

BLACK CARBON from COKE MAKING

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Coke Chimneys on road to Jiexiu in 2000

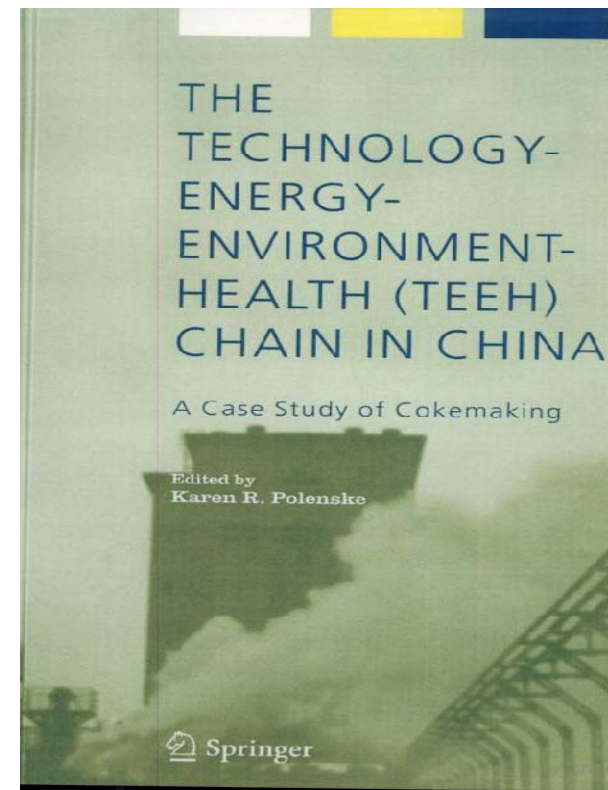
Source: Appendix A, Photo 4 from *The Technology-Energy-Environmental-Health (TEEH) Chain in China: A Case Study of Cokemaking*, edited by Karen R. Polenske. 2006. Beijing, Higher Education Press.

Coke making summary

- China dominates world coke production today (60%) and 96% of the growth in global production since 2000 has occurred in China.
- Global coke production is tightly linked to steel production.
- Information on coke production by country is available from several sources. Provincial production data is available for China.
- Air pollution emissions vary by major coke oven type and appear high for the more primitive coke ovens – with black plumes often reported.
- Reliable information on production by major coke-oven type is not readily available – but probably exists and can be obtained.
- Measurements of coke oven carbonaceous aerosol emissions are extremely limited (1-2 known).
- Upgrading from the more primitive coke ovens and installing appropriate emissions control technology can potentially reduce BC emissions to very low levels.
- Establishing a program to reduce global coke oven BC emissions to very low levels over one or two decades is probably feasible.

MIT background paper

- CATF contracted with Karen R. Polenske at MIT who managed a multi-year study of coke production in China and who has broad knowledge about global coke production.
 - Results of the China study are summarized in *The Technology Energy-Environment Health (TEEH) Chain in China*.
- ZHANG Xin, LI Shantong, LI Jinghua and LIU Hongtao also contributed to the paper.
- This work included some recent in-China research and has been supplemental by research by other CATF consultants.
- This presentation is based on the back ground paper. Sources for presentation data sources are provided in the background paper.



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Coke making industry

- Coke is an irreplaceable component of the iron and steel production process.
- Coke is produced by “baking” suitable coal in ovens, which creates coke oven gas as coal constituents are “baked off”.
- The coke making process creates a large amount of a wide range of highly toxic air pollutants.
- Coke production air emissions are typically highly regulated in Western countries.
- Coke production is concentrated in a relatively small number of coke making facilities ~ 1500 worldwide
- Recent coke production is dominated by China, producing 60% of global coke in 2008 and providing 96% of global production growth since 2000
- Coke technology capacity outside of China is aging – with average ages ranging from 17 years in Germany to 40 years in Sweden.
- Much coke production and market forecasting information is available (at considerable cost) from commercial sources.

Coke production

- Recent coke production is dominated by China (2008 data):

▪ China	60%
▪ Japan	7%
▪ Russian Federation	6%
▪ Ukraine	4%
▪ India	4%
▪ US	3%
- Several coke production statistics are included in the MIT background paper:
 - Production by country from 1988-2008
 - China production by province for selected years from 1995-2006
 - China production and exports 2002-Q12009
- Coke production growth has been flat over the past decade in In nearly every country except in India - where production has doubled between 2000-2008 (but production numbers remain low) - and China where production has increased by 66% for **96% of global production growth.**

China drives coke production growth

- World coke production can be projected through China.
- A simple projection shows coke production will reach 600 million tons in year 2020 (2008 estimated production was ~340 million tons and current capacity is estimated to be about 400 million tons).
- This projection does not consider the recent dramatic changes in the global economy.
 - Domestic China coke demand is estimated to drop to ~280-290 million tons in 2009 and ~100 million tons of capacity (25% of 2008 capacity) could be idle in 2009.
- A more accurate projection should be possible based on input-output analysis.

Baseline BC emissions projections

- As already noted, future global coke production is linked to global iron and steel production and nearly all global coke production growth for the foreseeable future will likely occur in China.
- Elimination of nearly all primitive coke oven production in China will likely occur within the next several years.
- The prospects for significant improvements in emissions control from modern coke oven technology in China and other non-Western countries are unclear.

Coke oven types

Three major types of coke ovens exist today:

- **Beehive** – “Primitive” technology in limited use – probably primarily in China. Emissions from this technology are high – with black plumes suggesting large BC emissions. These ovens are also called “pile” or “kiln” ovens and in China they are called “indigenous” or “modified indigenous” ovens.
- **“Slot Oven”** – Modern technology ovens that recover a wide range of chemicals from coke oven gas. These coke ovens have many potential air emissions points. With proper maintenance practices and appropriate air emissions controls, BC emissions can potentially be reduced to very low levels (Clairton coke works measurement). These ovens are also called “recovery” or “machinery” ovens.
- **“Clean”** – Modern technology ovens that combust coke oven gas and may recover heat but not chemicals. These coke ovens have fewer potential air emissions points and thus tend to have lower air emissions than recovery ovens. These ovens are also called “non-recovery” or “heat-recovery” ovens.

Coke production by oven type

- Coke production from primitive coke ovens was significant in China into the late 1990's.
- A significant fraction of China's primitive coke ovens (including small "slot/machinery" ovens) have been phased out, with current estimates of such production ranging from ~5% to 20%.
- As China continues to pursue phasing out primitive coke oven technology and given the recent and ongoing large additions of modern coke oven technology, it is plausible that nearly all primitive coke oven production could be soon eliminated.
- Accurate information on coke production by major kiln type in China (and elsewhere) is probably available.

BC and OC emissions data are limited

- There are several processes involved in making coke -- charging, coking, pushing, quenching, and conveying – where there is an opportunity to produce emission,
- Except in the clean coke ovens, air pollution is very high compared with production of other commodities.
 - Considerable data are available for a wide range of coke oven air pollutants (see EPA AP-42) – but no BC/OC emissions measurements are available except for the Clairton Coke Works measurement described below.
 - Considerable monitoring of community and occupational exposure to small particulate emissions from several coke oven types was conducted by the MIT China coke making study that found high small particulate emissions.
- U.S. industry has been subjected to technology-based regulation of fugitive emissions for over 30 years.
- One US measurement at Clairton Coke Works found BC emissions of 0.04g/kg of coke produced at a recovery coke oven facility.
- SO₂ emissions data will be needed in addition to BC/OC emissions measurements to understand climate response to potential actions to reduce BC emissions.

BC emissions control options

Potential BC controls measures vary by coke oven type:

- Primitive coke ovens –
 - Replace with modern technology with appropriate emissions controls.
- “Recovery” coke ovens –
 - A wide range of process features and localized emissions capture technologies and certain process equipment maintenance measures can significantly reduce particulate emissions.
 - Field measurements will likely be necessary to determine which actions reduce BC emissions and by how much.
 - The Clairton Coke Works measurements suggests that the full extent emissions control actions (maintenance procedures and emissions control measures) required by EPA can reduce BC emissions to very low levels.
- “Clean” coke ovens -
 - Emissions from pushing and quenching processes, as well as associated maintenance and emissions control measures that would be similar to those for recovery ovens. Clean coke ovens also have a combustion stack that can be controlled with conventional air pollution control devices.

BC emissions control observations

- US and European environmental regulation has demonstrated that air emissions – probably including BC emissions – can be reduced to very low levels through proper maintenance practices and installation of appropriate air emissions control technology.
- China’s government has phased out much primitive, highly polluting coke oven technology (including small “machinery” ovens) over the past decade.
- BC/OC emissions from modern coke oven technology in China are probably higher than in Western countries.
- The relatively small number of coke-making facilities globally, the concentration of coke production in China and the relative effectiveness to date of government-driven coke oven modernization in China suggest that large reductions in current coke-making BC emissions could plausibly be achieved by appropriate programs.

Next steps?

- **BC/OC/SO2 emissions measurements!!!!**
 - By coke oven type
 - With and without emissions control devices and air emissions-related maintenance procedures (where appropriate)
 - CATF will be developing a proposal for coke oven emissions measurement and welcomes any input on measurement method, potential in-country measurement team, etc. This work will likely focus primarily on facilities in China.
- Obtain reliable information on the current status of air emissions control (relevant maintenance practices and installation/operation of emissions control technology) at modern coke ovens in China and other non-Western countries. This information may be available for China from in-China sources.
- Obtain reliable information on coke production by major coke oven type – with emphasis on China. This information is probably available from in-country and/or commercial sources.
- Obtain (from commercial sources) or commission (from MIT) useful projections of coke production through 2030.