

“Metallurgical Reductants for the Ferrochrome Industry”

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Description of Metallurgical Coke

Definition of coke: the solid residue - hard, strong & porous - formed when bituminous coal is heated strongly in the absence of air under pressure.

Methods of production: most commonly in *vertical batteries* (90-95% of world total) from which by-products - tar, CO gas, ammonia etc - are recovered;

In horizontal *non-recovery batteries* in which by-products are burned internally (existing in the US, India, some other countries);

Minor production from “*bee-hive*” plants - small-scale primitive ovens - remains in some countries.

Control of air emissions is critical issue, especially of polycyclic aromatic hydrocarbons (PAHs).



Coke's Role in Reduction Processes

<i>Grade</i>	<i>Replacements</i>	<i>Approx Coke Rate – a</i>
Pig Iron	Injection of pulverized coal (PCI) or other materials into the blast furnace can cut coke rate down to 0.3-0.35 per tonne HM.	0.5
Ferrochrome	Gas coke and anthracite can cut coke rate by up to 50%. Phos content critical (<0.015%) adding to constrained supply.	0.65-0.7
Manganese Alloys	Technically, more possibility to reduce coke in Mn alloys than FeCr production. Anthracite and coal are main replacements.	0.3-0.4
Calcium Carbide	Petroleum coke and anthracite are main replacements. European capacity being progressively closed.	0.6
Base Metals	Some smelting processes for lead, zinc and copper use coke, but are increasingly being phased out on cost and environmental grounds.	various
Soda Ash, Sugar	For carbon dioxide production in lime kilns. Coke can be replaced up to 100% with anthracite in this application.	Low (<0.15)
<i>(Production of elemental phosphorous and silicon carbide also require carbon reductants.)</i>		

a – with no coke replacement

Coke Market Structure - 2010

Sector	M tonnes	% of total
Blast Furnaces for Iron Ore Reduction (30/90mm)	520	88%
Cupola Furnaces needing Foundry Coke (>80mm, low ash)	10	2%
Non-Ferrous Uses (10/30mm typical, reactivity CRI also important)	10	2%
Breeze (<10mm), Available for Sintering & Pelletizing of Ores	50	8%
Total	590	100%
(Above data are "ballpark"...)		

Of world coke production, 70-75% is situated on steelmaking sites for captive use, balance typically in coal-mining areas.

In 2001-08, 6-8% of coke production was traded across borders; since 2009 just 3-4%.

Constrained Supply of Coke

Why have coke prices escalated since the start of the last decade?

One, stricter environmental regulations around the world, leading to higher costs of compliance and some capacity closures.

Two, lower integrated steel production in “western world” leading to a smaller coke capacity base.

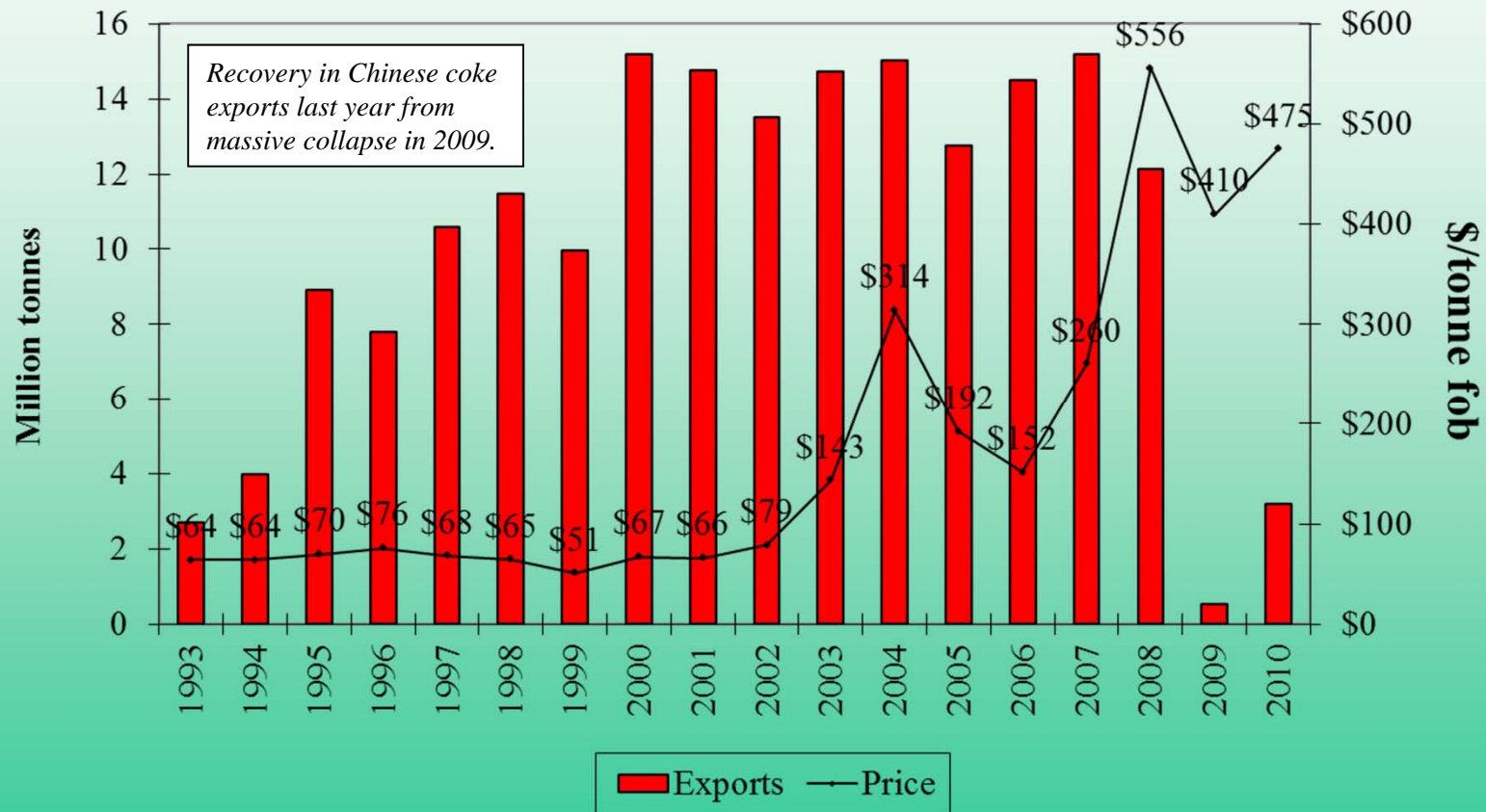
Three, controls on Chinese exports (before 2009 accounting for ½ world trade) e.g. annual volume ceilings, export taxes. Closures of bee-hive capacity in China; accounted for half of its production in mid 1990s.

Finally, coking coal prices on a higher level from 2005 due to investments to alleviate port and rail bottlenecks. Limited supply base for quality coal.



Example of so-called “bee-hive” coke plant (Santa Catarina, Brazil, 2008).

Chinese BF Coke Price versus Coke Exports



Market Influences

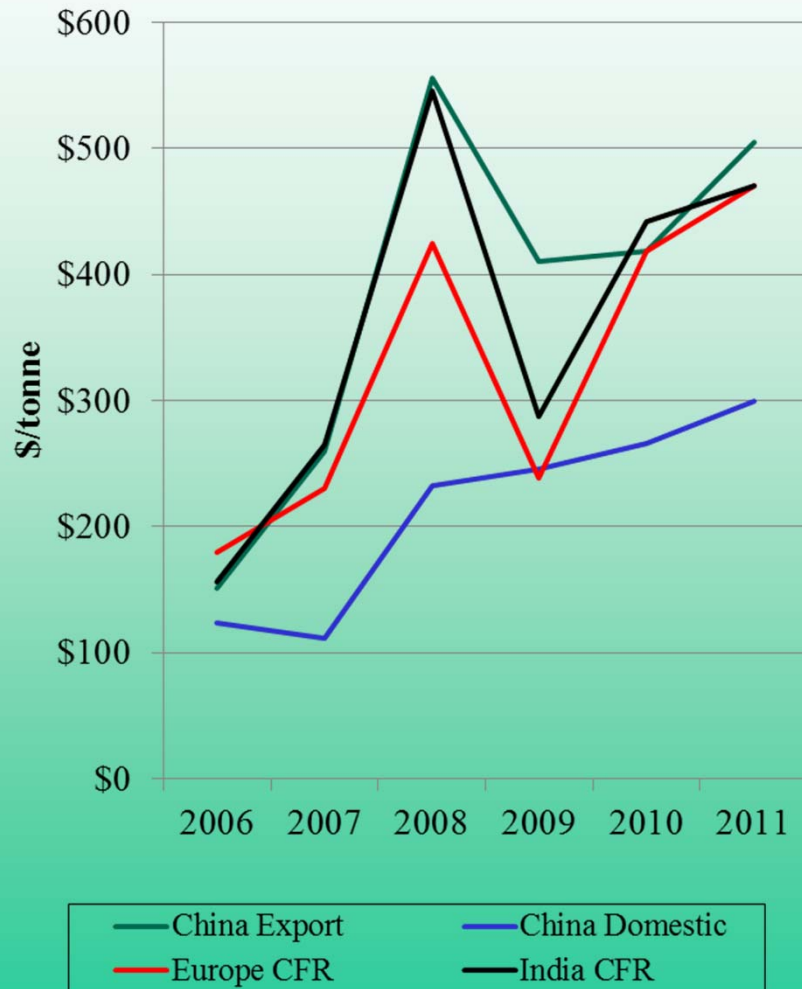
Chinese Export Prices: Most transactions from China are no longer workable due to the rise in the export tax to 40% (from 25%) in August 2008. Chinese price acts as “ceiling” on world market. Exports unlikely to recover to 12-14m tpy level seen in 2000-08.

Demand for Coke: Unlike other process plants, batteries cannot be allowed to go cold without risk of damage to their structure. Hence in a market downturn, production of coke continues at a rate above that required by the market.

Battery Constructions & Shutdowns: Rebuilds (needed every 30-40 years) are expensive due to stringent environmental regulations. Since the onset of the crisis in 2008, 15m tpy of capacity at 20 locations (outside China) has been closed due to costs of maintenance and repairs; this is equivalent to 6% of the total.

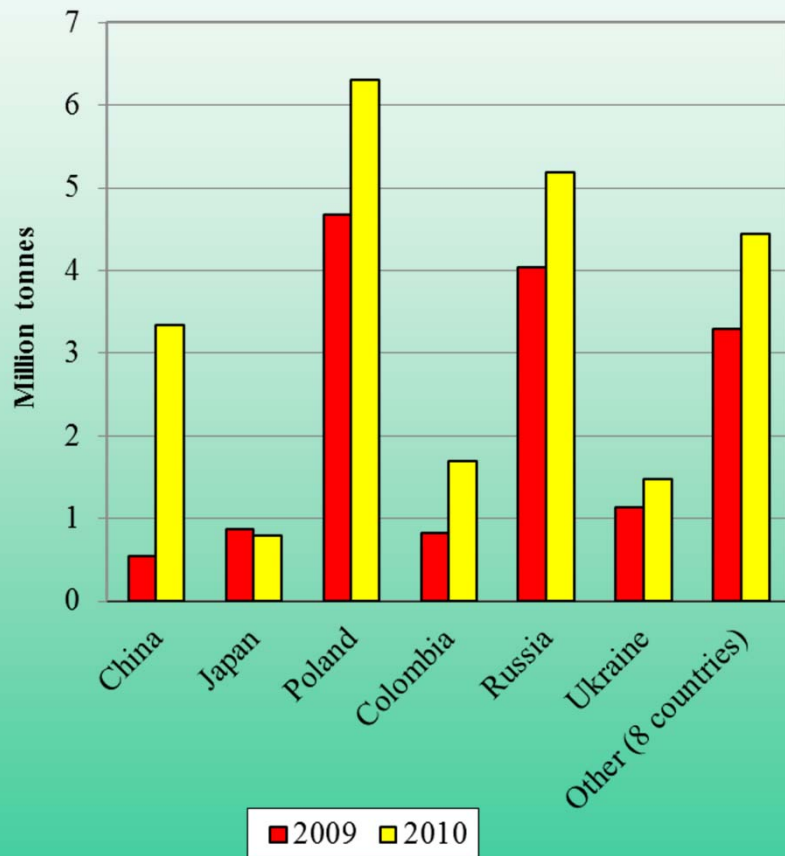
Coking Coal Prices: From 2010, pricing switched from annual to quarterly, adding a new dynamic to the coke market. This year, pricing has been high due to Australian supply disruptions from floods at the start of 2011.

Blast Furnace Coke Pricing



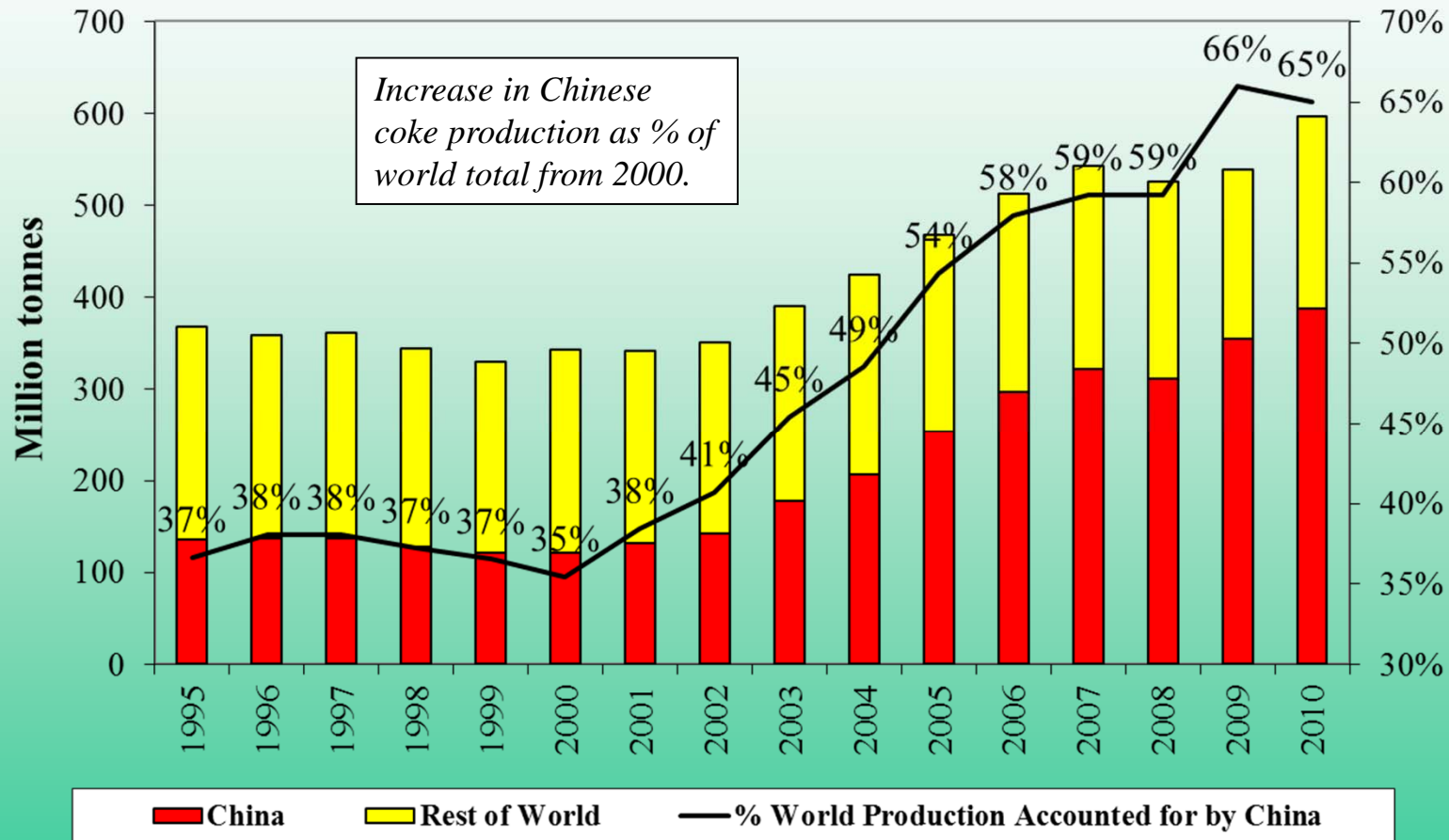
- Shown are the annual averages of the prices researched each month by “Resource-Net”. As well as Chinese export prices, we report “cfr” prices for Europe and India. Report blast furnace (30/90mm) and smaller sizes (10/25mm) also.
- In 2009, Chinese export prices were more than \$100/tonne higher than other world market prices, so exports were minimal.
- Since then, prices from China and those in Europe and India have been more alligned, leading to a resumption of significant exports in 2010 and 2011.
- The Chinese export price is likely to average around \$500/tonne fob in 2011. In India and Europe, it will be around \$470/tonne cfr.
- The widening gap between Chinese domestic and export prices is clearly evident: from just \$30/tonne in 2006 to >\$200/tonne in 2010 and 2011.

Key World Coke Exporters

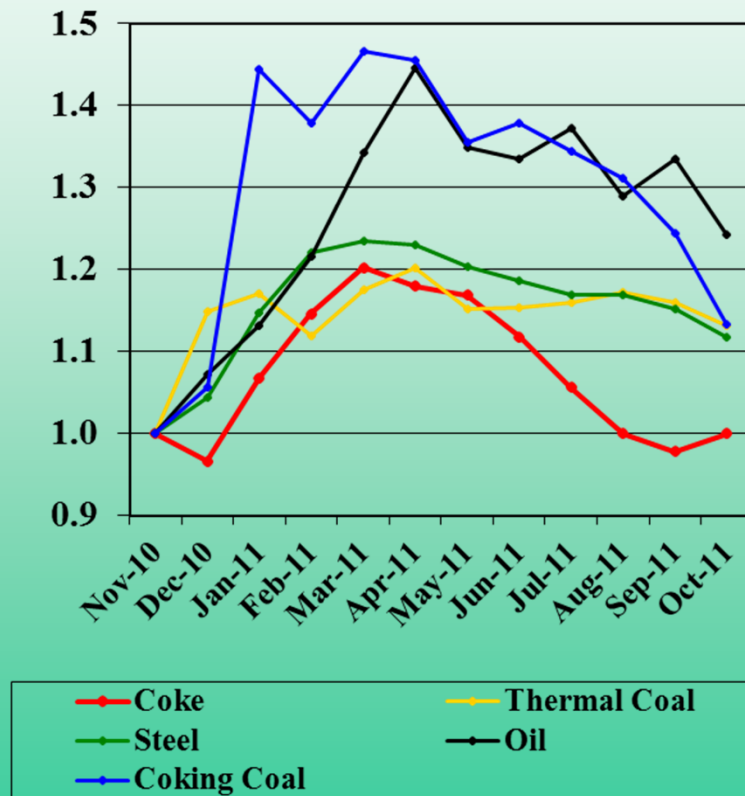


- Increase in export volumes from most suppliers in 2010 from previous year.
- **China:** 500% increase in export volumes from 2009 to last year due to rebound in world economy.
- **Japan:** exports in long-term decline, similar in 2010 compared to previous year.
- **Poland:** mainly supplies other European countries, though sales to Asian markets start in last three years.
- **Colombia:** traditional markets in Latin America, but also supplies Europe and India.
- **CIS (Russia & Ukraine):** becoming important suppliers to Middle East & India, as well as Europe.

World Coke Production

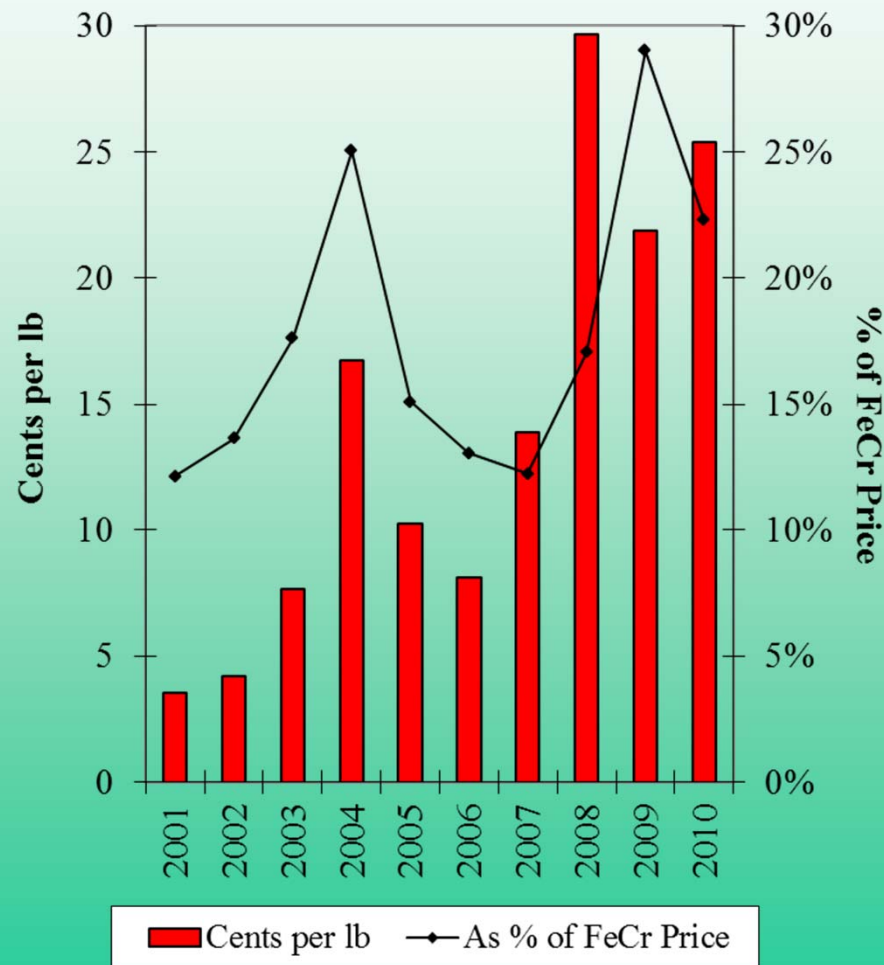


Pricing for Coke Indexed vs Steel & Other Raw Materials – 2010-11



- Despite low growth in “western world” economies in 2010-11, commodity markets increased by up to 20-50% from Nov 2010 to Mar-Apr 2011.
- Coking coal prices increased substantially at start of year, due to Australian floods; they have remained at high level in 2011.
- Prices for coke have not risen to same degree as coking coal, meaning there has been more profit in coal.
- Coke prices have declined to levels of one year ago.
- Instability in “Eurozone” economies had led to fears of economic downturn as severe as that of 2008-09.

Estimated Coke Cost As % of Ferrochrome Price



- Here, we show coke cost calculation for charge chrome, assuming 0.6 tonnes of coke per tonne of final product.
- In terms of cents per lb, the assessed coke cost increased from a typical level of <10c/lb before 2007 to 20-30c/lb in the past three years.
- In 2009-10, coke is shown as accounting for >20% of the ferrochrome price (delivered), compared to <15% previously.

Supply of Coke for EAF Applications

<i>Region</i>	<i>Supply Options</i>
Europe	Poland – most important merchant supplier for Europe. Russia and Ukraine - also options. Scandinavia has historically been supplied from UK.
CIS (Russia, Ukraine, Kazakhstan)	Ample coke availability in Russia and Ukraine. Kazakhstan has reduced dependence on China in last few years.
Southern Africa	Availability in South Africa cut by closure of battery for ferroalloys market in 2009. Imports continuing from China, joined by other sources mainly European. Zimbabwean supply – high phos, increasingly oriented to central African markets.
Latin America	Colombia has become main supplier. Brazil - some local availability. Mexico can source from USA.
East Asia (China, Japan, Korea)	China – domestic prices low by world standards. Main coke-producing province – Shanxi - attracts ferroalloys production to minimize transport costs. Japan and Taiwan have minor exports of small-sized coke.
India	Most merchant coke capacity in north-west, but demand is dispersed around other states. In the past, China was main source for imports.

Coke Replacements

We are most familiar with South African situation, where the highest degree of coke replacement appears to have been achieved (up to 50%).

Little knowledge about the situation in rest of the world; but these plants seem more likely to run with higher coke ratio.

In South Africa, the main coke substitutes have been:

Gas coke or char (de-volatilized coal) produced by vertical retort or chain grate – in South Africa, Xstrata has dominant position (700,000 tpy at five locations).

Anthracite (coal with low volatiles, high FC) – consistency of grades is main issue, seven significant mines including one in Swaziland.

Coking coal – less popular than in the past due to switch to closed furnaces.

Pricing is linked to that for coke, but at some discount.

Research from “Resource-Net”

“Coke Market Report”: monthly research report on coke and coking coal, including price indices for various grades and markets, trade stats etc.

“Coke Market Survey”: annual in-depth report on coke industry and market including price forecasts, 2011 version completed in November.

Anthracite: monthly coverage as combined report with coke. In-depth report on the world anthracite market completed in April 2011.

Summary of Coke Market

Metallurgical coke has become a more significant cost factor for non-ferrous applications, such as ferrochrome, since the start of the last decade.

Of non-ferrous uses, ferrochrome has about the highest coke ratio and less possibility for substitution than other sectors. Coke replacement is partial, up to around 50% max.

Next year, ample availability of coke is likely... but thereafter we expect tight supply to continue due to:

- Government controls on Chinese exports, accounting for around half of coke trade before 2009;
- High costs of capacity replacement and maintenance due to increasingly stringent environmental standards;
- More battery closures as a consequence of the world economic crisis.

Non-Chinese sources for coke often cannot offer broad range of specifications due to smaller supply base. Chinese coke production was 383m tonnes in 2010, 65% of world total.