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POLICIES, REGULATORY FRAMEWORK AND ENFORCEMENT FOR AIR QUALITY MANAGEMENT: THE CASE OF KOREA – ENVIRONMENT WORKING PAPER No. 158

By Daniel Trnka (1)

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Abstract

During past years, Korea figured among the OECD countries with the highest share of population exposed to excessive PM2.5 (atmospheric particulate matter that have a diameter of less than 2.5 micrometres) concentrations and PM2.5 concentration level in Seoul is about two times higher than the WHO's guidelines or the levels of other major cities in developed countries. A number of countermeasures have been recently introduced to address such challenges, including a tightening of air quality standards and increasing local inspection and enforcement capacity. This paper reviews these recent reforms, and discusses possible further improvements. This paper complements two case studies on air quality policies in China and Japan, and a third case study on international regulatory co-operation on air quality in North America, Europe and North-East Asia.

Keywords: air pollution, regulatory policy, monitoring and enforcement, Korea

JEL codes: Q52, Q53, Q58

Résumé

Ces dernières années ont vu la Corée aux premiers rangs des pays de l'OCDE les plus fortement exposés à des concentrations excessives de PM2.5 (particules en suspension dans l'air d'un diamètre inférieur à 2.5 micromètres) : à Séoul, le niveau enregistré représente environ le double du plafond recommandé par l'OMS. Pour y remédier, un certain nombre de mesures correctives ont récemment été prises, notamment en vue de durcir les normes de qualité de l'air et de renforcer les capacités locales d'inspection et d'application. Les travaux présentés ici portent sur ces réformes et contiennent une réflexion sur les autres améliorations possibles à apporter. Ils viennent compléter deux études de cas sur les politiques en faveur de la qualité de l'air poursuivies en Chine et au Japon, ainsi qu'une troisième sur la coopération internationale en matière de réglementation sur la qualité de l'air engagée en Amérique du Nord, en Europe et en Asie du Nord-Est.

Mots clés : pollution de l'air, politique réglementaire, surveillance et application, Corée

Classification JEL : Q52, Q53, Q58

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Executive summary

Key features of the environmental policy framework

Korea has been one of the fastest growing OECD economies over the past decade, driven by a large export-oriented manufacturing sector. However, growth has come with high pollution and resource consumption. Koreans' level of interest in environmental issues is generally increasing, and people are moderately satisfied with the environment overall. To tackle these challenges, Korea has invested considerable effort in improving environmental management.

Despite the progress, problems persist. Regarding air pollution, the PM2.5 concentration level, for example, is about two times higher than the WHO's guidelines or the levels of other major cities in developed countries. Local emissions play a significant role and are often sufficient to create air quality violations, but transboundary pollution must be considered as an exacerbating factor.

Korea has a centralised system of environmental governance, albeit with significant devolution and delegation of policy implementation responsibilities to provincial and local governments. Local authorities' political emphasis on economic growth, sometimes at the expense of environmental protection, and their capacity to adequately enforce environmental regulations remain key multilevel governance concerns. While over 60% of the MOE budget is spent on support to local governments, responsibilities were often devolved to the provincial and local levels without sufficient funding. As a result, subnational governments, especially outside the Seoul Metropolitan Area, lack human, technical and financial resources to carry out these responsibilities, notably in compliance monitoring and enforcement. Moreover, environmental tasks are often assigned low priority and fragmented across several divisions. Local authorities seem to have particular difficulty handling air quality issues, where powerful private sector interests are involved.

Environmental impact assessment (EIA), in use since the early 1980s, is the cornerstone of Korea's environmental regulation. EIA framework is in line with international best practices, though, only residents near the work site – but not the public at large or non-government organisations (NGOs) – have an opportunity to comment during the EIA consultation phase and while a draft EIA report is prepared.

Regulators are required to conduct regulatory impact assessment (RIA) which examines the objective, feasibility and goodness of fit of any regulation that is to be newly introduced or reinforced. RIA also requires regulators to extensively compare and review multiple alternatives (both regulatory and non-regulatory) to the regulation under review. RIA is also a key part of the Korean government's "cost-in cost-out" initiative for offsetting costs stemming from new regulations. This might lead to a risk of limiting possibilities for adopting necessary environmental regulations.

In general, Korea's performance on stakeholder engagement relates to the greater use of online tools. The general public as well as all stakeholders are engaged in the rule-making process. In particular, opinions of direct stakeholders are consulted even prior to drafting a bill. Despite these achievements, there have still been cases where lack of information and engagement of stakeholders and general public led to unconstructive citizen opposition to major government-promoted projects.

Since 1990, industrial facilities have been subject to emission standards and charges, which can vary with the severity of the air pollution where the facility is located. A number of national and subnational air pollution plans were adopted. The SmokeStack Tele-Monitoring System constantly measures air pollutants emitted by major industrial emitters through remote automatic sensing equipment.

Korea's air pollution plans have also introduced measures in the transport sector. Emission standards for fuel and automobiles have been strengthened. The government provides subsidies for the purchase of eco-friendly vehicles, with an effort to significantly expand the nationwide charging infrastructures. The government is trying to create low-emission zones, though stakeholder opposition makes this challenging.

When the new president and administration took office in 2017, the fight against fine dust became one of its top priorities. Accordingly, a package of fine dust countermeasures was announced in September 2017 and other measures are being introduced. Air quality standards have been progressively tightened, with the latest update for PM 2.5 in 2018.

Korea has made significant progress in increasing local inspection and enforcement capacity and strengthening related national supervision and evaluation mechanisms. Local environmental officers are appointed by the head of the jurisdiction (e.g. mayor). To ensure the quality of inspections, there are cross-checks between the central and local governments of the inspections carried out by the latter. Inspection planning has become more risk-based. Although the frequency of site visits fell the detection rate grew steadily. To further increase detection rates, the Ministry of Environment (MEnv) is encouraging local authorities to conduct more frequent random inspections. However, many municipalities do not have sufficient resources to do so.

Very significant criminal sanctions for non-compliance are set in issue-specific environmental laws. In practice, however, sanctions of this degree are rarely applied. At the same time, administrative sanctions are relatively weak: authorities can impose light monetary penalties for minor offences and issue orders to stop the polluting activity, but violators can avoid this by paying a higher "excess" pollution charge. Polluters often get away with a simple warning.

The MEnv promotes good environmental behaviour in the regulated community through voluntary agreements, information-based instruments and regulatory incentives. The MEnv provides information on environmental regulations and green business practices through its website and printed materials, and operates a web-based helpline. It is not clear to what extent also local inspections do provide information on compliance with environmental regulations.

Key recommendations

- Continue implementing measures included in the Comprehensive Plan. It is too early to evaluate the actual impact of the measures adopted in 2017. Some of them, such as the alternate-day driving limitations have to be broadened to include the private sector and other areas than SMA. Enforcement of those measures will be crucial. It is necessary to evaluate the impact of these measures in the near future and adjust where necessary.
- Pursue regional co-operation to tackle transboundary air pollution but also continue focusing on local sources of emissions. Both local and transboundary emission sources play a significant role and must be tackled at the same time. Knowledge of air pollution sources (domestic vs. transboundary) and of the impact of each upon health among citizens should be improved.
- Build provincial and local governments' capacity to carry out their statutory environmental responsibilities and tasks delegated to them by the central government; provide the necessary financial resources to ensure effective enforcement of national environmental regulations; strengthen the system of environmental performance indicators for all levels of government. Clearer and transparent rules for appointing and dismissal of the heads of environmental

inspections could strengthen the independence of inspections and therefore decrease potential risks of manipulating inspections towards political goals of the local leadership.

- Reinforce *ex ante* assessment of environmental policies and regulations through wider application of quantitative cost-benefit analysis, and expand *ex post* evaluation of their implementation. There is, so far, no evidence for effects of the "cost-in cost-out" policy on environmental protection in Korea, however, in the future, it is necessary to adopt regulations based on their necessity supported by evidence, rather than on simple accounting and offsetting of costs. A methodology for evaluating costs on environment should be included in the official RIA guidance.
- Improve public participation in environmental decision making by introducing mechanisms for public involvement in the development of environmental permitting decisions, and by opening the EIA process to input from the general public (beyond local residents) and NGOs. Better information on both goals of government policies and regulations but also on the regulation-making process and possibilities for stakeholders to participate in this process might lead to an increased trust in government and better perception of the quality of the regulatory framework among stakeholders.
- Increase the efficiency of compliance monitoring through better targeting of inspections based on the level of environmental risk of individual facilities; strengthen administrative enforcement tools and build the capacity of public prosecutors and the courts in applying penalties for criminal offences.

1. Introduction

This case study is part of a joint project of the OECD Environment Policy Committee and Regulatory Policy Committee focused on regulatory frameworks, enforcement and co-operation to address air pollution supported by the Ministry of Environment of Korea. The joint project comprises two pillars:

1. Country studies of policies, regulatory framework and enforcement for air quality management, covering China, Japan and Korea; and
2. Studies of international regulatory co-operation (IRC) initiatives to address air pollution, focusing on existing arrangements in North-East Asia, the Canada – United States Air Quality Agreement (Air Quality Agreement) and the Convention on Long-range Transboundary Air Pollution (CLRTAP).

This document complements the country studies of policies, regulatory framework and enforcement for air quality management in China (ENV/WKP(2020)4) and Japan (ENV/WKP(2020)3) and a three case studies analysing international regulatory cooperation on air quality in North America, Europe (the Convention on Long-Range Transboundary Air Pollution) and North-East Asia (COM/ENV/EPOC/GOV/RPC(2018)1).

These studies are carried out under Revised Output Proposal (ROP) for Intermediate Output 2.3.4.2.11 Environmental Policy Design and Evaluation- Regulatory quality and enforcement to address air pollution, under the 2017–2018 EPOC Programme of Work and Budget (ENV/EPOC(2017)1/ANN3). Overall, this joint project aims to support the broader ambition of countries in the region to improve their air quality policies by highlighting the challenges and possible solutions related to the design and enforcement of effective regulatory frameworks for air quality and the co-operation needs that transboundary air pollution generates.

This study builds on information collected by the Secretariat through deskwork, questionnaires, and interviews carried out during a fact-finding mission to China, Japan and Korea undertaken in May 2018. They studies be revised based in further comments from EPOC and RPC delegates.

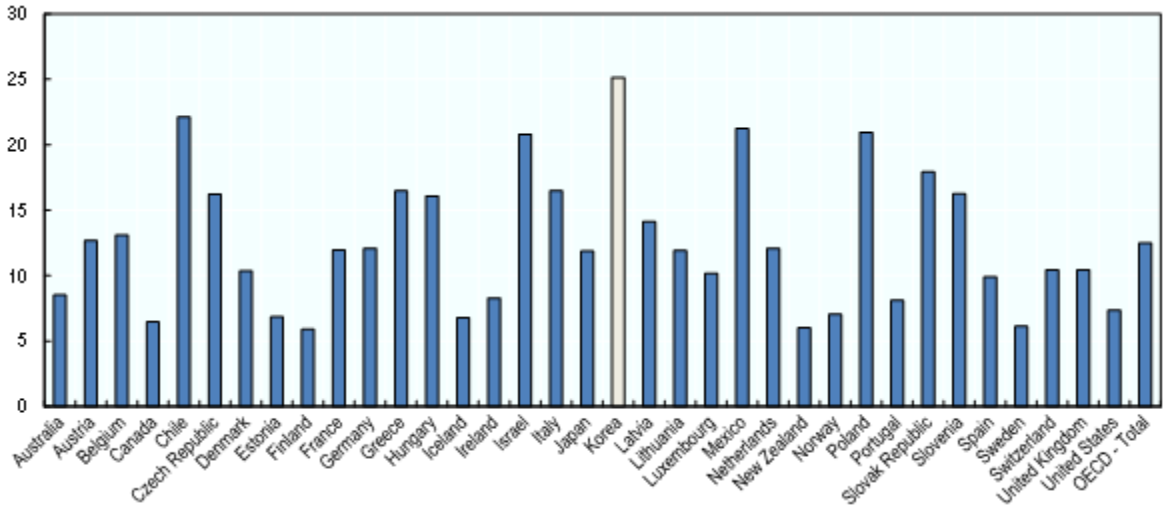
2. Historical and recent trends in air quality and emissions

Korea has a relatively large export-oriented economy, poorly endowed with natural resources. Over the past decade it has been one of the fastest growing OECD economies, but at the expense of environmental quality. Koreans' level of interest in environmental issues has fluctuated but is generally increasing, and people are moderately satisfied with the environment overall. Public perception of environmental quality is evaluated through a national conservation awareness survey regularly conducted since 1995 by the Ministry of Environment (MEnv), and an annual national environmental awareness survey conducted by the Korea Environment Institute (KEI). Satisfaction is highest for natural landscapes and lowest for noise and for pollution and accidents caused by chemical substances (MOE, 2016c).

Air pollution is a major health concern in Korea. In 2013, the country had the OECD's highest share of population exposed to excessive $PM_{2.5}$ (atmospheric particulate matter that have a diameter of less than 2.5 micrometres) concentrations (OECD, 2018).

Figure 2.1. Exposure to PM2.5 in OECD Countries

Mean population exposure to PM2.5 in μ/m3

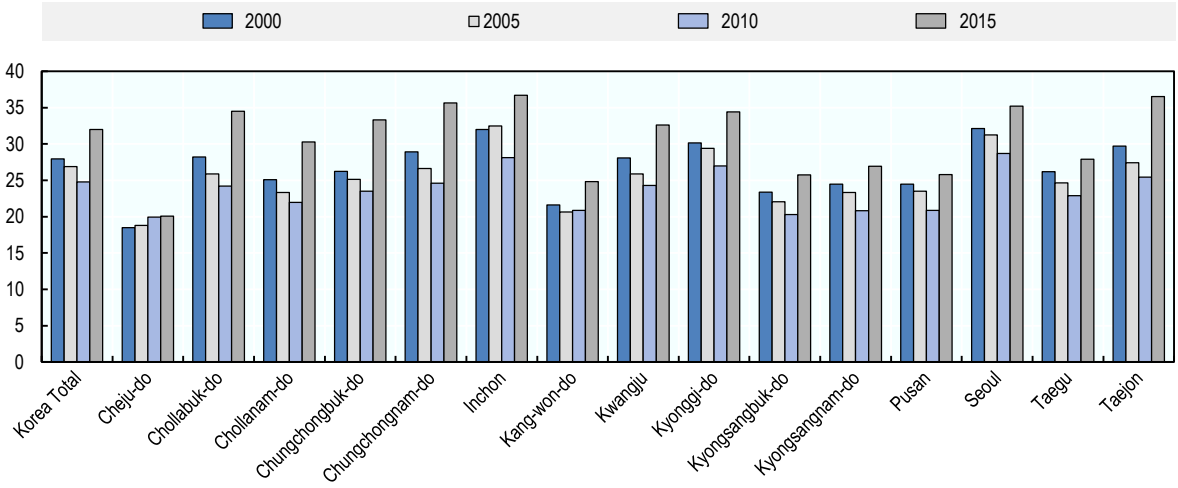


OECD (2019), "Air quality and health: Exposure to PM2.5 fine particles - countries and regions", OECD Environment Statistics (database), https://doi.org/10.1787/96171c76-en (accessed on 29 October 2019).

The PM2.5 concentration level in Seoul is about two times higher than the WHO's guidelines or the levels of other major cities in developed countries. Since 2015, PM2.5 levels in Korea have to meet the Air Quality Standards as laid out in the Framework Act on Environmental Policy. Nevertheless, Korean citizens experience aggravation in the fine particle pollution, especially in winter and spring, from December to

May. The annual average level of PM2.5 concentrations in these seasons has risen from 28 μ/m3 in 2015 and 29 μ/m3 in 2016 to 30 μ/m3 in 2017; so did the number of PM2.5 warnings and alerts issued from 72 in 2015 and 66 in 2016 to 177 in 2017. In particular, residents in Jeollabuk-do Gyeongsangbuk-do, Chungcheongnam-do, and Chungcheongbuk-do are facing severe air pollution, as "bad" air quality days were reported for the provinces on average two to three times more than in other provinces (see also Figure 2.2).

Figure 2.2. Mean population exposure to PM2.5 in Korea divided by provinces (in μ/m3)



Source: OECD (2019), "Air quality and health: Exposure to PM2.5 fine particles - countries and regions", OECD Environment Statistics (database), https://doi.org/10.1787/96171c76-en (accessed on 29 October 2019).

In addition, reported sand and dust storms in Seoul increased substantively. Due to these sandstorms, the visibility range decreased to 14.7km in 2015, having heavily affected Korean citizens' daily lives.

The contributing factors of fine dust concentrations in Korea are classified into two groups: local factors and foreign factors. The contribution rate of foreign factors to Korea's fine dust levels varies with seasonal and weather conditions including wind direction, wind speed, and precipitation.

The KORUS-AQ, a joint study project by the Korea's National Institute of Environmental Research (NIER) and the NASA, suggested in its mid-term report published in July 2017 that 48 percent of the ultrafine particulate matter measured from May to June 2016 in the air of the project area in Korea was caused by foreign factors, while the remaining 52% came from local sources. It is expected that the contribution of foreign factors to Korea's fine dust levels will continue.

Local emission sources can be divided into two groups: the Seoul Metropolitan Area (SMA) and the country as a whole. In 2015, "diesel vehicles" were the largest emitters in the SMA, accounting for 22% of the area's total emissions (compared to 11% in the whole country), followed by construction machinery (20% and 16 % respectively), while "business facilities" in the country accounted for 38% of the national total emissions compared to 16% overall (Ministry of Environment, 2018[1]).

Box 2.1. Primary and Secondary pollutants

Pollutants can be classified according to their generation mechanisms. Primary pollutants are those emitted directly as a result of human activity or natural processes, while secondary pollutants are created from primary pollutants through reactions with sunlight and other components in the atmosphere.

Photochemical oxidants, such as ground level ozone, are often classified as a secondary pollutant. In fact, ozone is not emitted directly into the air, instead it is mostly generated by chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOCs (US EPA, n.d.[2]).

Given its secondary nature, policies aiming at controlling ozone concentration focus on its main precursors, namely VOCs and NOx. In Japan, numerous instruments have been introduced to control the emission of these pollutants precursors, such as emission standards for fixed sources of VOCs and more stringent regulation for mobile-sources in specific regions. However, notwithstanding improvement in the concentration of these precursors, concentration levels of photochemical oxidants have remained relatively constant and further research on its generation mechanism is considered necessary.

3. The environmental policy-making framework

3.1. Main policy actors

Korea has a centralised system of environmental governance, albeit with significant devolution and delegation of policy implementation responsibilities to provincial and local governments. Local authorities' political emphasis on economic growth, sometimes at the expense of environmental protection, and their capacity to adequately enforce environmental regulations remain key multilevel governance concerns, provoking a slowdown and in some cases reversal of the devolution process. At the national level, many environmental responsibilities are fragmented across multiple ministries, and permanent rather than ad hoc co-ordination mechanisms have been put in place only recently.

The Ministry of Environment (MEnv) is responsible for environmental policy and legislative development, formulation and implementation of comprehensive plans for environmental conservation, and support for environmental management activities of local governments. Its annual budget grew by an average of 5.2% per year in real terms from KRW 2.9 trillion in 2006 to KRW 5.7 trillion in 2018.

The MEnv has three Regional Environmental Offices, in Wonju, Daegu and Saemangeum, and the Metropolitan Air Quality Management Office in charge of improving air quality in the Seoul Metropolitan Area. The Regional Environmental Offices' tasks include developing and implementing environmental management plans in their areas of jurisdiction, providing formal MEnv opinions on environmental impact assessment (EIA) and strategic environmental assessment (SEA) reports, and supervising compliance assurance by local governments.

Other ministries with environment-related responsibilities include the Ministry of Agriculture, Food and Rural Affairs (MAFRA), Ministry of Trade, Industry and Energy (MOTIE), Ministry of Land, Infrastructure and Transport (MOLIT) and Ministry of Oceans and Fisheries (MOF). These ministries, along with the MOSF and the Ministry of the Interior and Safety (MOIS), are part of the Commission on Sustainable Development, which since 2010 has been under supervision of the environment minister. The commission, consisting of high-ranking public officials and experts, reviews the National Sustainable Development Master Plan as well as legislation and key administrative plans with sustainable development implications. Initially, the commission was convened under the president's office, but was relegated to the MEnv with the Presidential Committee on Green Growth (PCGG) newly launched at the president level. That committee, established in 2009, became the prime minister's responsibility in 2013 under a new administration that prioritises a "creative economy". Such institutional instability may hinder effective environmental policy implementation.

Collaboration between key government players in the environmental field, such as the MOSF, the MEnv, MOLIT, MOTIE and MAFRA, needs to be reinforced significantly to overcome a historical "silo culture" of adversity and competition. As part of Government 3.0, a concept unveiled in 2012, efforts are underway to make inter-agency collaboration more effective.

Korea is divided into eight provinces (*do*), one special autonomous province (Jeju), six metropolitan cities, one metropolitan autonomous city (Sejong) and one special city (Seoul). Other administrative divisions include cities of at least 150 000 people (*si*), counties (*gun*), townships and villages.

Provincial and city governments play an important role, administering environmental permits and enforcing environmental laws as statutory delegates of the MEnv. They also develop and implement environmental conservation policies within their jurisdiction and are in charge of municipal waste management, local water supply and sewage treatment, as well as regulation of vehicle emissions and noise.

While over 60% of the MEnv budget is spent on support to local governments, responsibilities were often devolved to the provincial and local levels without sufficient funding. Financial transfers tend to address immediate priorities rather than long-term local capacity needs. As a result, subnational governments, especially outside the Seoul Metropolitan Area, lack human, technical and financial resources to carry out these responsibilities, notably in compliance monitoring and enforcement.

While administrative capacity of local governments has substantially improved in recent years, the lack of competent local environmental staff remains a major constraint. Moreover, environmental tasks are often assigned low priority and fragmented across several divisions. Local authorities seem to have particular difficulty handling air quality and industrial and commercial waste management issues, where powerful private sector interests are involved. More generally, local economic development considerations tend to take precedence over environmental ones.

General policy co-ordination between the central and local governments is carried out by the Local Government Policy Council, created in July 2015. The Central Government Policy Delivery Council also assists in communication between government levels. A joint annual evaluation assesses the performance of local governments in executing delegated responsibilities and state-funded projects (mostly using output indicators such as number of inspections conducted). Regional councils formed by the MEnv and several local governments address specific environmental issues in some regions. Environmental co-operative conferences on various environmental topics are held to promote vertical policy co-ordination. Still, the level of vertical collaboration is insufficient in some policy areas.

3.2. Environmental impact assessment of projects and regulations

Environmental impact assessment (EIA) and regulatory impact analysis (RIA) can be effective instruments to promote policy coherence and the consideration of air quality issues in different policy areas. These can be broadly defined as analytical tools available to government to evaluate the environmental impacts of projects (EIA) and the benefits and costs – also in terms of the environment – of regulations (RIA).

EIA, in use since the early 1980s, is the cornerstone of Korea's environmental regulation. The EIA framework is mostly in line with the OECD best practice. The Environmental Impact Assessment Act (1993, last amended 2012) requires EIA as a precondition for a construction permit in 17 activity sectors (81 types of projects), mostly covering infrastructure development. The government plans to extend EIA requirements to several other types of projects. For industrial sites, those with a surface area 150 000m2 or greater are subject to EIA, while those smaller than 150 000m2 are subject to Strategic Environmental Impact Assessment. A "Health Impact Assessment" is also conducted for industrial sites in addition to the EIA.

Decisions on EIA categories to be assessed and scopes, including description of alternatives (but not concerning site selection, already determined in a master plan), are set out by the EIA Consultation Body. The EIA Consultation Body is made up of representatives of the approving authority (a local government or a ministry), other relevant public officials, experts and residents' representatives. The 2012 amendment of the EIA Act gave residents near the work site – but not the public at large or non-government organisations (NGOs) – an opportunity to comment as early as the EIA consultation phase, and again

while a draft EIA report is prepared. Korea might consider opening up the process also to non-residents and the civil society.

The EIA report is submitted to the approving authority, which must consult the MEnv before deciding whether to grant the permit. After the report's approval, the operator is responsible for monitoring the project's impact and reporting to the MEnv and the approving authority. A project that does not fall under EIA Act requirements may undergo an EIA by a local government (in metropolitan cities, provinces and cities with a population of at least 500 000) based on a local ordinance if the project raises local environmental concerns. As of 2014, eight local governments, including the cities of Seoul, Busan, Incheon and Daejeon, had applied this provision.

An extensive information and services network supports the EIA procedure. The online EIA Support System provides EIA-related information to the project proponent, the local authority and the public to ensure transparency. The MEnv has developed about 50 guidelines and regulations on EIA in specific activity sectors. The Korea Environment Institute (KEI) has been a professional reviewing agency for EIA matters since 1997. The KEI reviews assessment reports and delivers formal opinions upon request from the MEnv. An EIA Agent System aids the MEnv in licensing professional engineers and EIA consulting firms. There were more than 350 EIA consulting firms in 2017.

By late 2014, over 5 100 EIAs had been conducted, with nearly 90% of EIA reports approved, almost always with additional environmental conditions. The effectiveness of the EIA system is illustrated by the fact that, between 2012 and 2015, EIA conditions imposed on industrial complex projects led to emission reductions of 56% for cadmium and 27% for PM_{10}, as well as 46% more green space conservation, compared to projections of preliminary assessment reports (MOE, 2016).

3.3. Regulatory impact analysis (RIA)

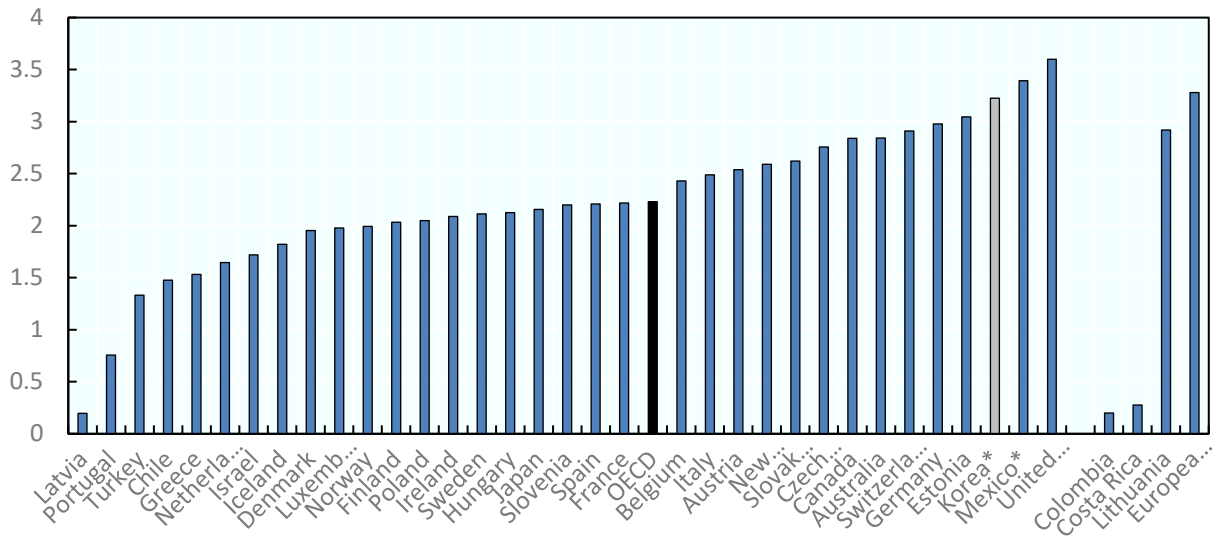
Regulatory impact assessment (RIA) provides crucial information to decision makers on whether and how to regulate to achieve public policy goals, including protection of the environment (OECD, 2012[3]). It is challenging to develop "correct" policy responses which also maximise societal well-being. It is the role of RIA to help assist with this, by critically examining the impacts and consequences of a range of alternative options. Improving the evidence base for regulation through RIA is one of the most important regulatory tools available to governments (OECD, 2012[3]).

When it comes to environmental protection, RIA can be instrumental by clearly illustrating the inherent trade-offs within regulatory proposals. RIA can therefore help analyse negative impacts of government regulations (e.g. in case of pro-business regulations) and choose regulations with the least costs for environment. RIA can also reduce regulatory failure by demonstrating where there is no case for regulating, as well as highlighting the failure to regulate when there is a clear need (OECD, 2009[4]). RIA, when conducted properly, also helps to explain the necessity and reasons for government intervention and therefore increases the likelihood of compliance by regulated subject.

As stipulated in Article 2 of the Framework Act on Administrative Regulations, regulatory impact analysis (RIA) in Korea aims to predict and analyse the economic, social and administrative impact of a regulation through the use of objective and scientific means, and thus establishing a standard which serves as the basis for determining the appropriateness of the regulation.

Korea's score on the OECD Regulatory Impact Analysis (RIA) Index has significantly improved between the 2015 and 2018 Regulatory Policy Outlooks for both primary laws and secondary regulations (Figure 3.1) (OECD, 2018[5]).

Figure 3.1. 2018 Indicators of Regulatory Policy and Governance (iREG): Regulatory Impact Assessment for developing primary laws



Note: Data for OECD countries is based on the 34 countries that were OECD members in 2014 and the European Union. Data on new OECD member and accession countries in 2017 includes Colombia, Costa Rica, Latvia and Lithuania. The more regulatory practices as advocated in the 2012 Recommendation a country has implemented, the higher its iREG score. The indicator only covers practices in the executive. This figure therefore excludes the United States where all primary laws are initiated by Congress. * In the majority of OECD countries, most primary laws are initiated by the executive, except for Mexico and Korea, where a higher share of primary laws are initiated by the legislature.
Source: Indicators of Regulatory Policy and Governance Surveys 2014 and 2017, http://oe.cd/ireg.

In order to promote an evidence-based rule-making and improve regulatory quality, regulators are required to conduct RIA which examines, but is not limited to, the necessity, objective, feasibility and goodness of fit of any regulation that is to be newly introduced or reinforced. RIA also requires regulators to extensively compare and review multiple alternatives (both regulatory and non-regulatory alternatives) to the regulation under review. For each alternative considered as part of RIA, regulators are mandated to analyse its costs and benefits, enforcement feasibility, and potential impact on SMEs, competition and technology, as well as a rationale for choosing or discarding the reviewed alternatives.

The RRC is composed of the Economic Sub-Committee and the Administrative and Social Sub-Committee to separately review regulations according to their nature. Members of the RRC are from both the government and non-government sector, and their participation in the committee is done on a part-time basis. From the government side, the RRC is comprised of the prime minister, ministers from the Ministry of Strategy and Finance, Ministry of the Interior and Safety, Ministry of Trade, Industry and Energy, Office for Government Policy Coordination, and Ministry of Government Legislation and the chair of the Fair Trade Commission. On the other hand, the rest of the RRC is composed of 13 non-government representatives, which includes one chair and 6 non-government representatives under each sub-committee (sub-committee on economy and sub-committee on administration and society).

The RRC regularly issues a guideline on the preparation of RIAS. A central administrative agency, then, drafts a RIAS on the proposed regulation in accordance with the guideline, and conducts a regulatory review through its internal regulatory review committee. The central administrative agency is also required to publish the RIAS to the general public during the advance notice period of the proposed legislation for the duration of approximately 40 days, as required by the Framework Act on Administrative Regulations.

The RIA framework in Korea is, at least concerning the *de jure* situation, on par with the best performing OECD countries. What remain to be seen is its practical implementation – to what extent RIA really leads to better and more efficient regulations.

RIA is a key part of the Korean government's "cost-in cost-out" initiative. This means that (in a simplified way) every KRW of additional costs stemming from newly adopted regulations must be offset by one won saved by removing or simplifying existing regulations. The OECD experience shows that when a country implements regulatory offsetting, this might lead to a risk of creating barriers for developing new regulations which might be needed, for example, for the protection of the environment. There is, so far, no evidence for such effects of the "cost-in cost-out" policy on environmental protection in Korea, however, in the future, it is necessary to adopt regulations based on their necessity supported by evidence, rather than on simple accounting and offsetting of costs.

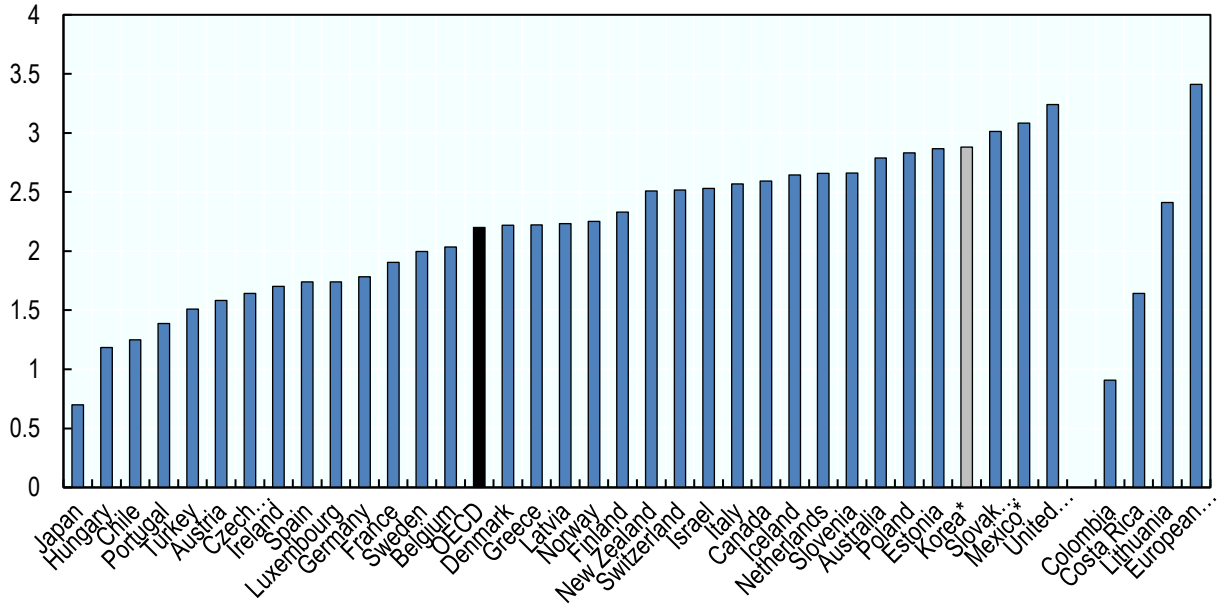
Also, a methodology for evaluating costs on environment is not included in the official RIA guidance. Following a court decision imposing rigorous ("scientific") cost-benefit analysis of draft policies and regulations, the MEnv developed a manual for such analysis of environmental measures and works with other agencies to conduct quantitative analysis of costs and benefits of draft regulations. In cases where such quantitative analysis is complicated, regulations are assessed using indices based on qualitative evaluation of their potential economic, social and financial impact.

3.4. Environmental democracy

The mechanisms to promote a working environmental democracy are – in general – not specific to air pollution. For this reason, a brief overview of the tools in place to ensure that the public can contribute to the environmental policy making process is provided below.

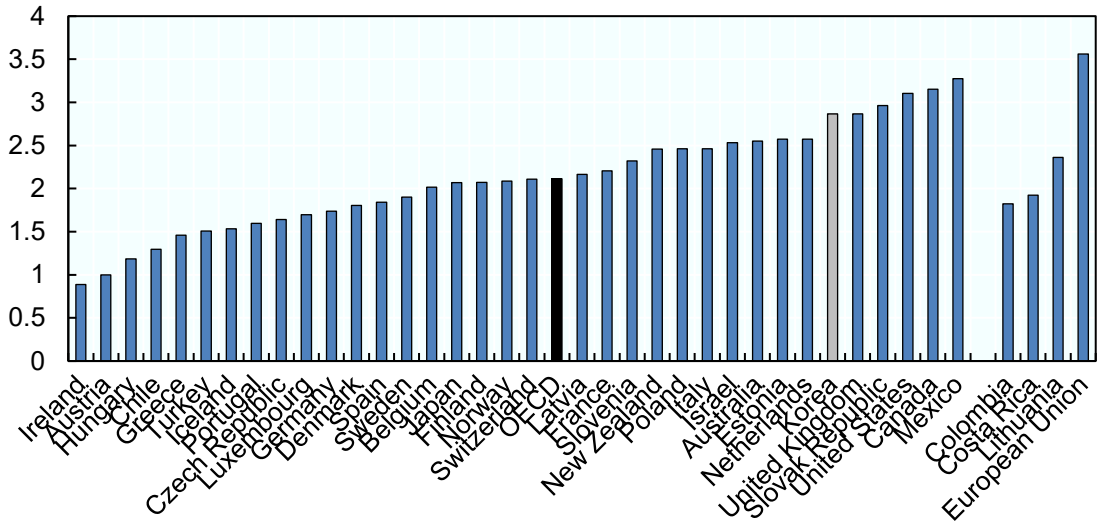
Korea's score on the OECD Stakeholder Engagement Index has significantly improved between the 2015 and 2018 Regulatory Policy Outlooks for both primary laws and secondary regulations for both primary laws and secondary regulations (Figure 3.2 and Figure 3.3) (OECD, 2018[5]).

Figure 3.2. 2018 Indicators of Regulatory Policy and Governance (iREG): Stakeholder engagement in developing primary laws



Notes: Data for OECD countries is based on the 34 countries that were OECD members in 2014 and the European Union. Data on new OECD member and accession countries in 2017 includes Colombia, Costa Rica, Latvia and Lithuania. The more regulatory practices as advocated in the 2012 Recommendation a country has implemented, the higher its iREG score. The indicator only covers practices in the executive. This figure therefore excludes the United States where all primary laws are initiated by Congress. *In the majority of OECD countries, most primary laws are initiated by the executive, except for Mexico and Korea, where a higher share of primary laws are initiated by the legislature.
Source: Indicators of Regulatory Policy and Governance Surveys 2014 and 2017, http://oe.cd/ireg.

Figure 3.3. 2018 Indicators of Regulatory Policy and Governance (iREG): Stakeholder engagement in developing subordinate regulations



Note: Data for OECD countries is based on the 34 countries that were OECD members in 2014 and the European Union. Data on new OECD member and accession countries in 2017 includes Colombia, Costa Rica, Latvia and Lithuania. The more regulatory practices as advocated in the 2012 Recommendation a country has implemented, the higher its iREG score.
Source: Indicators of Regulatory Policy and Governance Surveys 2014 and 2017, http://oe.cd/ireg.

In general, Korea's performance on stakeholder engagement relates to the greater use of online tools, which aim to create better information dissemination on issues relating to the country's regulatory policies. As an example, the Korean government has launched an online regulatory petition system in 2014, also referred to as the Regulatory Reform Sinmungo.

The general public as well as all stakeholders are engaged in the rule-making process. In particular, opinions of direct stakeholders are consulted even prior to drafting a bill. In accordance with the Framework Act on Administrative Regulations, the head of a central administrative agency shall sufficiently consult the opinions of stakeholders (such as administrative agencies, civic groups, research institutes and experts) when he intends to establish a new regulation or reinforce an existing one. This shall be conducted by means of public hearing and advance notice of the proposed legislation.

Despite these achievements, there have still been cases where lack of information and engagement of stakeholders and general public led to strong, sometimes unconstructive, citizen opposition to major government-promoted projects. During the fact-finding missions, stakeholders interviewed by the OECD Secretariat raised an issue of not being sufficiently informed on the purpose and impacts of government policies and regulations. Some of the stakeholders seemed not to be informed on the existence of RIA and the fact that RIA statements are published and accessible online. Better information on both goals of government policies and regulations but also on the regulation-making process and possibilities for stakeholders to participate in this process might lead to an increased trust in government and better perception of the quality of the regulatory framework among stakeholders.

4. Key policies and regulations

4.1. The objectives: the Air Quality Standards

Korea sets ambient air quality standards for seven major pollutants: SO_2, NO_2, CO, fine particulate matter (PM_{10} and $PM_{2.5}$), ozone, lead and benzene. Industry-specific emission standards are set for 29 substances. They have been progressively tightened every five years; the most recent ones went into effect in 2015. Even stricter emission standards can be applied to industrial complexes (as is the case for the Ulsan-Onsan and Yeosu industrial complexes) and other areas of severe air pollution designated as "air conservation special countermeasure areas".

Concentration limit values for most main air pollutants were established in 1978 and have been progressively tightened since. They are generally respected for SO_x, NO_x and lead, but more efforts are needed for fine particulates. PM_{10} concentration levels have respected the standard since 2011, but $PM_{2.5}$ concentration levels, for which standards have been applicable only since 2015, are still high. Although NO_2 and ozone concentration levels are under the limit value, they are increasing (MOE, 2016c).

The current air quality standards that have been applicable since 2011 are presented in Table 4.1.

Table 4.1. Air Quality Standards in Korea

Item		Standard
Sulfur dioxide gas (SO_2)		• Annual average of not more than 0.02ppm • 24-hour average of not more than 0.05ppm • Hourly average of not more than 0.15ppm
Carbon monoxide (CO)		• 8-hour average of not more than 9ppm • Hourly average of not more than 25ppm
Nitrogen dioxide (NO_2)		• Annual average of not more than 0.03ppm • 24-hour average of not more than 0.06ppm • Hourly average of not more than 0.1ppm
Fine particles	PM_{10}	• Annual average of not more than 50μg/m3 • 24-hour average of not more than 100μg/m3
	$PM_{2.5}$	• Annual average of not more than 15μg/m3 • 24-hour average of not more than 35μg/m3 (applicable from 2018)
Ozone (O_3)		• 8-hour average of not more than 0.06ppm • Hourly average of not more than 0.1ppm
Lead (Pb)		• Annual average of not more than 0.5μg/m3
Benzene		• Annual average of not more than 5μg/m3

Source: ECOREA (2015), Environmental Review 2015.

Over the past 15 years. Concentrations of SO_2, PM_{10}, and Pb are continuously decreasing, and this appears to be the outcome of the government's air quality management policies, including improvement

of Seoul Metropolitan air quality, increased supply of clean fuels such as low sulphur oil and LNG, supply of lead-free gasoline, and tighter emissions regulations. On the other hand, NO_2 and O_3 concentrations are yet to improve due to rising temperatures caused by climate change and increased number of vehicle registrations.

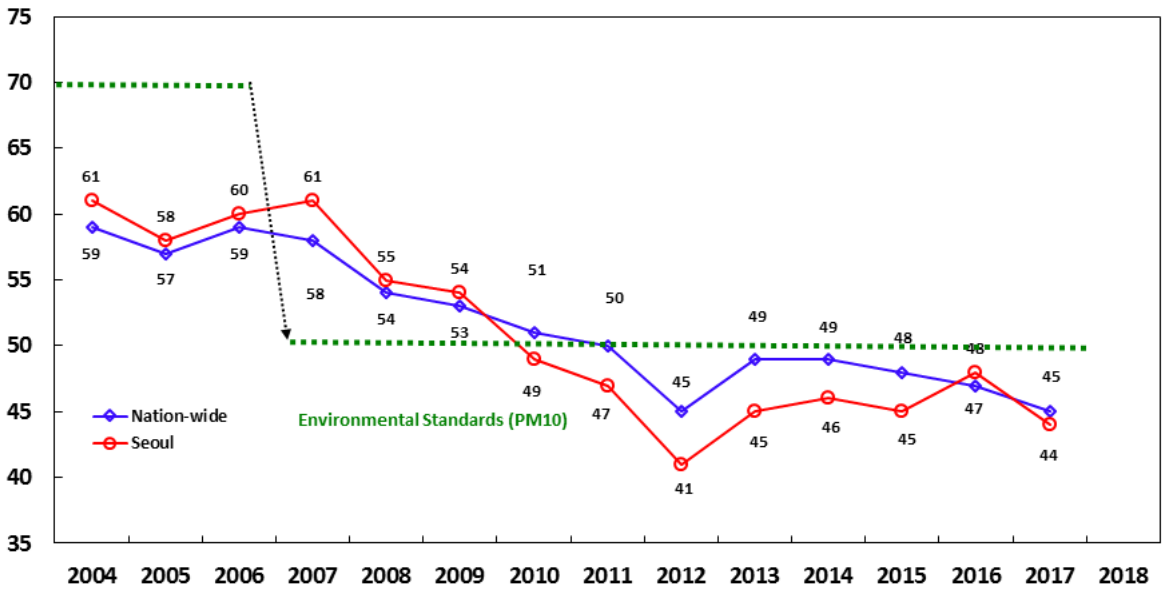
In terms of the national average air pollution level in 2017, the SO_2 concentration was 0.004ppm and has been maintained at less than one-third of the air quality standard of 0.02ppm for more than 10 years. At 0.024ppm, NO_2 has also been kept below the air quality standard of 0.03ppm strengthened in 2007. The atmospheric lead (Pb) concentration is 0.0120~0.0228μg/m3 (based on $PM_{10})_3$), which is only one-twentieth of the air quality standard of 0.5μg/m3.

Concentration targets for PM_{10} and NO_2 were also set by regional and municipal plans. In Seoul, PM_{10} concentrations significantly decreased from 61 μ/m3 in 2004 to 41 μ/m3 in 2012, but rebounded in 2013. Although NO_2 concentrations had decreased by 15% since 2004, Seoul did not reach that target by 2014, but all of the remaining regions achieved it.

As part of the new Comprehensive Plan on Fine Dust Management (CPFDM), Korea intends to tighten the air quality standards to be on par with other developed countries such as the US and Japan. The government strengthened the environmental and health standards, with a particular goal of protecting vulnerable groups. As of March 2018, the environmental standard for PM2.5 levels (24-hour average) was tightened from the current 50 μg/m3 to 35 μg/m3, and the threshold level to issue an alert was tightened from the current 90 μg/m3 to 75 μg/m3. In addition, a new standard will be introduced for indoor PM2.5 levels in buildings used mostly by vulnerable groups.

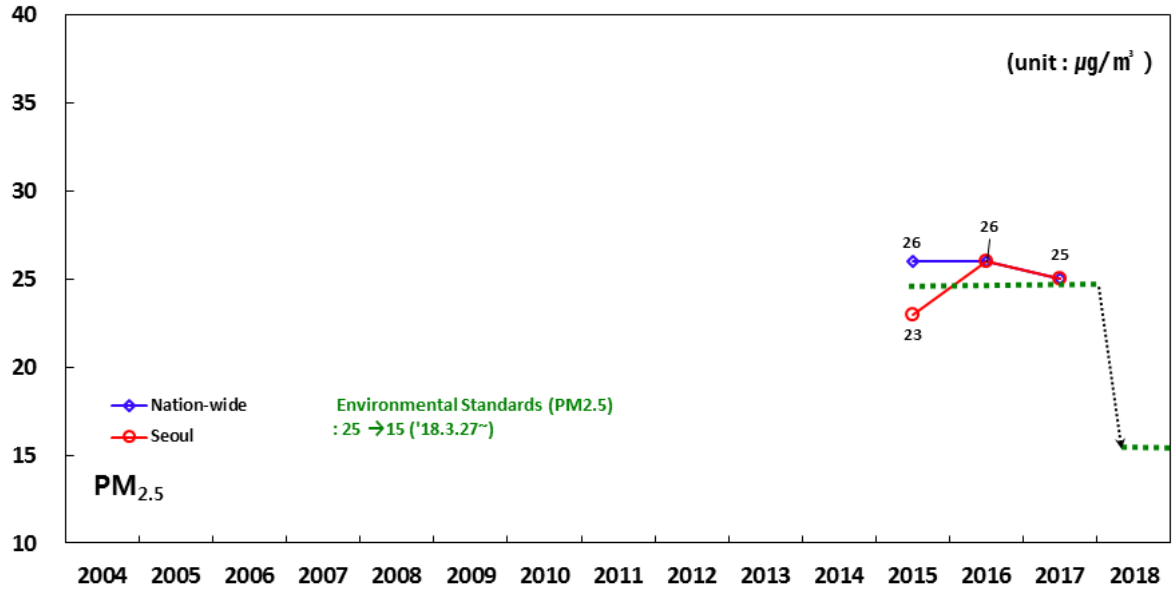
Korea's PM concentrations are exacerbated by transboundary particles. Korea has been actively participating in regional co-operation to monitor and mitigate transboundary air pollution (see the case study included in COM/ENV/EPOC/GOV/RPC(2018)1).

Figure 4.1. Koran air pollution level – PM10



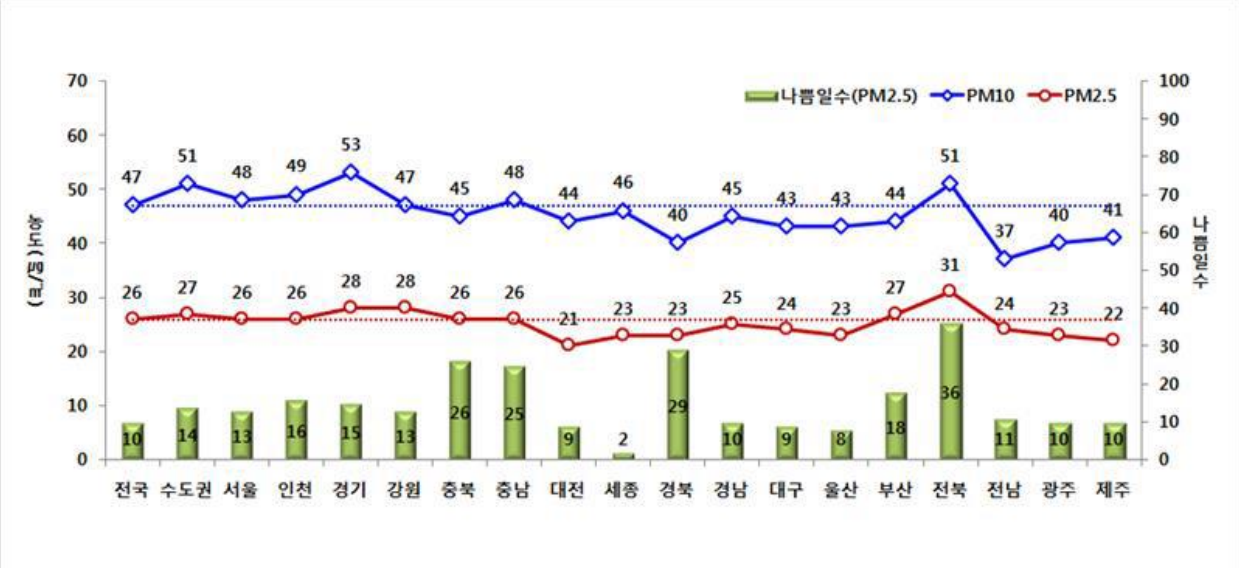
Note: **Blue**: Nation-wide / **Red**: Seoul / **Green**: Environment Standards.
Source: MEnv.

Figure 4.2. Korean air pollution level – PM2.5



Note: **Blue**: Nation-wide / **Red**: Seoul / **Green**: Environment Standards.
Source: MEnv.

Figure 4.3. PM pollution level in major cities and provinces (2016)

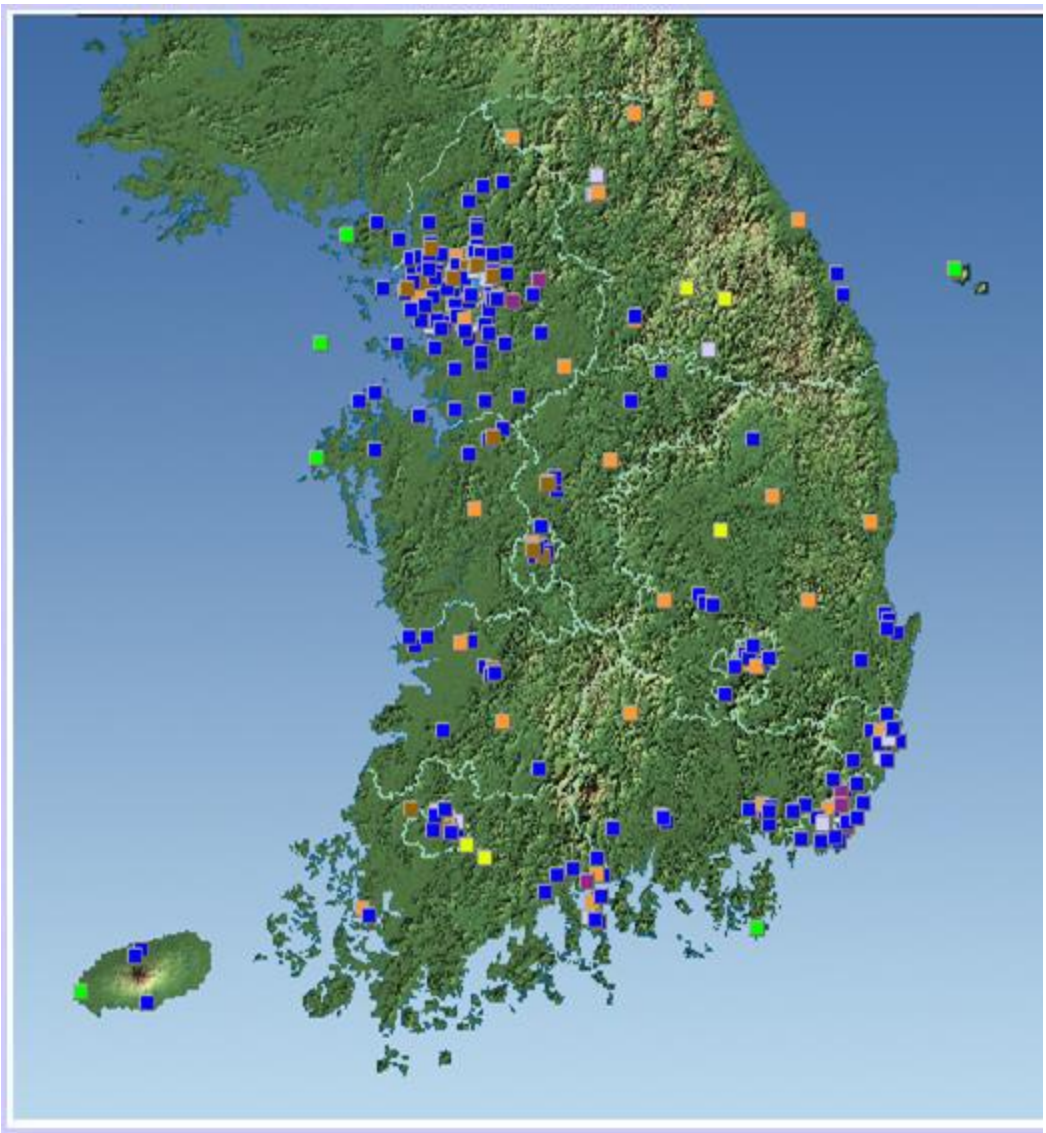


Blue: Nation-wide / **Red**: Seoul / **Green**: Environment Standards
•**PM2.5**: ('04~'14) unofficial measurements on five select cities / ('15~'17) official measurements
Source: Ministry of Environment.

4.2. Air quality monitoring

The National Institute for Environmental Research is monitoring concentrations of PM10, PM2.5 and Ozone in 19 regions through 469 sites four times a day (see Figure 4.4). Starting from data collection of global meteorological forecast data, the Institute produces a regional meteorological model, emission processing model and regional air quality model followed by source apportionment model for the following domains – Seoul Metropolitan Area, Korea and North East Asia. Based on the modelling, the Institute produces forecasts using numerical prediction and forecaster' subjective judgement. These data are available online to the general public.[1]

Figure 4.4. NAQF monitoring network



Source: NIER.

[1] https://www.airkorea.or.kr/index.

As part of the new Comprehensive Plan, the number of air quality monitoring stations near day care centers and primary to high schools will be increased. The scope of the air quality monitoring network will be significantly expanded in the vicinity of schools located in urban areas as well as around power plants. Additional monitoring equipment, such as portable monitoring devices and mobile monitoring vehicles, are planned to be supplied to support schools in securing their own daily air quality notification system with high accuracy.

In the long term, an air quality forecast and warning system that is based on artificial intelligence (AI) will be constructed. The government aims to build an AI air quality forecast system that combines big data technology, numerical forecast results, and machine learning technology. In addition, the government plans to invest KRW 7.95 billion by 2021 to develop the short-term (two-day) forecast system and to implement a pilot forecast project to finally complete the long-term (seven-day) forecasting system.

To accurately and realistically estimate administrative district level air pollutant emissions in Korea, a Korean Emissions Inventory System called the Clean Air Policy Support System (CAPSS) has been developed. In CAPSS, emissions factors for each classification category are collected from various domestic and international research reports, and the CAPSS utilizes various national, regional and local level statistical data, compiled by approximately 150 Korean organisations.

4.3. The tools: Policies and regulations to improve air quality

Korea's Constitution (Article 35) states that all people have the right to live in a healthy and pleasant environment. The country's environmental regulatory framework is made up of laws, enforcement decrees, ministerial decrees and regulations. Since 2006, many issue-specific environmental laws have been amended, notably those governing air, water and soil pollution, as well as EIA; and several important new laws have been adopted. Among others, Korea has implemented numerous measures to tackle air pollution.

4.3.1. Stationary sources

Since the Clean Air Conservation Act of 1990, industrial facilities have been subject to emission standards and charges, which can vary with the severity of the air pollution where the facility is located. However, these measures were insufficient to tackle Korea's serious air pollution challenge, so national and subnational air pollution plans were adopted: the first and second Comprehensive Plans for Air Quality Improvement (2006-15 and 2016-24) and the first and second Seoul Metropolitan Air Quality Control Master Plans (2005-14 and 2015-24) and recently the Comprehensive Plan on Fine Dust Management (2017-2022) to bolster efforts in the area most affected by severe air pollution.

The Clean Air Conservation Act, enacted in 1990, designates gaseous or granular materials that cause air pollution as "air pollutants" and requires them to be managed through monitoring and emission controls. There are 61 designated air pollutants, including carbon monoxide, ammonia, nitrates, and sulfates. Among these, substances that may be directly or indirectly harmful to human health or animal and plant growth and development in the event of long-term consumption or exposure, even at low concentrations, are designated and managed as "specified air pollutants." There are 35 types of specified air pollutants, including dioxins, benzene, chromium, and cadmium.

In addition, the Clean Air Conservation Act requires business facilities that produce fugitive dust (over 80% are construction businesses) to report to the local government and adopt preventive practices promoted by the government through continuous guidance, inspections and education.

Emission standards can be made more stringent by a municipal ordinance in designated "air quality control areas" and other areas where it is difficult to meet national or regional air quality standards (Box 4.1). For example, industrial installations emitting air pollutants in the Seoul Metropolitan Area are regulated by the

Special Act on the Improvement of Air Quality in Seoul Metropolitan Area (2003), which established an emission control regime as part of an air pollutant emission cap management system for the entire metropolitan area (Box 4.2).

The residential sector is a source of emissions, particularly from heating, cooling and appliance use. Many household boilers produce NOx emissions. According to the second national air quality plan, supports have been provided, since 2017, with households to replace their old boilers with low-NOx ones.

Box 4.1. Classification of areas with a special regime for air quality control

Air Quality Control Areas: Seoul Metropolitan City (all regions), Incheon Metropolitan City (excluding Ongjin-gun), Gyeonggi-do (Fourteen cities including Goyang-si), Busan Metropolitan City (excluding Gijang-jun), Gimhae-si (excluding Jinyeong-eup, Jangyu-myeon, Juchon-myeon, Jillye-myeon, Hallim-myeon, Sangdong-myeon, Daedong-myeon), Daegu Metropolitan City (excluding Dalseong-gun), site for Hadong Thermal Power Plant located in Hadong-gun, Gyeongsangnam-do, Gwangyang-si in Jeollanam-do (Bonggang-myeon, Ongnyong-myeon, Jinsang-myeon, Daap-myeon), Suncheon-si (excluding Seungju-eup, Juam-myeon, Songgwang-myeon, Oeseo-myeon, Nagan-myeon, Byeollyang-myeon, Sangsa-myeon, Hwangjeon-myeon, Woldeung-myeon), Yeosu-si (excluding Dolsan-eup, Hwayang-myeon, Nam-myeon, Hwajeon-myeon, Samsan-myeon)

Air Quality Control Region: Seoul Metropolitan City (all regions), Incheon Metropolitan City (excluding Ongjin-gun), Gyeonggi-do (Twenty-eight cities including Gimpo-si)

Regions having a population of 500 000 or more: Gwangju Metropolitan City, Daejeon Metropolitan City, Ulsan Metropolitan City, Yongin-si, Jeonju-si, Changwon-si, Cheonan-si, Cheongju-si, Pohang-si

Source: MEnv.

Since 2017, the government has reinforced volatile organic compounds (VOCs) emissions regulation for cities with a population of half a million or more. It also plans to gradually expand targets of the regulation depending on annual gasoline sales. In addition, it will increase the number of areas where installation of gasoline vapour recovery systems is obligatory to cities with a population of a half million or more, with a plan to provide financial support for installation costs. Other measures include prohibition of solid fuel use in regions that exceed or may exceed environmental standards (currently 20); mandatory clean fuel use in 37 regions for regional heating, cooling and power generation facilities, among others; and reinforcement of air quality monitoring networks (MOE, 2016c, 2015).

Since 2009, Korea has designated 37 VOCs, including acetaldehyde, benzene, and gasoline, and facilities that emit these substances are managed under regulations. In addition to managing emission facilities, regarding VOC content limits in paint, “organic compounds (excluding carbonic acid and carbonates, etc.) having a minimum boiling point below 250°C at 1 atm” are subject to controls. VOC content limits have been established for paint to reduce emissions from the use of organic solvents. The limits applied only to the Seoul Metropolitan region during the early stages of introduction but they were extended to the rest of the country in 2013.

Box 4.2. Cap-and-trade system for SOx and NOx in the Seoul Metropolitan Area

The Seoul Metropolitan Area air pollutant emission cap management system has been implemented since 2008 as part of measures to control metropolitan air quality. It allocates yearly emission allowances for nitrogen oxides (NOx) and sulphur oxides (SOx) to large facilities, requiring them to keep their emissions within the allowances and allowing them to trade any surplus allocations. Fines are imposed on facilities that exceed their total allocated emission amount and have not purchased adequate allowances to cover the excess emissions. The system initially covered 117 of the largest-emitting installations and has gradually been expanded to lower emitters; 295 facilities were participating by the end of 2013.

Allocations in the first year, 2008, were 2.3 times higher than emissions for NOx and 2.1 times higher for SOx, casting doubt on the system's effectiveness. However, allocations have since been continuously reduced, and in 2013 NOx and SOx allocations exceeded emissions by only 20%. Emission trading affected only 1.4% of NOx emissions and 0.5% of SOx emissions in 2008, but by 2013 the respective shares were 6% and 23%, at unit prices of KRW 285 000 per tonne of NOx and KRW 180 000 per tonne of SOx. Future allocations are expected to be assigned at the levels of actual emissions, further increasing demand for emission trading. Now that the system has been tested and shown to work, it could be expanded to other parts of the country with large industrial complexes.

The Seoul Metropolitan Air Quality Control Master Plan (2005-14), aimed at improving PM10 and NO2 concentrations to the levels of Tokyo, Paris and other major cities by reducing air pollutant emissions by half from 2001 levels by 2014. While air quality improved significantly over the period, the concentration targets were not achieved. In 2013, a second master plan (2015-24) was formulated, adding targets for PM2.5 and ozone. Measures to achieve these goals consist of motor transport management – including a project to reduce exhaust gas from vehicles in operation – and total emission load management for large installations.

Source: MOE (2015), Ministry of Environment, brochure, http://eng.me.go.kr/eng/file/readDownloadFile.do?fileId=115224&fileSeq=1&openYn=Y.

4.3.2. Mobile sources

Korea's air pollution plans have also introduced measures in the transport sector. Emission standards for fuel and automobiles have been strengthened. The government provides subsidies for the purchase of eco-friendly vehicles including electric cars and hydrogen cars, with an effort to significantly expand the nationwide charging infrastructures for better penetration of them. The government is trying to create low-emission zones, but stakeholder opposition makes this challenging.

Since the 1990s, vehicles have been commercialised in Korea and widely used by the public, contributing significantly to, in particular urban, air pollution. Nowadays, thanks to more stringent standards and regulations, cars are no longer the main cause of air pollution. The road and transport sector accounts for 12% of Korea's total emissions (39,005 ton) compared to business sites (38%) and non-road sectors including shipment, construction machinery, etc. (16%) Diesel cars are, however, the biggest contributor to PM emissions in large cities. In SMA, diesel cars account for 23% of PM emissions compared to construction machinery (16%), business sites (15%) and power plants (9%). Aged vehicles account for 31% or 9.27 million of all diesel cars but are responsible for 57% of annual PM emissions (18,887 ton out of 33,180 ton). In case of construction machinery, aged vehicles account for 36% or 177,000 of all construction machinery but are responsible for 61% of annual PM emissions (10,231 ton out of 16,823 ton). Gasoline cars are less of a contributing factor to air pollution than diesel cars. While in 2017, there were only 51 hydrogen cars on the market in Korea, in 2018 (by November), it was already 575. The goal

of the government, according to the Comprehensive Plan on Fine Dust Management is to have 15,000 hydrogen cars in the market and 150 hydrogen charging stations by 2020.

Korea has made considerable progress to strengthen vehicle emission and fuel efficiency standards. In 2009, it adopted California's "fleet average" system for non-methane organic gases (NMOG) from petrol fuelled vehicles, in which a carmaker can offer a range of models with different emission levels as long as its fleet meets a prescribed level of average NMOG emissions, which is lowered over time. Diesel vehicle emission standards follow the European example and were last updated in 2013. Since 2014, diesel emissions have been regulated under Euro 6 limit values. As studies have shown the results of real-driving tests of NO_x emission of diesel vehicles to be far worse than test-cycle measurements in laboratories, Korea introduced real-driving emission standards on top of existing in-laboratory standards in 2016 (MEnv, 2016a). Fuel regulations also apply; for example, the sulphur content of diesel and heavy fuel has been regulated since 1981, and standards have been continuously tightened. Since 2012, diesel fuel supplied throughout the country must have a sulphur content at or below 0.1% (MEnv, 2015).

Following the signature of Free Trade Agreements with the USA (2010) and with the EU in 2011, Korea has aligned its emission standards for vehicles with the norms valid in the EU and the USA (see Tables 4.1 – 4.7).

Table 4.2. Permissible Emission Standards: Gasoline cars and cars powered by gases

Model		Carbon monoxide (CO)	Nitrogen oxides (NOx)	Hydrocarbon (Exhaust gas) and nitrogen oxides (NMOG+NOx)	Hydrocarbon (CH)		Formaldehyde (HCHO)	Measure
					Blow-by-gas	Evaporation gas		
Light cars small passenger cars small trucks medium-sized passenger cars medium-sized trucks	Standard 1	2.61g/km or less	-	0.100g/km or less	0g/Single operation	0.35g/Test or less	0.0025g/km or less	CVS-75 mode
		5.97g/km or less	-	0.087g/km or less	-	-	-	US06 mode
		2.0g/km or less	-	0.062g/km or less	-	-	-	SC03 mode
	Standard 2	1.31g/km or less	-	0.078g/km or less	0g/Single operation	0.35g/Test or less	0.0025g/km or less	CVS-75 mode
		5.97g/km or less	-	0.075g/km or less	-	-	-	US06 mode
		2.0g/km or less	-	0.044g/km or less	-	-	-	SC03 mode
	Standard 3	1.06g/km or less	-	0.044g/km or less	0g/Single operation	0.35g/Test or less	0.0025g/km or less	CVS-75 mode
		5.97g/km or less	-	0.075g/km or less	-	-	-	US06 mode
		2.0g/km or less	-	0.044g/km or less	-	-	-	SC03 mode
	Standard 4	1.06g/km or less	-	0.031g/km or less	0g/Single operation	0.35g/Test or less	0.0025g/km or less	CVS-75 mode
		5.97g/km or less	-	0.075g/km or less	-	-	-	US06 mode
		2.0g/km or less	-	0.044g/km or less	-	-	-	SC03 mode
	Standard 5	0.625g/km or less	-	0.019g/km or less	0g/Single operation	0.35g/Test or less	0.0025g/km or less	CVS-75 mode
		5.97g/km or less	-	0.031g/km or less	-	-	-	US06 mode

Model		Carbon monoxide (CO)	Nitrogen oxides (NOx)	Hydrocarbon (Exhaust gas) and nitrogen oxides (NMOG+NOx)	Hydrocarbon (CH)		Formaldehyde (HCHO)	Measure
					Blow-by-gas	Evaporation gas		
		2.0g/km or less	-	0.012g/km or less	-	-	-	SC03 mode
	Standard 6	0.625g/km or less	-	0.0125g/km or less	0g/Single operation	0.35g/Test or less	0.0025g/km or less	CVS-75 mode
		5.97g/km or less	-	0.031g/km or less	-	-	-	US06 mode
		2.0g/km or less	-	0.012g/km or less	-	-	-	SC03 mode
	Standard 7	0g/km or less	-	0g/km or less	0g/Single operation	0g/Test or less	0g/km or less	CVS-75 mode
Large cars and trucks Extra-large passenger cars and trucks		4.0g/kW H or less	0.40g/kW H or less	0.14g/kW H or less	0g/Single operation	-	-	WHTC mode

Source: Data from MEnv.

Table 4.3. Average emission standards - Hydrocarbon (CH) and nitrogen oxides (NOx)

Year Type	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Light cars, small passenger cars (excluding multi-purpose motor vehicles weighing 1.7 ton or more), and small trucks weighing less than 1.7 ton	0.063 g/km or less	0.058 g/km or less	0.053 g/km or less	0.048 g/km or less	0.043 g/km or less	0.039 g/km or less	0.034 g/km or less	0.029 g/km or less	0.024 g/km or less	0.019 g/km or less
Small trucks weighing 1.7 ton or more, medium-sized trucks, medium-sized passenger cars, and multi-purpose small passenger cars weighing 1.7 ton or more	0.074 g/km or less	0.068 g/km or less	0.062 g/km or less	0.056 g/km or less	0.050 g/km or less	0.043 g/km or less	0.037 g/km or less	0.031 g/km or less	0.025 g/km or less	0.019 g/km or less

Source: MEnv.

Table 4.4. Permissible emission standards: Diesel cars

Model	Type	Carbon monoxide	Nitrogen oxides	Hydrocarbon and nitrogen oxides	Particulate matters	No. of particles*	Measure
Light cars and small passenger cars		0.50g/km or less	0.08g/km or less	0.17g/km or less	0.0045g/km or less	6×10^{11}#/km or less	ECE-15 and EUDC modes (WLTP)*
Small trucks, medium-sized passenger cars, and medium-sized trucks	RW≤ 1,305 kg	0.50g/km or less	0.08g/km or less	0.17g/km or less	0.0045g/km or less	6×10^{11}#/km or less	
	1,305 kg <RW≤ 1,760 kg	0.63g/km or less	0.105g/km or less	0.195g/km or less	0.0045g/km or less	6×10^{11}#/km or less	
	RW> 1,760 kg	0.74g/km or less	0.125g/km or less	0.215g/km or less	0.0045g/km or less	6×10^{11}#/km or less	
Large passenger cars and trucks, and extra-large passenger cars and trucks		1.50g/kW H or less	0.40g/kW H or less	0.13g/kW H or less	0.01g/kW H or less	8×10^{11}#/km or less	WHSC mode
		4.0g/kW H or less	0.46g/kW H or less	0.16g/kW H or less	0.01g/kW H or less	6×10^{11}#/km or less	WHTC mode

Note: * WLTP (Worldwide harmonized Light vehicles Test Procedure) introduced after 1 October, 2017.
Source: Data from MEnv.

Table 4.5. Permissible emission standards under real-driving conditions

Model	Type	Carbon monoxide	Nitrogen oxides	Hydrocarbon	No. of particles	Measure
Light cars, small passenger cars, and medium-sized passenger cars		-	0.168g/? or less	-	9×10^{11}	RDE-LDV
Small trucks, and medium-sized trucks	RW= 1,305?	-	0.168g/? or less	-	9×10^{11}	
	1,305? <RW= 1,760?	-	0.221g/? or less	-	9×10^{11}	
	RW> 1,760?	-	0.263g/? or less	-	9×10^{11}	
Large cars and trucks, and extra-large cars and trucks		6.0g/?H or less	0.69g/?H or less	0.24g/?H or less		PEMS

Source: MEnv.

Table 4.6. Permissible emission standards: Two-wheeled vehicles

Emissions from engine		Three-wheeled and four-wheeled	Engine displacement: 50 cc or less		Engine displacement: more than 50 cc	
			Maximum speed: less than 45 km/h	Maximum speed: 45 km/h or more	Maximum speed: less than 130 km/h	Maximum speed: 130 km/h or more
Carbon monoxide		2.00g/km or less	1.00g/km or less	1.14g/km or less	1.14g/km or less	1.14g/km or less
Hydrocarbon	Exhaust gas	0.55g/km or less	0.63g/km or less	0.38g/km or less	0.38g/km or less	0.17g/km or less
	Evaporation gas	-	-	-	-	2.0g/test or less
Nitrogen oxides		0.25g/km or less	0.17g/km or less	0.07g/km or less	0.07g/km or less	0.09g/km or less
Measure		ECE R40	ECE R47	WMTC	WMTC	WMTC

Source: MEnv.

Table 4.7. Permissible emission standards: Construction machinery

Engine output	Carbon monoxide		Hydrocarbon	Nitrogen oxides	Particulate matters	Measure
Less than 8 kW	8.0g/kW h or less		7.5g/kW h or less (Hydrocarbon and nitrogen oxides)		0.4g/kW h or less	NRSC mode and NRTC mode
8 kW or more and less than 19 kW	6.6g/kW h or less		7.5g/kW h or less (Hydrocarbon and nitrogen oxides)		0.4g/kW h or less	
19 kW or more and less than 37 kW	5.5g/kW h or less		4.7g/kW h or less (Hydrocarbon and nitrogen oxides)		0.03g/kW h or less	
37 kW or more and less than 56 kW	5.0g/kW h or less		4.7g/kW h or less (Hydrocarbon and nitrogen oxides)		0.03g/kW h or less	
56 kW or more and less than 130 kW	5.0g/kW h or less		0.19g/kW h or less	0.4g/kW h or less	0.025g/kW h or less	
130 kW or more and less than 560 kW	3.5g/kW h or less		0.19g/kW h or less	0.4g/kW h or less	0.025g/kW h or less	

Source: Data from MEnv.

Table 4.8. Permissible emission standards: Machinery for agriculture

Engine output	Carbon monoxide	Hydrocarbon	Nitrogen oxides	Particulate matters	Measure
Less than 8 kW	8.0g/kW h or less	7.5g/kW h or less (Hydrocarbon and nitrogen oxides)		0.4g/kW h or less	NRSC mode and NRTC mode
8 kW or more and less than 19 kW	6.6g/kW h or less	7.5g/kW h or less (Hydrocarbon and nitrogen oxides)		0.4g/kW h or less	
19 kW or more and less than 37 kW	5.5g/kW h or less	4.7g/kW h or less (Hydrocarbon and nitrogen oxides)		0.03g/kW h or less	
37 kW or more and less than 56 kW	5.0g/kW h or less	4.7g/kW h or less (Hydrocarbon and nitrogen oxides)		0.03g/kW h or less	
56 kW or more and less than 130 kW	5.0g/kW h or less	0.19g/kW h or less	0.4g/kW h or less	0.025g/kW h or less	
130 kW or more and less than 560 kW	3.5g/kW h or less	0.19g/kW h or less	0.4g/kW h or less	0.025g/kW h or less	

Source: MEnv.

4.3.3. Recent measures - The Comprehensive Plan on Fine Dust Management

When the new president and administration took office in 2017, the fight against fine dust became one of its top priorities. Accordingly, a package of fine dust countermeasures was announced in September 2017.

Air quality standards and monitoring

The Comprehensive Plan on Fine Dust Management (also known as “September 26 measures”) is much more ambitious than its predecessors in many respects, with the aim of cutting fine particulate emissions by 30 percent by 2022 across all sectors and decrease the number of “bad” air quality days by 180 (70%). For Seoul, the annual average level of PM2.5 concentrations is projected to decrease from 26 μ/m3 in 2016 to 18 μ/m3 in 2022.

The indoor air quality in buildings used by the groups that are vulnerable to air pollution will be monitored when fine dust concentrations are high. The government will provide financial support for elementary, middle, and high schools without gyms (5%, as of the end of 2017) to install indoor sports facilities, and schools, day care centers, and elderly care facilities to install air purifiers.

The government will start the “Visit and Care” service for vulnerable groups including elderly people who live alone. It will also construct a monitoring system for the diseases that are caused by fine dust and establish a system which will send air pollution alerts to citizens through text messages. Masks will be distributed to infants and young children. Response manuals will also be distributed, in order to guide people, especially those classified into vulnerable groups, to take proper steps according to air quality level and better respond to exposure to fine dust.

When fine dust concentrations reach high levels, emergency measures to reduce fine dust, such as alternate-no driving days and adjusted operating hours of businesses, are implemented. Currently, the emergency measures are applied mostly to the public sector in the SMA; however, they will be extended to private sectors and further outside the SMA.

To make these measures efficient, it is necessary to widen their application to other subjects than just the public sector and enforce them strictly. It might be useful to consider alternative methods, such as introducing circulation restrictions for more polluting and older cars rather than alternate days for all cars.

Strategic directions of the Comprehensive Plan

The Plan follows five strategic directions. First, it aims for an intensive fine dust control over "highly polluted areas." The "total emissions control" program, previously applied only to the Seoul Metropolitan Area, is now extended to cover virtually the entire country (including Chung-cheong, Dongman, and Gwang-yang), complete with a new charge on emissions of secondary pollutants such as nitrogen oxides (NOx).

Second, a holistic approach for fine dust reduction will be applied. The past measures dealt with each of the air pollutants without considering linkage between them in management; but the new plan will see precursors of PM2.5 as one of the targets to control and try to seek its own synergy with other national energy policies.

Third, international cooperation and joint actions will be promoted. Practical solutions for joint actions to practically reduce regional fine dust emissions will be developed and implemented.

Fourth, the Plan will concentrate on managing health risk and protecting people against fine dust. In particular, it aims to strengthen the management of indoor and outdoor activities during high-concentration episodes and provide public protection services for vulnerable groups.

Fifth, the science-based responsive capacity will be improved. The fragmented research results will be systematically integrated to enhance the accuracy of emissions inventory, and satellite or aircraft images will be applied for a 3-D analysis of fine dust.

The measures to be implemented under the framework of the Comprehensive Plan can be divided into two groups: short-term measures to be immediately pushed forward in the first half of 2018 and mid- to long-term measures to be completed by 2022, which is the last year of the Moon Jae-in administration. In a short-term, emergency reduction actions and health protection measures will be implemented with a high priority. In a mid- to long-term, more fundamental issues will be addressed through an intensive control over domestic emitters in four major sectors from power generation, industries, and transportation, to everyday surroundings, in parallel with the efforts to be made for international cooperation. (Ministry of Environment, 2018[1])

For an overview of measures included in the Comprehensive Plan, see Table 4.9.

Table 4.9. The Comprehensive Action Plan on Fine Dust – overview of measures

Categories		Major Strategies
Reduction of Local Emissions	1. Power Generation	Reduce the share of coal-fired power generation by shutting down of old coal-fired plants. Review the tax rate system for energy for generation use. Establish the "8th National Electricity Supply Plan" from an eco-friendly perspective. Increase the share of renewable energy.
	2. Industry	Extend the scope of targets of emissions cap regulation, and implement Total Suspended Particles (TSP) Emissions Cap Regulation. Introduce emission charges for NOx.
	3. Transportation	Reduce emissions from old, diesel vehicles, and expand the targets for driving restriction. Increase the use of eco-friendly vehicles including electric cars and hydrogen cars. Implement the "Bonus-Malus System (BMS)". Strengthen control over fine dust emissions from vessels and construction machines.
	4. Surroundings	Control intensively over blind spots in management such as construction sites and illegal incinerations. Distribute road-cleaning vehicles and extend urban forests.

Vulnerable Groups	5. Infrastructure and Services to Protect Vulnerable Groups	Formulate standards for indoor air quality in buildings mostly used by children. Strengthen monitoring networks in and around day care centers and schools. More indoor sports facilities installed in schools. Provide the "Visit and Care" service for vulnerable groups.
Solid Foundation for Policy Implementation	6. Solid Foundation for Scientific Management	Monitor air quality using environmental satellites, and strengthen the forecasting and warning system. Implement the national project (R&D) for PM reduction strategies.

Source: (Ministry of Environment, 2018[1]).

Stationary sources

There are plans to enact two Special Laws with a goal of improving fine dust management. First, the government enacted the Special Law on Fine Dust Reduction and Management in 2018 to support the implementation of the Comprehensive Plan and prevent health damages caused by fine dust pollution to vulnerable groups. The law includes paragraphs to specify implementation of emergency measures during an event of high fine dust levels; and control over operation of coal-fired power plants with a special focus of deteriorated plants for specific seasons when air pollution levels are rising.

Second, the Special Law on Air Quality Improvement of Air Quality Control Areas including the Seoul Metropolitan Area (tentative name) will be enacted in 2019 to extend the current scope of emissions cap regulation to the entire nation from the SMA. There are plans to designate the Chungcheong area (Dangjin, Taean, and others), Southeast Area (Ulsan, Changwon, and others), and Kwangyang Bay area (Yeosu, Kwangyang, and others) as an "Air Quality Control Area."

The core strategies for the power generation sector include decreasing the share of coal-fired power generation by re-evaluating new coal fired plants in the early stage of construction for their potential to convert them into eco-friendly sources for electricity production and thereby increasing the share of renewable energy sources in Korea's power generation mix. Accordingly, short-term and mid- to long-term measures were formulated with a goal of reducing emissions from this sector by 25% by 2022. This percentage corresponds to 12,511 tons of emissions, which account for 3.9% of the national total emissions.

The measures for the industrial sector include increasing the number of business facilities applicable to the emissions cap regulation and strengthening emissions monitoring to achieve an intensive and substantial emissions reduction. Accordingly, short-term and mid- to long-term measures were formulated with a goal of reducing emissions from this sector by 32% by 2022. This percentage corresponds to 52,791 tons of emissions, which account for 16.3% of Korea's total emissions. The standards for the management of fugitive VOCs (volatile organic compound) emissions from business facilities will be tightened. In addition, rules for checking VOCs loss or leakage will be introduced, for example, in gasoline storage facilities. The permissible level of the fugitive VOCs leaked from units (ex. valves, flanges, etc.) will be progressively tightened from the current 2,000ppm, to 1,000ppm in 2018-2019, and further lower levels on a gradual basis.

Mobile sources

Measures for the transportation sector are divided into two groups: on-road transportation sector and off-road transportation sector. The measures for on-road transportation focus on encouraging retrofitting of old diesel vehicles to lower their emissions and increasing the use of environmental-friendly vehicles, such as electric vehicles (EV) and hybrid vehicles (HV). The measures aim to reduce emissions from the transportation sector by 32% by 2022. This percentage corresponds to 28,984 tons of emissions, which account for 9% of Korea's total emissions.

Fine dust emitted from diesel vehicles will be reduced. The number of old diesel vehicles (manufactured before 2005) that are subject to the financial support for early scrapping will sharply increase by the government from 80,000 in 2017 and 110,000 in 2018, to 150,000 in 2019. In addition, on-going efforts are made to reduce burden of owners who plan to retrofit their vehicles for emissions reduction, such as revising rates of providing the subsidy. This aims at supporting the efforts of the transportation sector to lower exhausts. Emissions from the old trucks that come in and out of airports and harbours with a high frequency will be addressed by a reduction mandate and a financial support. Control over in-use vehicles and newly manufactured diesel vehicles will also be tightened. The government will toughen the permissible exhaust levels from 15% to 8% for a complete inspection and from 20% to 10% for a regular inspection. As is the case for large diesel vehicles, from now on newly manufactured, small diesel vehicles (weighing less than 3.5 tons) can obtain certification only after they pass the tests to show their compliance with the NOx standard both under a real-driving condition to be newly introduced and in laboratories. The Portable Emissions Measurement System (PEMS) will be utilized to check whether a newly manufactured vehicle satisfies the emissions standards before it is sold. For the in-use vehicle inspections for large buses that are older than six years, the Korea Transportation Safety Authority (KOTSA) takes responsibility as the sole executing agency to prevent ineligible inspection of the private sector.

Efforts will be made to encourage the use of environment-friendly vehicles. To achieve this, the government will enhance the support for electric and hydrogen buses. The obligated share of the purchase or lease of low-emissions vehicles to be given to public and administrative institutions will increase from the current 50% to 80% effective from 2021, as the first step to lead the wide use of environmental-friendly vehicles. Management over traffic demand will be improved as well. The government plans to designate “Green Transport Promotion Zones” where frequent traffic congestions have been reported.

The central government will support Seoul in promoting the special control areas within the Hanyang Doseong fortress walls. It also plans to increase the number of “Public-Transportation-Only Zones” (ex. Jungang-ro Street in Daegu and the Yonsei-ro Street in Seoul) where certain vehicles are prohibited from entering or subject to a fine.

Starting from 2021, a stricter exhaust inspection system will be operated, targeting diesel vehicles and two-wheeled vehicles. NOx emitted from small and medium-sized, in-use diesel vehicles will be controlled under close inspection that has already been applied to the other exhausts. The current scope of regular inspection will be expended to include small and medium-sized, two-wheeled vehicles with an engine size from 50cc to 260cc, in addition to large-sized, two-wheeled vehicles with an engine size of 260cc or bigger.

The current fragmented responsibilities for exhaust inspection will be progressively unified to an agency to eradicate arbitrary manipulation practices. In addition, the Clean Air Conservation Act will be revised to prevent the arbitrary manipulation of exhaust-related components or what is intended to cause damages to emissions reduction devices.

Measures for the off-road transportation sector are committed to strengthening the control over blind spots in management by reducing emissions from vessels and construction machinery. Accordingly, short-term and mid- to long-term measures were formulated with a goal of reducing emissions from the off-road transportation sector by 24% by 2022. This percentage corresponds to 12,360 tons of emissions, which account for 3.8% of Korea’s total emissions.

Diesel fuels having been used for mobile unloading equipment (yard tractors, 581 in total) at ports will be replaced with LNG by 2022. There are also plans to develop fine dust reduction devices for vessels and conduct pilot studies for their commercialization.

Construction machinery and diesel railway engines will be addressed to ensure low pollution with the government’s financial support and improvement in the relevant institutional systems. By 2022, 31,000 decrepit construction machinery (20% of the total decrepit machinery) will be retrofitted with low-pollution engines and the Diesel Particulate Filter (DPF).

The government will strengthen the management of emissions from ships and ports. Currently, only fuels with a sulphur content of 3.5% or less must be supplied to vessels, but this content standard will be tightened to 0.5% or less.

The measures to reduce fine dust from everyday surroundings focus on strengthening the management of emission sources in the sectors by increasing the number of road-cleaning vehicles and establishing a stricter standard for the VOCs content in paints. Accordingly, short-term and mid- to long-term measures were formulated with a goal of reducing emissions from everyday surroundings by 15% by 2022. This percentage corresponds to 8,987 tons of emissions, which account for 2.8% of Korea's total emissions.

The government plans to tackle re-suspended dust by installing a recessed flower bed on the road and changing the road design standards in a way that prevents inflow of sand and soil. In addition, the scope of target activities of construction that are required to declare fugitive dust will be expended to include farm land arrangement and remodelling businesses.

During the high fine dust concentration seasons, large-scaled construction sites, such as apartments, will be subject to intensive inspection to ensure proper installation and operation of dust layers and water spray facilities.

The management of VOCs at gas stations will be improved. In ten cities with a population of 500 000 or more, the progressively increasing number of gasoline vapour recovery systems will be installed at gas stations, accounting for annual gasoline sales volume.

Active steps will be promoted to root out illegal incineration. By 2021, 1,080 "Neighbourhood Recycling Stations" will be constructed for recycling and storage of solid wastes. The government also plans to increase the number of recycling stations in rural areas by 1,000 every year. In addition, the government aims to implement projects for the proper crushing and disposal of agricultural crop residues, most of which are currently disposed by illegal incineration.

Vulnerable groups protection

The new Comprehensive Plan aims to step up measures to protect citizens, particularly those classified in vulnerable groups, from fine dust in a pre-emptive way and issue an alert or warning to prevent health damages caused by air pollution. Accordingly, the government formulated the measures to introduce stricter standards for health protection, extend the scope of air quality monitoring network, and implement initiatives for the special management of outdoor and indoor activities. For example, more indoor sports facilities will be installed and students in primary to high schools are encouraged to refrain from outdoor activities when fine dust levels are high.

The government strengthened the environmental and health standards, with a particular goal of protecting vulnerable groups. The environmental standard for PM2.5 levels (24-hour average) were tightened from the current 50 μ/m3to 35 μ/m3, and the threshold level to issue an alert was tightened from the current 90 μ/m3to 80 μ/m3and 70 μ/m3. In addition, a new standard will be introduced for indoor PM2.5 levels in buildings used mostly by vulnerable groups.

Implementation

The measures to strengthen the foundation for implementing fine dust management policies emphasize a systematic and holistic approach, stepping forward from the past individual and fragmented plans. A focus is given to enhancing the capacity to respond to fine dust with the science-based infrastructure including national R&D initiatives and satellite observation technologies, and securing the foundation to respond to fine dust by enacting the Special Law on Fine Dust.

In addition, to ensure practicability of the measures, each ministry will conduct a self-evaluation on its own progress in fine dust reduction and implementation of the plan. The Office for Government Policy

Coordination will conduct final check and evaluation on the plan, supported by external advisories. The self-evaluation and feedback system will support the modification or complementation of measures. If necessary, new projects will be added.

In addition, with the "Special Act on Fine Dust Reduction and Management" to be enacted in Feb 2019, the government will establish the Committee on Fine Dust Special Measures that will be composed of private sectors including experts from power generation and industries and civil societies and public officials of related ministries. This Committee will take the role as a "control tower" for deliberation and coordination of fine dust issues which are identified government-wide.

International Cooperation

The Comprehensive Plan aims to lead actual air quality improvement through the collaboration. Accordingly, the government plans to promote the Korea-China bilateral cooperation and mobilize joint efforts based on the results of research collaboration that has long been continued with a more technical support. It also puts an emphasis on close regional cooperation with neighbouring countries in North East Asia. The government also plans to carry forward demonstration projects for environmental technologies.

The government plans to actively seek for a way to conclude an international agreement among East Asian countries on a cooperation for the mitigation of regional air quality such as North-East Asia Clean Air Partnership (NEACAP). It will also lead more collaboration activities through established Korea-China-Japan cooperation action channels (e.g., Tripartite Environmental Ministers Meeting (TEMM), Tripartite Policy Dialogue on Air Pollution (TPDAP)) and other multilateral channels of the regional community of North-East Asia.

4.3.4. Permitting

Managing air-pollutant-emitting facilities

As of 2017, Korea has at least 58,000 air pollutant-emitting facilities, which are managed by the following key measures.

The first is a permit and reporting system regarding the installation and modification of emission facilities. Any facility that emits specified air pollutants or is installed in an air conservation special countermeasure area must obtain a permit, and other facilities must be reported.

The second is the progressive tightening of, and an advance notice system on, permissible emission levels. Permissible emission levels have been specified for 29 substances; they are being progressively tightened after accounting for the development rate of industrial technologies and reduction ability and advance notices are given to allow establishments to prepare ahead of time. The advance notice system began with an announcement in 1991 regarding tightened permissible emission levels applicable from 1995. Since then permissible emission levels have been progressively tightened in 1999, 2005, and 2010. The tightened permissible emission levels applicable from January 1, 2015 were announced on December 31, 2012.

Third, emission facilities are particularly strictly managed in heavily polluted regions. Even stricter permissible emission levels can be applied to industrial complexes and other areas of severe air pollution that have been designated as "air conservation special countermeasure areas." Such strict permissible emission levels are currently applicable to the Ulsan-Onsan Industrial Complex and Yeosu Industrial Complex. Moreover, permissible emission levels may be tightened by a municipal ordinance in designated "air quality control areas" and other regions where it is difficult to meet national or regional air quality standards.

Fourth, emission facilities are provided with continuous guidance and inspections to ensure the appropriate operation of emission facilities and prevention facilities. Failure to operate prevention facilities without legitimate circumstances or installation of bypass ducts to discharge pollutants without passing through a prevention facility is subject to prosecution and administrative disposition, such as suspension of operation.

Fifth, emission of pollutants in excess of permissible emission levels is addressed by an improvement mandate and emission charges. There are two types of emission charges: the “basic charge” is imposed according to the quantity and concentration of pollutants emitted within permissible emission levels, and the “excess charge” is imposed on emissions in excess of permissible emission levels. The basic charge is currently imposed on sulphur oxides and dust, and the excess charge is imposed on nine types of pollutants, including sulphur oxides, ammonia, and dusts. Nitrogen oxides are not subject to the basic charge, but its inclusion is under review (ECOREA, 2015).

For the moment, local governments are responsible for issuing and inspecting environmental permits.

Similar to the pollution control manager system introduced in Japan in the 1970s, Korea introduced in the 1990s a system of environment engineers - technicians capable of measuring air pollutant data on the site and of proposing counter-proposals in the case of environmental emergencies. Five classes of certification of environment engineers exist, level 1 being the highest. Level 1 engineers manage facilities which emit over 80 tonnes pollutants a year. Hiring an environment engineer is obligatory for pollutant-emitting facilities, depending on their class.

Pollutant-emitting facilities need to be able to check their emission levels. Periodicity of emission checks depends on the type of facility, e.g. weekly emission checks for Class 1 facilities and bi-monthly ones for Class 2 facilities. Emission charges apply when facilities exceed their permitted emission levels. The charge is calculated depending on the pollutant substance. The permissible emission level is differentiated depending on the technologies used, pollutants emitted, year of establishment, etc. Data tampering is a criminal offence and can be detected through random, unannounced inspections.

Facilities should present their self-improvement plans if they find out that they have exceeded emission levels. Based on the self-improvement plans, inspectors provide advice for improvements. In case of more serious violations, they also issue orders on how to improve the situation.

Environmental permitting reform

Korea is undertaking a major environmental permitting reform, moving from issue specific to integrated permitting for large industrial installations. The existing system has 10 environmental permits prescribing uniform emission limit values (ELVs) for each activity sector, with permitting procedures involving multiple authorities and 73 types of documents.

Any facility with a potentially significant air emission or wastewater discharge, for instance, must obtain a permit from, or file a report with, the local government. The regulatory regime depends on whether the facility would release any specified hazardous air or water pollutants, or is located in an environmentally sensitive area. Self-monitoring requirements are more stringent for permitted facilities.

The new integrated permitting system, inspired by the EU system of integrated pollution prevention and control (IPPC) and following best international practices, is being introduced following adoption of the Act on Integrated Management of Environmentally Polluting Facilities in December 2015. It entered into force in January 2017, starting with power generation, steam supply, and waste management sectors.

The new system will be applied to 19 industry sectors once the regulatory framework is complete. Best available techniques (BAT) will be identified for each sector by technical working groups and specified in BAT reference documents (K-BREFs, an analogue of EU BREFs, which are also prepared and revised through a robust technical expert process), taking into account potential compliance costs and economic

feasibility. Industries participate directly in technical working groups to select and periodically review K-BREFs.

K-BREFs with ELVs for the power generation, steam, and waste management sectors were completed in 2014 and distributed in December 2016; the ones for steel manufacturing, non-ferrous metals manufacturing and organic chemicals industries were developed in 2015 and distributed in December 2017. Seventeen K-BREFs are expected to be developed by 2021. Existing industrial facilities will be given a four-year grace period. Mechanisms to link integrated permitting and environmental impact assessment, to avoid duplication between them, are being considered.

The reform is expected to reduce the administrative burden by combining medium specific permits into one through a single procedure involving online applications. The MEnv is expected to become the sole competent authority for issuing integrated permits and controlling compliance with them. An Integrated Permitting System Division was newly established within the ministry. There are on-going efforts to strengthen the foundation for issuance of integrated permits and implementation capacities.

An online integrated environmental permitting system was established in 2017 to provide technical information and application support. Permits will be reviewed and revised every five to eight years. Unlike in the existing system, the integrated environmental management will require facility operators to disclose information on permit application and decision and annual reports.

This reform will not affect industrial activities with low environmental impact – mostly small and medium-sized enterprises (SMEs). The administrative burden of current issue-specific permitting is particularly heavy for SMEs, which have little in the way of human resources and technical capacity. To simplify the regulatory regime for low-risk installations, Korea may consider replacing multiple permits with sector-specific general binding rules (GBRs), as other OECD countries have done.

4.3.5. Taxes and other market-based instruments

Korea applies taxes on actual emissions of pollutants, with some exceptions, e.g on emissions below 30% of the permissible emission standards. The charge is calculated according to the following formula: Charge per kg of pollutant * Quantity of pollutant exceeding the standard * Coefficient in the ratio of excess emission over standard * Coefficient of the frequency of violation, etc.

According to the Comprehensive Plan, the tax rate system will be modified in order to take into account social costs of fine dust and other pollutants caused by each type of generation fuels (e.g. bituminous coal, LNG, and others). Currently, the individual consumption tax per kilogram of LNG (KRW 60) is twice as high as that of coal (Bituminous coal: KRW 30).

4.3.6. Voluntary agreements and corporate social responsibility

The ministry makes extensive use of various kinds of voluntary agreements to address key environmental issues in a non-regulatory manner. Voluntary agreements help industry to either avoid additional regulation or better prepare for it, and to improve relations with affected communities. Examples of such agreements include two four-year regional agreements in the Kwangyang Bay and Ulsan areas that have engaged 40 companies in voluntarily designing and implementing their own reduction plans for particulate matter, SOx, NOx and volatile organic compounds (VOCs):

A 2012 sector-wide agreement with the shipbuilding industry (six companies) targeted VOCs and a 2014 agreement with 26 cement, power generation, and steel and iron manufacturing firms focused on voluntary cuts in SOx, NOx and particulates. Overall, the pledged reductions would amount to about 1% of the country's emissions of these pollutants.

4.3.7. Environmental management system certification and awards

The Green Enterprise certification programme was established in 1995 and converted in 2010 into a statutory programme under the Environmental Technology and Industry Support Act. The MEnv, through its regional offices, designates as Green Enterprises businesses that undertake substantial voluntary reductions of pollutant releases, carry out resource and energy saving measures, improve their products' environmental characteristics, adopt environmental management systems (EMS), etc.

Green Enterprises can submit a declaration instead of applying for a permit, are exempted from periodic inspections and are subject to more lenient penalty rules, which are important regulatory incentives for going beyond environmental compliance. The MEnv periodically reviews a company's Green Enterprise designation and can cancel it if the company's environmental performance deteriorates.

5. Monitoring and enforcement of regulations

5.1. Monitoring

5.1.1. Stationary sources

The SmokeStack Tele-Monitoring System (TMS) constantly measures air pollutants emitted by major industrial emitters through remote automatic sensing equipment. Automatic sensors installed in smokestacks continuously measure seven types of air pollutants (dust, SO_2, NO_x, NH_3, HCl, HF, and CO) to produce data every 5 minutes and 30 minutes. The SmokeStack TMS was first installed in the special countermeasure area of the Ulsan-Onsan Industrial Complex, and as of the end of June 2018, it has been installed in 1,696 smokestacks of 635 major industrial emitters nationwide. Construction of control centres to collect measurements began in 1998, and a total of four control centres have been completed in each region. The transmitted data is also used as administrative material for emission charges and administrative dispositions.

According to the Plan, the Total Suspended Particles (TSP) Emission Cap Regulation will be applied starting with common combustion facilities located in in the Seoul Metropolitan Area by 2018, and the applicable facilities will be increased on a phase-in basis. The applicable facilities (first to third group of the cap regulation) are obliged to install the SmokeStack TMS. The TSP Cap is a subset regulation under the Seoul Metropolitan Air Pollutant Emission-cap Management System. Three facility groups will be subject to the TSP Cap, starting with the first group of common combustion facilities from 2018 (108 generation and incineration facilities). Processing combustion and non-combustion will be added later in 2019.

Based on its stable operation over the years, the SmokeStack TMS has been the foundation of the Seoul Metropolitan Air Pollutant Emission-cap Management System from 2007. It is also expected to play a fundamental role in the emissions trading scheme to be introduced in the future.

The Clean Air Conservation Act requires establishments that produce fugitive dusts, or dust emitted directly into the air without a specific outlet, to be reported to the local government. As of the end of 2013, a total of 37,131 fugitive dust-producing establishments have been reported, and 82.4% of these were construction businesses. Compared to other air pollutants, fugitive dusts are more noticeable by the public and give rise to many civil complaints. Accordingly, efforts are being made to reduce fugitive dusts in an effective manner through continuous guidance, inspections, and education.

Fugitive dust-producing establishments are required to install dust control facilities or take the necessary action to inhibit fugitive dust production, and any violation is subject to implementation mandates, fines, prosecution, and other administrative dispositions. Special inspections are carried out on fugitive dust-producing establishments throughout the country each year in spring when fugitive dusts become common due to active construction work and dry weather. In 2013, local governments carried out special inspections on a total of 12,589 establishments, identified 868 violating businesses, and took administrative action, including prosecution, fines, and improvement mandates. Any construction business that is fined due to

failure to address fugitive dusts is penalized in bidding eligibility evaluations for government-funded construction projects to ensure strict fugitive dust management.

Mobile sources

Currently, car manufacturers and car importers have to obtain certification for importing or selling cars meeting standards that are similar to the ones applied in the USA. The administration counter-checks the data provided as part of the vehicle certification process through in-depth inspections. To verify the compliance of permissible emission levels, tests are conducted by the manufacturer on selected sample cars in its in-house test facility, and the test results are reviewed by the administration for certification. Documents are reviewed to confirm the technical feasibility (structure, function, durability, etc.) of components related to emissions and noise. Certification tests are conducted to verify motor vehicle manufacturers' compliance with permissible emissions and noise levels. A certain quantity is sampled and tested in proportion to the quantity of the imported batch (e.g. one out of ten vehicles is subject to the clearance process at the same point of time). Random inspections are also carried out to measure the emissions trends and the noise levels even before the vehicles are put on sale.

PEMS (Portable emission measurement system) devices are installed on large diesel vehicles since 2016, to measure NOx and fine dust emissions. Since October 2017, they have been installed on small- and medium- diesel vehicles certified after this date for the emissions control. Since October 2018, Korea has implemented a real-driving emissions test system for all vehicles including small and medium sized diesel vehicles prior to vehicles entering the market. After the VW scandal, there is a concern that indoor laboratory tests are not enough to exactly identify real-driving emissions status and to carry out strict emissions control.

According to the Air pollution Conservation Act, car owners have to make regular inspections of their vehicles including emissions. Random inspections (outdoor inspections) with a non-load method on parked or stored vehicles at roads, parking lots, and garages also have been taking place since 1992. In-use motor vehicles are inspected to verify their compliance with permissible emissions levels, and when determined not to be in compliance with the permissible emission levels, an order for improvement is issued. The non-compliance rate was 1.9% in 2011, 2.0% in 2013, went down to 0.6% in 2015 and up again to 1.7% in 2016 and 1.8% in 2017.

Emissions levels of in-use vehicles are measured using remote sensing devices (RSD) from February 2013. Gasoline cars and cars powered by gases in the Seoul Metropolitan Area, regions surrounding five metropolitan cities, and cities with a population of half a million are currently being checked, and the authorities are considering extending the scope of targets to include diesel vehicles.

In regions which are not covered as targets for the in-depth exhaust inspections, periodic inspections are conducted, in addition to safety inspections under the Motor Vehicle Management Act together with exhaust inspections (non-load test) under the Clean Air Conservation Act. (Non-compliance rates: 1.8% in 2013, 2.0% in 2014, 1.9% in 2015, 2.2% in 2016 and 2.1% in 2017).

In Air Quality Control Areas and regions having a population of 500,000 or more, stricter permissible emissions levels for in-use vehicles and more in-depth inspection methods are applied compared to those in periodic inspections with the following non-compliance rates Table 5.1:

Table 5.1. Non-compliance rates with in-depth inspections

Year	Non-compliance rate (%)		
	Diesel cars	Gasoline cars	LPG
2013	17.5	2.4	4.0
2014	18.4	2.3	4.0
2015	16.8	2.8	4.6
2016	15.2	2.2	3.9
2017	13.6	1.7	3.6

Source: MEnv.

Table 5.2. Summary of emissions inspection of in-use vehicles

	Constant inspection		Periodic inspection	In-depth inspection (Comprehensive inspection)
	Street patrol	Remote patrol		
Legal basis	Clean Air Conservation Act (Article 61)	Clean Air Conservation Act (Article 61)	Clean Air Conservation Act (Article 62)	Clean Air Conservation Act (Article 63) and Ordinances of si (city) and do (province)
Enforced region	Nationwide	Regions subject to in-depth inspection	Regions exempt from comprehensive inspection	Air Quality Control Areas and regions with a population of 500 000 or more (Seoul Metropolitan Area, five metropolitan cities, Cheonan, Cheongju, Jeonju, Changwon, Pohang, Gimhae)
No. of inspected vehicles	Approx. 22.53 million (as of 2017)	Gasoline cars and cars powered by gases in regions subject to in-depth inspection	5.68 million (as of 2017)	5.04 million (as of 2017)
Inspection cycle	All vehicles running on street instructed to stop on roadside and undergo inspection regardless of vehicle age	All vehicles running on street inspected without stopping regardless of vehicle age	? Passenger cars: Every two years from the fourth year of registration ? Vans and trucks: Every 6-24 months from the 1st-2nd year of registration	? Passenger cars (for personal purposes): Every two years from the sixth year of registration ? Vans and trucks (for business purposes): Every year from the 3rd-4th year of registration
Inspection type	Same as periodic inspection	Same as items covered by in-depth inspection	? Non-loaded test - Gasoline cars : CO, HC, air ratio - Diesel cars: Exhaust fume	? Loaded test - Gasoline cars : CO, HC, NOx - Diesel cars: Exhaust fume, engine output, NOx

Source: MEnv.

Notwithstanding the efforts, results do not seem to be fully satisfactory yet and issues remain. According to the MEnv, sanctions should be bigger for companies that do not comply as the penalties so far have been too low and not dissuasive enough.

5.2. Inspections and compliance assurance

Korea has made significant progress in increasing local inspection and enforcement capacity and strengthening related national supervision and evaluation mechanisms. The central and local governments have been reinforcing their compliance assurance programmes to better detect and deter non-compliance. The national government is also actively promoting voluntary compliance and adoption of green business practices.

5.2.1. Environmental inspections

Compliance monitoring responsibilities for air pollutants-emitting and water pollutants-discharging facilities were transferred from the MEnv to local governments (the authority that issues a permit also monitors compliance with it) in 2002.

Local environmental officers are appointed by the head of the jurisdiction (e.g. mayor) and given responsibilities for issuing permits for local environmental pollutants-emitting facilities, guidance and inspection, and administrative measures. The environmental officer may be dismissed in case of perceived incompetence also by the head of the jurisdiction. More clear and transparent rules for appointing the heads of environmental inspections could strengthen the independence of inspections and therefore decrease potential risks of influencing inspections towards political goals of the local leadership, though there is no hard evidence that this has been the case in the past.

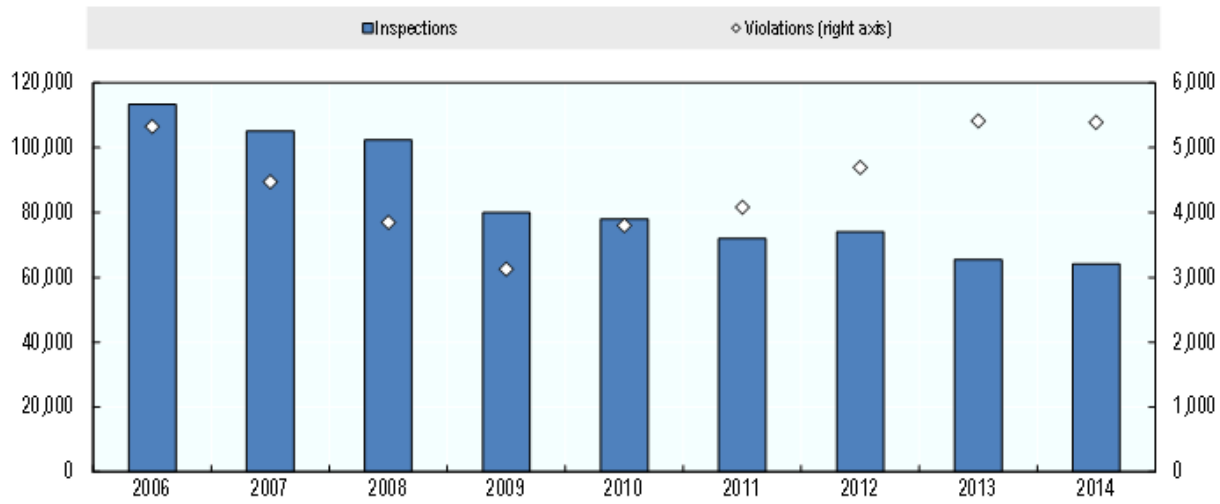
To prevent that and ensure the quality of inspections, there are cross-checks between the central and local governments of the inspections carried out by the latter. Local governments report the outcomes of inspections to the central government. The cross checking is based on feedback transmissions across levels of governments due to real time data exchange, which consists of both emission data collected directly from facilities and ambient air quality data generated by the local monitoring stations.

Figure 5.1 presents the number of local authority inspections and identified violations in 2006-14. Although the frequency of site visits fell – after a tele-monitoring system for air and water pollution from large facilities was introduced and inspections were focused on recidivist violators, but also due to resource constraints – the detection rate (the ratio between the number of detected offences and the number of inspections) grew steadily from 4.7% in 2006 to 8.4% in 2014. This proves that focusing inspections on those regulated subjects presenting higher risks (either because of the overall level of emissions or because of the bad record of non-compliance) makes inspections more efficient.

To further increase detection rates, the MEnv is encouraging local authorities to conduct more frequent random inspections. However, many municipalities do not have sufficient resources to do so. Local governments also rely on civil environmental monitoring groups to signal visible offences.

Figure 5.1. Inspections decreased but detection of violations by local governments rose

Total number of violations and inspections by local governments, 2006-14



Source: Country submission.

Inspections take place 2-3 times per year, without previous notice. Recently, new technologies like drones have been used to inspect emissions from polluting facilities. These technologies have improved significantly the number of facilities being inspected. In accordance with the OECD Best Practice Principles for Regulatory enforcement and Inspections, better targeting of inspections (Box 5.1), the number of random inspection may increase for facilities with previous records of non-compliance. Better targeting of inspections, based on the level of environmental risk of individual facilities, would help make compliance monitoring more efficient. It is, however, not clear, to what extent local governments have sufficient capacities to conduct proper risk assessment and risk-management. Further guidance from the centre on how to target inspections might be advisory.

Box 5.1. The OECD Best Practice Principles for Regulatory Policy: Regulatory Enforcement and Inspections

The OECD "Best Practice Principles for Regulatory Enforcement and Inspection" address the design of the policies, institutions and tools to promote effective compliance. These are based on extensive review of practices in OECD and non-OECD countries and are intended to represent an overarching framework to support initiatives to improve regulatory enforcement (OECD, 2014[89]). The principles are:

1. Evidence based enforcement. Regulatory enforcement and inspections should be evidence-based and measurement-based: deciding what to inspect and how should be grounded on data and evidence, and results should be evaluated regularly.
2. Selectivity. Promoting compliance and enforcing rules should be left to market forces, private sector and civil society actions wherever possible: inspections and enforcement cannot be everywhere and address everything, and there are many other ways to achieve regulations' objectives.
3. Risk focus and proportionality. Enforcement needs to be risk-based and proportionate: the frequency of inspections and the resources employed should be proportional to the level of risk and enforcement actions should be aiming at reducing the actual risk posed by infractions.
4. Responsive regulation. Enforcement should be based on "responsive regulation" principles: inspection enforcement actions should be modulated depending on the profile and behaviour of specific businesses.
5. Long term vision. Governments should adopt policies on regulatory enforcement and inspections: clear objectives should be set and institutional mechanisms set up with clear objectives and a long-term road-map.
6. Co-ordination and consolidation. Inspection functions should be co-ordinated and, where needed, consolidated: less duplication and overlaps will ensure better use of public resources, minimise burden on regulated subjects, and maximise effectiveness.
7. Transparent governance. Governance structures and human resources policies for regulatory enforcement should support transparency, professionalism, and results-oriented management. Execution of regulatory enforcement should be independent from political influence, and compliance promotion efforts should be rewarded.
8. Information integration. Information and communication technologies should be used to maximise risk-focus, co-ordination and information-sharing – as well as optimal use of resources.
9. Clear and fair process. Governments should ensure clarity of rules and process for enforcement and inspections: coherent legislation to organise inspections and enforcement needs to be adopted and published, and clearly articulate rights and obligations of officials and of businesses.
10. Compliance promotion. Transparency and compliance should be promoted through the use of appropriate instruments such as guidance, toolkits and checklists.
11. Professionalism. Inspectors should be trained and managed to ensure professionalism, integrity, consistency and transparency: this requires substantial training focusing not only

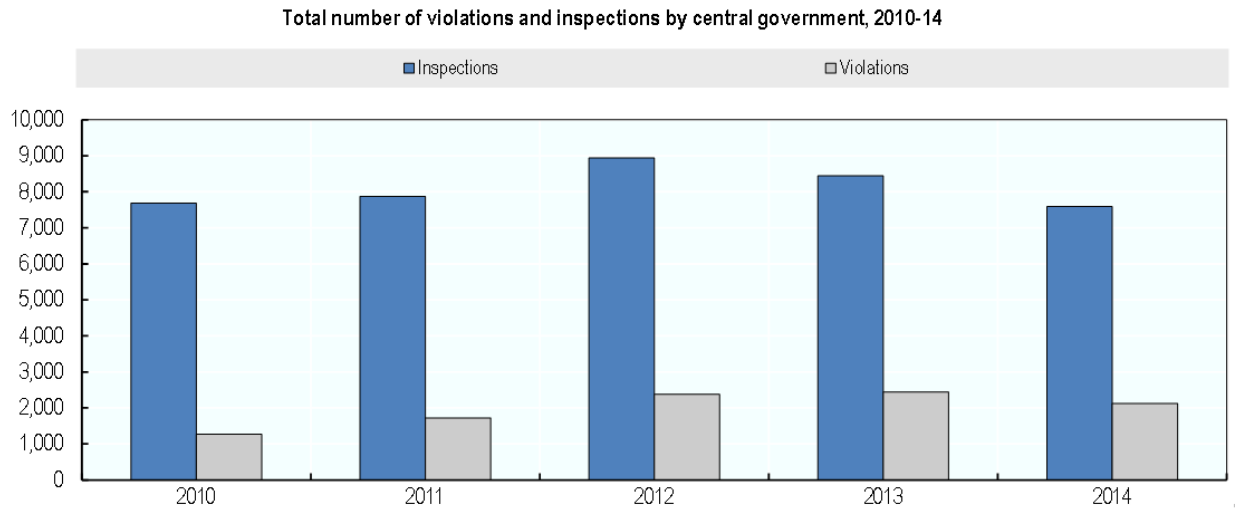
on technical but also on generic inspection skills, and official guidelines for inspectors to help ensure consistency and fairness.

Source: OECD (2014), *Regulatory Enforcement and Inspections*, OECD Best Practice Principles for Regulatory Policy, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264208117-en.

Local governments may put more importance on economic development over inspection of environmental polluting activities of companies. Therefore, the government placed an environment watchdog team within each local environmental office. Detection rates of MEnv inspections grew from 16.6% in 2010 to 28% in 2014 (Figure 5.2). In addition, since 2013 the MEnv's head office has had a Central Environmental Controls Task Force dedicated to compliance monitoring of the largest polluters or those provoking frequent citizen complaints. Thus far the task force has targeted over 630 polluting installations with an offence detection rate of 43.1%. Its recent focus was discharges from public sewage treatment plants and illegal wastewater dumping. MEnv compliance monitoring capacity was further reinforced in 2016 by the creation of an Environmental Offence Investigation Planning Division.

The transition to integrated environmental permitting also entails reform of the compliance monitoring regime, from largely reactive inspections triggered by incidents or complaints to planned periodic controls with a frequency based on the installation's level of risk.

Figure 5.2. Targeted inspections by the central government are becoming more effective



Source: Country submission.

As part of the new Comprehensive Plan, Korea plans to intensify inspections of surrounding emission sources (construction sites, illegal incineration, etc.). To prevent high concentration episodes in spring and winter seasons, special inspections are conducted in collaboration among the ministry of environment, Korea Forest Service, and local offices, at major spots with large emissions of fine dust (such as fugitive dust-emitting business facilities, illegal incineration, air pollutant-emitting business facilities at daily surroundings).

An intensive inspection and monitoring should be carried forward to root out illegal practices. More environmental inspectors will be dispatched with portable devices such as drones, to ensure efficiency in the inspection. A regular crackdown will be conducted to gain control over VOCs emitters such as petrochemical industries and painting businesses. Internet of Things (IoT) technologies and drones will be

utilised for a real-time monitoring and management of business facilities that still do not have an installed TMS.

5.2.2. Taxes

According to the Comprehensive Plan, a plan for tax rate system reform has been introduced which takes into account environmental costs of air pollutants cause caused by each type of generation fuels (bituminous coal and LNG). Related laws such as the Act on Individual Consumption Taxes will also be revised and be enacted from April 2019. In particular, the individual consumption tax per kilogram of bituminous coal will increase from KRW 36 to KRW 46, while the tax for LNG will decrease from KRW 91.4 to KRW 23.

5.2.3. Enforcement tools

Very significant criminal sanctions for non-compliance are set in issue-specific environmental laws. Criminal fines for operating without a permit are up to KRW 50 million under the Water Quality and Ecosystem Conservation Act (2005) and up to KRW 100 million (KRW 200 million in the Seoul Metropolitan Area) under the Clean Air Conservation Act (2007). In addition, if there are aggravating circumstances in terms of damage to public health or the environment, heavier criminal penalties (three or more years of imprisonment) can be applied under the Act on Special Measures for the Control of Environmental Offences and Aggravated Punishment. There are plans to amend this act in the near future to make the sanctions even more severe.

In practice, however, sanctions of this degree are rarely applied. For criminal proceedings to take place, the MEnv or the local authority that identifies a violation must refer the case for investigation to the special environmental police and then to the public prosecutor, who decides whether to pursue it in court. In 2013, such referrals occurred in only 1.8% of local authorities' enforcement cases related to air pollution and 1.5% of water pollution cases (MOE, 2014). Public prosecutors assign relatively low priority to environmental offences and rarely pursue such cases. Judges generally lack expertise to consider the merits of environmental cases. The MEnv should work more closely with prosecutors' offices and the courts to build capacity in this area.

At the same time, administrative sanctions are relatively weak: authorities can impose light monetary penalties for minor offences and issue orders to stop the polluting activity, but violators can avoid this by paying a higher "excess" pollution charge. Polluters often get away with a simple warning: in 2013, for air pollution cases, warnings accounted for 57% of local authorities' administrative enforcement actions, cessation orders for 30% and corrective action for only 13% (MOE, 2014). This does not necessarily have to be an issue if warning lead to actual compliance with regulations. There is no evidence that higher sanctions lead to higher deterrence. Publishing information on frequent violators of environmental regulations might be more useful for that purpose.

5.2.4. Promotion of compliance and green practices, advice and guidance

The MEnv promotes good environmental behaviour in the regulated community through voluntary agreements, information-based instruments and regulatory incentives.

According to the Comprehensive Plan, more support will be provided to small and medium-sized business facilities. The small-sized business facilities categorized into 4th and 5th classes will be subject to technical supports. For the installation of a preventing facility, a small and medium-sized business will be financially supported with the "Environmental Improvement Loan", a low-interest loan of KRW 5 billion or less payable over four years at a constant rate with a three-year grace period.

The MEnv provides information on environmental regulations and green business practices through its website and printed materials, and operates a web-based helpline where regulatory questions must be answered within five working days. The Korea Environmental Industry and Technology Institute (KEITI) operates the Green-Up programme, a customised consulting service for environmental improvement of SMEs. It also offers financial support for environmental performance audits. It is not clear to what extent also local inspections do provide information on compliance with environmental regulations.

References

ACEA (2018), *WLTPfacts.eu*, http://wltpfacts.eu/wltp-benefits/ (accessed on July 2018). [27]

Agency for Natural Resources and Energy (2018), *Supporting policies for environmental technology installation*, http://www.enecho.meti.go.jp/category/saving_and_new/ohisama_power/sien/hojyo.html (accessed on July 2018). [29]

Air Quality Expert Group (2007), *Air Quality and Climate Change: A UK Perspective*, Department for the Environment, Food and Rural Affairs, https://uk-air.defra.gov.uk/assets/documents/reports/aqeg/fullreport.pdf (accessed on July 2018). [30]

All guide for housing subsidy (2018), *List of subsidies for low energy housing*, http://www.sumai-fun.com/money/53/energy-saving.html (accessed on July 2018). [31]

Alphabet (2018), *WLTP & RDE The new test procedures*, https://www.alphabet.com/files/2018-02/wltp_and_real_driving_emission_flyer-en-ww.pdf (accessed on August 2018). [32]

Alphabet (2018), *WLTP & RDE The new test procedures*, http://www.alphabet.com/en-ww/wltp. (accessed on 16 August 2018). [26]

APCA (2017), *Order for Enforcement of the Air Pollution Control Act, as amended in 2017*, http://elaws.e-gov.go.jp/search/elawsSearch/elaws_search/lsg0500/detail?lawId=343CO0000000329&openerCode=1 (accessed on August 2018). [33]

APCA (2016), *Regulations for enforcement of Air Pollution Control Act, as amended in 2016*, http://elaws.e-gov.go.jp/search/elawsSearch/elaws_search/lsg0500/detail?lawId=346M50000500001&openerCode=1#207 (accessed on August 2018). [34]

APCA (2006), *Air Pollution Control Act, as amended in 2006*. [9]

APCA (2006), *Air Pollution Control Act, as amended in 2006*, http://www.japaneselawtranslation.go.jp/law/detail/?id=2146 (accessed on July 2018). [35]

APIS (2016), *Ozone | Air Pollution Information System*, http://www.apis.ac.uk/overview/pollutants/overview_O3.htm (accessed on August 2018). [147]

Canadian Council of Ministers of the Environment (2012), *Canadian Ambient Air Quality Standards (CAAQS) for Fine Particulate Matter (PM2.5) and Ozone*, https://www.ccme.ca/files/current_priorities/aqms_elements/caaqs_and_azmf.pdf (accessed on August 2018). [36]

Chiba Prefectural Government (2014), *Ordinance of Environmental Impact Assessment, as amende in 2014*, http://www1.g-reiki.net/chiba/reiki_honbun/g002RG00000751.html (accessed on August 2018). [142]

Chiba prefecture (2018), "Guidance on Air Pollution Act for business owners", http://www.pref.chiba.lg.jp/taiki/documents/201807tebiki-all.pdf (accessed on 13 July 2018). [14]

City of Yokohama (2012), *Ordinance of Environmental Impact Assessment, as amended in 2012*, http://www.city.yokohama.lg.jp/kankyo/etc/jyorei/jyorei/eikyou/jyorei/jyorei.pdf (accessed on August 2018). [143]

Cuesta, J. et al. (2018), "Transboundary ozone pollution across East Asia: daily evolution and photochemical production analysed by IASI + GOME2 multispectral satellite observations and models", *Atmospheric Chemistry and Physics*, Vol. 18/13, pp. 9499-9525, http://dx.doi.org/10.5194/acp-18-9499-2018. [155]

DBJ (2018), *Environmental management by DBJ*, https://www.dbj.jp/co/csr/responsibility/management.html (accessed on July 2018). [37]

DieselNet (2015), *Emission Standards: Japan: Cars and Light Trucks*, https://www.dieselnet.com/standards/jp/ld.php (accessed on August 2018). [38]

EEA (2018), *Air Quality e-Reporting (AQ e-Reporting), Air quality annual statistics*, https://www.eea.europa.eu/data-and-maps/data/aqereporting-8 (accessed on July 2018). [39]

Element Energy; ICCT (2015), *Quantifying the impact of real-world driving on total CO2 emissions from UK cars and vans*, https://www.theccc.org.uk/wp-content/uploads/2015/09/Impact-of-real-world-driving-emissions-for-UK-cars-and-vans.pdf (accessed on July 2018). [40]

Elliott, R. and T. Okubo (2016), "Ecological Modernization in Japan: The Role of Interest Rate Subsidies and Voluntary Pollution Control Agreements", *Asian Economic Papers*, Vol. 15/3, pp. 66-88, http://dx.doi.org/10.1162/ASEP_a_00452. [16]

ERCA (2018), *ERCA website*, https://www.erca.go.jp/erca/english/index.html (accessed on August 2018). [41]

ERCA (2014), *Environmental Restoration and Conservation Agency of Japan*, https://www.erca.go.jp/erca/english/pdf/pamphlet_en.pdf (accessed on 16 April 2018). [21]

ERCA (2014), *Environmental Restoration and Conservation Agency of Japan*, https://www.erca.go.jp/erca/english/pdf/pamphlet_en.pdf (accessed on July 2018). [42]

European Commission (2017), *Air Quality Standards European Commission, last updated by 2017*, http://ec.europa.eu/environment/air/quality/standards.htm (accessed on July 2018). [43]

Greenpeace Japan (2017), *Greenpeace Japan*, http://www.greenpeace.org/japan/ja/info/japan/ (accessed on August 2018). [44]

Hasegawa, K. (2010), "Collaborative environmentalism in Japan", in Vinken, H. et al. (eds.), *Civic Engagement in Contemporary Japan: Established and Emerging Repertoiries*. [22]

ICCT (2017), "GLOBAL BASELINE ASSESSMENT OF COMPLIANCE AND ENFORCEMENT PROGRAMS FOR VEHICLE EMISSIONS AND ENERGY EFFICIENCY", http://www.theicct.org (accessed on 23 July 2018). [156]

IEA (2018), *IEA PAM, Feed-in Tariff for renewable electricity and solar PV auction*, https://www.iea.org/policiesandmeasures/pams/japan/name-30660-en.php?s=dHlwZT1yZSZzdGF0dXM9T2s,&return=PG5hdiBpZD0iYnJlYWRjcnVtYiI-PGEgaHJlZj0iLyI-SG9tZTwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy8iPlBvbGljaWVzIGFuZCBNZWFzdXJlczwvYT4gJnJhcXVv. [145]

Ikeda, K. et al. (2015), "Source region attribution of PM2.5 mass concentrations over Japan", *Geochemical Journal*, Vol. 49/2, pp. 185-194, http://dx.doi.org/10.2343/geochemj.2.0344. [47]

Imura, H. and M. Schreurs (2005), *Environmental policy in Japan*, Edward Elgar Pub, https://play.google.com/books/reader?id=t3_pgPtf-QoC&printsec=frontcover&output=reader&hl=it&pg=GBS.PA28.w.1.15.0 (accessed on June 2018). [48]

Industrial Waste Management Foundation (2013), *Certification for excellent industrial waste processors*, http://www.env.go.jp/policy/ga/brief_info/brief-mat_d.pdf (accessed on August 2018). [133]

IPSuS (2018), *List of points given at the local bidding qualification in public construction works*, http://ea21.jp/files/starter/jichitai_hyoka.pdf (accessed on August 2018). [137]

IPSuS (2011), *Eco Action 21*, http://ea21.jp/ea21/ (accessed on July 2018). [49]

Itahashi, S. et al. (2017), "Nitrate transboundary heavy pollution over East Asia in winter", *Atmospheric Chemistry and Physics*, pp. 3823-3843, http://dx.doi.org/10.5194/acp-17-3823-2017. [50]

Jacob, K. et al. (2011), *INTEGRATING THE ENVIRONMENT IN REGULATORY IMPACT ASSESSMENTS The OECD Regulatory Policy Committee*, OECD, https://www.oecd.org/gov/regulatory-policy/Integrating%20RIA%20in%20Decision%20Making.pdf (accessed on July 2018). [7]

JAF (2013), *Latest emission regulation*, http://qa.jaf.or.jp/mechanism/engine/10.htm (accessed on August 2018). [51]

JAMA (2017), *The motor industry of Japan*, http://www.jama.org/wp-content/uploads/2017/09/mij2017.pdf (accessed on July 2018). [52]

JAMA (2017), *The Motor Industry of Japan*, http://www.jama.org/wp-content/uploads/2017/09/mij2017.pdf (accessed on August 2018). [53]

JEMAI (2018), *Japan Environmental Management Association for Industry*, http://www.e-jemai.jp/ (accessed on July 2018). [54]

JEMAI (2018), *Japan Environmental Management Association for Industry*, http://www.e-jemai.jp/ (accessed on 25 July 2018). [138]

JEMAI (2018), *Pollution Control Manager*, http://www.jemai.or.jp/english/pcm/outline.html (accessed on August 2018). [55]

JFC (2018), *JFC loans related to environment and energy*, https://www.jfc.go.jp/n/finance/search/15_kankyoutaisaku.html (accessed on July 2018). [56]

JFC (2018), *Loan program list by JFC*, https://www.jfc.go.jp/n/finance/search/index.html (accessed on August 2018). [57]

JFPI (2018), *Green Printing Certification*, https://www.jfpi.or.jp/greenprinting/ (accessed on August 2018). [58]

JFPI (2016), *The Greenized Practice of Japanese printing industry*, https://www.jfpi.or.jp/files/user/FAPGA%202016%20Japan%E3%80%80Final.pdf (accessed on August 2018). [59]

Kanagawa Prefectural Government (2014), *Ordinance of Environmental Impact Assessment, as amended in 2014*, http://www3.e-reikinet.jp/cgi-bin/kanagawa-ken/d1w_gaibu_jyoubundisp.exe?HOUCD=35590101003600000000 (accessed on August 2018). [141]

Keidanren (2018), *Environment and Energy Policy Proposals*, http://www.keidanren.or.jp/en/policy/index07.html (accessed on August 2018). [60]

Kühlwein, J., J. German and A. Bandivadekar (2014), *DEVELOPMENT OF TEST CYCLE CONVERSION FACTORS AMONG WORLDWIDE LIGHT-DUTY VEHICLE CO 2 EMISSION STANDARDS*, ICCT, https://www.theicct.org/sites/default/files/publications/ICCT_LDV-test-cycle-conversion-factors_sept2014.pdf (accessed on August 2018). [132]

Kuramochi, T. (2014), *GHG MITIGATION IN JAPAN: AN OVERVIEW OF THE CURRENT POLICY LANDSCAPE*, WRI, http://www.wri.org/sites/default/files/wri_workingpaper_japan_final_ck_6_11_14.pdf (accessed on July 2018). [61]

Lutsey, N. et al. (2018), *Power Play: How Governments are spurring the electric vehicle industry*, ICCT, https://www.theicct.org/sites/default/files/publications/EV_Government_WhitePaper_20180514.pdf (accessed on August 2018). [45]

Mason, R. (2014), "Japan's evolving Civic Environmentalism", in Leonard, L. and S. Kedzior (eds.), *Occupy the earth : global environmental movements*, https://books.google.fr/books?hl=it&lr=&id=LOG8BQAAQBAJ&oi=fnd&pg=PA37&ots=6ZjrbtuevG&sig=3ehaBHlwZ1M5SilKY-q4WWuVyvc#v=onepage&q&f=false (accessed on 7 June 2018). [11]

Matsuno, Y. (2010), *The impacts of the SOx charge and related policy instruments on technological innovation in Japan*, OECD, https://www.researchgate.net/publication/275531178. [62]

Matsuno, Y. (2010), *The impacts of the SOx charge and related policy instruments on technological innovation in Japan*, OECD, https://www.researchgate.net/publication/275531178. [108]

Matsuno, Y. (2007), "Pollution control agreements in Japan: conditions for their success", *Environmental Economics and Policy Studies*, https://link.springer.com/content/pdf/10.1007%2FBF03353952.pdf (accessed on July 2018). [128]

METI (2018), *Process of VOC voluntary agreements*, http://www.meti.go.jp/policy/voc/flow/steps.html (accessed on 30 August 2018). [152]

METI (2017), *Voluntary initiatives on VOC emission reduction as of 2015*, http://www.meti.go.jp/committee/sankoushin/sangyougijutsu/kankyo_taisaku/pdf/005_s02_00.pdf (accessed on August 2018). [153]

METI (2015), *Introduction of WLTP for vehicle testing*, http://www.meti.go.jp/committee/sougouenergy/shoene_shinene/sho_ene/jidosha_wg/2015/pdf/001_07_00.pdf (accessed on August 2018). [63]

METI (2014), *Strategic Energy Plan*, http://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/4th_strategic_energy_plan.pdf (accessed on July 2018). [65]

METI (2010), *VOC emission reduction guide (3rd revision)*, http://www.meti.go.jp/policy/voc/downloads/VOC-tebiki_22fy.pdf (accessed on August 2018). [151]

METI (2010), *VOC emission reduction guide (3rd revision)*, http://www.meti.go.jp/policy/voc/downloads/VOC-tebiki_22fy.pdf (accessed on 30 August 2018). [157]

METI (2007), *Report and guideline for environment management for pollution prevention*, http://www.meti.go.jp/policy/energy_environment/kankyokeiei/environmentguideline/downloads/kougaiboushi-houkokusho.pdf (accessed on July 2018). [66]

Ministry of Environment (2018), *Comprehensive plan on fine dust management*, https://repository.kei.re.kr/handle/2017.oak/22230?mode=full (accessed on 9 November 2018). [1]

Ministry of Health, Labour and Welfare (2018), *Management Standard of Environmental Sanitation for Buildings, as accessed in 2018*, https://www.mhlw.go.jp/bunya/kenkou/seikatsu-eisei10/index.html (accessed on July 2018). [67]

Ministry of Health, Labour and Welfare (2014), *Act on Maintenance of Sanitation in Buildings, as amended in 2014*, http://elaws.e-gov.go.jp/search/elawsSearch/elaws_search/lsg0500/detail?lawId=345AC1000000020&openerCode=1 (accessed on July 2018). [68]

Ministry of Internal Affairs and Communications (2018), *Result of Survey on the Fixed Number of Employees in local government in 2017*, http://www.soumu.go.jp/main_content/000545654.pdf (accessed on June 2018). [69]

Ministry of Internal Affairs and Communications (2017), *Implementation Guidelines for Policy Evaluation of Regulations, as ameded in 2017*, http://www.soumu.go.jp/main_content/000556223.pdf (accessed on June 2018). [70]

Ministry of Justice (2005), *Administrative Procedure Act, as amended in 2005*, http://www.japaneselawtranslation.go.jp/law/detail/?vm=04&re=01&id=85&lvm=02 (accessed on July 2018). [28]

Ministry of the environment (1975), *Law concerning partial revision to Air Pollution Control Act*, https://www.env.go.jp/hourei/04/000093.html (accessed on 4 July 2018). [13]

MLIT (2018), *Automobile: Regulation of exhaust gas for new cars - Ministry of Land, Infrastructure and Transport*, http://www.mlit.go.jp/jidosha/jidosha_tk10_000002.html (accessed on 23 August 2018). [131]

MLIT (2018), *Emission standards for diesel engines for heavy commercial vehicles*, http://www.mlit.go.jp/common/001185984.pdf (accessed on August 2018). [71]

MLIT (2018), *Implementation of on-road emission testing*, http://www.mlit.go.jp/common/001228743.pdf (accessed on July 2018). [72]

MLIT (2018), *Information on recall and malfunction of automobiles*, http://www.mlit.go.jp/jidosha/carinf/rcl/index.html (accessed on July 2018). [73]

MLIT (2018), *The Automobile Recall System*, http://www.mlit.go.jp/jidosha/carinf/rcl/report.html (accessed on July 2018). [81]

MLIT (2018), *Toll Policy*, http://www.mlit.go.jp/road/road_e/p2_ryokin.html (accessed on July 2018). [74]

MLIT (2017), *Amendment to Road Transport Vehicle Act to prevent the fraud by automobile manufacturers*, http://www.mlit.go.jp/report/press/jidosha08_hh_002555.html (accessed on July 2018). [75]

MLIT (ed.) (2016), *Overview of the Act on the Improvement of Energy Consumption Performance of Buildings (Building Energy Efficiency Act)*, http://www.mlit.go.jp/common/001134876.pdf (accessed on July 2018). [76]

MLIT (2015), *Asbestos measurement Q&A*, http://www.mlit.go.jp/jutakukentiku/build/Q&A/index.html#a1 (accessed on July 2018). [77]

MLIT (2015), *On-road emission gas sampling test for diesel*, http://www.mlit.go.jp/report/press/jidosha10_hh_000158.html (accessed on July 2018). [78]

MLIT (2014), *New Motorway pricing*, http://www.mlit.go.jp/common/001031042.pdf (accessed on July 2018). [79]

MLIT (2014), *Outline of Low Carbon City Development*, http://www.mlit.go.jp/common/001048781.pdf (accessed on July 2018). [80]

MoE (2018), *2016 Report on enforcement of Air Pollution Control Act*, https://www.env.go.jp/air/air/osen/kotei/Taiboho_gaiyo_H28.pdf (accessed on July 2018). [83]

MoE (2018), *2016 summary result of atmospheric air quality measurement*, https://www.env.go.jp/press/files/jp/108676.pdf (accessed on July 2018). [146]

MoE (2018), *Central Environment Council Information*, https://www.env.go.jp/council/b_info.html (accessed on May 2018). [97]

MoE (2018), *Communication with MoE*. [84]

MoE (2018), *Communication with MoE - 09/2018*. [158]

MoE (2018), *Eco Mark*, https://www.env.go.jp/policy/hozen/green/ecolabel/a04_01.html (accessed on July 2018). [85]

MoE (2018), *Environmental Management System*, https://www.env.go.jp/policy/j-hiroba/04-1.html (accessed on July 2018). [99]

MoE (2018), *Environmental Quality Standards in Japan*, https://www.env.go.jp/en/air/aq/aq.html (accessed on August 2018). [86]

MoE (2018), *Measures against VOCs: VOC Treatment Technologies*, https://www.env.go.jp/policy/etv/en/technologies/s04_c1.html (accessed on July 2018). [87]

MoE (2018), "Mission". [8]

MoE (2018), "Mission". [12]

MoE (2018), *Permission for the Soot and Smoke emitting facilities, accessed in August 2018*, http://www.env.go.jp/info/one-stop/26/001.html (accessed on 7 August 2018). [25]

MoE (2018), *Permission for the Soot and Smoke emitting facilities, accessed in August 2018*, http://www.env.go.jp/info/one-stop/26/001.html (accessed on 7 August 2018). [89]

MoE (2018), *Regulation on NOx emission, accessed in August 2018*, http://www.env.go.jp/air/osen/law/t-kise-3.html (accessed on 6 August 2018). [24]

MoE (2018), *Regulatory Measures against Air Pollutants Emitted from Factories and Business Sites and the Outline of Regulation - K-value Regulation for Sulfur Oxides, accessed in 2018*, https://www.env.go.jp/en/air/aq/air/air3.html (accessed on August 2018). [96]

MoE (2018), *Soot and Dust regulation, accessed in August 2018*, http://www.env.go.jp/air/osen/law/t-kise-2.html (accessed on 6 August 2018). [23]

MoE (2018), *The Basic Environment Law_Chapter 3*, https://www.env.go.jp/en/laws/policy/basic/ch3.html#section1 (accessed on May 2018). [98]

MoE (2018), *The Fifth Basic Environmental Plan*, http://www.env.go.jp/press/files/jp/108982.pdf (accessed on July 2018). [93]

MoE (2017), *Eco Action 21 guideline*, https://www.env.go.jp/press/files/jp/105700.pdf (accessed on July 2018). [92]

MoE (2017), *Interim review on the total emission reduction policy on NOx and PM from vehicles*, https://www.env.go.jp/press/Review.pdf (accessed on August 2018). [136]

MoE (2017), *Report by photochemical oxidants research and review committee*, http://www.env.go.jp/air/osen/oxidant/report-201703.pdf (accessed on August 2018). [149]

MoE (2016), *Better indicators to measure improvement in photochemical oxidants*, https://www.env.go.jp/air/osen/pc_oxidant/attach/interim_rep.pdf (accessed on August 2018). [148]

MoE (2016), *General investigation on air pollutant emission (actual data of 2014)*, https://www.env.go.jp/air/osen/kotei/h27-1.pdf (accessed on July 2018). [129]

MoE (2016), *Modification on Air Pollution Control Act; entry into force of Mercury emission regulation*, http://www.env.go.jp/air/suigin/slide_mercury.pdf (accessed on July 2018). [91]

MoE (2015), *Status of Air pollution*, http://www.env.go.jp/air/osen/jokyo_h27/full_h27.pdf (accessed on July 2018). [94]

MoE (2013), *Diameter of particular matters*, http://www.env.go.jp/council/former2013/07air/y078-02/mat03.pdf (accessed on July 2018). [90]

MoE (2013), *Q&A about PM2.5*, https://www.env.go.jp/air/osen/pm/info/attach/rep_20130227-qa.pdf (accessed on August 2018). [95]

MoE (2012), *Environmental Impact Assessment in Japan*, https://www.env.go.jp/en/focus/docs/files/20120501-04.pdf (accessed on June 2018). [82]

MoE (2012), *Summary of Air Pollution Control Act (fixed source)*, http://www.env.go.jp/air/osen/law/index.html (accessed on August 2018). [100]

MoE (2009), *Environmental standard for the air pollution by the fine particular matters*, https://www.env.go.jp/hourei/add/d010.pdf (accessed on August 2018). [135]

MoE (2008), *Guideline to create site inspection manuals based on Air Pollution Control Act*, https://www.env.go.jp/council/41air-wat/y411-01/ref05.pdf (accessed on July 2018). [64]

MoE (n.d.), "Examples of environmental management to prevent pollution", https://www.env.go.jp/air/info/pp_kentou/07/ref01.pdf (accessed on 26 July 2018). [20]

NALTEC (2016), *Categories of vehicle inspection*, https://www.naltec.go.jp/business/inspection/category.html (accessed on August 2018). [103]

NALTEC (2016), *NALTEC Service guide*, https://www.naltec.go.jp/english/serviceguide/ht50ut0000000hka-att/ht50ut0000000hlw.pdf (accessed on July 2018). [104]

NALTEC (2016), *Process of Renewal Inspection*, https://www.naltec.go.jp/english/business/inspection/process.html (accessed on July 2018). [105]

National Institute for Environmental Studies (2018), *Environmental database*, http://www.nies.go.jp/igreen/index.html (accessed on August 2018). [106]

NGVPC (2018), *Next Generation Vehicle Promotion Center*, http://www.cev-pc.or.jp/english/ (accessed on July 2018). [107]

OECD (2018), *OECD Regulatory Policy Outlook 2018*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264303072-en. [5]

OECD (2012), *Recommendation of the Council on Regulatory Policy and Governance*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264209022-en. [3]

OECD (2010), "OECD Environmental Performance Reviews: Japan 2010", http://www.oecd-ilibrary.org/docserver/download/9710121e.pdf?expires=1521813200&id=id&accname=ocid84004878&checksum=B9291AEE0D29C542DB0A2C28998C605A (accessed on March 2018). [112]

OECD (2010), "The impacts of the SOx charge and related policy instruments on technological innovation in Japan", http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=com/env/epoc/ctpa/cfa(2009)38/final (accessed on 29 June 2018). [15]

OECD (2009), "Ensuring Environmental Compliance: Trends and Good Practices", http://dx.doi.org/10.1787/9789264059597-en. [110]

OECD (2009), *Regulatory Impact Analysis: A Tool for Policy Coherence*, OECD Reviews of Regulatory Reform, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264067110-en. [4]

OECD (2005), "Environment and the OECD Guidelines for Multinational Enterprises: CORPORATE TOOLS AND APPROACHES", http://www.sourceoecd.org/industrytrade/9264009388 (accessed on August 2018). [111]

OECD (2003), "Working Party on National Environmental Policy: VOLUNTARY APPROACHES: TWO JAPANESE CASES Pollution Control Agreements in Yokohama City and Kitakyushu City", http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=env/epoc/wpnep(2002)12/final (accessed on 6 July 2018). [18]

OECD (2003), "Working Party on National Environmental Policy: VOLUNTARY APPROACHES: TWO JAPANESE CASES Pollution Control Agreements in Yokohama City and Kitakyushu City", http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=env/epoc/wpnep(2002)12/final (accessed on July 2018). [109]

OECD data (2018), *Air and GHG emissions, as accessed in 2018*, OECD Publishing, Paris, https://data.oecd.org/air/air-and-ghg-emissions.htm. [113]

OECD/UNECE (2016), *International Regulatory Co-operation and International Organisations: The Case of the United Nations Economic Commission for Europe (UNECE)*, OECD/UNECE, Paris, http://www.oecd.org/gov/regulatory-policy/UNECE_Full_Report.pdf. [159]

Ogata, T. (2006), *Environmental Administration in Japan and the Role of Local Governments*, National Graduate Institute for Policy Studies (GRIPS), http://www3.grips.ac.jp/~coslog/activity/01/04/file/Bunyabetsu-7_en.pdf. [114]

Okubo, N. (2014), "Judicial review of public authorities' omissions in Japan", https://www.unece.org/fileadmin/DAM/env/pp/a.to.j/TF7-2014/2.d_A2J_NewDevelopments_Japan_Okubo.pdf (accessed on 23 July 2018). [19]

Osaka Asbestos defense lawyers (2018), *Asbestos lawsuit in Sennan, Osaka*, http://www.asbestos-osaka1.sakura.ne.jp/sennan/ (accessed on 24 August 2018). [134]

Osaka Prefectural Government (2013), *Ordinance of Environmental Impact Assessment, as enforced in 2013*, http://www.pref.osaka.lg.jp/houbun/reiki/reiki_honbun/k201RG00000376.html (accessed on August 2018). [140]

Pavlovic, J. et al. (2018), "How much difference in type-approval CO 2 emissions from passenger cars in Europe can be expected from changing to the new test procedure (NEDC vs. WLTP)?", *Transportation Research*, pp. 136-147, http://dx.doi.org/10.1016/j.tra.2018.02.002. [115]

Policy Evaluation Council (2017), *Improvement suggestions on policy evaluation on regulation*, http://www.soumu.go.jp/main_content/000471068.pdf (accessed on August 2018). [144]

Qin, Y. et al. (2017), "Air quality, health, and climate implications of China's synthetic natural gas development", *PNAS*, http://dx.doi.org/10.1073/pnas.1703167114. [101]

Rie Sugiyama (1999), "CAVA Working paper: Voluntary Approaches in Japan", http://www.ensmp.fr/Fr/CERNA/CERNA/Progeuropeens/CAVA/index.html (accessed on 11 July 2018). [17]

RTVA (2017), *Road Transport Vehicles Act, as amended in 2017*, http://elaws.e-gov.go.jp/search/elawsSearch/elaws_search/lsg0500/detail?lawId=326AC0000000185&openerCode=1 (accessed on July 2018). [102]

Saitama Prefecture (2018), *Status of photochemical smog*, http://www.taiki-kansi.pref.saitama.lg.jp/smog.html (accessed on August 2018). [88]

Sustainalytics (2015), *Development Bank of Japan, Sustainability Bond Framework Overview & Opinion*, https://www.dbj.jp/pdf/ir/credit/sri/sustainability/001_opinion.pdf (accessed on July 2018). [116]

Takao, Y. (2016), *Japan's environmental politics and governance : from trading nation to econation*, Routledge, https://books.google.fr/books?id=yjolDwAAQBAJ&pg=PA146&lpg=PA146&dq=center+of+local+authority+for+international+relations+environment&source=bl&ots=jhedTQ9IJs&sig=dakR7vazjSgHDQX9cbjuICHSre4&hl=it&sa=X&ved=0ahUKEwidkqvJgMbaAhWKWRQKHRmbDbAQ6AEIdTAK#v=onepa (accessed on April 2018). [117]

Takao, Y. (n.d.), *Japan's environmental politics and governance : from trading nation to econation*, https://books.google.fr/books?id=yjolDwAAQBAJ&pg=PA146&lpg=PA146&dq=center+of+local+authority+for+international+relations+environment&source=bl&ots=jhedTQ9IJs&sig=dakR7vazjSgHDQX9cbjuICHSre4&hl=it&sa=X&ved=0ahUKEwidkqvJgMbaAhWKWRQKHRmbDbAQ6AEIdTAK#v=onepage&q&f=false (accessed on 19 April 2018). [10]

Tanabe, N. (2013), "Transboundary Air Pollution from China: Possibilities for Cooperation with Japan", *Japan for Sustainability*, https://www.japanfs.org/en/news/archives/news_id034262.html (accessed on August 2018). [118]

Task-force to ensure the appropriate completion testing (2018), *Interim report*, http://www.mlit.go.jp/common/001226554.pdf (accessed on July 2018). [119]

The Wild Bird Society of Japan (2018), *The Wild Bird Society of Japan*, https://www.wbsj.org/about-us/ (accessed on August 2018). [120]

Tokyo Bureau of Environment (2013), *Ordinance of Environmental Impact Assessment, as amended in 2013*, http://www.kankyo.metro.tokyo.jp/basic/guide/assessment/index.files/H25kaiseijoureikisokugenkou.pdf (accessed on August 2018). [139]

Tokyo Bureau of environment (2016), *New policy target for photochemical oxidants*, https://www.env.go.jp/council/07air-noise/y078-07/mat06.pdf (accessed on 29 August 2018). [150]

Tokyo Metropolitan Government (2016), *Tokyo Environmental Master Plan*, http://www.kankyo.metro.tokyo.jp/en/about_us/videos_documents/master_plan.files/5497a24cc603f33dbb96678fcf17135c.pdf (accessed on July 2018). [121]

UNECE (2017), *European countries implement new procedure improving measurement of vehicle fuel consumption and emissions*, https://www.unece.org/info/media/presscurrent-press-h/transport/2017/european-countries-implement-new-procedure-improving-measurement-of-vehicle-fuel-consumption-and-emissions/doc.html (accessed on August 2018). [122]

US EPA (2018), *What are the Air Quality Standards for PM?*, https://www3.epa.gov/region1/airquality/pm-aq-standards.html (accessed on August 2018). [123]

US EPA (n.d.), "Ozone Pollution", https://www.epa.gov/ozone-pollution (accessed on 27 August 2018). [2]

WHO (2006), *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide*, http://apps.who.int/iris/bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_eng.pdf;jsessionid=DFDA9BAE204770F4BA4490E3A309C33A?sequence=1 (accessed on August 2018). [124]

WHO (2000), *Air Quality Guidelines for Europe Second Edition*, WHO regional publications, http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf?ua=1 (accessed on August 2018). [125]

Wiener, J. and D. Ribeiro (2016), "Impact Assessment: Diffusion and Integration", in Bignami, F. and D. Zaring (eds.), *Comparative Law and Regulation*, Elgar. [6]

Wild, O. (2007), "Atmospheric Chemistry and Physics Modelling the global tropospheric ozone budget: exploring the variability in current models", *Atmos. Chem. Phys*, Vol. 7, http://www.atmos-chem-phys.net/7/2643/2007/ (accessed on August 2018). [154]

Yang, Z. and A. Bandivadekar (2017), *2017 Global update: Light-duty vehicle greenhouse gas and fuel economy standards*, ICCT, http://www.theicct.org (accessed on 22 August 2018). [130]

Yang, Z., R. Muncrief and A. Bandivadekaricct (2017), *Global baseline assessment of compliance and enforcement programs for vehicle emissions and energy efficiency*, ICCT, https://www.theicct.org/sites/default/files/publications/PV-C%26E-global-baseline-assessment_ICCT-report_14112017_vF.pdf (accessed on July 2018). [46]

Yashiro, N. (2016), "Regulatory Coherence: The Case of Japan", http://www.eria.org/ERIA-DP-2016-16.pdf (accessed on June 2018). [126]

Yashiro, N. (2016), "Regulatory Coherence: The Case of Japan", http://www.eria.org/ERIA-DP-2016-16.pdf (accessed on June 2018). [127]