Burden of disease from rising coal emissions in Asia

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Coal emissions are harmful to human health

SO$_2$ and NO$_x$ from power plants oxidize in the atmosphere to form particulate matter (PM). NO$_x$ can also increase ozone concentrations. Both PM and ozone lead to premature mortality in people.
Coal emissions declining in the U.S. due to public health concern

Difference in SO$_2$ emissions (2010 – 2005)

Coal emissions in many Asian countries are currently following the same upwards trajectory that has taken decades to reverse in the U.S. and Europe.

Klimont et al., 2013
Coal use is expanding rapidly in Southeast Asia.

There are currently more than 400 coal plants scheduled for development in Asia outside China and India. Many of these plants are already under construction.

Sources:
Platts WEPP Database, Coalswarm.org
**Project Objectives**

1. Calculate surface PM and ozone concentrations due to both present day and estimated 2030 coal emissions in East and Southeast Asia (excluding emissions from China and India).

2. Estimate the human health burden of this rising coal pollution.

**Approach**

1. Attribute changes in PM and ozone concentrations due to both present day (2011) and projected 2030 coal emissions using GEOS-Chem.

2. Apply concentration-response relationships from the literature (Krewski et al., 2009; Anenberg et al., 2010) to estimate the premature mortality due to coal-related pollution.
Power plant emissions vary widely by facility

<table>
<thead>
<tr>
<th>Boiler type</th>
<th>Emission control technologies</th>
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<tbody>
<tr>
<td>Fluidized Bed Combustion (FBC)</td>
<td>Selective catalytic reduction ($\text{NO}_x$)</td>
</tr>
<tr>
<td>Stoker</td>
<td></td>
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<table>
<thead>
<tr>
<th>Type of coal</th>
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</thead>
<tbody>
<tr>
<td>lignite</td>
</tr>
<tr>
<td>sub-bituminous</td>
</tr>
<tr>
<td>bituminous</td>
</tr>
<tr>
<td>anthracite</td>
</tr>
</tbody>
</table>

Plant specific factors such as the grade of coal being combusted or the emission control technologies in place affect the magnitude and type of emissions coming from each individual coal fired power plant.

Images: Ciris Energy; AECOM Process Technologies; dieselnet.com; energy-models.com/boilers
We develop a detailed inventory of the currently operating fleet

Emissions of SO$_2$ and NO$_x$ from coal plants are currently highest in Indonesia, followed by Thailand and Japan.

Lu et al., 2011; EPA Annual ARP report 2013
If all projected plants become operational, Asian coal emissions of SO$_2$ and NO$_x$ could triple by 2030. Indonesia and Vietnam together account for 67% of this projected increase, as well as an additional 35 million people by 2030.
GEOS-Chem simulates the concentrations of pollutants

GEOS-Chem is a global 3-D chemical transport model used by many research groups around the world to advance our understanding of atmospheric composition and to answer policy relevant questions pertaining to air quality and climate change.
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The largest annual average enhancements in PM from coal occur near populated areas, particularly Hanoi and Jakarta. Ozone enhancements are highest over Sumatra in Indonesia, as well as much of Thailand and Vietnam.
Exposure depends on both pollution levels and population density.

2010 Population Map

ΔPM$_{2.5}$ from 2030 Coal

Total Exposure in 2030 (ΔPM$_{2.5}$ x Population)

Total exposure is highest in Indonesia and Vietnam, followed by China due to high population levels in southern China near Vietnamese emissions.
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We estimate 16,000 deaths annually from current coal.

Including a 10% population increase by 2030 in both Indonesia and Vietnam, we estimate 43,000 deaths annually by 2030 if all projected plants become operational.

Excess Deaths Per Year

2011:
14,860 PM
1,530 ozone
16,390 total

2030 increase:
24,160 PM
2,390 ozone
26,550 total

= 42,940 excess deaths per year
Assessment of national contributions to coal pollution is ongoing

We have assessed country level contributions for South Korea, Vietnam, and Taiwan. Results for Japan, Indonesia, Malaysia, Thailand, Myanmar and the Philippines will be completed over the next few months.

Contribution of Vietnam to 2030 $\Delta{PM_{2.5}}$

- 2011: **3,827**
- 2030 increase: **14,169**
- **17,996** excess deaths per year
New projections for Japanese plants could change results

Japan’s New Coal Plants Threaten Emission Cuts, Group Says

Bloomberg Business, April 09 2015

Japan has 43 coal power projects either under construction or planned, representing combined capacity of 21,200 megawatts, according to a statement from the Kyoto-based Kiko Network.

Including emissions from recently announced coal plants could change estimates of health effects from Japanese coal emissions.
Summary

• Coal fired power plant emissions of SO$_2$ and NO$_x$ form particulate matter and ozone which are detrimental to human health.

• Coal emissions in Southeast Asia are projected to triple by 2030.

• Without abatement, these projected emissions could lead to more than 40,000 excess deaths every year.

Please email skoplitz@fas.harvard.edu for more information about this work. Thank you for listening!