

Audit of Fine Dust Management

Enforced on September 3, 2020

- Objective: To ensure the effectiveness of government plans on managing fine dust established since 2005
- Duration: 37 days (November 11, 2019 – January 21, 2020)

I. Overview

- The Board of Audit and Inspection (BAI) audited 24 government agencies, including the Ministry of Environment and the Ministry of Education, to examine how they are managing the issue of fine dust (i.e., PM_{2.5}, particulate matters less than 2.5 microns in diameter).

In this audit, the BAI found a total of 43 cases where, in the entire process of managing fine dust from planning to implementation, illegitimate or improper administrative actions or policies needing improvement were observed.

The BAI delivered its audit decisions (31 notifications, and 12 warnings) to the heads of audited agencies, including the Ministry of Environment, by asking them to establish measures to improve their flaws.

- This audit was to respond to public concerns over the effectiveness of the government's measures for managing fine dust, insufficiencies in improving high concentrations, and inadequacies of analyses on the effectiveness of relevant policies.

* On March 5, 2019, the average daily concentration of ultrafine dust (PM_{2.5}) in Seoul hit a record-high of 135 µg/m³.

In order to enhance the effectiveness of government activities for managing the issue of fine dust, it seemed necessary to examine the entire process of government activities from establishment to implementation. Accordingly, the BAI included this issue in its annual audit plan for 2019 and carried out this audit.

- This audit was to examine how the government dealt with the issue of fine dust through its management policies since 2005, bringing each phase of policy cycle to light, from establishment to implementation.
- Particularly, the audit focused on: the establishment phase, management systems, measures for each source of pollution, such as stationary sources (industrial facilities),

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mobile sources (roads and seas), and the establishment of infrastructures and health protection.

- In preparing this audit, BAI auditors employed multifaceted modules to glean and analyze useful information, such as:
 - paying on-sight visits,
 - holding seminars with experts,
 - acquiring relevant information from citizens, and
 - holding hearings with and conducting polls among public officials, relevant industries, civic groups, etc.

For the objectivity of this audit, the BAI:

- outsourced relevant researches to external research firms,
- requested reviews from experts on technical matters, and
- collected information on other countries (i.e. U.S., Germany, China, etc.) on the status of how they were managing fine dust.

II. Major Findings

1. Establishment and management

A. Insufficient improvement of air pollutants emission inventory (pages 46-57 of full report)

As per the *Clean Air Conservation Act*, the Ministry of Environment is provided with 250 national statistics by government agencies as well as public corporations to develop air pollutants emission inventory called the Clean Air Policy Support System (CAPSS), which is to estimate the total amount of air pollutants emissions.

Based on this, the Ministry established a Comprehensive Plan on Managing Fine Dust in November 2019, and utilized it in managing their policies toward controlling air quality.

* PM (Particulate Matter) is the mixture of a direct emission of particulate matters from industrial facilities or automobiles and a secondary generation of air pollutants in a gaseous form, such as nitrogen oxides (NO_x) and sulfur oxides (SO_x), turning to particulate matters through photochemical reaction. According to the *Special Act on the Reduction and Management of Fine Dust*, those particulate matter less than 10 micrometers (μm) in diameter are defined as fine dust, whereas those under 2.5 micrometers (μm) are considered as ultrafine dust.

When a measured data of the emission amount of air pollutants is not available, the Ministry of Environment estimates the emission amount by applying an emission coefficient (emission amount of air pollutant matters per the unit of fuel/base material usage) after collecting basic statistics for the amount of fuel used by each emission source.

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Therefore, it is important to make a correct calculation on the total emission amounts of air pollutants, which are used as primary data for establishing management policies toward controlling air pollution. Also, when establishing management policies, the latest data on the current emission amount should be used, so the *status quo* of the moment is reflected.

And yet, having looked at the process of calculating the emission amounts of eight major emission sources, including industrial combustions, (a total of 1,148,749 tons was emitted, amounting to 92% of the emission amount of nitrogen oxides in 2016), it was found that the emission amount of ultrafine dust (PM_{2.5}) was underestimated by 39,513 tons due to the usage of undetermined emission coefficients and omissions of emission sources.

* The previous estimation of PM_{2.5} emission (the sum of direct emission and secondary generation of air pollutants) was 347,278 tons while the re-calculated value was 386,791 tons.

** Some emission coefficients were estimated with the emission coefficients developed by foreign countries as per the advice of the Korean Society for Atmospheric Environment. Hence, the exact difference should be studied further.

① Undetermined emission coefficient: Because the emission coefficients of solid refuse fuel* facilities as well as the dusts/wears from automobile tires/brakes had not been determined, it was assumed that 10,523 tons of PM_{2.5}, 112,074 tons of NO_x (nitrogen oxides), and 15,507 tons of SO_x (sulfur oxides) were omitted in the calculations of emission of year 2016 (CAPSS 2016).

* A solid fuel that was produced through drying and transforming combustible wastes, such as vinyl, timber, paper, etc.

② Omission of emission sources: In the course of applying the European categorization for emission sources into domestic situations, the manufacturing process for nonferrous metals, such as Zinc, Lead, Copper, etc., was omitted in the calculations, leaving out 44,094 tons of SO_x. This led to the underestimation of 446 tons of PM_{2.5}, 1,814 tons of NO_x, and 44,331 tons of SO_x in 2016 emission (CAPSS 2016) calculation.

- Also, emergency power generators and harbor loading equipment, among others, belonged to the subjects to be managed as pollution sources, as prescribed in the *Clean Air Conservation Act*, but were omitted. Subsequently, PM_{2.5} and NO_x were underestimated by 446 tons and 11,663 tons, respectively, in 2016 emission (CAPSS 2016) calculation.

③ Application of outdated statistics: Instead of using the “Statistics on Timber Use,” the official national statistics conducted every year by the Korea Forest Service (KFS), other research conducted in 2012 and 2013 were used in calculating the amount of air pollutant emissions, including wood-burning stoves.

It was found that the referred research dealt with only 39.0% (398,781 tons) of the national statistics of the KFS, leading to an underestimation of PM_{2.5} and NO_x by 2,264 tons and 3,813 tons, respectively, in 2016 emission (CAPSS) calculation.

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In addition to this, the Ministry of Environment conducted the estimation of emission amount of air pollutants for 2016 in July 2019 (31 months later). This implied that the Ministry's plan on managing fine dust was established without timely data.

Therefore, it seemed difficult to expect the plan to be effective as it failed to reflect correct data on the increase/decrease and omission of emission amounts of air pollutants in a timely manner.

Decision

- The BAI **notified** the Minister of Environment to establish comprehensive measures for improving the national estimation of emissions of air pollutants by:
 - ensuring no more omission of emission sources and amounts; and
 - utilizing timely statistics and data to devise a management plan for improving air quality.

B. Improperly established plan for reducing the emission amounts of air pollutants, including ultrafine dust (pages 58-65 of full report)

The Ministry of Environment has set a “Comprehensive Plan on Managing Fine Dust” in November 2019, which prescribes the reduction of emissions of ultrafine dust (PM_{2.5}) by 19.1% (19,140 tons), sulfur oxides (SO_x) by 42.0% (151,340 tons) and nitrogen oxides (NO_x) by 63.6% (793,324 tons). This was to reduce the average nationwide concentration of PM_{2.5} to 16 µg/m² in 2024 from 26 µg/m² in 2016.

However, it turned out that the Plan overestimated the effects of reduction as it double-counted the emission amounts to be reduced, and omitted the amount of pollutant matters to be emitted, anticipating that PM_{2.5} will be reduced by 5.488 tons.

- ① Double-counting of emission amounts to be reduced: Since the 6th coal-fired thermal power station was scheduled to be closed early (by 2022), this station was supposed to be excluded from the list of subjects that are required to cut down emission amounts. However, the station still remained on the list, leading to an overestimation of the emission amounts to be curbed by 135 tons of PM_{2.5} and 9,827 tons of NO_x.
- ② Omission of emission amount: When calculating the emission amount of air pollutants that are expected to be reduced due to the early scrapping of old diesel vehicles (1.46 million cases), if the vehicles' owners purchase a new vehicle, the amount of air pollutants emitted from the new ones should also have been reflected in the calculation. However, this was not the case. Subsequently, the amounts of PM_{2.5} and NO_x expected to be reduced were overestimated by 376 tons and 28,319 tons, respectively.
 - Hybrid vehicles (1,998,000 cars sold) were categorized as an emission-free vehicle, like electric or hydrogen cars, due to the fact that the emission coefficient for hybrid cars had not been developed yet. This led to an overestimation of the emission amount expected to be

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reduced by 20 tons of PM_{2.5}, 11 tons of SO_x, and 265 tons of NO_x.

- ③ Arbitrary change to the calculation equation of emission reduction target: The Second Basic Plan on the Metropolitan Area Air Quality Management (established in May 2017) evaluated that 0.249 tons of PM_{2.5} get eliminated by each road sweeper *per* year. In this Comprehensive Plan, though, the reduction value has been adjusted to being 5.3 times greater at 1.312 tons/each road sweeper annually without any proper background research. As a result, the amount of PM_{2.5} emission to be reduced was overestimated by 627 tons.
- ④ Improper application of a revised regulation: The revised law to tighten the limit of air pollutant emission was to be applied to newly-manufactured vehicles only. But, it was applied to all vehicles that were already registered. Subsequently, the total emission amount to be reduced was overestimated by 131,385 tons of NO_x.
- ⑤ Impossible measure to execute: The PM/NO_x emission reduction equipment is not fit for construction vehicles as it has been designed only for general pick-up trucks. However, the Plan presupposed that the said reduction equipment was built-in to the construction vehicles, as well, like dump trucks and two other types of construction vehicles (a total of 14,466 vehicles). In doing this, the emission amount of air pollutants anticipated to be reduced was overestimated by 912 tons of PM_{2.5} and 25,897 tons of NO_x.

Considering these, it is worrisome that the reduction target of air pollutant emission may not be met, with the reduction rate hovering around 13.6% of PM_{2.5}, 39% of SO_x, and 32.8% of NO_x.

(Unit: ton, %)

Air Pollutant Matter	Previous (Comprehensive Plan on Managing Fine Dust, 2019)		Adjusted Estimation		Difference (A-B)
	Reduction amount (A)	Reduction percentage (total reduction amount/total emission amount)	Reduction amount (B)	Reduction percentage (total reduction amount/total emission amount)	
PM _{2.5}	19,140	19.1	13,652	13.6	5,488
SO _x	151,340	42.0	140,013	39.0	11,327
NO _x	793,324	63.6	409,750	32.8	383,574

Decision

- The BAI **notified** the Minister of Environment to:
 - re-calculate the emission amounts that were excessively overestimated to be reduced, and
 - explore new ways to meet the target of emission reduction in close cooperation with relevant public agencies.

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2. Management of stationary sources of pollution (industry facilities)

A. Negligence in managing industry emitters that required separate standards (pages 82-94 of full report)

The *Environmental Impact Assessment Act* regulates that, when an industry facility that is subject to the environmental impact assessment cannot meet the extant standards for fine dust applied to its surrounding areas (even if it complies with the emission limit set by the *Clean Air Conservation Act*), a separate set of standards be required to the emitter upon the environmental impact assessment to cap the emission amount of air pollutants to be allowed.

In addition, local environmental management offices bear the responsibility of checking whether the emitters are in compliance with the separate standards.

In the meantime, in August 2016, the Ministry of Environment established an automatic monitoring system for checking the emitter's compliance, using the smokestack Tele-Monitoring (TMS)* System.

* Smokestack Tele-Monitoring System requires a device in the smokestack of an industry facility to be installed to assess the real-time emission concentration of air pollutants. According to the *Clean Air Conservation Act*, industrial facilities are required to install the device if they emit larger amounts of pollutant matters than certain levels. The Korea Environment Corporation is then in charge of setting up/operating the TMS (CleanSYS), which monitors the assessment values of the smokestack devices.

Also, the Ministry planned to modify relevant regulations to have local environmental management offices provide the Korea Environment Corporation (KEC) with a list of industry emitters upon which a separate standard is imposed, along with information on their facilities. The KEC reports back to the local environmental management offices if it detects any assessment values that go over the allowed limit.

Yet, it was unveiled in the audit that the local environmental management offices were neglecting their responsibilities by not checking the compliancy of industrial emitters. Moreover, the Ministry of Environment also has not been taking action to modify relevant regulations to implement the aforementioned plan since August 2016.

Against this backdrop, the BAI checked the assessment values of the TMS installed in 79 facilities, to which separate emission standards have been required upon the assessment of environmental impact, and discovered that:

- Facility A has been emitting nitrogen oxides (NO_x) up to 12.5 times more than what is allowed (less than 20 ppm) on 6,357 occasions, while Facility B has been emitting up to eight times more NO_x than what is allowed (less than 30 ppm) on 4,769 occasions; and

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- A total of six facilities have been emitting significantly over the allowed limit. But, four local environmental management offices, including the Youngsangang River Environmental Management Office, failed to perform follow-up checks on them.

Decision

- The BAI **notified** the Minister of Environment to:
 - carry out the modification of relevant regulations, so that relevant agencies can have a clear picture of what to do; and
 - explore ways to revise relevant laws to have local environmental management offices and for the Korea Environment Corporation to ensure industrial emitters' compliance to separate standards.
- The BAI **warned** four local environmental management offices (the offices of Nakdonggang River, Youngsangang River, Keumgang River, and Daegu) to pay keen attention to managing the industry facilities that require separate standards, and notified them to request corrective actions. They were also requested to issue administrative orders to those industrial emitters that failed to keep separate standards.

3. Management of mobile sources of air pollution

A. Improper management of national program for promoting retrofit of diesel particulate filters (pages 122-130 of full report)

Since 2005, the Ministry of Environment has been carrying out a national program for promoting retrofit of diesel particulate filters (hereinafter referred to as DPF) for 510,000 old in-use diesel vehicles with 830 billion KRW (approx. 830 million USD) of the national budget plus an additional local government budget totaling half the amount of the national one).

According to the *Environmental Improvement Cost Liability Act*, those vehicles retrofitted with DPFs are exempted from the environmental improvement cost liability payment (from 106,000 KRW up to 530,000 KRW/year, approx. 100 USD up to approx. 500 USD) for the duration of a valid DPF warranty (three years).

Meanwhile, the *Clean Air Conservation Act* regulates that vehicles with DPFs should take a DPF performance test before or after 15 days from the 60th day after retrofitting.

For the vehicles that passed the DPF performance test (showing less than 10% of exhaust concentration), the mandatory regular inspection for exhaust emission required by the *Clean Air Conservation Act* for every year (business vehicles) or every other year (personal vehicles) is exempted for the duration of the DPF warranty (three years).

Meanwhile, even if the DPF performance test is not performed, there are no statutory measures to punish the vehicle owners. What's more, those vehicles that either did not

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undergo the DPF performance test or underwent the test but failed it could still be exempted from the environmental improvement cost liability, only if the mandatory inspections are being conducted regularly, as the law prescribes.

* The standard for the concentration level of exhaust gas emission of the abovementioned regular inspection is two to four times less strict (20% at the lowest, 40% at the highest) than the passing standard for DPF performance tests (less than 10%).

Against this background, the BAI checked whether the vehicles retrofitted with DPFs had taken the DPF performance test in the last five years (2014-2018), and analyzed the concentration levels of exhaust gas emission (as shown at emission inspection) of those cars that had taken the DPF performance test but failed it.

Out of 59,191 vehicles retrofitted with DPFs, 16,538 vehicles (27.9%) did not take the DPF performance test, or did not re-take the test after failing it.

Also, out of these 16,538 vehicles, 12,406 received an inspection for exhaust gas emission later. But, 2,569 of them (20.7%) were found to have exceeded the threshold for passing the DPF performance test, which is less than 10%.

And, of those cars that have passed the DPF performance test and have been exempted from the gas emission inspection accordingly in the last five years (2014-2018), 1,549 vehicles ended up taking the mandatory emission inspection anyway during the warranty period because of the administrative errors of inspection authorities.

The BAI investigated the concentration levels of exhaust emission of these vehicles, and found that 453 vehicles (29.2%) had exceeded the concentration threshold for passing the DPF performance test (less than 10%) during the period when their warranties were valid though they had already passed the DPF performance test before.

* Even if a vehicle has passed the DPF performance test (usually not long after retrofitting a DPF), it does not mean that the performance level will stay the same. In fact, the DPF performance level may change later depending on the car's condition, driver's driving pattern, car cleaning/maintaining, etc. In other words, the DPF performance level for reducing exhaust gas emission may decline as time passes.

The Ministry of Environment, however, did not establish any plan to manage those cars that did not take the mandatory DPF performance test, or did not re-take the test after failing it.

Also, without taking it into consideration that the DPF performance may downturn later, the Ministry has just been granting exemptions of environmental improvement cost liability to those vehicles that have once passed the DPF performance test with presumably a new DPF, supposing that the DPF performance will stay the same during the duration of the warranty.

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Decision

- With a view to enhancing the effectiveness of the national program for promoting retrofit of DPFs, the BAI **notified** the Minister of Environment to devise ways to:
 - ensure the DPF performance of those vehicles that have either not taken the DPF performance test after retrofitting, or taken the test but failed it;
 - ensure the levels of DPF performance of those vehicles that have passed the DPF performance test with a newly purchased DPF by inspecting the DPF performance regularly over the entire duration of the warranty; and
 - grant exemption of payment for environment improvement liability cost only to the vehicles whose level of DPF performance had been maintained.

B. Improper methods of inspecting emission amounts of in-use vehicles and inappropriate standards for the inspection (pages 145-157 of full report).

According to the *Clean Air Conservation Act*, the Ministry of Environment sets up standards for the emission amounts of pollutant matters from vehicles in use, and determines inspection methods. Then, the Korea Transportation Safety Authority (TSA) implements the inspection.

The inspection methods are divided into: (1) loaded-mode test (for vehicles registered in air quality regulated regions*), which tests the amount of exhaust gas emitted in a real road-running setting, and (2) non-loaded mode test (for all other vehicles, including those that cannot take a loaded test due to their mechanical structure), which tests the same by pressing the gas pedal when the car is not in motion.

* It refers to metropolitan areas and other regions considered by the *Clean Air Conservation Act* to be necessary to control air quality thereof.

Out of a total of 10.3 million cases of non-loaded emissions test conducted over the last three years, 97.4% (10 million cases) of them satisfied the emission standard while only 2.6% (270,000 cases) failed to meet it. *

* In case of loaded-mode emissions test, out of a total of 6.42 million cases, 86.3% (5.54 million) passed the inspection, whereas 13.7% (880,000 cases) failed.

Against this background, the BAI scrutinized whether the non-loaded mode emissions test had been conducted properly, and whether inspection authorities have complied with the rules for inspection.

In order to create a setting similar to real driving, the gas pedal should be pressed to the fullest extent (to the maximum RPM: Revolutions Per Minute) for one to two seconds*, so the amount of fuel supply reaches its peak. Yet, the Ministry of Environment set the time standard to be for four seconds.

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- * The European Union defines it to be for one second, whereas Japan sets it for two seconds to assess the amount of exhaust gas at full and sudden acceleration.
- * The BAI assessed the amount of fuel supply by trying full acceleration at the maximum RPM for each time frame (from one to four seconds). When the gas pedal is pressed to the maximum RPM for two seconds, the fuel supply reached the highest. Yet, the level only corresponds to average level when the car was running at a moderate speed during the real-driving setting.

In the meantime, it was also found that the TSA did not inspect cars by pressing the gas pedal to the maximum RPM, though the law requires it to do so. Instead, the TSA assessed the exhaust gas emission through accelerating only up to 80% of a full RPM.

The BAI sample-tested 17 old diesel-fueled vehicles. The result showed that when these cars were accelerated to the fullest RPM for two seconds, the exhaust concentration was 46% (seven cars failed) on average. And yet, when cars were tested by pressing the gas pedal up to 80% of full RPM for two to four seconds, the exhaust concentration dropped to 17.8% on average, with only one failed vehicle. This sample test implied that the extant emission inspections were not strict enough.

Decision

- The BAI **notified** the Minister of Environment to establish ways to ensure the effectiveness of the non-loaded emissions test by:
 - modifying relevant rules governing the time limit for reaching maximum RPM, so that the emission amounts of in-use diesel vehicles can be assessed at a setting where the fuel supply is the highest.
- The BAI **warned** the President of TSA to implement their inspection duties properly, in accordance with the established rules when assessing in-use diesel vehicles by ensuring that they do not stop pedaling before the RPM reaches its maximum level.

4. Management of maritime mobile source of air pollution

A. Improper management of air pollutant matters of old vessels imported for domestic lines (pages 170-175 of full report)

As of 2016, vessels emitted 161,826 tons of nitrogen oxides (Nox), taking up 12.9% of the entire amount of NOx emitted into the air. Of this, 119,481 tons (73.8%) was emitted by domestic vessels.

Nonetheless, the Ministry of Oceans and Fisheries allowed the importation of domestic-line vessels built before June 29, 2006 (effective date of the former *Marine Pollution Prevention Act*), not requiring inspection for NOx emission, nor devising any measures to strengthen its management for old imported vessels.

Against this backdrop, the BAI scrutinized 69 used vessels imported after 2015 for

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domestic use, and found that:

- all 49 vessels built before June 29, 2006, including those built in 1972, were all in operation without being inspected for NOx emission; and
- as of 2018, 5,487 (61.1%) out of 8,985 registered vessels (excluding fishing boats) were 15 years old or over and had been excluded from the list of vessels subject to an emission limit. This manifested a blind area in pollution management.

Decision

- The BAI **notified** the Minister of Oceans and Fisheries to establish ways to strengthen its management for imported second-hand vessels that are not required to comply with the emission limit for nitrogen oxides.

B. Inappropriate exclusion of three types of on-road construction vehicles from regular emissions checkup (pages 187-192 of full report)

Amongst heavy construction equipment acknowledged by the *Construction Machinery Management Act*, the Ministry of Environment defined three types of construction vehicles as freight vehicles that have similar driving features as general automobiles – namely, dump trucks, concrete mixer trucks, and concrete dump trucks, as stipulated in the *Enforcement Rules of Clean Air Conservation Act*.

* As of 2016, there were 90,916 aforementioned construction vehicles. Although these vehicles accounted for only 2.0% of recreational vehicles (a total of 4,549,753 cars), the emission amount of PM from each of these construction vehicles is nine times greater than that of recreational vehicles.

Since February 1991, owners of such construction vehicles have been required to get an annual emissions inspection (for exhaust concentration)* according to the *Construction Machinery Management Act* and the *Clean Air Conservation Act*.

* The regular emissions inspection tests the exhaust emission upon pressing the gas pedal suddenly to the maximum RPM at non-loaded mode (when wheels are idle). This way of inspection places limitations in manifesting how much pollutant matters are emitted during a real-driving setting.

Meanwhile, the Ministry of Environment amended the *Clean Air Conservation Act* in February 2002 to newly require a separate emission checkup for owners of vehicles registered in air quality regulated regions, in addition to the extant regular emissions inspections.

* This emission checkup is conducted on loaded mode to reflect a real-driving setting (with running wheels). Compared to the regular emission inspection, a relatively higher exhaust concentration is observed.

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Therefore, it is appropriate to include on-road construction vehicles (if they are registered in air quality regulated regions) as being vehicles subject to separate emission checkups, as they are similar to general automobiles in terms of their driving features and because they emit a substantial amount of pollutant particles.

However, when the Ministry of Environment defined the subjects that required separate emission checkups in the *Enforcement Rules of the Clean Air Conservation Act* in December 2003, they narrowed down the subjects to only the automobiles that are registered as cars as per the *Motor Vehicle Management Act*. As of 2019, the Ministry of Environment has excluded the three aforementioned types of construction vehicles from the list of vehicles subject to a separate emission checkup.

Decision

- The BAI **notified** the Minister of Environment to include dump trucks, concrete mixer trucks, and concrete pump trucks that are registered in air quality regulated regions into the list of subjects to a separate emission checkup required by the *Clean Air Conservation Act*.

5. Establishment of infrastructure and protection of citizens' health

A. Inappropriate management of school air quality (pages 205-226 of full report)

With a view to maintaining good air quality in classrooms when the concentration of fine dust is high, the Ministry of Education ran a pilot program to install air-purifying devices at 662 schools with bad air quality.

This pilot program was extended to some 28,000 schools nationwide in July 2018 to install a total of 380,000 air-cleaning facilities, including 360,000 air purifiers and 20,000 mechanical air ventilation devices.*

* Unlike air purifiers, the mechanical air ventilation devices are installed by piercing a hole on the outer wall of the classroom, and installing a pipe to connect a fan that will circulate the classroom air by bringing the outside air in, purifying the air inside with it, and then clearing it out of the classroom.

In March 2018, after the close of the pilot program, the Ministry of Education established a standard on installation and use of air purifiers whose capacity satisfy an area larger than 100m², 1.5 times larger than a classroom (66m²).

The BAI found that 4,644 air purifiers (35.5%) out of the air purifiers placed in 13,095 classrooms were those that could satisfy only the area of 66-81m², less than 100m². However, the Ministry has yet to take any specific improvement actions as of December 2019.

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Meanwhile, the *Enforcement Rule of School Health* stipulated that in-class noise be less than 55dB. Therefore, it is necessary to check in-class noise levels with the air purifiers installed.

But, the Ministry's standard established in March 2018 touched only on installation and usage, requiring the installation of air purifiers that make less than 55dB (in laboratory condition) of noise without requiring an assessment of the noise level after it is installed in a classroom.

The Gyeonggido Office of Education went on to install mechanical air ventilation devices (from June 2018 to March 2019) without assessing in-class noise levels. However, it was later discovered that the in-class noise levels were excessively high: eight out of nine devices installed were making noise levels between 56-64 dB, hovering less than the standard, according to the on-sight inspection by the Ministry of Education. The remainder of planned installations were cancelled.

In addition, it was found that local offices of education were only checking whether or not the air purifier filter performance ratings were being submitted, not examining whether they satisfy the given standard. What's more, the Ministry of Education was not establishing any responsive measures toward this issue.

Consequently, there were some cases where the air purifier providers (rental companies) submitted performance ratings of the filter fabric, instead of providing filter ratings, making it impossible to identify the filter performance. In other cases, the filter performance ratings themselves did not meet the given standards, but the air purifiers were still contracted to be used*.

* The filter performance rating should be over E11 (as per European rating system) to be contracted. But some were E10-rated filters.

Decision

- The BAI **notified** the Minister of Education to:
 - conduct a thorough review of the effectiveness of their programs for fine dust, as well as on the factors that jeopardize a good educational environment;
 - investigate further into the air-cleaning device providers (rental companies) that were offered a contract by submitting inappropriate filter performance ratings, and take necessary corrective actions; and
 - establish a comprehensive plan on installing air-cleaning facilities, including improvement of air purifier performance.

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B. Ill-managed plans for fine dust at subway stations (pages 231-244 of full report)

According to the *Indoor Air Quality Control Act*, and the Five-year Plan for Improving Air Quality in Subway Stations (1st five-year plan: 2008-2012, 2nd: 2013-2017, and 3rd: 2018-2022), the Ministry of Environment has been carrying out five-year comprehensive plans for managing the air quality in subway stations since 2008.

As per the 3rd five-year plan (2018-2022), the particulate matter (PM) concentration in subway tunnels are four to six times higher than that of outdoors, and three to four times higher* than that of subway platforms due to the influx of polluted air from the outside, rail wear, grinding of gravel, and soil.

*According to the “Policies for Improving Fine Dust in Subway Stations and Coaches” (released in November 2018) of the Research Center for Health Environment of the Seoul Metropolitan Government, the highest PM concentration in subway stations were 394 $\mu\text{g}/\text{m}^2$ in tunnels, 114 $\mu\text{g}/\text{m}^2$ in platforms, and 32 $\mu\text{g}/\text{m}^2$ in waiting halls.

The PM generated in tunnels is the main source of air pollution in subway stations as it flows to the platforms when the platform screen doors are open.

While the Ministry of Environment has set standards for managing the air quality in subway stations, an air quality standard for inside the tunnels was not established.

In fact, only 1.5% (47 million KRW, approx. 47,000 USD) of the budget for controlling fine dust in subway stations (3.23 billion KRW, approx. 3.23 million USD, in the 2nd abovementioned plan) was invested in managing the PM in tunnels.

Also, the Ministry of Environment did not conduct a hazard assessment of the PM in subway stations for its impacts on the human body even though the concentration of heavy metals (i.e. hexavalent chromium, nickel, aluminum, zinc, etc.), in the PM in the stations is much higher than that of the PM outdoors.

Decision

- The BAI **notified** the Minister of Environment to:
 - set up air pollution monitoring stations in subway station tunnels as tunnels are the main source of PM generation;
 - establish measures against managing the air quality based on the results of air condition monitoring; and
 - conduct hazard assessments of the heavy metals in the PM for its impact on the human body.

III. Audit results and policy recommendations

■ **Audit results** (pages 275-277 of full report)

The Ministry of Environment established numerous policies for fine dust within a short period of time. Without improving the flaws of their previous policies, the Ministry went on to develop ensuing policies with similar components to that of the previous ones. Due to these flaws, there were concerns that the Ministry's policies for fine dust may not be effective.

- As for the fine dust management plan, the amount of air pollutants emitted were underestimated, while the emission amount expected to be cut down was overestimated. This implies that it will be difficult to achieve national targets for improving fine dust even if things went accordingly as described in the plan.
- As for the management plans for each source of the pollutants, stationary sources (industrial facilities), as well as mobile sources (roads and seas), and various programs for reducing fine dust were operated and managed in inappropriate ways. Thus, there were concerns that the effectiveness of the programs may not be ensured.
- As for the programs related to establishing infrastructures and protecting citizens' health, the programs for improving air quality were carried out without a thorough review of their effectiveness, leading to concerns that the budget may not be used effectively.

■ **Performance evaluation results of management programs for fine dust** (pages 285-294 of full report)

The Office for Government Policy Coordination (OPC) conducted an evaluation on the implementation of the Comprehensive Plan on Managing Fine Dust (established in September 2017) twice in February 2018 and 2019.

In four out of 18 programs which showed decent performance in reducing air pollutant emissions, the equations for calculating reduced emission amounts were different between those suggested in the said plan and those applied to the evaluation. As such, the difference made it inappropriate* to evaluate the effectiveness of the programs through, for example, the success rate of achieving planned targets.

* Distribution of road sweepers: The comprehensive plan categorized road sweepers by each type, and calculated the emission amounts to cut down for each type of sweeper. However, instead of doing the same, the OPC and the Ministry of Environment merely estimated the total emission amount of PM_{2.5} from 307 road sweepers that were in-use, and assessed that a total of 431 tons of PM_{2.5} was reduced from those sweepers.

- When the BAI re-examined all of this, however, it was found that instead of 307, a total of 299 road sweepers (108 vacuum sweepers, 156 broom sweepers, and 35 sprinkler trucks) were in-use. And, considering the reduced amount of emissions from each type of these sweepers, a total of 158 tons of PM_{2.5} was reduced, leaving 273 tons in difference.

<Summary>

All in all, it was considered that it was necessary to improve the establishment and evaluation of the plans on managing fine dust. To this end, the BAI notified the Minister of OPC to take the BAI's analysis of fine dust management plans as a reference in:

- analyzing the causes of low implementation rates of programs in which national budgets had been allocated but not invested; and
- improving the plans by evaluating the effect of reducing pollutant matters against the costs to be incurred for each responsive measure.

* For more details, please refer to the full report of this audit available at www.bai.go.kr.