Title:

Challenges and opportunities for merchant OBMs along the pathway to carbon-neutral steelmaking

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Abstract:

IIMA has launched an ongoing investigation into the role ore-based metallics (OBMs) are likely to play in the pathways to carbon-neutral steelmaking. Four "Whitepapers" have been published to-date on this topic and a recent analysis of strengths, weaknesses, opportunities (SWOT) and threats was undertaken. From this work so far five key outcomes have been identified and are discussed in this short paper.

1.1 Introduction

The changes to steelmaking to achieve the necessary reduction in emissions of carbon dioxide will not happen overnight and so most companies and organisations are developing strategies or pathways towards carbon-neutral steelmaking based on intermediary steps that reflect the marriage of existing assets with investment in future adaptable technologies. As a result, there are a plethora of pathways. The aim of this section is to provide a summary of the strengths, weaknesses, opportunities, and threats identified and, in some cases, implied in the preceding Whitepapers that relate to the utilisation of merchant ore-based metallics (OBMs) along these pathways.

Five key outcomes can be drawn from the analysis and discussion so far:

- **There will be increasing demand for ore-based metallics primarily due to the expansion in electric arc furnace steelmaking.**
- **Existing initiatives and technological advancements demonstrate that carbon-neutral production of ore-based metallics is realistic.**
- **Sustaining the merchant OBMs market will depend on reductions in Scope 3 emissions as much as Scope 1 and 2.**
- **OBM's are enablers of scrap recycling and decarbonisation of steelmaking and in so doing contribute to the circular economy.**
- **Creating a carbon-neutral OBM sector requires collaboration throughout the steelmaking supply chain.**

1.2 Expanding EAF use and demand for OBMs

Significant uptake of EAF based steelmaking and a corresponding reduction in utilisation of BF/BOF is envisaged as a core element in many of the currently proposed pathways. Electric steelmaking based on the use of renewable energy and hydrogen as a fuel and reductant linked to increased utilisation of ferrous scrap can achieve up to 75% less CO_2 emissions compared to traditional BF/BOF steelmaking.

This in part explains why the International Energy Agency (IEA) is predicting a 411 mt demand led annual production of DRI by 2050 which is an increase of 280% over the 108mt produced in 2019.

In practice OBM's can be used in a variety of furnaces in combination with other forms of metallics. Indeed, this flexibility coupled with the advantages of process digitisation can assist in realising operational efficiencies and associated reductions in CO_2 emissions.

A potential disruptor to this scenario would be the advancement of steelmaking technologies such as Molten Oxide Electrolysis (MOE) that would eliminate the need for carbon or hydrogen based chemical reduction of iron ore. Instead, iron ore would be melted by an electro-chemical process that uses direct electric current to separate out the iron and oxygen from the ore. Of course, for this process to be carbon-neutral there would need to be an abundant supply of renewable energy, the same energy source that could be employed in the production of hydrogen to be used as a reductant for transforming iron ore into an OBM or "green iron".

1.3 Carbon-neutral production of OBMs is realistic

There is proven capability of carbon-neutral production of OBMs or "green iron". The use of charcoal in the production of green pig iron is a forerunner technology primarily used in Brazil. The charcoal is derived from planted, sustainable forests whereby the growing trees absorb an amount of CO_2 that offsets what is released by burning the charcoal. There are challenges to expanding the use of charcoal in pig iron production notably the cost of producing charcoal and the low mechanical strength of the material which poses constraints on the size of the blast furnace that it can be used in and therefore the production capacity.

The larger proportion of pig iron production is currently coal-based but the development of carbon capture utilisation and storage (CCUS) technology could sustain its production and use. However, the growing efforts to reduce the use of coal and the likely impact this will have on the cost and availability of coke will be a continuing threat to the sustainability of pig iron.

Direct reduced iron (DRI) production using hydrogen as both a fuel and a reductant is featured in many of the carbon-neutral steelmaking pathways seen today. The technology to produce DRI using hydrogen is available today and some DRI is already produced using reducing gases that include a mix of hydrogen. Here the hydrogen is derived from cracking of natural gas and is the type referred to as blue hydrogen. Some researchers argue that the carbon footprint of blue hydrogen can be greater than natural gas. The virtues of using blue hydrogen in absence of the widespread availability of green hydrogen is likely to be an ongoing debate. However, what some commentators may fail to appreciate is that hydrogen would be utilised as a reductant as well as a fuel in DRI production. Given the time it takes to build and commission DRI units it may be advantageous to use blue hydrogen in the interim as a primer for green hydrogen-based production.

It is important to reflect on the fact that the speed of development of the pathway to hydrogen-based production of DRI will be dependent on the cost-effective production and availability of both DRI pellets (primary feedstock) and hydrogen (fuel and reductant).

- DRI grade pellets: The balance of supply and demand for DRI pellets today is precarious with significant volatility arising at the end of 2015 when the Samarco operations were halted following the tragic tailings dam collapse. Although Samarco has restarted production it has yet to reach capacity and is beset with ongoing regulatory and financial challenges. Section 5 discusses in depth the challenge of building DRI pellet supply in the face of predicted rising demand, looking at the perspective for short to medium supply and the longer term. The prospect of iron ore miners extending their operations downstream to include DRI pellet production is one potential scenario, but this will be heavily dependent on the quality of iron ore and/or the technology for low-carbon beneficiation of ores.

- Hydrogen: One mining company Fortescue Metals Group (FMG) recently announced details of their ambition to go one step further and generate green iron based on hydrogen DRI production a similar proposition to that of LKAB. Here again the availability of hydrogen is a key ingredient to success but in this instance Fortescue's diversification into renewables and future green hydrogen production could underpin their success. What is also interesting to note is that judging by recent partnership announcements, current prospects for green hydrogen production by Fortescue appear to lie outside of Australia, the territory that holds the bulk of their ore deposits. For example, Fortescue recently signed a Master Development Agreement with Papua New Guinea which they state is "one of the most renewable energy - rich countries in the world". This example demonstrates how the supply of both green hydrogen and DRI grade pellets could be geographically diverse, which coupled with interest in value-add production of green iron like that of Fortescue, could signal significant increase in the production of "merchant" DRI. What is not clear is the proportion of OBMs that will be produced in captive steelmaking operations compared to that of merchant OBMs.

1.4 Sustaining the merchant OBMs market will depend on reductions in Scope 3 emissions as much as Scope 1 and 2

As discussed in the preceding section the prospect of production of carbon-neutral OBMs is realistic however the sustainability of the merchant OBM market will depend heavily on the ability of miners and shippers to realise carbon-neutral operation.

Both miners and shippers are actively seeking ways of reaching carbon-neutral operations through development of electrified digging and haulage equipment in mining and zero-carbon fuels in shipping. However, if shipping does not keep pace with the decarbonisation efforts of the iron and steel sector it could similarly result in the import of merchant OBM's being at a disadvantage to captive or integrated mine-to-steel production.

The potential for future carbon pricing and carbon border adjustment mechanisms (CBAM) like that envisaged in the EU introducing taxes and surcharges based on the carbon footprint of raw materials and products could disadvantage merchant OBM production. In the case of the EU CBAM significant clarity and agreement on measurement and reporting of carbon emissions relating to hot metal and OBM production is required to not create disproportionate impact on merchant OBMs. There is currently a paucity of information on the carbon footprint of merchant OBMs which needs addressing.

1.5 OBMs are enablers of scrap recycling for decarbonisation and the circular economy

Throughout the four whitepapers it has been noted that OBMs are a crucial source of clean iron units that can be used to supplement and enhance the scrap charge in steelmaking. With their high Fe content, low gangue content, and relative chemical purity OBMs provide steelmakers with the essential ingredient for ensuring the composition of the iron melt is of the right quality for the finished steel product. A fact that since OBMs are essentially an intermediate step in the route from iron ore to steel production is often lost on many both inside and outside the industry. The limited visibility of the merchant OBM sector in this regard in the face of larger and higher profile industrial concerns with respect to decarbonisation could disadvantage the sector, through ignorance and a lack of understanding of the vital role played by merchant OBMs.

While analysts confidently predict year-on-year increases in the availability of ferrous scrap over the coming decades to 2050, what is less clear is the trajectory for the quality of this material. There already is acknowledgement that the content of residual impurities such as copper, which can be deleterious to the production of steel, is rising in some ferrous scrap types.

Continued deterioration in scrap quality will lead to increased demand for OBMs however this will soon reach a point where the benefits of decarbonisation and the circular economy are undermined, certainly in the short-to-medium term where more iron ore will need to be mined and processed to meet rising demand in OBMs to sustain high quality steelmaking feedstocks. However, whilst this could be a relatively good outcome for merchant OBMs the continued deterioration of scrap quality will likely cause breakdown in the circular economy for steel, reduced investment in EAF steelmaking and possible steel substitution.

There is growing urgency for steps to be taken towards better definition, sorting, and tracking of ferrous scrap to ensure different qualities and grades of scrap are confined to discrete channels which are then directed towards the production of specific types of steel based on quality and performance requirements. Given the movement of ferrous scrap across international boundaries this needs to happen in a collaborative and harmonised manner globally. It is probable that different economic models will be needed with new pricing structures and incentives for maintenance of clean scrap. These measures should affect scrap processors and product manufacturers alike, incentivising the latter to design products where metals such as copper that occur alongside steel are easily separated on dismantling of the discarded product.

1.6 Creating a carbon-neutral OBM sector requires collaboration throughout the steelmaking supply chain.

A universal truth arising throughout the Whitepapers is the interdependency of stakeholders such as iron ore miners, OBM producers, scrap processors, shippers, and steelmakers along the pathways to successful realisation of sustainable carbon-neutral production. This message is already highlighted at the end of Section 3 in the case of the future of DRI reduction. Collaboration is called for in the first instance to understand better the needs and aspirations of each stakeholder with respect to balancing the reduction of their Scope 1 and 2 emissions with the requirements of others to reduce theirs. In so doing this collaboration should bring about an effective decrease in the Scope 3 emissions of that stakeholder.

Collaboration would benefit the development of complementary technology and ensure that the timing of transitions in the properties and production of raw materials do not undermine the balance of supply and demand of the feedstock for steelmaking to the detriment of emergent low carbon processes.

One area of development that would benefit greatly from collaboration particularly between the public and private sectors and the regulation thereof is renewable energy supply and demand and the hydrogen economy. Whether and how this is achieved is still unclear as is the technology pathway for hydrogen. Collaboration will be difficult to perfect in such a deeply competitive space and even now some stakeholders are calling for greater clarity in the pathway(s) to green hydrogen and carbon-neutral steelmaking to aid a more efficient transition. The best route of change is often disruptive with winners and losers such that open discussion on a regular basis can best serve to ensure such change is sustainable.

1.7 Conclusions

The present suite of Whitepapers offer some perspective on the potential role of OBMs in the decarbonisation of steelmaking, seeking to prompt a sustainable pathway for the sector to 2050 and beyond.

It provides insight into the complexity surrounding the sector involving both upstream and downstream actors and highlights the need for technological innovation and adaptation, new business models and enabling policy. Research and development and knowledge sharing will be key to maintaining momentum and achieving the goal of decarbonisation as will collaboration.

The IIMA Whitepapers are one of many thought pieces on the topic of the pathway to carbon-neutral steelmaking emerging over the past two years, although the IIMA papers somewhat uniquely look at the issue through the lens of sustainability in the merchant OBM sector. IIMA will continue to progress thinking on this topic and promote knowledge sharing, treating the Whitepapers as living documents subject to regular updates in a form that best serves the timely delivery of information and messaging. In addition, further Whitepapers are envisaged on specific topics to complement the existing suite of papers.

References:

IIMA Whitepaper 1 – Ferrous Metallics for Steelmaking

IIMA Whitepaper 2 – Future Challenges for the Electric Arc Furnace Process

IIMA Whitepaper 3 – Future DRI Production and Iron Ore Supply

IIMA Whitepaper 4 – Blast Furnace/Basic Oxygen Furnace Steelmaking and Alternative Iron Smelting Technologies