FUTURE STEEL MAKING
BF/BOF VS DRI/EAF TECHNOLOGY -
A NORTH AMERICAN PERSPECTIVE

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Plan of Presentation

1. Introduction – setting the scene
2. Global steel technology – BF/BOF vs. DRI/EAF
3. North American steel options, today and tomorrow
4. Is this the end of Met Coke in North America?
5. Global implications – is the US a model for the future?
6. The future for coke, the good, the bad and the ugly
7. Concluding remarks
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Steel demand growth will continue

Although often shown this figure forms the basis of the future potential for steel demand. Emerging and developing markets require steel as the building blocks for their economic transformation.

Stylized depiction of the relationship between per capita GDP and commodity demand

Source: World Bank, IMF, Saul Eslake Grattin Institute
Global steel production has risen to meet demand, but are we seeing a turning?

4th age of steel: the China age is possibly coming to the end? Are we at, or have we passed “peak” Chinese steel production? Is there another lift as its economy improves?

- The golden age: 1945 – 1973, 6.2% pa
- The emerging age: pre 1945, 2.8% pa
- The efficiency age: 1974 – 1995, 0.2% pa
- China age: 1996 + >4.5% pa

Privatisations
Consolidation

Source: WSA
Global steel production has risen to meet demand, but are we seeing a turning?

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The emerging age
pre 1945
2.8%pa

The golden age
1945 – 1973
6.2%pa

The efficiency age
1974 – 1995
0.2%pa

Privatisations
Consolidation

China

Fall of Berlin Wall
Oil Shocks

Source: WSA

Ouch

H & W Worldwide Consulting
Production has seen dips in 2000-1 and the GFC in 2008-9, signs are that we are in for another 2014-15 as the global economy weakens. The role of China in sustaining growth might be coming to an end?
Weaker Chinese growth in the past two years is lowering global growth rates. This raises questions as to whether we are at, close to or even past peak steel in China?
Steel consumption remains a China story

The rise of China and the fall of the developed world is apparent. Other Asia is yet to really have a large impact, will India begin to drive consumption in the next 10 years? North America peaked in 2006, with USA and Canada ~80% of such peak levels.

Source: wsa
China has led global steel production growth, but is it now faltering? With the Developed world still below GFC levels are we entering a new slow growth phase.....who will drive growth?
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Steel technology with demand growth

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- Few large BF/BOF mills + advanced EAF move to TSC EAF MM
- Closure of BF & BOF mills + move to >50% advanced EAF
- Large BF/BOF mills + advanced EAF
- Larger mills rise of BF/BOF
- DRI EAF, small BF
- Small EAF
- Subsistence, agriculture
- Russia
- China
- Manufacturing & urbanization
- Indonesia
- India
- Rising Scrap availability

Source: World Bank, IMF, Saul Eslake Grattin Institute
Blast Furnace based steelmaking

- Coke Oven
- Sinter Plant
- Blast Furnace
- Oxygen Converter

- Coke
- Coal
- Met Coal
- Iron Ore
- Sintered ore
- PCl coal
- Slag
- Molten pig iron
- Molten Steel
The BF has been the King and has seen off many challengers. It will remain the main producer of iron for steelmaking into the future, no change in near term.

Recent Blast Furnace Changes:

- Reline enlargements
- Pulverised coal injection
- Oxygen enrichment of the blast
- Larger working volumes
- Low gangue feed
- Bosh / Hearth cooling
- Computer control / heat & mass balance models
- Instrumentation advances
Rise and rise of the EAF, a threat to the BF?

EAF's have been around a long time, are cheap, simple and rely on low cost scrap – China post 2020?

- Basic EAF designed for simple construction steels
- Size from 10t to 350t, AC, DC systems with auxiliary equipment
- Wide range of products depending on inputs and equipment
- Low, variable capex, simple to run, more complex with higher grade steels
- Easy to add on with new TS casting
- Cost linked to scrap and power, higher scrap lower cost
- Could EAF’s suffer in a structurally low priced iron ore environment?

H & W Worldwide Consulting
Increased demand and the rise of China has seen BOF production grow in percentage terms of total output. This has seen rising pig iron production and led to increased demands on the BF for production and quality.

- Trends for BF/BOF based production rise inc. more scrap
- Driver China and other merging markets – no/limited scrap
- Rising scrap in BOF in certain countries – close to limits in US
- HM/Scrap dynamics based on price and steel quality
- Higher grade EAF steels support use of merchant pig iron in EAF
- Overall costs pressure to lift BF productivity and HM efficiency
China vs. USA

Snapshot of differences, even when China was a 88Mtpa steelmaker basic process was BF based with BOF and OH technologies – is the difference the availability of metallic, power or coke?
# Basics of Steelmaking Technologies

## BF/BOF Steelmaking

### Requirements
- Range of low cost iron ores, met coals, scrap and ferroalloys
- Best sited close to raw materials or easy access to ports/seaborne materials
- Good access to markets and/or distribution systems/warehouses
- Large skilled workforce
- Good logistics for product distribution
- Continuous output, inability to stop coke ovens, BF with difficulty

### Benefits
- Range of size from MBF to Mega BF size > 5700 M³
- Full range of steels long to flat products
- Wide range of product sizes/features
- Wide range of raw materials, but with plus/minus
- Integrated energy systems across steelworks
- High product add-ins, e.g. VdeC, advanced finishing
- Can be operated in regions of low or very limited scrap

### Issues/Disadvantages
- Large capital cost
- Large footprint, land area and labour force
- Limited ability to flex production
- Requires range of raw materials and burden preparation
- Requires coke plants and/or coke imports
- Generally heavily unionised - low flexibility
- Large sustaining capital
- Most effective (cost) at >6 Mtpa
- Slow recovery after problems or relines

## EAF Steelmaking

### Requirements
- Access to large volumes of low cost scrap
- Efficient scrap recovery and steel recycling collection system
- Access to low cost power

### Benefits
- Best operations in range 0.5 – 2.5 Mtpa
- High operation flexibility
- Best for long products in basic form
- More options as scrap levels rise

### Issues/Disadvantages
- Need large scrap reservoir – not available in emerging countries
- Need large deep power grid – not available in emerging countries
- Require higher cost/quality feeds for higher grade steels
Increased availability of scrap, advanced EAF mini mill technology and TSC, led by Nucor, has seen a move away from BOF to EAF steelmaking technology. Increased high grade steel production has seen higher levels of “virgin” metallic e.g. DRI to meet quality requirements.

- Trends toward EAF production based to scrap availability
- Driver low cost power and plentiful scrap – increase in TSC MM
- Rising scrap in close to limits in US not affected move to EAF
- Higher grade EAF steels support use of MPI/HBI/DRI in EAF
- HM/Scrap dynamics based on price and steel quality
- Rise on non unionised labour – high productivity

Source: WSA
North American steelmaking today and tomorrow

**Drivers**

- Large scrap reservoir and plentiful cheap power
- Efficient scrap collection and recycling industry
- Well established existing EAF base
- Leadership in EAF/TSC and thin strip casting
- Rising steel demand in regions in the south away from BF production
- Large skilled labour force
- Availability of gas and steelmaking raw materials

**Today**

- EAF holds upper hand
- Moving to add primary metallics e.g. DRI (BF considered/rejected)
- Quality drift require more high grade scrap or clean metallics

**Tomorrow**

- Sustainability of domestic raw materials?
- Costs competitiveness can BF survive?
- Role of steel imports
- EAF/TSC penetration into premium flat products markets
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US BF hot metal production has been on a downward path for over 20 years, driven by weak steel fundamentals high costs and low/medium productivity and threats from Asian steelmakers.

- With declining BOF production BF output follows
- Rising competition from advanced EAF’s has impacted BF output
- US has many small and less economic BF’s
- Higher costs have seen numerous BF’s close
- Weaker BF production has lowered coke demand
- Coke replacement PCI, NG also reducing demand for coke
Steel Trade patterns are seeing more and more Chinese steel

Key trends are rising Chinese exports as domestic production remains strong and domestic consumption moderates, forcing steelmakers to seek exports markets, with severe impact on price.

Net Exports (Mt)

Source: wsa
2015 has seen a continuation of weak steel markets and prices, increasing Chinese exports have acted to depress global prices, and even lower RM prices have not preserved steel margins.

Source: TSI

H & W Worldwide Consulting
Current prices for major steelmaking raw materials are mixed, met coal is the lowest levels for many years, and has declined to around US$80. Iron ore has seen a temporary pick up on low inventory levels. Sustainability in met coal is very low but iron ore can go much lower to <US$40/t dmtu.
US Coke production is trending down

Reduced BF production has reduced demand for coke as coke prices have declined on the back of cheaper coking coal and coke import prices, plus coke replacement by PCI and Natural Gas.

Coal Consumption in Cokemaking

Source: EIA
Based on modified cost curve, essentially a C1+, much of industry unprofitable and weaker met coals are in major difficulties. Potential for switch into thermal which is occurring Poses major issues for US HVB and lower quality US met coals?

Source: Macquarie Research, July 2015
Challenges facing the US coke industry

- Poor integrated steel industry conditions
- Decreasing demand
- High cost feedstocks (met coal)
- Environmental pressures on emissions
- Low cost imports from China
- Rising coke replacement fuel sources
- Aging batteries and replacement capital costs
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Global steel demand in 2013 was 225kg/capita or 1.41bt. Although emerging economies such as China was over 515kg/capita, India was just 58kg, other Asia 77kg, Africa 41kg, compared to Germany almost 500kg, Japan 516kg, Korea >1,000kg, all suggest very significant demand growth in the next 20+ years.
Future steel consumption could still double by 2040

Global steel demand in 2014 was lower than 2013 at 216kg/capita. The major change was China which declined from 530kg/capita to 510kg/capita. Global consumption ex China will continue to pick as Indian demand rises together with other Asia, Middle East and Africa.
Risks to global growth and steel demand

Significant risk to steel demand and production growth exist. One factor in favour is low global oil prices, but will this be enough to counter other negative factors, can oil go below US$40/barrel

**Short Term**

- Increased financial market turmoil, e.g. Chinese stock market and wider market risks
- Economic distress from rising geo-political factors, Middle East etc.
- Flow on effects of possible US interest rate rise, effects on emerging market debt

**Medium Term**

- China hard landing, flow on effects of significantly weaker Chinese growth
- Strong US dollar appreciation and impact on global debt and currency markets.
- Advanced economies fail to solve unemployment = instability, anti austerity
- Sustained low commodity prices under mining growth in low income countries
Summary of Steel Industry future drivers and technology

- China has been the major driver of steel production leading to the dominance of Asia since 2000, but has it peaked?

- Post GFC divergence: Asia growth, Developed world stalls, slower future growth trends, lower steel demand, growth in scrap/EAF

- Traditional BF/BOF steelmaking dominant, important in emerging economies, benefiting iron ore and coking coal

- Growing scrap volumes in Asia, especially China will we see the rise of EAF steelmaking soon?

- Potential for alternate iron and steelmaking – is the US a role model for the future?
Basic NG based DRI - Midrex

Two basic gas based DRI systems Midrex is the largest global DRI producer technology. USA has experience of this technology and a shaft is being built for Nucor in Louisiana and has a plant in Trinidad.

The MIDREX® Process

Source: Midrex
The second technology is that of HYL which is a similar shaft based process. There are differences in process conditions, gas composition and DRI carbon levels but it is basically a further source of metallics.
Could the US model be the way of the future for China?

- China has limited scrap resources and uses low levels in the BOF, but its high production is building a large steel base.
- China is short of power but its grid is developing rapidly so excess power is a possibility post 2020.
- China’s raw materials are increasing in cost, iron ore is ~80% imported and coking coal is plentiful high quality material costs are rising.
- Other emerging markets are also scrap short, but some have iron ore e.g. India, Brazil, S Africa but little/no coking coal – coal based DRI?
- Key will be plentiful scrap and low cost power, countries with these could well see a rise in EAF steelmaking at the expense of the BF.
Direct Reduction - Shaft Coal based

- Already in place in India
- Potential in future
- Wide range of carbon sources
Option for small scale, cheap, wide range of raw materials can be used for ferrous wastes, ultrafine iron ores potential for addition in Indian steelplants.
Direct Reduction - other coal based

Exciting potential as metallic feed for both BOF and EAF. Separation of liquid iron from gangue and coal ash holds potential for India situation.
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H & W Worldwide Consulting
Coke’s Future – the Good

- New style HRCO – e.g. Sun technology
- Environmentally friendly
- Lower capex
- Some upgrading of coking coals, CSR uplift
- Lower operating costs
- Increased operational flexibility
- Potential for lower cost blends
- Require higher volatile blends
China’s coke exports are increasing as domestic demand declines with pig iron production and domestic coking coal moves into a surplus.
China’s steel exports are replacing domestic BF/coke based steel e.g. US, Brazil, Europe and steel from exports of coke based steel production in Asia e.g. Korea, Taiwan.
Met Coal has seen prices decline from weather related peaks of US$400/t to US$80/t today. Prices have drifted down in the past 3 months as sharply increased volumes from rising productivity has boosted supply from Australia and Canada. Mines closures have and are occurring to reduce oversupply.
In the near term further cost cutting is underway and could reach iron ore levels, adding to further US met coal problems. Could this even lead to increased met coal imports to keep coke plants operating?
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Concluding Remarks and Final Comments

- The BF is facing future challenges as scrap and power become more available.
- China is causing major issues for the global steel, coke and met coal markets.
- With “cheap” NG DRI+EAF become more attractive and could make further inroads in the US at coke’s expense.
- The traditional pathway could see more coal based DRI in some emerging countries such as India.
- Life is tough for steel, coke and met coal producers and could get worse.
- But it is a cycle and things will improve….but who will be left standing.
ADDITIONAL SLIDES
Is this the end of met coal?

With pig iron trending down led by China and a dramatic reduction in China’s met coal imports is this the end of met coal as a growth commodity?

Global Pig Iron trends (2014 = 100)

Seaborne Met coal 2014 - 2020 (Mt)

Source: Macquarie Research
Summary of effects on met coal

- Chinese steel replacing met coal made steel
- Cheap Chinese coke replacing seaborne met coal
- Declining Chinese met coal imports
- Falling raw materials costs - sustainable?
Coking coal costs have been affected by sharp falls in exchange rates, as the A$ has fallen from a peak of 1.1 to 0.70c in the past 2-3 years. However, prices are falling compressing margins.

Source: Macquarie Bank
Cost reductions have led to major reduction in the global cost curve

Chinese steel production costs have moved from 3rd quartile to 1st or 2nd quartile on the cost curve, resulting in high sustainability of large low cost exports.

Source: Macquarie Bank
Reasons to believe it's not the end of Met Coal and Coke

- Slower peaking of China pig iron and reduced Chinese steel exports
- Rising cost and depletion issues for domestic supply = return to seaborne met coal imports
- Underestimation of Indian growth = more met coal imports
- Rising BF/coke in SE Asia and rising imports in other markets, e.g. Vietnam, Indonesia Ukraine
- Lower export volumes from high cost producer US
Globally near to medium term output falters before recovering in 2016-17.

With weaker economic activity in 2015 global steel and pig iron production is predicted to decline YOY before recovering. Current forecasts are >100Mt lower by 2018; to ~1.77bt and ~1.25bt respectively.

Source: WSA, H&W Worldwide Consulting
Will this still be coke based steel?

- Globally YES
- BF/BOF steelmaking will remain the major route supporting increased met coal consumption
- Low scrap/metallic levels
  - in most emerging countries are not going to be sufficient for strong EAF growth
  - More scrap and or DRI in BOF
- Rising power costs support integrated facilities
- Coke will come back as a key issue – rise again of HRCOs
Concluding remarks

- Current Steel Industry
  - Situation tough, weaker demand, low prices and falling margins
  - Improvements in steel industry conditions are unlikely before 2016
  - Steel production will decline this year as China’s output is down YOY
  - China’s exports are hurting the global steel and met coal industries

- Steel Technologies
  - Could rising DR technologies impact the BF,
  - India future coal based DR? Reducing demand for seaborne coking coal

- End of Met Coal
  - Declining met coal imports into China are leading to oversupply and low met coal prices
  - FX changes and cost cutting is just keeping met coal’s head above water but overall position is not sustainable
  - Views exist that declining Chinese imports will result in decline in the industry to 2020.
  - I DO NOT – THERE IS LIFE IN THE INDUSTRY