



Global overview of ore-based metallics

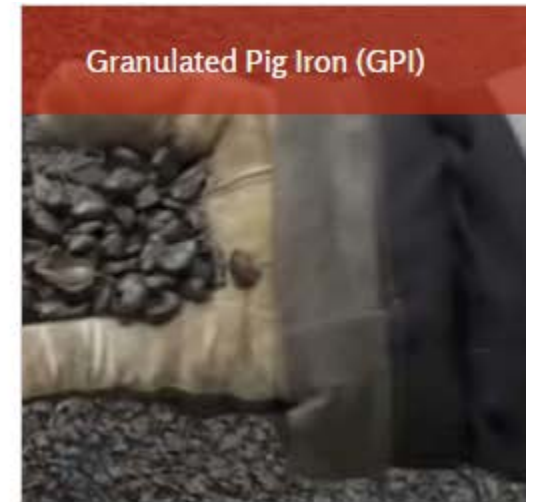
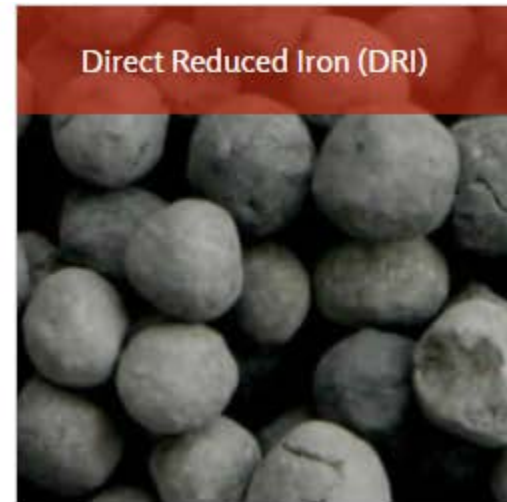
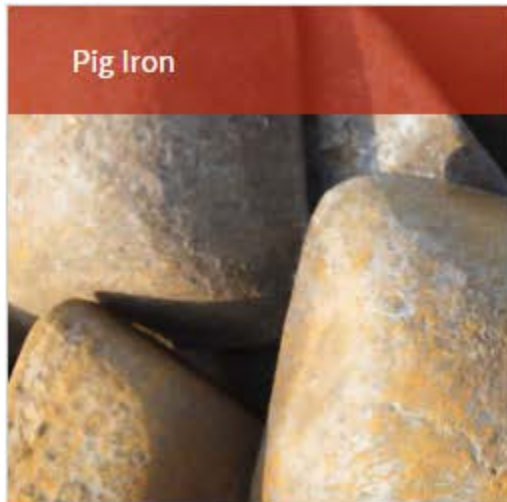
AMM DRI & MINI-MILLS CONFERENCE – NOVEMBER 2017

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Presentation brief from AMM

- 1. What international developments are compounding the supply of ore-based metallics to the USA?**
- 2. To what extent could future DR plants in the USA replace the demand for international pig iron?**
- 3. Could the increasing number of DR plants in the USA change the global trends of raw materials?**
- 4. Are the difficulties of procuring ore-based metallics outweighed by their benefits?**

IIMA is the trade association for the ore-based metallics industry.....



What does IIMA do?

As the unified voice of the ore-based metallics industry:

- furthers the interests of members and the industry
- **promotes ore-based metallics as value-adding feedstock for the steel and ferrous casting industries**
- identifies and addresses threats to and opportunities for the industry
- communicates with stakeholders at industry level
- provides regulatory support
- provides a forum for exchange of ideas at the scientific and technical levels

Benefits of ore-based metallics in EAF

- Consistent quality and low residual content
- Dilutes impurities in scrap
- Better slag foaming
- Controlled C content, consistent C recovery
- N scavenger = low N content in steel
- Easier on hearth refractory & electrodes
- High density feedstock (pig iron & HBI), less charging time
- DRI/HBI can be continuously charged to EAF

= added value relative to scrap

Ore-based metallics are **NOT** scrap substitutes, they are **VALUE-ADDING** feedstock materials which have a value greater than that of their iron content! They are **SCRAP SUPPLEMENTS!**

(.... and while we're at it, we hate the term "alternative irons!")

What is value-in-use?

- **Value-in-use as applied to steelmaking raw materials is a methodology that attempts to capture the true contribution and penalties associated with the use of particular feedstock materials in the steelmaking process**
- **In the past:**
 - historically, conventional scrap models aimed at providing the least cost scrap charge to meet specified residual levels
 - such models do not take into account process parameters, environmental factors and other important scrap characteristics
 - not set up for feedback from process data, e.g. “real time” slag analysis
 - do not capture true “value in use”

- **Relative value-in-use of EAF feedstock materials relates to how they impact steel manufacturing costs**
 - **Slag Generation Rate**
 - **Flux Consumption**
 - **Yield**
 - **Electricity and Energy Consumption**
 - **Alloy costs**
 - **Productivity**
 - **Electrode consumption**
 - **Requirements for scrap dilution**
 - **Environmental issues**
- **These costs are real and can overtake price differences!**

IIMA's value-in-use model

- **Developed by Jeremy Jones of CIX LLC in co-operation with IIMA**
- **Based on Excel and Visual Basic, easy to operate and should give quickly principle judgements**
- **The model determines the value of OBM's relative to scrap**
- **More complex models may optimize the whole scrap charge and take into account additional factors**
- **More information at <https://www.metallics.org/viu-model.html>**

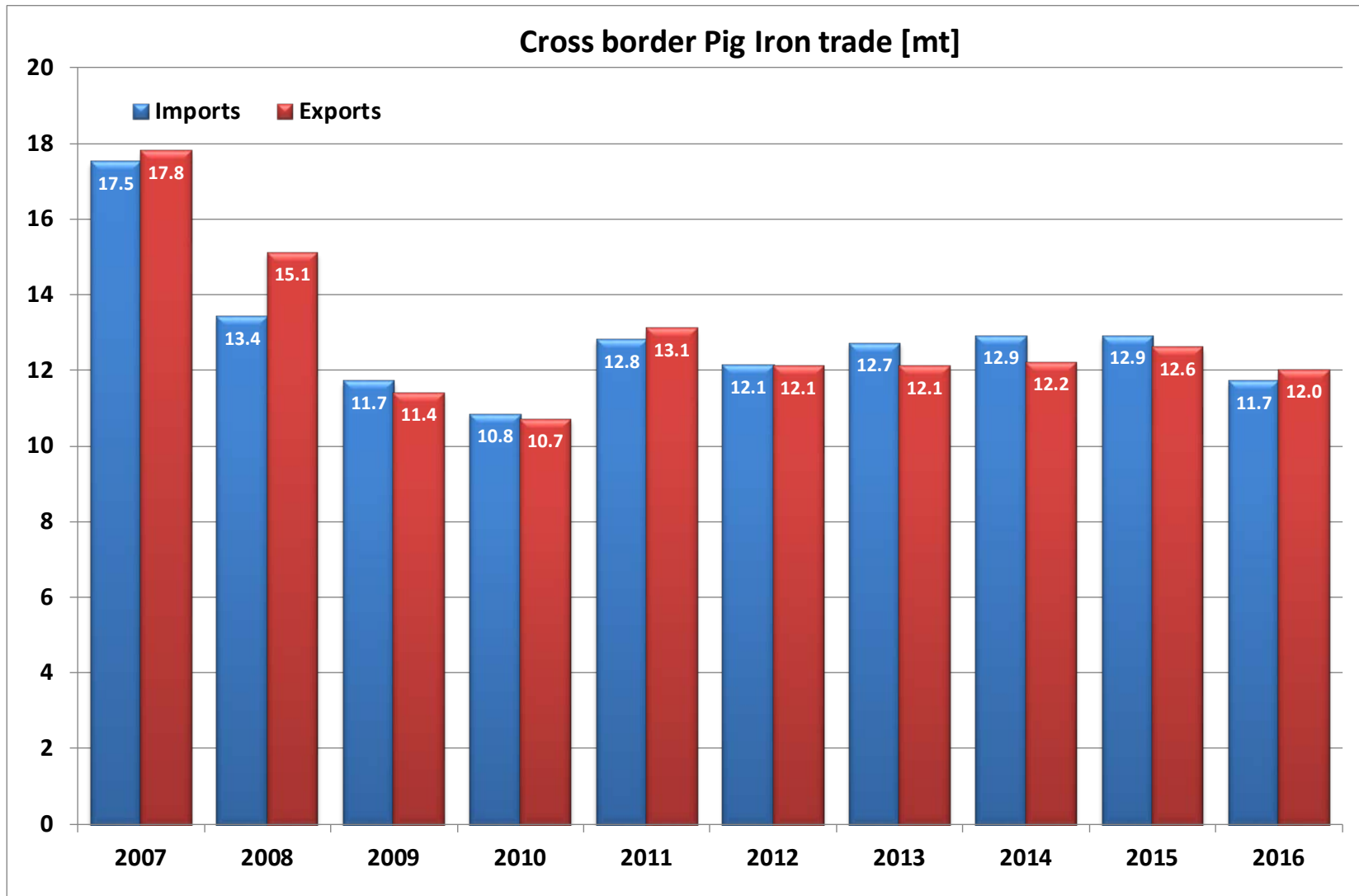
So, are the difficulties of procuring ore-based metallics outweighed by their benefits?

A rhetorical question in return: what are the difficulties?!

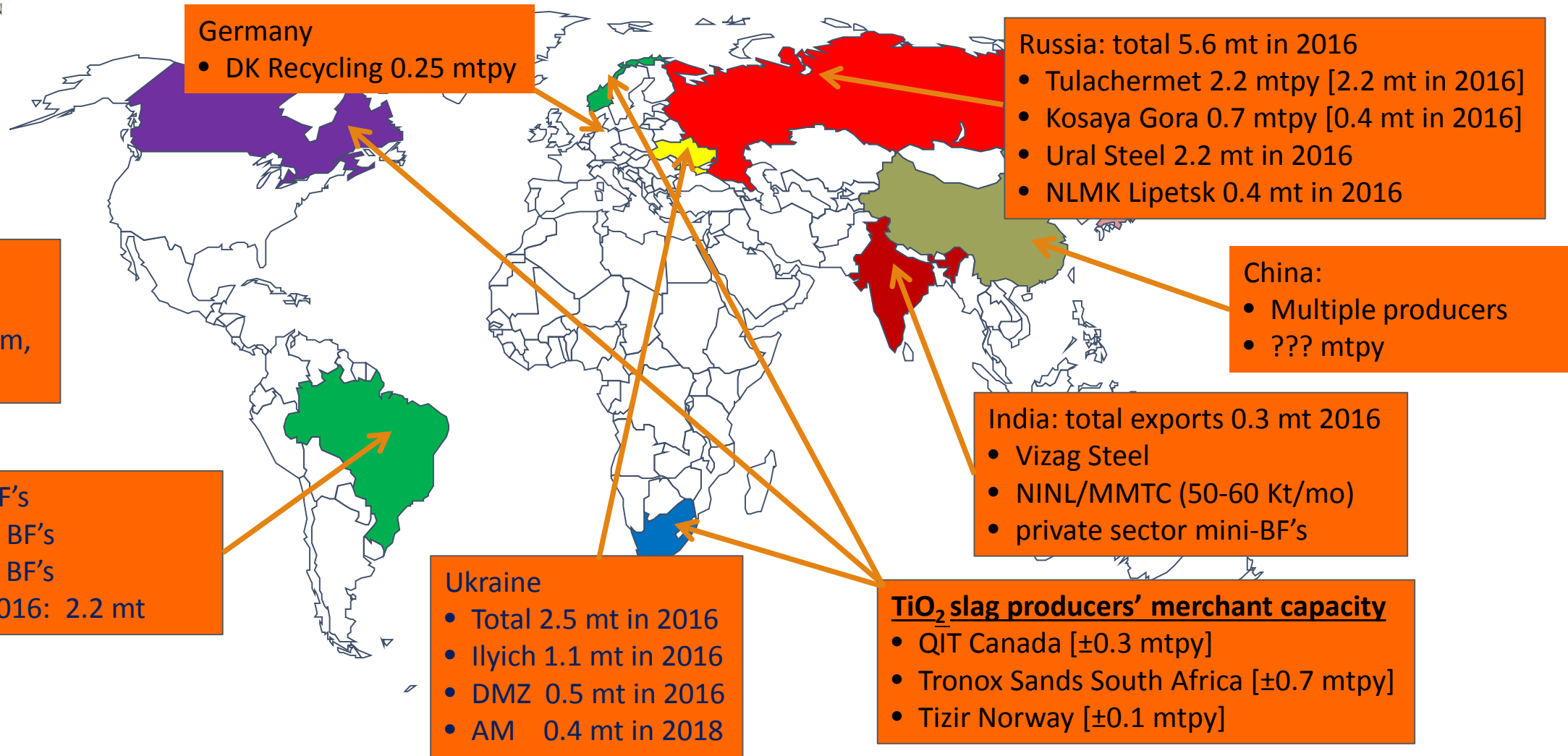
Answer: in general, yes, of course, but the quantum varies from EAF to EAF and according to steel product specifications, local scrap supply, etc.

If a perceived difficulty is handling and transportation, especially of DRI, please refer to Nucor.....

Global trade in pig iron

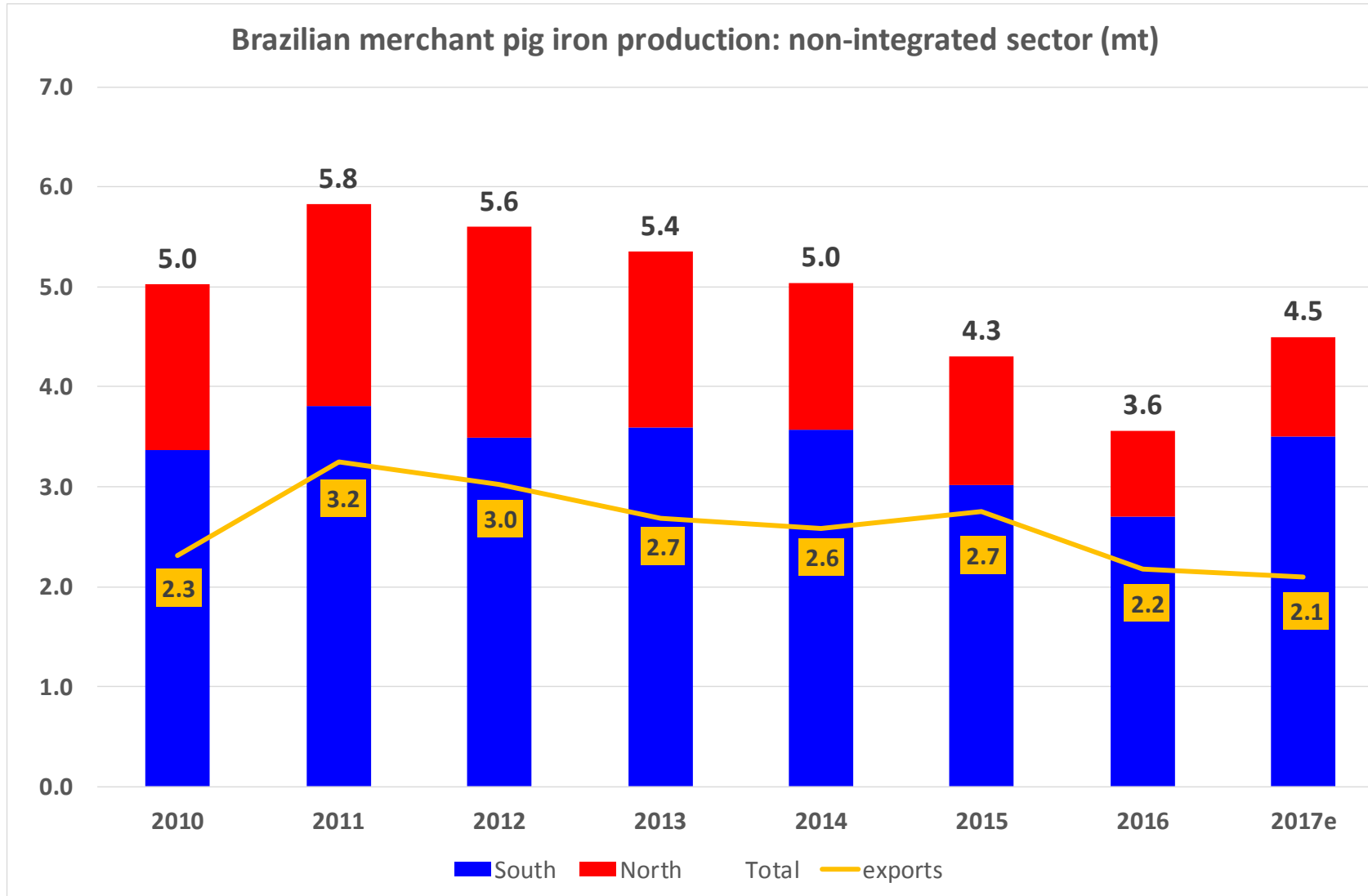


Global merchant pig iron supply

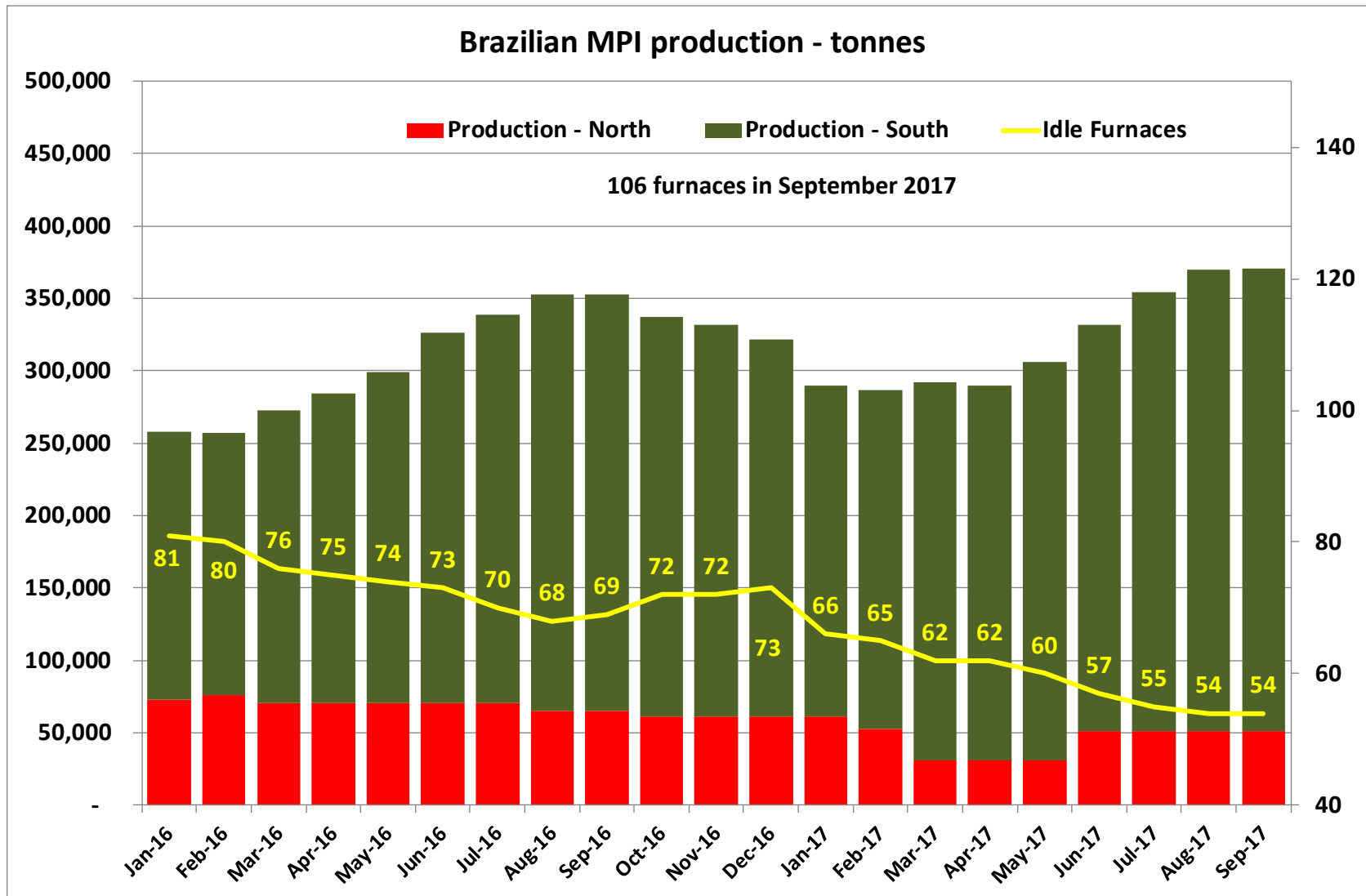


MERCHANT PIG IRON PRODUCING COUNTRIES

MPI supply-side: Brazil



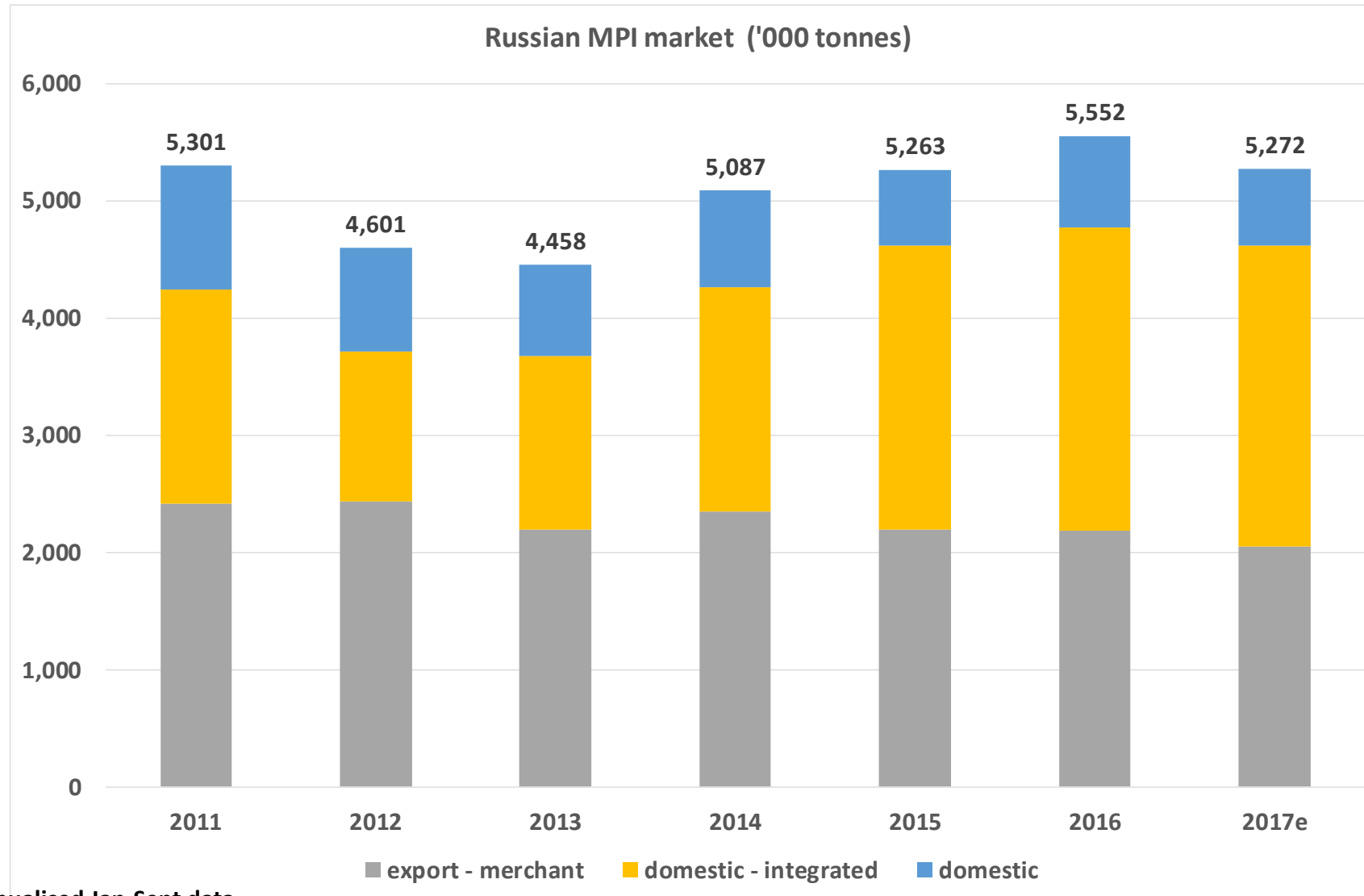
MPI supply-side: Brazil



MPI supply-side issues: Brazil

- **Although Brazil's nominal MPI capacity is about 10 mt, it is unlikely that this level will be reached again:**
 - charcoal supply could be a constraint
 - many of the smaller furnaces are not competitive cost-wise
 - some pig iron producers now also have the option to produce steel
- **A more realistic estimate would be that production of 5-6 mt is achievable in the foreseeable future**

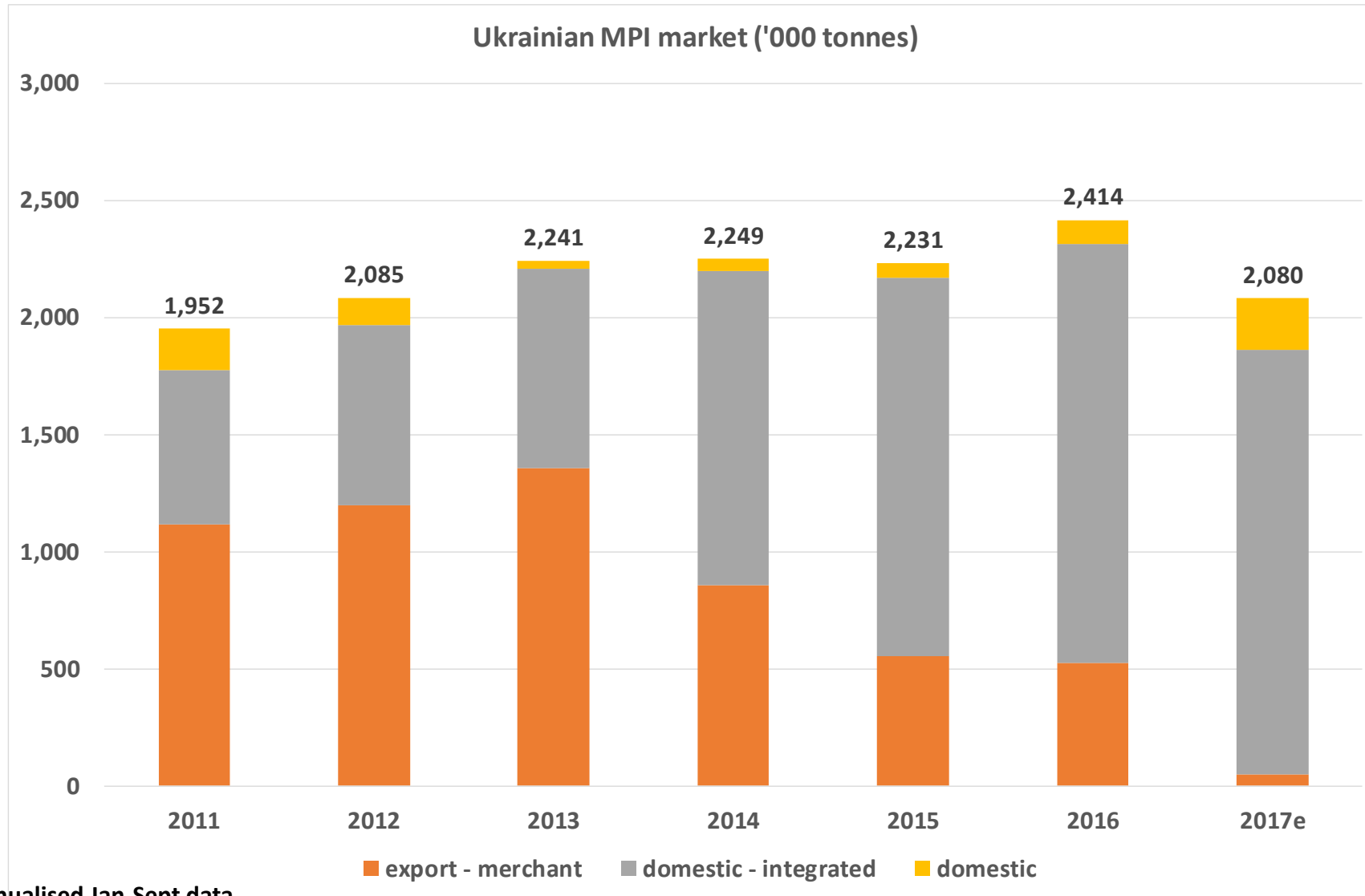
MPI supply-side: Russia



Data source: Metal Expert

Note: 2017 estimate is annualised Jan-Sept data

MPI supply-side: Ukraine



Data source: Metal Expert

Note: 2017 estimate is annualised Jan-Sept data

- **CIS integrated steel mills have the choice to sell pig iron or make steel, so relative margin is an important driver**
- **Tulachermet will commission its adjacent steel mill in 2018 which will consume 1.2 mt pig iron by 2020**
 - BF #1 will be blown in and BF #2 will be taken out of service in 2018, BF#3 will be refurbished in 2018 (BF#2 could be rebuilt in the future)
 - MPI availability will fall to 1.9 mtpy from 2020 (2.1 mt in 2018, 2.2 mt in 2019)

MPI supply-side issues: CIS



- **Ukrainian supply influenced by political situation in Luhansk and Donetsk**

MPI supply-side: new projects in US/Canada

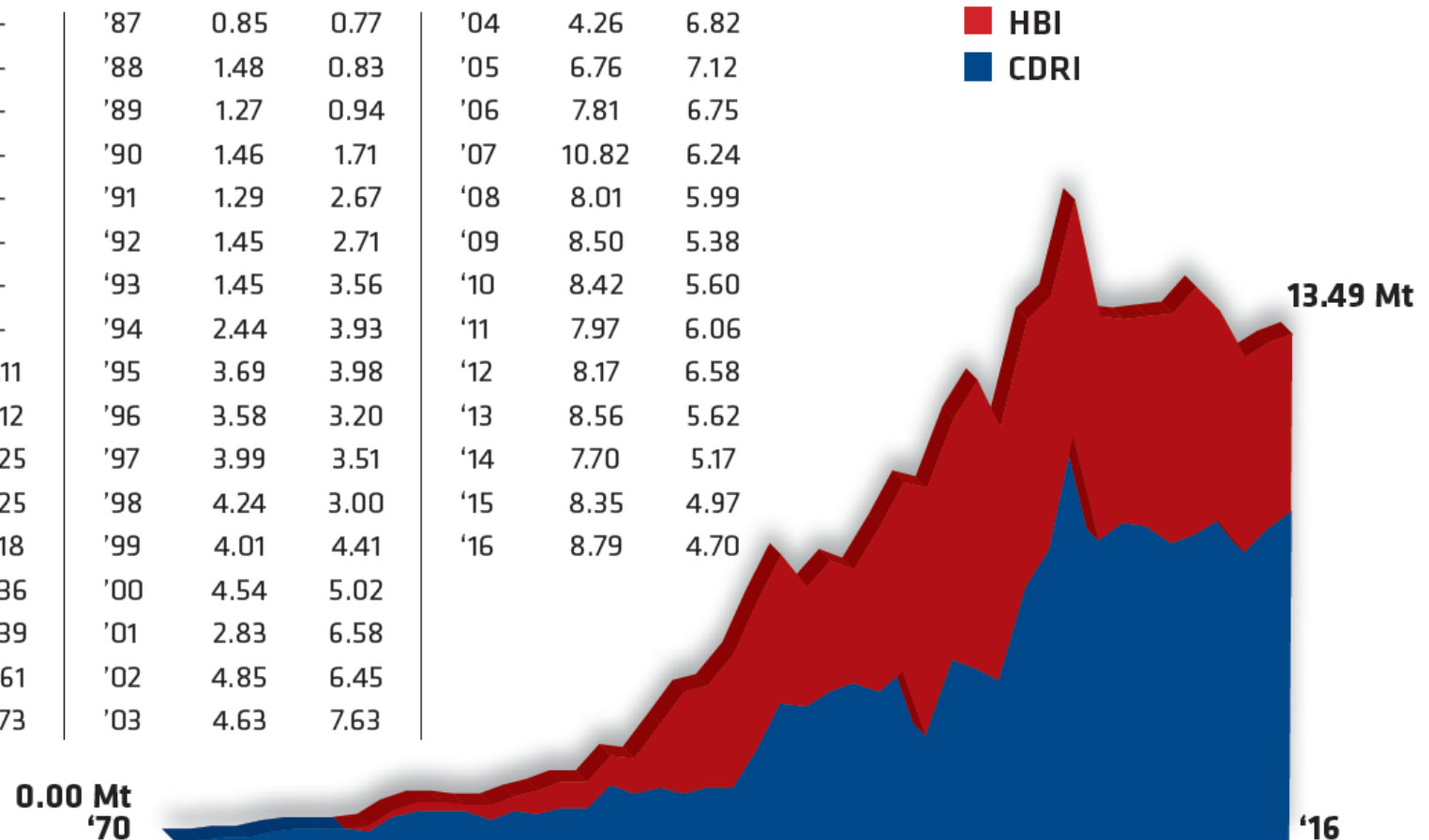
- **North Atlantic Iron Corp: planning 0.425 mt merchant pig iron plant, based on purchased iron ore pellets, considering two locations, in Quebec and Ohio.**
- **Republic Steel / ERP Iron Ore joint venture: plan is to restart the blast furnace at Lorain, OH and sell 1 mt pig iron, based on pellets from ERP's Reynolds, IN pellet plant.**
- **BlackRock Metals: plans to exploit V- and Ti- bearing magnetite and ilmenite deposits in Chibougamau, Quebec to produce ferro-vanadium, TiO₂ feedstock and potentially 0.525 mt high purity pig iron**

World DRI/HBI shipments

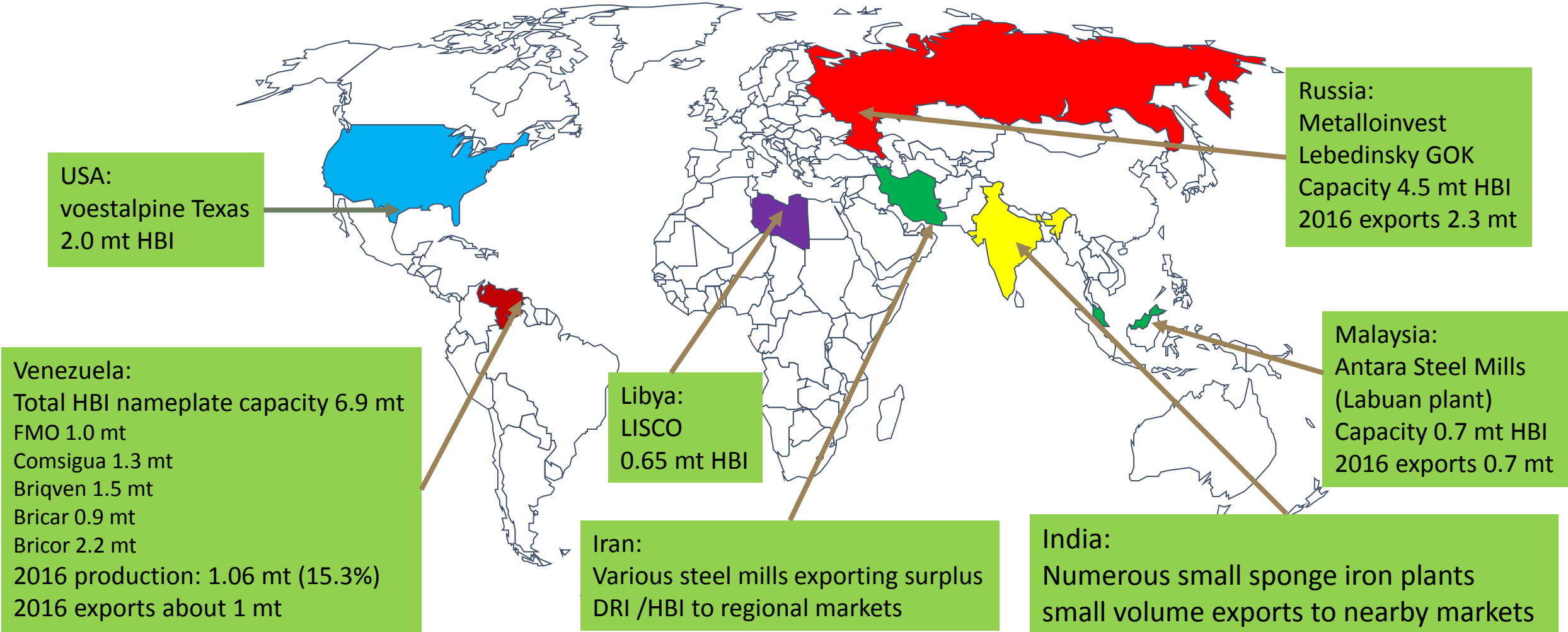
World DRI Shipments (Mt)

Source: Midrex Technologies, Inc.

Year	CDRI	HBI	Year	CDRI	HBI	Year	CDRI	HBI
1970	0.00	-	'87	0.85	0.77	'04	4.26	6.82
'71	0.04	-	'88	1.48	0.83	'05	6.76	7.12
'72	0.08	-	'89	1.27	0.94	'06	7.81	6.75
'73	0.13	-	'90	1.46	1.71	'07	10.82	6.24
'74	0.26	-	'91	1.29	2.67	'08	8.01	5.99
'75	0.34	-	'92	1.45	2.71	'09	8.50	5.38
'76	0.37	-	'93	1.45	3.56	'10	8.42	5.60
'77	0.32	-	'94	2.44	3.93	'11	7.97	6.06
'78	0.28	0.11	'95	3.69	3.98	'12	8.17	6.58
'79	0.66	0.12	'96	3.58	3.20	'13	8.56	5.62
'80	0.81	0.25	'97	3.99	3.51	'14	7.70	5.17
'81	0.83	0.25	'98	4.24	3.00	'15	8.35	4.97
'82	0.80	0.18	'99	4.01	4.41	'16	8.79	4.70
'83	0.59	0.36	'00	4.54	5.02			
'84	0.83	0.39	'01	2.83	6.58			
'85	0.71	0.61	'02	4.85	6.45			
'86	0.89	0.73	'03	4.63	7.63			



Global merchant DRI/HBI supply




HBI supply-side developments

- **LebGOK HBI #3 module started up in March 2017, adding at least 1.8 mt to global HBI capacity**
- **voestalpine Texas HBI plant started up in October 2016, adding 2.0 mt to global HBI supply (about 50% to be consumed in own blast furnaces in Austria)**
- **HBI production in Venezuela is severely constrained by lack of pellet supply, maintenance and spare parts, etc.**
- **Nucor Louisiana DRI production has been constrained by plant/equipment issues.**

New sources of HBI, actual and potential

- **Cleveland Cliffs' 1.6 mt Midrex HBI plant at Toledo, OH, scheduled for start of commercial production in mid-2020, to be supplied with DR grade iron oxide pellets from captive North Shore operation**
- **Chippewa Capital Partners plans 1.8-2.0 mt Energiron DRI/HBI plant as part of plan to revive the Essar Minnesota/Mesabi Metallics project at Nashwauk, MN. Under the bankruptcy agreement, construction of the DR plant must be completed by end 2021.**
- **IMC (International Metallics Corp (Canada), Ltd.) plans 2 mt Midrex HBI plant at Bécancour, Quebec (project is at study stage)**


Granulated pig iron – a new old commodity



a unified voice for the metallics industry

Use of Granulated Pig Iron (GPI) in the Electric Arc Furnace (EAF)

- Steel production in the EAF continues to grow worldwide.
- EAF operators prefer to use GPI to blend with scrap and other metallics due to its high Fe and energy (C, Si) content, low gangue and chemical purity, rapid melting properties as well as for easy and automated handling, being possible to top-feed the EAF.
- GPI should not be considered as a scrap substitute but rather as a source of clean iron units that can be used to supplement and enhance the scrap charge.

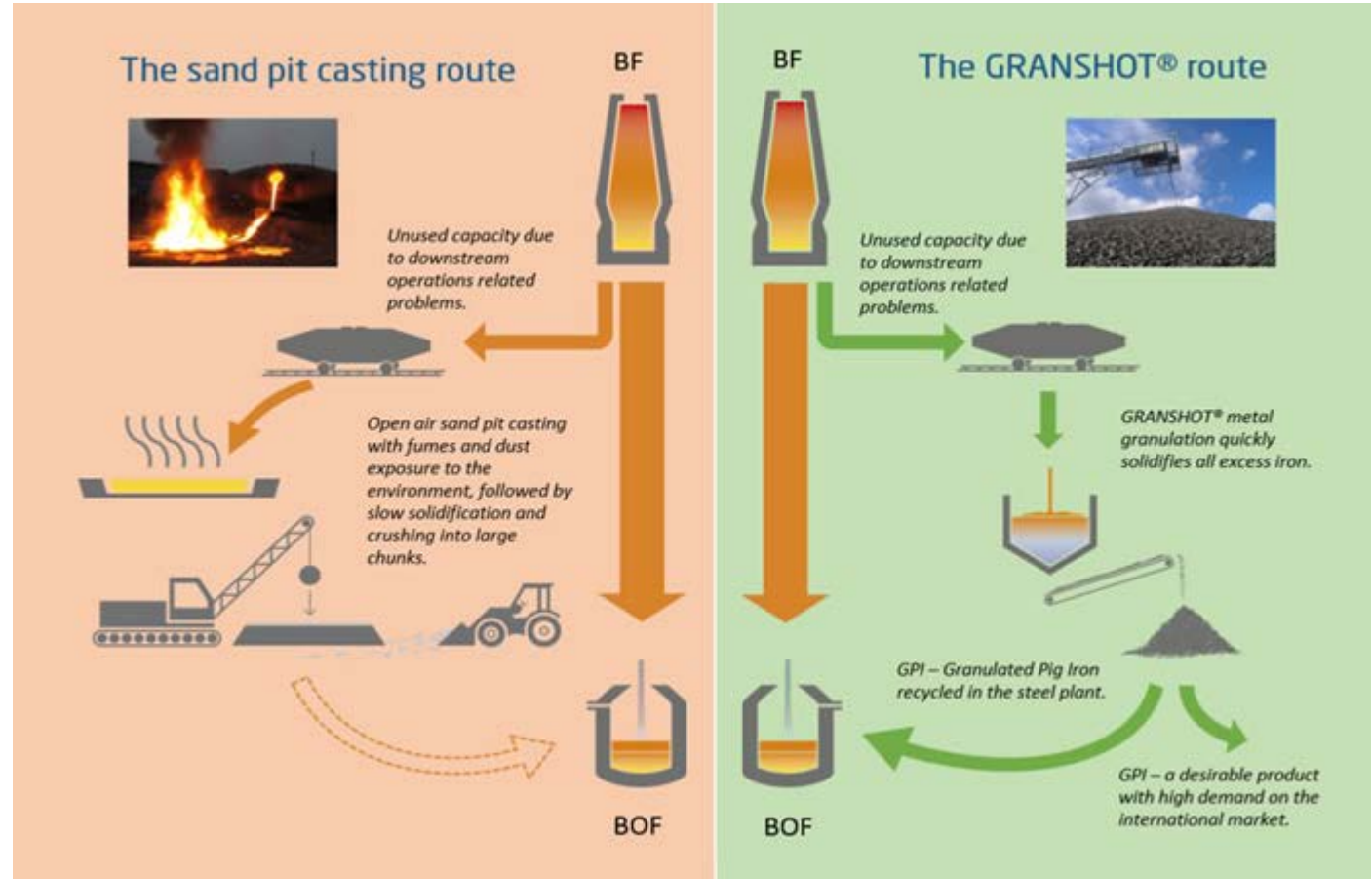


Benefits of Using GPI in the EAF

- High purity, low gangue allows for the production of steel products requiring low residual content or the use of a higher proportion of lower cost scrap in the charge mix
- Known and consistent chemistry, same as the source blast furnace iron
- Chemical energy, C & Si, delivered rapidly due to the large surface area promotes early liquid pool formation, foaming slag, faster melting and thus increased productivity
- Continuous feeding to the furnace through top feed in 5th hole of EAF
- Easy to handle manually and ideal in automatic operation, GPI is an inert material
- Melts faster than Pig Iron at lower temperature and faster dissolution
- Promotes foaming slag in EAF
- Early liquid pool formation
- Can also be used in BF, BOF and induction furnaces

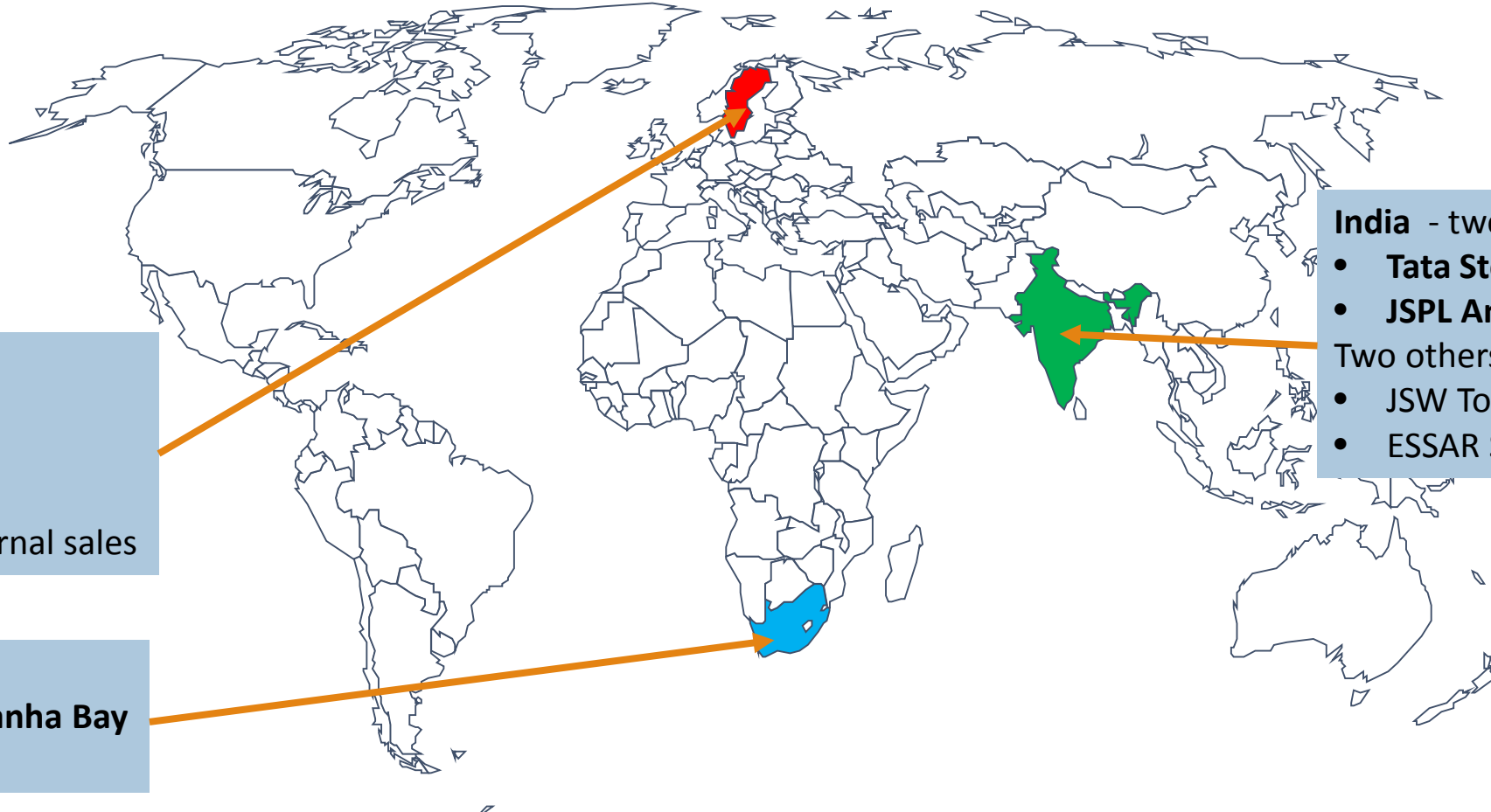



www.metallics.org.uk
IIMA Fact Sheet #10 (2017)
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Global granulated pig iron (GPI) supply

GPI production countries



Sweden

SSAB Oxelosund:

- Use in own BOF
- Use in USA EAF
- Some local external sales

South Africa

ArcelorMittal Saldanha Bay
(internal use)

India - two suppliers:

- **Tata Steel KPO** (Ferrosshots)
- **JSPL Angul** (Panther shots)

Two others for internal use:

- JSW Toranagallu
- ESSAR Steel Hazira

- **What international developments are compounding the supply of ore-based metallics to the USA?**
- **Limited supply of HBI from Venezuela – but increased supply from LebGOK and voestalpine TX – and in 2020 from Cliffs**
- **Uncertainty about MPI supply from eastern Ukraine**
- **Impact of Tulachermet steel mill from 2019**
- **Recovery of domestic MPI demand in Brazil**

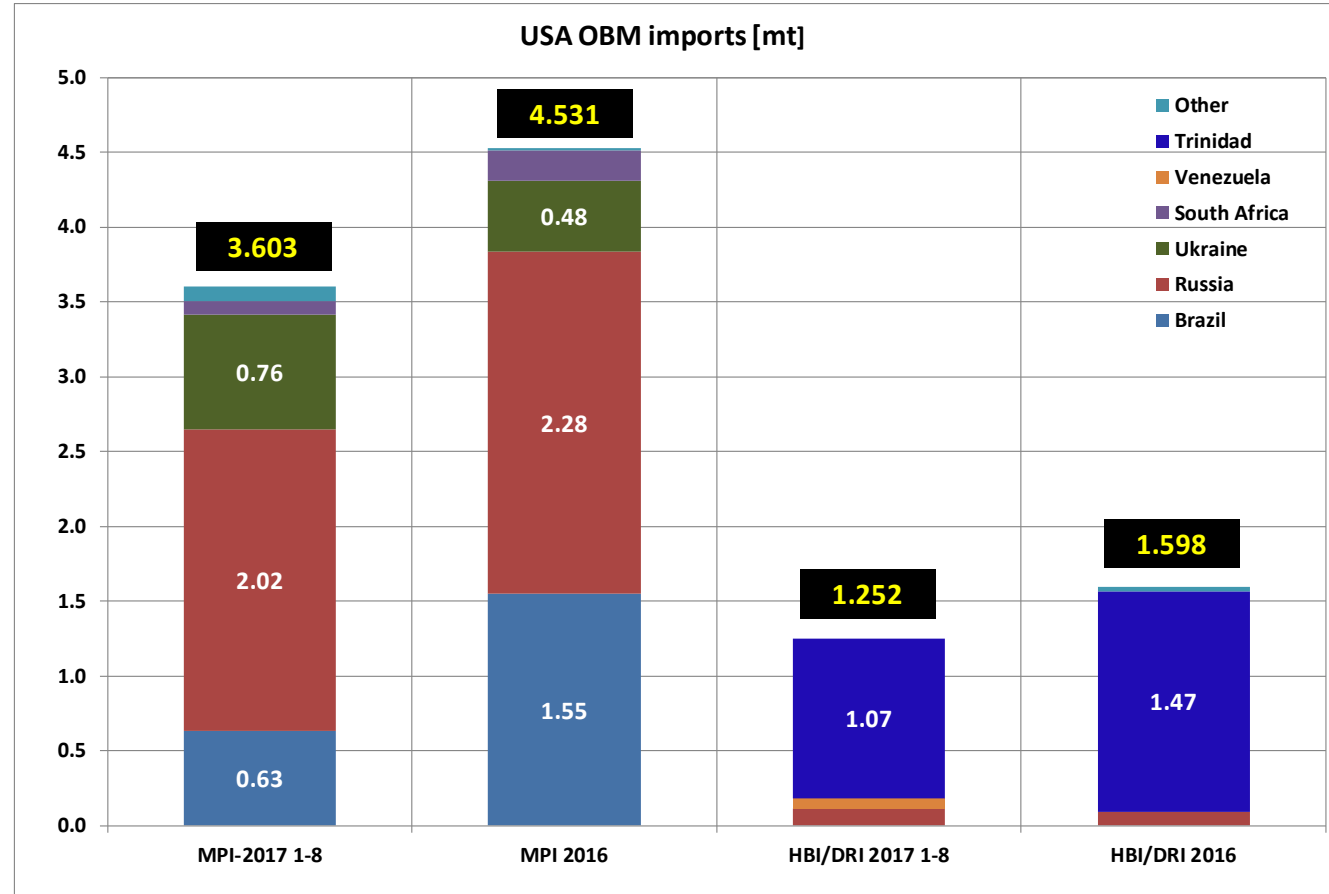
To what extent could future DR plants in the USA replace the demand for international pig iron?

hard to quantify – depends on location and logistics, i.e. competitiveness in regional markets.

DRI/HBI cannot replace pig iron in its entirety – they are complementary.

DRI/HBI cannot replace pig iron in foundries.

exports from US plants are a possibility, but again, location & logistics is the issue here.



- **Could the increasing number of DR plants in the USA change the global trends of raw materials?**
- **In essence, probably not in the foreseeable future. So far, we are talking about two more plants in the Midwest with aggregate capacity of about 3.5 mt, “local” pellet supply and “local” markets - small in the global context.**
- **In the short to medium term a major issue for existing, let alone new DR plants is adequacy of iron oxide pellet supply.**
- **Longer term, natural gas prices may be an issue.**



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