Chinese Low Chlorine Coals Need Bromine for Co-benefit Mercury Capture

Bernhard W. Vosteen, Vosteen-Consulting GmbH

EUEC 2010: The 13th Annual Energy & Environment Conference
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Track C2: Mercury Control & Sorbents (#C 2.8)
Global Atmospheric NO$_2$ Emissions 2006

Conclusion: high dust SCR-DeNOx needed in China, as well

(Prof. Dr. Lothar Reh, ETH Zurich)
Agenda

- Introduction - Global Mercury Emissions
- Coal Consumption and Mercury from Chinese Coals
- Vosteen Consulting and AE&E - Activities in China
- Low Chlorine Coals - Possible Co-benefits of BBA in China
- Legislation still open
Global Anthropogenic Emissions of Mercury to the Atmosphere, 2000:

2269 tons per year (growing + 1.4 % per year)

J. M. Pacyna et al.: http://amap.no/Resources/HgEmissions/
Global emissions of total Hg from anthropogenic sources in the year 2000

Categories - Total emission: 2269 tonnes

- Stationary Combustion: 67%
- Cement Production: 3%
- Non-ferrous Metal Production: 7%
- Pig Iron & Steel Production: 5%
- Caustic Soda Production: 5%
- Mercury Production: 1%
- Gold Production: 1%
- Waste Disposal: 1%
- Other: 10%

KNX™ Coal Additive – Addition on coal conveyor belt

Coal Conveyor (shown in black)

Injection Spray Header

KNX™ Additive Storage Tank

Metering Pump
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Synergistic mercury removal of SO₂ control policies for coal-fired power plants in China

ZHANG Lei, WANG Shuxiao, WU Te, HAO Jining

Department of Environmental Science & Engineering, Tsinghua University, Beijing, China
Trends in raw coal consumption in China, 1995-2005

Source: David G. Streets, Argonne National Laboratory, and Jiming Hao, Shuxiao Wang, Ye Wu, Tsinghua University, Beijing: "Mercury Emissions from Coal Combustion in China", International Conference of the UNEP, Rome, Italy, April 7-11, 2008
Trends in mercury emissions from coal combustion, 1995-2005

Source: David G. Streets, Argonne National Laboratory, and Jiming Hao, Shuxiao Wang, Ye Wu, Tsinghua University, Beijing: "Mercury Emissions from Coal Combustion in China", International Conference of the UNEP, Rome, Italy, April 7-11, 2008
Mercury content of raw coal, as mined (g Mg\(^{-1}\))

National average, \(\sim 0.19\) g Mg\(^{-1}\)

Source: David G. Streets, Argonne National Laboratory, and Jiming Hao, Shuxiao Wang, Ye Wu, Tsinghua University, Beijing. „Mercury Emissions from Coal Combustion in China“, International Conference of the UNEP, Rome, Italy, April 7-11, 2008
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Annual electricity generation and installed capacity of coal fired power plants (> 200 MWe/unit) throughout 2000 - 2008

by courtesy of Wojciech Jozewicz, Arcadis US (2010)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Electricity Generation [TWh]</th>
<th>Portion of Total Electricity Generation, %</th>
<th>Total Installed Capacity [GW]</th>
<th>Portion of Total Installed Capacity, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1108</td>
<td>81.0</td>
<td>237.6</td>
<td>74.4</td>
</tr>
<tr>
<td>2001</td>
<td>1204</td>
<td>81.2</td>
<td>253.1</td>
<td>74.8</td>
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<tr>
<td>2002</td>
<td>1342</td>
<td>81.7</td>
<td>265.5</td>
<td>74.5</td>
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<tr>
<td>2003</td>
<td>1905</td>
<td>82.9</td>
<td>384.5</td>
<td>74.0</td>
</tr>
<tr>
<td>2004</td>
<td>2187</td>
<td>82.6</td>
<td>442.0</td>
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<tr>
<td>2005</td>
<td>2498</td>
<td>82.0</td>
<td>517.2</td>
<td>75.7</td>
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<tr>
<td>2006</td>
<td>2850</td>
<td>83.0</td>
<td>623.7</td>
<td>78.0</td>
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<tr>
<td>2007</td>
<td>3264</td>
<td>83.0</td>
<td>718.2</td>
<td>77.6</td>
</tr>
<tr>
<td>2008</td>
<td>3451</td>
<td>81.0</td>
<td>792.7</td>
<td>75.9</td>
</tr>
</tbody>
</table>

Data are retrieved from the reliability management statistics for years 2007 and 2008:

2007 年火电100兆瓦、水电40兆瓦及以上容量机组和核电机组运行可靠性指标

2008 年火电100兆瓦、水电40兆瓦及以上容量机组和核电机组运行可靠性指标.
Recent Mcilvaine Forecast for China (January 28th, 2010):

Over 300 coal projects are in the planning stage.

It is estimated that 75 percent of them will be constructed prior to 2020.

This results in 300,000 MW of new capacity.
The installed units size against the number of units

by courtesy of Wojciech Jozewicz, Arcadis US (2010)
The market share of different power generation units

by courtesy of Wojciech Jozewicz, Arcadis US (2010)
The comparison of installed FGD capacity with power generation capacity since 2000 (mainly wet limestone FGD)

by courtesy of Wojciech Jozewicz, Arcadis US (2010)
The deployment status of SCR technology against unit size

by courtesy of Wojciech Jozewicz, Arcadis US (2010)
Vosteen Consulting GmbH in China - together with

AE&E, Raaba (Austria) and affiliates as AE&E China
**Strong Triangle – VOSTEEN+AE&E+MERQUEL™**

- Combination of Simple Technology, high efficient additive and long term experience in the installation of Air Pollution Control Systems especially in China

- **AE&E Wet FGD Technology** is installed for more than 120,000 MW of coal fired power plant capacity in China

- **AE&E’s Air Pollution Control Technologies** including DeNOx-Systems, Dry Desulphurization Systems and Wet Flue Gas Desulphurization Systems is used from more than 10 Licensees in China

**What makes the VOSTEEN Technology Unique?**

- Pre-combustion Merquel™ addition is the most effective method to enhance mercury oxidation from coal-fired boilers and industrial processes

- Merquel™ from ICL-IP is already used by the power generation industry and the waste incineration industry; The additive is cost-effective and readily available

- The VOSTEEN Technology is simple and inexpensive to retrofit to any boiler

Total: 120,000 MWe
SCR experience (1986 – 2009)

- Installed catalyst volume: ~ 20,000 m³
- ~ 72 % thereof in honey comb type
- 98 % high dust applications (pitch 7.3 mm)
- 2 % tail end applications (pitch 4.3 mm)
- Replacement of catalyst: ~ 1,000 m³ / year
- 50 % of replaced catalyst regenerated by washing
- Catalyst replacement for tangential fired boilers: every 5 to 10 years
  opposite wall fired boilers: every 3 to 5 years
- Special sieves can avoid blocking of catalyst (popcorn ash)
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Evaluation Prof. Vosteen of preliminary data from NCRDS on 305 Chinese Coal Samples - courtesy of Harvey Belkin, USGS (2010)

Coal samples originating from Anhui, Beijing, Chongqing, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hebei, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Jilin, Liaoning, Nei Mongol (Inner Mongolia), Ningxia, Qinghai, Shaanxi, Shandong, Shanxi, Sichuan, Xinjiang, Yunnan

Arrangement of these data by Prof. Vosteen with respect to the regional sources in China (number of samples, available up to now):

North: Beijing (1), Hebei (17), Inner Mongolia (16), Shangxi (89)
North-East: Heilongjiang (10), Jilin (5), Liaoning (9)
East: Anhui (11), Fujian (3), Jiangsu (6), Jiangxi (7), Shandong (19)
Center and South: Guandong (2), Guangxi (5), Henan (27), Hunan (10)
South-West: Chongqing (7), Guizhou (16), Sichuan (5), Yunnan (7)
North-West: Gansu (5), Ninxia (4), Qinghai (1), Shaanxi (11), Xinjiang (4)

etc.

Harvey Belkin, USGS, is analysing for bromine and iodine as well (publication intended in fall 2010)
Preliminary data from NCRDS on 305 Chinese Coal Samples
- courtesy of Harvey Belkin (USGS, 2010)

Coal samples originating from Anhui, Beijing, Chongqing, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hebei, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Jilin, Liaoning, Nei Mongol (Inner Mongolia), Ningxia, Qinghai, Shaanxi, Shangdong, Shanxi, Sichuan, Xinjiang, Yunnan

- Hg IN PPM ON DRY, WHOLE-COAL BASIS
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![Diagram of coal sample data distribution.](image-url)
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Conclusions with respect to China:

- Normal mean mercury content (0.16 ppm), but strong scatter - even within the same origin (making coal blending difficult)
- Mainly low chlorine content, but also here strong scatter
- Low up to extremely high sulfur contents, strong scatter
- Cl/Hg mass ratio small - lower than in US Ebit coals, i.e. values comparable to low chlorine coals as Columbian bituminous or Western lignite coals
- S/Cl mass ratio large - higher than in PRB coals etc. (limiting mercury chlorination even more)
- Harvey Belkin, USGS, is analysing Br as well (data to be published in fall 2010)

> Precombustion/Boiler Bromide Addition (BBA) will enhance co-benefit mercury control effectively (wet and dry) in case of low chlorine coals, and has been proven the most cost effective solution, as well.
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Categories of Chinese power plants

I
All the plants commissioned, built, or reconstructed before Dec. 31, 1996

II
All the plants commissioned, built, or reconstructed between Jan. 1, 1997 to Dec. 31, 2003

III
All the plants commissioned, built, or reconstructed after Jan. 1, 2004
Regulations on emission of \( \text{SO}_2 \), NOx and dust given - different limits for plant categories I, II, III

Regulations on Hg still not given - but in focus

Meeting in Beijing (October, 2008) - Prof. Vosteen presenting Boiler Bromide Addition to Yonghong Li, Having Li, Ministry of Environmental Protection, and Prof. Dr. Lei Duan from Tsinghua University
Thanks for your attention.

Questions ?