10 years is stagnant (Table 4). However, the stagnant share of older vehicles might be a result of outdated information, when old vehicles are not being used but remain on the registries.

The Russian government recognizes the problem of air pollution from transport. The government wants to modernize

Table 2
On-road vehicle fleet, 2014, in thousands.

	2000	2005	2010	2011	2012	2013
Cars	20,353	25,570	34,354	36,415	38,792	41,428
Trucks	4401	4848	5414	5545	5751	6050
Buses	640	792	894	902	928	891

Source: Rosstat (2014).

Table 3
The share of diesel vehicles in the Russian bus and truck fleet, %.

	2010	2011	2012	2013
Buses	35.7	38.3	41.1	43.3
Trucks	46.6	49.1	53.2	55.8

Source: MNRE (2013).

Table 4
The age distribution of the on-road fleet, %.

Average age by vehicle type	2000	2005	2010	2011	2012	2013
Cars						
<5 years	21	22	27	28	26	31
5.1–10 years	32	28	25	24	25	25
>10 years	47	51	48	48	49	45
Trucks						
<5 years	14	14	17	17	16	22
5.1–10 years	35	24	19	19	20	20
>10 years	51	63	64	64	64	58

Source: Rosstat (2014).

the vehicle fleet through various programs, but this process is slow. In 2014, sales of new passenger cars decreased by 8%, light-commercial vehicles by 15%, trucks by 21%, and buses by 25%. Meanwhile, the market for used vehicles grew by 4–6%. An Association of European Businesses forecast indicates that, in 2015, the total market for cars and light-commercial vehicles will contract by 24% on a year-on-year basis (AEB, 2015). This will likely slow the fleet upgrade trend.

2.3. BC emissions from on-road transport in Russia

On-road transportation accounts for a large share of diesel fuel consumption in Russia. In 2010, on-road vehicles consumed 12.5 million t of diesel (IEA, 2012). Of that total, heavy-duty trucks accounted for about 80% of total diesel consumption, buses consumed 15% and cars used only 4% in 2010 (Donchenko, 2013).

There are a few estimates of BC emissions from on-road transport in Russia and uncertainty is very significant. According to the U.S. Environmental Protection Agency (EPA) report, BC emissions from transport (including aircrafts and marine shipping) in Russia were 32,000 t in 2000 (EPA, 2012b). Fu et al. estimated BC emissions in Russia (including rail and non-road transport) at 52,900 t in 2010; on-road transport accounted for 45,500 t of BC (Fu et al., 2015). Evans et al. (2015) estimated BC emissions from on-road transport in Russia using two methods. The first, developed by the Russian Scientific Research Institute of Automobiles and Transport, resulted in estimated BC emissions from diesel on-road transport at 16,700 t in 2010. The second method used bulk emissions factors from the European emission guidebook, to arrive at an estimate of 19,900 t in 2010 (Evans et al., 2015). More than 60% of diesel BC emissions from on-road vehicles in Russia come from heavy-duty trucks without emission controls.

We used the Global Change Assessment Model (GCAM) developed by the Joint Global Change Research Institute to build a forecast for BC emissions resulting from diesel on-road transport in Russia. GCAM is an integrated assessment tool for exploring consequences and responses to global climate change. The model provides estimates of transportation energy demand and emissions. GCAM operates in 5-year time periods.

Fig. 1 shows the GCAM estimate of BC emissions from on-road transport in Russia by 2050. BC emissions decreased due to economic recession in the 1990s, then increased due to a growing number of vehicles from about 2000 to 2010, when BC emissions are projected to decrease due to newly introduced emission standards for on-road vehicles.

Similarly, according to the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model, developed by the International Institute for Applied Systems Analysis (IIASA), BC emissions from on-road transport are projected to decrease in Russia due to more stringent emission standards (Arctic Council, 2011). Given recent trends in the vehicle market, we should expect decreasing reductions in BC emissions from on-road diesel sources

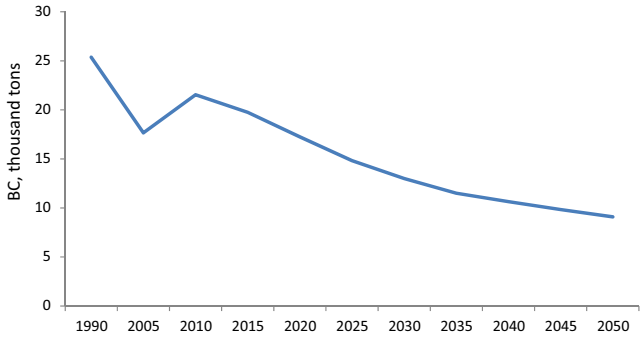

Fig. 1. GCAM forecast of BC emissions from on-road transport in Russia.

in the short run. However, the reductions could accelerate if Russia strengthens existing policies and implements additional measures for vehicular emission reductions.

2.4. BC emissions from other diesel sources

Off-road vehicles include agricultural vehicles and equipment, forestry equipment, construction vehicles and equipment, mining vehicles and equipment and diesel locomotives. Other non-road BC emission sources include stationary sources and marine vessels.

Off-road vehicles in agriculture and forestry emit about 13% of diesel BC emissions in Russia. The mining industry contributed an additional 6%, while construction vehicles and equipment emitted 4%. Diesel locomotives are responsible for 3% of BC emissions and ships are not a significant source of emissions nationwide (Evans et al., 2015).

In the Russian Arctic, however, off-road vehicles are the largest source of diesel BC emissions. Mining trucks and equipment emit about 70% of BC emissions in the Murmansk Region (Evans et al., 2015). According to an estimate by the Russian Scientific Research Institute for Atmospheric Air Protection, the mining industry emits 80% of diesel BC emissions in the Russian Arctic (Morozova, 2015).

3. Emission reduction strategies from diesel on-road transport

3.1. Retrofit policy for existing diesel fleet

In most countries where the vehicle fleet is a significant source of emissions, governments implement various emission reduction programs using retrofits (EPA, 2006, 2012a; World Bank, 2014). The term “diesel retrofit” includes any technology or system that achieves emission reductions from the legacy fleet. The most common retrofit option to reduce BC emissions is to install advanced emission controls such as diesel particulate filters which can remove over 90% of BC from vehicle exhaust.

There are three basic requirements for a successful retrofitting program for diesel vehicles. First, vehicles need to be relatively new with long remaining life or high usage rates. Second, low-sulfur diesel is required to enable using particulate filters for PM emission reductions. Third, because diesel retrofits do not pay for themselves, vehicle owners should have incentives or be required to invest in retrofits.

In Russia, Euro 0–Euro II heavy-duty trucks make up more than 70% of the truck fleet, and these trucks cannot be retrofitted with particulate filters due to their poor mechanical condition. On the other hand, the Russian government currently does not finance any retrofit programs, though the country has a sufficient supply of ultra-low-sulfur diesel. Rather, the government is trying to remove old vehicles from the roads and stimulate production of cleaner vehicles using other programs, as described below.

3.2. Scrappage program

The Russian government is trying to encourage modernization of the vehicle fleet by promoting an end-of-life vehicle scrappage and trade-in program. Protecting the environment in large cities is one motivation for the program; however, the government's primary goal is to stimulate the domestic automobile industry.

The first scrappage program in Russia, implemented in 2010–2011, helped replace 600,000 light-duty vehicles, mainly Russian-made passenger cars. Recently, the government has modified the program allowing buses and heavy-duty trucks to participate.

The government allocated 35 billion rubles ($915 million) in 2014–2015 to subsidize scrapping vehicles older than 10 years. Owners can receive up to $1500 for replacing passenger cars and $10,000 for buses or heavy-duty trucks. The government expects to replace 200,000 vehicles in 2014–2015. The government considers the scrappage program as beneficial to the state, producers and consumers. According to the estimate of the Ministry of Industry and Trade, 10 billion rubles spent on the program will generate 15 billion rubles in sales taxes (Minpromtorg, 2014).

The scrappage program, however, has had a limited effect on BC emission reductions for several reasons. First, the program design implies that old vehicles must be destroyed. However, control over this process is inadequate. According to the Russian Scrappage Association Ruslom.com, up to 44% of vehicles retired through the scrappage program in 2014 have returned to the roads or their components have been reused (Izvestia, 2014). Second, financing the scrappage and trade-in program is hardly enough to make a significant change in the vehicle fleet. For example, more than 40% of the Russian on-road fleet (about 48 million vehicles) is older than 15 years. KAMAZ, one of the largest truck manufacturers, plans to sell only 5500 vehicles in 2015, while there are 1.5 million KAMAZ trucks in Russia. Third, only 3% of the vehicles being replaced are high-emitting heavy-duty vehicles, while passenger cars (mostly petrol-driven) account for 87% of replacement.

In general, experience of other nations indicates that scrappage programs have had a limited effect on emission reductions, and, in most cases, such programs are not cost-effective. Nevertheless, the scrappage program could be an instrument for eliminating old vehicles in Russia. The program design should be improved to ensure that scrapped vehicles are actually destroyed and none of their components will be used. For example, EPA developed an effective process for eliminating scrapped vehicles from the roads by requiring them to be run with sodium silicate solution instead of oil, thus destroying engines so they cannot be used.

From the perspective of cost-effectiveness and effective targeting of government funding, retrofit programs might be a better option for Russia because they produce significantly greater environmental benefits for the same investment, and the chance of scrapped cars returning to the roads is much smaller. The smaller cost per vehicle also allows retrofit programs to affect a larger share of the vehicle fleet.

3.3. Vehicle inspection and maintenance programs

Many countries use vehicle inspection and maintenance programs to ensure that emissions from vehicles meet the standards. Compliance with emission standards is an important component of an effective emission reduction strategy. Inspection and maintenance programs help identify high-emitting vehicles and their owners are required to fix vehicles in order to use them.

According to the Russian rules, all vehicles older than 7 years must be tested annually; buses and taxis should be tested twice a year. Before 2012, traffic police were responsible for annual vehicle inspections. The police issued stickers confirming that vehicles are technically reliable and emissions do not exceed the maximum allowable limits. The new law on technical inspections basically canceled state technical inspections and delegated the procedure to commercial companies. After 2012, insurance companies have become responsible for annual vehicles checks. Insurers mainly focus on technical reliability of vehicles; emission checks are not always high on the priority list. A driver should have a diagnostic card that shows all technical information about the vehicle. The penalty for excessive emissions is 500 rubles ($8) or simply a verbal warning. The Russian Union of Vehicle Insurers oversees vehicle-inspection centers. As a result, many Russian experts argue that the system of emission checks is not functioning properly.

To make the system work properly, the government should oversees inspection centers to ensure the quality of inspection and maintenance program. Emission inspections should receive the same emphasis as safety inspections. Traffic police should test vehicle emissions to identify gross polluting vehicles on the roads.

In the United States, local governments require inspecting vehicle emission systems annually or every 2 years in regions with high levels of air pollution. Vehicles that fail emissions tests must be repaired and pass a re-inspection by licensed inspection stations. The United States also has a rigorous emission-compliance program for new vehicles. If EPA determines that a substantial number of engines do not meet emission standards, it has authority to require manufacturers to recall vehicles or enforce strict fines for noncompliance.

3.4. Promoting more efficient and cleaner vehicles

Russia is trying to promote domestic vehicle production. One of the most ambitious government programs is called "Development of Industry and Increasing Its Competitiveness," which the Russian government approved in 2014. Part of the program involves a national scheme of fiscal subsidies for manufacturers of Euro 4 and Euro 5 vehicles. The government allocated 25 billion rubles for this program in 2014 ($700 million). The subsidies range from 12,000 rubles ($330) for cars to 47,000 rubles ($1300) for buses and 90,000 rubles ($2500) for heavy-duty trucks (Ministry of Industry and Trade, 2014).

With emissions standards in place, this program would help vehicle manufacturers upgrade their production facilities but does little for emission reductions since vehicle manufacturers are already required to produce Euro 4 and Euro 5 vehicles.

The government should focus instead on fuel economy improvements for on-road transport. Improving vehicle fuel economy has recently become one of the most important strategies for emission reductions from on-road transport. Indicators of vehicle fuel efficiency will be included in the new UN Sustainable Development Goals (UN, 2015).

In Europe, legislation sets mandatory fuel efficiency standards. For new cars, the EU wants to achieve average performance of 5.6 l per 100 km (l/100 km) of petrol or 4.9 l/100 km of diesel in 2015, and 4.1 l/100 km of petrol or 3.6 l/100 km of diesel by 2021(EC, 2015).

The United States also proposed ambitious standards for passenger vehicles, which will require average performance of 54.5 miles per gallon (mpg), or 5.2 l/100 km by 2025, a 50% improvement in fuel economy. The United States started working on fuel economy improvements in the 1970s. The Energy Tax Act of 1978 requires manufacturers of new cars to meet the minimum fuel economy level of 22.5 mpg (12.6 l/100 km).

Russia has virtually no policies in place to promote fuel economy. A World Bank report indicates that Russia can reduce energy consumption in the transport sector by 41% compared to 2005 levels; large reductions in emissions can be achieved with current technology (World Bank, 2008).

In addition to fuel economy improvements, many countries are actively promoting zero-emission vehicles. For example, electric vehicles now represent 14% of total new vehicle sales in Norway. Norway is a world leader in promoting electrical vehicles and the government effectively uses tax incentives and fee exemptions. The Netherlands, Iceland, Estonia, and Sweden also have programs following the Norwegian example. In Russia, sales of hybrid and electrical cars are still very low.

3.5. Government procurement

The Russian government is encouraging government and public companies to modernize their fleets using public procurement rules for transportation services. Central and local governments are large buyers of services and can use their market power to influence transportation companies' investment decisions. If a company wants to receive a public contract for providing transport services, it should compete with others in the tender. The government may modify tender rules to give preferences to companies with upgraded fleets. For example, the government of Moscow banned procurement of buses below the Euro V standard. The government of the Murmansk Region introduced the tender system that allows companies with an advanced bus fleet (e.g. Euro IV and Euro V buses) to receive additional points during public tenders.

3.6. Vehicle taxes

Vehicle taxes in Russia are based on engine horsepower and do not account for ecological class or age of vehicles. Russia introduced age-based taxation only for luxury cars. All regions of the Russian Federation have a right to set vehicle tax rates within a range defined by the Tax Code of the Russian Federation, but none of Russia's regions introduced such a tax.

3.7. Banning old vehicles

In addition to market measures aimed at reducing vehicular emissions, Russia also uses administrative actions to retire old vehicles. The government is considering banning the use of old vehicles starting in January 2016. A draft federal law proposes limiting the maximum vehicle age. The Russian Ministry of Industry and Trade that initiated this bill believes that there are no other ways to solve the problem of the aged vehicle fleet in Russia.

The government provides two rationales for the proposed law. First, the annual vehicle retirement rates are low (5.3% for trucks and 5.7% for buses) and old vehicles cause a large number of road fatalities due to technical failures. The second reason is that old vehicles do not have any emission controls and forced retirement of these old vehicles will significantly improve the air quality. Finally, in addition to vehicle fleet modernization, the government also wants to stimulate domestic vehicle production.

While this initiative was supported by vehicle producers, drivers complained that the program would not take into account the physical condition of vehicles and the only criterion is the vehicle age. It would also violate private property rights. Nevertheless, the draft law successfully passed the parliament committee and still might be approved.

While banning old vehicles is not a common policy in other countries, many countries introduced age limits for specific categories of vehicles. For example, controls over the age of taxis or public transportation vehicles are practiced in many countries; usually local authorities set the rules for age limits. Many countries, including Russia, also ban high-polluting vehicles from entering designated low-emission zones in cities.

3.8. Low-emission zones

The Russian government encourages public transportation companies to upgrade their fleet by imposing restrictions on the use of old vehicles in the centers of the largest cities by creating low-emission zones. Low-emission zones help reduce emissions in the most populous areas and potentially keep polluting vehicles out of the market. The first such zone was established in Moscow in 2011 and it was further reinforced in 2014. The system is designed to ban Euro II/Euro III heavy-duty trucks from entering the center of the city, but enforcement is hard without a toll system. Many other Russian cities also ban heavy-duty trucks from entering city centers in the day-time, which reduces traffic jams and idling.

The penalty for violating low-emission-zone rules, however, is low in Russia. For example, in Moscow the penalty is 500 rubles (less than $10) while in London this penalty ranges from 500 to 1000 pounds, or 100–200 times higher than in Moscow. There are also no mechanisms for systematically enforcing this ban in Moscow, meaning that many high-emission vehicles are still on the roads.

4. BC emission reductions from off-road vehicles

Strategies to reduce pollution from off-road vehicles and equipment are similar to those for on-road sources and include engine retrofits, replacing older engines, using cleaner fuels, reducing idling time, and ensuring proper maintenance.

Introducing emission standards is key for emission reductions from off-road sources. For example, the United States adopted its first emission regulations (Tier 1) for off-road vehicles in 1994. It introduced more stringent Tier 2 and Tier 3 standards in 2008 and Tier 4 standard was fully phased in by 2014. The United States has also adopted the emission standard for ships and locomotives and requires reductions of PM emissions from these engines by as much as 90%.

Russia initially adopted European emission standards for off-road vehicles in 1999. In 2011, Russia developed a new standard for PM emissions from off-road engines at 0.2 g/kWh (equivalent to U.S. Tier 2 and European Stage II standards). However, this standard was never enforced due to disagreements in the Customs Union consisting of Russia, Kazakhstan, and Belarus. In order to adhere to the Customs Union Protocol, Russia removed all PM emission control requirements for off-road vehicles.

In February 2015, Technical Regulation 031/2012 of the Customs Union came into force. According to this technical regulation, agricultural and forestry off-road vehicles in all members of the Customs Union should meet the UNECE standards. For the period from February 15, 2015 to February 15, 2017, off-road vehicles in agriculture and the forestry industry in the countries of the Customs Union must meet Stage II standard and standard Stage III B will kick in February 2017. However, emission standards for all other off-road vehicles are regulated by outdated Technical Regulation 010/2011, and particulate matter is not included in the list of pollutants.

5. Switching from diesel to natural gas

Another alternative to reduce BC emissions from transport is to replace diesel with compressed natural gas (CNG). Introducing vehicles that run on CNG can significantly reduce BC emissions from on-road vehicles. Switching to natural gas will increase the ecological class of natural-gas-powered vehicles to levels comparable to that of the Euro V standard. It would also reduce fuel costs by 40–60% and increase engine life.

Russia has unique possibilities for using natural gas as an alternative to diesel. First, Russia is the second largest producer of

natural gas after the United States and the largest exporter in the world. It produced 671 billion cubic meters of natural gas or 19% of total world production in 2013 (IEA, 2014). Second, Russia has technologies for CNG vehicle production including production of gas engines. For example, the KAMAZ natural-gas-powered, heavy-duty truck placed in the top three in the overall standings of the International Africa Eco Race 2015 rally. Finally, the government has shown a strong commitment to using more natural gas as a vehicle fuel.

Compressed natural gas as a vehicle fuel is used in more than 80 countries worldwide and the global CNG fleet is increasing steadily every year. However, despite the high level of natural gas production, Russia was only 20th in the world in total natural gas vehicles in use in 2013. Russia had about 90,050 CNG vehicles which consumed about 400 million cubic meters of CNG in 2013 (NGVA Europe, 2014; NGVA Russia, 2014). Only about 1% of Russian buses were running on CNG in 2014.

In 2013, the Russian government made a decision to radically expand the use of natural gas as a vehicle fuel. It approved an ambitious program to replace diesel with CNG in public transportation. By 2020, the government plans to increase the share of CNG-based public transport to 50%, 30%, and 10% in cities with populations over a million, 300,000 and 100,000, respectively. The government also wants to increase the share of CNG freight vehicles, personal cars and agricultural vehicles to 10–30% of total fleet.

There are several obstacles in expanding the use of natural gas as a transport fuel in Russia. First, while switching to CNG is cost-effective, the lack of infrastructure limits development of the CNG fleet. The lack of infrastructure, especially in remote areas, is the largest hurdle to implementing the program. There were only 260 CNG refueling stations in the country in 2012, most owned by Gazprom, the biggest natural gas producer in Russia. Second, CNG fueling stations require a connection to the natural gas supply system. While 65% of the Russian population has access to natural gas, many remote regions have limited access to centralized natural gas supply because of extreme climate and long distances. In some cases, liquefied petroleum gas (LPG) can serve as an alternative, and LPG is more commonly shipped by rail (it is a product of associated petroleum gas, which Russia has in abundance). Third, gas-powered vehicles could have problems with engine starts in the cold climate. Finally, almost all CNG vehicles in Russia were retrofitted in order to use CNG, they were not originally designed for this, and rebuilding the fuel system for CNG is expensive.

The government should focus on developing CNG infrastructure, providing financial incentives to retrofit vehicles for using

Table 5
Russian policy, international best practice, and opportunities for additional emission reductions.

Policy	Russia	International best practice	Opportunities for additional emission reductions in Russia
Standards for on-road vehicles	The minimum emission standard for on-road vehicles is Euro 4.	EU introduced Euro VI standard for heavy-duty engines in 2013 and Euro 6 standard for passenger cars and light-commercial vehicles in 2014.	Russia should adopt Euro 5 standard in 2016 and formulate clear plans regarding Euro 6 standard.
Standards for off-road vehicles	Russia has introduced emission standards for agricultural and forestry vehicles but does not have any standards for other off-road vehicles.	EU: Stage III B standard in 2011–2013 (0.025 g PM/kWh) and will introduce Stage V standard in 2019 (0.015 g PM/kWh). United Stated: Tier 4 standard since 2008–2014 (0.03–0.02 g/kWh).	Russia should develop emission standards for all off-road vehicles and approve them at the level of the Customs Union.
Low-sulfur fuel	The minimum standard is Euro 4 (50 ppm), with limited testing	EU: 10 ppm since 2009. United States: 15 ppm for highway and off-road transport since 2010 and locomotive and marine since 2012.	Russia will switch to Euro 5 (10 ppm) in January 2016. However, the government should improve the control over the fuel quality during all stages of production, distribution, and consumption.
Retrofit policy	None	U.S. federal and local governments finance retrofitting school buses, heavy-duty trucks, locomotives, and off-road vehicles.	Russia should develop a policy to retrofit public transportation in large cities.
Scrappage program	Scrappage program helped replace 600,000 light-duty vehicles in 2010–2011. In 2014–2015, Russia plans to replace 200,000 vehicles, including some heavy-duty trucks and buses.	Scrappage programs have had a limited effect on BC emission reductions. The scrappage programs are not cost-effective.	The government should develop a strict procedure to eliminate scrapped vehicles from the roads. The government should also require fuel economy improvements.
Vehicle inspection program	Russia has a vehicle inspection program but control over the emission inspection process is not adequate.	Private "test-only" facilities are responsible for inspection program; governments set the policy framework and provide overall management of the inspection program.	The government should develop a quality assurance program and "inspect the inspectors". It should make inspection compliance a requirement for being able to operate a vehicle, and enforce this requirement.
Fuel economy	Russia has no policy on vehicle fuel economy.	Many countries set minimum fuel economy requirement for different types of vehicles. EU: 4.9 l of diesel per 100 km in 2015.	Russia should set a goal to achieve fuel economy of less than 6 l per 100 km for diesel light-duty vehicles.
Government procurement	The government may modify the tender rules to give preference to companies with an upgraded vehicle fleet.	Environmental considerations must be taken into account when procuring goods and services. Diesel-powered vehicle must utilize best-available technology to reduce emissions.	The government should include environmental requirements into procurement rules.
Low-emission zones	Moscow is the only city with a low-emission zone in Russia. It bans Euro II heavy-duty trucks from entering the city. There is no legislation at the national level.	In Europe, all cities have the right to establish low-emission zones. Cities are building systems for automatic enforcement of low-emission-zone rules.	Russia should allow other cities to create low-emission zones. The penalty for violation of low-emission-zone rules should be higher.
Promoting CNG as a motor fuel	The government is promoting procurement of CNG vehicles.	Governments use grants and tax credits for vehicles or infrastructure.	The government should promote construction of CNG fueling stations and provide financial stimuli to vehicle drivers to switch to CNG.

CNG and promoting CNG technology development. The government can begin by establishing so-called blue corridors – networks of refueling stations along widely-used highways. The experience of other countries, namely Sweden, shows it is possible to build a network of fueling stations without pipelines by supplying liquefied gas. The government also needs to simplify building permits for constructing CNG fueling stations.

The government should support switching to CNG from diesel by providing subsidies to diesel vehicle owners. Given that most Russian heavy-duty trucks cannot be retrofitted with diesel particulate filters, replacing diesel with CNG would dramatically reduce BC emissions. Providing subsidies for CNG retrofits could be more cost-effective than paying for scrappage programs.

6. Conclusions

On-road transportation is growing steadily in Russia over the last 15 years. The growing diesel fleet is a large source of BC emissions that have adverse health effects and negative impact on the environment. Russia implemented a number of policies aimed at vehicular emission reductions. Table 5 summarizes the Russian policies and compares them with international best practices.

Russia has implemented emission standards for on-road vehicles and these standards have had a strong effect on emission reductions. Russia also increased production of ultra-low sulfur diesel to enable using emission controls devices. The government does not finance retrofit programs, and vehicle owners do not have incentives or requirements to invest in retrofits. Moreover, the majority of Russian diesel vehicles cannot be retrofitted due to their poor technical condition.

The government is encouraging modernization of the fleet by promoting vehicle scrappage programs. Though international practice shows that scrappage programs have had a limited effect on emission reductions, the Russian government considers its scrappage programs as beneficial to the state, producers and consumers. The program design should be improved to ensure that the scrapped vehicles are actually destroyed.

Russia should improve vehicle inspection mechanisms and procedures to ensure that high-emitting vehicles are banned from the roads. The government should improve control over vehicle inspection stations to make sure that they follow inspection procedures.

The Russian government is trying to promote vehicles productions in the country using fiscal stimuli but it has not formulated clear plans for vehicle fuel economy improvement. Increased fuel economy of conventional vehicles and promoting zero-emission vehicles can radically decrease vehicular emissions. Procurement of cleaner vehicles and transportation services from companies with updated fleet also promote vehicles fleet modernization.

As the second largest producer of natural gas in the world, Russia has unique possibilities for using natural gas as an alternative to diesel. The government has created an ambitious program to replace diesel with CNG in public transportation. The government should encourage gas companies to invest in CNG infrastructure and support switching to CNG from diesel by providing subsidies to diesel vehicle owners.

The Russian government should also focus on emission reductions from off-road vehicles that are a dominant source of emissions in the Arctic. The government should introduce emission standards for off-road vehicles and stationary sources that will reduce BC emission in the future.

Finally, the government also should improve emission methodologies and work on the development of detailed emission inventories as well as development of air quality monitoring systems. Better information would allow the government to focus on the largest sources of emissions and develop emission reduction policies.

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