



JAMES F. KING

STEEL MARKET OUTLOOK

CONTENT

The steel industry is a major consumer of refractories and therefore of magnesia.

This presentation considers the outlook for the steel market and the steel industry. It covers:

- *Short-term trends in the steel market – the outlook for production, prices, and profitability*
- *The long-term outlook for production to 2050*
 - *processes*
 - *location of production*
 - *requirements for materials*
- *The importance of refractories as a cost factor for steel producers.*

STEEL MARKET OUTLOOK

SPEAKER'S BACKGROUND

James King is an independent consultant, analysing the economic and commercial aspects of the steel and associated raw materials industries since 1982.

Information and forecasts to 2050 are maintained on capacity of steel plants, production, consumption and trade in finished steel products, crude steel, iron, iron ore and coal, as well as related products such as ferro-alloys. Production costs for all of these items are also estimated on a regular basis at the level of individual operations.

Forecasts of prices are continuously updated.

A monthly report on the steel market is issued.

METHODS

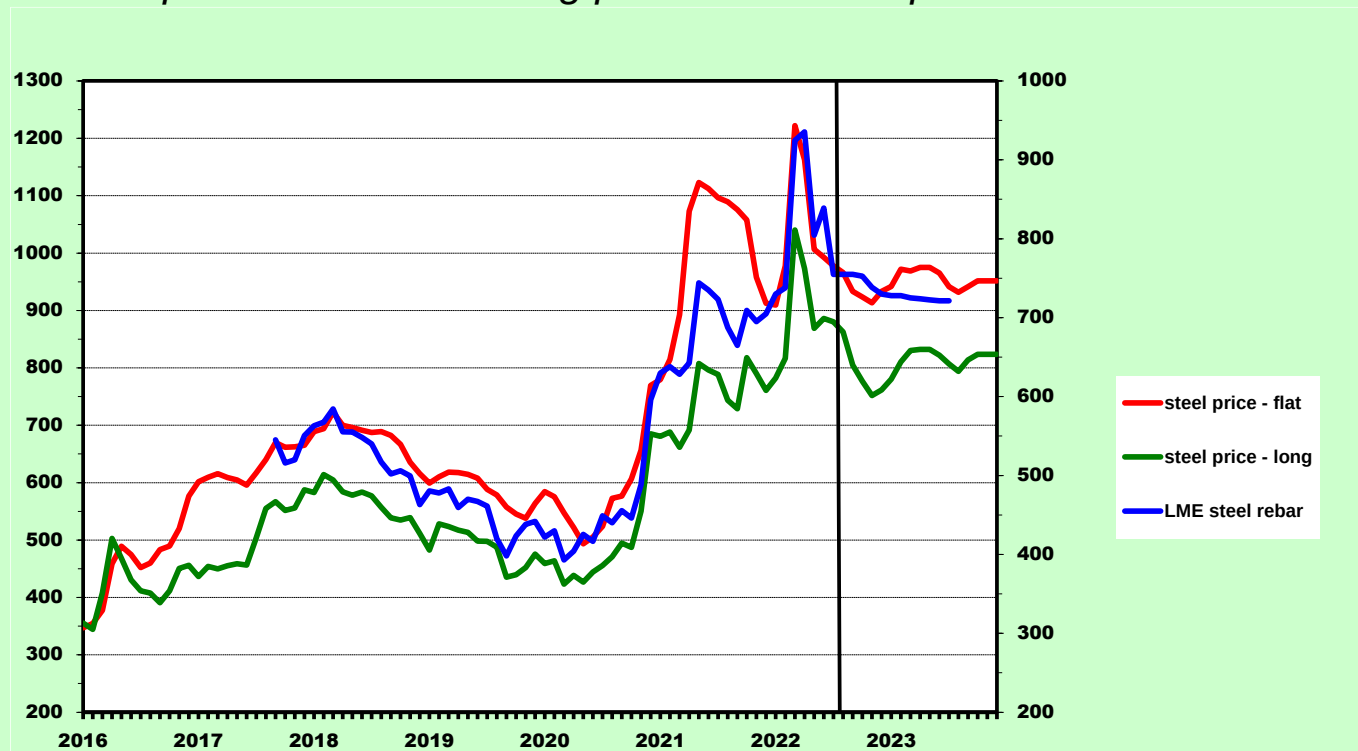
Analysis of the market for steel and raw materials is based on a comprehensive set of data for each of over 100 countries. To obtain production of crude steel the factors considered are:

- economic growth in individual countries.*
- the relationship between economic activity and the consumption of individual finished steel products.*
- International trade and production of finished and semi-finished steel products*
- the relationship between the production of finished steel and crude steel (“yield”).*
- the balance of processes for the production of crude steel.*

STEEL MARKET OUTLOOK

STEEL PRODUCTS

- *The steel industry has a wide range of products - “long products” such as bars for concrete reinforcement and “flat products” such as sheet for car bodies and welded tubes. Flat products are about 45% of world consumption.*
- *Some producers can switch production between flat and long products, so in practice prices for all steel products move in parallel.*
- *But from 2021 prices of flat products have been much higher than long products because of limited supply and high costs for raw materials.*
- *The chart shows prices for flat and long products in US\$ per tonne from 2016*



STEEL MARKET OUTLOOK

SHORT-TERM TRENDS

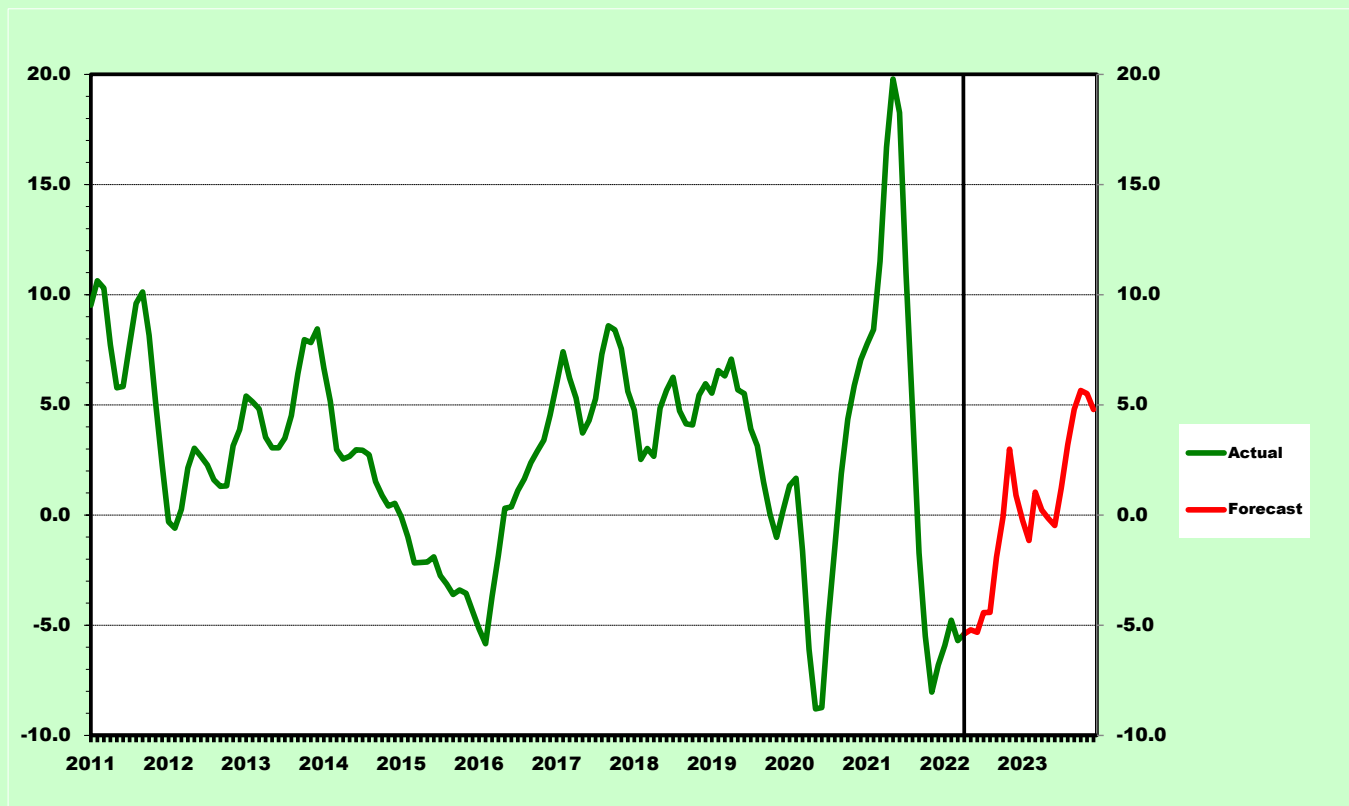
- The movement in the steel market is normally dominated by changes in the world economy and the growth of major economies.*
- Construction takes about 50% of steel products and transport a further 14%. Both of these sectors are highly cyclical.*

End Use	2000	2010	2020	2030	2040	2050	annual growth	
							2000-20	2020-50
Transport, automotive	67.2	116.8	136.0	178.2	181.3	191.8	3.6	1.2
Transport, other	50.6	96.7	118.4	142.8	146.1	156.9	4.3	0.9
Oil + gas + water	46.2	82.6	93.9	105.3	94.3	88.1	3.6	-0.2
Engineering	120.3	225.0	330.8	409.0	440.7	490.5	5.2	1.3
Electrical	34.3	62.7	89.9	107.1	114.7	127.2	4.9	1.2
Construction	380.7	700.8	880.2	1124.4	1172.0	1281.0	4.3	1.3
Packaging	21.9	24.4	28.1	34.2	36.0	38.4	1.3	1.0
Durables	22.4	38.2	46.7	59.4	62.2	67.4	3.8	1.2
Other	18.5	32.7	45.6	55.2	59.8	67.5	4.6	1.3
Total finished steel	762.1	1379.7	1769.6	2215.7	2307.1	2508.9	4.3	1.2
share of construction	50.0%	50.8%	49.7%	50.7%	50.8%	51.1%		
share of transport	15.5%	15.5%	14.4%	14.5%	14.2%	13.9%		

STEEL MARKET OUTLOOK

SHORT-TERM TRENDS

- *As a result, production of crude steel shows wide variations in the short term.*
- *The chart shows that changes in production from the previous year frequently range between +10% and -5%. At the moment, world crude steel production is running about 5% below the same period in 2021.*



STEEL MARKET OUTLOOK

SHORT-TERM TRENDS

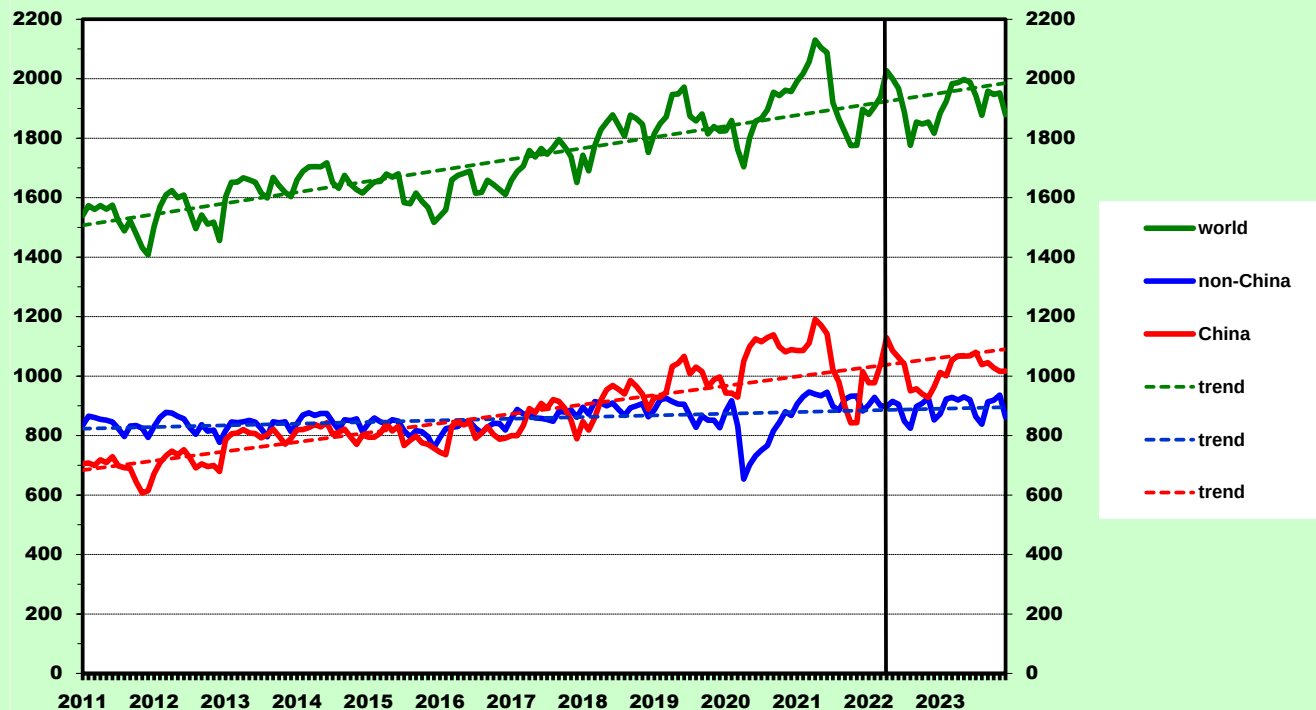
- The COVID-19 pandemic had very little impact on world crude steel production (up 0.3% in 2020), because growth in China offset large falls in other areas.*
- In 2021 production fell in China, but rebounded strongly everywhere else.*
- In 2022 China is expected to be down 5%, with other regions not doing so well either and the CIS down over 20%, World production is forecast to be down 3.1%, with some recovery in 2023.*

Area	2019	2020	2021	2022	2023
World	2.7	0.3	3.8	-3.1	2.5
North America	0.6	-16.8	18.0	-3.1	1.8
USA	1.3	-17.1	18.0	-2.9	1.9
Latin America	-7.7	-7.7	15.7	-2.3	3.6
Brazil	-8.0	-3.5	15.2	-2.9	0.6
Europe	-6.5	-8.7	14.4	-5.6	1.9
CIS Countries	-0.3	-0.4	5.2	-20.3	-1.7
Africa	-1.4	-0.4	19.4	0.2	7.7
Asia - Middle East	2.4	2.9	2.3	2.2	3.6
Asia - China	7.1	7.0	-3.0	-2.8	3.7
Asia - Other	0.1	-7.5	13.5	0.9	0.1
India	1.9	-10.0	17.9	9.6	0.8
Japan	-4.8	-16.2	15.8	-3.7	0.3
Oceania	-2.9	-1.4	5.7	-1.5	1.1
Australia	-3.4	0.0	5.3	-1.4	1.2

STEEL MARKET OUTLOOK

SHORT-TERM TRENDS

- The chart shows the importance of China in the world total steel production, and the contrary movements of production in China and the rest of the world.
- The green line is total production of crude steel from 2011.
- The red line is production in China, booming in 2019 and 2020
- The blue line is production in the rest of the world, slumping in 2019.
- Outside China the underling rate of growth is low (dotted blue line).
- China is expected to remain below its past trend.



STEEL MARKET OUTLOOK

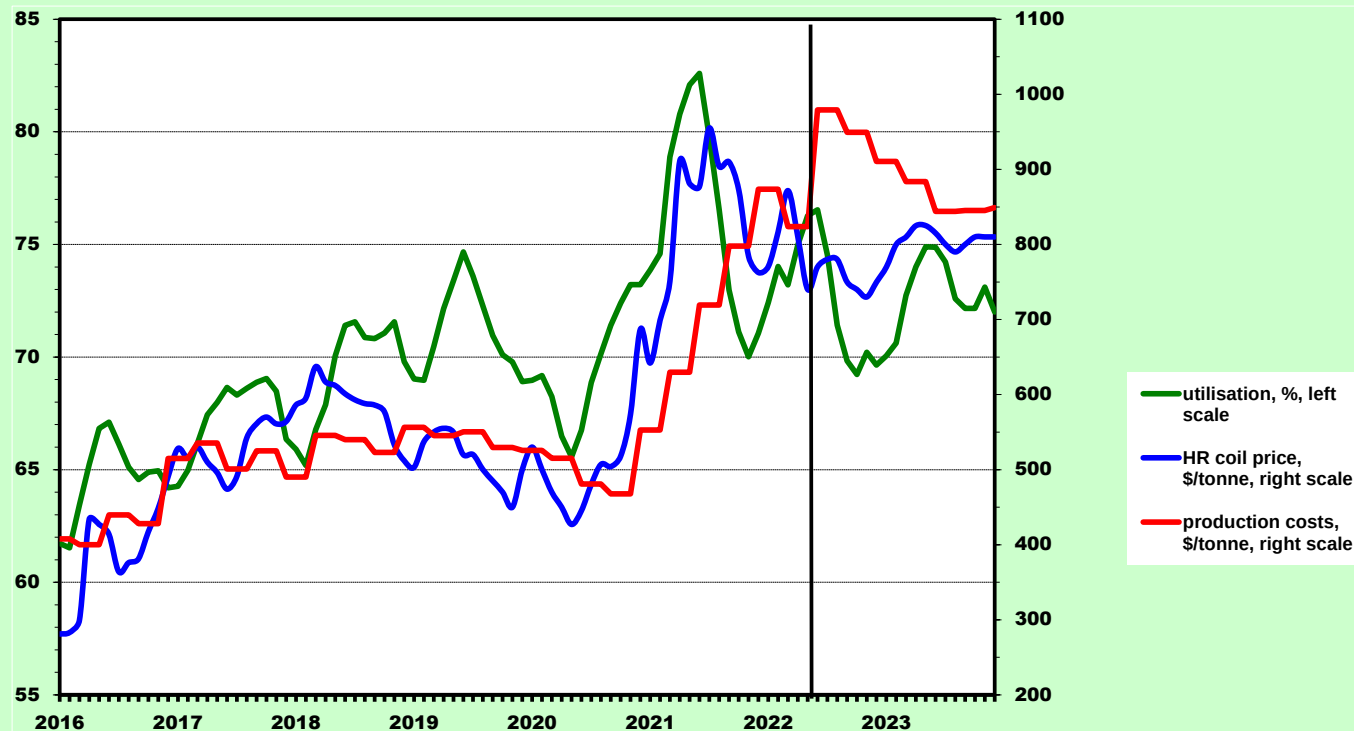
SHORT-TERM TRENDS

- *Prices fell quickly at the start of the COVID-19 outbreak in 2020 and steel producers cut production.*
- *From mid-2020 prices started to recover as demand was not as badly affected as expected.*
- *From about October 2020 the announcement of successful vaccines caused a complete change of sentiment, leading to large orders and a massive increase in prices.*
- *This continued to a peak in June/July 2021 when prices were at an all-time high, above those of the boom of 2008.*
- *Part of the reason for high prices is that steel producers have been slow to increase output in response to high prices. Possible reasons are:*
 - *lack of raw materials*
 - *shortage of labour because of COVID-19*
 - *fear that this price bubble will burst very soon*
- *Prices are now falling as demand has been affected by the slowdown in China, rising energy costs affecting consumers and the supply difficulties for the automotive and construction industries.*

STEEL MARKET OUTLOOK

SHORT-TERM TRENDS

- The chart shows steel prices (a benchmark product – hot-rolled coil, blue line, right hand scale), the costs of production of HR coil (red line, right hand scale) and capacity utilisation for crude steel (green line, left hand scale).
- Prices respond to capacity utilisation: high utilisation $\Rightarrow$ high prices
- Prices also respond to costs: high costs $\Rightarrow$ high prices
- In 2021 steel prices ran ahead of costs, giving massive profits for the steel industry. Costs are still rising, prices are falling and 2022 will be a difficult year.



STEEL MARKET OUTLOOK

LONG-TERM TRENDS - INDUSTRY STRUCTURE

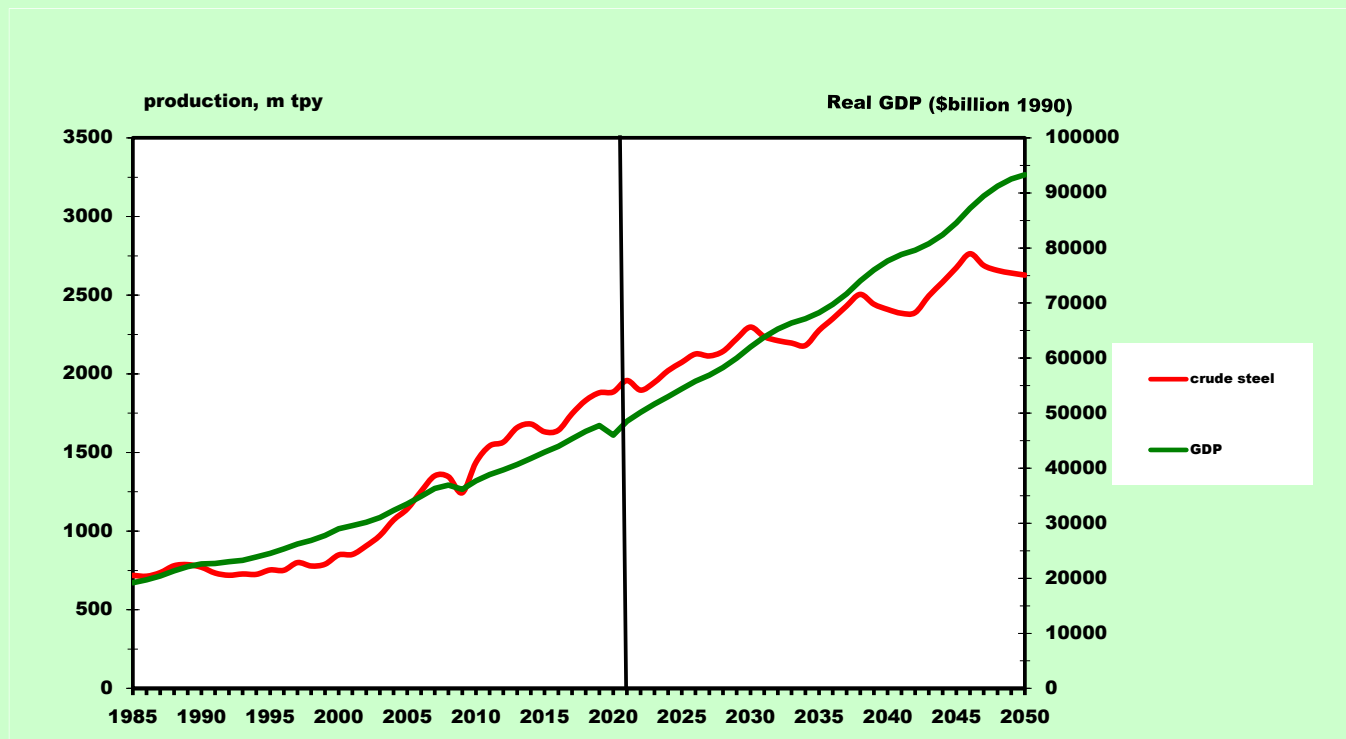
- *This table shows the crude steel production in million tonnes of the 10 largest companies in 2020 and 2000.*
- *There have been major changes to the structure of the industry.*
- *Chinese producers were 7 of the top 10 companies in 2020, only 1 in 2000.*
- *World production more than doubled between 2000 and 2020 and so did the size of companies, but the share of the top 10 was little changed.*

Rank	2020			2000		
	Company	Base Country	2020	Company	Base Country	2000
1	Baowu Steel Group	China	115.3	Nippon Steel	Japan	29.1
2	ArcelorMittal	Luxembourg	78.5	Posco Group	Korea, South	28.5
3	Hebei Iron & Steel Group	China	43.8	Arbed Group	Luxembourg	24.1
4	Jiangsu Shagang Group	China	41.6	Usinor/Sacilor	France	21.0
5	NSSMC	Japan	41.6	ArcelorMittal Group	United Kingdom	20.9
6	POSCO	South Korea	40.6	Corus	United Kingdom	20.0
7	Anshan Iron & Steel	China	38.2	Thyssen Krupp Group	Germany	18.0
8	Jianlong Group	China	36.5	Shanghai Baosteel	China	17.7
9	Shougang Group	China	34.0	Riva Group	Italy	15.6
10	Shandong Steel Group	China	31.1	Kawasaki Steel	Japan	15.0
	Share of Top 10	%	26.6	Share of Top 10	%	24.7
	World		1881.0	World		849.0

STEEL MARKET OUTLOOK

LONG-TERM TRENDS – WORLD PRODUCTION AND GDP

- *This chart shows total crude steel production in million tonnes (red line, left-hand scale) and real GDP in billion US\$ (green line, right-hand scale).*
- *In the 1980's and 1990's steel production grew less than real GDP.*
- *From 2000 steel production grew more than real GDP.*
- *After the major fall in 2009, there was rapid growth led by China.*
- *Steel production is forecast to grow in line with GDP to 2030 then more slowly than GDP to 2050.*



STEEL MARKET OUTLOOK

LONG-TERM TRENDS – LOCATION OF PRODUCTION

- *Behind the history and forecasts for production of crude steel are forecasts of consumption of finished steel products. There is a relationship between economic development and steel consumption. Consumption rises rapidly at certain stages of development, then stabilises or falls as income (real GDP) per person increases.*
- *The major industrial countries (USA, Japan, Germany and other countries of Europe) have falling consumption per unit of GDP. China, South Korea India and Vietnam are have rising consumption of steel as industrialisation spreads. Other developing countries are expected to show the same trends, with periods of rapid growth in steel consumption followed by installation of steel capacity and growing production (Indonesia, Ethiopia, Nigeria ?)*
- *In 2021 China account for 56% of world production of crude steel, up from 15% in 2000 and 44% in 2010, so developments in China will continue to be crucial to the total production of steel. The forecasts assume that peak consumption of steel products in China was reached in 2020, at 1.01 billion tonnes, with a gradual decline to 731m tonnes by 2050. China is forecast to remain a large exporter of steel products, so crude steel production is forecast to remain at around 1 billion tonnes per year until 2038, falling to 908m tonnes by 2050.*

STEEL MARKET OUTLOOK

LONG-TERM TRENDS – LOCATION OF PRODUCTION

- The base case forecast for crude steel production is in the table, with the largest 10 countries ranked by size in 2020. Historic producers like France, Italy and UK do not now appear in the top 10.*
- Growth in world production to 2050 is forecast at 1.1% per year (from a low start in 2020). In this growth:*
 - China stabilises*
 - USA and Japan decline; Germany is static*
 - India, Russia, Brazil, Iran grow. Vietnam is forecast at 54m tonnes by 2050.*

Country	2000	2010	2020	2030	2040	2050	growth	growth
	million tonnes						2000-20	2020-50
China	127.2	638.7	995.4	1067.7	993.2	907.7	10.8%	-0.3%
India	26.9	69.0	111.4	205.5	350.3	497.9	7.4%	5.1%
Japan	106.4	108.6	99.3	97.4	88.2	75.3	-0.3%	-0.9%
United States	101.8	80.5	87.8	81.2	76.3	67.0	-0.7%	-0.9%
Russia	59.1	66.9	71.7	84.2	98.8	109.1	1.0%	1.4%
South Korea	43.1	58.9	71.4	79.9	81.6	78.8	2.6%	0.3%
Germany	46.4	43.8	39.6	44.7	46.3	44.6	-0.8%	0.4%
Turkey	14.3	29.1	33.7	54.6	73.1	94.3	4.4%	3.5%
Brazil	27.9	32.9	32.6	50.4	69.2	89.8	0.8%	3.4%
Iran	6.6	12.0	25.6	36.4	44.6	54.0	7.0%	2.5%
World	849.2	1437.2	1880.2	2223.6	2443.1	2628.0	4.1%	1.1%

STEEL MARKET OUTLOOK

LONG-TERM TRENDS – PRODUCTION PROCESSES

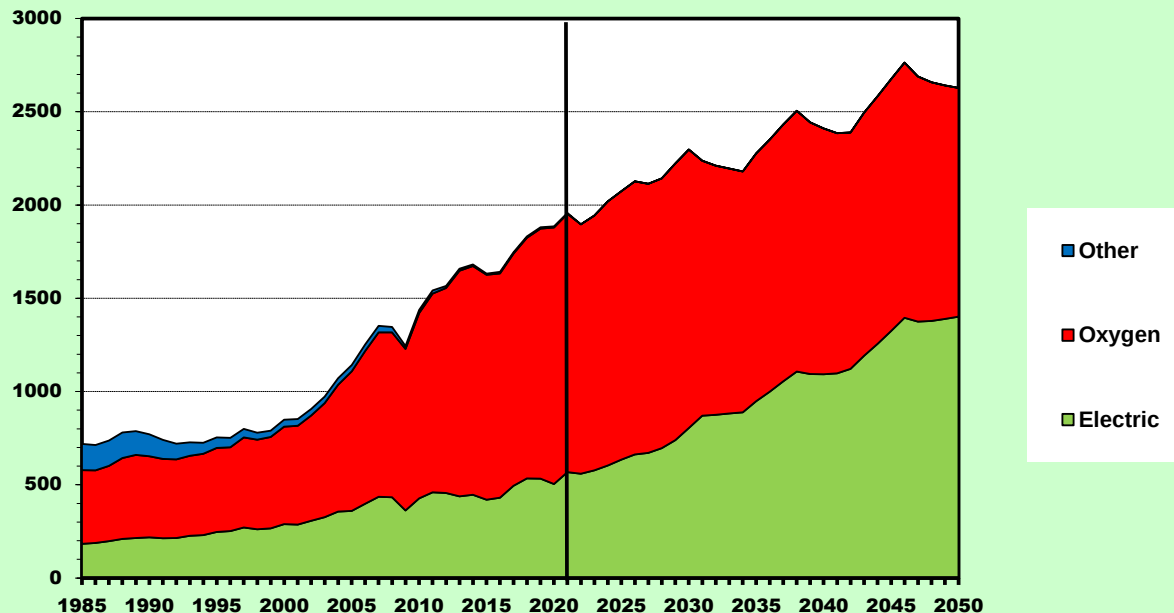
- The balance of steelmaking processes is important for the consumption of refractories. The table shows world production of crude steel by process in million tonnes.*
- In China and the CIS the integrated (iron ore/coal/blast furnace/BOF) steel process dominates in all carbon steel products. The growth of steel production in China caused the share of electric (EAF) steel in world production to fall from its peak of 34.0% in 2000 to 25.6% in 2015, but that share is rising again.*
- The base case forecasts that oxygen steel will start to fall after 2030, while EAF steel continues to grow strongly.*
- This reflects the existing shift toward EAF steel in China and the CIS and the expected change in processes caused by environmental policies.*

Country	2000	2010	2020	2030	2040	2050	growth 2000-20	growth 2020-50
million tonnes								
Total crude steel	849.2	1437.2	1880.2	2223.6	2443.1	2628.0	4.1%	1.1%
electric (EAF)	289.0	427.1	533.0	739.6	1093.5	1402.0	3.1%	3.3%
oxygen (BOF)	522.4	993.3	1341.1	1484.0	1349.6	1226.0	4.8%	-0.3%
other (OHF)	37.9	16.9	6.2	0.0	0.0	0.0	-8.7%	
electric share	34.0%	29.7%	28.3%	33.3%	44.8%	53.3%		

STEEL MARKET OUTLOOK

LONG-TERM TRENDS – PRODUCTION PROCESSES

- *The chart shows the balance of processes to 2050.*
- *Products made by the blast furnace/BOF process generate about 2.2 tonnes of carbon dioxide per tonne of finished steel product. Products made by the scrap/EAF process generate about 0.9 tonnes.*
- *There is social pressure to reduce emissions of CO₂ to maintain reputations for good corporate behaviour. This will increase.*
- *There is also cost pressure. CO₂ permits now cost about \$90 per tonne, 2.2 tonnes adds \$198 per tonne to the cost for the BF/BOF producer, but only \$81 per tonne for the EAF producer.*



STEEL MARKET OUTLOOK

LONG-TERM TRENDS - STEELMAKING MATERIALS

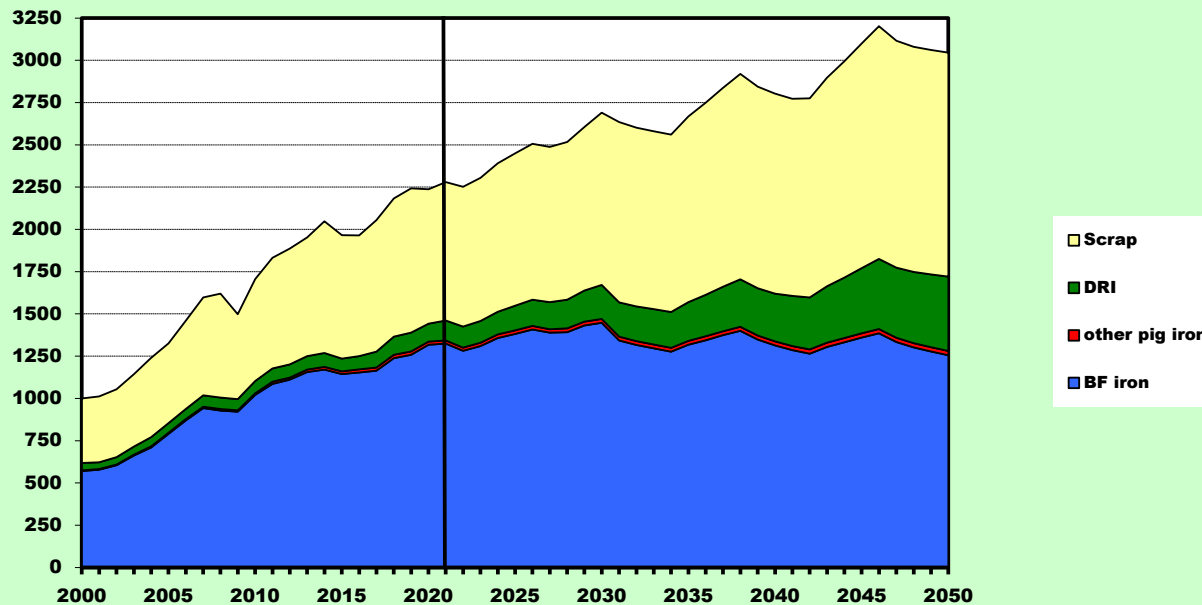
- *Based on the forecasts for steel, this table shows the expected requirements for steelmaking raw materials. It shows that*
 - *Blast furnace iron will rise before it falls after 2030.*
 - *DRI (direct reduced iron) will show a massive increase.*
 - *Collection of old scrap will need to grow at 3% per year*

<i>Product</i>	<i>2000</i>	<i>2010</i>	<i>2020</i>	<i>2030</i>	<i>2040</i>	<i>2050</i>	<i>growth</i>	<i>growth</i>
			<i>million tonnes</i>				<i>2000-20</i>	<i>2020-50</i>
Total primary iron	617.8	1103.3	1442.7	1670.9	1619.6	1720.7	4.3%	0.6%
Blast furnace iron	570.5	1020.7	1317.2	1448.3	1313.5	1255.2	4.3%	-0.2%
Other pig iron	4.4	9.9	18.9	22.5	23.8	25.1	7.6%	1.0%
DRI	42.9	72.8	106.6	200.1	282.4	440.3	4.7%	4.8%
Scrap consumption	382.2	602.6	794.8	1020.0	1183.9	1325.3	3.7%	1.7%
internal steelworks	84.2	126.4	192.1	194.7	142.2	127.6	4.2%	-1.4%
external new scrap	96.2	190.7	243.8	277.0	310.7	342.2	4.8%	1.1%
external old scrap	197.1	288.0	357.0	553.0	662.3	863.9	3.0%	3.0%
Arisings of scrap	441.2	680.8	887.6	1214.6	1242.0	1424.2	3.6%	1.6%
Collection rate	86.6%	88.5%	89.5%	84.0%	95.3%	93.1%		

STEEL MARKET OUTLOOK

LONG-TERM TRENDS – ACTION ON CARBON DIOXIDE

- This results partly from existing trends and partly from the strategy of steel producers in the face of growing pressure on CO₂ emissions. That strategy is:
 - Switch from blast furnace/BOF steel to scrap/EAF steel
 - This is limited by the availability of scrap. There is not enough steel scrap to produce all new steel from scrap. Some primary iron must be used.
 - produce that primary iron without CO₂ by making direct-reduced iron – DRI, based on natural gas or, preferably, hydrogen.



LONG-TERM TRENDS – ACTION ON CARBON DIOXIDE

- *The EAF process uses about 0.5 MWh of electricity per tonne of steel. Produce that electricity from renewable resources, not coal. This is a major problem for switching to EAF's in China, India, USA and Japan, since much of their electricity is still generated from coal*
- *A huge increase in the production of DRI creates major problems in the supply of the high-grade iron ore required for the process. Supply is now limited to a few sources, mainly Brazil. Natural ores with the necessary quality are scarce, so existing iron ore operations will have to invest heavily to upgrade their products by further processing. This, and not hydrogen or natural gas, will probably be the factor that limits the growth of DRI in practice.*
- *Avoid or delay the switch to EAF and continue to operate existing blast furnace/BOF plants by:*
 - *Using DRI in the blast furnace and/or BOF furnace (Voest-Alpine)*
 - *Using more natural gas (or preferably hydrogen, if technically possible) in the blast furnace instead of coke or coal*

LONG-TERM TRENDS – ACTION ON CARBON DIOXIDE

- *Reduce use of oil and gas elsewhere in the steel plant by :*
 - *More “direct rolling” of hot steel without the need to re-heat it*
 - *Switching re-heating of steel before rolling from gas- or oil-fired furnaces to electric furnaces*
 - *Improving heat recovery throughout the plant*
 - *These measures are desirable, but in practice will make an insignificant contribution to the main problem of CO₂ emissions.*
- *The key limits to the steel industry’s ability to reduce CO₂ will therefore be:*
 - *iron ore supply for DRI*
 - *Electricity from renewable sources for EAF steel*
 - *Technology for using hydrogen for DRI or blast furnaces*
 - *Electricity from renewable sources to produce hydrogen*
 - *International transport of liquid hydrogen if it cannot be produced locally*
 - *Money to make all these investments. With the industry’s recent profitability, money is possibly the least of the problems at present, but in a cyclical industry that will not last.*

LONG-TERM TRENDS – ACTION ON CARBON DIOXIDE

- *With major progress on all items, the steel industry could probably reduce CO₂ to about 0.5 tonnes per tonne of steel. This will not be zero carbon, but it will be much better than today.*
- *Unless governments provide massive assistance under environmental programmes, steel prices will have to be higher to provide the funds for the investments. Carbon charges can drive this change. CO₂ is now about \$90 per tonne. If they reduce CO₂ to 0.5 tonnes, this would add \$45 per tonne to the cost of steel. That would add less than 10% to the normal price of steel products.*

STEEL MARKET OUTLOOK

IMPLICATIONS FOR REFRACTORIES

- Continuous casting is an important use of certain types of refractories. This table shows world production of total crude steel and continuous cast steel in million tonnes and also the share of continuous cast steel in the total (CC ratio).*
- The CC ratio has risen from 59% of all steel production in 1990 to 96% in 2020. It cannot reach 100% because some special steel must be ingot cast for quality reasons, so growth of CC steel can only be slightly faster than the production of total crude steel.*

Country	2000	2010	2020	2030	2040	2050	growth 2000-20	growth 2020-50
Total crude steel	849.2	1437.2	1885.2	2297.3	2409.8	2628.0	4.1%	1.1%
Continuous- cast	742.0	1365.9	1817.3	2210.2	2331.9	2561.4	4.6%	1.2%
CC ratio	0.874	0.950	0.964	0.962	0.968	0.975		

STEEL MARKET OUTLOOK

IMPLICATIONS FOR REFRACTORIES

- *This table shows estimates of the average costs of steel production in 2022 Q1.*
- *The cost structures of the two main steelmaking processes are widely different and in the short term can move in opposite directions.*
- *For crude steel, refractories are estimated at about \$8 per tonne, of a total cost and normal profit (i.e. viable selling price) of over \$700 per tonne.*
- *For a finished steel product such as HR coil, refractories are estimated at about \$15 per tonne (1.7%) of a viable selling price of \$878 per tonne.*

Item	Crude Steel		HR Coil	
	BOF	EAF	Total	Total
Iron ore	180	39	136	169
Coal and coke	293	15	207	257
Scrap, pig iron + DRI	81	440	191	105
Thermal energy + electricity	-6	59	14	40
Refractories	7	9	8	15
Labour	21	10	18	36
Other operating	79	69	78	144
Operating costs	654	640	651	766
Capital charges	32	14	26	57
Total costs	686	654	678	824
Target profit	29	12	24	54
Total costs + target profit	715	667	702	878

CONCLUSIONS

- *Slow growth in crude steel production can be expected, in the range of 1% per year – back to the situation in the 1980's.*
- *Most future growth in crude steel production will come from countries other than China and the major western industrial countries.*
- *Electric steel will grow faster than oxygen steel and will be the only viable process in the smaller developing countries without a market large enough to support integrated steelmaking.*
- *Blast furnace iron will decline in the long term and DRI will grow rapidly, but for this to happen major investments will be required in the iron ore and electricity generating industries. Those may be the limiting factors.*
- *Further consolidation of steelmakers, increasing the power of buyers of refractories, will be limited in the western countries, but could be very large in China.*
- *Refractories remain a minor cost for a steel producer. When profit margins are only a few dollars per tonne, every dollar counts, so there will be continued interest in reducing the consumption of refractories and using cheaper materials. This will probably be offset by greater emphasis on product quality and the potential to permit production of higher grade, more profitable, steels.*

Thank you for your attention and good afternoon

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