Energy Sector and Trilateral Cooperation between the Republic of Korea, China, and Japan for Addressing Both Air Pollution and Climate Change

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Abstract

Ambient air pollution and climate change are key environmental issues for the Asia region, with the death toll from these problems projected to rise in the future. There are significant synergies between policies to address both challenges. This article outlines the current state of air pollution impacts and policy responses in the Republic of Korea, China, and Japan, the co-benefits of phasing out fossil fuel use, and the potential of decarbonizing the electricity generation sectors in the three countries as an efficient means of achieving dual gains. The article focuses on the importance of regional cooperation as both air pollution and climate change are challenges that no single country can solve alone. To effectively address these issues, a shared policy response is required. The article also discusses the importance of trilateral leadership to foster momentum for achieving mutual health and climate benefits and for realizing the 2030 sustainable development goals.

Introduction

Ambient air pollution exposure is the largest environmental risk factor for premature death worldwide (UNEP, 2023b). Air pollution causes over 6.5 million deaths annually, with 70% of deaths occurring in the Asia-Pacific region (UNEP, 2023c). Reducing the level of air pollutant emissions would vastly enhance health outcomes in Asia (Conibear et al., 2022)"ISSN":"1748 9326","abstract":"Air pollution exposure is a leading public health problem in China. Despite recent air quality improvements, fine particulate matter (PM2.5. Given that air pollution is a cross-boundary problem, cooperation is vital to address it. Climate change is also a serious environmental problem that will inflict massive amounts of damage in Asia if it continues unmitigated. The effects of climate change are increasing in Asia, causing losses to human life and economic development (WMO, 2023). Similar to air pollution, climate change is a problem that no single country can overcome alone and would require international cooperation to be addressed effectively. The primary cause of both air pollution and climate change is the combustion of fossil fuels; therefore, there are significant synergies between efforts to mitigate both environmental issues. The decarbonizing of our energy systems would yield significant health co-benefits (Ouyang et al., 2022).

The energy sectors in the Republic of Korea, China, and Japan combust the largest volume of fossil fuels and, therefore, are the most significant sources of air pollution. This article focuses on how changes in the energy sectors of the Republic of Korea, China, and Japan can achieve the double dividend of addressing air pollution and climate change and also the vital role of regional and international cooperation in achieving these double benefits. The study begins by presenting an overview of the impacts of ambient air pollution in the Republic of Korea, China, and Japan and proceeds to discuss promising emission reduction technologies and policies within the three countries. It also discusses how cooperation in terms of collaborative research between the countries and combined leadership in capacity building in the wider Asia region can address both air pollution and climate change, resulting in mutually beneficial outcomes.

Air pollution in the Republic of Korea, China, and Japan

The leading pollutants in the Asia region are particulate matter (PM10 and PM2.5), sulfur dioxide, nitrogen oxides, volatile organic compounds (such as hydrofluorocarbons), and short-lived climate pollutants (such as carbon, methane, and tropospheric ozone). The World Health Organization (WHO) issues guidelines on air quality levels and recommendations on exposure limits to various pollutants based on the most updated available findings on the pollutants' impact. For example, the current WHO guidelines state that annual average concentrations of PM2.5 exposure should not exceed 5µg/m (WHO, 2021), updated from the previous recommended limit of 10µg/m (WHO, 2005). As can be seen in Figure 1, the average ambient air pollution exposure levels in the Republic of Korea, China, and Japan exceed WHO guidelines.

Emission sources discharge multiple types of air pollutants that have a variety of characteristics and effects. Therefore, building our understanding of multi-air pollution risk processes is important (Sakti et al., 2023).

PM2.5 is especially harmful to human health as it can be breathed most deeply into the lungs, and exposure to PM2.5 increases the risk of lung cancer, chronic

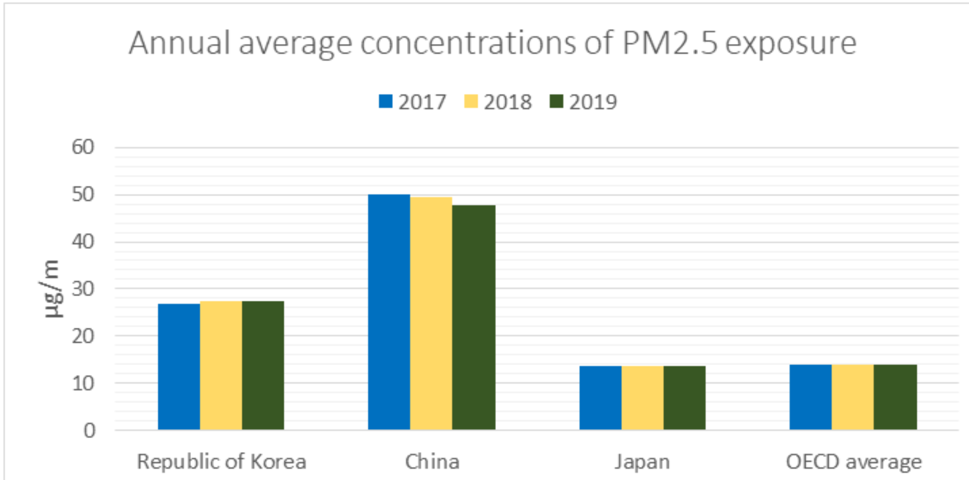

Figure 1. Annual average concentrations of PM2.5 for the Republic of Korea, China, Japan, and the OECD average

obstructive pulmonary disease (COPD), acute respiratory infections, ischemic heart disease, and strokes (EPA, 2023). PM2.5 greatly increases mortality and morbidity from these diseases and other PM2.5-related illnesses in these countries. Table 1 shows deaths due to PM2.5 exposure in 2019 in the Republic of Korea, China, and Japan. The majority of deaths occur in China, with PM2.5-related deaths nearing 1.5 million in 2019. Accounting for China's far larger population using the standardized unit of deaths per 100,000, China still has over twice the number of deaths due to PM2.5 exposure than the Republic of Korea and Japan. Therefore, the country can achieve the greatest rate of mortality reduction if radical action is taken to reduce PM2.5 emissions in the region.

The Republic of Korea, Japan, and the Eastern half of China, where over 90% of its population reside, are located within a 2000km radius. Therefore, the countries share the same airmass and are majorly affected by air pollutants emitted by each other. The adverse impact of ambient air pollution in the Republic of Korea, China, and Japan will increase over time as the three countries face changing demographic structures with a greater proportion of older citizens. By the year 2050, the population aged 50+ is projected to be 61%, 52%, and 56% for the Republic of Korea, China, and Japan respectively (UN, 2022). Older individuals are more vulnerable to air pollution-related diseases; thus, the death toll from poor [air] quality will rise sharply (Conibear et al., 2022). Air pollution exposure may even alter the genetic aging pathway, further increasing the air pollutant disease burden (Kuntic et al., 2023). Radical action to reduce air pollution would entail massive health and overall quality of life benefits for citizens in the region.

The governments of the Republic of Korea, China, and Japan have implemented various policies to reduce ambient air pollution. The governments of all three countries have introduced various policies to improve air quality, such as clean production incentives, vehicle emissions standards, fuel sulfur content regulations, and strengthened target air quality standards. The Republic of Korea began the phasing out of old diesel vehicles, with them being replaced by electric or LPG vehicles, launched various public awareness campaigns, and limited the operation of high air pollutant sources during extremely low air quality.

China's Air Pollution Prevention and Control Action Plan, launched in 2013, has helped reduce the trend in all pollutants except for tropospheric ozone (Dilawar et al., 2023). In 2022, to reduce the number of days of extreme air pollution, PM2.5 levels in Northeast China were targeted for the first time (Cheng et al., 2023). Air pollution pilot studies in cities have demonstrated a decrease in air pollutant levels compared to those in the cities not included in the pilot studies (Niu et al., 2023). Clean air policies have brought about substantial health benefits, generating major savings in air-pollution-related healthcare spending, which has helped alleviate

Table 1. PM2.5 air pollutant impacts in 2019 in the Republic of Korea, China, and Japan.

Sector	Total deaths due to PM2.5 exposure	Deaths per 100,000 people due to PM2.5 exposure	Percentage of ischemic heart disease deaths attributable to PM2.5
Republic of Korea	21,837	41	15%
China	1,423,633	100	20%
Japan	39,692	31	7%

Source: UNEP. (2023b)

health expenditure inequality (Weng et al., 2023). Technological advancement in modeling based on openly available data from China's Environmental Protection Agency has greatly improved their forecasting capacity (Dai et al., 2022). Despite the progress made over the past decade to achieve their own updated PM2.5 emission target, the Chinese government will need further action (Li et al., 2023).

In Japan, the "Comprehensive Policy Efforts on PM2.5 commenced in 2013, and this resulted in various positive progress outcomes, like a reduced number of extreme PM2.5 level alert incidents from 37 in 2013 to just 2 in 2017 (TPDAP, 2019). Vehicle emission controls in Japan strengthened over time, with the latest measure introduced in June 2018, which included reducing motorbikes and gasoline direct injection (GDI) PM2.5 emissions and enacting further controls for fuel gas evaporation during parking. Further electrification of the residential building and transportation sectors, increasing use of electric vehicles, and electrified heating and cooking systems can reduce PM2.5 and combat ozone depletion. These are estimated to have large positive human health and economic impacts (Long et al., 2023). End-of-pipe measures such as the phasing out of small-scale polluting factories and outdated industrial boilers, as well as strengthening vehicle emission standards, would also have similar beneficial effects.

Co-benefits of air pollution and climate change mitigation

The principal source of both air pollutants and climate change-inducing greenhouse gas (GHG) emissions is the burning of fossil fuels. Therefore, moving away from fossil fuels to low-carbon sources of energy such as renewables and nuclear power has dual benefits in terms of both of these environmental issues. These additional benefits of climate change mitigation policy are generally termed co-benefits. Recognition and understanding of interrelations and synergies between these issues are vital for building policy momentum. Holistic approaches to climate change and human health impacts require an integrated approach (Zhang et al., 2022).

There is a significant potential to decrease air pollution through decarbonization of the countries' energy mixes. Rapid decarbonization of the electricity generating sector would yield substantial air quality improvement co-benefits in near-term improvements of health outcomes (Jiang, 2023). Electricity generation in the Republic of Korea, China, and Japan is still fossil-fuel intensive. As shown in Figure 1, the energy mixes of the three countries still rely heavily on fossil fuel energy sources, primarily coal and natural gas. The green transition of the electricity generating sector would reduce the volume of air pollutant emissions while simultaneously helping to mitigate climate change by reducing GHG emissions.

As can be seen in Figure 2, over the past twenty years, all three countries have increased their renewable energy capacity, particularly solar PV, yet their energy mixes are still dominated by the fossil fuels of coal and natural gas. Achieving carbon neutrality over the next few decades would be impossible without the rapid growth of low-carbon electricity generation infrastructure. The governments of three countries should push for more rapid expansion of their low air pollutant and GHG-emitting energy capacity through support to solar PV, wind, hydro, and nuclear energy. Decarbonization of the electricity sector is relatively less complicated than other sectors, such as the

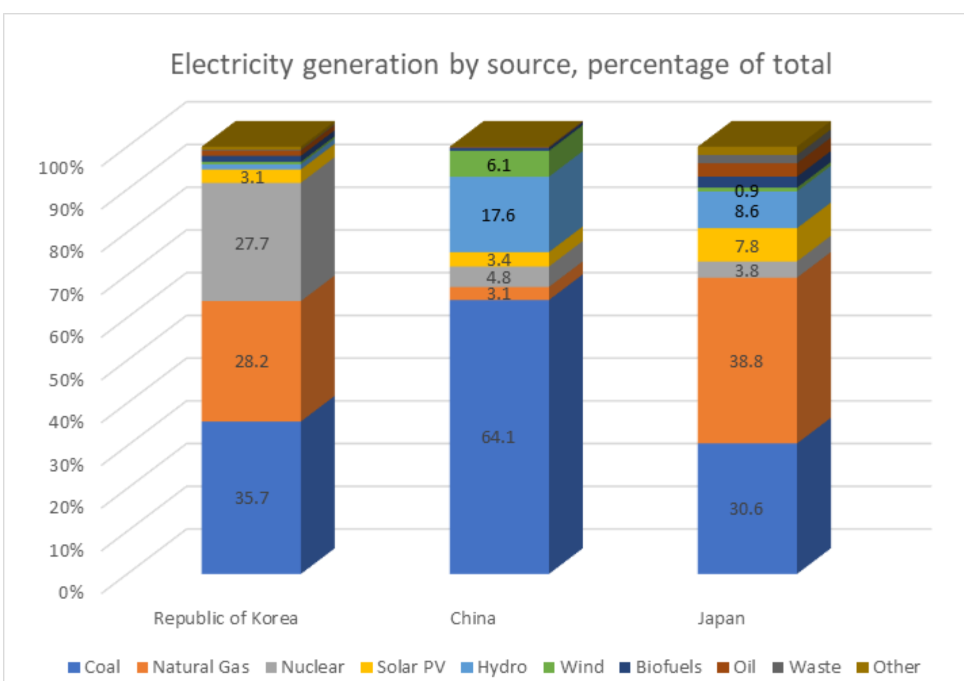

Figure 2. Electricity generation by source, percentage of total electricity generated, 2020. Source: (IEA, 2023)

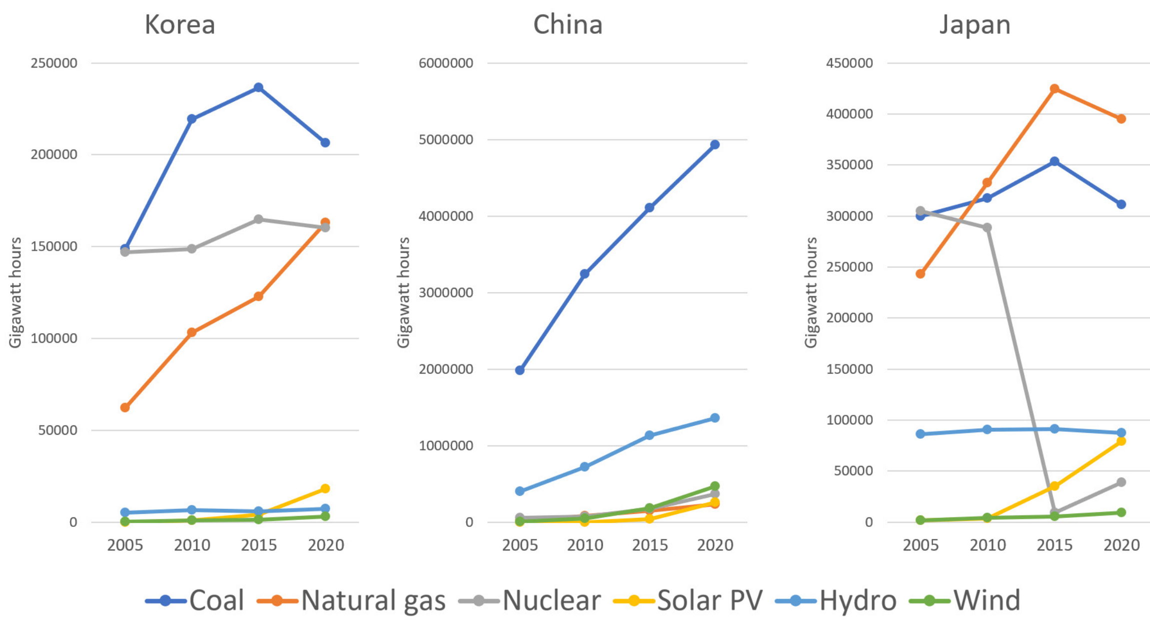

Figure 3. Electricity generated by sources of Korea, China, and Japan, 2005-2020. Source: (IEA, 2023).

transport and industry sectors, due to the government's power to set out and implement policies and construct the required green electricity generation infrastructure.

Trilateral cooperation and leadership

International cooperation is very important to reduce air pollution as air pollutants travel across national borders. As the largest economies and emitters of both air pollutants and GHGs, the Republic of Korea, China, and Japan should take an active role in accelerating regional cooperation on air pollution and climate change. The three countries can play a leading role in disseminating knowledge regarding air pollution control technology and effective policy responses due to their experience in these matters. For example, the Republic of Korea has experience in development collaborations between local government and experts from state research institutes to provide practical, context-specific advice for enterprises on how to reduce their air pollutant emissions. A key strength of this customized approach is enterprise leaders engaging with the process, as the steps were pragmatic and based on realistic constraints. In China, although a similar process still needs to be made, the government has vast experience implementing and overseeing long-term environmental action plans and creating successful subsidy programs for end-of-pipe pollution control for coal power plants and heavy industry (Liu et al., 2023). China has applied various technologies to reduce air pollutants in its coal and steel industries, such as hydrogen-rich fuel injection and semi-coke sintering technologies, flux and carbon-containing pellet technologies, and flue gas desulfurization technologies (Yu et al., 2023). Japan has a similarly vast experience with air pollution control policies and measures, with its Air Pollution Control Act of 1968 being regularly updated to incorporate the changing nature of the local emission profile. Numerous platforms for dialogue and cooperation on air pollution have already been established. Regional committees play an important role in communicating and reconciling interests, discovering mutually beneficial areas of cooperation, and facilitating coordination in the region. Current cooperation and policy measures include air pollution monitoring and data sharing. The Asia-Pacific Clean Air Partnership, established in 2015, allows policymakers and stakeholders to engage in knowledge sharing and the diffusion of effective tools and solutions for reducing air pollution (UNEP, 2023a). Its additional aims are to act as a mechanism for improved collaboration of clean air programs in Asia, serve as a platform to create and share knowledge on air pollution initiatives, and strengthen the institutional capacity of countries in the region. The Tripartite Policy Dialogue on Air Pollution (TPDAP) was established to enable the Republic of Korea, China, and Japan to exchange information on air quality management policies and discuss potential future initiatives. The 10th TPDAP, held on September 20, 2023, was hosted by Japan's Ministry of Environment and focused on the topic of the latest research on synergistic control technologies for PM2.5 and tropospheric ozone (TPDAP, 2023). Examples of new technologies include the improved air emission filters in coal power plants and the use of triboelectric nanogenerators in air dust removal systems (Zheng et al., 2022). Still, widespread adaption remains a challenge due to cost feasibility at a large scale. Other future initiatives outline the dialogue for increased utilization of satellite data for air quality monitoring and incorporation of the Acid Deposition Monitoring Network in East Asia (EANET) and other international frameworks.

Despite these initiatives, more action in terms of regional cooperation can be taken. Republic of Korea, China, and Japan can take further action to aid capacity building and share best practices on how to reduce air pollutant emissions with other countries in Asia. Further cooperation in terms of collaborative research between the countries and combined leadership in capacity building in the wider Asia region can address both air pollution and climate change, resulting in mutually beneficial outcomes.

Subsidies and other support for renewable energy development should be primarily focused on replacing fossil fuel energy sources rather than just providing government funding for domestic industries or constructing other trade barriers. For example, in the case of solar PV, there have been various WTO trade disputes regarding subsidies and domestic content requirements involving the three countries in complainant and respondent roles (Hajdukiewicz & Pera, 2020). Additionally, the promotion and sharing of technologies for improving efficiency in fossil fuel electricity generation, such as the installation of flue gas desulphurization and other emission control technologies, would help emerging economies improve national and regional air quality.

Future policy initiatives could include the sharing of air pollutant filtering technologies and chemical analytic methods with less developed countries in Asia and discussion on grid interconnection for efficiency gains, as China, in particular, has a huge renewable energy generation potential that could be utilized for national and regional gain. The creation of knowledge management hubs would help other countries in the region develop their capacity to address air pollution. Further installation of remote monitoring equipment in countries would help authorities prepare for periods of high levels of air pollution. The governments of the three countries should also lead and accelerate increased cooperation among government departments, universities, research institutes, and private sector actors in the Asia region.

Sustainable Development Goal (SDG)17 recognizes cross-country collaborations and coordinated policies are crucial for achieving the other SDGs. Figure 3 visualizes the crucial role cooperation and partnerships can play in achieving health, climate action, inequality reduction, and increased innovation outcomes in the Asia region. Through regional cooperation, the green transition of the energy sector, industrial sector, and other emission-intensive sectors can be enhanced. This will lead to positive impacts in terms of both SGD3 (Good Health and Well-being) and SDG13 (Climate Action), as the volume of high air pollutants and GHG emissions from fossil fuel combustion would be greatly diminished. Partnerships through regional agreements and research collaborations would also foster innovation for the development of technologies to address both air pollution and climate change, thus helping to advance SDG 9 (Industry, Innovation and Infrastructure). Regional inequality would also be addressed as wealthier and more powerful countries in Asia could provide expertise, capacity building, and other kinds of support to the less developed countries in the region.

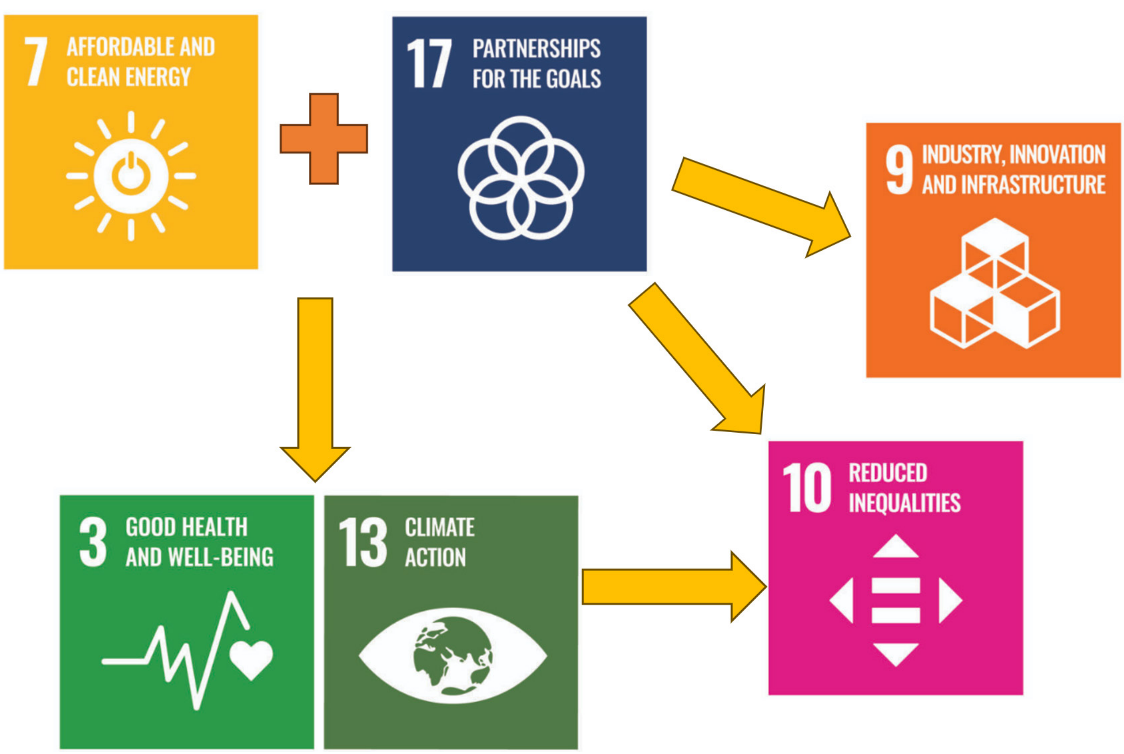

Figure 4. The vital role of partnerships in achieving the SDGs

Conclusion

Despite advancements in addressing air pollution over the past twenty years in the Republic of Korea, China, and Japan, significant progress still needs to be made. The stated air quality targets and carbon neutrality goals of the three countries will also be extremely difficult to achieve without a swift change in policy trajectory. The rapid phasing out of fossil fuel electricity generation offers the most efficient, near-term solution for addressing both issues. Regional cooperation is vital to improve air quality in Asia effectively. Enhancing cooperation and partnerships can help achieve the goal of addressing air pollution and mitigating climate change. Recognition of shared interest can lead to constructive and fruitful dialogue toward mutually beneficial outcomes. Regional cooperation plays a vital role in lowering air pollution levels and spreading awareness about successful policy options and technological solutions. The Republic of Korea, China, and Japan should play an active leadership role in promoting regional collaboration and capacity building.

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