Air pollution control in the Republic of Korea

Enabling Technology and Regulatory Policies to Support SMEs

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Abstract

Air pollution is a serious issue that has major detrimental impacts on people's health and quality of life. Effectively addressing air pollution is complex due to the variety of pollutants' sources, the complexity of measurement and oversight, as well as the need to not place unreasonable burdens on businesses. To effectively reduce air pollution and its origins, governments must enact and enforce enabling technologies and regulatory policies, which will correctly incentivise and support small and medium-sized enterprises (SMEs) in their efforts to reduce their emissions of air pollutants. This article provides an overview of the recent air pollution trends and the policies in the Republic of Korea, and the practical steps the government has taken, focusing on technology and regulatory policies that assist SMEs in decreasing their emissions, and discusses the enabling policies that support air pollution reduction by SMEs.

Introduction

Air pollution is the biggest environmental risk to human health, and annually, it causes about one in every nine deaths. Air pollution is estimated to cause around seven million premature deaths annually through diseases such as lung cancer, respiratory diseases, heart diseases, and strokes, with 4.2 million of these premature deaths each year due to outdoor air pollution (WHO, 2016). Air pollution also impacts people's health indirectly as people spend less time outdoors, or exercise less when the pollution levels are high. Air pollution has even been found to threaten the mental health of individuals living in areas with high concentration of air pollutant particulates (Yang et al., 2021). Nine out of ten people reside in areas that exceed the WHO recommended guideline limits of air pollutant levels and is particularly severe in some of the world's fastest-growing urban areas. Although some air pollution is a result of naturally occurring events such as volcanic activities or airstream movement of sand particles, human activity is the predominant cause of air pollution, primarily through the burning of fossil fuels.

As Asia undergoes rapid economic development, air pollution levels have also risen, with 70% of the global air pollution related deaths now occurring in the Asia Pacific region (UNEP, 2022). In 2016, the welfare losses in South Asia was the equivalent of 7.4% of the region's gross domestic product (GDP), and in East Asia and the Pacific, the equivalent welfare loss was 7.5% of the regional GDP (World Bank Group & IHME, 2016). The enhancement of air quality has a major potential to greatly improve the wellbeing of millions of people residing in Asia and the Pacific region. The decoupling of air pollution and other environmental damages, such as climate change from economic growth is vital to ensure long-term prosperity and quality of life for all. The failure to achieve this will result in continued massive detrimental impacts, which will undermine sustainable development growth pathways. Even though air pollution is a multifaceted problem, and is difficult to effectively address due to the variety of the sources of the pollutants, based on the complexity of measurement and oversight, as well as the regionality dimension of the issue, decisive actions must be taken.

This article provides an overview of recent air pollution trends and the policies in the Republic of Korea, and the practical steps the government has taken to address the problem. It aims to provide insights for the executives of small and medium scale enterprises (SMEs), as well as the government decision makers, on the types of policies that help create an enabling environment to reduce air pollution without placing unreasonable burdens on businesses. By outlining technology trends, successful regulatory management practices and disseminating useful information regarding air pollutant reduction policies and methods, this article seeks to contribute to overcoming the serious issue of air pollution through mutually beneficial engagements with the SMEs.

Air pollution in the Republic of Korea

The Republic of Korea faces some of the highest level of air pollution in the Organization for Economic Co-operation and Development (OECD) and the total deaths due to air pollution has been estimated to be about 40,000 per year (Farrow et al., 2020). Improving the air quality has emerged as a major national priority, with increasing numbers of citizens demanding urgent action to reduce air pollution levels and the exposure of vulnerable groups such as children and the elderly. The negative effects of air pollution in the Republic of Korea are likely to become more severe in the future as the country has a rapidly aging population. The Republic of Korea currently has the lowest birth-rate in the world, with its fertility rate falling to 0.81 in 2021. By the year 2050, the population aged 50 or older is forecasted to be almost 60% of the population, and the population aged 70 or older is forecasted to be over 30% (UN, 2022). Older people are more vulnerable to diseases caused by air pollution, such as strokes, heart disease, lung

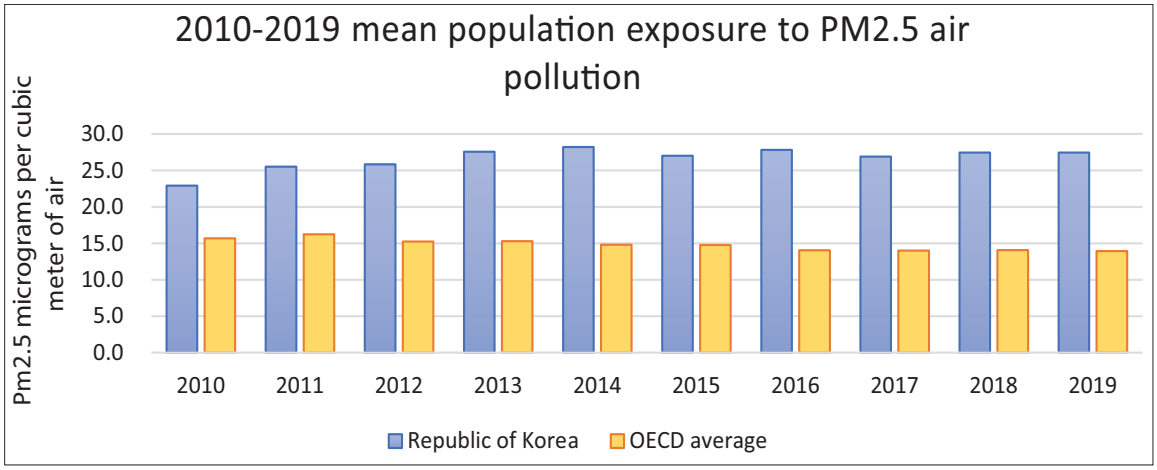


Figure 1: 2010-2019 mean population exposure to PM2.5 air pollution (OECD, 2022)

cancer and respiratory diseases. Increasing urbanization will also increase the severity of the air pollution's negative impacts as air quality tends to be lower in cities. In 2021, 81.4% of the Republic of Korea's population lived in urban areas, and by 2050 this figure is expected to rise to 86.4%.

Policy changes to address air pollution

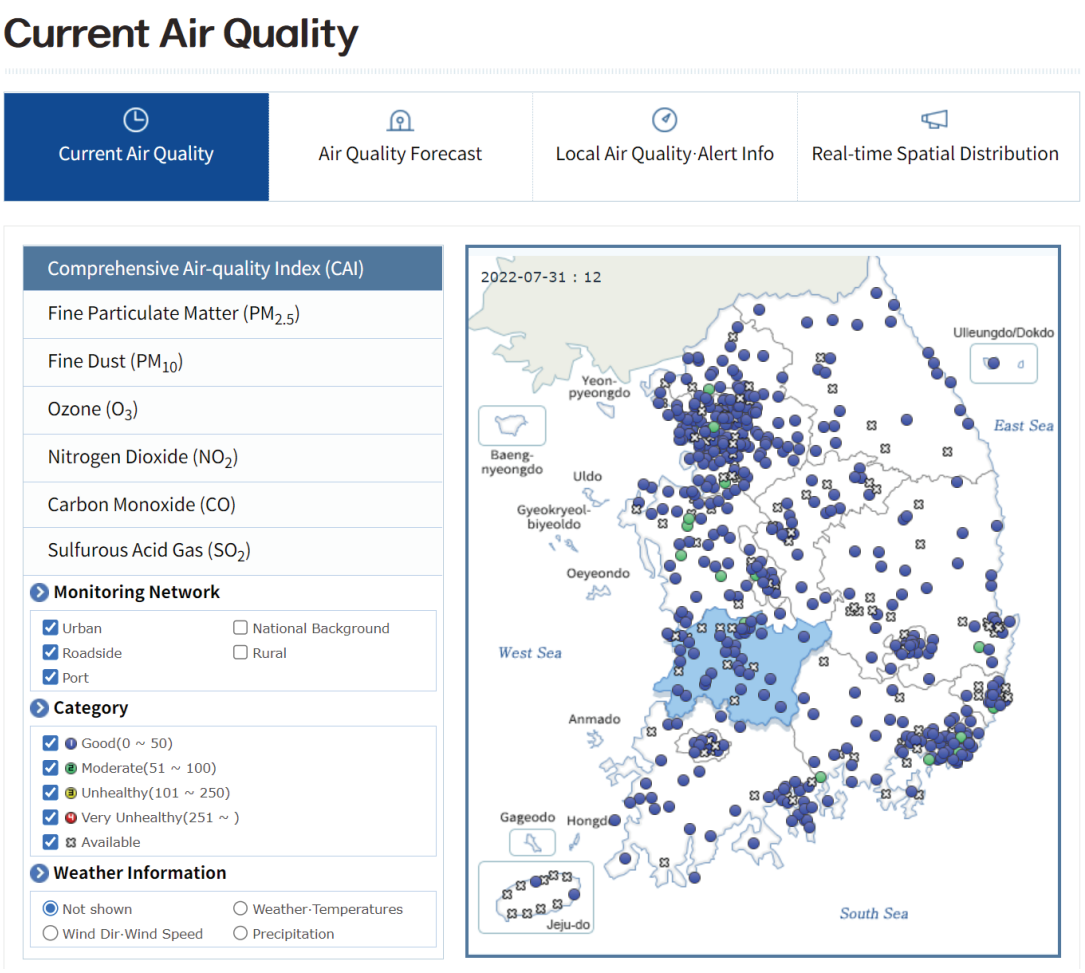
The government of the Republic of Korea has enacted a diverse range of policy measures to address air pollution. The country operates an Air Pollutant Emission-Cap Management System, which sets a maximum quantity of air pollutants to be emitted annually in each area. In cases of a business exceeding their assigned limit, a charge is levied and if a business's emissions are below their allocation, the remainder may be transferred to alternative sites of business or the unused allocation can be saved until the next year (KECO, 2022). The Republic of Korea also introduced increased support for early scrapping for old diesel vehicles and limitations on the areas where they are allowed to drive as a part of a policy to phase-out such vehicles (Ministry of Environment, 2018). This supported the uptake of newer lower emission vehicles such as those powered by electricity or liquefied petroleum gas (LPG).

In 2019, the government designated low air quality as a social disaster and established The National Council on Climate and Air Quality (NCCA), which was chaired by former diplomat and United National Secretary-General Ban Ki-moon (Office of the President, 2019). The NCCA's first focused on taking immediate actions that could bring near instantaneous benefits. In the second stage of its operation, the council began evaluating longer horizon solutions to address the problem, considering policy options that require medium-to-long-term discussions and planning (Jung, 2019). The council carried out seasonal management measures to significantly reduce the air pollution levels during periods of severely low air quality, such as from March to May in which the air quality levels are particularly low mainly due to air currents transporting pollutants from China to the Korean peninsula. The NCCA also fulfilled a vital role in carrying out polices that were led by engagements with the general public, as citizens presented their perspectives through the discussions of the national policy participation group. This helped in deciding the policies and the implementations to be made in accordance with the public consensus. The NCCA broadly succeeded in achieving its stated objectives and helped to boost national air quality with its seasonal monitoring system, which enabled the central government to enforce more stringent air pollutant emission limits during periods of elevated air pollutant concentration. The NCCA was terminated in April 2021, having completed its term limit of two years.

The government of the Republic of Korea has also taken active steps to raise awareness and transparency regarding air quality levels. Public awareness and understanding helps in promoting a cleaner environment and enhances the trust of the public in the responses of the government's policy. The Real-Time Air Quality information portal operated by Air Korea provides data on nationwide outdoor air quality nationwide, displaying data in an easy-to-understand way. The portal promotes the safety and health of Korea's citizens by informing the public when the outdoor air pollution is dangerously high, so that they can refrain from outdoor activities. It additionally helps citizens comprehend the impact of long-term policy changes on air quality levels. The National Air Emission Inventory and Research Center (NAIR) was also established with the goals of intensifying research and internal and external collaboration, communication, and organizational capabilities, and building expertise (NAIR, 2022).

Electricity generation sector

The electricity generation sector in the Republic of Korea uses the biggest amount of fossil fuels, and thus is the largest domestic source of air pollutants. For the dual objectives of reducing air pollution and mitigating climate change, the Republic of Korea has been taking



Source: Air Korea https://airkorea.or.kr/eng/currentAirQuality?pMENU_NO=68

Figure 2: Air Korea Real-Time Air Quality information portal.

measures to expand its renewable electricity generation capacity as an alternative to the consumption of fossil fuels. Over the past five years, the gross renewable electricity generation has increased from 27,928 gigawatt hours (GWh) in 2017 to 39,102 GWh in 2021, which is an increase of 40% (KEPCO, 2022). Despite this major increase, renewable energy stills makes up a small portion of the total electricity generated, under 7% of total GWh generated in 2021. Coal remains the largest source of electricity followed by liquefied natural gas (LNG) and nuclear energy (primarily from pressurized water reactors). The Republic of Korea has gradually strengthened the production and performance standards of its coal power plants and promoted technological or process changes to lesson air pollution from coal powered electricity generating stations. This has resulted in the coal power plants installing flue gas desulphurization and other emission control technologies, which have reduced their emissions (UNEP, 2019). The government also reviewed and modified the tax system for fossil fuels used to generate electricity, raising the tax on the use of coal and lowering the tax on the use liquefied natural gas (LNG). This positively altered the incentive structure of electricity generating plants, encouraging the electricity generating plants to use more LNG as an alternative to coal, resulting in air pollutants being emitted from the energy sector. Despite these policy changes and the use new technologies, coal power plants are still major sources of local pollution, therefore, during periods of high air pollution, such as in the early spring period, the operations of coal power plants are reduced.

The changes of policy directions between the different administrations has added an increased uncertainty to the energy sector and its emissions, as different Presidents aim to move the electricity sector in divergent directions during their five-year terms. For example, the previous Moon Jae-in stated its goal to phase out nuclear power and closed some nuclear power plants ahead of schedule, but the newly elected Yoon Suk-Yeol administration is seeking to increase the use of nuclear power domestically, as well as expand the exports of the nuclear power related supplies, and increase the nuclear plant projects overseas. A greater policy consistency across different administrations would help the Republic of Korea meet its air pollution and climate change mitigation targets.

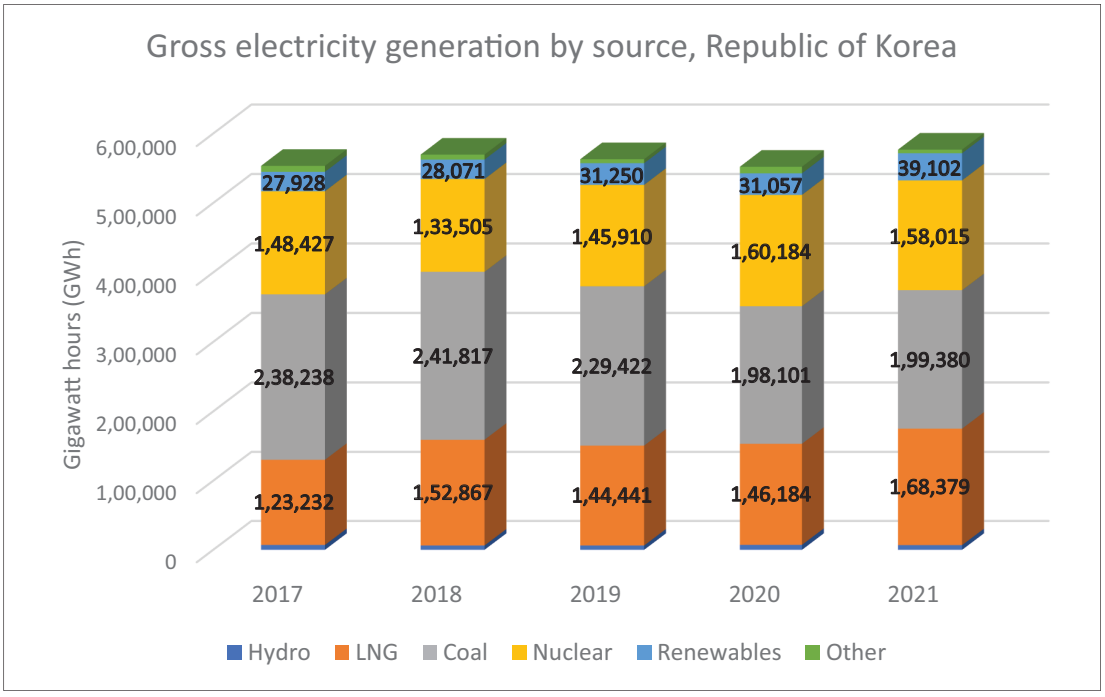


Figure 3: Gross electricity generation by source in the Republic of Korea, 2017-2021.

Small and medium-sized enterprises (SMEs)

The government of the Republic of Korea has taken active steps to decrease air pollutant emissions from businesses of all sizes. Larger companies received more direct supervision as they account for almost 65% of emissions, but the government also undertook a diverse range of measures to assist SMEs reduce their emissions as well. The number of inspection teams has risen greatly, with particular attention given to enterprises that are based in urban areas. Financial support for SMEs to support them in reducing their air pollutant emissions was made available through expanded regional and local public sector budgets. A heightened financial support for SMEs with yearly air pollutant emissions lower than ten tonnes was provided. For the installation of equipment and facilities that reduce air pollution, SMEs may be eligible and apply for "Environmental Improvement Loans" (Ministry of Environment 2018). These low-interest loans of up to five billion Korean won (about 3.8 million USD) are to be repaid to the Ministry of Environment over four years at a fixed interest rate, with a three-year grace period to ensure that the loan payments are not too cumbersome for the enterprises. This funding allowed businesses to take practical action to reduce their air pollution impact, which would not have been possible due to their financial constraints. From 2021, a more stringent exhaust inspection system was also carried out. The scope of a regular inspection for diesel vehicles was expanded to include more diverse types and classification of vehicles emitting gases such nitrogen oxides. Targeted loans and funding for the installation of catalytic converters in vehicles used by SMEs such as trucks, cars, and forklifts, as well as for electrical generators used on business sites, made emission reduction possible in a way that was mutually beneficial for both the SME owners as well as the overall welfare of the society.

Expert help of professionals were made available to the SMEs to assist them in reducing their air pollutant emissions. Local governments worked with the experts from the Korea Environment Corporation (KECO), the Korea Environmental Industry and Technology Institute (KEITI), and the National Institute of Environmental Research (NIER), to create teams to give information, advice, and technical support to SMEs. These teams were designed according to industry type to ensure that had the best knowledge and approach in assisting the SMEs. This customization enabled credible engagement between the public and the private sectors as the teams had deep understanding of the enterprises they were issuing support to. The expert advice and technical support focused on pragmatic and realistic steps that the SMEs could take to reduce air pollution from their production and operational processes. The overall reduction strategies by industry type plans were devised, taking into consideration the unique characteristics of the industry type. Information and guidance were also provided to the SMEs regarding purchasing options of new vehicles and equipment, which emit fewer pollutants or none at all. The use of hybrid and electric cars was expanded through tax structures, which subsidized the purchase of environmentally friendly options.

Transparency is a vital factor in the creation and implementation of successful policies to address air pollution. In the context of

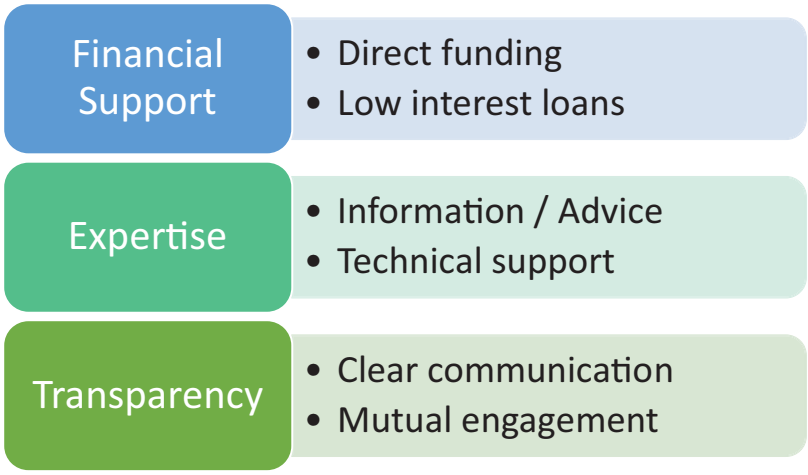


Figure 4: The three pillars for successfully assisting SMEs reduce air pollution.

the Republic of Korea, the authorities attempted to make their intentions and requirements of the businesses clear from an early stage, so that enterprise operators had a clear understanding of what was expected of them and what supports they could avail. Periodic evaluations of the enactment of the created reduction plans take place to ensure that the reduction plans are working effectively and being engaged with by businesses. Information regarding the basic charges and the required standards were communicated well in advance of enforcement to give SMEs a clear timeline of the regulatory changes. Real-time disclosure of the results of inspections began in December 2019 to enhance openness and public trust in regulatory procedures. To increase the overall credibility of the environmental regulatory frameworks, the authorities addressed the oversight blind spots in areas such as construction sites and prohibited incinerations.

There are various obstacles still present in the Republic of Korea that bars SMEs from effectively reducing their negative environmental impacts. While many processes and procedures have been simplified and streamlined, significant bureaucratic hurdles still remain for SMEs in relation to the environmental regulation compliances. Due to their limited technical and human resource capacity, the administrative burden of current issue-specific permits is still relatively high for SMEs in the Republic of Korea, therefore, to address this the authorities are considering replacing multiple permits with general binding rules according to an SME's sector. Sector specific general binding rules have been utilized in many OECD countries to make compliances more straightforward for SMEs.

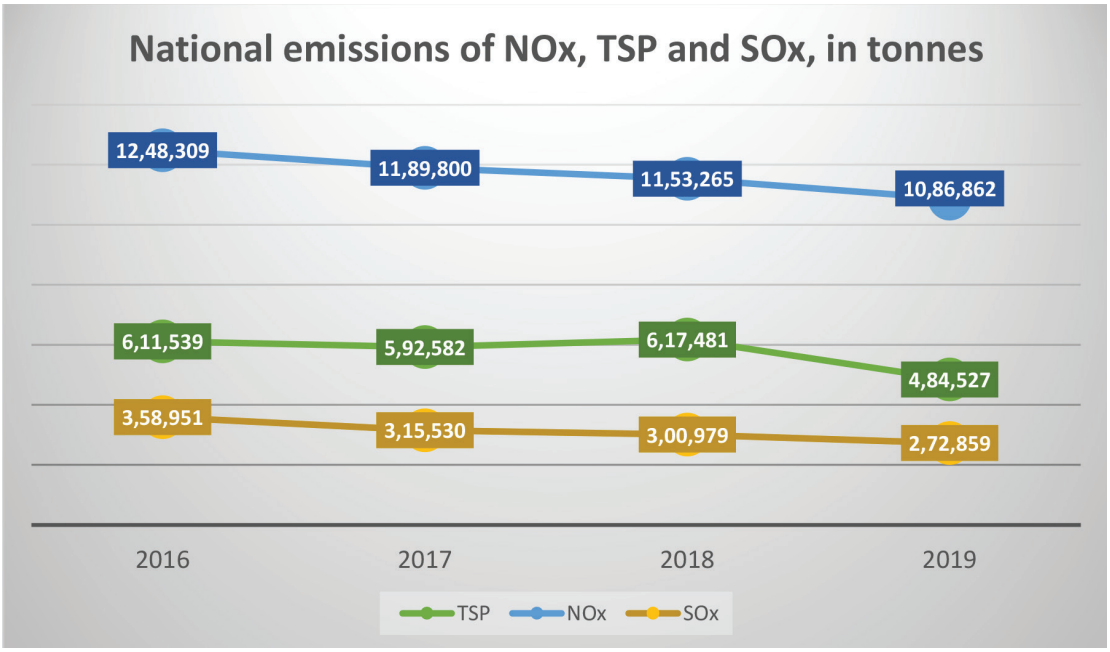
Results of air pollution policy changes

The policies introduced by successive governments of the Republic of Korea have helped reduce emissions from national sources, but the overall level of emissions is still high due to factors such as the large size of the country's industrial sector and the high number of vehicles in its densely populated urban areas. The Air Pollutant Emission-Cap Management System has shown some success in reducing air pollutant emissions through the real time collection of data from emission monitoring devices at business sites. The Air Pollutant Emission-Cap Management System targets the air pollutants such as nitrogen oxides (NOx), sulphur oxides (SOx), and total suspended particulates (TSP). In 2016-2019, the emissions of both NOx and SOx continually decreased year by year. Over the same period, the TSP levels decreased overall as well, expect for a spike of emissions in 2018.

The levels of Particulate Matter (PM10) and PM2.5 exposure in the Republic of Korea are extremely high and an enhanced policy to address this has been taken by the national government, as well as by the regional and local authorities. Policies such as bolstering the monitoring f emissions for factories and other production sites, and increased regulation of deteriorated diesel vehicles have resulted in lower emissions than a nonpolicy action baseline. However, PM2.5 and PM10 exposure levels remain high particularly in the Seoul Capital area, where over half of the Republic of Korea's 50 million population reside. The total national emissions for PM2.5 and PM10 have dropped comparatively between 2016 and 2021, yet there was also a sharp rise in emissions of both air pollutants in 2018 due to the large increase of fossil fuel combustion by the industrial sector.

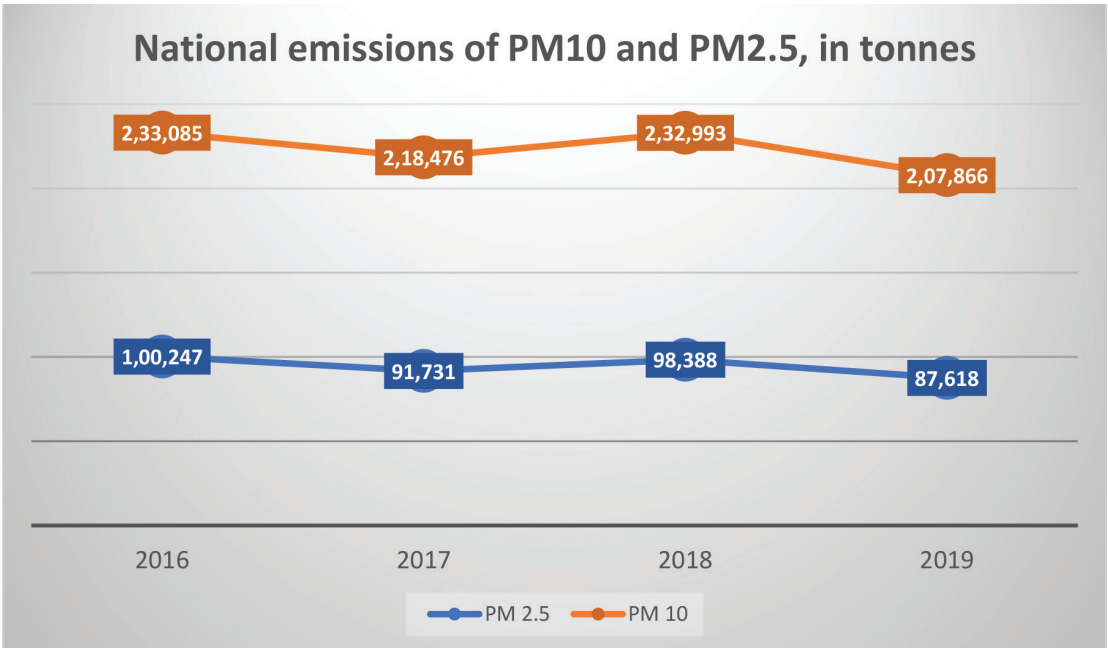
Regional cooperation

The air quality in the Republic of Korea is also strongly affected by the air pollutant emissions from other countries in the region, particularly China (Kim, 2019). For a more effective impact on increasing air quality levels in the Republic of Korea, regional cooperation is essential. The Korean government recognizes this and has initiated diplomatic measures to deepen mutually beneficial collaboration with China



Source: National Air Emission Inventory and Research Center, 2022.

Figure 5: National emissions of NOx, TSP, and SOx in tonnes, 2016-2019, Republic of Korea.



Source: National Air Emission Inventory and Research Center, 2022.

Figure 6: National emissions of PM10 and PM2.5, in tonnes, 2016-2019, Republic of Korea.

to reduce air pollution in East Asia. Over the past twenty years environmental ministerial meetings have occurred annually to discuss environmental policy issues such as regional air pollution and climate change. Environment ministers from both the countries have also announced a strengthening of cooperation to manage and decrease air pollution. The Republic of Korea currently promotes international joint research mitigating air pollution in the Northeast Asia in cooperation with China (NIIER, 2019). In the joint research project for Long-range Transboundary air Pollutants in Northeast Asia (LTP),

researchers from the Republic of Korea and China co-operate to use remote monitoring equipment for the Northeast Asia to analyze the air quality, seeking to improve the air quality in the region. Such a bilateral cooperation improves the comprehensive understanding about the causes and the origins of air pollution, while such cooperation also maintains communication and knowledge sharing among the various stakeholders.

International cooperation is also crucial to reduce air pollution for disseminating knowledge regarding technology and the responses of effective policies. The Republic of Korea also works in partnership with the United Nations Environment Programme (UNEP), sharing its experience and learning the best practices with regions experiencing low air quality to combat air pollution globally (UNEP, 2021). The UNEP partners with many countries in the Asia-Pacific region to support the development of national and subnational action plans and policies on air quality, and they also provide assistance in lowering emissions from major sectors such as industry and transport.

Enabling policies for SMEs

In order to effectively reduce air pollution and its origins, governments must enact and enforce enabling technology and regulatory policies that correctly incentivize and support small and medium scale enterprises (SMEs) in their efforts to reduce their air pollutant emissions. Given their environmental and economic importance, SMEs have the potential to be major drivers of green and sustainable growth, so careful consideration of policies that impact them is paramount. The manufacturing sector SMEs account for a significant portion of the world's resource consumption, pollution, and waste generation, and thus it is essential to enact policies that enable and strongly encourage them to reduce their adverse environmental impacts (Koirala, 2018). To not do so would be a major missed opportunity to improve the air quality through public and private sector cooperation.

A key issue is balancing the efficacy of legal requirements and oversight procedures that ensure that environmental goals are met without impeding the functioning of the SMEs through excessive compliance costs (OECD/Economic Research Institute for ASEAN and East Asia 2018). The continuation of one-size-fits-all approaches when designing and implementing environmental regulations can be a major drawback to SMEs as they do not operate on a substantive scale as larger enterprises, for which compliances to rules and regulations are less arduous. Regulations need to be designed with thorough attention to the SME sectors and the unique aspects of the local market in which they operate. The simplification of regulatory compliances is one of the first steps authorities should take to create an enabling environment for SMEs to reduce their air pollutant emissions. To streamline a regulatory system, regulators should introduce sector specific general binding rules as a substitute for multiple permits schemes, which create avoidable administration burdens for SMEs.

Regulatory impact analyses are an important tool for the environmental regulation of enterprises. To enhance the quality of regulatory oversight and to ensure that the created regulations are based on sufficient rigorous scientific foundations, it should be mandatory for regulators to carry out regulatory impact analyses. A regulatory impact analysis assesses the need for goals and feasibility for any new or reinforced regulation, and necessitates that regulators comprehensively compare various alternative regulatory options. They are highly beneficial as they clearly illustrate the inherent trade-offs between different policy options and regulatory proposals (Trnka, 2020). They also increase transparency by clarifying the reasons why a government intervenes in a private sector's business operations, which consequently raises the possibility of active compliance by the enterprises being regulated. This is especially important in the context of regulating SMEs to evaluate how the changes in the regulations and enforcements would affect their competitiveness and overall profitability.

Governments must ensure that it is practical for SMEs to utilize new air pollution reduction technologies. The advancements in air pollution reduction have, and will continue to take place. However, unless these new technologies are feasibly and rapidly adopted by SMEs, a meaningful reduction in the emission of air pollutants by SMEs will likely not occur. It is the responsibility of legislative and regulatory bodies to create enabling policies that facilitate speedy and widespread adoption of air pollution reduction technologies by SMEs. Increased use of air pollution reducing technologies, such the installation catalytic converters and flue gas scrubbers, are not possible without the government playing an active and facilitatory role in their adoption. Governments must be more stringent and dynamic in engaging with the SMEs in their technology adoption strategies into the future and provide the vision and funding for policies to be successful. A national budget funding should be specifically allocated for air pollution control measures for SMEs. SMEs must also engage with their local and regional authorities for effective coordination, and actively seek information regarding technological solutions and financial support for the reduction of their emissions of air pollutant.

Governments should also consider alternative and new policies to utilize SMEs in improving national air quality. SMEs can be supported to increase the number of trees in urban areas, which helps reduce air pollution levels. Trees absorb harmful airborne particles, so local authorities in various countries have taken measures to extend urban forests. While most trees will be planted at a large scale, SMEs can still be utilized to increase the total number of trees in cities. Local authorities can provide funding for businesses, landowners, building owners, etc. to plant trees on small unused patches of land. Generally, these patches of land are too small for other purposes, so it will result in a win-win situation for the property owners and the local authorities seeking to expand the number of trees in urban areas.

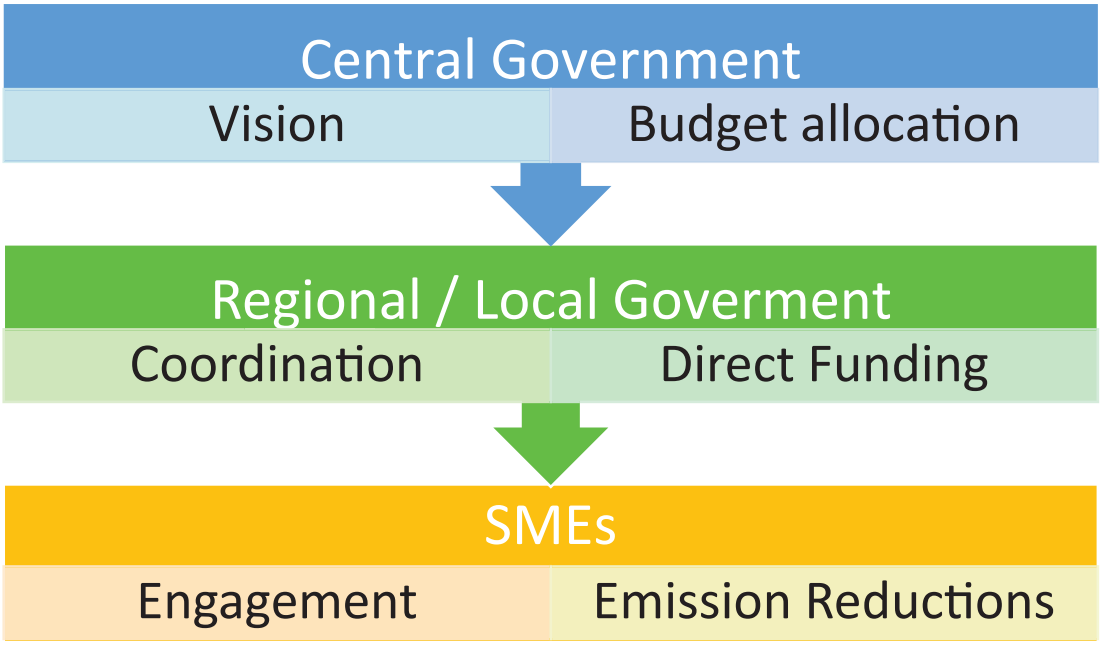


Figure 7: Process for effectively supporting SMEs in reducing air pollution.

Conclusion

The Republic of Korea has taken various measures to reduce air pollutant emissions from national sources, including from SMEs. By providing an overview of its recent air pollution trends and policies, this article aims to contribute to spreading practical knowledge for governments to take measures to improve air quality. Air pollution continues to be the greatest environmental threat to human health and wellbeing, and overcoming it requires innovation and change from all actors from the public sector, private sector, and civil society. An enabling environment for air pollution reduction by SMEs through technology adoption and regulatory measures must be actively created by governments in collaboration with SMEs. SMEs must play their role in reducing air pollution and be actively supported by governments in doing so. Through the three pillars of financial support, expertise, and transparency, the national, regional, and local authorities need to enact innovative and viable measures for controlling air pollutants. Regulatory frameworks need to move away from one-size-fits-all approaches, but be designed with consideration of the unique country and sector specific circumstances of SMEs. The air pollution control policies must not place unreasonable burdens on the operations of SMEs so that they can continue to be competitive. The managements of the SMEs must also actively cooperate with the regulatory authorities to reduce air pollution for the overall benefit of society, which will ensure cleaner air for the current and future generations.

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