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ENVIRONMENT, ENERGY & HEALTH
A&WMA 111TH Annual Conference & Exhibition
June 25-28, 2018 Hartford, Connecticut
Clean Air: A Global Perspective
by John Bachmann

In this month’s *EM*, we highlight many of the air quality issues and related health and environmental challenges from around the world.

Features

- An Introduction to Global Air Quality
  by Sara Terry

- U.S. Embassies Host Air Quality Monitors
  by Phil Dickerson and Caroline D’Angelo

- Soot-Free Urban Bus Fleets
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- Clean Air for Ghana—Building on Success
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- Reducing International Air Pollution under the Convention on Long-Range Transboundary Air Pollution
  by Paul Almodóvar and Kimber Scavo

- Analytical Tools to Support Air Quality Policy-Making Globally
  by Amanda Curry Brown, Neal Fann, Christopher Malley, Johan Kuylenstierna, and Harry Vallack

- Asian Cities and Clean Air Action Plans
  by Scott Voorhees

- Tackling the Waste Crisis in Kenya: Advancing Integrated Waste Management
  by Alice Kaudia and Erika Rosenthal

Columns

Asian Connections:
A Return to the Land of the Blue Sky
Given the severity of the air pollution in the Mongolian capital, Ulaanbaatar, the necessity to bolster emissions inventory capacity to accurately determine emission sources and pollutant concentrations is a government priority.

Departments

Message from the President:
Building Relationships Is the Key to Success
by Chris Nelson

Last Stop:
Getting to Know A&WMA’s Organizational Members
Building Relationships Is
The Key to Success

by Chris Nelson, P.E. » president@awma.org

In this month’s issue of *EM*, we explore the state of our global air quality. Over the past 50 years, many countries have dramatically improved their air quality while others have experienced increases in air pollution levels, often in urban areas. Causes and solutions are often complex and intertwined with economic development, local politics, and technology. I hope this issue of *EM* helps you better understand our challenges and potential solutions in a practical way. As we enter 2018, A&WMA will leverage our excellent monthly *EM* content with our other publications, conferences, and technical offerings to benefit our members and other environmental professionals around the globe.

Technology continues to disrupt global organizational planning and A&WMA does not get a pass. Thirty years ago, we could bring experts together and be the source of technical information for environmental professionals. Now anyone can jump on the internet and find more information than they can process. Online access to unlimited data is not paired with opportunities to build working relationships across our profession. These relationships are valuable for interpreting available data and charting a course forward on policy development and implementation.

A&WMA can provide value through building member knowledge and relationships. Our members have improved our Association’s financial situation over the past few years through hard work and solid programming. We have many strong Sections and Chapters at the local level and engaged Young Professionals across the association. In 2018, we can expand on that success by improving access to programming or content and creating new avenues for building effective business relationships.

Conferences and publications (like *EM*) will continue to be core products and services of A&WMA. Our goal is to leverage our existing content and expand into new areas to benefit our members. Specifically, we will tie topics from our publications to related webinars and conference speakers, giving members the opportunity to gain depth in those topics and access information in different forms. Our challenge is to add new methods of value-added content delivery, potentially including YouTube videos, podcasts, and other online content.

We can collect ever increasing numbers of followers and likes across our social media platforms (follow @AirandWaste and @CJNelson7 on Twitter!), but those connections do not take the place of professional relationships when we have difficult problems to solve or want a trusted advisor. I want to explore ways for A&WMA to make specific professional and mentoring connections for our members.

As A&WMA members, I encourage you to communicate with your Board and headquarters staff about your training and technical needs. We stand ready to plan the next webinar or find the right author to discuss a hot topic. We want A&WMA to be your resource for assistance with professional development and environmental decision-making. Contact us with your ideas or volunteer to help us move a specific initiative forward.

We all benefit from those members who shared their ideas or planned past events. Thank you to our past and present members of the Board of Directors for giving your time, talent, and intellect in service of A&WMA. I am fortunate that my time on the Board coincided with the terms of Presidents Mike Miller, Dallas Baker, Brad Waldron, and Scott Freeburn. Each is a great A&WMA leader. Stephanie Glyptis and our A&WMA headquarters staff continue to drive our activities and serve our members. We are lucky to work with them.

I look forward to talking with members at conferences and events throughout 2018 and appreciate all your contributions to A&WMA’s success. em
Spotlight on air quality issues and related health and environmental challenges around the world.

Clean Air
A Global Perspective

Cover image: Smog over China, October, 2010. During this week-long episode, Chinese authorities declared air quality “poor” to “hazardous” around Beijing and 11 eastern provinces. Grayish areas in the middle are smoke and fog (smog) across a wide region; whitish areas are clouds. Satellite sensors suggest particle pollution from fires, industrial emissions, and vehicles were likely contributors.

Photo credit: NASA Earth Observatory.
This issue of *EM* focuses on programs to improve air pollution in cities and regions around the world. The issue was conceived and coordinated by Rob Pinder and Sara Terry of the U.S. Environmental Protection Agency’s (EPA) Office of Air Quality Planning and Standards (also my alma mater). EPA’s air office has long participated in international activities, including binational agreements with Mexico and Canada, multilateral efforts on long-range transport, as well as technical and policy support to a variety of nations. Terry’s introduction to the issue highlights the importance of the disparate air pollution trends in the United States and other developed nations (substantial declines) and low and middle income countries (generally increasing). Recent estimates from the Health Effects Institute (https://www.stateofglobalair.org/sites/default/files/SoGA2017_report.pdf) find outdoor air pollution is responsible for 4.4 million premature deaths per year (2015 data); household air pollution from solid fuels accounted for an additional 2.8 million deaths. The articles that follow outline a variety of areas where EPA is cooperating with international organizations to improve air quality. EPA staff have assembled a team of in-house experts, as well as an impressive list of collaborators from organizations around the world for this task.

EPAs Paul Almodovar and Kimber Scavo provide an overview of the history and accomplishments of EPA and U.S. Department of State participation in the Long-Range Transboundary Air Pollution Convention. The program began with a focus on acid rain, but expanded to multiple pollutants, including ozone, fine particles, and persistent toxics.

Phil Dickerson (EPA) and Caroline D’Angelo (State Department) describe a targeted effort to place real-time PM2.5 monitors in U.S. embassies in cities with substantial air pollution, and report results using the Air Quality Index. These efforts have provided both U.S. citizens, as well as residents in the host country, with data and guidance that help raise awareness of the level of health risk on a daily basis.

Amanda Curry Brown and Neal Fann of EPA and coauthors from the Stockholm Environment Institute (SEI) outline the development and use of two analytical tools that help support air quality policy decisions around the world: BenMap, which estimates health and economic benefits of reducing air pollution, and SEI’s LEAP-IBC, which models air quality changes associated with potential mitigation strategies.

Ray Minijares of the International Council on Clean Transportation discusses development and implementation of “soot free” buses. Diesel transportation is a significant contributor to particle pollution in urban areas.

The last three articles discuss specific air and waste programs in Asia and Africa. EPA’s Scott Voorhees consolidates submissions from Clean Air Asia, ICLEI-Local Governments for Sustainability, and the Clean Air Alliance of China that outline air quality management programs in Vietnam, South Korea, and China. Emmanuel Appoh, Deputy Director for Environmental Quality of Ghana’s EPA and Sara Terry provide a brief overview of air pollution issues for all of Africa, followed by a focus on the first EPA Megacity Partnership with Ghana to improve air quality. Alice Kaudia, head of the Kenya Ministry of Environment and Natural Resources and Erika Rosenthal of Earthjustice summarize how Kenya is attacking a major waste crisis through cooperative efforts to develop and implement integrated management through policy and legislation. While focused on waste, the authors note these programs will produce air quality and climate benefits.

Air quality in major urban areas and regions around the world presents significant health and environmental challenges that are clearly linked to climate, energy, and the economy. These articles provide a useful look at the kinds of activities that can help.
An in-depth look at how improved measurement and analytical capabilities are enabling motivated countries to take meaningful action on the issue of international air quality management.
The United States has some of the world’s most effective air quality management programs, demonstrated by dramatic improvements in air quality since the passage of the original U.S. Clean Air Act. Since 1970, emissions of six common pollutants for which National Ambient Air Quality Standards (NAAQs) are established have decreased by 73 percent; at the same time, economic growth, as measured by Gross Domestic Product, has increased more than 250 percent. Similar trends can be seen across most high-income countries. Unfortunately, for low- and middle-income countries (LMICs), air pollution is trending higher, with air pollution responsible for more than 4.4 million deaths globally each year.

As dangerous air pollution episodes make the front pages of the international press, the public is demanding their leaders act to reduce emissions and protect public health. In response, LMIC governments are mobilizing to take action, often turning for guidance toward those countries that have demonstrated success in improving air quality. Fortunately, there are many models of successful air quality management planning, as well as for international cooperation. This special issue brings attention to the issue of international air quality management, and examines how improved measurement and analytical capabilities are enabling motivated countries to take meaningful action.

In the United States, success can be attributed in part to a public with an environmental consciousness that was heightened by environmental disasters in the 1960s, 1970s, and 1980s. The public demand for clean air was reinforced by a legal and organizational framework that supports continual improvement and implementation responsibility shared between national and state governments. In addition, success has been achieved due to continued investments in research and analysis to help improve and expand scientific understanding of air pollution over time. Given the global air pollution challenge, the potential of international air pollution to impact U.S. air quality, and the known benefits of clean air for public health and development internationally, the U.S. has made strategic investments in supporting clean air initiatives in priority regions and sectors. This includes work with both developed and developing countries. Some of those programs are presented in this issue of EM.

The U.S. Environmental Protection Agency, other U.S. federal partners, and a range of non-governmental and multilateral organizations are collaborating with LMIC governments around the world to improve air quality management. The focus of this work is to build knowledge and capabilities, including technology transfer, policy best practices, and analytical capacity building such that these countries can manage their own air quality and improve public health for their own citizens. This special issue is designed to highlight this work and the potential for a new generation of technical and policy solutions to a pressing global challenge.
Reducing International Air Pollution under the Convention on Long-Range Transboundary Air Pollution

EPA perspective on 38 years of collaboration with Canada, Europe, The Russian Federation and Eastern Europe, the Caucasus, and Central Asia for the Convention on Long-Range Transboundary Air Pollution (CLRTAP).
Air pollution does not recognize international boundaries. The environmental and public health challenges created by the flow of air pollution across political borders spurred the need for regional solutions to this problem. In 1979, 32 nations signed the Convention on Long-range Transboundary Air Pollution (CLRTAP) under the United Nations Economic Commission for Europe (UNECE), bringing together countries in this region to coordinate efforts on research, monitoring, and the development of emissions reduction strategies to address regional air pollution and its effects. This scientific, technical, and policy work has become a model to other regions of the world facing similar regional air pollution issues.\(^1\) Initially aimed at reducing the effects of acid rain through control of the emissions of sulfur, its scope later widened to include nitrogen pollutants, volatile organic compounds, heavy metals and persistent organic pollutants, ozone and most recently, particulate matter.\(^2\) To date, CLRTAP has been extended by eight protocols containing legally binding targets for emission reductions through the application of emission limit values and the use of best available techniques.\(^3\)

**U.S. Participation in CLRTAP**
The United States has been a key contributor and participant in CLRTAP since its inception, mainly by sharing technical and policy expertise on air quality management and by actively participating in both the policy-making and decision-making bodies of the Convention. The United States has benefited greatly from this participation. Addressing and reducing transboundary air pollution is critical to achieving U.S. air quality management goals. Through active participation in international treaties such as CLRTAP, the United States can continue collaborating effectively with our partners in the UNECE region to assess and eventually quantify the levels of transboundary air pollution affecting our domestic air quality. For example, CLRTAP's strong science and modelling of transboundary air pollution have shown how other countries impact North America's environment, particularly in vulnerable Arctic and sub-Arctic areas. In addition to meeting our commitments under CLRTAP, the United States and Canada cooperate on transboundary air pollution under the 1991 Canada–U.S. Air Quality Agreement and the Great Lakes Binational Toxics Strategy.\(^4\) Ensuring reductions of these transboundary air emissions leads to improvements in public health and the environment.

**Progress and Trends**
As shown in Figure 1, significant progress has been made in reducing emissions of sulfur dioxide, nitrogen oxides, volatile organic compounds, and particulate matter in the UNECE region. Most progress has been made in reducing sulfur dioxide emissions, which has resulted in reduced acidification. Some forest and lakes across the region are showing signs of recovery. By applying measures such as flue gas desulfurization and low-sulfur fuels, countries in Europe have achieved a total reduction in sulfur emissions of approximately 80 percent since 1990. Abatement measures for nitrogen oxides, which include flue gas cleaning and catalytic converters in vehicles have also roughly halved emissions over this period. Particulate matter concentrations at European monitoring sites declined by around one third between 2000 and 2012. In addition, the number of days on which ozone concentrations in Europe exceed the World Health Organization guideline level is now about 20 percent lower than in 1990.\(^5\)

In the United States, annual emissions estimates are used as one indicator of the effectiveness of air quality management programs. Between 1980 and 2016, total emissions of the six principal air pollutants declined by 67 percent. These reductions have taken place while gross domestic product increased 158 percent, vehicle miles traveled increased 111 percent, energy consumption increased 25 percent, and U.S. population grew by 42 percent.

**New Amendments**
In 2012, Parties negotiated amendments to the 1998 Protocol on Heavy Metals and the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol). The United States was the first to accept the amendments to the Protocol on Heavy Metals in 2015, and accepted the Gothenburg Protocol amendments in early 2017. These amendments have not yet entered into force, as 17 ratifications of the amended protocols from the original signatory Parties are required (to date there are 9 ratifications). When the United States takes steps to accept amendments, this encourages other countries to work toward the same goal. We are hopeful that both protocols will enter into force in 2018.

**Facilitating Emission Reductions in the EECCA Region**
The amendments to both protocols included revisions to the emission reduction obligations and provided implementation flexibility in order to encourage and facilitate ratification by countries in the Eastern Europe, the Caucasus, and Central Asia (EECCA) region. Furthermore, a very important feature of the work in CLRTAP is assisting countries in the EECCA region. Capacity-building programs funded through CLRTAP, as well as from other countries in the UNECE, are important for improvements in EECCA country technical programs. Developing emissions inventories and building general air quality management infrastructure can spur ratification and implementation of CLRTAP's protocols. In addition, this encourages the application of best available technologies on emissions sources across the region and levels the regulatory playing field for industry.
Reducing Air Pollution under CLRTAP by Paul Almodóvar and Kimber Scavo

Scientific Assessment

In 2016, the scientific and technical community within CLRTAP published an assessment report that presented the current scientific knowledge on transboundary air pollution issues within the UNECE region. The report described the effectiveness of air pollution measures in addressing large-scale effects on forests and lakes, as well as in protecting human health and preventing other air pollution effects, such

Figure 1. Decline in emissions over recent decades for a range of pollutants.
as loss in biodiversity and damage to crops, the built environment, and cultural heritage. The report also identified the challenges still remaining on improving air quality within CLRTAP’s boundaries. These challenges range from continuing to make progress on reducing ozone and particulate matter to acknowledging the need to more formally address nitrogen pollution, air pollution impacts on biodiversity, emissions from agriculture, and the linkages between air quality and climate change.

The Future

In response to the assessment report, a group of experts was established to provide a policy response to the findings in that assessment and make recommendations on whether and how CLRTAP should take action over the short and long term. The group, chaired by a U.S. expert, finalized their report and how CLRTAP should take action over the short and long term. The group, chaired by a U.S. expert, finalized their report and how CLRTAP should take action over the short and long term. Continuing with the multipollutant theme of the Gothenburg protocol, one key recommendation from the group is to continue to move CLRTAP forward with an integrated approach to addressing air pollution policy for the energy, transport, and agriculture sectors.

As CLRTAP moves forward to address the policy recommendations in response to the 2016 scientific assessment report, we believe that continued regional progress on reducing particulate matter and ozone should be a primary goal of CLRTAP in the next several years, with an emphasis on encouraging ratification and implementation of the Gothenburg protocol, particularly in the EECAA region. In addition, transboundary air pollution is an increasingly global problem. Emissions in other parts of the northern hemisphere contribute substantially to ozone concentrations in Europe and North America. An additional challenge to those noted above is how CLRTAP can effectively work together with UNEP and other international organizations with common goals on approaches to address global ozone, as well as how to coordinate effectively on other air pollution and related environmental issues of concern.

The regional agreements developed within CLRTAP are a model for global agreements under the United Nations Environment Programme (UNEP). The strong scientific and technical work of CLRTAP and its Protocols on Persistent Organic Pollutants (POPs) and Heavy Metals provided the framework for developing both the global Stockholm Convention (2001) and Minamata Convention on Mercury (2013). While there is still useful technical work to accomplish under CLRTAP and share with other international organizations for heavy metals and POPs, we believe that addressing the remaining challenges from these pollutants is more effectively done and with greater potential for emission reductions through the global multilateral environmental agreements under UNEP. However, this additional work under CLRTAP may be needed in the future where it can add value to the activities under either the Stockholm or Minamata Conventions.

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Notwithstanding progress in air quality improvement in the United States, there is more work to be done. In 2016, an estimated 123 million people nationwide lived in counties with pollution levels above the U.S. Environmental Protection Agency’s (EPA) primary national ambient quality standards. Furthermore, EPA scientists estimate that exposure to recent air pollution contributed to 1 of every 20 deaths in the United States and that reducing exposures to fine particulate matter and ozone nationwide by 33 percent would avoid approximately 43,000 premature deaths, tens of thousands of non-fatal heart attacks and respiratory and cardiovascular hospitalizations, and hundreds of thousands of acute respiratory symptoms. The economic value of premature deaths, heart attacks, hospital admissions, emergency department visits, and missed school work exceeds US$1 trillion every year.

Negotiating agreements with the countries in the UNECE region has a large and ongoing benefit to the United States. Collectively, we have made progress over the years in reducing emissions in key pollutants that affect public health and the environment. While problems still exist, there are tangible improvements in levels of smog, acid rain and other harmful pollutants, such as mercury. The United States will continue to collaborate with our UNECE colleagues to make sure that the reductions and commitments in CLRTAP’s protocols are achieved and continue to lead to integrated solutions to regional and hemispheric air pollution challenges and to real public health and environmental improvements.

Paul Almodóvar and Kimber Scavo are both with the U.S. Environmental Protection Agency’s (EPA) Office of Air Quality Planning and Standards.

Disclaimer: The views expressed in this article reflect those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency (EPA).

References
In 2015, EPA and the State Department partnered to create the Diplomatic Air Quality Monitoring Program to provide improved air quality data to U.S. citizens abroad by installing monitors at U.S. embassies and consulates around the world.
As a leading contributor to deaths and illnesses worldwide, air pollution continues to be not only a growing public health concern, but also a substantial economic burden. In 2013 alone, air pollution accounted for an estimated US$225 billion in lost labor income worldwide and more than US$5 trillion in welfare losses.\(^1\) Based on modeling data from the World Health Organization’s Data Integration Model for Air Quality (DIMAQ), more than three-fourths of the U.S. Department of State’s diplomatic posts are in locations that exceed the U.S. Environmental Protection Agency’s (EPA) annual standard for PM\(_{2.5}\) (fine particles with diameters generally 2.5 microns or less).\(^2\) With half of all the State Department’s posts in areas with limited, or no, monitored air quality data, the lack of real-time air quality information for diplomats and their families presents a major challenge. Real-time air quality information allows people to make informed decisions about everything from when to be outside to whether to operate air filtration systems.

Through implementation of the U.S. Clean Air Act, the United States has dramatically improved air quality while growing its Gross Domestic Product (GDP). Advancing the science and technology on air quality and health through partnerships with other countries is beneficial for those abroad and aids in further reducing air pollution here at home. For example, the U.S. Embassy Beijing led the way when they installed an air quality monitor in 2008 and communicated real-time PM\(_{2.5}\) concentrations to the public. Chinese citizens began to take notice, eventually leading to more protective air quality standards and increased monitoring by the government. EPA and the State Department partnered in 2015 to create the Diplomatic Air Quality Monitoring Program to replicate this success and provide more air quality data to U.S. citizens abroad by installing monitors at U.S. embassies and consulates.

**How It Works**

The Diplomatic Air Quality Monitoring Program leverages EPA’s expertise in monitoring air quality, managing real-time air quality data, and providing relevant health messaging. The State Department provides secure locations at embassies and consulates in countries where there is little or no publicly available, reliable air quality data. The monitors are selected, installed, and maintained using EPA guidance and standards. The data are then fed to and displayed by the EPA’s AirNow system (https://www.airnow.gov/), a public database and visualization tool set up in 1998 that publishes air quality data and forecasts from all 50 U.S. states, Canada, and Mexico in real time. AirNow was expanded in 2015 to accept data streams from the State Department monitors. The data are displayed using the same color-coded Air Quality Index (AQI) that has been featured on the AirNow system for years, allowing the public to compare and contextualize the local air quality numbers. The AQI developed by EPA is based on National Ambient Air Quality Standards (NAAQS), which classifies air quality in six levels from good to hazardous, and is accompanied by recommendations on outdoor activity.

Currently, nearly two dozen State Department posts are reporting air quality data through AirNow, with more on the

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**Figure 1.** Air quality conditions at U.S. embassy monitors, as reported by AirNow on December 19, 2017.

*Note: The level of the PM\(_{2.5}\) AQI is denoted by color (red: unhealthy; yellow: moderate; green: safe; purple: very unhealthy; grey: not available).*
way. From this experience, the benefits, lessons learned, challenges, and successes have come into focus.

**Benefits**

Installing U.S. regulatory-grade monitors at embassies and consulates provides U.S. citizens abroad—as well as host country populations—with reliable data they can use to help raise awareness and reduce their exposure to air pollution. Using the AirNow system ensures compatibility with EPAs existing domestic health messaging and research. Moreover, using a science-based approach enhances the agency’s efforts to work with host governments on improving air quality—and with such improvements, reducing the impact of transboundary movements of air pollution.

Looking forward, AirNow’s growing historical database of international measurements offers opportunities to advance air quality science. That database can be used for studies, modeling, and even as a basis to develop new air quality forecasting programs. With air pollution levels at many State Department posts far exceeding typical values in the United States, scientists can evaluate a broader range of data from relatively more polluted environments. The transparent and public sharing of this data has also led to the development of new applications and websites that use this previously unavailable data in new ways.

Besides improving data availability, the program promotes skill building and knowledge transfer. EPA and the State Department created a fellowship program in which U.S. experienced air quality professionals “adopt” a U.S. diplomatic post. Fellows from the program transfer their U.S. air quality skills and experience into capacity building in air quality monitoring, data analysis, and monitor maintenance at posts across the globe. Fifteen fellows participated during the first year of the program, providing everything from data analysis to advising host governments on air quality monitoring systems.

**Lessons Learned**

The data gathered by this program have provided important insights for both EPA and the State Department, and has helped people know when to take action to reduce their exposure. The partnership also led EPA to update the AirNow system to process global air quality data and improve system responsiveness. For example, air pollution levels abroad can be orders of magnitude higher than levels seen in the United States, and these high air pollution levels can last for much longer. A wintertime event at one post, for example, created hazardous AQI levels that exceeded the maximum of 500 on EPA’s AQI chart. As a result, the AirNow system’s real-time quality assurance routines had to be adjusted for use outside of the United States.

**Challenges**

Several challenges have surfaced as the program expands. For example, AirNow reports both raw pollutant concentration values and the public-friendly EPA AQI units. However, other countries have different air quality standards and air quality reporting indices based on different pollutant concentrations, creating confusion. Another major challenge has been...
Comparing measurements to in-country monitoring so that we can respond to host government questions about data disparities. Such a comparison requires knowledge of the equipment, siting, quality assurance, and of the air quality indices being used by the host country. Although we know those parameters for the State Department monitors, it can be difficult to ascertain them for others. Thanks to the increased diplomatic and scientific efforts stimulated by this program, we now have regular exchanges with many governments about these questions. Some have reached out to learn more about how the EPA performs data quality assurance, siting, and reporting.

For the State Department, evaluating the impacts of air pollution levels outside the United States on the health of overseas employees and families can be difficult as well. State Department personnel now have information on air quality at many posts, but translating that into health risk estimates is a challenge. Many health studies evaluate long-term exposure to air pollution or long-term residence in polluted areas, rather than the one to three-year tour of duty that our diplomats typically undertake. In addition to its partnership with EPA, the State Department is working with academics, other government agencies, and private companies to identify areas for further study and work.

**Successes**

Offering data in areas that previously had no reliable, real-time information has provided a platform for diplomatic engagement with other governments and citizens on air pollution and air quality information. One indicator of the program’s success is that the Embassies and Consulates page on the AirNow website has seen tremendous traffic, with 478,000 page views from October 1, 2016 through October 1, 2017.

Another fruitful avenue for engagement has been EPA’s Air Quality Awareness Week, held during early May each year.

In 2017, embassies and consulates around the world participated by hosting events that included film screenings, panel discussions, hackathons, and social media campaigns. Availability of real-time data at posts generated the interest that drove Air Quality Awareness Week’s success at posts around the world.

**Next Steps**

As the Diplomatic Air Quality Monitoring program grows, the State Department and EPA are installing monitoring stations at more posts, as well as equipment to monitor other air pollutants, such as ozone. Although the current monitoring network is focused on PM$_{2.5}$, ozone instruments are already up and running in Kathmandu and Manama. With the flexible real-time reporting infrastructure of EPA’s AirNow system, the State Department’s monitoring initiative can continue to expand, both in geographic reach and in pollutants measured.

The Embassy Fellows program also continues to grow and expand. Experienced air pollution professionals are always a great help to diplomatic posts, especially as the availability of monitor data increases, sparking interest within diplomatic and expatriate communities, as well as with host country partners. Use of the AirNow infrastructure to report the U.S. embassy data has also generated even more interest from countries considering their own AirNow systems.

While serving as a public resource for air quality data, AirNow’s historical database of international measurements continues to grow, providing significant research possibilities. From modeling worldwide air pollution concentrations, to providing reference data to test the reliability of a new generation of low-cost monitoring devices in high pollution areas, the Diplomatic Air Quality Monitoring program will continue to serve the public welfare and offer unique, expanding and valuable data resources for present and future research.

**References**

Analytical Tools to Support Air Quality Policy-Making Globally

A look at two key analytical tools that provide critical information to policy-makers about the benefits of policies that target pollution.
In recent years, a number of major studies have highlighted the impact of air pollution on health. In its 2017 State of Global Air report (https://www.stateofglobalair.org/health/current), the Global Burden of Disease project estimated that exposure to outdoor air pollution was responsible for 4.5 million premature deaths in 2015. Yet, even with this global health burden estimate, policy-makers may find it challenging to prioritize action on air pollution in the absence of locally-relevant data on emission sources and the benefits of mitigation. Analytical tools can provide critical information to policy-makers about the benefits of policies that reduce air pollution.

Since 2012, the U.S. Environmental Protection Agency (EPA) has been engaged in the development of two such tools: EPA’s environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE; https://www.epa.gov/benmap), a PC-based open-source software program that estimates the number and economic value of air pollution-related deaths and illnesses; and the Stockholm Environment Institute’s (SEI) Long-range Energy Alternatives Planning system with Integrated Benefits Calculator (LEAP-IBC; http://sei-us.org/software/leap), which allows users to build emissions models and implement hypothetical control strategies to reduce emissions.

LEAP-IBC links the estimated emission changes to a global air quality model to estimate the changes in concentrations of particle pollution and ozone in order to calculate the potential health (premature mortality), agricultural (ozone-induced crop yield loss), and climate (global temperature change) benefits of a policy. Both tools are publicly available, transparent with respect to the input data and assumptions and consistent with the current state of the science regarding air pollution benefits assessments, particularly with respect to the relationship between poor air quality and adverse health outcomes.

These tools can be used for countries that have a range of existing data and technical capacity, from those with advanced air quality monitoring and modeling capabilities to those with almost no locally available data. This article provides background on each tool, their application, and plans for future development (see Anenberg et al. Survey of ambient air pollution health risk assessment tools; Risk Analysis 2016, 36: 1718-1736 for a complete survey of available tools in the literature).

**BenMAP-CE**

In 2012, the BenMAP-CE program replaced an earlier proprietary version of the tool that was used for more than a decade, principally by analysts at EPA, to evaluate the benefits...
A new trainer certification program to train analysts in how to instruct others in the best practices for air pollution benefits assessments and how to operate the BenMAP-CE tool to answer critical policy questions. In April 2017, a core team of analysts from countries including Mexico, Chile, Colombia, and Peru received training certification in Lima. Then in August, another team of analysts from the Asian Development Bank in Manila and researchers from Thailand, South Korea, and Japan also received training certification. In September, the development team released new self-paced training guides (https://www.epa.gov/benmap/benmap-ce-training-materials) for each region of the world and launched a user forum (https://forum.benmap.org/).

Maintaining and supporting BenMAP-CE and developing software packages is both time- and resource-intensive. As the science underlying the practice of air pollution benefits analysis evolves, so too should the tool. For this reason, the team is keen to cultivate a cadre of software developers who are interested in contributing to this open-source platform, which is hosted on GitHub (https://github.com/BenMAPCE/BenMAP-CE). Developing a critical mass of users and developers who apply the tool and can contribute to its continued enhancement is central to our goal of making BenMAP-CE a community-owned program.

LEAP-IBC
The overall aim of LEAP-IBC is to provide users with robust methods to assess the implications of mitigation actions for health and the environment. LEAP-IBC is currently being used by 12 countries as part of the Climate and Clean Air Coalition (CCAC; http://www.ccacoalition.org/en) initiative on Supporting National Action & Planning (SNAP) to mitigate short-lived climate pollutants, including black carbon and methane. Since April 2016, more than 100 people from 15 countries have attended LEAP-IBC trainings, including a regional training workshop in Accra, Ghana, that brought together representatives from nine African countries.

LEAP-IBC is preloaded with default emissions factors and activity data that can be customized by users to represent local circumstances. Estimating emissions from a particular source sector (e.g., transportation or residential) requires data on the level of activity within that sector and an emission factor per unit of activity. There are different ways a user can choose to model emissions from a particular source sector in LEAP-IBC. These range in complexity, the level of data required, and the extent to which the data are suited to model the implementation of a particular mitigation action or policy. For example, the activity data used to calculate emissions from the residential sector can range from simply the total energy consumed in this sector to a detailed end-use analysis of the proportion of households within the country using different types of fuels and technologies for cooking.
lighting, heating, and other activities, and for example also split between urban and rural households.

The intent of LEAP-IBC is to enable practitioners in different countries to conduct analyses for themselves and provide training to enhance their capacity to undertake such analyses. It has been our experience that using data generated within a country is often more effective in supporting national policy than analyses undertaken internationally. To facilitate this, careful consideration was given to developing the user interface (see Figure 3) and providing flexibility to enable the user to modify the tool to reflect the emission sources in their country.

The use of a tool that can evaluate the effect of both air pollution and greenhouse gas emissions has resulted in greater synergies between air pollution management, energy planning, and greenhouse gas mitigation initiatives in several countries.

For example, Daniel Benefoh from Ghana EPA has been developing Ghana's actions to tackle climate change as part of its Nationally Determined Contribution (NDC) submission to the UN Framework Convention on Climate Change.

“Rather than using multiple tools, I use LEAP-IBC which allows both energy and non-energy emissions from all sectors to be calculated with the added ability to assess impacts of mitigation scenarios. LEAP-IBC can easily be modified to capture the impact of specific activities, such as replacing kerosene lamps with solar lanterns if you want to, a convenience you can’t find in any other software. This means that LEAP-IBC can effectively serve the interests of local users”

—Daniel Benefoh

Ghana EPA is using LEAP-IBC to model the effect of these actions not only on greenhouse gas emission reductions, but also the emissions of co-emitted air pollutants, some of which also affect climate, and the change in particulate matter and ozone concentrations and associated impacts on human health and crop yield in Ghana. This information will be included in Ghana's NDC submission to provide quantitative estimates of
the co-benefits from Ghana taking action to reduce climate change.

Future development of LEAP-IBC will focus on extending the range of impacts included. For example, additional health impacts and metrics will be added, such as years of life lost, or impacts of air pollution on adverse pregnancy outcomes. Quantification of the impact of ozone on a wider range of vegetation will be added, including additional crop species and natural vegetation (e.g., forests).

A key challenge in the application of LEAP-IBC to date has been to understand the scenarios that users in each country want to evaluate, which source sectors these scenarios relate to, and how to design the optimum way to represent these source sectors in LEAP-IBC, while accounting for the data constraints within the country. The development team is in the process of creating scenario development guidance for LEAP-IBC to provide users with some strategies to design a LEAP-IBC template optimized for their particular application.

The team is also developing the capabilities of LEAP-IBC to spatially grid national total emissions that will allow the user to selectively reduce emissions from a particular source in a particular area of the country. Finally, in addition to the current national application, they are also developing the capabilities to apply LEAP-IBC at the city-scale to evaluate the effect of mitigation actions—implemented at a city level, across a country or across a region, on air pollution and associated health impacts within a particular city.

**Conclusion**

Analytical tools play a key role in supporting policies to reduce air pollution by providing robust, locally-relevant information on the impacts of mitigation to policy-makers, stakeholders, and the public. BenMAP-CE and LEAP-IBC are two such tools that are currently being applied by analysts from a range of technical backgrounds in countries with varying levels of local data. Continued improvements to these tools will further enhance the ability of policy-makers around the world to take data-driven action on air pollution.

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**What’s on the horizon for EM in 2018?**

*EM* will explore environmental issues of supreme importance at the local, national, and international levels. Kicking off the year will be a focus on Global Air Quality (January), followed by Environmental Education (February), Waste Issues (March), Climate Policy (April), Sustainability Analytics (May), and Transportation (June).

The complete 2018 *EM* Editorial Calendar is available online (http://pubs.awma.org/EM/2018%20EM%20Editorial%20Calendar_FINAL.pdf).

Have an idea for an article or issue theme that you would like to share with your peers? Contact Managing Editor Lisa Bucher @lbucher@awma.org with questions.

**New and Exciting for 2018: Paper Makes a Comeback!**

Starting in first quarter 2018, A&WMA will publish a quarterly print digest that will complement the monthly digital *EM*. The new print edition will keep members up to date on Association activities, programs, and products, as well as provide original editorial content that will expand on the topics published monthly via the A&WMA App.

Look for the new print edition to mail by the end of January.
Soot-Free Urban Bus Fleets

A look at the Soot-Free Urban Bus Fleets Project, an effort by the Climate and Clean Air Coalition to eliminate the black carbon climate impacts of diesel coach and transit buses in urban areas.
Rapidly growing transportation systems in countries where vehicles do not meet best practices for emission controls, including older technology diesel engines without particulate filters, are contributing to the air quality and climate challenges we face. Anywhere between 12 and 23 percent of ambient particulate matter (PM)- and ozone-related mortality is attributable to the transportation sector. Urban buses alone, which account for about 1 percent of the global transportation fleet, account for approximately 25 percent of transportation-related PM emissions. This can be explained by the high share—more than 80 percent—of new buses sold today with diesel engines.

Ahead of the COP21 Paris Accords in 2015, the Union Internationale des Transports Publics (UITP), representing 1,400 public transport operators and private sector entities in 96 countries, issued a Declaration on Climate Leadership to double the market share of public transport by 2025. But massive new investments in public transport—particularly older technology diesel bus fleets—can deliver high diesel particulate and black carbon emissions that may undermine the air quality and climate goals these investments intend to achieve. Soot-free urban bus fleets offer a solution, while creating new opportunities to scale-up the transition to soot-free, low-carbon transportation globally.

Diesel engines produce 99 percent of the black carbon (i.e., soot particle) emissions generated by the transportation sector. Diesel exhaust is carcinogenic, and black carbon may contribute to this by operating as a universal carrier of a wide variety of toxics directly to the lungs and into the bloodstream. Black carbon is also a short-lived climate pollutant, causing more than 3,000-times greater warming than an equivalent amount of carbon dioxide over a 20-year period. These black carbon emissions can essentially be eliminated by a diesel particulate filter and ultra-low sulfur diesel fuel (i.e., 10–15 parts per million, ppm), which combined can achieve upward of a 99-percent reduction in diesel black carbon emissions (see Figure 1).

A “soot-free” engine is any diesel engine that meets Euro VI or US 2010 emissions where such filters are required, as well as any other diesel engine with a diesel particulate filter. Alternative non-diesel engines such as a gas engine or dedicated electric drive engine also meet our definition of soot-free. No more than 20 percent of all new buses sold today are soot-free, which explains the need for widespread adoption of the enabling fuels and access to soot-free engine technology as governments rapidly expand their urban bus fleets. Further reductions in climate impacts are achievable with low-carbon fuels and engines that deliver the lowest lifecycle greenhouse gas emissions.

**The Soot-Free Urban Bus Fleets Project**

The Soot-Free Urban Bus Fleets Project is an effort by the Climate and Clean Air Coalition to eliminate the black carbon climate impacts of all diesel coach and transit buses (see Figure 2). The project is co-implemented by the International Council on Clean Transportation and UN Environment, jointly with C40 Cities and the Centro Mario Molina-Chile. Since 2015, these groups have worked in 20 megacities where the needs are greatest: Abidjan, Accra, Addis Ababa,
We Are Seeing Progress

Based on policies implemented, adopted, and proposed, it is estimated that 55 percent of the global bus market will be soot-free by 2020.

National emission standards are the principal policy vehicle for delivering these changes. Turkey and India are the most recent countries to join the United States, Canada, Japan, the European Union, and South Korea in requiring national soot-free emissions from urban buses and other heavy-duty vehicles. China, Mexico, and Australia have proposed equivalent national standards, while Brazil and Thailand are in the process of developing them.

We hereby express to you the commitment of Mexico City to undertake programs of urban bus fleet renewal for soot-free vehicles that significantly reduce emissions of particulates and black carbon, in

Bangkok, Bogotá, Buenos Aires, Casablanca, Dar es Salaam, Dhaka, Istanbul, Jakarta, Johannesburg, Lagos, Lima, Manila, Mexico City, Nairobi, Santiago, Sao Paulo, and Sydney (see Figure 3). The project advises and supports public officials to adopt minimum soot-free emissions requirements in bus procurements. The project also works directly with manufacturers to secure voluntary public commitments to bring soot-free technology to targeted cities. And the work is supported by underlying technology procurement, emissions, and cost modeling at the city and national scales.

U.S. Actions to Accelerate the Transition

The U.S. Environmental Protection Agency’s (EPA) 2007 emission standards where the first to require a diesel particulate filter on buses in the United States, supported the previous year by new diesel fuel sulfur limits requiring no greater than 15-ppm levels to enable this technology. Mexico and Chile have proceeded to integrate the U.S. regulatory approach into their emission standard development. Meanwhile, the United States has led international engagement to advance such approaches. This includes multi-lateral support as a co-lead of the Heavy-Duty Vehicles and Engines Initiative of the Climate and Clean Air Coalition, as well as bilateral activities, including with China, Chile, and Ghana. The U.S. private sector has also demonstrated leadership through a voluntary public commitment by Cummins Inc. to make soot-free engine technology available to all 20 targeted cities by 2018.8

Figure 2. Euro 6 emission standards applied to buses achieve a greater than 99 percent reduction in diesel black carbon emissions when combined with 10-ppm sulfur diesel fuel.7

We hereby express to you the commitment of Mexico City to undertake programs of urban bus fleet renewal for soot-free vehicles that significantly reduce emissions of particulates and black carbon, in
Soot-Free Urban Bus Fleets
by Ray Minjares

accordance with emission technology provided under Euro VI or EPA.

While 17 of the 20 targeted cities have the necessary fuels, access to engine technology was found to be a larger limiting factor. In response, the International Council on Clean Transportation joined four global bus and engine manufacturers to announce in September 2017 the Global Industry Partnership on Soot-Free Clean Bus Fleets; Scania, BYD, Volvo Buses, and Cummins publicly committed to make soot-free engine technology available in all 20 targeted cities by 2018 (see Figure 4).12

Roadblocks Ahead

Despite the growing trend toward soot-free urban bus fleets, more than 40 percent of the global population in 2020 will not benefit from the cleanest soot-free engine technology. The problem will be particularly acute in the world’s largest megacities where national actions on emission controls are not being taken and where exposure to urban air pollution will grow. More aggressive actions are needed in nearly all of the cities targeted in this project, particularly those that have not made a commitment to soot-free urban bus fleets, such as Abidjan, Accra, Addis Ababa, Bogotá, Buenos Aires, Casablanca, Dar es Salaam, Dhaka, Jakarta, Johannesburg, Lagos, and Lima. Access to a range of clean fuels, urea supply, sufficient local servicing and maintenance capacity, access to finance, transparent procurement and engine certification procedures, and political will all present key barriers to accelerated deployment of soot-free engine technology.

The Future Is Zero

The city of Shenzhen, China plans to achieve 100-percent penetration of zero-emission technology in its 15,000 bus fleet by the end of 2017, the largest zero-emission bus fleet in the world.13 Los Angeles Mayor Eric Garcetti has set a target for a 100-percent zero-emission bus fleet by 2030.14 Many other cities are considering leapfrog of soot-free directly toward zero-emission technologies. The future is headed toward zero-emission technologies and not only soot-free technologies.

Our work has shown that in the majority of the 20 cities we target, investments in soot-free engines, including zero-emission electric drive, could pay for themselves between 5 and 9 years on average.2 These cleaner low-carbon engines could prove more affordable even than existing higher polluting and higher carbon buses operating in the cities today. The challenge in securing these savings is to treat fleet operation from a total cost of ownership perspective, which is atypical for public financing and operation of urban bus fleets. From this perspective, the obstacle is financial and not technical.

Despite the incredible potential for zero-emissions technology, local and national officials must not lose sight of the real opportunity to shift to soot-free technology. Investments at the city level in soot-free urban bus fleets will not only reduce this impact, but also enable a transition to cleaner technology in the broader transportation fleet, introducing clean fuel infrastructure that other vehicle types can utilize. These

Figure 3. The Climate and Clean Air Coalition Soot-Free Urban Bus Fleets Project targets 20 megacities to advise and support commitments to shift bus procurements to minimum soot-free emissions performance.8
investments will provide the technical capacity and experience needed to deploy the latest generation of vehicle technology. And they will enable a long-term technology transition.

Each new procurement that cannot be zero-emission must at minimum be soot-free. National policy-makers, local officials, financial institutions, and the private sector each have a role to play in accelerating this. More rapid progress is possible if all stakeholders can work together.

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References
Asian Cities and Clean Air Action Plans

Faced with a pressing need to reduce emissions and improve air quality, Asian cities are increasingly adopting holistic Clean Air Action Plans to address pollutant emissions from a range of sources. This article highlights aspects of air quality management in four Asian cities: Can Tho, Iloilo, Shenzhen, and Seoul.
A number of Asian cities are prioritizing sustainable development in their local and national development agendas, ensuring that economic growth does not come at the expense of air quality, public health, or the environment. In order to achieve this, they are adopting Clean Air Action Plans (CAAPs)—comprehensive, cross-sectoral air quality management plans—as a means to address emissions from a range of sources.

**Can Tho’s Monitoring Network**

Can Tho is the fourth largest city in Vietnam and the largest city in the Mekong Delta. The city has focused on expanding its industrial and agricultural sectors and improving its economic and social infrastructure. Though air pollution levels are not yet severe, the adoption of a CAAP earlier this year will enable national and local authorities to ensure that economic development does not compromise air quality.

The CAAP (http://cleanairasia.org/caap-cantho/)—developed under Clean Air Asia’s cooperation agreement with the Ministry of Natural Resources and Environment through the Viet Nam Environment Administration, and implemented by the Integrated Programme for Better Air Quality (IBAQ)—facilitates the implementation of targeted actions and activities to improve air quality. The measures outlined in the CAAP will be implemented over a five-year period, and are focused on addressing the main contributors to air pollution: motor vehicles, rice straw open burning, and production of textiles, metal, steel, and paper.

Critical to any air quality management program is monitoring. In Can Tho, this will include air quality monitoring in localized high concentration locations (hotspot monitoring), building the capacity of staff at the Department of Natural Resources and Environment to use semi-automatic monitoring devices, and installation of an automatic air quality monitoring system in the city’s industrial zone.

To supplement its existing monitoring network and to address its limited capacity to monitor particulate matter, hotspot monitoring in the city is intended to better characterize emission levels within its jurisdiction. This information is important to determining measures that will ensure that the adverse impacts of particulate matter on health and environment, and consequently on the city’s economic growth, are anticipated and effectively abated.

*Authored by Dang Espita, Tanya Gaurano, and Robyn Garner (Clean Air Asia)*

**Iloilo’s Jeepneys and Buses**

Iloilo, the capital of the Western Visayas region of the Philippines, is the region’s commercial and governance hub. As one of the Philippines’ rapidly developing cities, Iloilo is seeking to balance growth with environmental sustainability.

A growing population and the accompanying demand for transportation have prompted the development of a comprehensive strategy to combat the projected rise in emissions.

Cognizant of the importance of air quality management, the Iloilo City Government, with support from Germany’s Gesellschaft für Internationale Zusammenarbeit’s (GIZ) Clean Air for Smaller Cities in the ASEAN Region project, embarked on a multi-year, multi-stakeholder clean air development process that culminated in “The Clean Air Ordinance of the City of Iloilo” (http://en.aseantoday.info/philippines-a-clean-air-plan-for-iloilo-city/).

One of the first steps in that process was the conducting of a citywide emission inventory (EI) in 2011, which confirmed known pollution sources and shed light on sources that previously were not considered to be major air quality problems. It was determined that mobile sources emitted 30 percent of particulate matter (PM), 56 percent of oxides of nitrogen (NOx), and 50 percent of volatile organic compounds (VOCs), primarily from jeepneys, motorcycles, and passenger vehicles.

The data generated through the EI became the foundation for Iloilo’s first Clean Air Plan, which took effect in 2014 with a focus on measures to reduce pollutant emissions and measures to improve air quality management at both the local and national levels. To address high levels of ambient ozone, several transportation-related measures were included, such as the use of buses for selected routes, the enforcement of a vehicle registration system, and the introduction of “green zone areas” as a way to regulate exposure to transport emissions and provide drivers with incentives to use vehicles that comply with higher emission standards (such as Euro IV).

Additional measures for ozone pollution reduction included transition to Euro IV engines for jeepneys, and improving the efficiency of jeepney routes within the city (i.e., routes with the highest transport activity will be traversed by higher capacity vehicles such as buses, and vice versa, given due consideration to road size and origin-destination information.

*Authored by Dang Espita, Tanya Gaurano, and Robyn Garner (Clean Air Asia)*

**Shenzhen’s High Polluting Fuel Exclusion Zone**

Shenzhen, a southern Chinese city of 12 million people and the world’s 13th largest city, has established an unusual, but successful approach to controlling air pollution. It is China’s first megacity (i.e., with population greater than 10 million) to attain China’s annual fine particulate matter (PM$_{2.5}$) air quality standard. Furthermore, Shenzhen made a significant commitment in 2016 to achieve the World Health Organization’s Stage II PM$_{2.5}$ annual concentration guideline of 25 μg/m$^3$ by 2020.
Over the past decade, the city had faced serious haze problems with annual average PM$_{2.5}$ concentrations above 60 $\mu$g/m$^3$. In response, the local government collaborated with the Clean Air Alliance of China (CAAC) and employed an economic strategy to improve air quality, including reforming the industrial and energy structure, and implementing and enforcing stricter environmental policies. In both 2015 and 2016, Shenzhen’s Gross Domestic Product growth rate was around 9 percent, which is higher than most Chinese cities.

By 2014, most of Shenzhen’s highly polluting industries were relocated or closed down, leaving only coal-fired power plants. This resulted in a decrease in coal consumption from 38 percent in 2000, to 6.3 percent of primary energy. Natural...
gas consumption has risen to 8 percent, almost twice the national average. Clean energy power supply for the city (including nuclear, natural gas and co-generated electricity) has increased to 88 percent of the total power supply, which significantly contributed to the reduction of both air pollutants and greenhouse gases emissions. By 2016, Shenzhen’s annual average PM$_{2.5}$ concentration had dropped to 27 $\mu$g/m$^3$, well below China’s PM$_{2.5}$ annual air quality standard level of 35 $\mu$g/m$^3$.

New measures have been adopted to control pollutant sources. Power plants are in the process of upgrading their desulfurization and denitrification controls and are changing their fuel feedstock from oil to natural gas. For industrial sources, a citywide high polluting fuel (e.g., coal, bunk oil, straw, etc.) exclusion zone is now implemented for ozone pollution control, focused on control of volatile organic compounds from industrial and commercial boilers.

**Seoul’s Targeted LEZ for Wholesale Markets**

Seoul, the capital and largest metropolis of South Korea, is the world’s 16th largest city, and with a population of approximately 10 million, is home to about one half the country’s residents. The Air Quality Management Division of the Seoul Metropolitan Government recently unveiled a low-emission zone (LEZ) to target public wholesale market areas. These areas have the highest concentration in the city of trucks that are noncompliant with Euro III emission standards. Seoul’s strategy combines expansion and enforcement of LEZ standards with a diesel particulate filter (DPF) grant program, which is already showing tangible success.

Three components of the new LEZ policies are designed to expand the program area and improve its efficiency.

First, the implementation of a second type of LEZ, expanding on the 2012-2016 conventional LEZs in the city center and heavily trafficked roads of Seoul by targeting public wholesale markets. These are outside the city center and are also hubs for heavily polluting trucks. By targeting these areas, Seoul can regulate trucks originating from outside its jurisdiction, binding them to stricter standards.

Second, the introduction of financial grant programs for DPFs, providing truckers with a viable method to adhere to lower emission limits for the LEZs. In 2016, Seoul committed US$3.8 million and affixed 1,700 DPFs. The Ministry of the Environment is now introducing similar grant programs for local governments nationwide.

Third, the establishment of a Seoul-Incheon-Gyeonggi (SIG) regional LEZ monitoring network, for improved regional coordination. The successes of Seoul, together with recent episodes of high-density pollution throughout Korea, are leading more local governments to adopt similar LEZ and DPF grant policies nationwide.

**Summary**

The rapid pace of urbanization is presenting Asian city administrators and urban planners with a range of social, economic, health, and environmental challenges. This is particularly apparent in deteriorating air quality and its impacts on public health. Growing demands for energy, transportation, and industries is triggering a greater reliance on fossil fuels that, in turn, increases air pollution and greenhouse gas emissions. As demonstrated in these four cities, local monitoring and emission source identification are important building blocks for targeted actions that result in more efficient and effective priority control of the most important mobile and stationary sources.

Asian city initiatives demonstrate flexibility in addressing degraded air quality, tailoring innovative approaches to local conditions. In Can Tho, hot spot monitoring is a complement to the existing network, allowing for rapid identification of significant sources. In Iloilo, an emissions inventory identified mobile sources as significant pollution contributors, and was instrumental in singling out jeeps for emission reductions. In Shenzhen, reform of the energy and industrial sectors allowed for advanced pollution controls at coal-fired power plants and for a citywide high polluting fuel exclusion zone. And in Seoul, a zoning approach was used to address truck emissions in public wholesale market districts.
In Sub-Saharan Africa, Ghana focuses on air quality challenges.

Clean Air for Ghana
Building on Success

In Sub-Saharan Africa, Ghana focuses on air quality challenges.
Africa is a vast and varied continent, facing many developmental and environmental challenges. Air pollution may not appear to be the most pressing concern for many governments, yet indoor and outdoor pollution combined is currently the most significant cause of premature death, outpacing that of malaria and HIV. Though ground-based monitoring is limited, new methods allow improved estimates of emissions and ambient concentrations of air pollution and corresponding estimates of pollution impacts. The estimated economic cost of air pollution-related deaths is greater than that caused by unsafe sanitation or underweight children. Over 45,000 African children under the age of five die annually due to air pollution (2012 data), which is one of the highest regional child mortality rates in the world. Estimates of the economic cost to Africa of indoor and outdoor air pollution approach US$250 billion annually.

More than half of the world’s projected population growth through 2050 will occur in Africa, and the continent is also experiencing rapid urbanization rates. By the end of this century, it is projected that 5 of the 10 most populous cities on earth will be in sub-Saharan Africa. Some of the largest African cities today are projected to nearly double to over 20 million inhabitants by 2030. This growing rural–urban migration and increase in population will likely outpace and challenge the already inadequate infrastructure that exists to manage pollution. At the same time, there is very little quantitative data regarding air pollution levels and very little public awareness of the impacts of pollution on health. There are a handful of personal exposure studies focused on household air pollution, and some limited ambient monitoring, but there is not a reliable network of high quality monitors in most African countries. Neither is there much in the way of national emission source inventories.

In sum, very little is known about air pollution sources in African cities, and with a few notable exceptions, national and municipal governments have little human and technical capacity to manage air quality. Recognizing this confluence of challenges, the U.S. Environmental Protection Agency (EPA) engaged with the Ghana Environmental Protection Agency (Ghana EPA) to develop a template for air quality management in African cities—the Africa Megacity Partnership—with the ultimate goal of preventing unchecked air pollution growth in African cities as they expand and develop, and to reduce the health burden on the public. Ghana provides an excellent and instructive case study of air quality management planning in a context of limited data.

**Historical Aspect of Air Quality Management in Ghana**

This recent work in Ghana builds on more than 10 years of successful air quality measurement, focuses on health benefits assessment and making a business case for air quality management, and is establishing a framework that can be applied in other African cities. The Ghana EPA is mandated by a 1994 Act of Parliament to conduct environmental quality monitoring and prescribe guidelines and standards for air, water, noise, and soil/sediment, among others. For the air program, Ghana EPA’s approach is to draw conclusions on the priority emissions sources to control; estimate the baseline health and climate effects and other economic implications of those mitigation choices; and enhance monitoring and laboratory technical capacity. While there is much work to be done to improve air quality in Accra, the Ghana EPA has made significant strides. Successes to date are many, with only a few explored here.

One of the highlights of Ghana’s air program is its monitoring program, one of the oldest of its kind in sub-Saharan Africa, collecting important information about air pollution and its sources since 1997. Monitored pollution indicators and climatic variables include sulfur dioxide, carbon monoxide, nitrogen dioxide, black smoke, ozone, particulate matter (PM10) and total particulate matter (TSP). This program was enhanced with equipment and training by EPA, the U.S. Agency for International Development, and the United Nations Environment Program in 2005. Since that time, Ghana EPA has increased air quality monitoring sites from 8 to 15 sites in residential, commercial, and industrial areas in Accra. The program currently monitors PM10 and PM2.5. In addition, Ghana EPA built institutional capacity in the chemical analysis of filter packs and in understanding household air pollution, which may be a contributor to the ambient pollution problems in the urban environment.

Another recent highlight is the country’s roadmap to vehicular emissions and fuel economy standards (2014–2020). The roadmap outlines plans for cleaner fuels, stringent emissions standards for imported vehicles, ways to ensure proper maintenance of in-use vehicles, and transportation planning and demand management. Ghana has successfully reduced sulfur levels from 3,000 parts per million (ppm) in fuel to 50 ppm and issued new fuel standards, which took effect September 1, 2017.

**Recent Legislative Advancements**

On the legislative front, Ghana recently made three significant advancements.

First, to reduce the importation of over-aged vehicles (older than 10 years), Ghana introduced an age-based tax system for imported vehicles. This tax system imposes graduated penalties on imported over-aged vehicles to deter importers from bringing high-emitting vehicles into Ghana. The Ministry of Transport has also set vehicle testing centers across Ghana to test for emissions and also help gather data for policy decisions.
Then in 2016, Ghana EPA initiated the passage of the Hazardous and Electronic Waste Control and Management Act, which requires those who manage hazardous wastes and other wastes to take steps to prevent pollution. To improve public health, the law also provides for e-waste recycling and prohibits e-waste burning.

Also in 2016, Ghana passed a new Local Governance Act, designed to strengthen local government administration and to abate nuisances such as solid waste and pollution from open trash burning. Recognizing the urgent need for a program to address waste and sanitation issues, the government established a Sanitation Ministry in 2017. The ministry is tasked with ensuring effective implementation of sanitation policies and relevant laws in the country.

The First Megacity Partnership

It is within this strong historical context that EPA selected Ghana as its first Megacity Partner. With a solid environmental foundation in place, and a real organizational commitment to make further progress, the Megacity Partnership focused on three major areas: staff training, developing a model air quality management plan (AQMP), and communication planning.

A broad range of Ghana EPA staff participated in the first staff training. That training covered the basics of the iterative cycle of air quality management, from goal setting to inventory development and other baseline assessments to mitigation activities and reassessment and setting new goals over time. Staff were introduced to analytical tools, such as EPA’s Positive Matrix Factorization (PMF) Model and BenMAP, to help understand which sources were contributing to ambient air pollution, and the health impacts of those pollution levels.

The preliminary health benefits assessment estimates that if Ghana moves forward with business as usual, Accra can expect to experience between 10,000 and 17,000 premature deaths per year in 2020, as a result of exposure to ambient PM pollution. Taking action to reduce PM pollution by 50 percent (e.g., by implementing a suite of vehicle, cookstove, and industrial emission policies) could reduce the number of premature deaths by 3,500–7,800 each year. In addition, hospital admissions for asthma could be reduced by approximately 470,000–325,000 per year.

Following this general training and baseline assessment work, EPA delivered more focused training to a subset of Ghana EPA staff who required specialized skills to perform their work. Specifically, the Ghana EPA management identified three staff to be trained in detail in BenMAP (see the article by Amanda Curry Brown et al. elsewhere in this issue for additional information about BenMAP), additional staff who would focus on communications, and four staff, along with the Ghana Health Service, who received extensive training in laboratory analysis. By focusing training on those who are expected to work in each area, and providing on-going exercises and expectations for applying lessons learned to real world work products, the Megacity Partnership is able to deliver real results and build meaningful capacity within the Ghana EPA.

Lead Phase Out—A Victory for Public Health

Ghana became party to the Partnership for Clean Fuel and Vehicles Lead Phase Out program in June 2001 and was the first country in the sub-region to develop a program under this initiative. To begin, Ghana EPA conducted a baseline assessment of lead in air, soil, and blood of high-risk groups in Ghana. This assessment found that 82 percent of the study population of 396 persons recorded blood lead levels above the World Health Organization (WHO)-recommended level of 20 µg/dl. This research provided useful data to inform policy-makers, who then took action to phase out lead in fuel by December 2003. A follow-up study on lead in blood of high-risk groups in 2006 found that none of the study population (470) recorded blood lead levels above the WHO-recommended limit of 20 µg/dL.1

Public market, Ghana
The Megacity Partnership is also working with Ghana EPA to find solutions that really work for the Agency. Therefore, when it came time to find a model AQMP, it was important to find an example that would offer the right level of detail and be in a format that would be usable for Ghana EPA. Examples from the United States were limited, with State Implementation Plans not being easily transferable to the African context. Ultimately, EPA offered two examples and converted these into a template for use by Ghana EPA. These were the draft Waterberg–Bojanala Priority Area Draft Air Quality Management Plan (http://www.saaqis.org.za/file-download.aspx?fileid=1139) and the South Coast Air Quality Management District 2016 AQMP (http://www.aqmd.gov/home/library/clean-air-plans/air-quality-mgt-plan/final-2016-aqmp). Ghana EPA then used that template to strategize about the goals for clean air and the activities, new and existing, needed to achieve clean air. The result was a draft AQMP that is currently undergoing internal Ghana governmental review.

A key component of the analytical and planning effort is to consider how best to communicate to both the public and key decision-makers about the impacts of air pollution. In the course of the training on communication planning, and working collaboratively with the Ghana EPA communications team, it became clear that there was also work to be done to communicate within Ghana EPA on some key aspects of air pollution and building communication skills. They determined that, because air pollution is a cross-cutting issue, a broader understanding across the organization was needed to improve the ability to perform key job functions. For example, internal communications and training would enable multiple departments to be able to respond to air pollution and climate related questions from the public and affected industry and stakeholders. As a result, Ghana EPA developed both internal and external communication strategies.

Finally, though not part of the original Megacity Partnership plan, the team served to bring together a number of different organizations who were working on air quality related activities in Accra. The Global Alliance for Clean Cookstoves is working on a number of projects related to indoor air pollution; the World Health Organization and others are collaborating to mobilize the health sector to improve health data and act on air pollution; and the World Bank Pollution Management and Environmental Health Program has selected Accra as one of seven focus cities to support technical and program development around air quality management planning. The Megacity Partnership has served as a kind of clearinghouse for these various activities, improving communication and data sharing across organizations and helping to prevent duplication of effort.

The project began with an initial scoping mission in March 2015 and is now moving toward the last phases, to finalize the AQMP with a robust communication plan, and identify priority measures for implementation. The Megacity Partnership then expects to transfer the knowledge and templates piloted in Accra to another African city in the next year.

As we look forward, and as interest and action build across Africa, Ghana EPA, EPA, African-based governments and academic institutions, and other multi-lateral donor institutions are considering how to advance the technical and policy aspects of air quality management across the continent. In addition to programs like the Megacity Partnership, focus should be given to building regional based communities of practice, thereby enhancing information sharing and creating a sustainable community of African air quality experts.

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Disclaimer: The views expressed in this article reflect those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency (EPA).

References
Tackling the Waste Crisis in Kenya

Advancing Integrated Waste Management

A look at Kenya’s multipronged approach to improve solid waste management.
Effective sustainable waste management is a key national priority for Kenya. As in many countries where economies and cities have grown rapidly, the waste problem is now a major health and environmental crisis. The public is demanding and deserves action. The government considers safe waste management to be both a right, enshrined in Article 42 of Kenya’s constitution guaranteeing the right to healthy environment, and a key pillar of Kenya’s Vision 2030 sustainable development blueprint.

Kenya is therefore taking a multipronged approach, including legal and policy reform, local pilot projects, and measures to incentivize private investment in the waste sector, to improve waste management for multiple benefits. These actions aim to advance integrated waste management and circular economy principles, as well as to reduce emissions of methane and black carbon (a component of soot) in key regions and sectors across the country.

The Situation on the Ground
The current poor state of solid waste management (SWM)—open dumps, illegal dumping, and absence of a collection infrastructure—is a major threat to public health and the environment. Poor waste management also forfeits valuable resources for job creation and economic growth, while indiscriminate dumping of waste is an eyesore that negatively affects tourism, a mainstay of the economy, and the well-being of all Kenyans.

Kenya’s Vision 2030, the nation’s sustainable development blueprint, has set a goal of implementing an integrated waste management approach that delivers improved air and water quality, and better health for all, including waste-pickers and fence-line communities bordering waste dumps. Vision 2030 also seeks to improve livelihoods and economic opportunity in poor communities and incentivize start-ups in waste collection and recycling enterprises.

The waste crisis in Kenya is complex. Dumpsites are overflowing with a mix of all types of waste and are very poorly managed. Some of the dumps in Kenya’s major urban areas, such as the Dandora dumpsite in Nairobi, Kachok in Kisumu, and Kibarani in Mombasa, have been in operation for over 40 years. Moreover, only a small fraction of the waste that is generated is collected. This poorly managed system, combined with lack of accountability on the part of private sector companies responsible for most waste collection, has hampered recycling efforts. Approximately, 60–70 percent of the waste stream is organic matter. Yet, source separation is rare, reducing the potential for compost production, thus increasing methane emissions from dumpsites, and the potential for materials recycling. Rampant illegal dumping fouls waterways and roadsides. In Kenya’s sprawling poor communities there is often no waste collection at all. Pilot waste collection, separation, and recycling initiatives have been launched, but are in need of massive scaling up.

The capital city, Nairobi, generates more than 3,200 metric tons of waste daily, but only about 800 tons reach the nearby Dandora dumpsite—one of the world’s largest open dumpsites. Leachate and toxic smoke from Dandora fires contribute to chronic respiratory and waterborne disease in neighboring communities; conditions are deplorable for the more than 3,000 waste pickers that attempt to eke out a livelihood from the site (see Figure 1).

Figure 1. A woman picking through waste at the Dandora dumpsite in Nairobi.
Waste is illegally dumped along roadsides and accumulates in alleys in cities around the county, giving off noxious odors and providing breeding grounds for insects and rodents. Nationwide, it is estimated that only 10 percent of waste generated is recycled or composted, even though there are significant international market opportunities for polyethylene terephthalate (PET) plastics and paper, as well as a potentially large domestic market for organic compost.

Critical near-term challenges in Kenya start with a lack of policy and regulatory frameworks at the national and subnational level — the 2010 Kenyan constitution devolved many responsibilities, to the counties, including for solid waste management. On the ground, the country faces low rates of waste collection... transporters. The need to provide alternative employment for current waste sector workers as dumpsites are closed is also a major challenge.

Taking Action to Tackle the Waste Crisis
Kenya is rising to meet the waste challenge and is poised to make significant advances in waste management. Growing citizen outrage has resonated with elected officials. Political pressure combined with new opportunities to tackle SWM through the climate lens has garnered renewed commitment from the highest levels of government. The growth of international markets for recyclables, especially paper and plastics, and new national regulations facilitating the establishment of member-owned waste picker cooperatives (SACCOs) create further incentives for waste sector reforms. Several pilot enterprises are producing organic compost as a soil amendment from separated organic wastes.

The Kenya Vision 2030, the national development blueprint, aims for a clean, secure and sustainably managed environment by the year 2030, including reducing by half all environment-related diseases. Specific waste management strategies in furtherance of this vision include closing the nation’s largest dump site, Dandora, and the development of SWM systems and engineered sanitary landfills for the nation’s five largest metropolitan areas. The constitutional provisions and aspirations of Vision 2030 have led to the prioritization of waste management as a strategic approach to ensuring a healthy environment and improving the well-being of all Kenyans.

Kenya’s constitutional reforms in 2010 devolved responsibility for waste management to 47 newly formed counties, but so far counties have been unable to effectively collect, transport, and recycle or securely dispose of waste. Scant data has hampered planning and investment decision-making. Vision 2030 prioritizes the establishment of solid waste management systems in the five largest counties, including the construction of an engineered sanitary landfill for final disposal of non-recyclable waste, a mechanical-biological waste treatment (MBT) plant, and a composting facility and recycling center to replace the nation’s biggest dumpsite, Dandora, located in the peri-urban area of Nairobi. The development and enforcement of waste management laws at both the national and sub-national levels are key to implementing a new approach to waste management that emphasizes waste reduction, recycling, and reuse; capitalizes on the waste value chain; reduces methane and black carbon emissions; and achieves environmental, health, social, and poverty reduction objectives.

Enabling Policy and Legislation for Integrated Waste Management
The National Solid Waste Management Strategy, adopted in May 2015 after a full, constitutionally required consultative process in the 47 counties, marked the first major milestone in the implementation of Vision 2030. The strategy has the potential to achieve climate and development benefits, if robustly implemented. However, the strategy does not include a roadmap for implementation, and it lacks legal force.

The government has therefore prioritized the adoption of a legally binding waste management act to incentivize accelerated action at the national and county level, increase compliance, and facilitate increased private investment flows to the waste
Tackling Waste in Kenya by Alice Kaudia and Erika Rosenthal

recycling and sanitary disposal activities. (In parallel, additional work is underway to develop approaches to address medical and hazardous waste to ensure separation at the source and appropriate treatment and disposal.)

As part of the process, the government established a National Waste Management Steering Committee with representatives from across all relevant government agencies and stakeholders to advance the adoption and implementation of the waste management act. These agencies and stakeholders include the Ministry of Environment and Natural Resources, the National Environment Management Authority (the semi-autonomous enforcement arm of the ministry), the National Treasury, Council of Governors, Judiciary, National Police Service, State Law Offices, and faith-based and community organizations.

The government received legal support from the Climate and Clean Air Coalition, a voluntary international partnership working to catalyze reductions in short-lived climate pollutants such as methane and black carbon, to draft a bill for a national waste management act with the aim of improving waste management to reduce emissions of these pollutants from the waste sector.

The draft Waste Management Act was completed in June 2017 and is currently going through the constitutionally required stakeholder and county consultation process prior to presentation to Parliament. The Act will drive improved waste management at the county level via the adoption of an enabling regulatory framework, including tax reform to incentivize private investment in recycling and treatment facilities; setting goals and timetables for waste collection and separation at source; requiring counties to allocate land for sustainable waste management facilities; improved labor and health standards; tax relief on imported sustainable waste management equipment (e.g., recycling, composting, and waste-compacting equipment); tax incentives to expand investment in material recovery and recycling facilities; and the promulgation of certification standards for organic compost to encourage growth of the domestic market.

Moving Forward
Kenya has recently taken some significant strides toward creating a facilitative policy environment for integrated waste management and advancing pilot projects. Two illustrative initiatives are discussed below: a model county level integrated waste management project, and a national ban on plastic carrier and flat bags.

Figure 2. Kids playing at the Ngong dumpsite in Kajiado county.
The Kajiado Pilot Project

National action is being complemented with county action to help shift from reliance on dumpsites to advancing the implementation of policies and projects that facilitate waste minimization, through resource use efficiency and cleaner production, diversion and recycling of significant percentages of the waste stream, and final disposal of non-recyclable waste at secure sanitary landfills.

For example, the Ngong dumpsite in Kajiado county receives an estimated 400 tons of waste daily from neighboring Nairobi city to the north, as well as from across the county (see Figure 2). Local residents have for years voiced concerns over the negative environmental and public health impacts of this site, including noxious odors, air pollution from fires at the dump-site, flies, rodents, and other pests.

The Kajiado initiative was conceptualized as a pilot project for decommissioning a dumpsite in a major town through the construction of a prototype composting facility, waste recycling plant, and sanitary landfill for final disposition of the non-recyclable fraction of the waste stream. The organic waste fraction of waste stream entering the Ngong dumpsite is by far the largest, making separation and composting a priority; nevertheless, as the middle class grows in in Kenya’s main urban areas an increasing fractions of recyclable plastic and electronic wastes are projected to enter the waste stream making an integrated approach essential. In addition, the intent is to build capacity across the solid waste management value-chain leading to resilient livelihoods in commercially viable enterprises, particularly by youth and women.

With support from international partners, county government leadership, and broad community participation—including the local waste pickers collective—work is ongoing to strengthen the public-private partnership with the waste collection company to ensure accountability and more extensive collection across the county. Key initiatives include significant engineering improvements to the Ngong dumpsite; training to increase youth employment in the waste industry; establishing systems for separation and recycling; and the adoption of county level regulations and action plans. The project aims to be a model that can be replicated in counties across the nation.

National Plastic Bag Ban

On August 28, 2017, Kenya’s plastic bag ban, one of the world’s toughest, came into force, attacking a major challenge to sustainable solid waste management in Kenya as in many countries worldwide. Kenyans are estimated to use 24 million bags a month, many of which end up in piles by the roadside or hanging from trees; huge quantities are consumed by livestock, and dog and contaminate water drainage infrastructure and rivers. The ban, which was strongly resisted by the plastic manufacturing sector and survived a challenge in the high court, is creating new market opportunities for small-scale entrepreneurs who produce jute and cotton bags and baskets from other biodegradable materials.

Conclusion

It is hoped that these initiatives will take the country one step closer to the constitution’s promise of a clean and healthy environment for all, and represent a major advance for Kenya to meet its sustainable development aspirations and fulfill its Paris Agreement commitments. There is a growing community of practice on waste management in east and southern Africa. Kenya will continue to exchange new approaches and lessons learned with colleagues across the continent and around the world to provide effective integrated waste management solutions that improve the lives of our citizens and contribute to the global fight on climate change.

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The smoggy haze that blankets Mongolia’s capital, Ulaanbaatar, belies the country’s reputation as “The Land of the Blue Sky.” With levels of fine particulate matter (PM$_{2.5}$) recorded at more than 80 times World Health Organization guidelines during the winter months, and with a mounting public outcry over declining air quality, the national government and municipal authorities are working on multiple fronts to address the city’s growing health and environmental crisis.

A Return to the Land of the Blue Sky

by Clean Air Asia’s Air Quality and Climate Change Program

Given the severity of the air pollution in the Mongolian capital, Ulaanbaatar, the necessity to bolster emissions inventory capacity to accurately determine emission sources and pollutant concentrations is a government priority.

Through the Guidance Framework for Better Air Quality in Asian Cities, Clean Air Asia’s Integrated Programme for Better Air Quality in Asia (IBAQ Programme) is assisting Mongolia in improving the city’s air quality. Mongolia was selected as one of the pilot countries for Guidance Framework implementation, building on its recent developments in air quality management (AQM) and long-standing cooperation on air quality between the Ministry of Environment and Tourism (MET) and Clean Air Asia. Support for PM$_{2.5}$ monitoring in
Ulaanbaatar facilitated by the Asia Center for Air Pollution Research under the IB AQ Programme in 2015 provided the basis for the provision of further assistance.

Ulaanbaatar faces a unique set of geographical and socio-economic circumstances. The city is located in a valley surrounded by mountains, which leads to thermal inversions, predominantly in the colder months from October to April when energy consumption from heating is at a peak. Thermal inversions result in an accumulation of pollutants near the ground. Exacerbating the city’s geographical challenges are the social and economic changes that have taken place in the more than two decades since Mongolia’s transition from a centrally planned economy to a market economy in the wake of the collapse of the Soviet Union. Rapid urbanization fueled by an exodus of people from rural areas has seen the city’s population swell, with more than 60 percent settling in under-serviced and largely unregulated peri-urban “ger districts” (a “ger” is a traditional Mongolia round felt tent). With economic growth concentrated in the capital, more than two-thirds of Mongolia’s total population is now urbanized—significantly higher than the Asian regional average.

Population growth and urban expansion have resulted in a sharp increase in travel demand in Ulaanbaatar. From 2010 to 2014, motorization increased by 72 percent, with a total recorded vehicle population in 2014 of 437,677 units, 88 percent (383,725) of which were cars. In addition to rises in vehicle emissions, accommodating the energy needs of the city’s expanding population has led to a deterioration in air quality. Coal accounts for 73 percent of the national energy consumption and is forecast to remain the primary energy source in Mongolia given the country’s massive coal reserves that render other energy resources, such as oil and gas, insignificant. Ger district residents rely on coal for heating during Mongolia’s long winter months, with coal-fueled ger stoves and boilers producing plumes of toxic black smoke. The average family consumes 5 tons of raw coal each winter, resulting in an estimated annual ger-household consumption of 800,000 tons of raw coal.

The sources of air pollution are primarily located in Ulaanbaatar, including heating and cooking activities, motor vehicles, industrial boilers, power plants, dust from construction activities, brick kiln operations, re-suspension of road dust and fly ash, and garbage burning. Fuel combustion for domestic cooking and heating (60 percent), motor vehicles (20 percent), and power plants (6 percent) represent the main sources of air pollution.

Air pollution is having a profound impact on public health. According to the Public Health Institute of Mongolia, air pollution contributes to 20 percent of cardiovascular diseases, 9.2 percent of overall population mortality in Ulaanbaatar, 28.8 percent of deaths caused by lung or combined heart and lung diseases, 39.9 percent of lung cancer, and 50 percent of respiratory diseases.

For More Information

Clean Air Asia, the region’s premier air quality network, is an international non-governmental organization leading a regional mission for better air quality, and healthier and more livable cities throughout Asia, and helping cities address air pollution on multiple fronts with a range of comprehensive tools, including:

Under the Integrated Programme for Better Air Quality in Asia (IB AQ Programme), the Guidance Framework for Better Air Quality in Asian Cities targets policy- and decision-makers and is organized around six priority air-quality management areas, mapping out a series of steps and actions to guide cities in the development of cleaner, greener and healthier urban spaces.

The online Clean Air Scorecard tool (http://www.cleanairasia.org/cast) provides a synthesis of current air quality management in Asian cities that responds to the growing need for more accessible, objective, and in-depth understanding of air quality levels and the management capacity of cities in the region, offering an accessible portal for cities and stakeholders to assess related policies and actions.

The Clean Air Certification (http://www.cleanairasia.org/ccap) scheme recognizes actions that cities take to improve air quality.

For more information, visit cleanairasia.org.

Asian Connections is sponsored by A&WMA’s International Affairs Committee. A&WMA has invited Clean Air Asia to contribute one column each quarter to highlight air quality and climate change issues in Asia. Clean Air Asia is an international nongovernmental organization that promotes better air quality and livable cities by translating knowledge to policies and actions that enable Asia’s 1,000+ cities to reduce air pollution and greenhouse gas emissions from transport, energy, and other sectors. A&WMA has collaborated and partnered with Clean Air Asia since 2006.
Ulaanbaatar is hence the focus of national AQM efforts, and at present there are 10 ambient air quality monitoring stations throughout the city providing real-time data on pollutant concentrations. The National Agency for Meteorology and Environmental Monitoring (NAMEM) within the MET is overseeing air pollution monitoring, implementing national air quality action plans, and developing emissions inventories (EIs) covering PM$_{10}$, PM$_{2.5}$, nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOCs), and carbon monoxide (CO). The MET itself is mandated by the Mongolian government to develop a National Clean Air Plan that will provide a framework for AQM initiatives.

Given the severity of the air pollution in Ulaanbaatar, the necessity to bolster EI capacity is a priority. As part of Clean Air Asia’s IBAQ Programme, in collaboration with the Asia Center for Air Pollution Research, training was provided for local EI compilers and relevant agencies in conjunction with the development of a guidance document on undertaking a national EI system in Mongolia.

In addition, a review paper on AQM highlighting the experiences and good practices between Beijing, Delhi and Ulaanbaatar was integrated into an Action Plan and National Action Program on Reducing Air Pollution, along with relevant sections of the Guidance Framework. Clean Air Asia also helped to facilitate the development of the Action Plan by convening decision-makers, policymakers and AQM stakeholders in Mongolia. At the first of a series of EI trainings in Ulaanbaatar in March 2017, the IBAQ Programme brought together representatives from government, research institutions and provincial environment monitoring agencies for a technical training on national EI development.

The “Training Workshop to Improve Capacity on Developing Emission Inventory” was aimed at increasing the technical knowledge of government staff and other stakeholders on EI approaches; improving local capacity for EI data collection, the evaluation of emissions factors and activity data for local technologies, and EI management; and identifying the next steps for EI implementation in line with the Guidance Framework. It provided NAMEM and local EI compilers with a thorough understanding of EI concepts and approaches suitable to current EI capacities in Mongolia, including the improvement of data collection systems and the assessment of appropriate emission factors for EI development.

The strengthening of capacity to estimate emissions through the development of a manual for national-level EI was also reflected in a cooperation plan between Clean Air Asia and the MET, which is aligned with the government’s priority of gathering national-level emissions estimates of air pollutants to serve as baseline data for the formulation of emissions taxation and to inform the implementation of emission-control regulations. As part of these efforts, Clean Air Asia and the Asia Center for Air Pollution Research are developing an EI manual and emissions calculation tools using available statistical data in Mongolia. The trainings supplement the development of the manual to enable the MET, NAMEM and other agencies to undertake a thorough EI.

The air quality challenges facing both the national and city authorities are not insurmountable. With the demonstrated commitment of Mongolia’s government, a comprehensive and accurate EI, multi-sector collaboration, accurate emissions monitoring, and long-range urban and industrial development planning, the skies over Ulaanbaatar may once again be blue.

References
Getting to Know
A&WMA’s Organizational Members

On this page you will find the company profiles of a randomly selected grouping of Organizational Members. A&WMA thanks you—and all of our current Organization Members—for your continued support of this Association.

Lakes Environmental Software is internationally recognized for its technologically advanced environmental modeling software and data products. Since 1995, Lakes Environmental has remained dedicated to providing industry and the regulatory community with exceptional service and cost-effective environmental IT solutions. Lakes Environmental’s products increase productivity, reduce errors, and provide unique solutions in an ever-increasing regulatory constrained world. Company expertise includes: Air Dispersion Modeling; Emissions Inventory; Regulatory Permit and Compliance Solutions; Custom IT Solutions; Real-Time and Forecast Modeling Solutions; Meteorological Data Processing (WRF/MM5); and Training. Based in Waterloo, Ontario, Lakes Environmental is dedicated to continuously investigating new areas of research to provide users with superior state-of-the-art software solutions and data services.

In 2017, Lakes Environmental was recognized by The Silicon Review as one of the 50 Most Admired Companies of the year.

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Xcel Energy is a recognized industry leader in providing renewable energy and reducing emissions, efforts that have put the company on a path to delivering a more sustainable energy future for its customers. Since 2005, Xcel Energy has reduced air emissions, such as sulfur dioxide and nitrogen oxides by approximately 70 percent and mercury emissions by 85 percent. The company also is an industry leader in reducing carbon emissions. Last year, it reached a significant milestone, reducing carbon emissions 30 percent since 2005. With the right policy and advancements in technology, the company’s goal is to reduce carbon emissions 60 percent from 2005 levels by 2030. In addition to reducing air emissions, the company has reduced fresh water consumption by 35 percent and coal ash generation by 28 percent over the past decade.

To achieve these results, Xcel Energy continues to follow a successful clean energy blueprint. This plan includes repowering existing generating plants with cleaner natural gas, adding significant amounts of low-cost wind and solar power, and encouraging customers to use energy efficiently. As the nation’s leading utility wind provider, the company has challenged itself to increase the use of wind generation by adopting advanced wind forecasting and other practices. To help customers manage their energy use and monthly bills, the company offers a market-leading portfolio of more than 150 efficiency and rebate programs, as well as several renewable energy programs that give customers choice in how their energy is produced.

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A&WMA Student Opportunities

Each year, the Air & Waste Management Association (A&WMA) recognizes outstanding students who are pursuing courses of study and research leading to careers in air quality, waste management/policy/law, or sustainability. Award opportunities include:

Scholarships
A&WMA has scholarships available for air quality research, solid and hazardous waste research, waste management research and study, and air pollution control and waste minimization research. Last year the Association headquarters awarded $49,000 in scholarships. Applications are due Wednesday, January 10, 2018.

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A&WMA acknowledges up to two exceptional Masters Thesis and up to two exceptional Doctoral Dissertations each year. Nominations shall be made by the student’s faculty advisors, who are members of A&WMA, only. Applications are due Wednesday, January 10, 2018.

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EM Magazine (Online) ISSN 2470-4741 • EM Magazine (Print) ISSN 1088-9981
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