AIR POLLUTION

Small and bad

It is well known that electricity production from the combustion of fossil fuels is a major source of air pollutants and greenhouse gases. Now, research shows that large generation plants are not necessarily the worst emitters.

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Fossil fuel power plants, major sources of carbon dioxide (CO_2) emissions[1], also produce a large amount of harmful air pollutants such as, for example, particles less than 2.5-micrometres in diameter — known as fine particulate matter ($PM_{2.5}$) that cause serious impacts on human health[2,3]. Exposure to $PM_{2.5}$ poses serious challenges to environmental sustainability. More than 4.2 million deaths per year have been attributed to exposure to outdoor $PM_{2.5}$ in 2015, representing 7.6% of total global mortality, 59% of these in east and south Asia[4]. The universal 2030 Agenda for Sustainable Development, adopted in September 2015 by the United Nations General Assembly, offers an important opportunity to tackle air pollution at a global scale. Although there is no stand-alone Sustainable Development Goal (SDG) on air quality included in the 2030 Agenda, air quality has been incorporated into the targets and proposed indicators of the goals for health (Goal 3) and sustainable cities (Goal 11), and at least five additional SDGs contribute either directly or indirectly to securing or improving global air quality without, however, referring to the issue explicitly[5]. Quantifying emission patterns from power plants can help inform policy makers to identify significant emitters and implement advanced pollution control technologies to reduce emissions.

The cooling towers of a thermal power plant in Northern China. Credit: tingimage / Alamy Stock Photo

Nevertheless, not all power plants are equally damaging in terms of air pollution. In this issue of *Nature Sustainability*, research by Dan Tong and colleagues[6] shows that smaller and older plants emit a disproportionately large share of air pollutants given their energy generation capacity. To identify these 'super emitters', Tong et al. developed an emissions database per individual generating unit, covering CO_2, and three air pollutants, sulfur dioxide (SO_2), nitrogen oxides (NO_x) and $PM_{2.5}$, for global fossil fuel and biomass burning power plants in 2010. Their newly developed global power emission database comprises the capacity of the power plants, fuel type, age, location and installed pollution-control technology in order to determine those units with disproportionately high levels of air pollutant emissions.

This work is an interesting example of large data compilation providing thorough information about the identified super-polluting units. The analysis also shows how much air pollutants can be reduced if the super-polluting units in different regions were updated with advanced control technologies, improved fuel quality or replaced by large units.

Despite climate change concerns, fossil energy production worldwide almost doubled from 1990 to 2010[7], primarily driven by population growth, industrialization and urbanization in developing countries. In tandem with the growth of fossil energy use, greenhouse gas and air pollution emissions from the power sector have also surged. As a result, electricity production, more than any other industrial sector, is now responsible for severe human health impacts[3,8], and for climate change[1]. In 2010, fossil-fuel-burning power plants accounted for ~40% of energy-related CO_2, ~7% of primary $PM_{2.5}$ emissions, ~48% of SO_2 emissions and ~28% of NO_x emissions[6,9]. SO_2 and NO_x are important precursors of secondary $PM_{2.5}$ and can cause significant impacts on air quality[10].

Based on the newly developed emission database, Tong and colleagues[6] found a large proportion of power plants were new — more specifically, in 2010, 34% of the plants operating worldwide were less than 12 years old. Many of the new coal-fired operating units are located in emerging economies, particularly China and India, primarily due to rapid economic growth and industrialization, whereas in advanced economies like the United States and Europe, coal-fired units tend to be older than gas-fired units — a reflection of the transition to cleaner energy production.

The environmental and health impacts of power generation differed across countries as a result, among other issues, of different degrees of stringency in environmental regulations with most of the emissions reductions achieved in developed countries. After decades of effort in management of air pollution control, air pollutant levels in most developed countries have been decreasing dramatically whereas in many developing countries, as well as countries in transition, although air pollution levels have been slightly decreasing or have remained stable, they are still higher than those in developed countries[11].

In addition, control technologies for $PM_{2.5}$ emissions in coal-fired units are highly effective in the United States, Europe and China, but have low penetration rate in India. Similarly, control of SO_2 emissions is now required in most regions worldwide, but only less than 6% of India's coal-fired power plants were equipped with SO_2 control technology (compared with the 82% global average) in 2010, with the resulting SO_2 emission intensity in India being twice above the global average.

The main finding by Tong and colleagues is that a large proportion of the air pollutants from the power sector is emitted by a disproportionately small fraction of power-generating capacity. For example, 0.8% of coal-fired capacity in China produced 16% of the $PM_{2.5}$ emissions from all coal-fired units in 2010. Across all regions, coal-fired power-generating units of less than 100 MW are responsible, despite the small amount of electricity produced, for significant share of emissions of SO_2, NO_x and $PM_{2.5}$. This is mainly due to small units not being equipped with the most advanced and effective emissions control technologies and not being able to achieve significant operating efficiencies. But policies targeting a small number of 'super-polluting' units could substantially reduce pollutant emissions and the associated impacts on human health, Tong et al. argue.

In power plants, air pollutants and greenhouse gases are emitted from the same sources. Thus, controls directed at air pollutants (end of pipe) frequently affect greenhouse gas emissions, and vice versa. This co-control generates additional beneficial or negative environmental and health impacts that complement the main objective of an emission control strategy. Discussion regarding the potential co-benefits of air pollution control is currently missing and worth exploring in future.

Given the regional disparities across emission intensities of electricity generation highlighted by Tong and colleagues, efforts to strengthen international collaboration and technology transfer from developed to developing countries are needed. Such efforts can accelerate the transition to clean energy and penetration of advanced air pollution control technologies in developing countries to improve local and regional air quality.

This study is a major step towards building a consistent, global, spatially resolved dataset for different air pollutants emissions based on the best available information and statistics. The data set and its analysis are a big piece of work. Tong and colleagues show potential for using big data to further understand facility-level emissions, identify super-emitters and investigate regional and global emission reduction options. Such advances towards building a reasonable dataset with appropriate details represent an important step that can help the assessment of environmental sustainability of power plants. Tong et al. indicate they intend to further develop the database for the years after 2010 to identify the most cost-effective measures for air-quality management at regional and global levels. Such data updates will inform the next generation of public health policies and increase the chances of effective decision making in the fight against air pollution. ❐

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