Future steel and coke industry trends



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Presentation outline

- Background - steel industry trends
- Critical issues for the global steel industry
  - Future structure of China's steel industry
  - Consolidation
  - Future Blast furnace trends
- Implications for coke
- Recent studies to understand coke its reactions & performance
- Summary and Conclusions

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The world has changed

But the need for coke and hard coking coal remains

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Areas where the world has changed…….

- Industry structure – consolidation; the new wave
- Regional consolidation moves global
- Price volatility – industry consensus; potential to be lower
- Increased market “power” re customers (flat products)
- Current high profitability in the steel industry continues
- *Raw materials – too early to be definite, but potential move to higher quality seaborne raw materials*

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Areas where the world has not changed

- New phase of strong demand growth - BRICS
- China driving major uplifts
- Technology trends - BF still king
- Planned new capacity SE Asia, Brazil, India etc
- Drive for higher productivity = high quality RM's esp coke
- Environmental conditions
- Raw materials – the benefits of high quality esp coke

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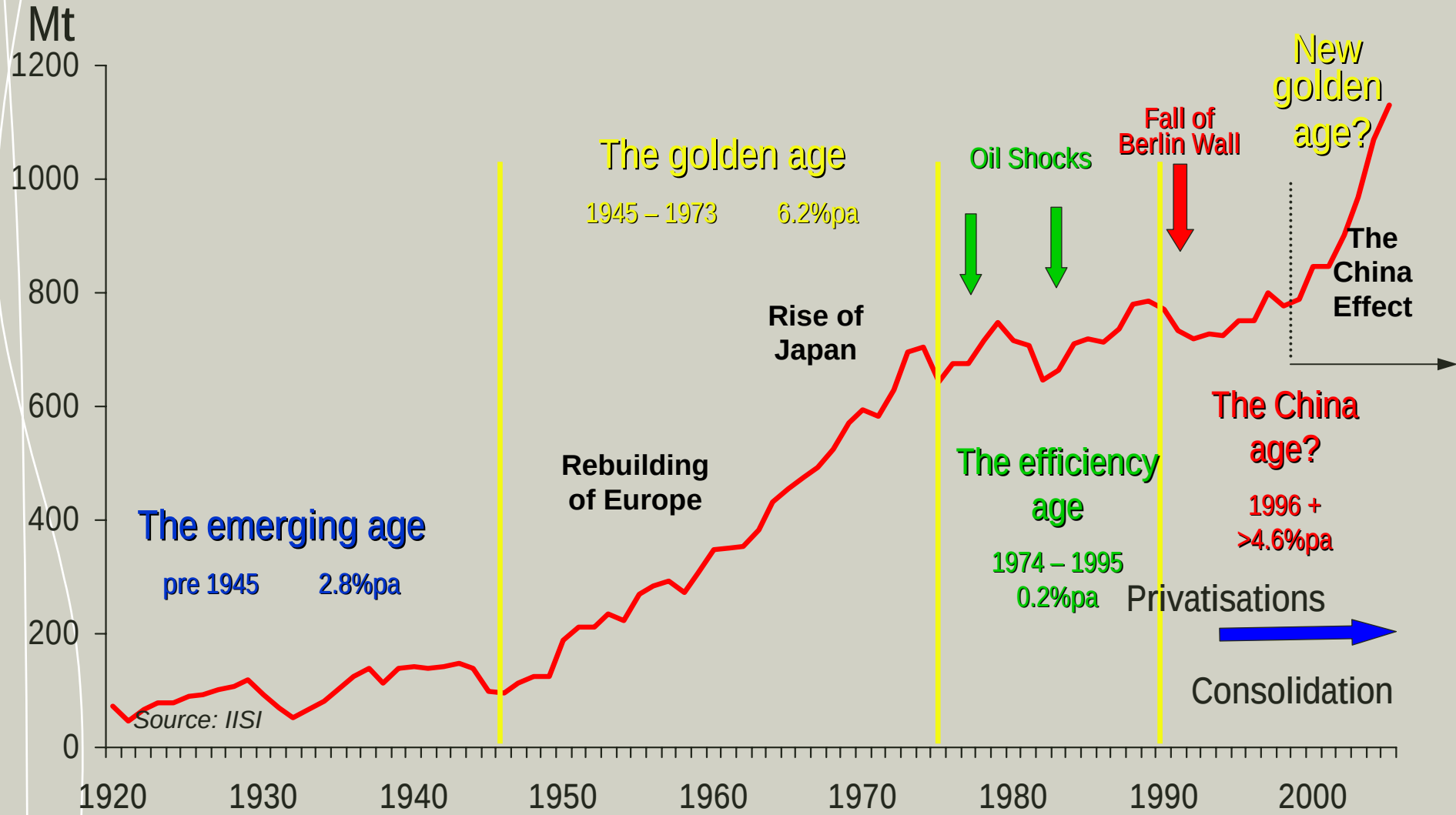
The global steel industry continues to power on



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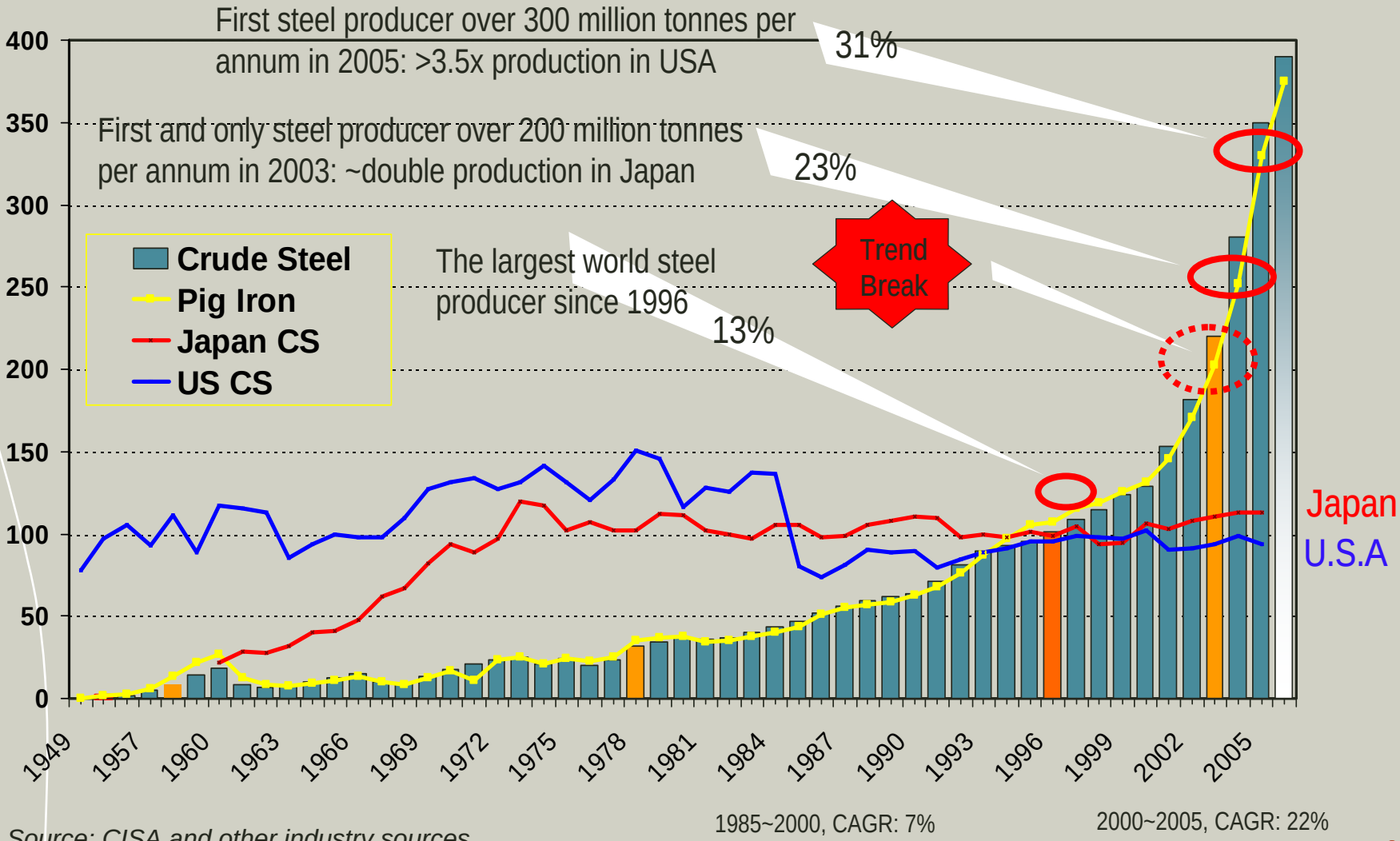
Global steel growth rates have picked up a gear

	CAGR (%)	Comments
1970 – 1975	1.6	First oil shock, ending of Japan steel boom
1975 – 1980	2.2	Steady global recovery from oil shock
1980 – 1985	0.1	Second oil shock, recession, reduction in steel intensity
1985 – 1990	1.4	Strong steel efficiency drive
1990 – 1995	-0.5	Fall of Berlin wall, collapse of USSR, continued steel efficiency gains
1995 – 2000	2.4	Slow CIS recovery, signs of emerging China
2000 - 2005	5.9	China takeoff, US/EU recession then recovery, emerging steel demand SE Asia

Source: IISI

China remains the main driver of this growth



Source: CISA and other industry sources

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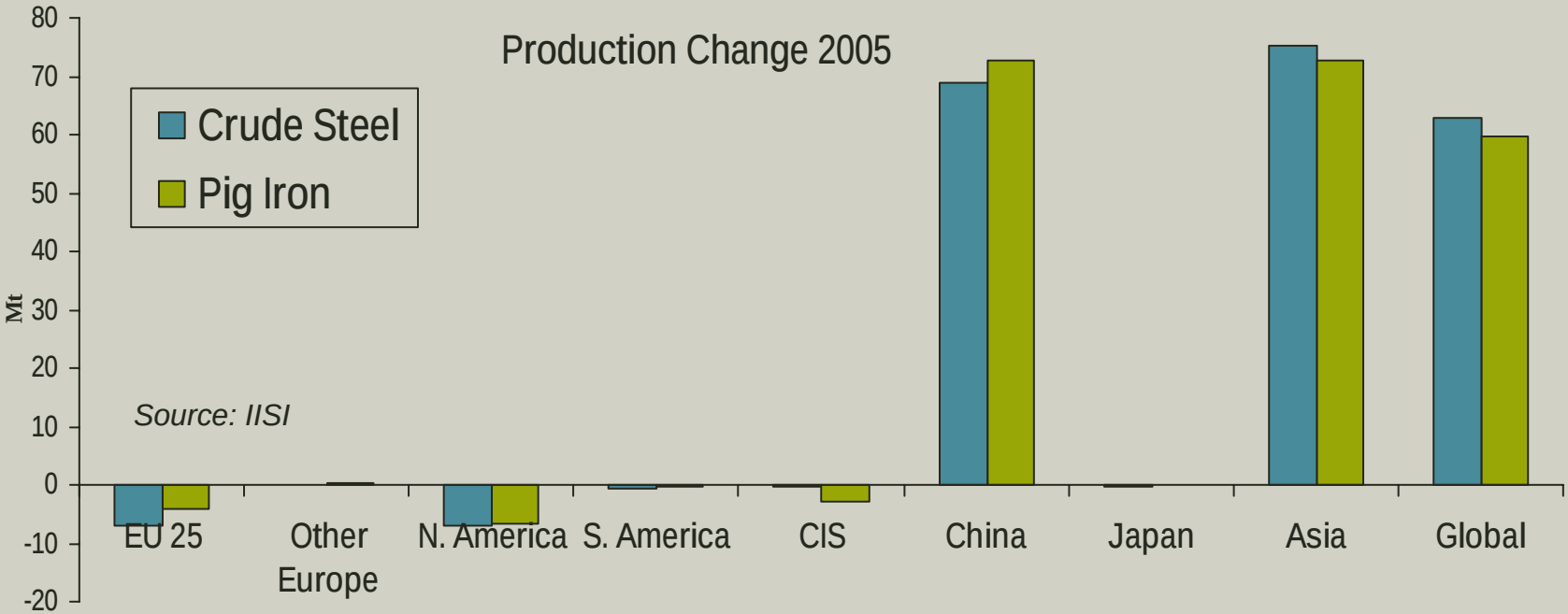
Steel 2005; 2 worlds – balanced & uncontrolled growth



- Market sentiment roller coaster – strong, weak and strengthening again
- China responsible for global increase – world ex China –ve growth in 2005
- Demand led by China, contribution from SE Asia: growing +ve signs US, Europe later
- Chinese production remains buoyant strong steel and stronger pig iron growth

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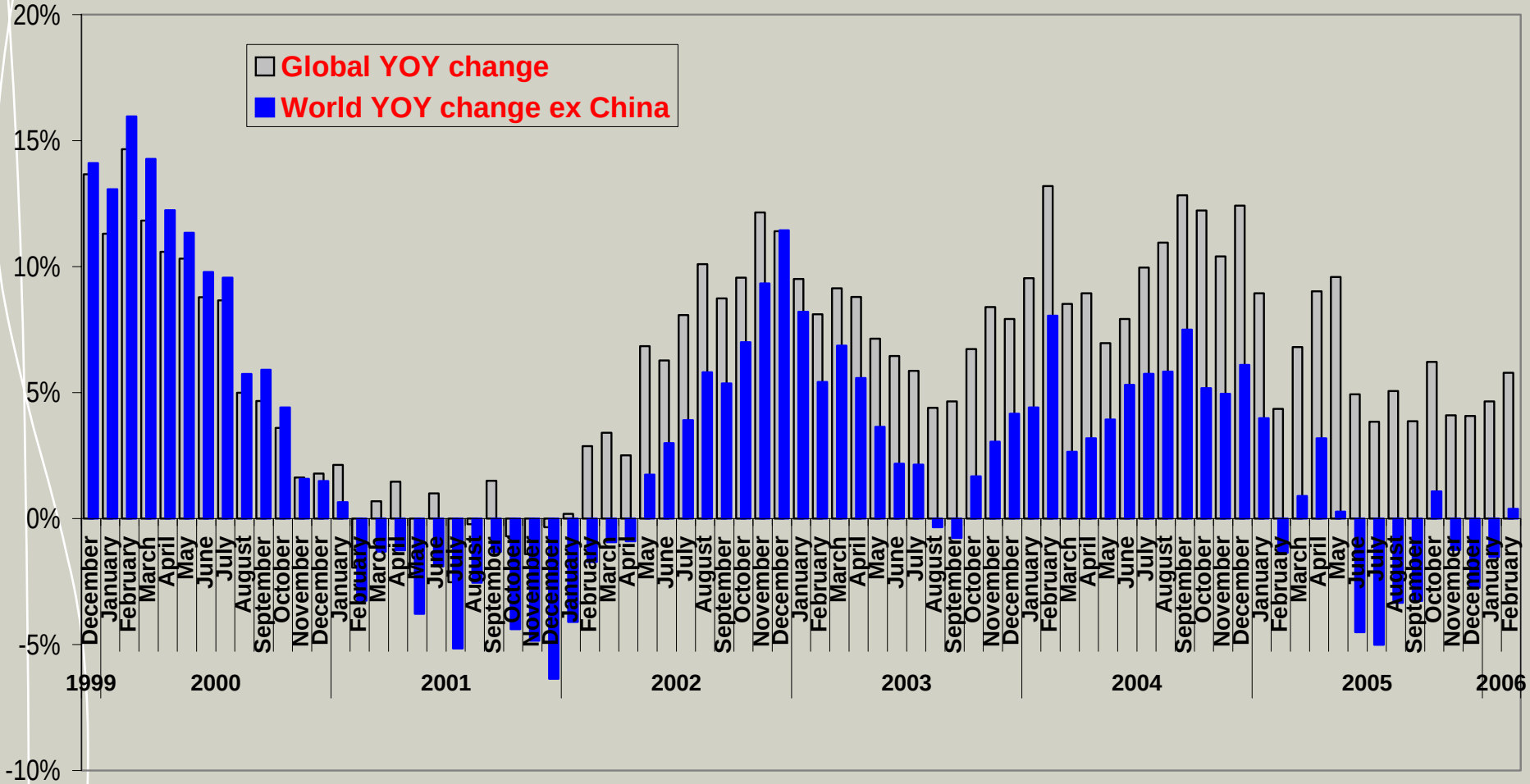
The China effect



Source: IISI, BHP Billiton

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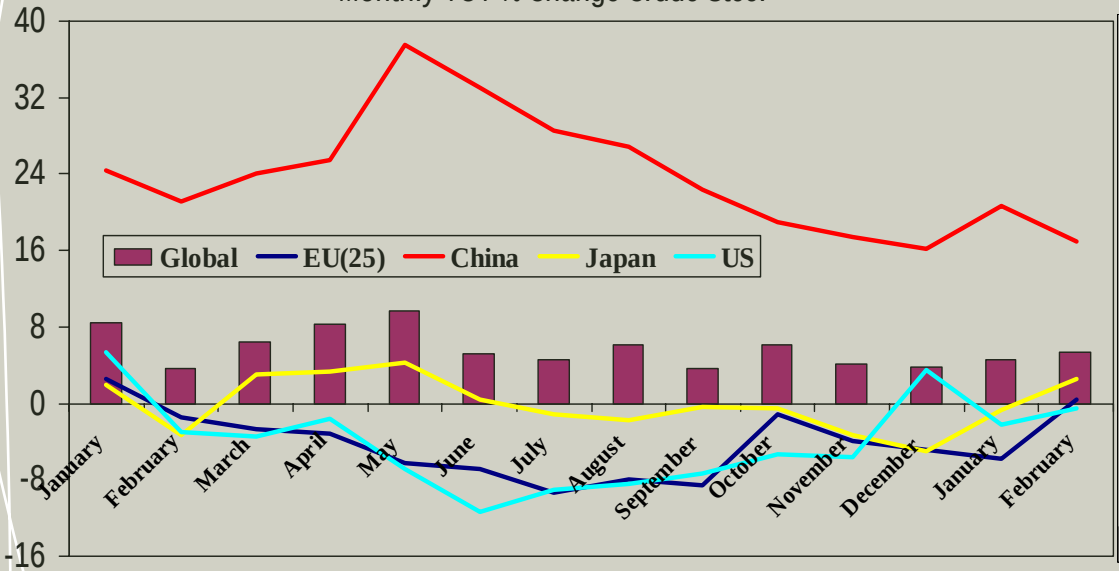
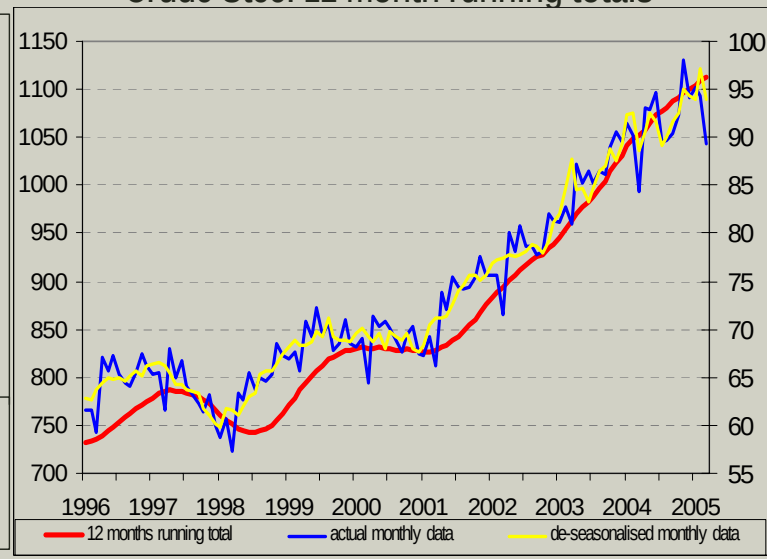
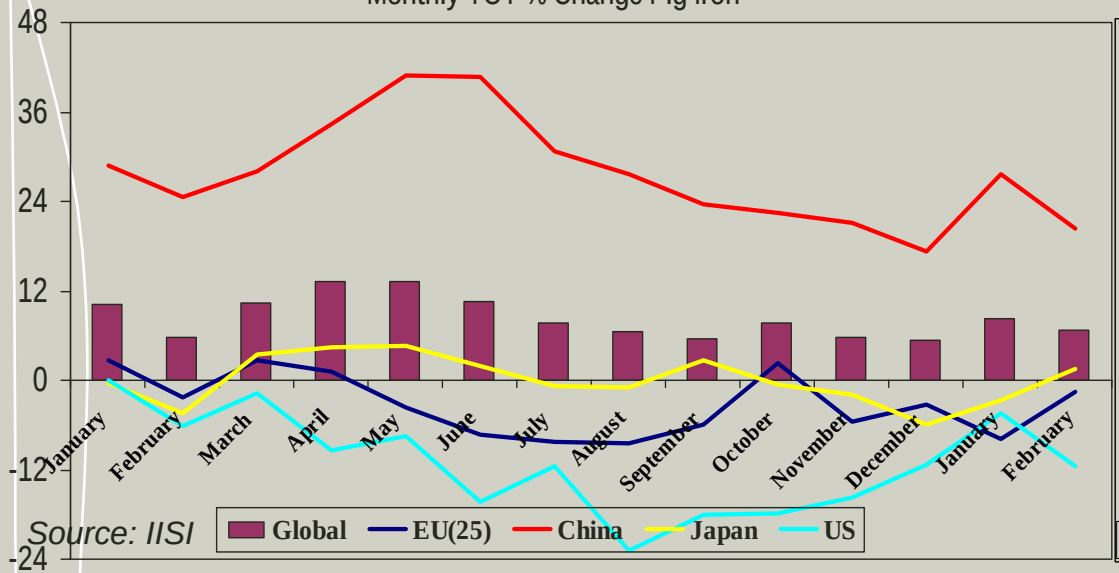
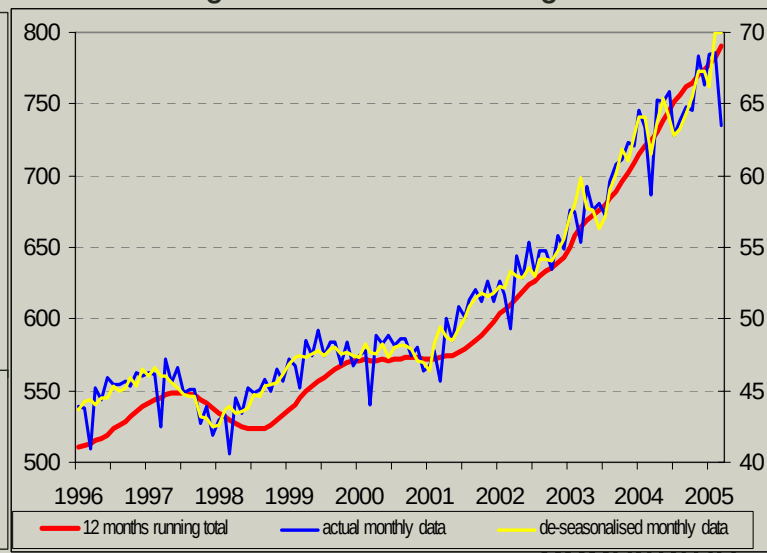
Changing trends emerged during the year



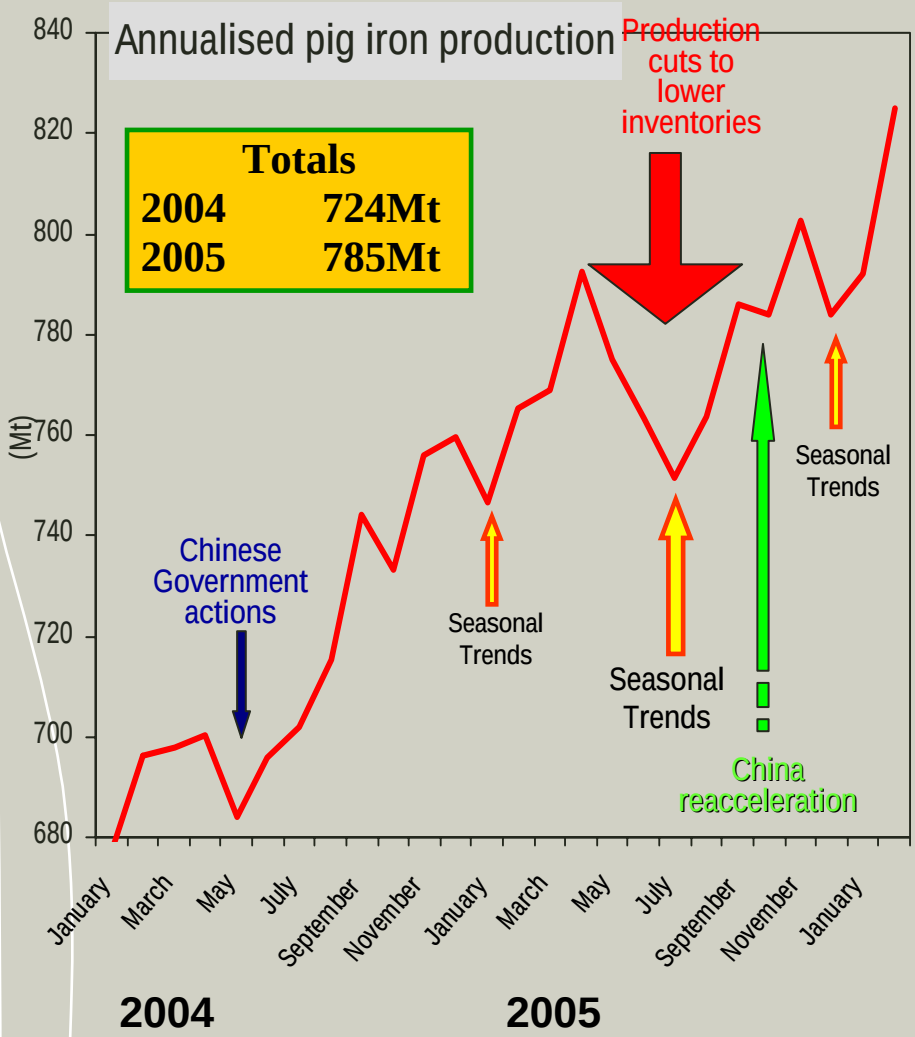


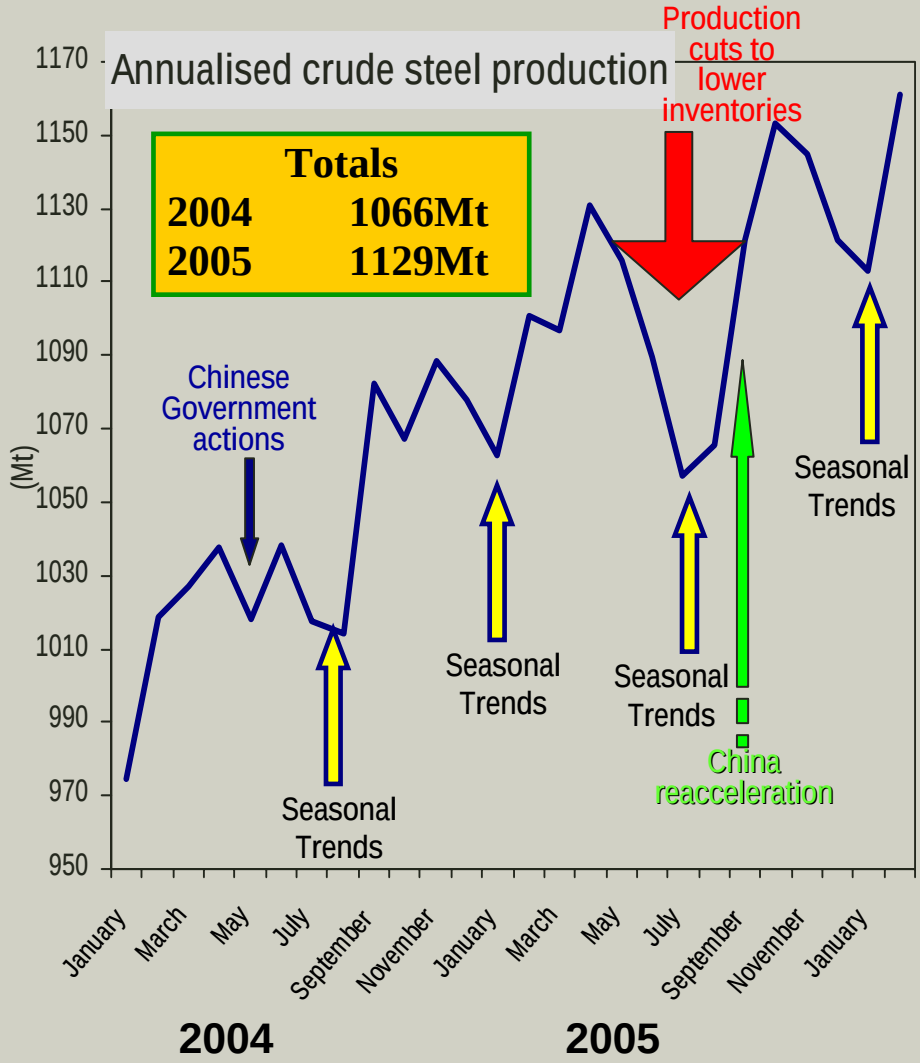




Source: IISI

Annualised steel and pig iron production trends





Source: IISI

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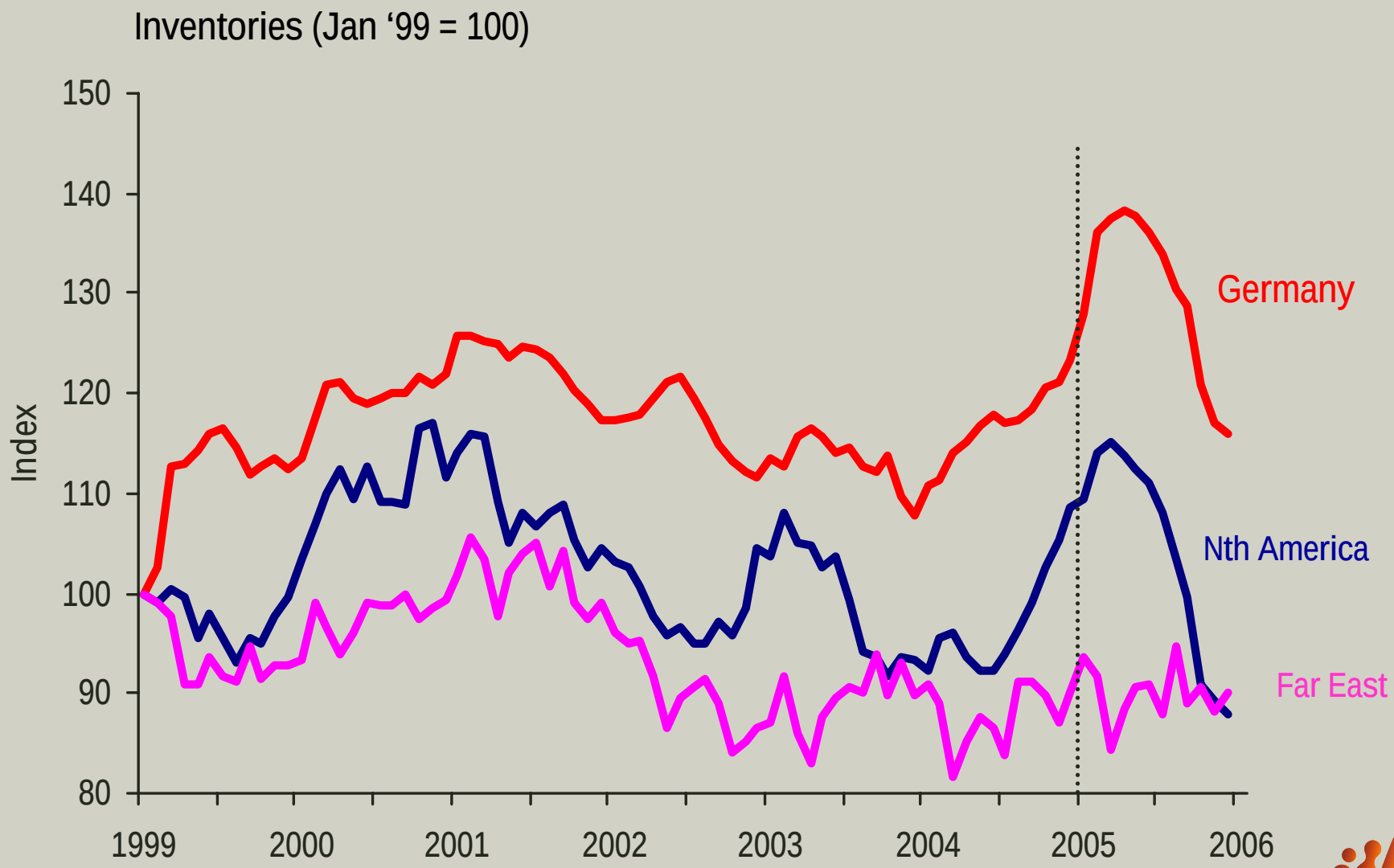
Massive steel de-stocking during 2005



Source: CRU

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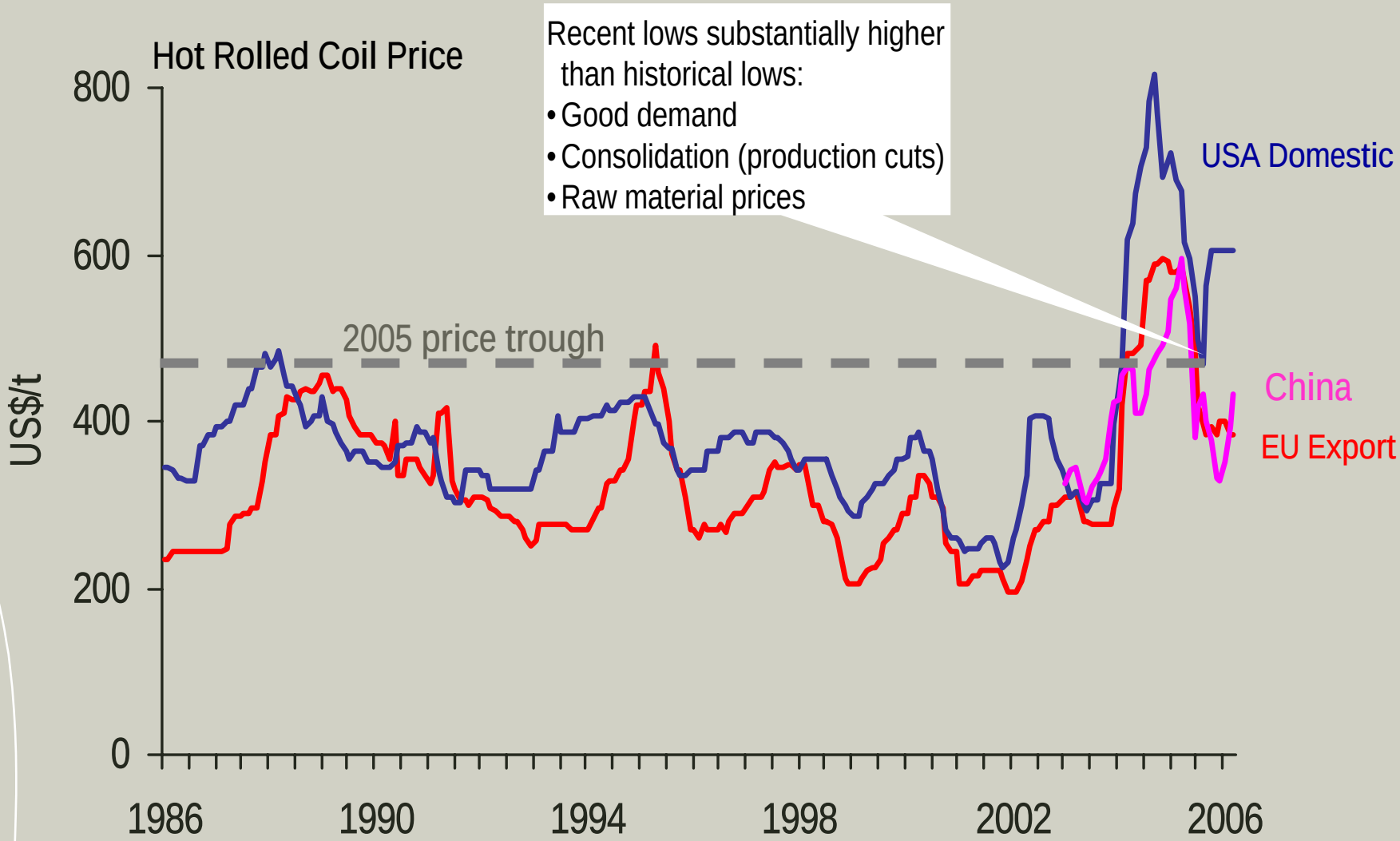
Successful price stabilisation – current prices turning up



Source: CRU, China – Shanghai spot

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Profitability remained very strong

PROFITABILITY	EBITDA Margin %			Pre-Tax Margin %			ROIC (EBIT) %		
	2004	2005	2006E	2004	2005	2006E	2004	2005	2006E
BlueScope*	18.0	18.9	11.5	14.0	17.1	8.2	24.3	34.3	14.6
OneSteel†*	9.7	9.5	10.7	5.8	5.2	6.9	13.9	14.8	15.6
Australasia (Mkt cap wgtd ave)	**15.0**	**16.2**	**11.0**	**10.7**	**13.4**	**7.4**	**20.4**	**28.6**	**14.7**
JFE Holdings	17.8	23.1	23.0	7.5	10.8	16.1	12.7	24.8	25.0
Nippon Steel*	13.9	18.0	19.0	2.5	10.9	13.6	8.6	17.1	21.2
Sumitomo Met Ind.	15.4	21.2	23.9	3.6	13.7	18.9	6.4	13.8	23.5
Tokyo Steel	13.0	34.2	30.7	8.2	31.6	26.8	18.9	136.4	100.5
Japan (Mkt cap wgtd ave)	**15.2**	**20.5**	**20.7**	**5.0**	**11.9**	**14.8**	**10.3**	**25.1**	**24.8**
Baosteel (G)	38.6	22.2	15.9	23.2	13.9	8.2	33.6	28.1	15.8
Maanshan I&S	22.7	17.2	13.2	15.2	11.8	7.0	22.2	18.4	9.6
Wuhan Steel	30.6	25.3	25.0	22.1	19.4	19.2	48.1	38.7	39.8
China Steel	40.6	36.8	25.5	38.6	35.4	24.4	55.2	57.4	31.7
POSCO	32.8	34.1	25.8	26.4	24.7	17.6	45.3	48.7	25.1
Asia (Mkt cap wgtd ave)	**34.4**	**28.9**	**22.7**	**26.7**	**23.0**	**16.5**	**42.3**	**41.5**	**24.7**
CSN*	47.0	46.5	45.7	28.6	28.9	27.3	30.0	33.3	29.2
Usiminas	45.2	42.4	34.4	36.2	38.2	28.2	49.2	46.1	25.3
Mechel*	24.4	19.3	20.1	42.5	14.1	14.7	52.4	28.9	25.0
Severstal*	32.3	27.0	21.8	28.4	22.0	15.2	59.6	40.7	23.8
Novolipetsk*	54.3	46.8	41.1	52.1	41.3	44.9	106.2	67.6	51.2
Evraz*	33.6	28.4	23.6	28.1	24.6	19.9	86.4	48.4	35.0
Tata Steel	25.6	35.5	35.5	23.5	34.7	32.6	25.5	48.9	42.9
Emerging markets (Mkt cap wgtd ave)	**37.3**	**35.4**	**30.7**	**32.9**	**29.3**	**25.7**	**54.4**	**47.6**	**33.5**
Arcelor*	15.2	17.3	13.3	10.5	13.3	9.9	23.3	25.1	18.8
Corus	10.0	10.1	8.6	6.1	5.7	4.9	16.7	17.7	14.5
SSAB	20.6	23.7	19.9	19.4	20.4	16.4	28.4	38.5	31.6
ThyssenKrupp Group*	8.1	8.2	7.8	4.0	4.4	4.2	7.6	9.0	7.5
Europe (Mkt cap wgtd ave)	**12.6**	**15.8**	**12.1**	**8.3**	**11.8**	**8.6**	**17.4**	**23.1**	**17.2**
Nucor	19.5	19.7	18.7	15.9	16.7	15.9	55.1	60.8	61.1
US Steel	14.1	12.8	11.4	10.5	9.4	8.1	91.6	64.9	40.6
North America (Mkt cap wgtd ave)	**19.3**	**19.5**	**19.1**	**15.4**	**16.0**	**16.0**	**63.0**	**56.6**	**52.3**
Carbon Steel Sector (Mkt cap wgtd ave)	**24.7**	**24.8**	**21.5**	**18.2**	**19.0**	**16.5**	**34.2**	**36.7**	**28.1**

Source: UBS

**: Company report from full year*

Summary – background steel industry trends

- Strong steel growth phase continues led by China
- Industry highly successful, current steel prices maintained at historically high levels
- Industry profitability currently very strong
- Consolidation benefits
- Widening differentials between global and Chinese steel prices

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Future critical issues for the steel industry

1. Future structure of China's steel industry

2. Consolidation

3. Future blast furnace trends

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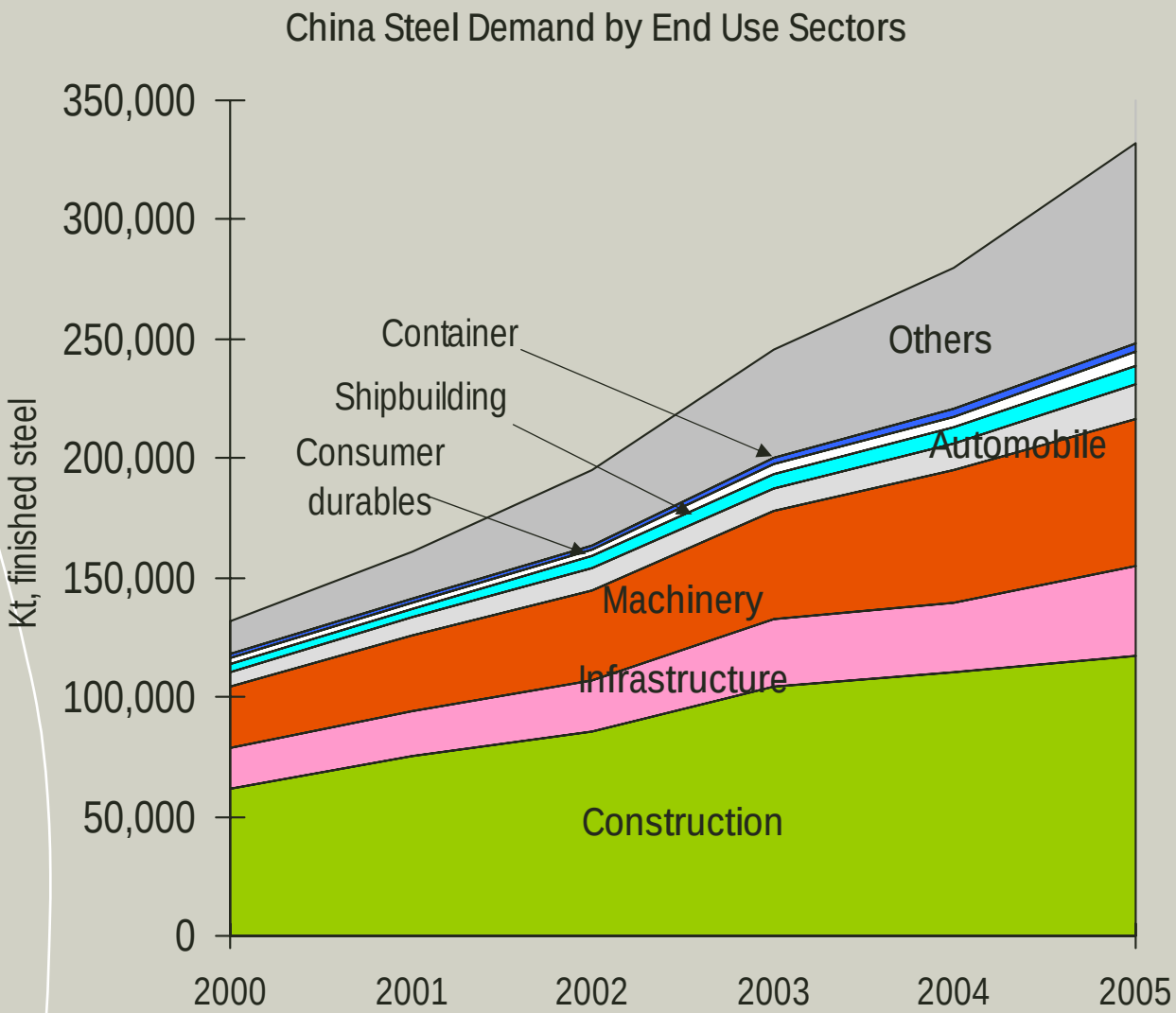
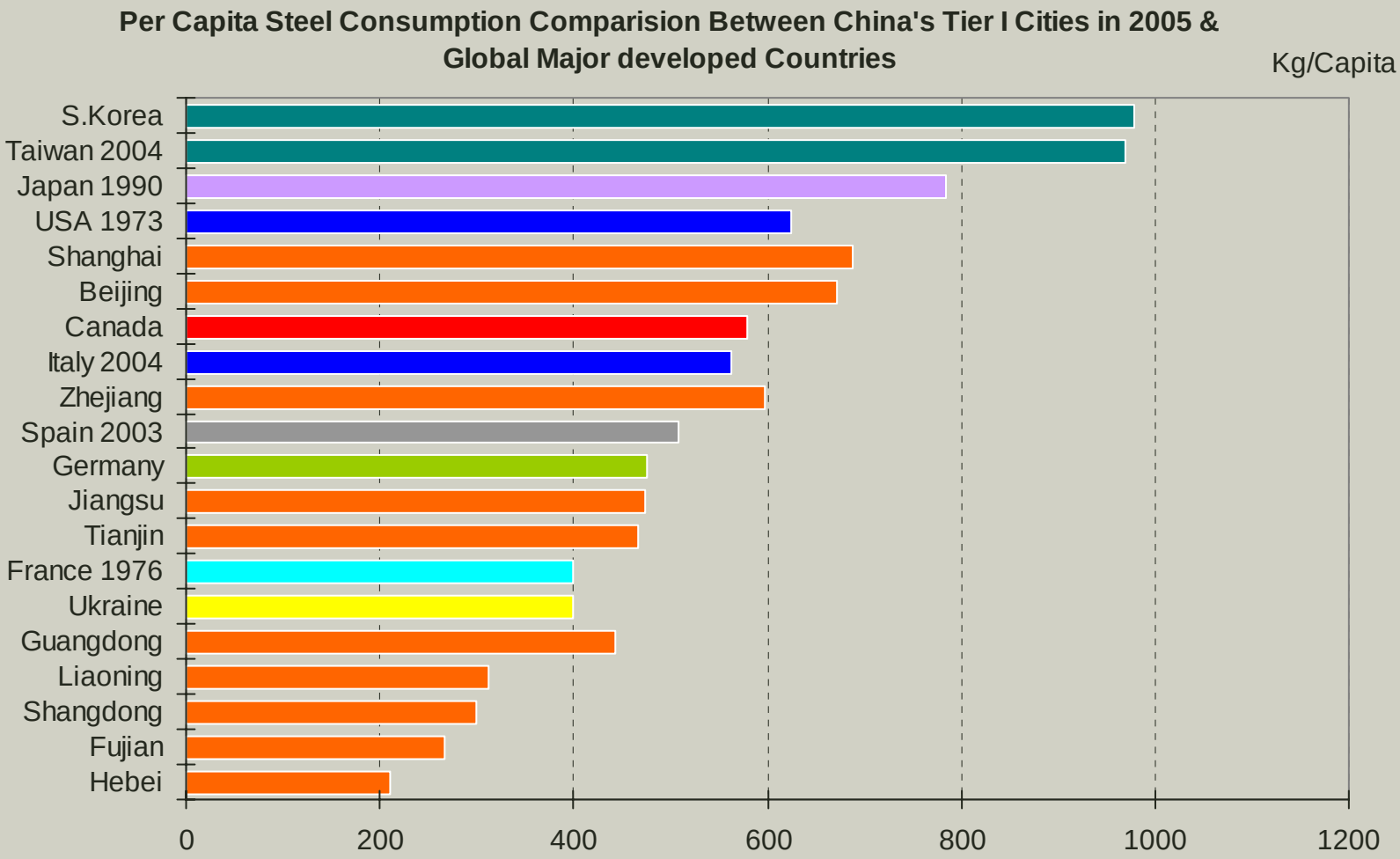
Demand driven by construction, infrastructure & machinery



	CAGR %
	00~05
Total	19
Others	40
Container	13
Shipping	21
Cons. Durables	16
Automobile	20
Machinery	19
Infrastructure	16
Construction	14
	2005
Total kg/capita	233

Source: CISA

China per capita steel consumption still below Asian standards



Source: China Metallurgical Planning and Research Institute, IISI, BHPBilliton

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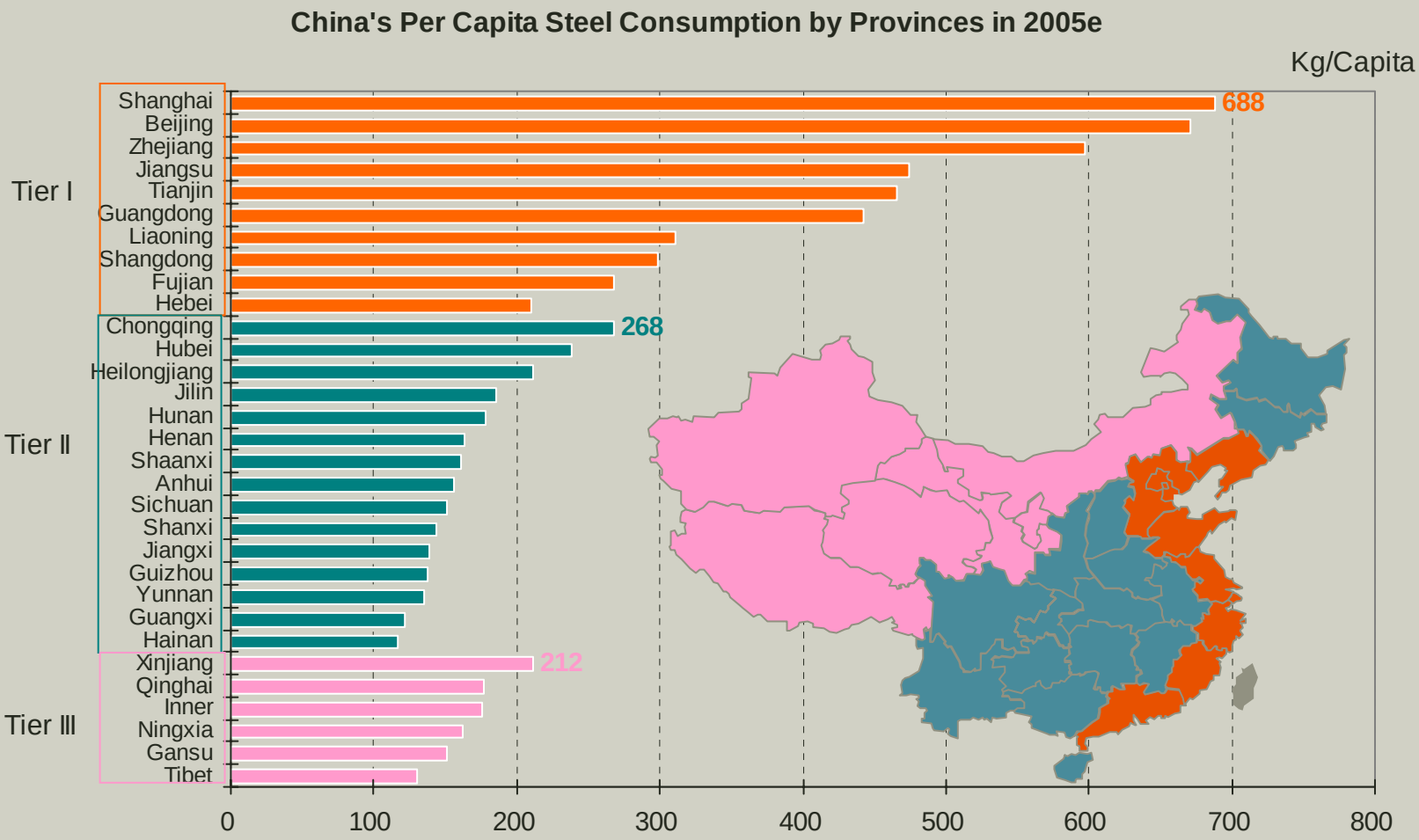
Coastal provinces are the key steel consumers in China



Source: China Metallurgical Industry Planning & Research Institute, BHPBilliton

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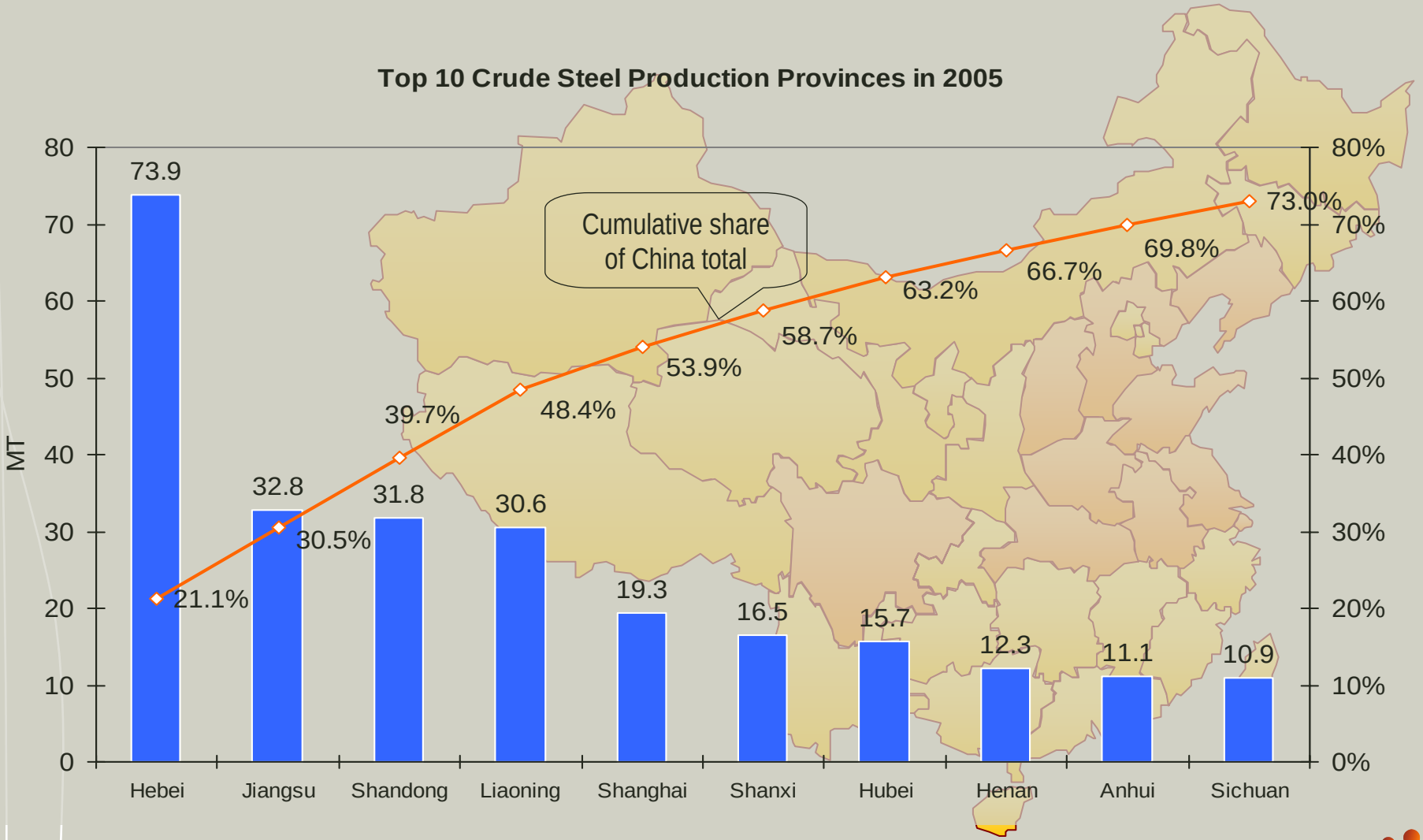
China steel industry is very fragmented



Source: CISA

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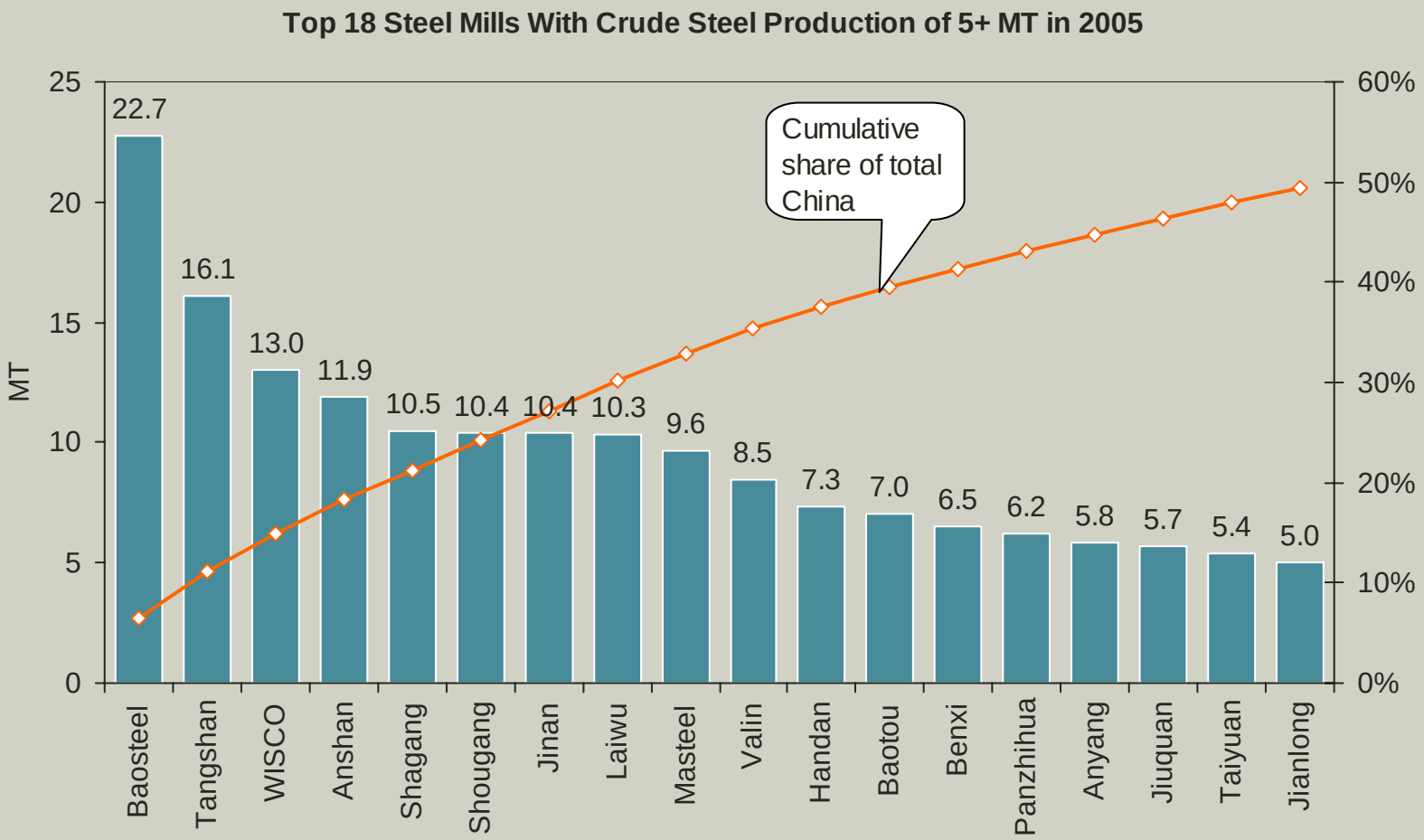
Top 10 steel mills only account for 35.4% of total in 2005



Source: CISA

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China's new steel policy 2005

- Objective
  - Competitiveness of China Iron & Steel Industry to be improved significantly
  - Top 10 steel mills should account for > 50% of total by 2010, and 70% by 2020
- Technology & equipment upgrade policy
  - Outdated processes, equipments and techniques; highly pollutant, raw material & energy consumption and low efficiency to be phased out
  - Pollutant discharge and efficiency standards raised
- Foreign investment policy
  - In general, foreign companies are not allowed to acquire a controlling stake in Chinese steel makers, especially medium and large ones
  - No greenfield project is allowed
  - Advanced technology with intellectual property is needed

Source: NDRC

Plans and Implications

- Industry structure optimization policy
  - Steel mills, especially big ones, are supported to grow through M&A
- Industry layout improvement policy
  - Steel mills encouraged to relocate or build greenfield plant in coastal or along Yangtze River areas to take advantage of markets and overseas raw materials
  - Inland steel mills should cap the capacity based on the available ores in line with the local markets and the mineral resources
  - Those steel mills locate in provincial capital and tourism cities are not allowed to expand capacity of iron-making & steel-making
- Raw materials policy
  - International cooperation with the overseas mineral resources should be enhanced

Source: NDRC

Consolidation targets

Source: CISA

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Target 100Mt pig iron closed…….but will take time

	Sintering	Iron-Making	Steel-Making
Phase Out	⩽ 30 M^2	BF ⩽ 300 M3	BOF ⩽ 20 Mt EAF ⩽ 20 Mt
Brownfield	⩾ 180 M^2	BF ⩾ 1000 M^3	B0F ⩾ 120 Mt EAF ⩾ 70 Mt
Deep Port Greenfield	⩾ 180 M^2	BF ⩾ 3000 M^3	B0F ⩾ 200 Mt Crude steel Capacity ⩾ 8 Mt Mln

Source: NDRC

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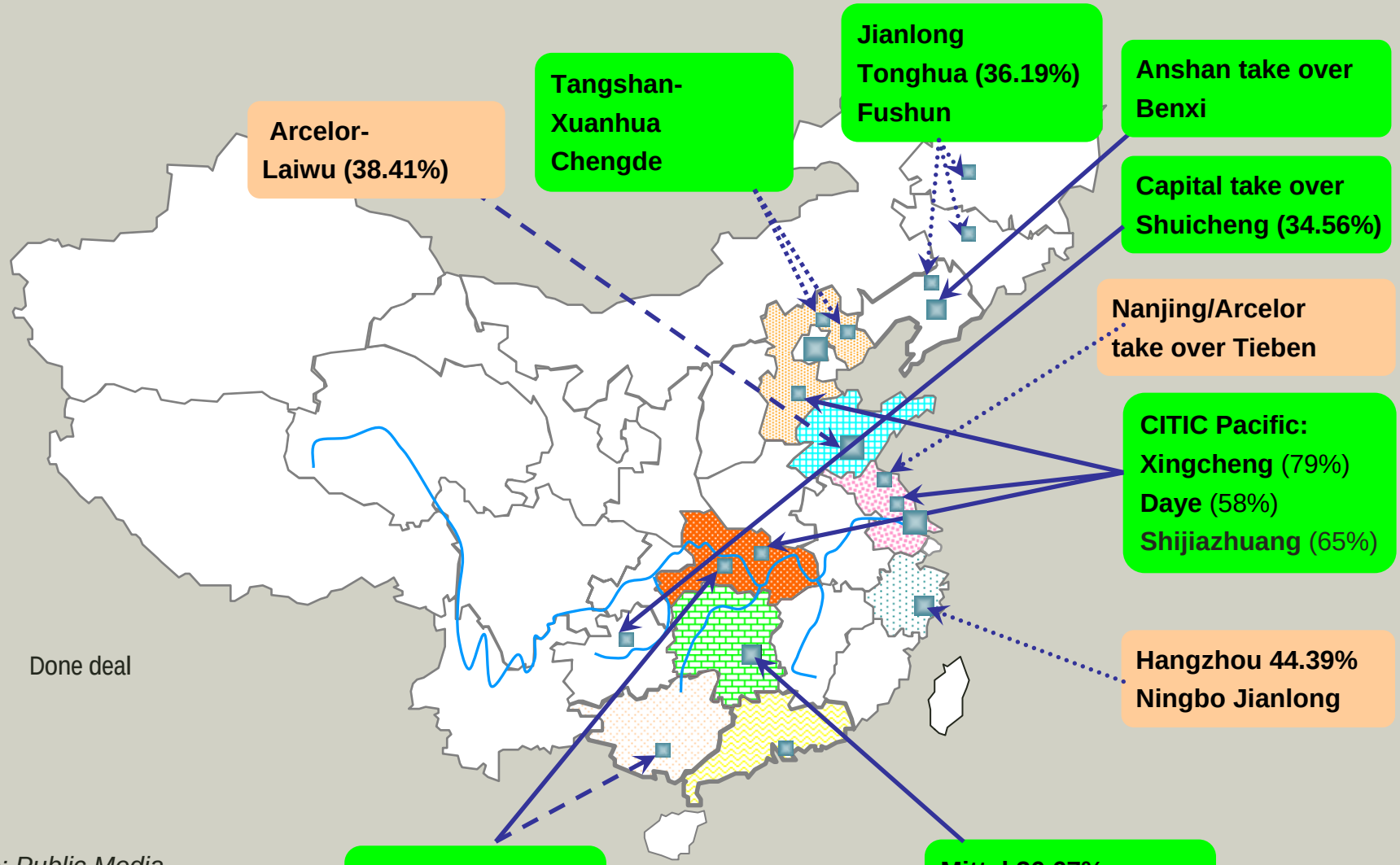
Consolidation increased in 2005 more underway



Source: Public Media

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Implications of future structure of Chinese steel industry

- Consolidated more profitable industry
- Larger capacity, more efficient BF production
- Rising higher quality flat product production

Overall implications likely to see rising demand for higher quality coke made with increasing quantities of higher quality hard coking coals

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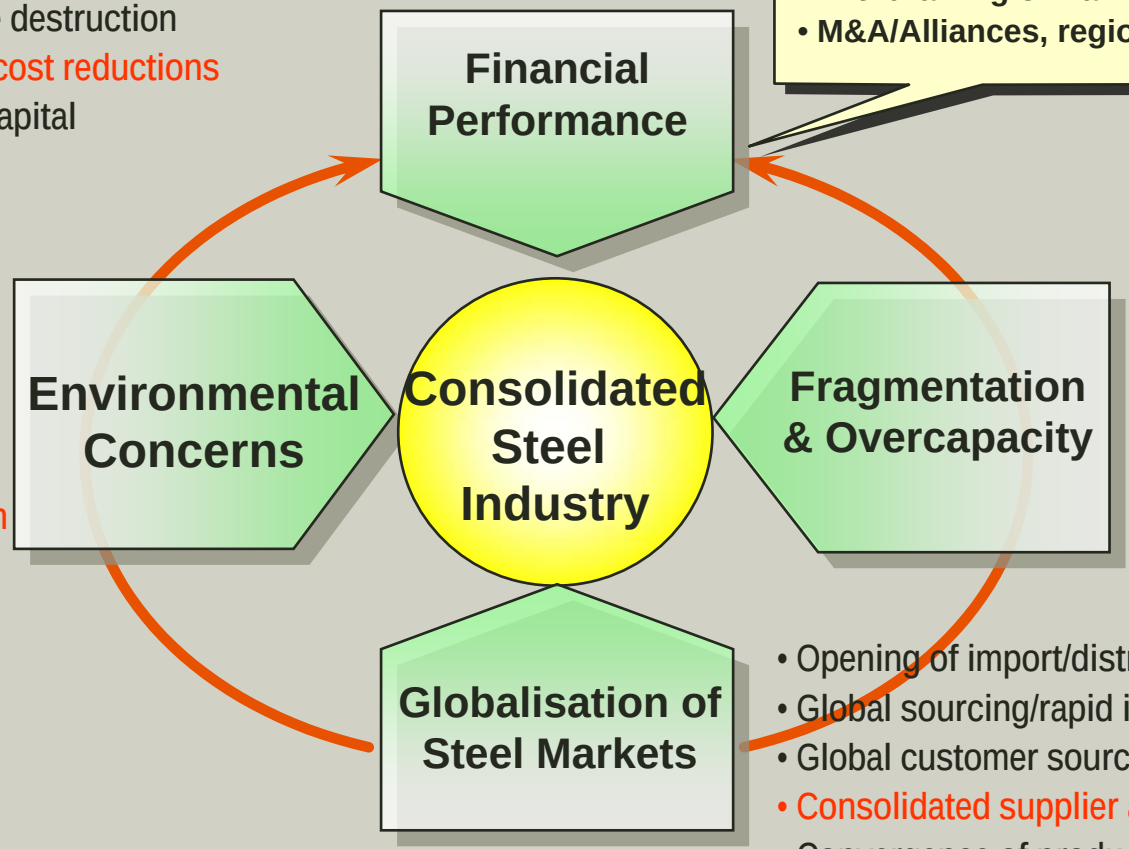
Consolidation will improve market conditions and profitability

- Ending "Social/national" business
- Government support/interference
- Shareholder value destruction
- Inability to retain cost reductions
- Inability to raise capital

- **Worldwide move to privatisation**
- **Shareholder demand for value creation**
- **Capital & opex constraints**
- **Withdrawing of Bank supports**
- **M&A/Alliances, regional consolidation**



- SOx, NOx, Dioxins
- CO_2
- Effluent discharge
- Hazardous chemicals
- Waste management
- Poor public perception

- Emerging regions building own capacity
- Technology diffusion
- Capacity creep
- Low entry/high exit barriers
- Economies of scale

- Opening of import/distribution channels
- Global sourcing/rapid information flow
- Global customer sourcing and specifications
- Consolidated supplier and customers
- Convergence of product standards
- Increased JV's

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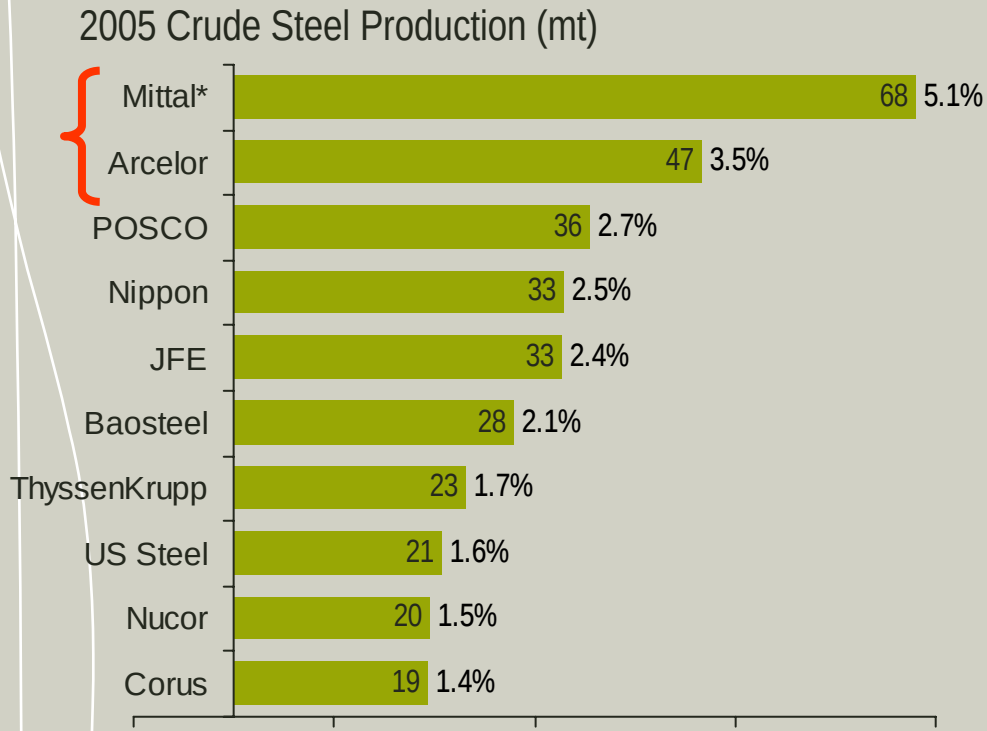
The steel industry remains fragmented, despite M&A activity

Market share (% global steel output)	2000	Current
Top 5	16%	19%
Top 10	23%	28%



Source: IISI, Metal Bulletin, BHP Billiton

* Mittal data includes ISG (16.1mt) and Kryvorozhstal (7.7 mt)

Consolidation:

- has increased slightly (+3 and +5 percentage points for the top 5 and 10 steel producers respectively from 2000 to 2005)
- favoured by strong cash flows and increasing desire to escape sluggish and expensive home markets (Europe, US)
- 'hot spots' in the US, E. Europe, CIS and China
- currently appears to be enabling improved production control - aligning demand with supply

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Further consolidation directions:

Regional consolidation:

- **China**, with government support but low foreign involvement (ownership limited to minority stakes)
- **CIS**: further consolidation, especially as focus shifts from raw material acquisitions
- Smaller **acquisitions between second tier producers** in Europe and North America

Global / Cross-regional consolidation:

- **Mergers between groups** (competition issues?): catalyst for rapid consolidation
- **Russian mills going global**
- Acquisitions in **Latin America**, **Middle East**, **Ukraine** (partly driven by captive raw materials)

Product consolidation:

- **Focus on flat products**
- Limited in long products: Ample opportunity but disincentives

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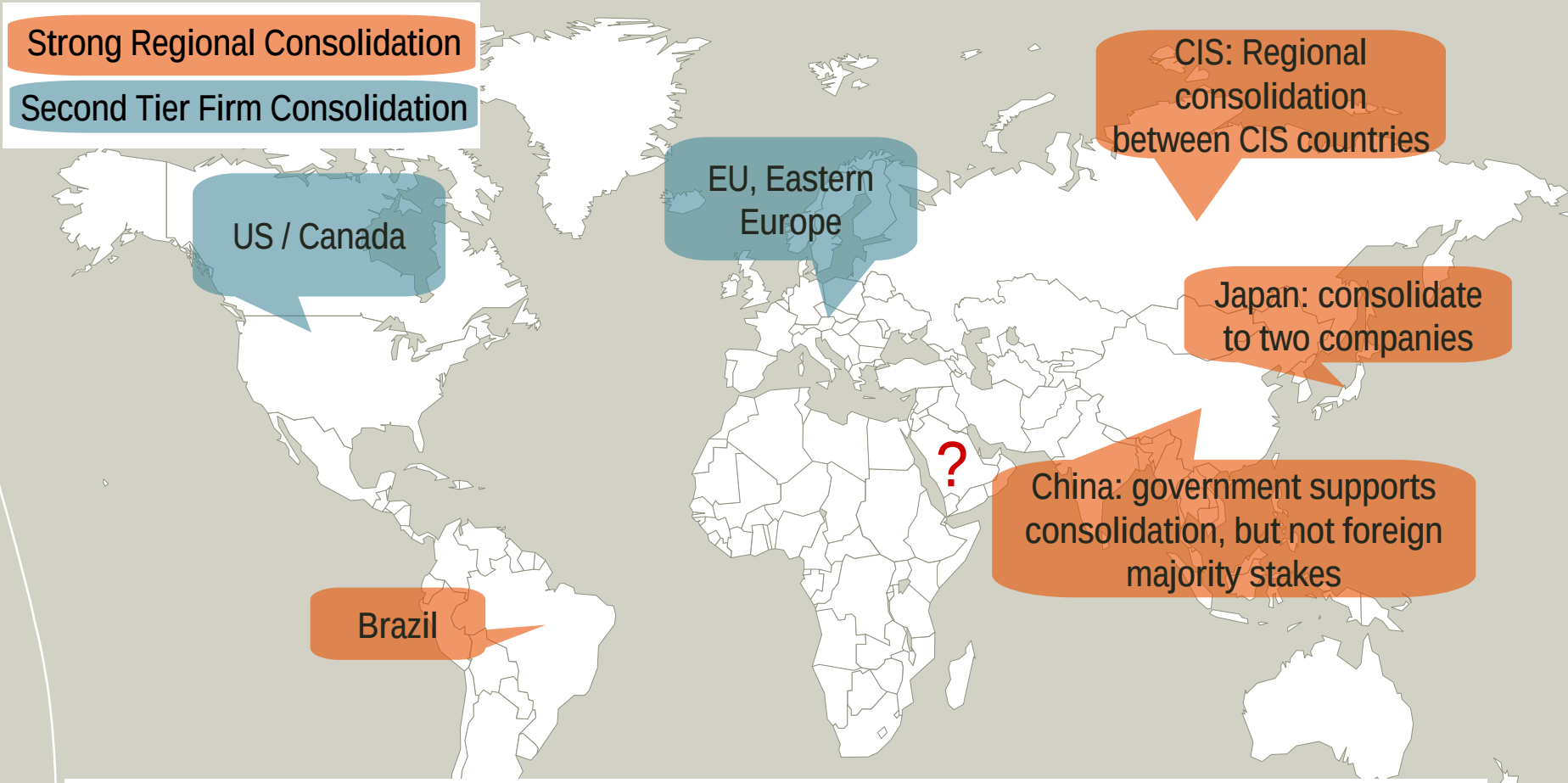
Regional consolidation: CIS, China and Brazil; Europe and N. America

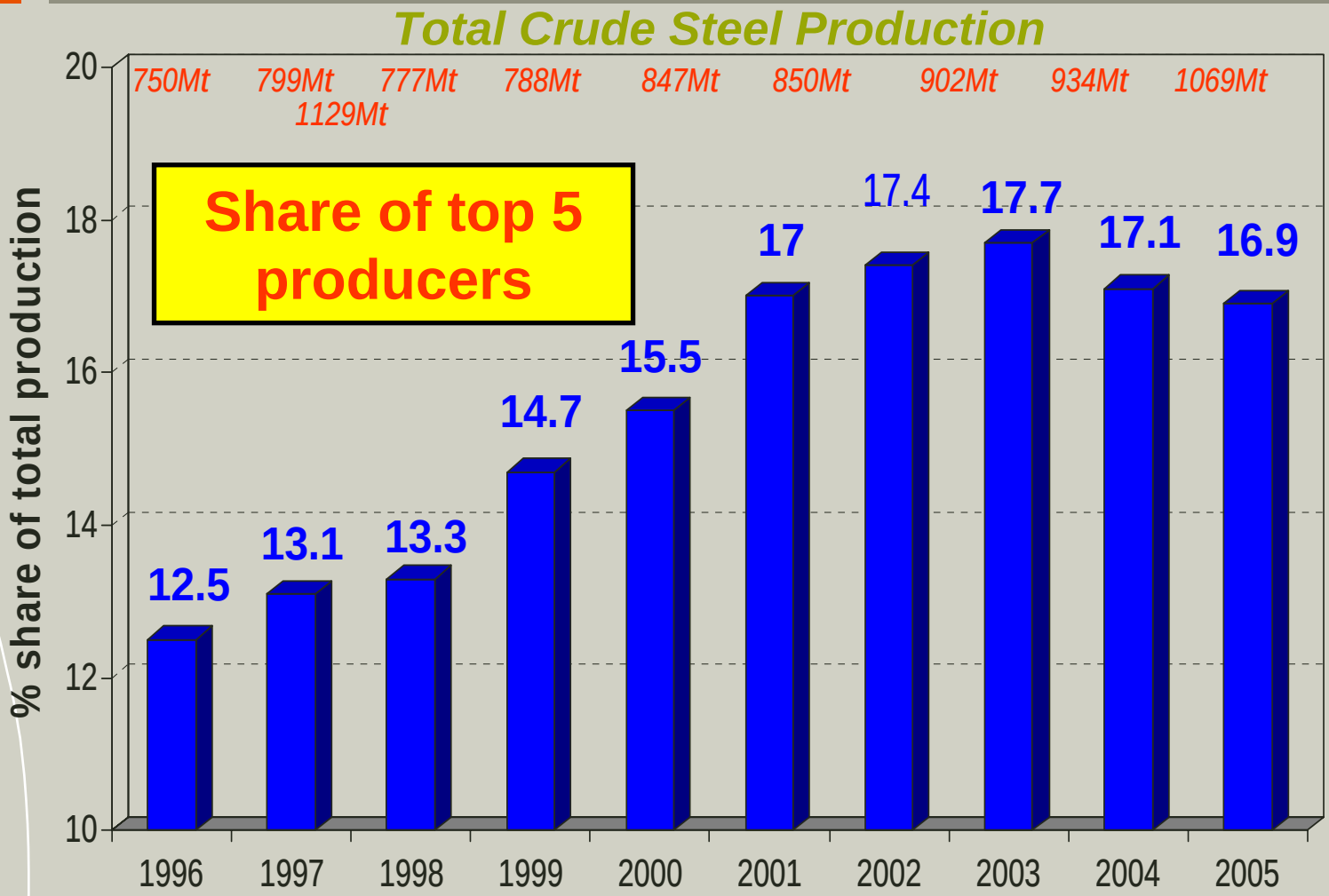


Regional consolidation: likely to result in more benefits than global consolidation:

- Operations are strongly linked (both customer and supply side) to regional markets
- Most products sourced regionally with some global support, even though ~20% of steel production is aimed at global customers

Source: Company reports and news coverage; World Steel Dynamics

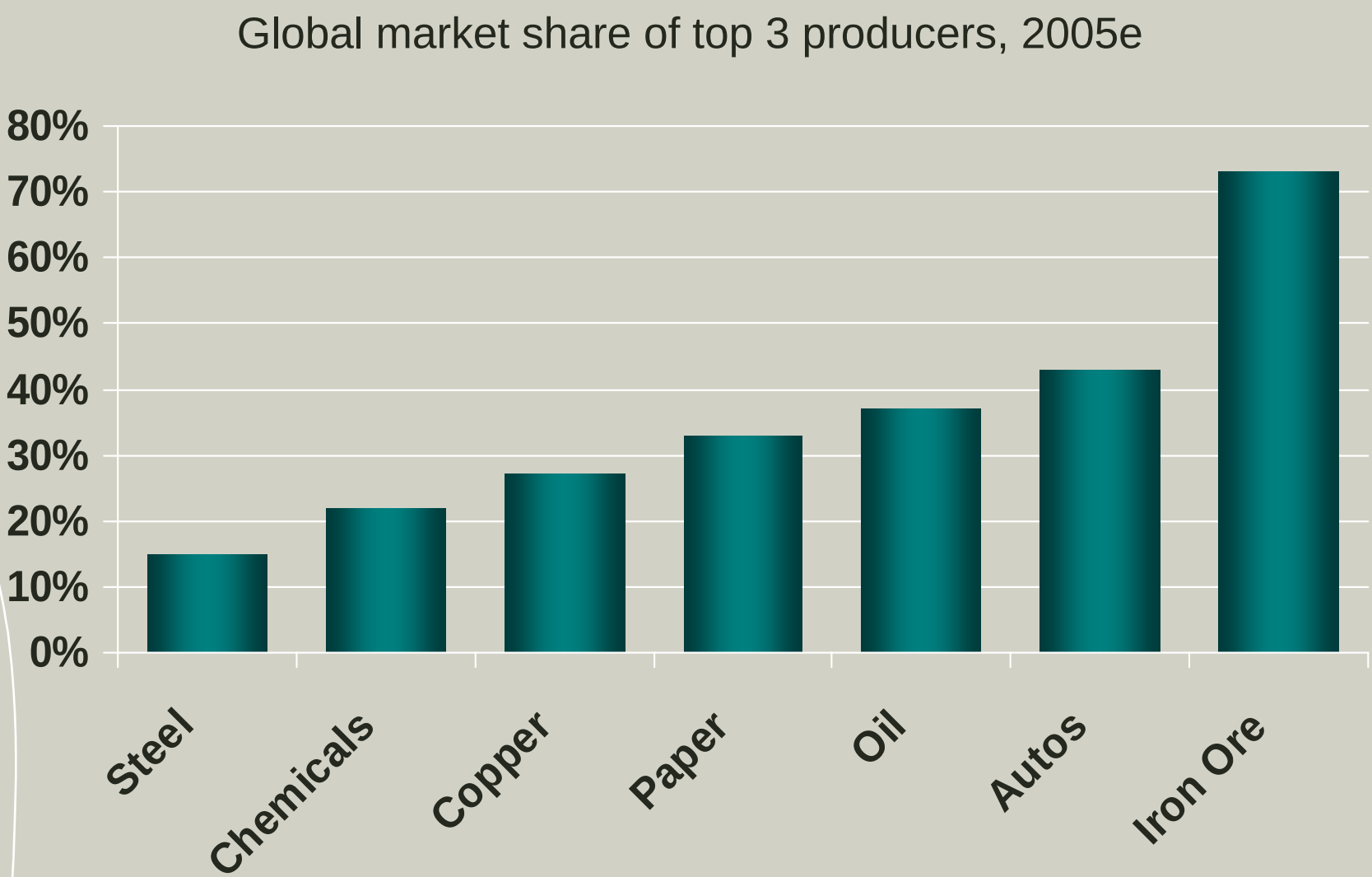
Fragmented industry now consolidating – regional impact



Source: IISI, Metal Bulletin, BHPBilliton

Note growth in Chinese steel has countered global consolidation impacts – although regional consolidation has occurred

Even after recent mergers, industry concentration is low



Source: CRU Analysis, Deutsche Bank

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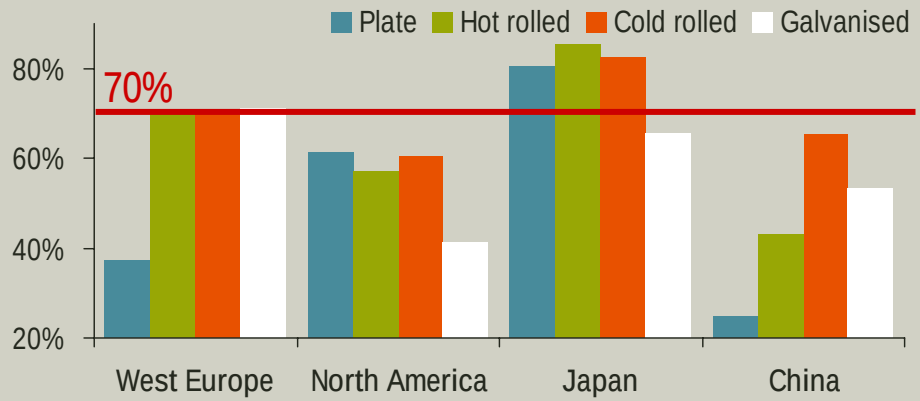
Flat products is relatively consolidated, unlike long products

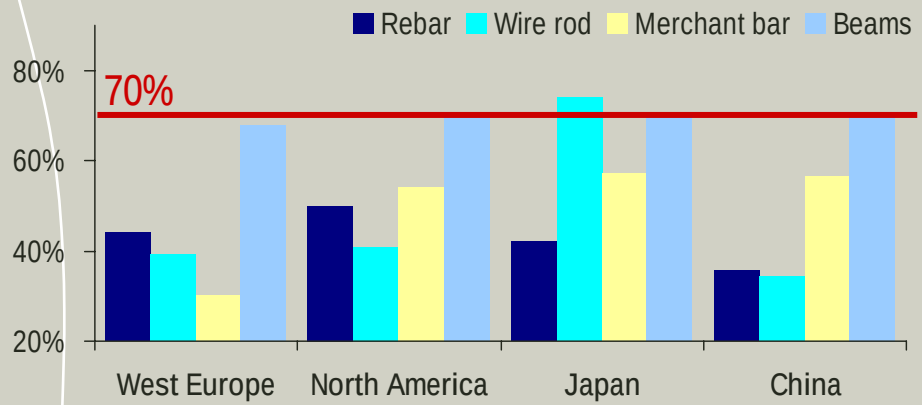
Regional Market Share of Top 3 Producers:

Flat Products



- High regional consolidation in W. Europe, USA, Japan
- Scope for consolidation in:
  - China: flat product consolidation has fallen
  - North America (limited scope)
  - Western European plate capacity

Long Products



- Significant consolidation is unlikely: the rationale is less compelling:
  - local markets,
  - low barriers to entry
  - low economies of scale
- Consolidation isolated:
  - Beams and structural products
  - Gerdau, CELSA, Nucor and Mittal

Source: CRU

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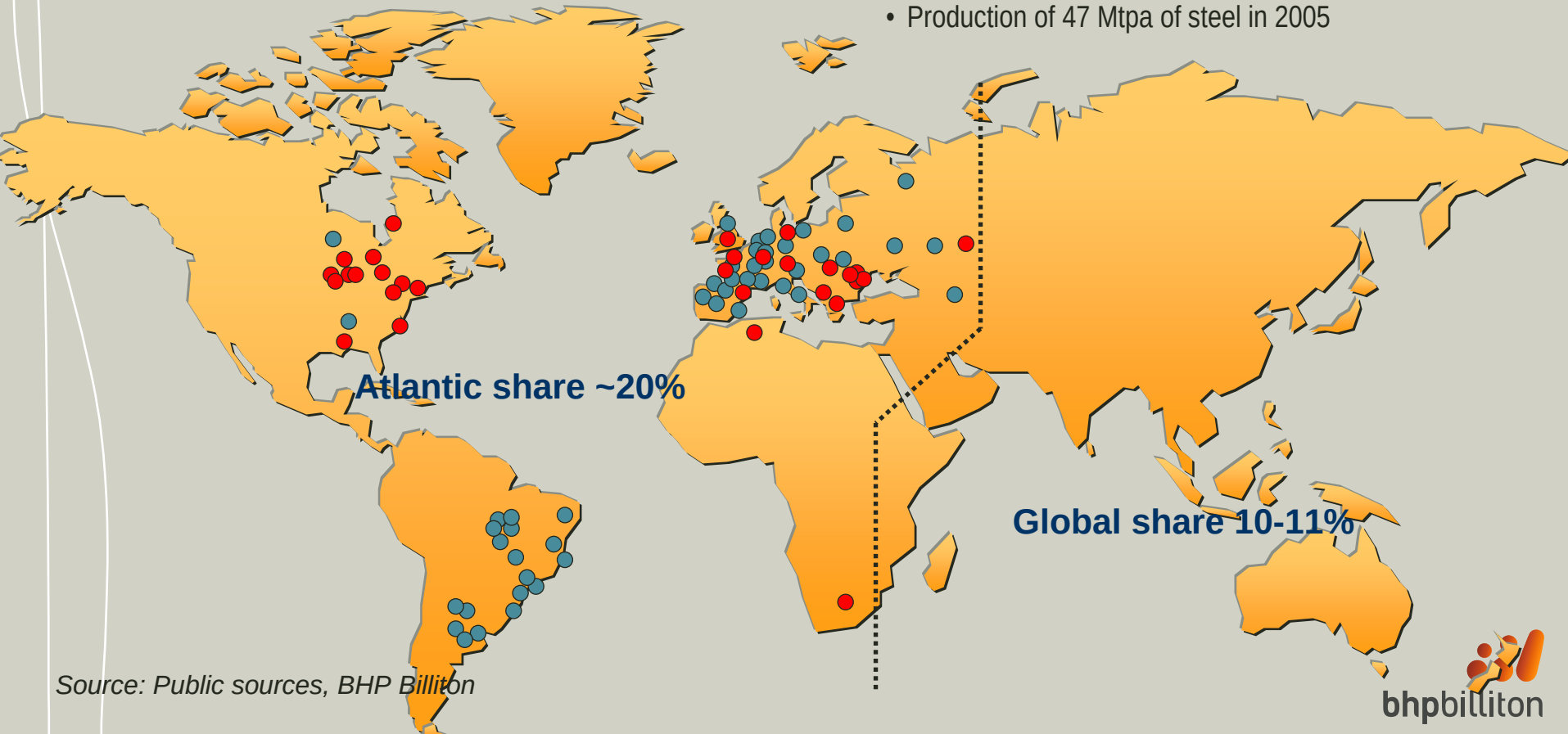
Arcelor & Mittal Steel Plant Locations

Mittal Steel Plants

- Major player in NAFTA market, Eastern Europe, Africa and Kazakhstan
- Limited in Western Europe in production and distribution, no presence in South America
- Annual production capacity of Steel of 70 Mtpa

Arcelor Plants

- Major player in Western Europe, South America
- Minor operations in North America, Eastern Europe, Asia
- Arcelor has decided to turn their external growth efforts to countries such as Brazil, Russia, India, China, Eastern Europe and Turkey.
- Production of 47 Mtpa of steel in 2005



Source: Public sources, BHP Billiton

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Mittal is vertically integrated using high levels of domestic coal

	IRON ORE		COKING COAL	
	MITTAL	ARCELOR	MITTAL	ARCELOR
Brazil (Fines)	20%	54%		
Brazil (Pellets)		10%		
Australia		6%	10%	49%
CIS	9%		13%	
Canadian	13%			12%
Mauritania		11%		
Sweden		5%		
Own/ Dom Mines / Strategic LT Contr	54%	3%	76%	
USA				24%
South Africa				6%
Poland				5%
Others	4%	10%	1%	4%

Source: Mittal, Public sources, BHP Billiton

About 50% of iron ore and 70% of coking coal consumed by Mittal are supplied by own resources or sources outside the "seaborne" markets generally lower quality than seaborne supplied materials

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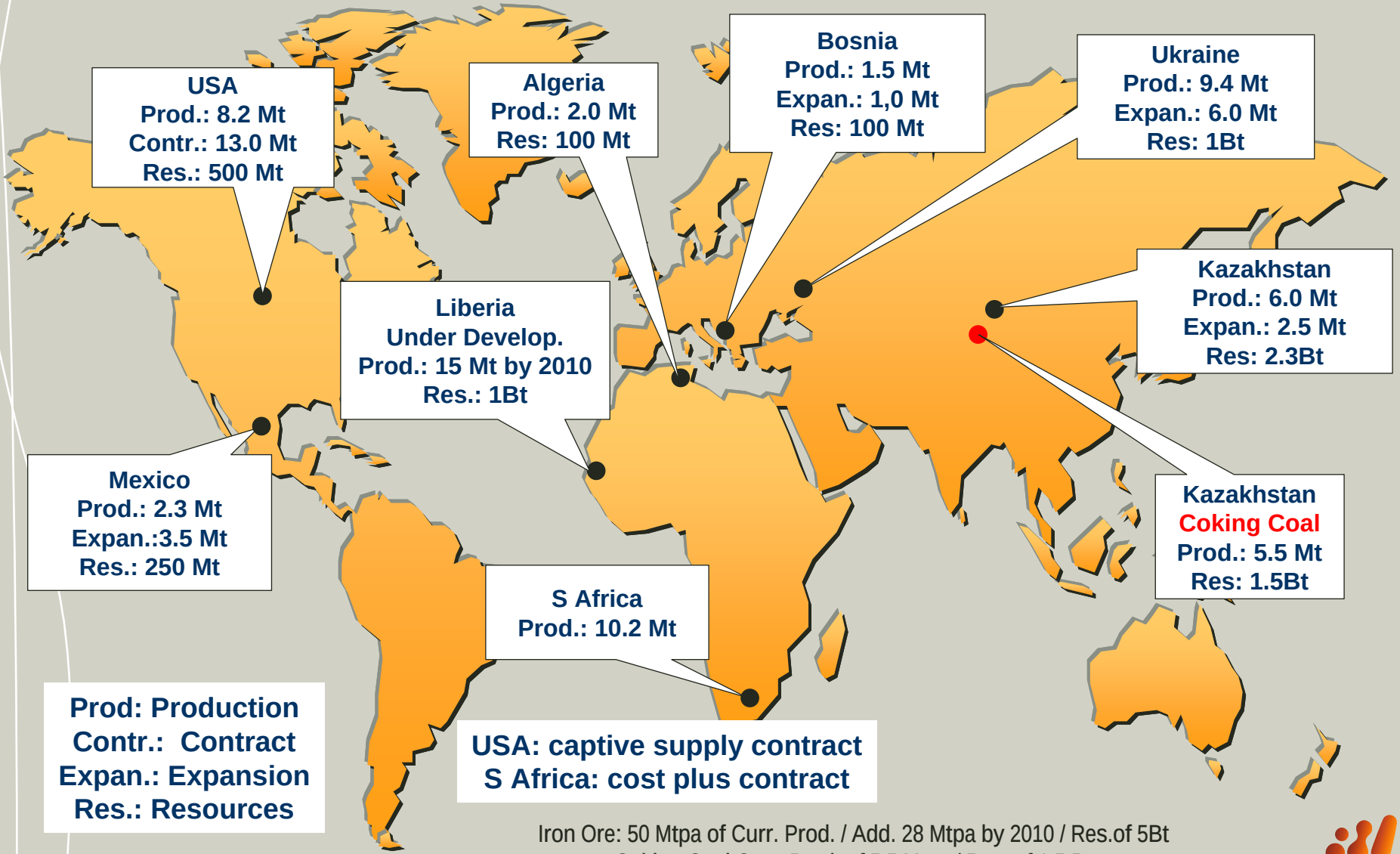
Mittal Mining Operations:



Iron Ore: 50 Mtpa of Curr. Prod. / Add. 28 Mtpa by 2010 / Res.of 5Bt
Coking Coal Curr. Prod. of 5.5 Mtpa / Res. of 1.5 Bt

Source: Mittal

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Summary steel consolidation - implications

- Steel industry will continue to consolidate
- Moving from regional to global industry players
- Flat product will continue to lead consolidation

Overall implications likely to see more profitable steel industry operating more efficiently requiring high quality coke likely to be made with increasing quantities of higher quality hard coking coals

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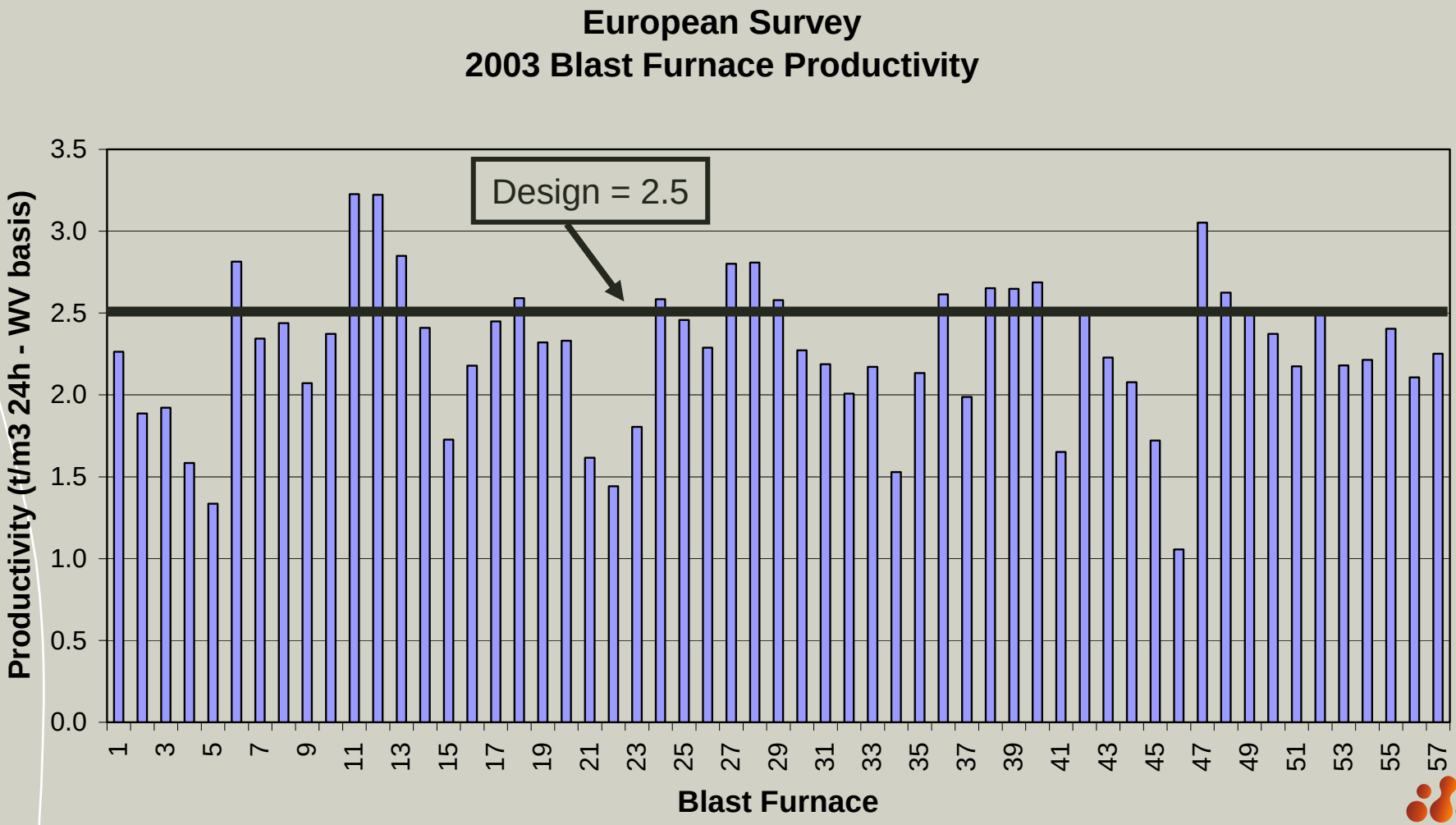
Blast furnace – trends in operating philosophy/practice

Most modern EU-15 Blast Furnaces operate at less than design productivity of 2.5 t/d/m3, further improvements will be made



Source: European BF committee, Hatch

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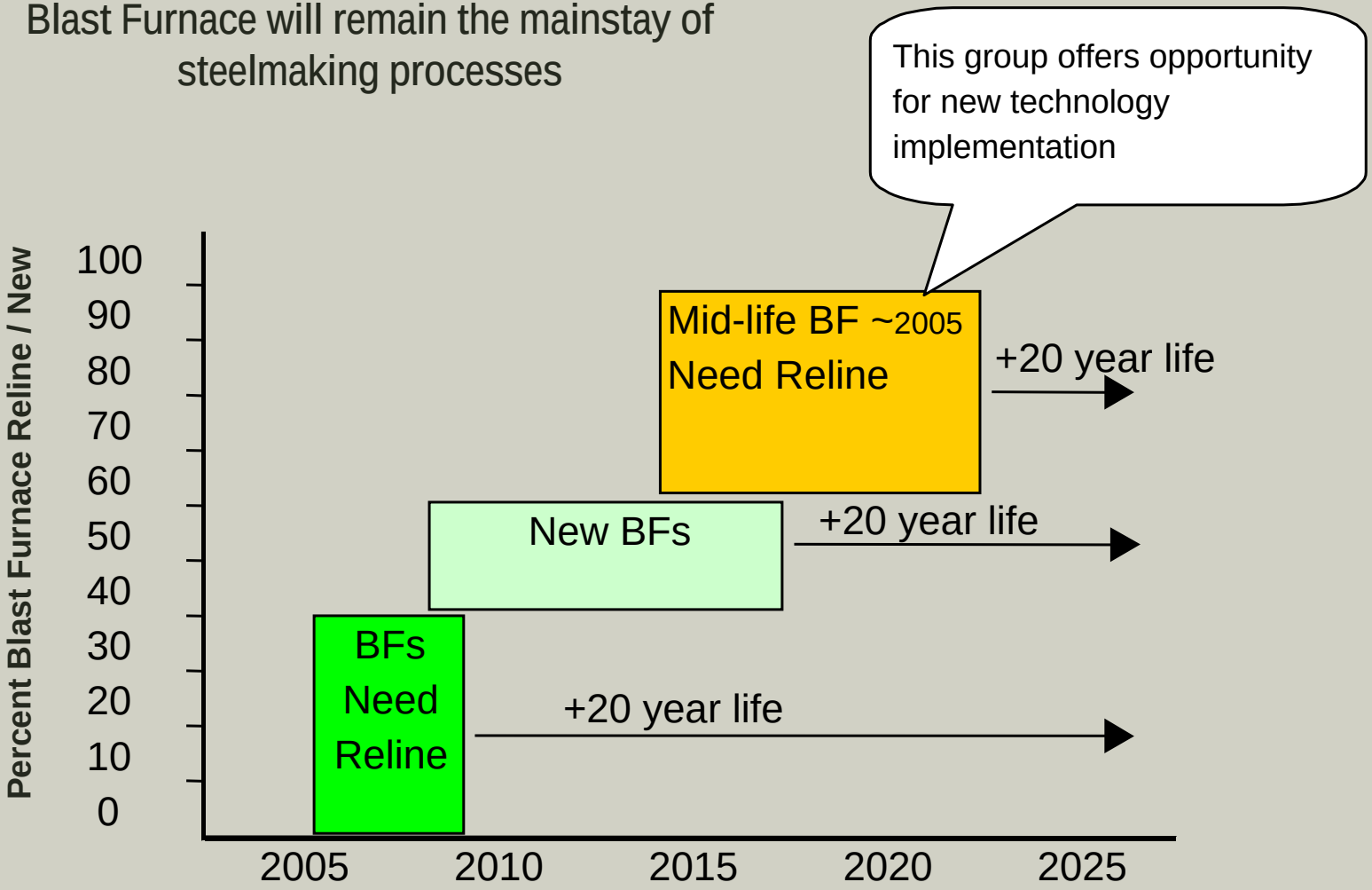
BF technology changes will be delayed to well after 2013.

Blast Furnace will remain the mainstay of steelmaking processes



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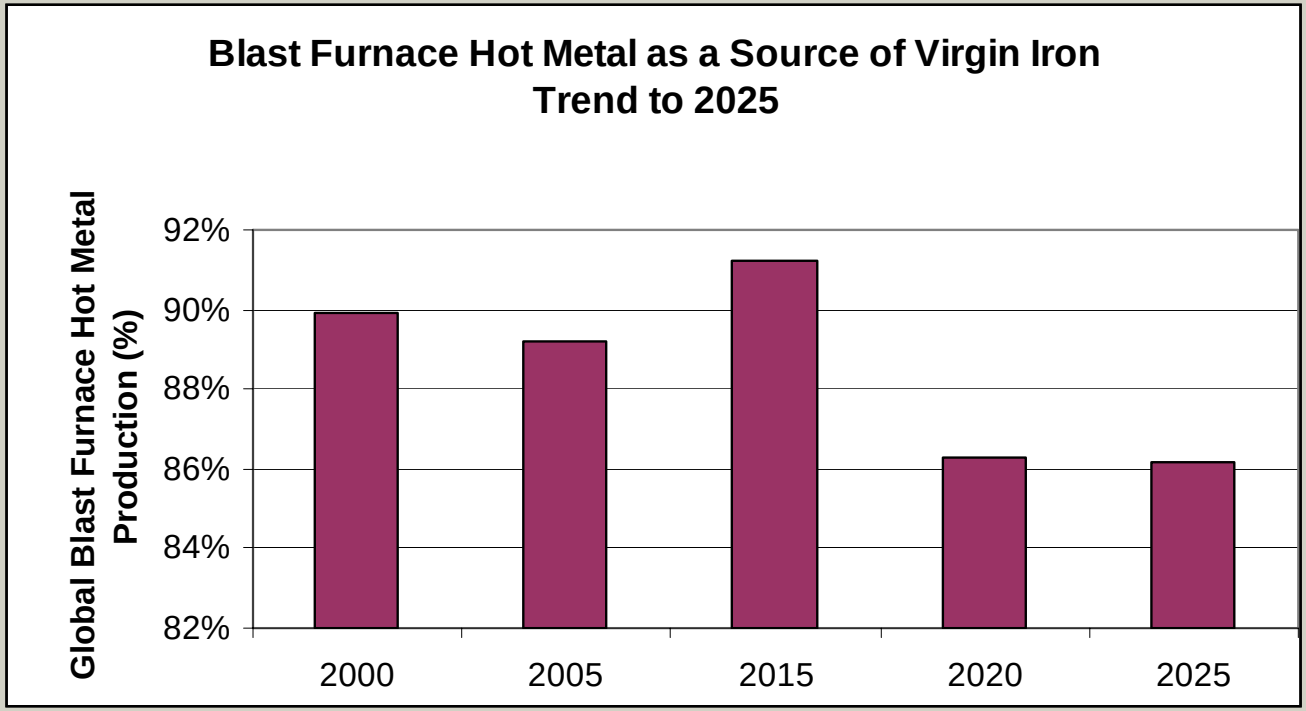
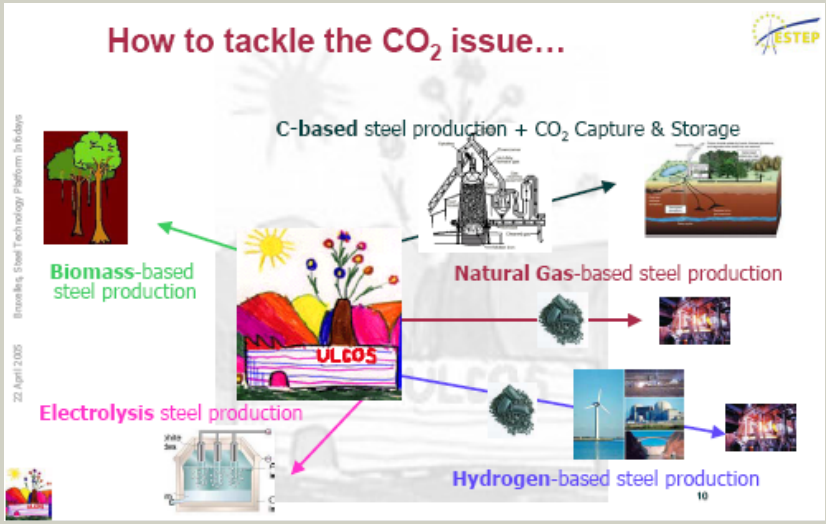
The BF's domination of virgin iron unit production will remain



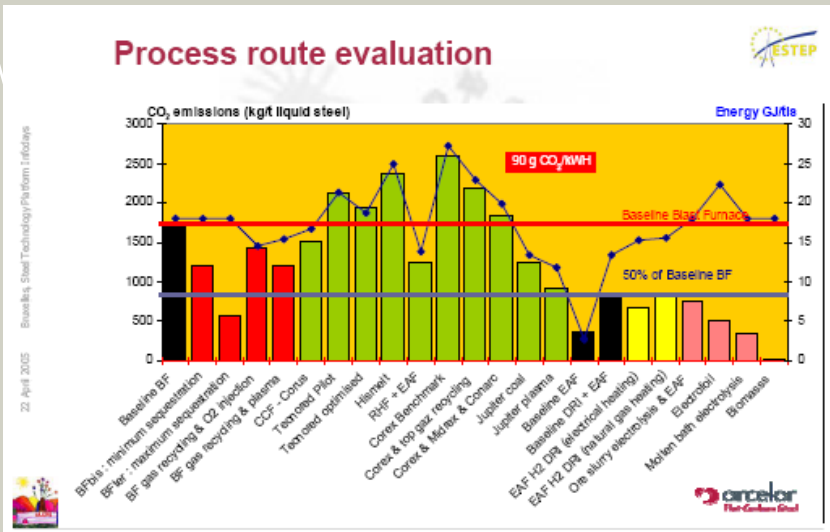
	Yr 2000	Yr 2015	Yr 2025
Virgin Iron Units (Mt)	450	870	1300
Blast Furnace (Mt)	400	800	1120
Other (MT)	50	70	180

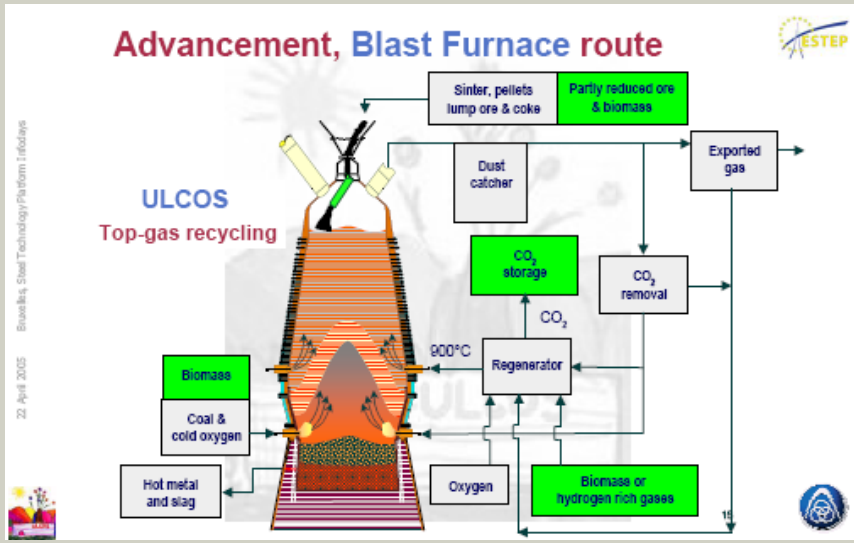
Source: Hatch

ULCOS (Ultra Low CO_2 Steelmaking) program likely impact after 2025



- Step 1 (2005–10) exploring wide range of steelmaking concepts
- Including future BF concepts
  - O_2 blast
  - Biomass/plastics injection
  - Top gas recycling with CO_2 removal
  - CO_2 sequestration





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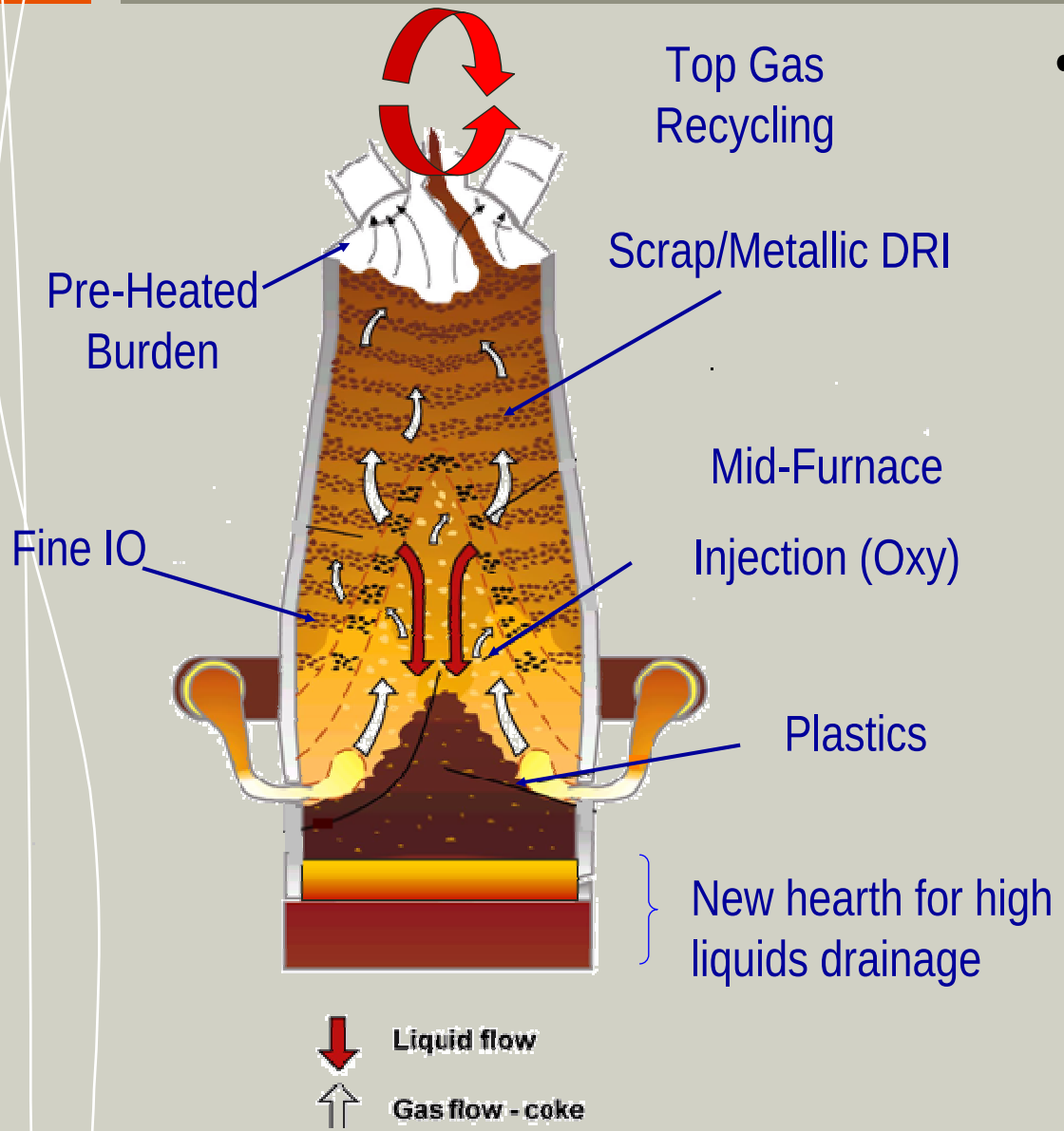
Blast Furnace - future evolution



- Outlook for the BF
  - Decline in no = higher productivity
  - Expanded campaign life >20 years
  - Shorter down periods
  - Higher PCI, O_2, lower fuel rates
  - More stable operations
  - Enhanced computer models and control, value-in-use
  - Enlargement during relines
  - New hearth designs

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Summary future BF trends and implications

- BF will remain the main source of iron for steelmaking
- Longer lived, high productivity & efficiency future for the BF
- Size will increase as MBF's move to larger >3000m^3

Overall implications likely to see more productive, efficient BF operations requiring high quality coke likely to be made with increasing quantities of higher quality hard coking coals

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What happens if you use poor quality……

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Blast Furnaces must be looked after!

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Overall implications for coke in the new world

- Current trends:-
  - China's future, growth and structure
  - Industry consolidation
  - Future BF trends

- All lead to the conclusion that
  - Coke will remain vitally important to steelmaking
  - Coke quality trends are likely to be for higher quality
  - Coke ovens are a valuable asset
  - Implications are for continue requirements for HQHCC

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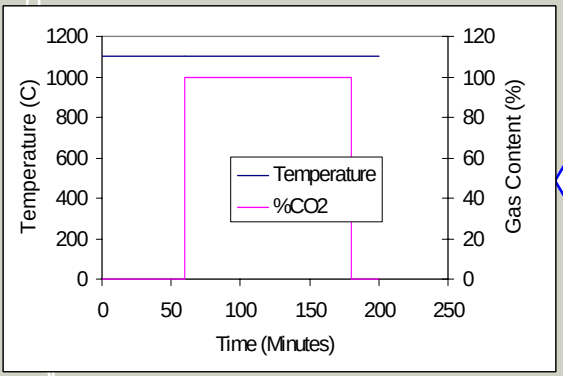
Understanding coke reactions and performance

- Are traditional methods for assessing coke still relevant
- BF operations have changed and will continue
- Coke characterisation tests developed 20 years ago!!
  - Cold strength — probably OK
  - Hot strength(CSR) — generally useful
- New techniques/evaluations for the new world????
- Role of coking coals in making coke

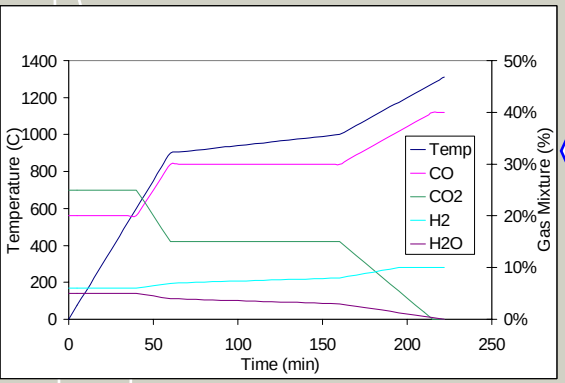
Simulating coke conditions in the blast furnace

Does CSR adequately account for high temperature coke properties?



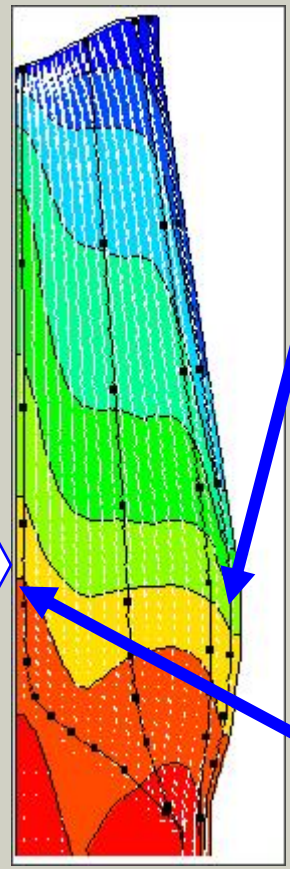
CSR represents one reaction, under one set of conditions

CSR/CRI

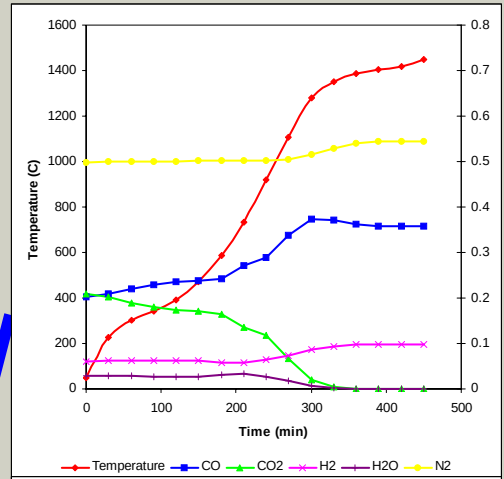


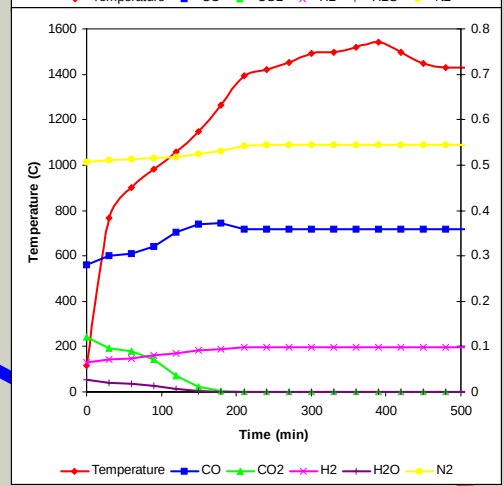
European BF

Conditions vary through (gas, temp) but are also different in various parts of a blast furnace.



Australia BF conditions





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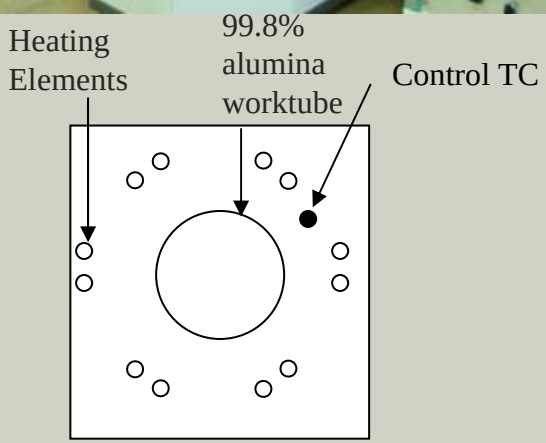
High temperature coke reaction furnace (HTCRF)



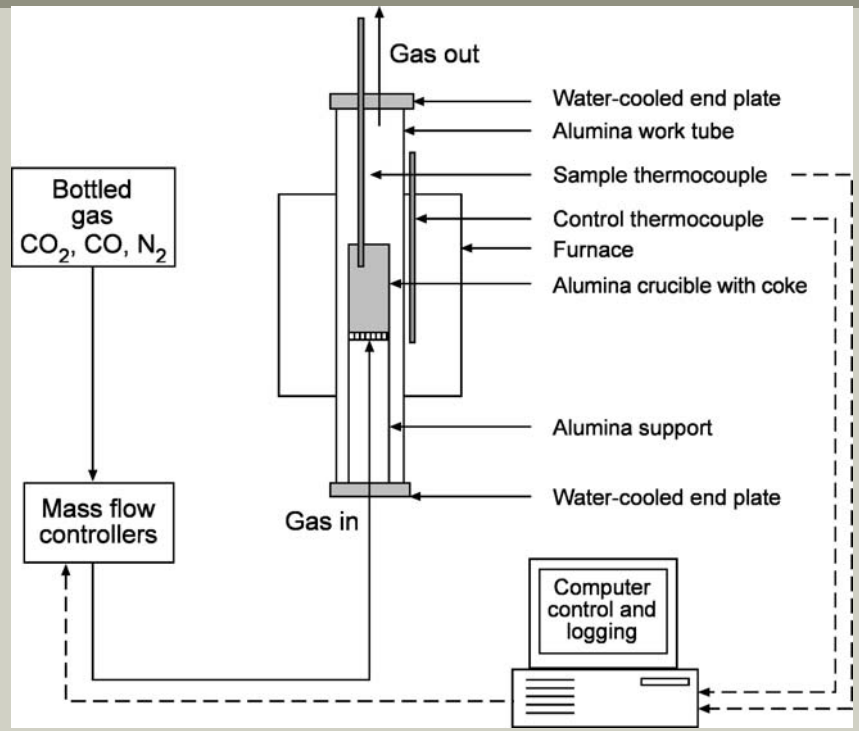


Figure 2. High Temperature Coke Reaction Furnace (HTCRF)

1. Up to 200g coke
2. 1600°C Sample temperatures
3. N_2, CO_2, CO, H_2 controlled atmospheres
4. Programmable gas-temperature regimes

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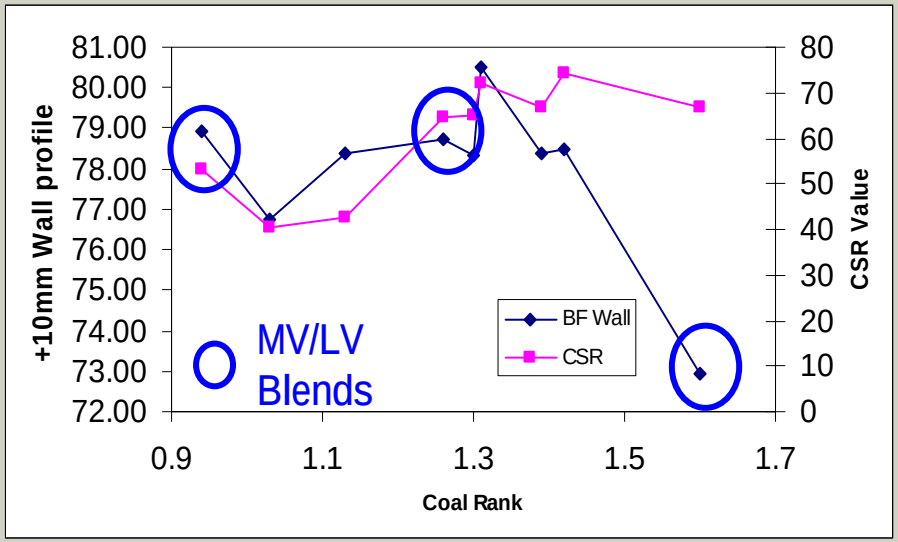
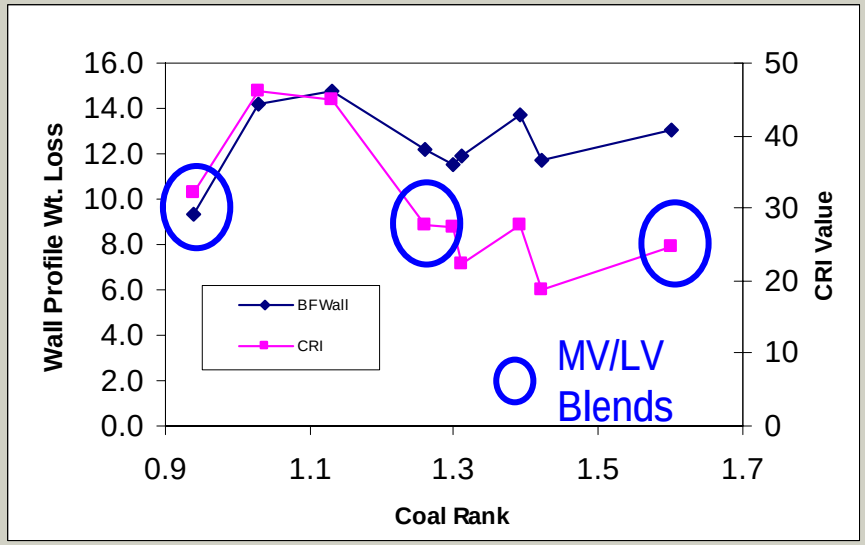
More realistic BF Conditions vs CSR and CRI





Key Findings

1. CRI/CSR indices similar, but there is less differentiation between cokes under the blast furnace profile. CSR and CRI overestimate the differences in cokes
2. Strength indices show different behaviour between CSR and BF profile. The drop at high rank is likely due to thermal damage (as shown in nitrogen data)
3. High rank coals increase fines when 100% of battery feed, but do not appear generate increased fines when present in blends.

Source: BHP Billiton

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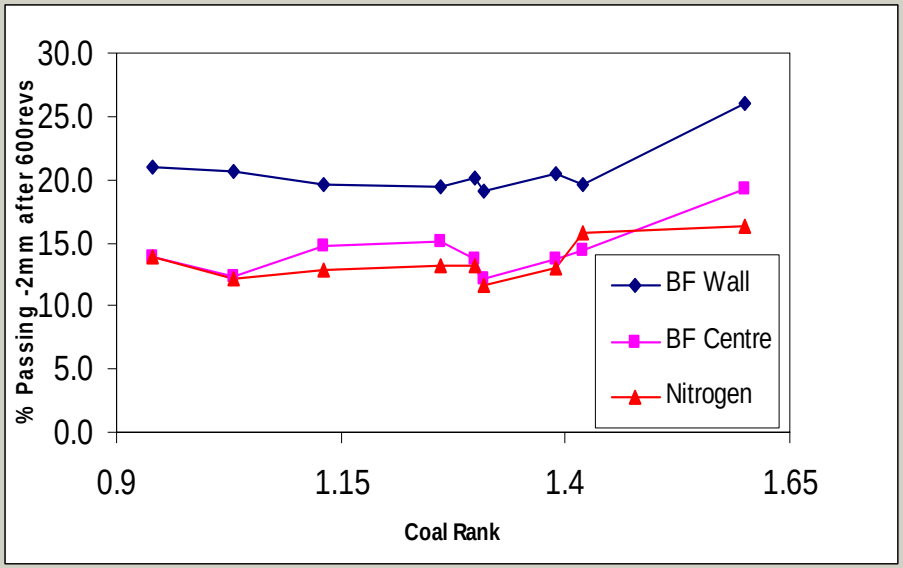
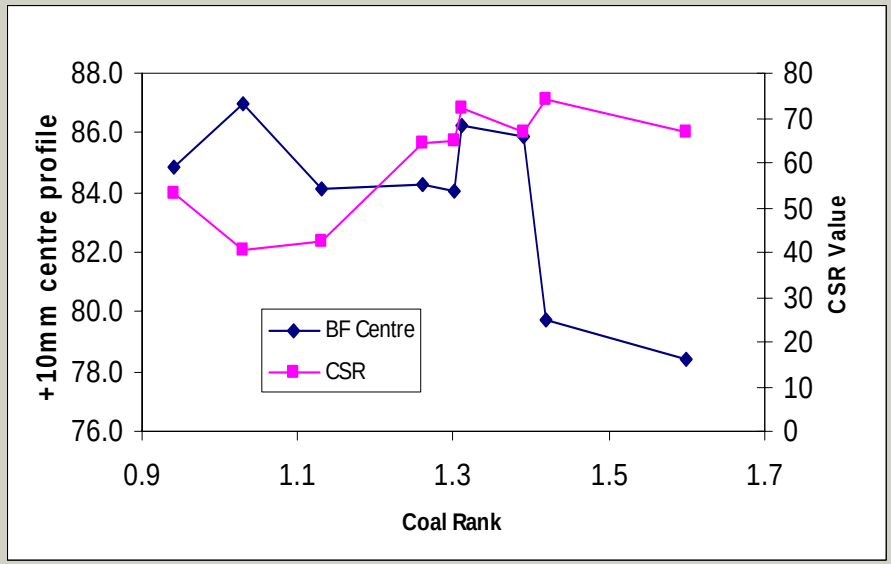
Different parts of the blast furnace





Key Findings

1. Coke behaviour depends on where you are in the BF.
2. At the centre, thermal effects predominate.
3. At the walls (and most likely the mid radial locations, chemical attack via CO_2 becomes much more significant).
4. Similar, non-additive behaviour MV/LV blend.

Source: BHP Billiton

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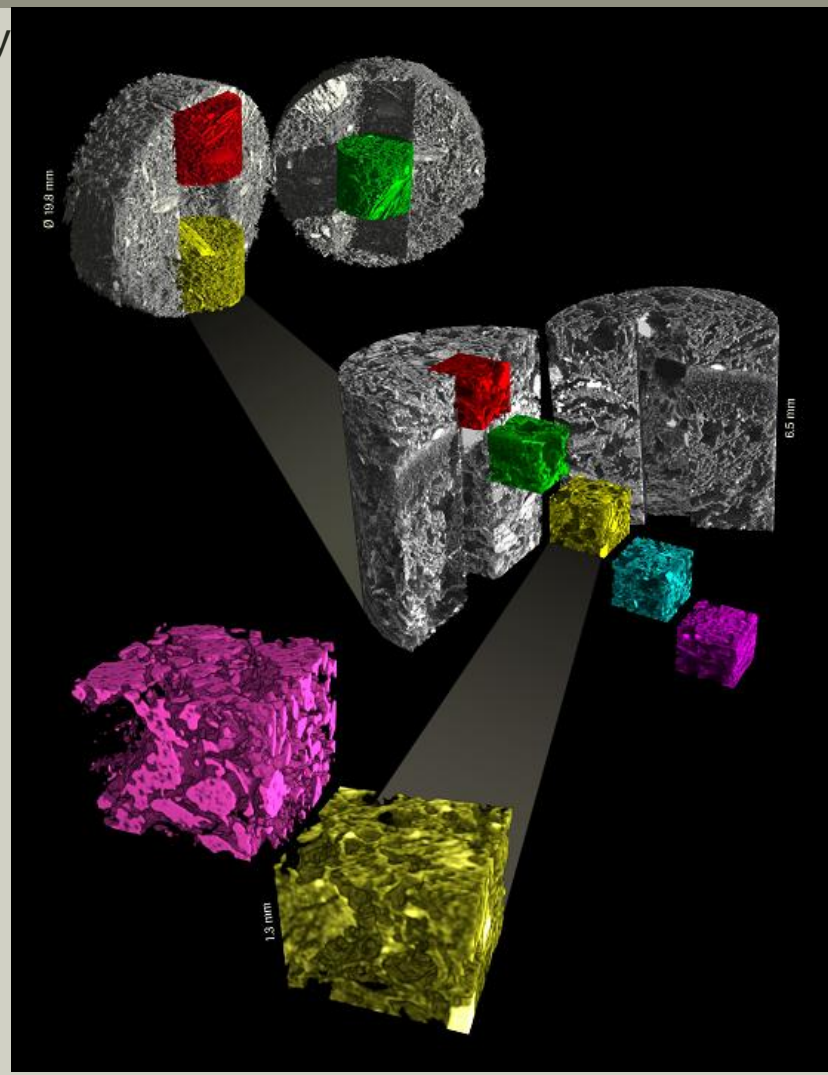
New methods for looking at coke structure

X-ray computer tomography (CT) is a non-destructive imaging technique that has been applied extensively in medical and engineering fields to visualise internal features of humans and objects

X-ray micro-tomography (XRMT) is based on the same essential principles of X-ray absorption as standard X-ray CT but differs in sample transport and in size of the X-ray source



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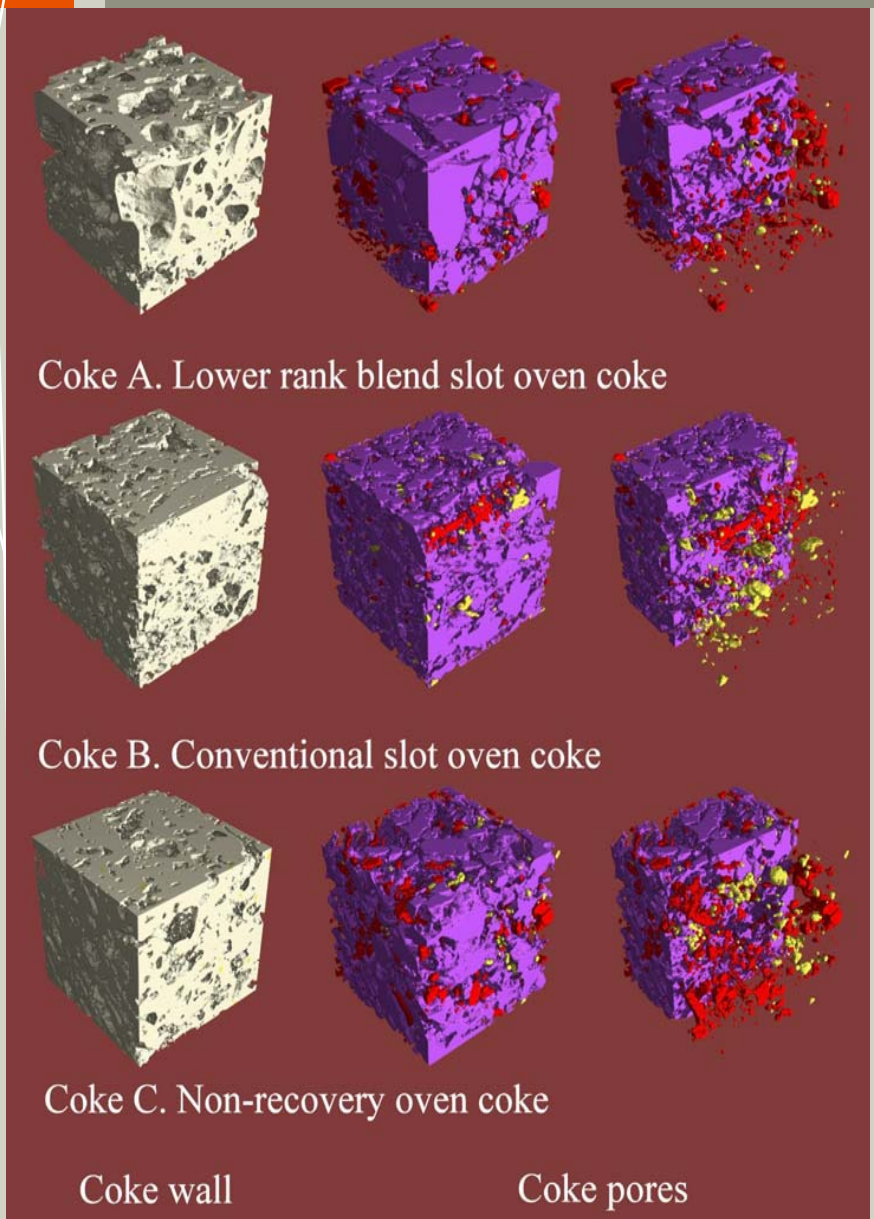
X-Ray Micro Tomography (XRMT)-
Effect of gasification on coke structure



Use High Temperature Coke Reaction (HTCR) furnace & XRMT to study the change in coke microstructure through the BF.

Coke microstructures showed significant difference between the effects of

- **CSR conditions &**
- **a typical BF gas-temperature profile**

- **CSR reaction penetrated deep into the coke lump for all cokes studied**
- **BF profile resulted in reaction confined to lump surface.**

Coke made from higher rank coals showed a more limited change in coke microstructure.

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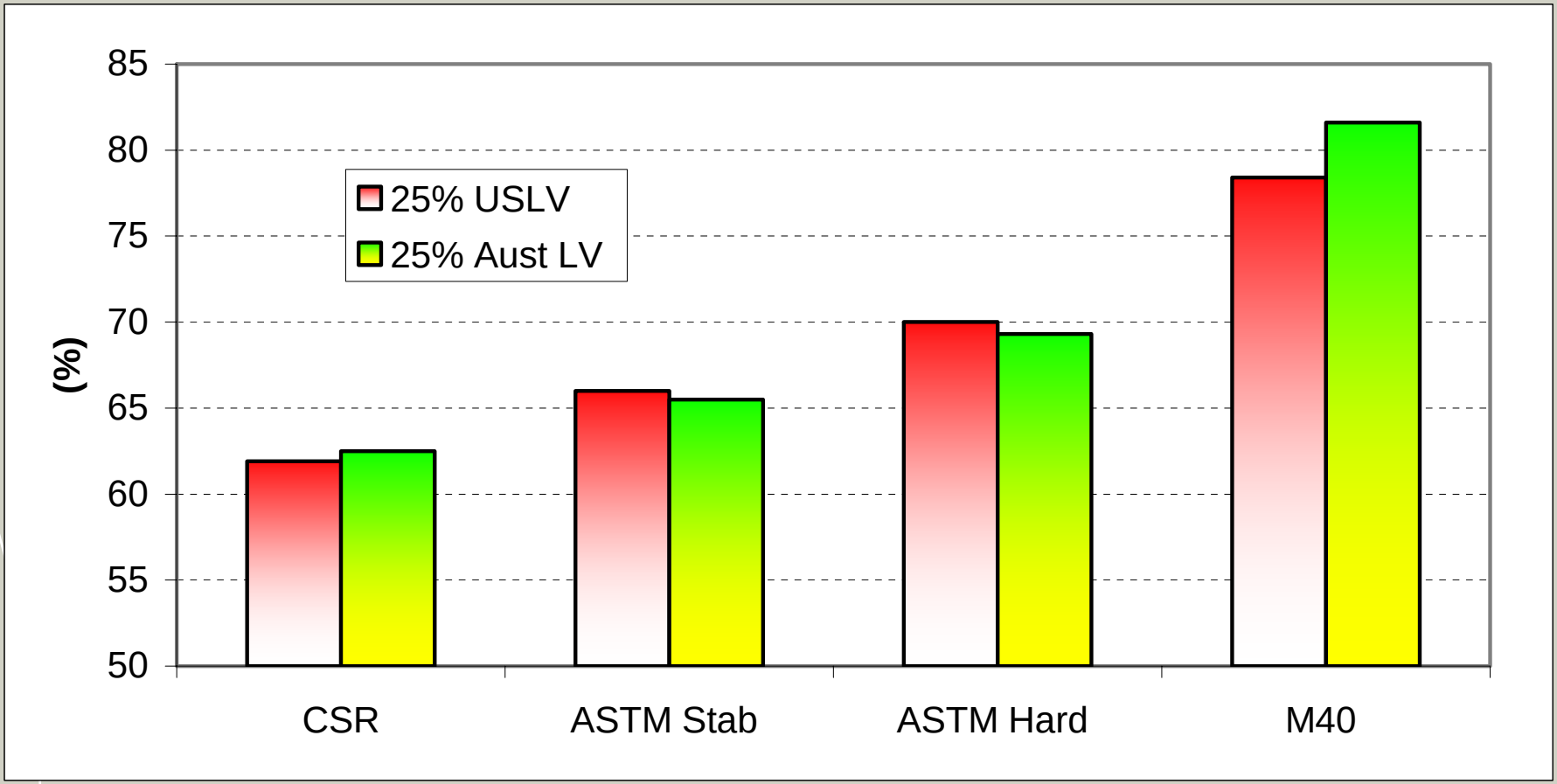
US LV v Aust LV Coals – Effect on coke strength



Source: BHP Billiton

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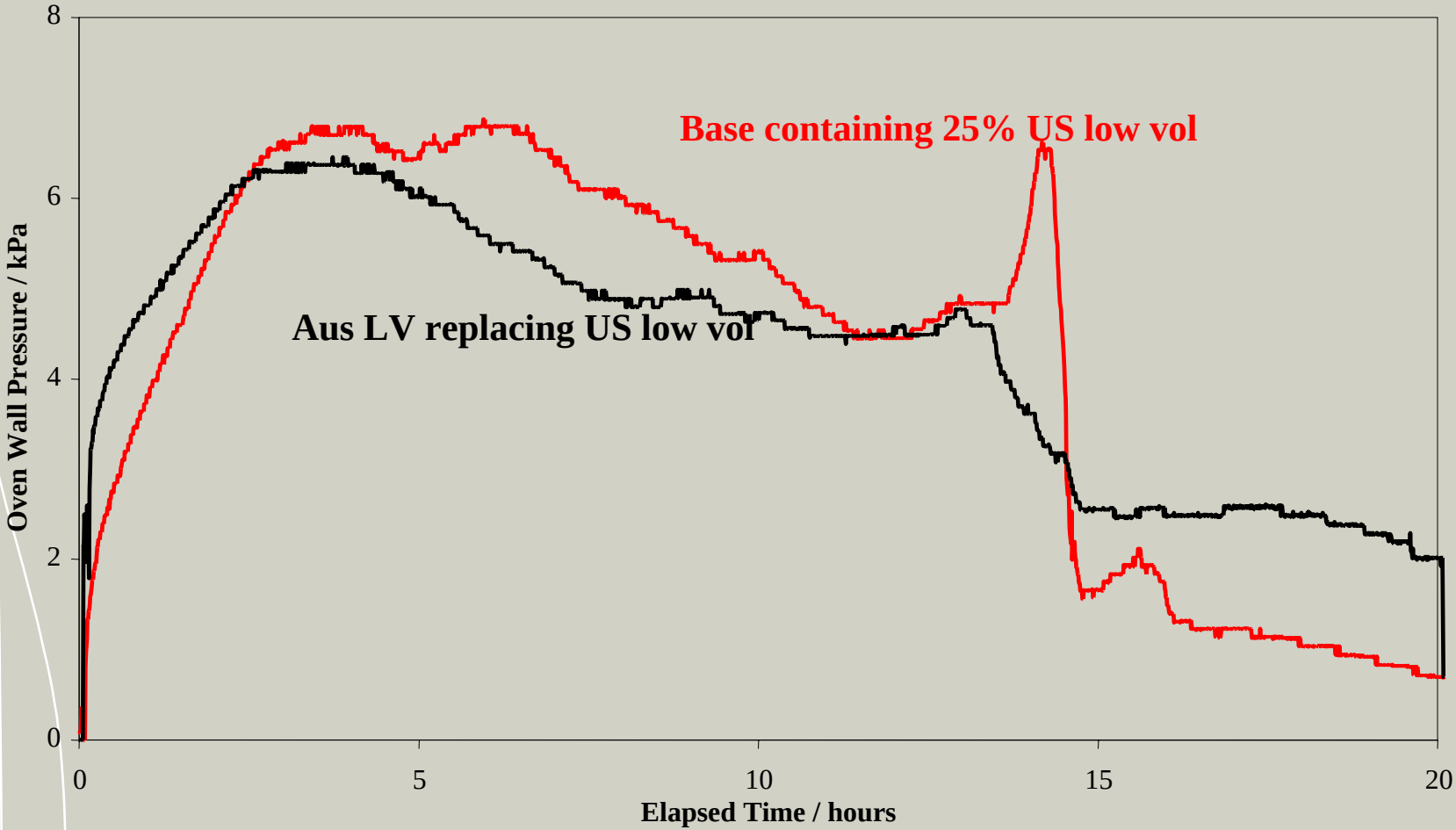
Measurement of oven wall pressure (OWP)

- Moveable wall pilot coke ovens provide a direct measurement of OWP
  - Research Coke Oven at Newcastle completed over 750 experiments since 1994

Standard Conditions	
Moisture	5%
Bulk density	825kgm^{-3} (db) box charge
Grind	85% minus 3.35mm
Heating	Simulation of Australian slot ovens

Oven wall pressure studies



Source: BHP Billiton

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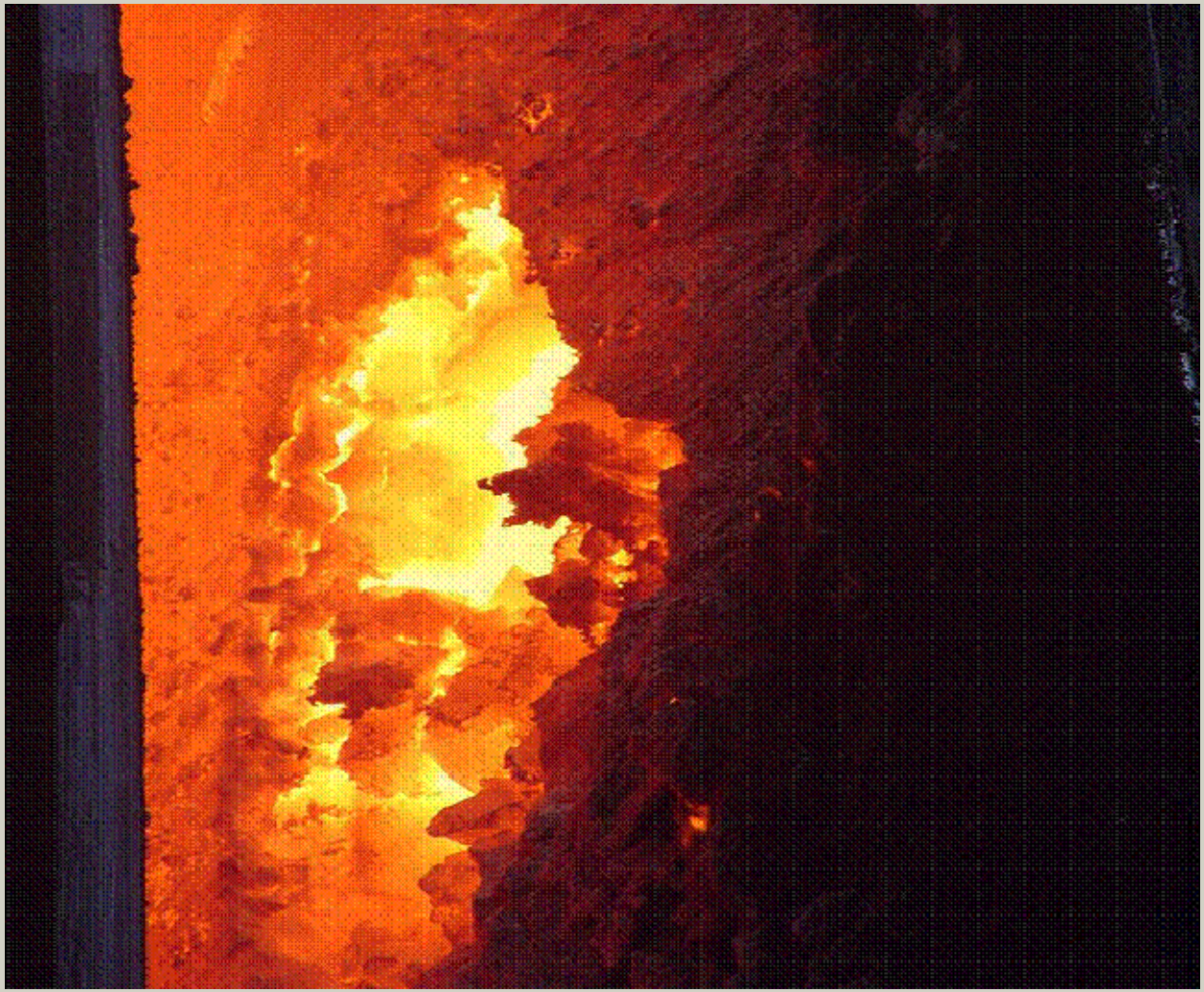
Oven wall failure



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And the end of the road

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Summary

- The global steel industry remains firmly in the “new world” led by China
- Future trends in China, industry consolidation and changing BF practices all suggest the need for higher coke quality
- Traditional techniques to characterise coke lack the precision to provide superior BF performance
- OWP remains an important parameter esp. with aging ovens
- High quality Australian hard coking coals esp. low vols will remain a core part of current and future coke blends

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