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Best Practices for Achieving Cleaner Air and Lower Carbon

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1. Introduction

This paper is an update of RAP's *Climate-Friendly Air Quality Management* manual.[1] The manual provides a step-by-step approach to optimize reductions of criteria, hazardous, and greenhouse gas pollutants and to integrate the environmental attributes of clean energy policies and energy efficiency into air quality plans. The steps and processes described in the manual remain valid today, as are the models recommended to be used to optimize co-control of pollution. However, since 2011, systematic, enterprise-wide approaches to reduce pollution discharges have matured and become mainstream. Many European Union (EU) Member States have adopted zero waste objectives. And, while national level action in the United States (U.S.) is absent as of this writing, states, led by California and many in the Northeast, continue to implement laws, regulations, and policies that require industrial facilities and power plants to co-control pollutants through on-site and system-wide control measures and projects.[2]

Over the last several years, China has made great progress to develop and implement comprehensive air quality management plans. The Air Law is broader and stronger, and the State Council has required air quality agencies to develop policies that broadly recognize the value of multi-pollutant planning. However, while energy efficiency and clean energy receive attention in these policies, to date China has not taken advantage of their value. Blunt, short-term curtailments have been used to temporarily provide "blue skies," and billions of renminbi (RMB) have been spent to install scrubbers on power plants and industrial sources. These measures have improved air quality, but ambient pollutant concentrations remain at levels twice that of China's Grade I standard and have been increasing again in 2019.

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[1] James, C., and Schultz, R. (2011). *Climate Friendly Air Quality Management: Strategies for Co-Control*. Montpelier, VT: Regulatory Assistance Project. Retrieved from: https://www.raponline.org/knowledge-center/climate-friendly-air-quality-management-strategies-for-co-control/.

[2] The U.S. states mentioned have also enjoyed better economic growth than states that have not embraced a clean energy future.

Air quality and regulatory agencies in Europe and the United States include the environmental benefits from energy production and consumption in their plans to improve air quality and reduce greenhouse gas emissions. These agencies, along with many businesses, are routinely implementing policies, standards, and practices that address the environment and energy systems as a whole, as reflected by these examples:

- The most recent update to the EU Industrial Emissions Directive requires applicable sources to implement enterprise-wide environmental and energy management systems.[3]
- The ISO 50001 (Energy Management Systems)[4] was developed in 2011 and revised in 2018. Over 23,000 facilities have been certified under this standard. Large companies are responding to shareholder and public pressure to improve their environmental footprints and to provide a leadership role to decarbonize their energy consumption. Many companies have committed to a goal to use only renewable energy to satisfy their energy needs.[5] For companies with operations in multiple locations, implementing energy and environmental systems enables consistency across operations in different countries. Companies also enjoy a competitive advantage in adopting these systems and increasingly require suppliers and contractors to meet the same standards.
- California's greenhouse gas regulations require industrial and power sector enterprises to conduct energy audits to identify energy saving measures that reduce greenhouse gas emissions and criteria pollutants.[6] California's parallel efforts to reduce water consumption have also saved energy and reduced air pollution.
- The U.S. Environmental Protection Agency (EPA) adopted regulations for commercial and industrial boilers[7] and proposed regulations for existing power plants[8] that define a system of best performance to include on-site projects that improve boiler heat rates and fuel efficiency, as well as system-wide approaches that reduce electricity demand. A new administration has narrowed the definition of the EPA's power plant rules to restrict compliance projects to those involving the boiler only. However, many states, including California and New York, as described later in examples of best practices, have finalized air quality management plans that include the broad systematic approach to compliance that had been part of the initial EPA proposal.
- A joint project by the European Commission and EU Economic Council established a

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[3] European Commission. (2018, last updated). Summary of Directive 2015/75/EU on industrial emissions (integrated pollution prevention and control). Retrieved from: http://ec.europa.eu/environment/industry/stationary/ied/legislation.htm. All permits must address overall environmental performance (air, water, waste) as well as energy efficiency and the use of raw materials.

[4] International Organization for Standardization. SO 50001 - Energy Management. Retrieved from: www.iso.org/iso-50001-energy-management.html.

[5] That is, companies like Google, which achieved its goal to obtain 100 percent of its energy needs from renewable energy in 2017. Google is on a list of about 165 companies that have pledged to go 100 percent renewable; see http://there100.org/companies.

[6] California Air Resources Board. Energy Efficiency and Co-Benefits Assessment of Large Industrial Facilities: Regulatory Activities. Retrieved from: www.arb.ca.gov/cc/energyaudits/energyaudits.htm.

[7] U.S. EPA. (2016). Area Source Boiler NESHAP, 40 CFR, Part 63, Subpart JJJJJJ (6J). Question-and-answer document; see pages 9-13. Retrieved from: www.epa.gov/sites/production/files/2016-10/documents/areaboiler_qa_oct2016.pdf.

[8] U.S. EPA. (2015). Fact Sheet: Clean Power Plan; Proposed Federal Plan and Proposed Model Rules. Retrieved from: https://archive.epa.gov/epa/cleanpowerplan/fact-sheet-clean-power-plan-proposed-federal-plan.html.

circular economy information hub to organize case studies, regulations and policies, and evaluations to accelerate penetration of low- to zero-carbon industrial practices.[9]

The accumulated and combined exposure from pollutants and their impacts on public health and the environment are well understood. Recent epidemiological evidence concludes that, for $PM_{2.5}$, adverse health effects occur even at the level of the U.S. standard of 12 ug/m^3, and there is no known minimal exposure that will not cause or contribute to such effects.[10] Projections made years ago about the possible disruptions to the Earth's climate system from high greenhouse gas emissions seem conservative today in light of 300 billion RMB damage costs of the storms that occur with increasing frequency and geographic coverage. This strong evidence suggests that air quality plans should address pollutants as a whole and implement actions to reduce ambient concentrations and greenhouse emissions concurrently.

This paper is organized as follows. Section 2 summarizes RAP's original paper. Section 3 underscores the importance of developing climate-friendly air quality plans. Section 4 illustrates how today's best practices drive measures to co-control pollutants. Section 5 provides examples of the best climate-friendly practices for the power and industrial sectors. Section 6 provides climate-friendly practice recommendations for China to evaluate and adopt. Section 7 provides the conclusion.

2. Overview of 2011 Paper

Climate-friendly air quality management refers to techniques, policies, and regulations that promote concurrent reductions of criteria and toxic pollutants and greenhouse gas emissions.[11] Recent studies have shown that significant benefits can be achieved through integrating climate change mitigation and air quality improvement efforts.[12] According to one study, these benefits may amount to additional CO_2 reductions of 15 percent in Western Europe and 20 percent in China.[13] A combined policy scenario for China—in which greenhouse gas mitigation measures, such as energy efficiency, cogeneration, and renewable electricity generation, are employed to meet air quality objectives—may achieve those goals at an estimated 60 percent of the cost of using end-of-pipe (or so-called smokestack) air quality measures exclusively, while also

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[9] European Union. European Circular Economy Stakeholder Platform. Retrieved from: https://circulareconomy.europa.eu/platform/.

[10] For example: Shi, L., et al. (2016). Low-concentration $PM_{2.5}$ and mortality: Estimating acute and chronic effects in a population-based study. *Environmental Health Perspectives*. https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.1409111. $PM_{2.5}$ comprises a complex mix of compounds that includes sulfates, nitrates, metals, and salts. $PM_{2.5}$ is responsible for the majority of health effects and monetary damages associated with air pollution.

[11] Criteria pollutants include sulfur oxides, nitrogen oxides, carbon monoxide, particulates, and ozone. Toxic pollutants include, but are not limited to, metals, such as lead and mercury; volatile organic compounds, such as toluene, benzene, and xylene; and polycyclic aromatic hydrocarbons. We recognize that the term "criteria pollutants" has a particular meaning in the United States. Here, we use the term more broadly to apply to those pollutants for which an air quality standard has been established by any country.

[12] The term "air quality" refers broadly to pollutants, and the policies to control them, that contribute to the condition of the atmosphere, and its impacts on public health, in a particular region. While these pollutants may also have climate change impacts, they are not the major greenhouse gases and historically have been distinguished from greenhouse gases for regulatory purposes. We follow that naming convention here. Indeed, it is the purpose of this paper to show how the actions to reduce local and greenhouse gas emissions can be combined and integrated to achieve better outcomes at lower overall cost, thus the new term "climate-friendly air quality management."

[13] Bollen, J., et al. (2009). Local air pollution and global climate change: A combined cost-benefit analysis. *Resource and Energy Economics, 31*(3): 161–181.

reducing CO_2 emissions by 9 percent.[14] Similar analysis for the EU has shown that "co-control" can decrease the costs of local air pollution reductions, which then pays for as much as 40 percent of the cost of greenhouse gas mitigation.[15] Control measures that address only local air quality will likely lead to increased greenhouse gases. This is because SO_2 and NO_X are controlled through smokestack technologies, which, because they require additional electricity to operate, reduce plant efficiency and increase greenhouse emissions.[16] Conversely, because currently there are no smokestack technologies to remove greenhouse gas emissions, it is only through thermal and end-use efficiency improvements, fuel-switching, and changes in the overall resource portfolio that reductions in CO_2 and other gases can be achieved. It is also the case that, when efficiency is improved, emissions of criteria pollutants also decrease.[17]

The 2011 paper includes a comprehensive assessment of climate-friendly air quality measures adopted in China, the EU, and the United States and concludes that, to be successful, five conditions must be met. They are:

- The institution of an open and multi-disciplinary planning process to evaluate potential policies and determine cooperative strategies for achieving goals and, in particular, the establishment of a firm foundation of cooperation between energy and environmental regulators;
- The adoption of initial benchmarks based on the best information available at the time;
- The establishment of mechanisms for continuous evaluation and assessment and revisions as appropriate;
- Adequate and sustained agency resources, with opportunities for training and professional development; and
- The implementation of policies that transcend their champions—that is, policies that do not depend upon their original designers and supporters to remain in place.

These five conditions are still valid and provide a useful framework for policymakers interested in improving public health and reducing greenhouse gas emissions.

[14] United Nations Development Program. (2010). China Human Development Report 2009/10*: China and a Sustainable Future; Towards a Low Carbon Economy & Society.* Beijing: China Translation and Publishing Corp. Retrieved from: hdr.undp.org/sites/default/files/chine_2010.pdf.

[15] Amann, M., et al. (2008). *GAINS-Asia: Scenarios for cost-effective control of air pollution and greenhouse gas emissions in China.* Laxenburg, Austria: International Institute for Applied Systems Analysis (IIASA); Amann, M., et al. (2007). Cost-effective emissions reductions to meet the environmental targets of the Thematic Strategy under different greenhouse gas constraints*: NEC Scenario Analysis Report #5*. Laxenburg, Austria: IIASA. Retrieved from: www.iiasa.ac.at/rains/CAFE_files/NEC5-v1.pdf; Amann, M., et al., (2009). Potential and costs for greenhouse *gas* mitigation in *Annex* 1 countries*: Methodology*. Laxenburg, Austria: IIASA Interim Report. Retrieved from: www.iiasa.ac.at/Admin/PUB/Documents/IR-09-043.pdf.

[16] On average, NO_X and SO_2 controls can reduce power plant efficiency by 2 percent. Graus, W.H.J., and Worrell, E. (2007). Effects of SO_2 and NO_X controls on energy-efficiency power generation. *Energy Policy, 35*(7): 3898–3908.

[17] This last point is almost always true, but there are exceptions. In certain applications, both combustion efficiency and NO_X emissions are functions of combustion temperature, but both are not optimized at the *same* combustion temperature. There is a trade-off, therefore, between NO_X and CO_2 emissions in such cases. This only reinforces, however, the need for a multi-pollutant strategy, since only then will challenges of this kind be addressed head-on and the most effective, least costly solutions found.

A foundation of climate-friendly air quality management is the coordination of environmental and energy policymaking. Integrated policies can save money and time while reducing pollution and can improve the reliability of electricity service while minimizing unintended consequences. Shifting to regulation through a multi-pollutant approach will require institutional, policy, and technical changes. From our 2011 review of international experience, we conclude that the most important lessons for China are:

- **Institutional**—Although it is important for air and utility regulators to coordinate their respective long-term plans, even more critical is the need for air regulators to develop power sector expertise that transcends their traditional knowledge of boiler design and operation. As utility regulators discuss the next steps in power sector structure and topics such as regional transmission plans, the participation of air regulators in these exercises will expose how inextricably linked environmental and energy policies are, will reveal how poor policy design in one arena will have deleterious effects in the other (will show, for example, how energy policies such as renewable portfolio standards and energy efficiency resource standards are also environmental policies), and will help air regulators consider a variety of policy measures that could be more cost effective than solely relying on end-of-pipe technologies to reduce emissions. Government institutions can be designed to enable this cross-fertilization and ultimately create stronger and more effective regimes for clean air and low carbon growth.
- **Policy**—The most effective policies are those that affect the root causes of emissions, rather than deal with them solely through control efforts at the smokestack. Affecting the root causes of emissions pushes the point of regulation farther upstream away from the smokestack, to influence how energy is made and how it is consumed. Incorporating energy efficiency, renewables, and less polluting coal-fired generation technologies into air regulatory practices is a good starting point. Innovative financing instruments have also been developed, such as the "recycling" of pollution permit revenues into energy efficiency and renewable energy programs. There are all kinds of policy solutions, across an array of sectors, that demonstrate that reducing local air pollution and global climate change emissions can be done simultaneously and cost-effectively.
- **Technical**—More recently, the United States and Europe have adopted integrated multi-pollutant approaches that address pollutants that the authorities want to control now and expect to control in the future. Such programs target, for example, PM, NO_X, SO_2, mercury, and, increasingly, CO_2. By setting goals for a broad range of pollutants, these approaches encourage industry to develop long-term financial and environmental plans to optimize investment in and configuration of pollution control equipment. This is a primary objective of multi-pollutant strategies. Such an approach offers better planning, greater certainty, lower costs, and more environmental benefits per dollar invested.[18] Such approaches also require technical knowledge about how reductions of one pollutant will affect other pollutants, both from the perspective of government planning and that of enterprises.

[18] For resources related to the U.S. EPA's multi-pollutant analyses and technical supporting documents, see http://www.epa.gov/airmarkets/progsregs/cair/multi.html. See also Napolitano, S., et al. (2009). A multi-pollutant strategy. *Public Utilities Fortnightly*. Retrieved from: http://www.epa.gov/airmarket/resource/docs/multipstrategy.pdf.

Today's policymakers will find that many of these institutional, policy, and technical opportunities still exist. Sections 4, 5, and 6 draw on more recent experience to provide updated best practices, case studies, and recommendations for China's policymakers.

Institutional Best Practices

The scope of climate change policies spans across all economic sectors, from residential households to large industrial sources. Such economy-wide policies often require input and approval from several different government agencies and public stakeholders. To build broad support for climate-friendly air quality management, the planning, implementation, and assessment of policy measures must be coordinated within a structure that includes government leadership from a full range of affected sectors, the public, and academia. Best practices for generating broad institutional support for air quality planning to successfully integrate greenhouse gas and local air pollution control measures include the following:

- Institute an open and multi-disciplinary planning process that involves several executive branches;
- Establish initial benchmarks based on the best information available at the time;
- Establish mechanisms for continuous evaluation and assessment;
- Ensure adequate and sustained agency resources, with opportunities for training and professional development; and
- Ensure that policies adopted can transcend their champions.

Policy Best Practices

Numerous policies have been shown to effectively reduce greenhouse gas emissions and local air pollution. Though characterized by their particular political, economic, and social contexts, they offer lessons and principles that have implications for broader replication. These policies span the following dimensions:

- Regulatory and planning
    - Integrated planning and permitting for multiple pollutants
    - Integrated resource planning or scientific energy planning
    - Transparent reporting to ensure accountability and efficacy
- Energy efficiency
    - Energy efficiency as an air quality control measure
    - Energy efficiency procurement standards
    - Adequate funding to build and sustain effective efficiency programs
    - Incentives to reward superior performance
- Power
    - Energy efficiency power plants
    - Environmental dispatch
    - Environmental fees and recycling revenue
    - Differential electricity pricing for industry

  - Renewable portfolio standards
  - Feed-in-tariffs for renewable electricity
  - Emissions performance standards
  - Combined heat and power

- Building codes and standards
  - Whole building retrofits
  - Mandatory building codes
  - Net-zero-energy homes
  - Hookup fees for building developers

- Transportation
  - Fuel efficiency standards
  - Registration fee linked to CO_2 emissions
  - Pay-as-you-drive insurance
  - Multi-modal urban planning

- Industry
  - Emissions standards
  - Industrial ecology

- Appliances and equipment standards
  - Energy Star appliance rebate program
  - Negotiated performance agreements

Technical Best Practices

Two areas that require careful consideration in climate-friendly air quality plans are:

- The technical modeling tools that are used to evaluate the energy, environmental, and economic attributes of policy measures that can be implemented to reduce pollution; and
- The sequencing of emissions control and monitoring equipment installed to capture criteria pollutants and measure effluence concentrations.

Assessing ambient air quality and emissions inventory data is also a critical component to the iterative air quality planning process. However, its characteristics are not distinguished between traditional and climate-friendly air quality management, so this section will only briefly identify best practices to reinforce the point that data assessment is crucial, but that there are no essential differences between such practices whether they are conducted as part of traditional regulatory practices or climate-friendly air quality management.

- Derivative and spreadsheet models
- Primary models
- Interactions and synergies among greenhouse gases and other air pollutants
- Pollution control equipment
- Emissions monitors

3. An Integrated Approach Cleans the Air Faster and Cheaper

To reach China's Grade I $PM_{2.5}$ standard of 35 ug/m³, pollution levels must drop by two-thirds or more from their 2013 concentrations. Together, the State Council's Ten Measures Action Plan and regional efforts like those in Jing-Jin-Ji, Yangtze River, and Pearl River deltas have reduced the severity and duration of air pollution. According to the latest national ecological environment quality report, Beijing's annual $PM_{2.5}$ concentration of 51 ug/m³ in 2018 is still much higher than China's Grade I standard.[19] And the Grade I standard itself is nearly triple that of the equivalent U.S. standard of 12 ug/m³ and more than triple the recommended World Health Organization objective of 10 ug/m³ deemed adequate to protect public health.[20]

The public health and environmental damage costs of air pollution are extremely high, and billions of renminbi have been spent since 2013 to install and operate emissions control equipment for power plants and industrial facilities. Although this equipment captures 90 percent of SO_2 and NO_X emissions, end-of-pipe controls increase CO_2 emissions and also require additional equipment to treat solid waste and water discharges. Blunt efforts to improve air quality in the short term have been the default approach applied during major sporting events (e.g., Beijing 2008 Olympics, Shanghai 2010 World Expo, and Nanjing 2014 Youth Olympics) and global economic meetings (APEC 2012). Each of these events imposed major disruptions to businesses and the public, costing billions of renminbi, only to see air pollution return after the conclusion of the event. One recent study estimates that as much as 6.6 trillion RMB will be required over five years to reduce air pollution and greenhouse gas emissions.[21]

Increased pollutant concentrations in 2019 show that emissions control expenditures alone will not be enough to modify China's air quality standards. Energy sector policy must also play a significant role. Research by Ma Jun,[22] J. Bollen,[23] and others confirms that reducing China's air pollution levels by two-thirds or more depends on both emission controls *and* a restructuring of the energy sector. This research also demonstrates that doing so would achieve public health objectives at much lower cost, thereby imposing smaller burdens on businesses and consumers.

The recent strengthening of China's Air Law lays the foundation to include energy saving

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[19] Ministry of Ecology and Environment. (2019). 生态环境部发布《2018年全国生态环境质量简况》. Retrieved from http://www.mee.gov.cn/xxgk2018/xxgk/xxgk15/201903/t20190318_696301.html. Significant portions of industry were closed in areas surrounding Beijing in order to reach this target. Those industries have since resumed production.

[20] The World Health Organization has initiated a process to review its $PM_{2.5}$ objective, based on recent epidemiological and public health data that reflect adverse response to $PM_{2.5}$ doses, even at low concentrations.

[21] McGarrity, J. (2016). The US$1 Trillion Cost of Cleaning Up China's Cities. China Dialogue. Retrieved from: http://www.chinadialogue.net/blog/9005-The-US-1-trillion-cost-of-cleaning-up-China-s-cities/en.

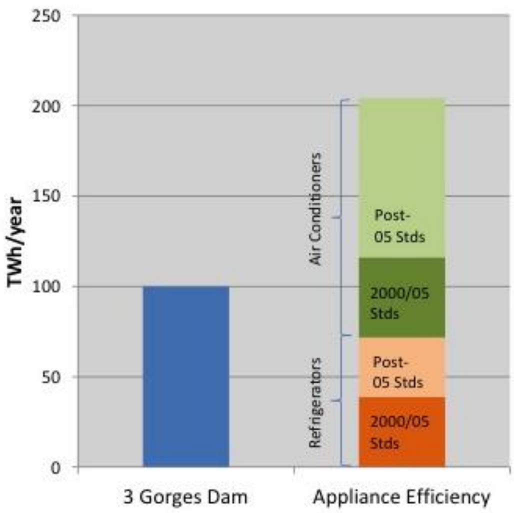
[22] Jun, M. (2017). *The Economics of Air Pollution in China: Achieving Better and Cleaner Growth*. New York: Columbia University Press. Jun's literature review has extensive citations to work dating back more than a decade to emphasize his points that energy restructuring is essential to achieving air quality goals.

[23] J. Bollen has published numerous articles since 2009 illustrating the co-benefits of multi-pollutant emission control plans and their lower costs. See, for example, a recent study that cites Bollen's work: Markandya, A., et al. (2018). Health co-benefits from air pollution and mitigation costs of the Paris Agreement: A modelling study. *The Lancet*, *1*(3): 126–133. Retrieved from: https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(18)30029-9/fulltext.https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(18)30029-9/fulltext

measures in air quality management plans.[24] The revised law contains two relevant articles that should be integrated into all future plans: One requires air quality plans to recognize and implement energy saving actions for air quality control purposes; the second requires China's electricity grid companies to implement environmental dispatch.

China has good experience with energy efficiency and energy saving measures. The Top 10,000 Energy-Consuming Enterprises Program more than achieved its ten-year goal to avoid burning 250 million metric tons (MMT) of coal. As shown in Figure 1, China's energy standards for refrigerators and air conditioners will have saved energy equal to the output of two Three Gorges Dams in the 15-year period ending in 2020.[25] This is consistent with experience from the EU and the United States: Systematic programs of energy efficiency achieve long-term and consistent benefits.

Figure 1: Annual Energy and Cost Savings in 2020 by China's Refrigerator and Air Conditioning Standards versus Annual Output from Three Gorges Dam



China also has experience in how to determine the potential air quality improvements that can result from the inclusion of energy savings requirements in air quality plans and permits. Reflecting on the Top 10,000 Program example, the overall goal of 250 MMT coal saved was differentiated by province. Each province in turn assigned responsibility for saving coal, in specified quantities, to obligated enterprises. The air quality analogue to this program would target the tons of pollutants that have to be removed from an airshed to meet China's Grade I standards. Air quality modeling is routinely performed by China's air quality agencies and research institutions. One of the inputs to the model would be the air quality benefits from

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24 Clean Air Alliance of China. (2015). *Final New PRC Air Law on Air Pollution and Control.* English Translation. Beijing: Author. Retrieved from: http://en.cleanairchina.org/product/7332.html.

25 Rosenfeld, A. California Enhances Energy Efficiency. Lawrence Berkeley National Laboratory. Retrieved from https://eta.lbl.gov/sites/all/files/related-files/caenhancesenergyefficiency.pdf. Note: Appliance efficiency savings are calculated on the basis of annual savings in 2020. "Post-05" standards account for China's periodic standards revision schedule of four to five years.

energy savings and energy efficiency programs.[26] Based on the model results, each airshed would be responsible for reducing emissions by a specific quantity. Air quality agencies would then assign specific targets that facilities would have to meet to help the airshed comply with ambient air quality standards.[27]

4. Summary of Best Practices

Government and businesses practices in the United States and the EU have recently evolved toward a holistic approach to environmental management. These developments, detailed in the descriptions of selected programs in Section 5, have occurred in spite of laws that retain a single media focus and controvert decades of experience with air quality plans that mitigate only one pollutant at a time. Increasing climate instability, documented links that illustrate how higher greenhouse gas emissions increase air pollution and affect public health, and our increasing business interconnectedness have all influenced the implementation of policies and measures that concurrently reduce multiple pollutants. A review of these best practices reveals that the following factors are driving pollution control efforts today.

Processes and discharges are treated systematically

Multi-pollutant and multi-media (or "co-control") management is a systematic planning process that optimizes reductions of all pollutants. Actions are not limited to sequencing installation of emissions controls (i.e., installing NO_X controls concurrently with SO_2, PM, and Mercury) but are also inclusive of processes, manufacturing designs, and measures that affect how products are made and used.

Upstream and downstream measures to reduce pollution are implemented concurrently

Upstream measures include process design, layout of piping and ductwork in factories, selection of chemicals, and integration of continuous improvement (energy efficiency measures). Large companies work with their contractors to ensure that the entire supply chain is engaged in systematic improvement to reduce greenhouse gases and air pollution. Downstream measures include traditional approaches like emissions control devices but also policies like switching from coal to natural gas for power plants, or from gasoline and diesel to electricity for cars.

There are multiple entry points to reduce air pollution

Traditional approaches to install pollution control equipment are effective to capture emissions, but, as shown by Ma Jun and others, they are not cost-effective as a means to achieve significant air quality improvement. One must evaluate the root causes of pollution and the interrelated roles of energy consumption and production. Root (or demand-side) solutions are

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[26] Emissions factor data are available from Chinese statistical handbooks and emissions correlations that have been completed for the air quality plans completed after 2013. See also James, C., Taylor, B., and Junchao, G. (2016). *Integrating Industrial Efficiency Measures into Air Quality Plans*. Beijing: Regulatory Assistance Project. Retrieved from: https://www.raponline.org/knowledge-center/integrating-industrial-efficiency-measures-into-air-quality-plans/

[27] A more holistic and possibly more flexible approach could be to assign each facility a specific quantity of tons to be reduced (for multiple pollutants) and allow the facility to determine how to meet these targets, prohibiting outsourcing or shifting production to another airshed. But this could include energy management systems as well as end-of-pipe controls. Of course, stringent monitoring, record keeping, and reporting requirements included in each enterprise's permit would be essential to ensure compliance.

highly cost-effective and can minimize discharges to other media.[28] The E-Merge process, developed by the Regulatory Assistance Project, illustrates a step-wise method to meet energy and air quality goals.[29] E-Merge builds on the steps first outlined in the 2011 report on climate-friendly air quality management.[30] It recognizes that air quality regulators can influence the pace of change to cleaner energy and more efficient energy consumption and that the design and implementation of electric vehicle infrastructure, battery storage, and increased renewable energy penetration, among other things, can also help to improve air quality and reduce greenhouse gas emissions.

In China, each ton of coal that is not burned avoids 2.3 to 2.8 tons of CO_2 and several pounds of NO_X, and SO_2.[31] If, for example, a wastewater treatment plant improves its energy efficiency, then less fossil fuel is burned to provide that facility with electricity. California has focused extensive efforts to improve water consumption and efficiency, not just because of water scarcity but also because 12 percent of in-state energy consumption is due to water infrastructure and treatment processes.[32] Recent efforts to reduce water consumption reduced energy consumption by 1,830 gigawatt-hours and greenhouse gas emissions by 521,000 MMT.[33]

Energy management systems are integral to reducing environmental impact

The ISO 50001 is based upon the concepts developed in ISO 9001 (Quality Management Systems) and ISO 14001 (Environmental Management Systems). The goal of ISO 50001 is to implement a system of continuous energy improvement, including energy efficiency, resilience, and energy consumption. ISO 50001 was released in 2011 and updated in 2018.[34] The standard itself does not require specific reduction targets; rather, each facility develops its own goals and a plan to achieve them. The facility must also verify the reductions and improvements made and provide such data to customers, investors, and inspectors. Implementing an ISO 50001 system would meet the energy management system principles in the EU Large Combustion Directive.

Through its Lawrence Berkeley National Laboratory, the U.S. Department of Energy has established an ISO 50001 information portal to help facilities establish energy management systems. As of early 2019, over 23,000 facilities have implemented such systems, with many reporting energy intensity improvements of 20 percent or more.[35]

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[28] Emissions control equipment such as flue-gas desulfurization and selective catalytic reduction/selective non-catalytic reduction can reduce SO_2 and NO_x emissions by 90 percent, but they generate high volumes of solid waste that must be treated and disposed of, as well as water that may require additional treatment before it can be discharged.

[29] Colburn, K., and James, C. (2017, April 27). E-Merge: Retooling Regulation for Clean Air and Clean Energy [Webinar]. Retrieved from: https://www.raponline.org/event/retooling-regulation-for-clean-air-and-clean-energy-webinar/. See also four blog posts dating from December 2016 to April 2017 that are accessible from this link.

[30] James and Schultz, 2011.

[31] Depending on the conversion factor used. The World Bank uses 2.5 tons CO_2 per ton of coal combusted in China.

[32] California Department of Water Resources. (2019). Water Energy Nexus. Retrieved from: https://water.ca.gov/Programs/All-Programs/Climate-Change-Program/Water-Energy-Nexus.

[33] Fell, A. California Water Drive Saved Energy, Too. UC Davis, Energy and Efficiency Institute. Retrieved from: https://energy.ucdavis.edu/california-water-saving-drive-saved-energy/.

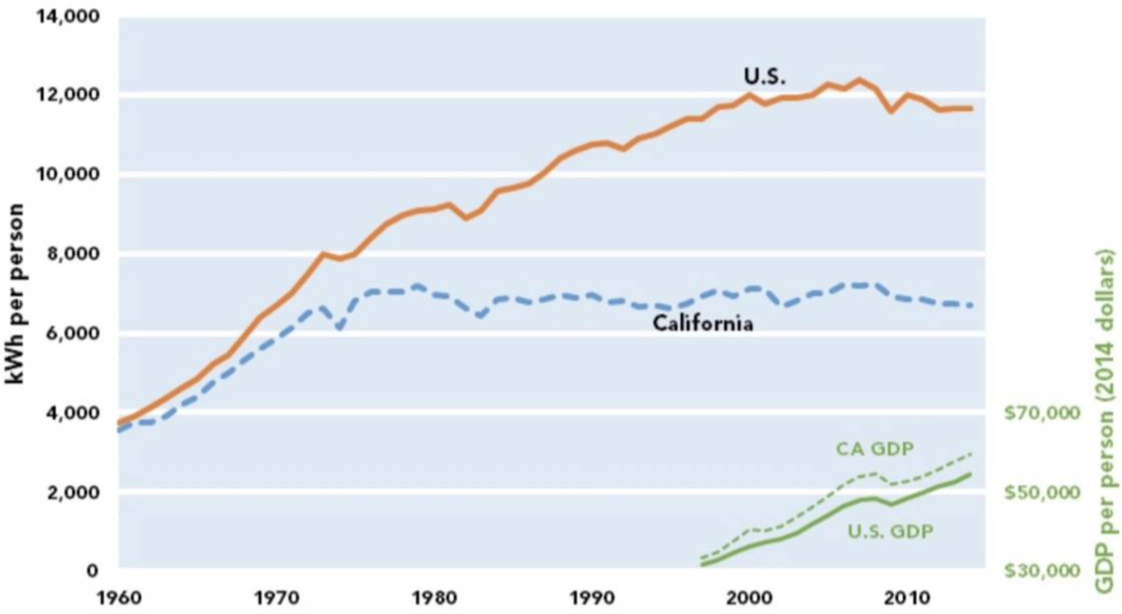
[34] International Standards Organization (ISO). Retrieved from: https://www.iso.org/obp/ui/#iso:std:iso:50001:ed-2:v1:en.

[35] U.S. Department of Energy. 50001 Ready: Navigator. Lawrence Berkeley National Laboratory. Retrieved from: https://navigator.lbl.gov/guidance/dashboard.

Codes and Standards and Performance Specifications Also Help to Reduce Pollution

California's excellent building codes and appliance standards have resulted in assembling gigawatts of "energy efficiency power plants."[36] The state has maintained per capita energy consumption at the same level for over 40 years (Figure 2).[37, 38] Absent these policies, the state would have had to construct power plants that would have increased emissions to air basins like San Francisco and Los Angeles, which already had unhealthy pollution levels, and required additional pollution control measures on businesses and consumer products.[39] California's leadership in implementing new and revising existing codes and standards has been followed by other states and has led to improved national energy standards developed by the U.S. Department of Energy.

Figure 2: California per Capita Electricity Use



[36] An energy efficiency power plant is a virtual power plant that consists of a bundle of energy efficiency measures that provide predictable load carrying capacity. Dupuy, M., and Weston, F. (2010). *The Guangdong Efficiency Power Plant: An Assessment of Progress*. Montpelier, VT: Regulatory Assistance Project. Retrieved from: https://www.raponline.org/knowledge-center/the-guangdong-efficiency-power-plant-an-assessment-of-progress/.

[37] California has the lowest per capita electricity use of any state in the United States, equal to about one-half that of the U.S. average. See California Energy Commission. (2016). U.S. per Capita Energy by State. Retrieved from: https://www.energy.ca.gov/almanac/electricity_data/us_per_capita_electricity.html.

[38] Shirey, J. (2016). California Sets the Bar for Energy Efficiency + Maintains Its Vibrant Economy. Brummitt Energy Associates. Retrieved from: https://brummitt.com/california-sets-the-bar/.

[39] See graphs of California consumption since 1975 in Rosenfeld, A.H., and Poskanzer, D. (2009). A graph is worth a thousand gigawatt-hours: How California came to lead the United States in energy efficiency. *Innovations.* Retrieved from: http://www.energy.ca.gov/commissioners/rosenfeld_docs/INNOVATIONS_Fall_2009_Rosenfeld-Poskanzer.pdf.

5. Case Examples

In this section we provide examples of two types of best practices: those of overall air quality management and those targeted to specific source sectors. Both exemplify a systematic, multi-pollutant design and count on the environmental benefits of energy efficiency and clean energy policies.

Air Quality Management Best Practices

U.S. state and local agencies have demonstrated leadership in the design and implementation of multi-pollutant air quality plans. Although the country's Clean Air Act does require air quality plans to be approved by the EPA, state and local agencies have wide flexibility regarding the contents of plans and the control measures employed to meet national public health standards. The examples shown here demonstrate planning input and coordination across several agencies, including those responsible for the environment, energy, and transport sectors.

Bay Area Air Quality Management District (BAAQMD)

The BAAQMD (San Francisco metropolitan area) *2017 Bay Area Clean Air Plan* builds on the seminal *2010 Clean Air Plan*,[40] whose 55 control measures covered all economic sectors and envisioned the use of renewable energy and energy efficiency to reduce pollution. The 2017 plan requires:

- Industrial sources to improve on-site combustion efficiency;
- Increased penetration of electric vehicles;
- Policies to transform buildings to low- to zero-carbon through energy efficiency and renewable energy technologies; and
- Commercial facilities to switch from natural gas to electricity for water and building space heating.[41]

Colorado Clean Air-Clean Jobs Act

The Colorado Clean Air-Clean Jobs Act required the air quality and utility regulatory agencies to work together to develop and implement plans by December 2017 to reduce emissions from coal-fired power plants. The act also directed the regulatory agencies to evaluate cost, electricity reliability, compliance with renewable energy standards, and the benefits of energy efficiency programs to transition the state toward clean energy sources.[42]

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[40] Bay Area Air Quality Management District. (2010). *Bay Area 2010 Clean Air Plan: Final Clean Air Plan*. Vol. 1. San Francisco: BAAQMD. Retrieved from: www.baaqmd.gov/~/media/files/planning-and-research/plans/2010-clean-air-plan/cap-volume-i-appendices.pdf.

[41] Bay Area Air Quality Management District. (2017). *2017 Bay Area Clean Air Plan.* Retrieved from: www.baaqmd.gov/plans-and-climate/air-quality-plans/current-plans. This link provides access to all planning and technical documents for the 2017 plan and also to the original 2010 plan. The 2017 plan uses a revised version of the original model that the BAAQMD developed for the 2010 plan to assess multi-pollutant benefits from control measures.

[42] State of Colorado. HB 10-1365, Clean Air-Clean Jobs Act. (2010). Retrieved from: http://www.leg.state.co.us/clics/clics2010a/csl.nsf/fsbillcont/0CA296732C8CEF4D872576E400641B74?Open&file=1365_ren.pdf.

New York comprehensive air quality and energy plan

The state of New York air quality and energy offices worked with Northeast States for Coordinated Air Use Management (NESCAUM)[43] to develop a multi-pollutant analysis framework that is being applied to plans to improve air quality, reduce greenhouse gas emissions, and increase the penetration of energy efficiency and renewable energy resources. The framework uses air quality, energy, and public health models to evaluate how various measures affect pollutant discharge, utilization of renewable energy, energy efficiency investment, and their costs.[44]

Maryland Modeling Project

As part of a multi-pollutant planning process, the state of Maryland modeled the air quality and public health benefits of that state's energy efficiency and renewable energy programs. Model results showed that, even though the programs were not yet fully implemented, they reduced ozone and $PM_{2.5}$ ambient concentrations by up to 0.60 parts per billion and 0.10 ug/m^3, respectively. The reductions caused by the energy efficiency and renewable energy programs were more cost-effective and had air quality benefits equal to or greater than many traditional measures that were being considered.[45]

Sector-Specific Best Practices: Industrial and Power

Drawing from experience in China, Europe, and the United States, this section describes best practices for industrial and power sector sources that reduce their environmental footprint through projects and measures that improve a facility's energy consumption. Implementing these measures also reduces on-site energy costs and improves a facility's economic competitiveness.

Air quality benefits of China's Top 10,000 Program

An analysis of 84 energy savings projects, all part of the Top 10,000 Program completed in eight industrial sectors across China, identified energy savings, coal savings, and avoided emissions of both greenhouse gases and other air pollutants.[46] The highest savings occurred at one district heating boiler project, which avoided more than 177,000 tons of coal per year. Twenty-one projects saved more than 50,000 tons of coal per year at each enterprise, with many more saving more than 10,000 tons of coal. Table 1 provides a summary of the energy and emission savings from the projects that were analyzed.[47]

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[43] Northeast States for Coordinated Air Use Management is a regional organization focused on air quality policy and technical issues. It was formed in 1967. See http://www.nescaum.org.

[44] NESCAUM. (May 2012). Applying the Multi-Pollutant Analysis Framework to New York: An Integrated Approach to Future Air Quality Planning. Albany, NY: New York State Energy Research and Development Authority. Retrieved from: https://www.nescaum.org/documents/applying-the-multi-pollutant-policy-analysis-framework-to-new-york-an-integrated-approach-to-future-air-quality-planning/

[45] Aburn, T. (2013). Building Energy Efficiency and Renewable Energy Programs Into the Clean Air Planning Process: Taking Credit for Non-Traditional Programs. Presentation to the American Council for an Energy-Efficient Economy, Washington, DC. Retrieved from: https://aceee.org/files/pdf/conferences/mt/2013/Tad%20Aburn_D2.pdf.

[46] James, Taylor, and Junchao, 2016.

[47] James, Taylor, and Junchao, 2016.

Table 1: Annual Energy and Emissions Savings for 84 Industrial Projects

Industrial Category	On-Site or Off-Site Avoided Emissions	Number of Projects	Average Energy Savings Per Project (tce)	Average NO_X Avoided (tons)	Average SO_2 Avoided (tons)	Average CO_2 Avoided* (tons)
District heating improvements	On-site	19	40,000	310	780	100,000
Industrial boiler upgrades	On-site	4	13,000	170	410	32,500
Waste heat or gas for electricity generation	Off-site	9	20,000	150	160	50,000
Waste heat or gas for process use	On-site	7	25,000	180	460	62,500
Industrial kiln upgrades	On-site	2	15,000	160	390	37,500
Power plant efficiency upgrades	On-site	6	25,000	90	100	62,500
Industrial system optimization	Both	16	25,000	150	350	62,500
Motor system and lighting upgrades	Off-site	16	8,000	50	50	20,000
Natural gas substitution for coal	Off-site	5	17,000	280	690	42,500

Converted from tce at 2.5 tCO_2e/tce

California greenhouse gas sector-based summaries

California has adopted regulations to reduce greenhouse gas emissions across all economic sectors. These regulations also emphasize the co-benefits to lower criteria pollutant emissions and require large industrial sources and power plants to identify techniques to reduce energy consumption.

California's cement plants implemented 15 energy saving projects to comply with the requirements of the state's greenhouse gas regulations. The eight plants subject to this regulation identified projects that will reduce CO_2 emissions by 15 percent and NO_X emissions by almost 20 percent.[48] The energy saving projects also reduced hazardous air pollutants, carbon monoxide, and SO_2.

California's power plants identified 129 energy saving projects to comply with the requirements of the state's greenhouse gas regulations. The plants subject to this regulation identified projects that will reduce CO_2 emissions by 16 percent and NO_X emissions by 25 percent.[49] The energy saving projects also reduced hazardous air pollutants, SO_2, $PM_{2.5}$, and carbon monoxide.

EU best available techniques for large combustion sources

The EU best available technique (BAT) conclusions require enterprises to use energy efficiently and to undertake and complete a program of continuous improvement to manage energy consumption. Each BAT describes the energy management system requirements and projects that a company should complete. The BAT conclusions also require each company to implement an environmental management system, each of which must involve the review and approval of a company's senior management. The BAT conclusions for the cement industry,[50]

[48] California Air Resources Board. (2013). *Energy Efficiency and Co-Benefits Assessment of Large Industrial Sources: Cement Sector Public Report.* CARB: Stationary Source Division. Retrieved from: https://www.arb.ca.gov/cc/energyaudits/eeareports/cement.pdf.

[49] California Air Resources Board. (2015). *Energy Efficiency and Co-Benefits Assessment of Large Industrial Sources: Electricity Generation Sector Public Report*. CARB: Transportation and Toxics Division. Retrieved from: https://www.arb.ca.gov/cc/energyaudits/eeareports/electricity.pdf.

[50] European Commission. Commission Implementing Decision of 26 March 2013 establishing the best available techniques (BAT)

iron/steel industry,[51] and glass industry[52] are particularly relevant.

National Association of Clean Air Agencies Menu of Options for the power sector

The association's *Menu of Options* contains over two dozen measures to reduce power sector greenhouse gases and air pollutants. Among the most applicable to China are Chapter 1: On-site Projects to Reduce Emissions and Chapter 22: Adopt and Implement Utility Resource Planning Processes.[53]

EU circular economy hub

The European Circular Economy Stakeholder Platform, a joint effort by the European Commission and the European Economic and Social Committee, is an information hub that provides descriptions of best practices to minimize pollution discharges across all media.[54]

Global examples of best practices for industries and the power sector

The following resources offer additional insights and recommendations to reduce on-site energy costs and improve a facility's economic competitiveness. These same measures also reduce emissions of both greenhouse gases and other pollutants.

- A Lawrence Berkeley National Laboratory report identifies 20 energy saving measures that can be implemented.[55]
- An International Finance Corp. report describes international best practices for the cement industry.[56]
- The World Cement Association 2018 Climate Action Plan aims to accelerate the pace of decarbonization.[57]
- A European Commission paper proposes a system-wide approach to building design and

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conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the production of cement, lime and magnesium oxide. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0163&from=EN

[51] European Commission. Commission Implementing Decision of 28 February 2012 establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for iron and steel production. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012D0135&from=EN

[52] European Commission. Commission Implementing Decision of 28 February 2012 establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the manufacture of glass. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012D0134&from=EN

[53] National Association of Clean Air Agencies. (2015). *Implementing EPA's Clean Power Plan: A Menu of Options*. Retrieved from http://www.4cleanair.org/NACAA_Menu_of_Options

[54] Users can query case studies to find national strategy plans, regulations and standards, and sector-based examples; also, users can participate in discussion forums and submit best practices themselves. See https://circulareconomy.europa.eu/platform/en.

[55] Hasanbeigi, A., Khanna, N., and Price, L. (2017). Air Pollutant Emissions Projections for the Cement and Steel Industry in China and the Impact of Emissions Control Technologies. Berkeley, CA: Lawrence Berkeley National Laboratory. Retrieved from https://www.osti.gov/servlets/purl/1372903.

[56] International Finance Corp. (2017). *Improving Thermal and Electric Energy Efficiency at Cement Plants: International Best Practice*. Washington, DC: Author. Retrieved from https://www.ifc.org/wps/wcm/connect/51b456cd-1460-4f64-860a-ab4db6b87602/Elect_Enrgy_Effic_Cement_05+23.pdf?MOD=AJPERES

[57] World Cement Association. (2018). *The World Cement Association Climate Action Plan*. London: Author. Retrieved from http://www.worldcementassociation.org/sustainability/the-wca-climate-action-plan

construction, including recycling and reuse of iron and steel. The paper also highlights building design and construction techniques that emphasize the ability to reuse materials if the building is demolished.[58]

- The Netherlands demonstrates how to implement the circular economy at steel plants through techniques that include a high utilization of slag, and the burning of sewage sludge as a fuel.[59]
- A blog piece by the Regulatory Assistance Project describes how China can improve air quality by increasing the rate of steel recycling.[60]

6. Recommendations for China

China is in a good position today to accelerate progress to improve air quality. Stronger laws broaden authority to regulate pollutants systematically and to incorporate renewable energy and energy efficiency programs as part of any air quality management plan. The recommendations described here transcribe the essence of best global practices into concrete steps that China's environmental agencies can implement and enforce.

Air Quality Management Plans

Use air quality modeling and planning to value and include the benefits of renewable energy and energy efficiency

Air quality plans should include energy efficiency and renewable energy as air pollution control measures and as best available control technologies. At current consumption levels, each coal-fired kilowatt-hour avoided or not generated saves about 308 grams of coal.[61]

These coal savings should be translated, using emissions factors for each region or default factors if such data are all that are available today, into equivalent emissions reductions. These metric tons of reductions can then be input into air quality models. For example, every 500-megawatt coal plant that is displaced through efficiency or clean alternatives avoids the emission of 11,250 metric tons of SO_2, 1,250 metric tons of nitrogen oxides (NO_X), 2.5 MMT of CO_2, and 5,000 metric tons of $PM_{2.5}$ annually.[62]

To adopt to China the work referenced above for Maryland and the multi-pollutant planning exercises completed by the San Francisco Bay Area and New York, there are two main ways to assess the air quality benefits of energy efficiency and renewable energy. First, existing programs and policies can be evaluated. These include the 0.3 percent energy efficiency

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[58] Rossetti di Valdalbero, D. (2018). *The Future of European Steel*. Brussels, Belgium: European Commission. Retrieved from https://publications.europa.eu/en/publication-detail/-/publication/f5a82742-2a44-11e7-ab65-01aa75ed71a1

[59] Kemp, R., Barteková, E., and Türkeli, S. (2017). The innovation trajectory of eco-cement in the Netherlands: a co-evolution analysis. *International Economics and Economic Policy* 14: 409. Retrieved from https://doi.org/10.1007/s10368-017-0384-4

[60] Shapiro-Bengsten, S., and James, C. (2017). *Industrial Efficiency Can Improve Air Quality*. Regulatory Assistance Project. Retrieved from https://www.raponline.org/blog/industrial-energy-efficiency-can-improve-air-quality1/

[61] China Energy Portal. 2018 electricity & other energy statistics. Retrieved from: https://chinaenergyportal.org/en/2018-electricity-other-energy-statistics/.

[62] This example assumes the plant operates for 5,000 hours per year. Emissions calculations are based on typical power plant performance.

obligations of the grid companies and the quantity of renewable energy deployed. A second method is to determine the number of tons of pollution that must be removed from an airshed to meet China's Grade I standards. Then, a portion of that obligation could be assigned to energy efficiency and renewable energy programs. Using standard conversions, like that shown in the previous paragraph, the number of megawatt-hours of energy efficiency and renewable energy needed could be derived. This calculation might be iterative to develop initial targets, which can then be input into energy planning documents and used by the grid companies to help implement environmental dispatch.[63]

China air regulators have worked with Tsinghua University to model the efficacy of various measures to improve air quality. Adding the value of energy efficiency and renewables, using the process described here, to this modeling work can reveal their benefits and demonstrate how these resources can accelerate pollution reductions and increase their cost-effectiveness. Collaboration and input from China's energy regulators will also help to design policies that work and avoid placing constraints on power sector systems and electricity grids.

Use the step-by-step energy saving templates in air quality plans

To illustrate how agencies could effectuate the air pollution benefits of the Top 10,000 Program, described earlier, RAP developed templates for seven different sectors. The templates can be included in the menu of options that air quality agencies are using to improve air quality. They provide examples of the types of projects that can be completed, their air quality benefits, and the steps needed to complete the projects.[64]

Develop an information hub to showcase best practices

The geographic size and diversity of China's industries makes it challenging to disseminate information about best practices. The role of third-party consultants is still emerging, and air quality agencies' resources are often limited. An information hub, like that for the European circular economy, would help to publicize best practices and to connect practitioners wishing to evaluate how their facilities could improve their environmental performance. The hub could be housed at the Ministry of Ecology and Environment or one of its research institutions.

Permitting and Compliance

Energy management systems in permits

For industrial facilities and power plants, add conditions in each permit to require subject enterprises to improve energy performance. This can be accomplished through the following actions:

- Implementing energy management systems per the example of the EU Large Combustion Directive to complete energy audits, identify energy saving measures, and implement all cost-effective ones;
- Becoming certified per the ISO 50001 standard, which could be a proxy to comply with

[63] Article 42 of China's Air Law requires grid companies to implement environmental dispatch. The steps outlined here would help to inform that process.

[64] Example template for district heating projects is found at http://en.cleanairchina.org/m/100/air/airmanage/jx_detail.jsp?id=8626&menuId=589. Detailed templates were developed for seven sectors and are available from RAP.

requirement to implement an energy management system; and

- Completing on-site improvements to boilers and turbines that improve the heat rate and reduce the quantity of fuel consumed to generate electricity.

Encourage improved energy and environmental performance through competitions

Create a competition to highlight the enterprises with the best energy performance. The China Electricity Council already organizes a competition for thermal power plants and recognizes the best performing plants each year.[65] The competition could be expanded to include all large industrial sources. Another way to highlight performance would be to build upon the publication of China's real-time $PM_{2.5}$ air quality data by listing enterprises based on their energy intensity. Consistent with the "Ten Measures" ranking concept for measuring cities' performance to improve air quality, the top ten best- and worst-performing enterprises could be listed in each province. The bottom performers could be encouraged to work with the top performers and local officials to reduce consumption.

Streamline information collection

China maintains four separate systems for emissions information: one for permits, a second for inventory, a third for census data, and a fourth for statistics. This is administratively complicated and makes it difficult to assess trends. It is also challenging for the public and businesses to learn about environmental performance. China could consider the example of the U.S. EPA following passage of the Clean Air Act Amendments of 1990. Like China's revised Air Law that came into effect on January 1, 2016, the U.S. law also required the EPA to implement a new permit system and required industrial facilities and power plants to install, maintain, and operate continuous emissions monitoring systems. Through the Clean Air Markets Division, the EPA built and maintains a database for all facilities subject to the expanded permit and monitoring requirements. Any person can access the database and submit queries to learn about emissions, emissions trends, and compliance.[66]

7. Conclusion

This paper describes how systematic approaches to air quality management improve air quality, reduce greenhouse gas emissions, and improve public health. Such approaches are cost-effective and yield co-benefits that include reduced water and waste discharges and lower energy bills for consumers and businesses. China has the legal and policy framework to effectuate these approaches in its current air quality plans and permits.

The degree to which energy management systems, clean energy development, and energy efficiency can help to meet air quality goals can be analyzed by research institutions and the environmental protection bureaus responsible for implementing air quality programs. Then these tools can be included as control measures in air quality plans. Tools like the energy saving project templates make it easier for the environmental protection bureaus to prioritize which industrial sectors to first target and to directly adopt the language in the templates into

[65] Press release from China Electricity Council: http://kjfw.cec.org.cn/dongtai/2018-07-23/182913.html. List of best performing units in 2018: http://news.bjx.com.cn/html/20180612/905278.shtml.

[66] U.S. EPA. Clean Air Markets Division. Information hub. Retrieved from: https://www.epa.gov/airmarkets

applicable control measures.

Likewise, a permit can require enterprises to complete audits and develop management systems as part of a plan to continuously improve energy consumption. An upgraded permit information system will enable best practices to be shared and adapted more quickly by others and facilitate compliance through improved monitoring, record keeping, and reporting.

The processes and practices described in this paper will help China to reach its air quality targets more quickly, ensure that progress is independent of short-term economic factors, and decrease greenhouse gas emissions.

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