

## STEEL 2003: A ROAD MAP TO THE 21ST CENTURY

Donald Barnett  
Economic Associates, Inc.

John T. Kopfle  
Midrex Direct Reduction Corporation

### ABSTRACT

The world steel industry has been through some wrenching changes over the last few years, including plant closings, massive layoffs, and financial losses. The future may promise more of the same. Total steel production will not increase greatly to the year 2003 and nearly all the growth will be via the electric arc furnace. This promises to create a metallics supply problem since there will be little growth in generation of prime scrap. A larger supply of scrap substitutes, including direct reduced iron, is a likely solution due to the availability of natural gas, coal, and iron ore in many areas of the world. However, achieving an increase in scrap substitutes sufficient to meet the projected deficit in scrap supplies will be a major challenge. The competitive arena of the steelmaking world will benefit progressive steelmakers, both mini-mills and integrated producers, and result in a stronger industry overall.

### INTRODUCTION

Steel production consists essentially of moving and transforming iron atoms. Iron in various forms is transported to and charged into steelmaking furnaces, in which the iron is purified and combined with alloying elements. Steel is produced in electric arc furnaces (EAF), basic oxygen furnaces (BOF), and open hearth furnaces (OH). Iron is made in foundry furnaces and blast furnaces. Iron and steelmaking metallic charge materials include scrap, scrap substitutes such as direct reduced iron (DRI) and hot briquetted iron (HBI), hot metal, and cold pig iron. These are sourced domestically and imported from offshore.

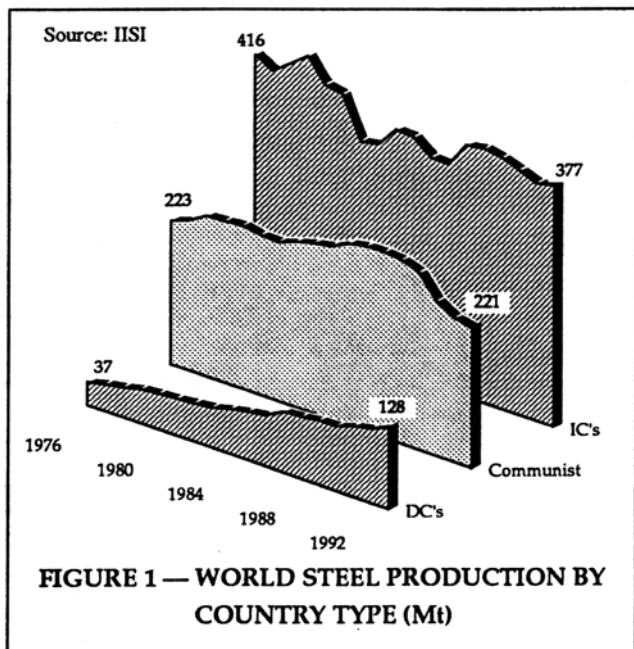
The optimum combination of charge materials for a given operation depends on a complex mix of technical and economic considerations. Due to the importance of scrap and scrap substitutes to the continued growth of the world steel industry, this paper focuses on these charge materials (the terms "scrap substitutes" and "DRI/HBI" are used interchangeably).

What does the future hold? An analysis of the world metallics situation shows we are heading down a path that leads to a severe problem. In order to understand it, we need to look at where we have been, where we are, and where we are going.

### WHERE WE HAVE BEEN

The world steel industry has undergone an incredible restructuring during the past few years. Plant closings, massive layoffs, financial losses, and corporate failures have wreaked havoc throughout the industrialized countries (ICs), including the US, Europe, and Japan.

This restructuring was driven in part by shifts in the location of steelmaking facilities and changes in product mix. The growth element of the industry became the developing countries (DCs), both in production and consumption. A telling change is that in 1991 steel production by the Steel Authority of India Ltd. (SAIL) exceeded that of US Steel. Figure 1 shows world steel production by country type for 1976 to 1993.

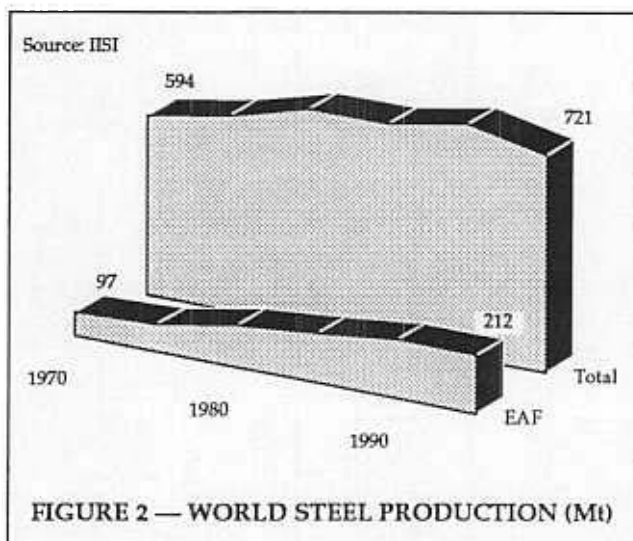


From 1976 to 1993 the DCs increased steel production by 7.6 percent per year, the Communist countries' production was flat, and the ICs decreased by 0.6 percent per year.

Steel producers in the established steel economies resisted closure of their facilities and sought protection via government policies, tariffs, quotas, and other trade restraints. Major shifts occurred in both the types and quality of products required by the market. Many established steelmakers found themselves with outdated technology and were unable to adapt. Caught with excess capacity and obsolete equipment, they tried to keep plants operating. When they found that the desired production level could not be maintained, they were forced to eliminate some facilities and modernize others. The most recent extensive modernization has involved continuous casting.

With these changes came monumental financial losses, which forced the worldwide steel industry to reevaluate where it was going. The consequence was a terribly pessimistic industry.

Electric arc furnace (EAF) steelmaking assumed a growing role during this period. As shown in Figure 2, from 1970 to 1992 the EAF share of world steel production increased from 16 percent to 29 percent.



This was principally the result of the modest capital cost of the facilities in comparison with an integrated mill, the identification of new market niches by entrepreneurial EAF operators (indeed, many observers now use the term "market mill" rather than mini-mill), and the ready availability of low cost scrap.

These mills began with an EAF, caster, and a simple rolling mill to produce reinforcing bar and merchant bar. Over time, they moved into wire rod, light structurals, and then larger structurals. Each generation of mini-mills has been superior in efficiency, lower in production cost, and more profitable.

## WHERE WE ARE

Today, we have come to the point where EAF operators are capable of producing virtually all grades of long products. In the US, almost all long products are produced in electric furnaces; exceptions are Bethlehem Steel (although Bethlehem has announced this facility will be closed soon), USS/Kobe, and Inland Steel. Now, mini-mills in the US are capturing an increasing share of the flat products market via thin and intermediate slab casting. In Europe, EAFs now have about a 31 percent share of the total steel market, and their potential share from a metallurgical perspective could be 67 percent. (1)

The big challenge facing EAF operators in making flat products is a metallurgical one - can the scrap-based EAF meet the lower residual requirements for flat products? EAF operators thinking of entering the flat products market are looking to purchase Number 1 bundles and other prime scrap to meet product quality standards. Mills producing special bar quality (SBQ), wire rod, and seamless tube are also potential consumers. All this demand on prime scrap has resulted in higher prices and increased pressure on availability, which is expected to continue, further expanding the differential between top quality and ordinary scrap.

This has been borne out by the tremendous increase in scrap prices from December 1992 to the present. As Figure 3 shows, the Number 1 Heavy Melting Steel (HMS) Composite jumped \$50/t from November 1992 to December 1993 and is at an all-time high. This increase also affects the price of scrap elsewhere in the world, since the US is the world's largest scrap exporter.

The differential between No. 1 HMS, a common grade, and No. 1 bundles, a premium grade, increased from \$13.50/t in November 1992 to \$29/t in December 1993.

Higher coke prices are also likely in the future, which adds to the problems facing integrated producers. With market pressure to cut capacity, eliminate excess facilities, and

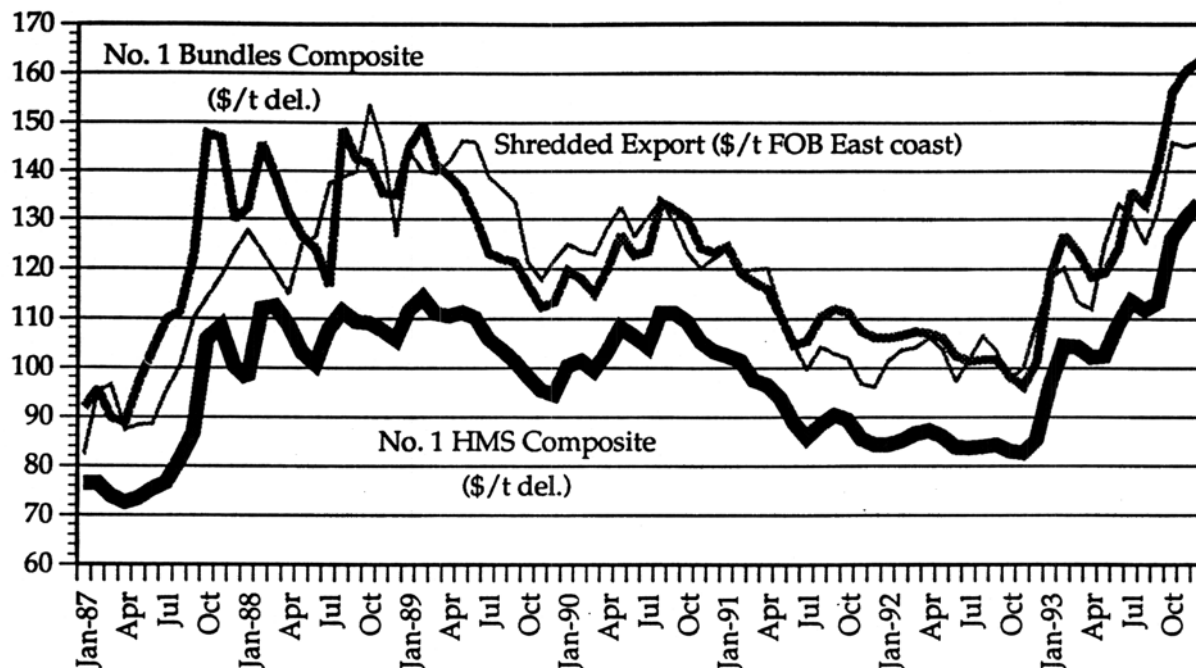


FIGURE 3 — US SCRAP PRICES

modernize essential ones, big steel must make hard choices as to where to spend its limited development funds. Robert Darnell, Chairman and CEO of Inland Steel, summed it up in a recent article:

*"The cokemaking, ironmaking, and steelmaking facilities in many companies are approaching an age at which simple repairs and maintenance will not restore them to an efficient, competitive state. Steelmakers must undertake costly refurbishing of existing facilities or use new technologies that can deliver significant benefits at about the same or less capital expenditure."* (2)

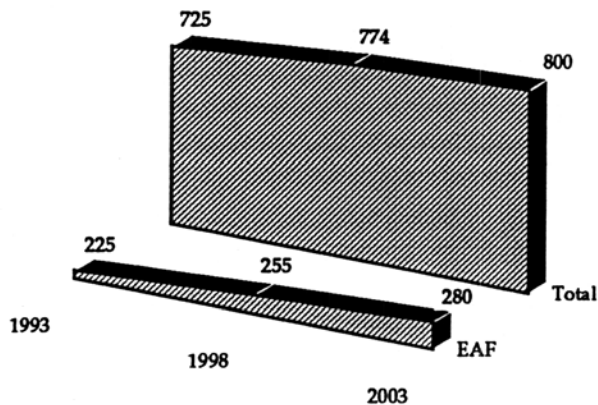
Inland recently closed its remaining coke ovens and will purchase all its coke in the immediate future. With a good one-third of US coke batteries having a life expectancy of five years or less, many others will be faced with the same decision. Azusa Tomiura, Managing Director of Nippon Steel, recently warned of a worldwide coke shortage by the year 2010. (3)

Integrated producers are trying to defer the major costs of modernizing the front end of the mill in hopes of a new technology, such as direct steelmaking, coming along - but that will not occur until the year 2000 at the earliest. Therefore, steelmakers are trying to extend the lives of their present facilities. Some are using pulverized coal injection, but this only reduces the need for coke and does not eliminate it. Others are buying slabs from suppliers in Eastern Europe, Russia, and Latin America or from domestic suppliers with excess capacity. The price of these slabs can fluctuate widely, however, and it is difficult for a company to base its entire operation on purchased semifinished material. Currently, the industry is in balance, but much of that balance is borrowing from the future and eventually a day of reckoning will occur.

#### WHERE WE ARE GOING

Economic Associates has developed and is updating a world steel production forecast to the year 2003. Figure 4 shows total steel production worldwide and the share produced by the EAF.

Source: Economic Associates, Inc.



**FIGURE 4. WORLD STEEL PRODUCTION (Mt)**

The metallics required to feed this growing production can be met by three major sources: hot metal, scrap, and scrap substitutes. Forecasting steel production by various routes enables one to estimate these metallics requirements. Table I is a world metallics balance.

The aforementioned problems facing the integrated producers will enable only a small increase in hot metal production to 2003.

There are also constraints on scrap supplies. Production of **home scrap**, which is generated within the steel mill, will decline as casting and rolling yields continue to improve. By the year 2000, the US and most other steel industries will be at essentially 100 percent continuous casting. Home scrap generation in the primary end falls from the traditional 18 percent to only two percent due to continuous casting. Add to this the impact of efficiency improvements in the rolling mill and the result is a drop in home scrap generation.

**Prompt scrap**, which is generated by the steel consumer, is expected to increase only marginally to 2003 as a result of efficiency improvements by consumers.

Thus, any significant growth in scrap requirements must be met by **obsolete scrap**, which consists of worn out and unused iron and steel products. If the 31 percent increase in "Other" requirements is met primarily by obsolete scrap, this will create problems for many low metallic residual products since obsolete scrap is the lowest quality. Also, as more obsolete scrap is required, collection and processing costs increase. There is a tremendous potential supply of scrap worldwide, but much of it cannot be economically recovered.

**TABLE I  
WORLD METALLICS REQUIREMENTS (Mt)**

	1993	1998	2003	% Increase 1993-2003
Crude Steel production	725	774	800	10.3
EAF	225	255	280	24.4
BOF/OH	500	519	520	4.0
Steelmaking metallics requirements	841	907	949	12.8
Hot metal	407	421	420	3.2
Scrap	408	448	479	17.4
Home scrap	113	115	108	-4.4
Prompt scrap	87	93	98	12.6
Other*	208	240	273	31.3
Scrap substitutes	25	38	50	100.0

\* Other (primarily obsolete scrap) is defined so that non-steel requirements for scrap (e.g., foundries) and availability is assumed in balance

Source: Economic Associates, Inc.

It should be noted that Table I is a forecast of the metallics requirements given our steel production scenario. If there is a shortfall in either hot metal, home scrap, prompt scrap, or scrap substitutes, it must be met by an increase in other metallics.

For example, Midrex Direct Reduction Corporation forecasts world DRI production of 28 Mt in 1995, 35 Mt in 2000, and 40 Mt in 2005, based on the likelihood of specific projects proceeding. If this is the case, the scrap substitute requirements shown in Table I will not be satisfied and this shortfall must likely be met by a further increase in obsolete scrap or pig iron.

Merchant pig iron may play a more important role in providing the EAF charge requirements in the future. As of early December 1993, Japanese integrated producers had contracted for 800,000 t of pig iron exports for delivery between October 1993 and March 1994. This material is now available due to low Japanese domestic steel demand. In the fourth quarter of 1993 there has been a significant amount of Brazilian, Russian, and Japanese pig iron imported to the US for use in EAFs; this contrasts with imports of just 16,000 t from April - September 1993. However, the availability of merchant pig iron is variable and EAF producers cannot rely on it as a major long-term source of metallics. Also, the environmental situation in Brazil may limit future charcoal-based pig iron production. Low cost supplies from Russia and the former Communist Bloc countries will decrease in the future as those countries move toward market economies.

Along the same lines, semifinished steel, such as billets and slabs, is being traded freely now. As with pig iron, the supply of semifinished products varies widely in cost and tonnage; in contrast, however, it does not reduce world-wide demand for metallics because the metallics to produce the steel are still required. Regional imbalances in steel supply and demand result in the availability of low priced pig iron and semifinished, but these imbalances are short-term. Over the long term, thin slab casting may decrease slab trade because thin cast material must be rolled where it is produced.

As noted earlier, the EAF is expected to play an increasing role in worldwide steelmaking. This includes producing products once considered "reserved" for integrated producers, such as flat products. However, mini-mills will in most cases be relegated to the lower end of the flat products

market and will encounter barriers to marketing unless they can match the integrated metallurgically as well as physically.

One solution to his dilemma is larger supplies of direct reduced iron (DRI) and hot briquetted iron (HBI). In 1993, 24 million metric tons (Mt) was produced worldwide (compared with scrap consumption of over 400 Mt), with about 2 Mt used in North America. DRI and HBI are being used as a complement to prime scrap in the EAF, BOF, and blast furnace; they enable steelmakers to reduce metallic residuals and improve the overall metallurgical, chemical, and physical characteristics of their products. Mills use from 10 to 60 percent to produce high quality products such as wire rod, SBQ, seamless pipe, and flat products. The high metallic iron content, consistent chemical and physical characteristics, and carbon content of DRI and HBI provide steelmakers broad flexibility in selecting their furnace charges while maintaining normal operating procedures.

Gas-based and coal-based direct reduction are excellent solutions to the world's need for charge materials because of the availability of reasonably priced natural gas, coal, and iron ore. The DR/EAF steelmaking route offers a cost effective, environmentally compatible steelmaking method for newly developing steel industries and established operations.

Several factors have contributed to improved prospects for gas-based and coal-based DR projects to serve the North American market. Increased scrap prices are an incentive for EAF and integrated mills to search for supplies of scrap substitutes. Mini-mills entering the high quality markets must find a way to control metallic residuals. In addition, the enhanced profitability of the major mills has caused them to look for ways to maximize hot metal output in existing facilities. As a result many projects are being developed to provide North America with DRI.

Many of the planned projects, as well as the majority of the world's present DR plants, are "captive" facilities; i.e., they produce DRI for use in an adjacent meltshop. Some of the planned plants will be "merchant," which are set up to produce HBI or other scrap substitutes for sale on the open market. These merchant plants, which can be located on-shore or overseas, will satisfy the demand for a source of metallic iron by steel mills without their own DR plants.

## CONCLUSION

What does the future hold for integrated producers? Many are at present buying time until a new steelmaking technology becomes available because they do not have either the necessary capital or desire to modernize their primary facilities. Some are installing pulverized coal injection systems and buying slabs. Another option, now used by Armco and Weirton, is to feed DRI and HBI to the blast furnace to increase productivity and lower the coke rate. However, these are not long-term solutions. Some form of direct ironmaking probably will be the most suitable long-term solution for the integrated producers, but that will be many years coming.

For the minis, the future is not entirely rosy, despite their successes. As more competition evolves in both the flat and long products markets, only the strongest will survive. Also, the surviving integrated companies will be even better positioned and more formidable competitors. The metallics shortage will affect all.

The increased head-to-head competition between the minis and integrats will provide a great learning experience for all. It is not an "either/or" situation. Those steelmakers, both large and small, who are able to successfully adapt to the changing scene will survive; those who cannot will die. Integrats, such as Dofasco (J/V partner with Co-Steel in

Gallatin Steel, a new flat products mini-mill) and LTV, with its new direct charging mill staffed at a mini-mill level, are now adopting some mini-mill concepts. The minis are also looking into some lessons from their larger brethren; Nucor's backward integration into ironmaking (Iron Carbide) is an example.

"There's room in the steel industry for a blend of both more traditional and also the newer lower-cost alternatives," notes John Mayberry, Dofasco's President and CEO. "There's not one answer that will work for every company." (4)

## REFERENCES

- 1) Bryan Berry, "Big Steel vs. Mini Steel," New Steel, December 1993, p. 22
- 2) Bryan Berry, "An Identity Crisis at Big Steel," New Steel, December 1993, p. 12
- 3) Norman Samways, "International Iron and Steel-1993," Iron and Steel Engineer, December 1993, p. 49
- 4) Bryan Berry, "Big Steel vs. Mini Steel," New Steel, December 1993, p. 24