How China Can Leapfrog the World in Mercury Emission Reductions

Sid Nelson Jr.
Impressive Development Throughout China
But Ever-Increasing Pollution
Mercury from Power Plants
Chinese Coals Average ~50% Higher Hg

Various sources. The difference may be even greater.
Overview of the Mercury Problem

Source: U.S. EPA
Effects Observed in Small Newborn Samples


In the U.S., Hg from Fish Lowers IQ

Oken (2005):
- lowering Hg 50% → raises IQ = 2 points

Oken (2008):
- lowering Hg 50% → raises IQ = 1.5 points

Lederman (2008):
- lowering Hg 50% → raises IQ = 2.5 points

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**Fish MeHg Varies Directly with Deposited Hg**

- Isotopically enriched Hg(II) (90.9% $^{202}$Hg$^{+2}$) was spiked into large, isolated lake sections.

- Uptake monitored in zooplankton, benthic invertebrates, & fish.

- “We conclude that concentrations of spike MeHg in the food web of the mesocosms were directly proportional to the rates of Hg(II) loading.”

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**Graph:**

- **Equation:** $Y = -0.33 + 0.91X$
- **F = 297, $p < 0.00001$**
- **$R^2 = 0.97$**

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How Is Hg Done in the U.S.? ACI

Brominated Powdered Activated Carbon Injection (ACI) before the ESP
ACI System

We have installed 10 systems

Lances sticking into the ductwork

10-cm transport line

Silo to hold the PAC & blower(s)

& sold many millions of kgs of brominated carbons

Delivering brominated PAC
Over 100 ACI Systems Sold

Can be expensive for 90% (but “micro-injection” is not & is suited to plants without FGD)

55,000 MW of capacity
Leverage Hg Reductions from Scrubbers

Fraction of Power Plants with FGD

- China
- USA
Many Chinese Coals Have Low Halogens

USGS preliminary data on 305 samples

Oxidize Hg(0) with CaBr$_2$ on Coal

While wet scrubbers remove most of the Hg$^+$ from the flue gas, they remove essentially zero of the Hg(0)

Adding a small amount of bromide to the coal can change Hg(0) to Hg$^+$ so the scrubber can remove it
Very Simple & Inexpensive

Just drip a CaBr$_2$ salt solution onto the coal
Chinese Wet Scrubbers


Usually ~ 70% from ESP+FGD;

But sometimes much less

Guizhou, Guizhou, Guangdong, Shanxi, Beijing (SCR)
Two More

Fig. 3 – Average mercury removal efficiency compared to US


Hebei

Mercury Removal Efficiency %

Mercury Reduction

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

No SCR  SCR On
Ozone Season
Br Additives – Oxidation Performance

Injection rates of 2 to 200 ppm Br to coal

Luminant Monticello Station

TX Lignite/PRB & LSFO + KNX™ CaBr\textsubscript{2} - CaCl\textsubscript{2} not work, but CaBr\textsubscript{2} did:

- Results of long-term test (FGD outlet vs. average coal Hg)
  - Baseline: 10%–40% removal
  - 55 ppm Br in coal: 65% removal
  - 113 ppm Br in coal: 86% removal
  - 330 ppm Br in coal: 92% removal

30% $\rightarrow$ 85% with $\sim$100 ppm

NRG Energy’s Limestone Station

Coal Blend with Wet Scrubber
Tried CaBr2 with & without PAC

<table>
<thead>
<tr>
<th>Conditions</th>
<th>%Hg Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>30%</td>
</tr>
<tr>
<td>0.5 lb/MMacf</td>
<td>50%</td>
</tr>
<tr>
<td>100 ppm CaBr2</td>
<td>70%</td>
</tr>
<tr>
<td>0.5 + 100 ppm</td>
<td>80%</td>
</tr>
<tr>
<td>1.6 + 280 ppm</td>
<td>90%</td>
</tr>
</tbody>
</table>

30% → 70% with 100 ppm
We Energies’ Pleasant Prairie Plant with SCR

- PRB coal
- SCR
- Wet FGD
- KNX™ = CaBr2

55% $\rightarrow$ 90% with 10-20 ppm

## Costs Are Tiny Compared to Other Pollutants

**Costs in the USA**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Method</th>
<th>$/kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO2</td>
<td>Scrubbers</td>
<td>$250</td>
</tr>
<tr>
<td>NOx</td>
<td>SCR</td>
<td>$150</td>
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<tr>
<td>PM</td>
<td>Fabric Filter</td>
<td>$60</td>
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<tr>
<td>Hg</td>
<td>ACI</td>
<td>$3</td>
</tr>
<tr>
<td></td>
<td>CaBr2</td>
<td>$1</td>
</tr>
</tbody>
</table>

- Work underway on United Nations global legally binding instrument on mercury
- China can inexpensively lead the way
Take-Home Messages

1. Every year that China delays reducing Hg, it lowers its IQ

2. Brominated activated carbon in the U.S., but can be expensive

3. Adding small amounts of CaBr\(_2\) to the coal can result in significantly improved Hg co-reductions in FGD at many plants

4. Very simple, very cheap, and very cost-effective

5. With CaBr\(_2\) on FGD (and micro-injection without FGD), China can leapfrog the U.S. & the world in Hg reductions