Fastmarkets

Global Iron Ore

Outlook for DR grade iron ore: issues and challenges for the industry

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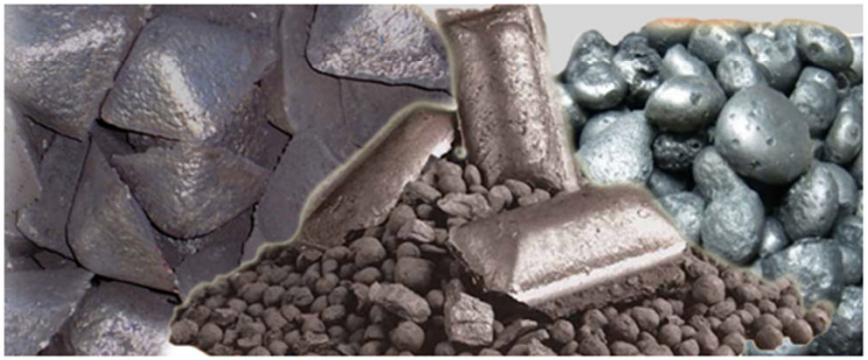
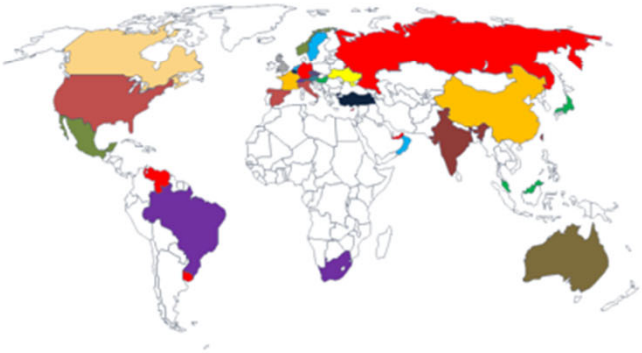
Presentation overview

- **Setting the scene**
- **Outlook for DR grade pellet supply-demand out to 2030**
- **DRI and the pathway to carbon-neutral steelmaking**
- **Supply-side challenges for the steel & iron ore industries**

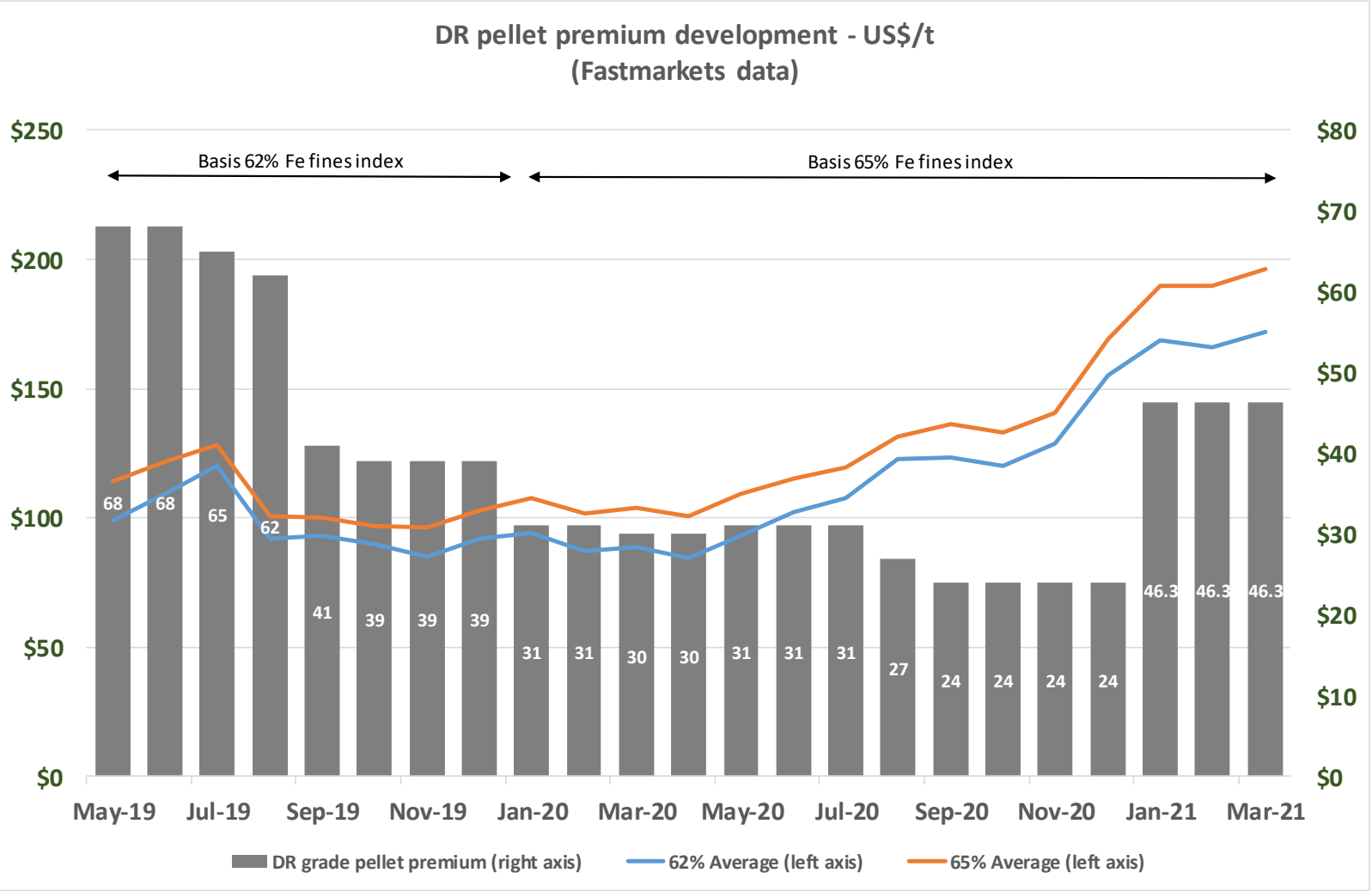
What is IIMA?

- The trade association for the ore-based metallics industry
  - producers [pig iron, HBI, DRI]
  - traders
  - associates [raw materials, technology, plant & equipment, logistics]
  - users of ore-based metallics
- >70 members – on all continents
- Associate member World Steel Association, ICMM
- NGO with consultative status at International Maritime Organisation





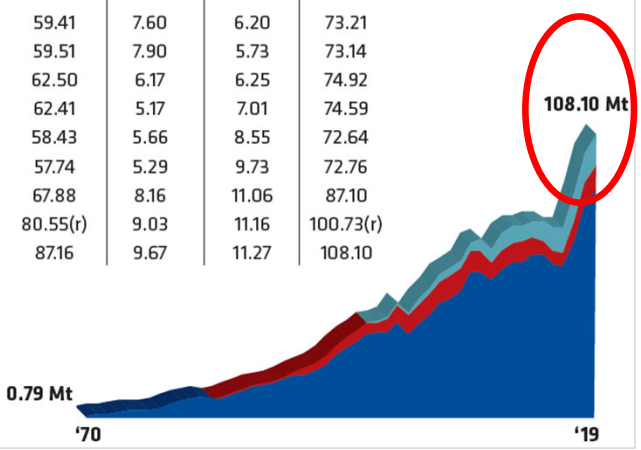
Setting the scene

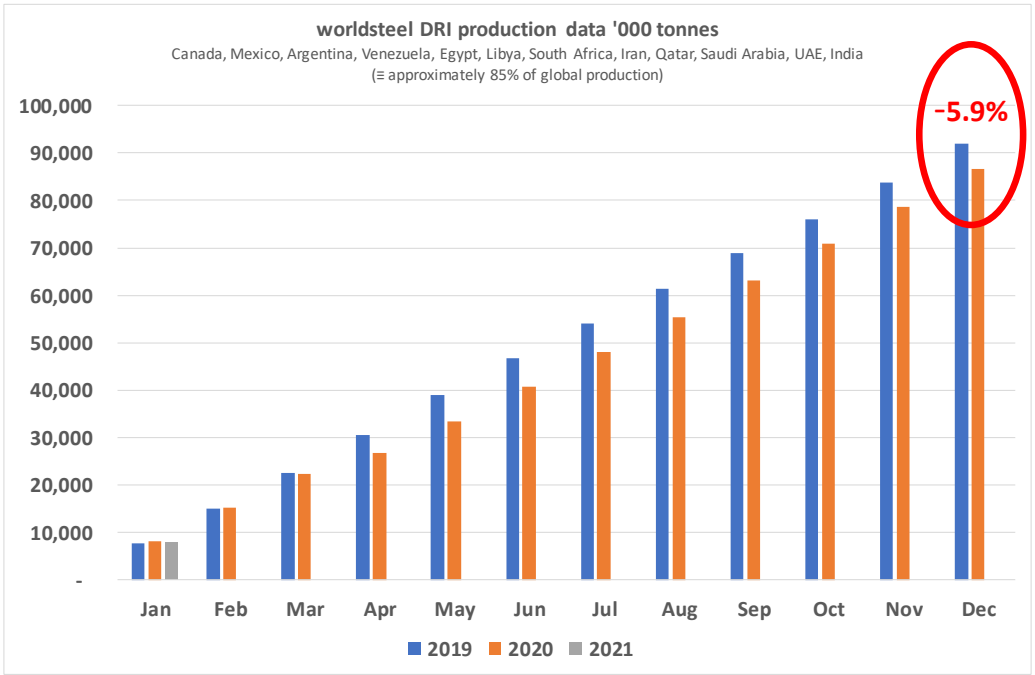


World DRI Production by Year (Mt)

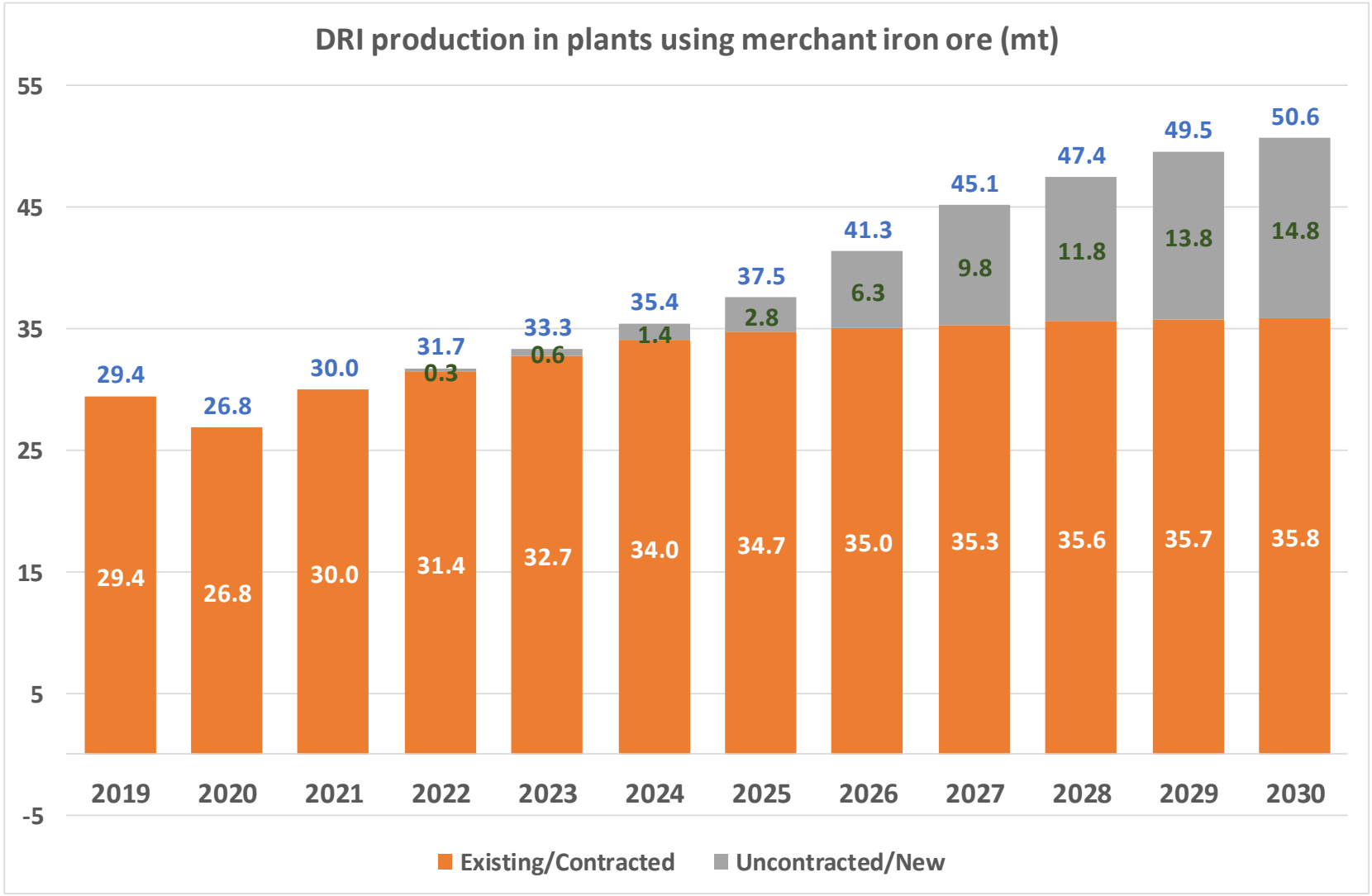
Source: Midrex Technologies, Inc.

Year	Total	Year	Total	Year	CDRI	HBI	HDRI	Total
1970	0.79	'88	14.09	'06	48.41	8.60	2.69	59.70
'71	0.95	'89	15.63	'07	55.79	8.34	2.99	67.12
'72	1.39	'90	17.68	'08	55.52	8.19	4.24	67.95
'73	1.90	'91	19.32	'09	52.54	6.93	4.86	64.33
'74	2.72	'92	20.51	'10	56.60	7.21	6.47	70.28
'75	2.81	'93	23.65	'11	59.41	7.60	6.20	73.21
'76	3.02	'94	27.37	'12	59.51	7.90	5.73	73.14
'77	3.52	'95	30.67	'13	62.50	6.17	6.25	74.92
'78	5.00	'96	33.30	'14	62.41	5.17	7.01	74.59
'79	6.64	'97	36.19	'15	58.43	5.66	8.55	72.64
'80	7.14	'98	36.96	'16	57.74	5.29	9.73	72.76
'81	7.92	'99	38.60	'17	67.88	8.16	11.06	87.10
'82	7.28	'00	43.78	'18	80.55(r)	9.03	11.16	100.73(r)
'83	7.90	'01	40.32	'19	87.16	9.67	11.27	108.10
'84	9.34	'02	45.08					
'85	11.17	'03	49.45					
'86	12.53	'04	54.60					
'87	13.52	'05	56.87					





Argentina
Trinidad
USA
Germany
South Africa
Algeria
Libya
Egypt
Saudi Arabia
Qatar
Bahrain
UAE
Oman
Malaysia



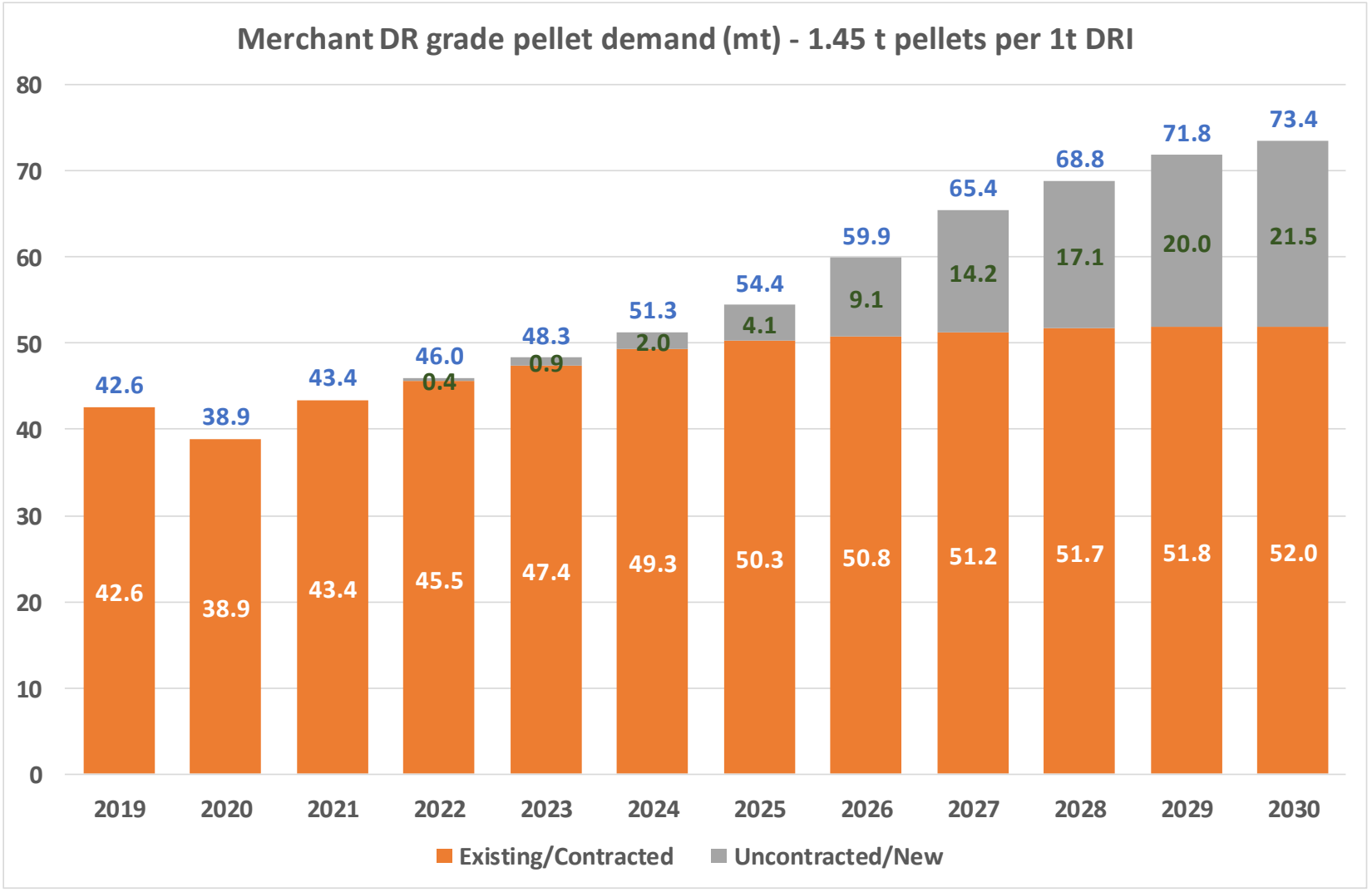
DRI production from new projects

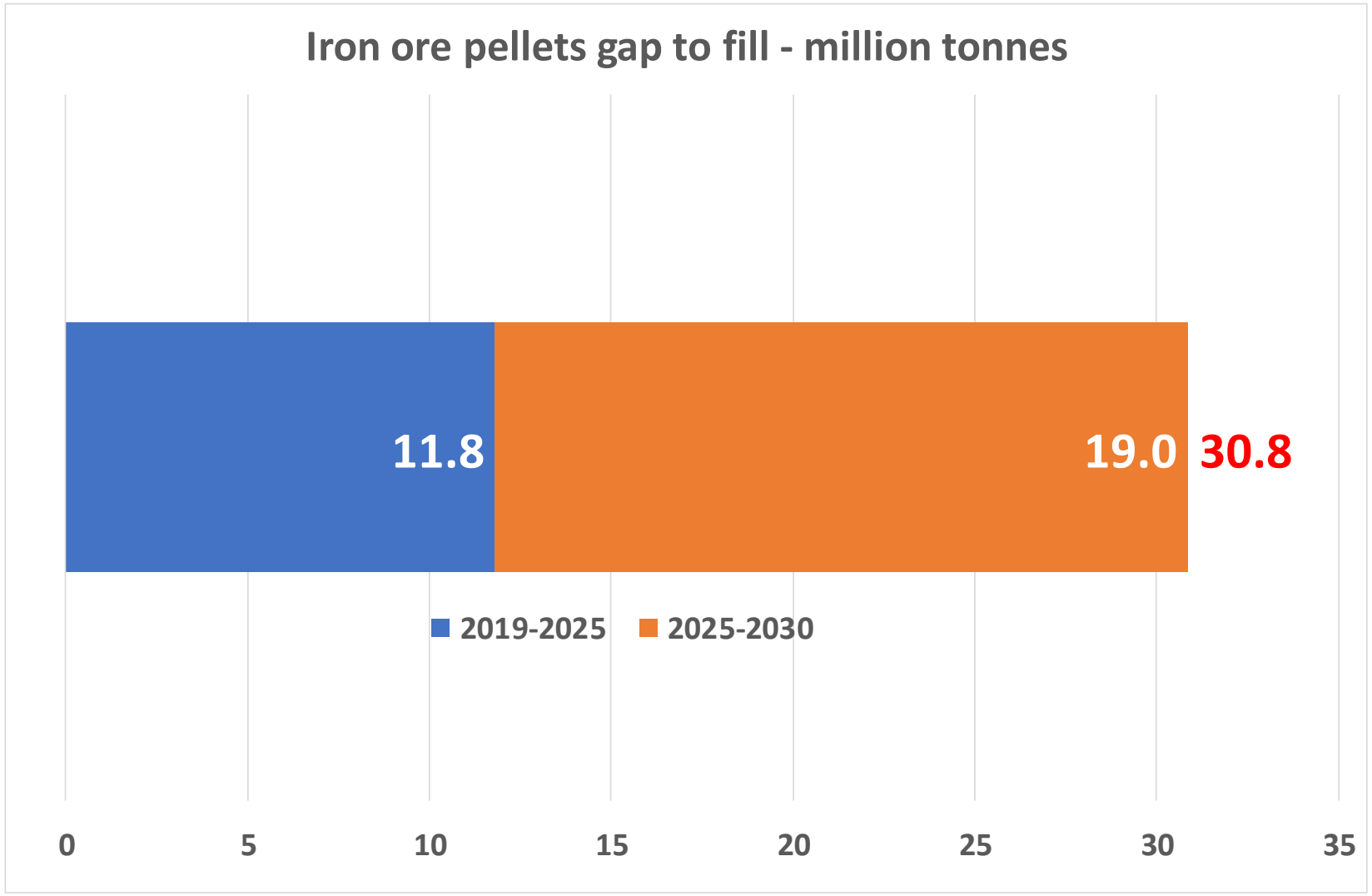
(based on merchant iron ore)

Project	2022	2023	2024	2025	2026	2027	2028	2029	2030	Location
HBIS Group	0.3	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	China
Salzgitter			0.8	1.6	2	2.0	2.0	2.0	2.0	Germany
TKS				0.6	1.2	1.2	1.2	1.2	1.2	Germany
Liberty/PW/SHS					1.0	2.0	2.0	2.0	2.0	France
IOC/PW/SHS					0.5	1.0	1.0	1.0	1.0	Canada
MENA 1					1.0	2.0	2.0	2.0	2.0	North Africa
MENA 2						1.0	2.0	2.0	2.0	North Africa
EU							1.0	2.0	2.0	Austria, Italy, Romania, Germany
Asia								1.0	2.0	ASEAN, China
Total	0.3	0.6	1.4	2.8	6.3	9.8	11.8	13.8	14.8	

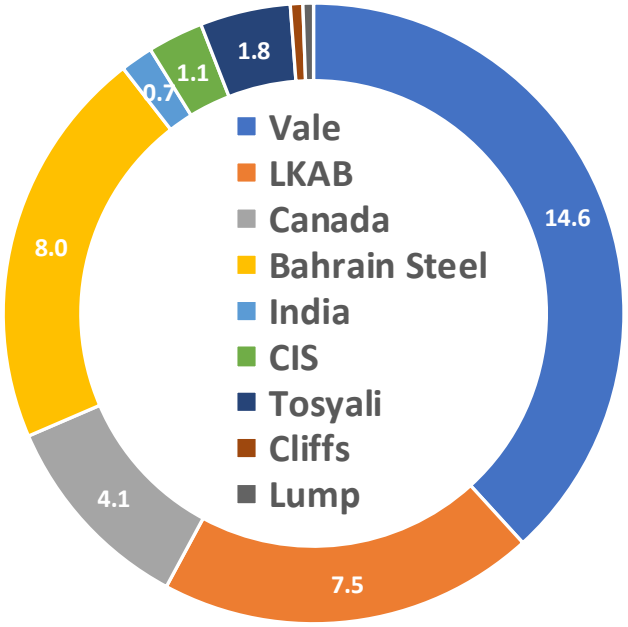
Subsequent note: ArcelorMittal reported to be planning DR/EAF plants at Bremen and Eisenhuettenstadt by 2026.

Argentina
Trinidad
USA
Germany
South Africa
Algeria
Libya
Egypt
Saudi Arabia
Qatar
Bahrain
UAE
Oman
Malaysia

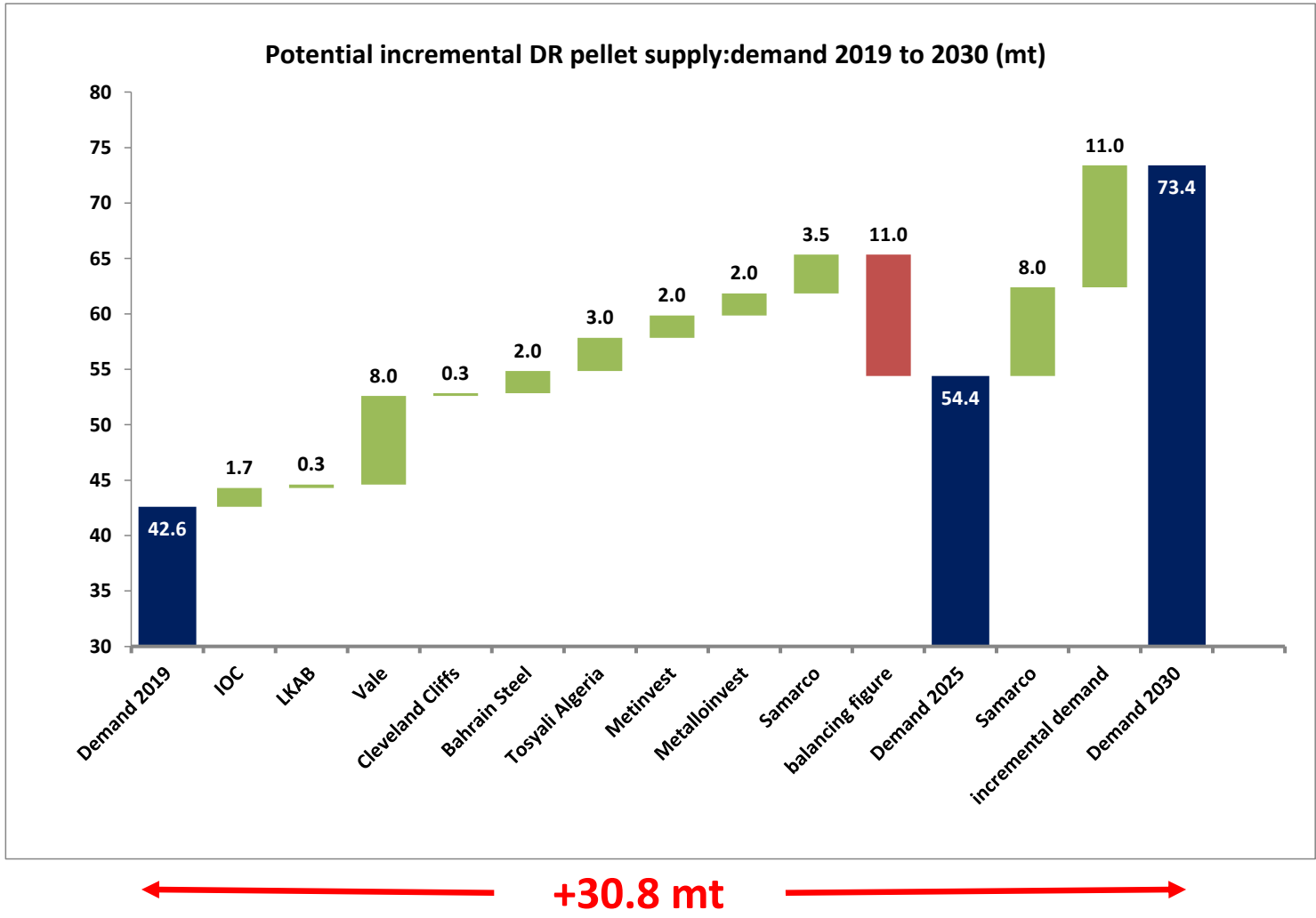



Iron ore pellets gap to fill - million tonnes
11.8
19.0
30.8
2019-2025
2025-2030
0
5
10
15
20
25
30
35

Seaborne Ore Supply to DR plants 2020 (mt) - total 38.2 mt
(preliminary estimate)
source: trade statistics and author's estimates
(compares with 38.9 mt derived from DRI production data)



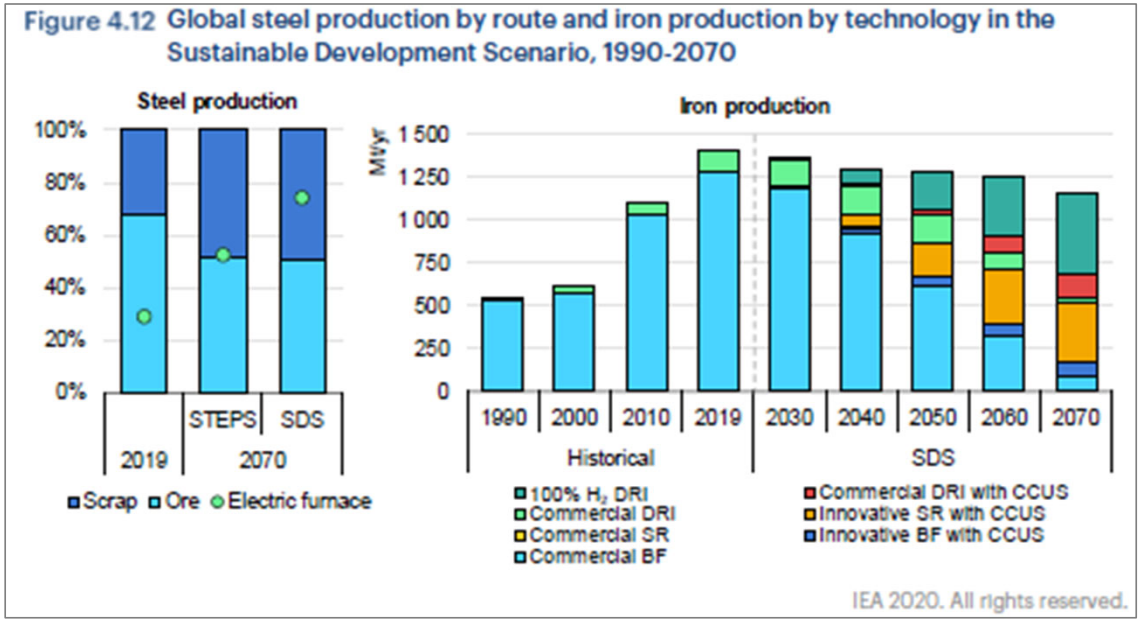
- Assumes Vale reaches 60 mt pellet production of which 45% is DR grade
- Assumes 12 mt from Bahrain Steel
- Assumes Tosyali Algerie is self-sufficient in pellets by 2025
- Assumes start date for Samarco Phases 2 & 3 during second half decade
- According to this scenario, potential 2025 DR pellet supply exceeds demand by 20%
- To meet the 2030 level of demand, Samarco Phases 2 and 3 and much more will be needed….



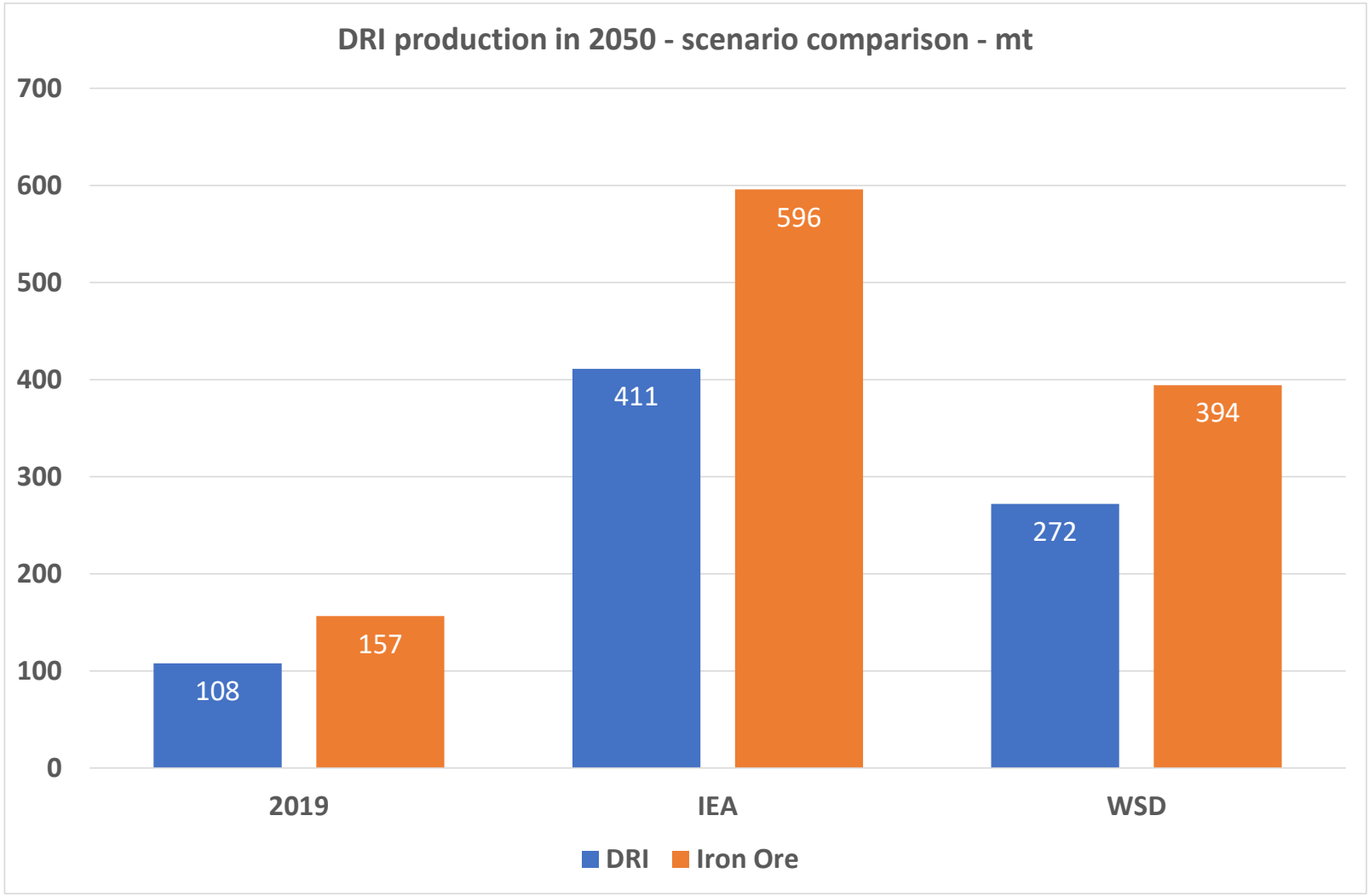
International Energy Agency's "Energy Technology Perspectives 2020" and "Iron & Steel Technology Roadmap"

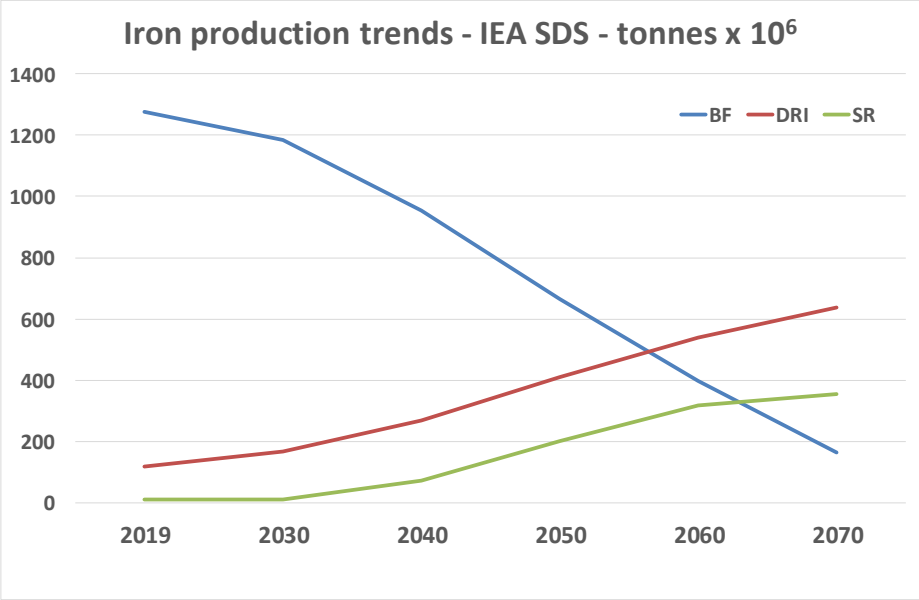
The IEA considers two scenarios:

- **The Stated Policies Scenario (STEPS) takes into account countries' energy- and climate-related policy commitments, including nationally determined contributions under the Paris Agreement, to provide a baseline against which to assess the additional policy actions and measures needed to achieve the Sustainable Development Scenario.**
- **The Sustainable Development Scenario (SDS) sets out the major changes that would be required to reach the main energy-related goals of the United Nations Sustainable Development Agenda, including an early peak and subsequent rapid reduction in emissions, in line with the Paris Agreement, universal access to modern energy by 2030 and a dramatic reduction in energy-related air pollution. The trajectory for emissions in the Sustainable Development Scenario is consistent with reaching global "net-zero" CO_2 emissions for the energy system as a whole by around 2070.**

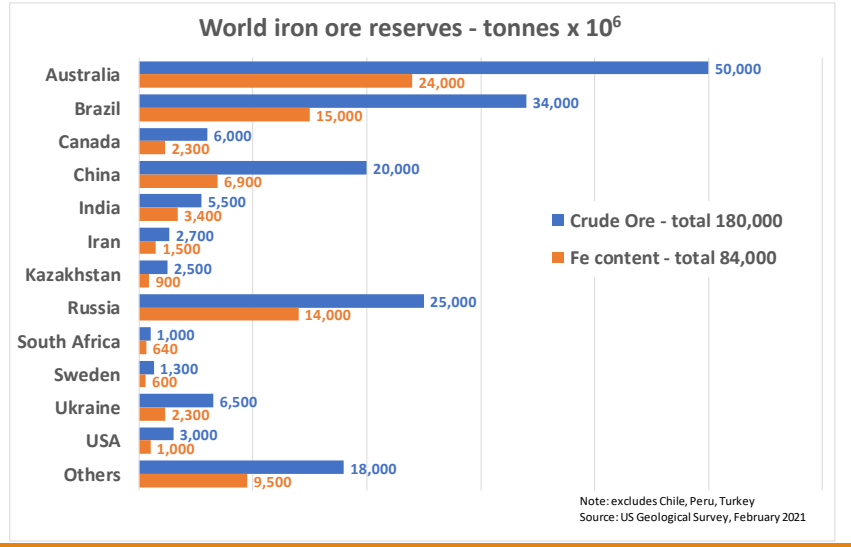



DRI production according to IEA's sustainable development scenario - mt
700
600
500
400
300
200
100
0
116
167
269
411
540
638
115
157
174
162
92
25
80
14
213
37
350
98
471
141
2019
2030
2040
2050
2060
2070
Commercial DRI
Commercial DRI with CCUS
100% H₂ DRI


DRI production in 2050 - scenario comparison - mt
700
600
500
400
300
200
100
0
108
157
411
596
272
394
2019
IEA
WSD
DRI
Iron Ore



- **On the face of it, the shift from BF/BOF to DR/EAF does not appear to be too much of a quantitative problem from the iron ore supply perspective….**
- **2020 production 1.5 bn tonnes Fe-contained with reserves of 84 bn tonnes**
- **Of course in practice it's not as simple as that….**
- **The real issue for DR/EAF is ore quality….and value-in-use**



Some interim remarks….

- **The iron & steel value chain is like a super-tanker - it takes a long time to change course….**
- **The roadmap to "carbon-neutral" steelmaking has a timeline of 30-50 years and there are several pathways under active consideration, with common themes being hydrogen as reductant/energy source and the eventual destination of EAF.**
- **Many steel companies are moving rapidly toward the first steps, notably in Europe (e.g. ArcelorMittal, Salzgitter, thyssenkrupp, voestalpine, SSAB, SHS Saar).**
- **Direct reduction plays a vital role in most roadmaps and thus iron ore is fundamental to success.**
- **DRI and HBI are essential EAF steelmaking inputs, their clean analysis diluting residual metallic impurities in scrap, thus enabling:**
  - **production of high quality steel products, and**
  - **inclusion of lower grades of scrap in the charge**

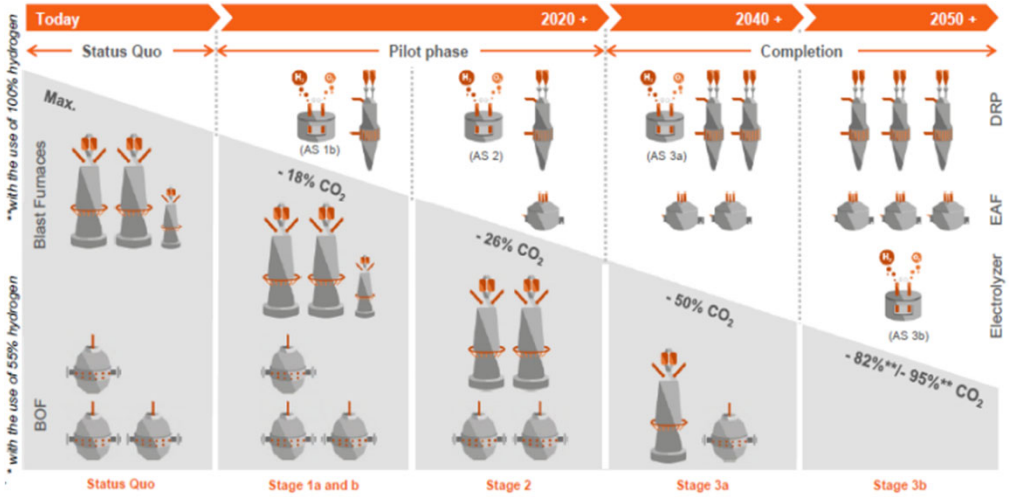
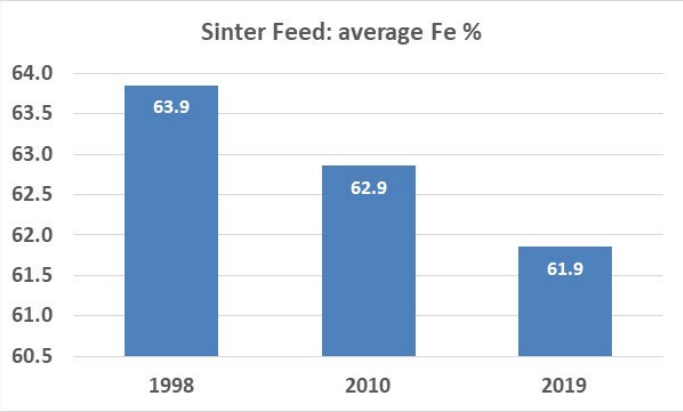
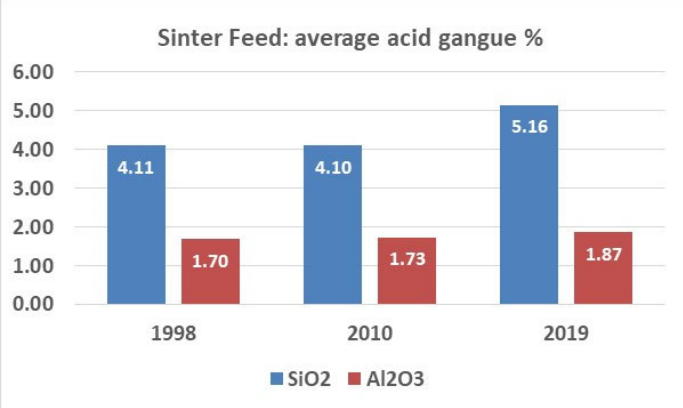
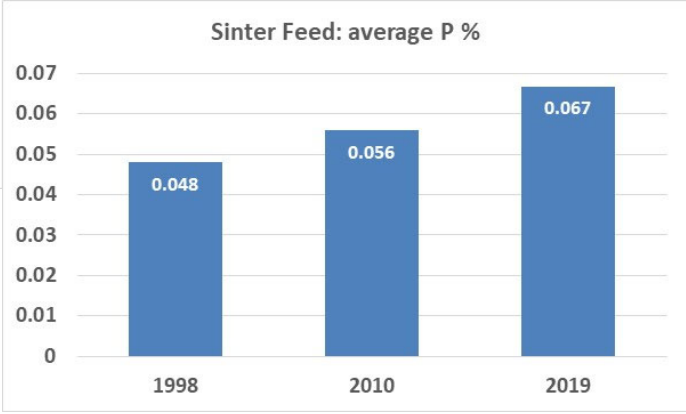


Image source: Salzgitter AG/Salcos

Iron ore quality trends







source: Raw Materials & Ironmaking Global Consulting

- **Iron ore quality has been declining gradually as shown in these charts.**
- **Conversely, over the same period, the quality of seaborne iron ore pellet feed and concentrates has remained rather constant, as has the quality of seaborne DR grade pellets, although in some cases this masks the need for additional beneficiation and concentration of the source ore in order to maintain grade.**

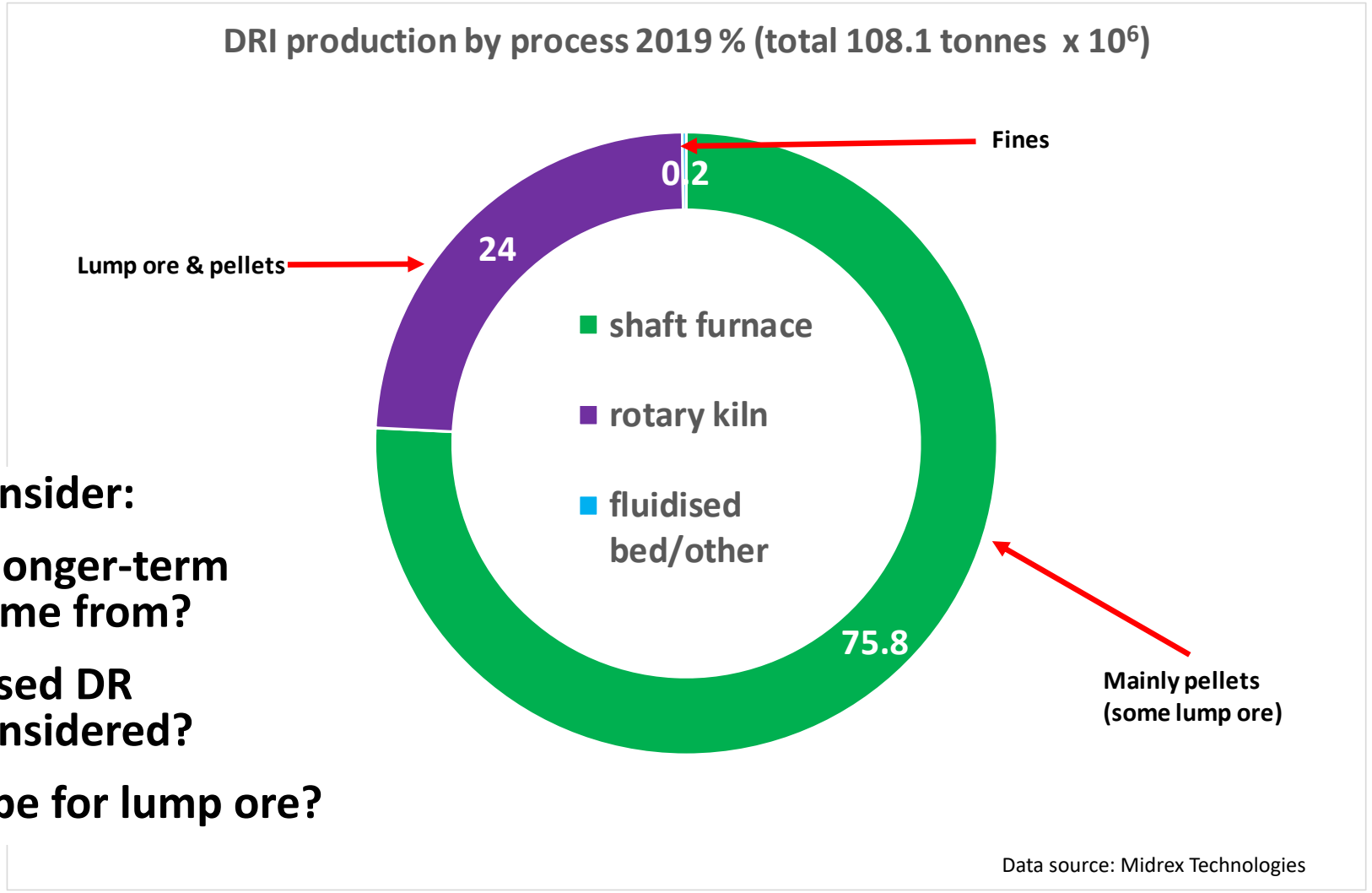
Impact of declining iron ore quality

DR/EAF

- **Lower yield and productivity in both DR and EAF**
- **Greater slag volume in EAF / higher Fe yield losses**
- **Higher power consumption in EAF**

BF/BOF

- **Increased sinter production required to provide the same Fe units from the sinter plants**
- **Increased blast furnace slag volumes and therefore increased fuel rates**
- **Increased BOF flux consumption to maintain P removal**



Three issues to consider:

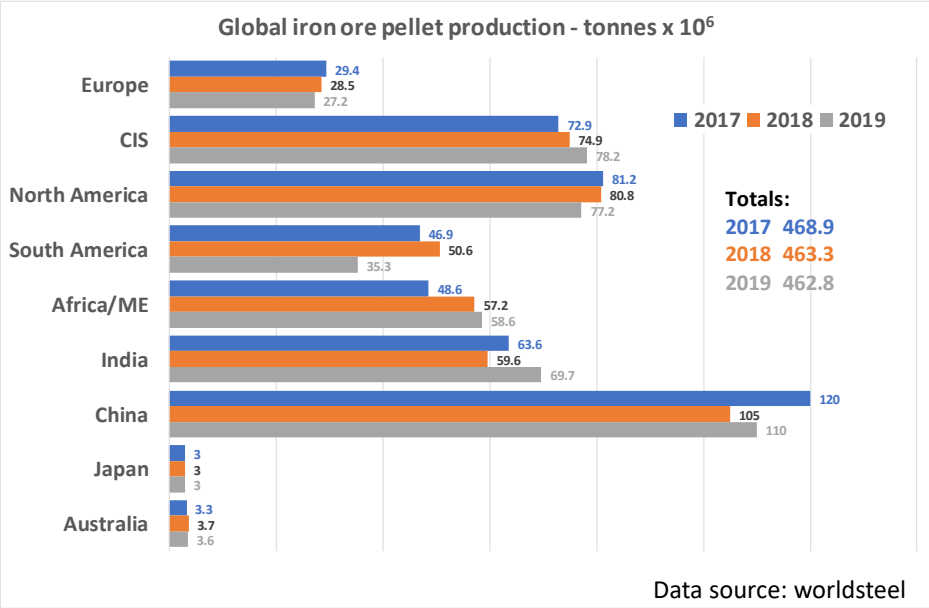
- **Where will the longer-term pellet supply come from?**
- **Should fines-based DR processes be considered?**
- **What is the scope for lump ore?**

Iron ore quality requirements for DR/EAF

- **Fe content as high as possible, minimum 65-66%, ideally ≥67%**
- **Acid gangue content (SiO_2 + Al_2O_3) as low as possible, maximum 3.5%, ideally maximum 2% (also TiO_2 <0.35%, ideally <0.15%)**
- **CaO up to 2.5%**
- **MgO up to 1%**
- **Phosphorus (as P_2O_5) as low as possible, maximum 0.03%, ideally maximum 0.015%**
- **Sulphur as low as possible, maximum 0.025%, ideally maximum 0.015%**
- **Metallic impurities such as Cu, Cr, Ni, V, as low as possible**
- **For shaft-based DR processes using mainly iron ore pellets, minimal content of fines <5 mm - maximum 5%, preferably <3%**
- ***Note: actual specifications and tolerances will depend ultimately on the make up of the EAF charge in question.***

Future merchant pellet supply

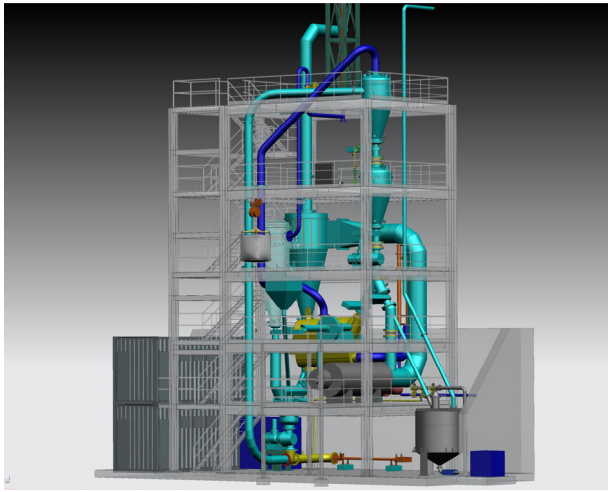
- **"Traditional" suppliers of merchant DR grade pellets:**
  - Vale, Samarco, IOC, AMMC, LKAB, Bahrain Steel
- **"Emerging" suppliers of merchant DR grade pellets:**
  - Cleveland Cliffs, Metalloinvest, Metinvest, Ferrexpo
- **Other suppliers of merchant pellets to DR plants:**
  - CMP, Severstal Resources, various Indian plants e.g. KIOC
- **Failed or dormant DR pellet projects:**
  - Canada: LabMag/KéMag (New Millennium Iron/Tata Steel) - 9 mt
  - USA Mn: Mesabi Metallics - 7 mt
  - Mauritania: El Aouj (SNIM/Glencore) - 7 mt
  - Oman: Jindal Shadeed - 7 mt
  - Saudi Arabia: Wadi Sawawin (National Mining Company) - 5 mt
- **New opportunities:**
  - 2nd line at Vale Oman
  - India (likely domestic use with 80 mt sponge iron target)
  - Algeria (Tosyali Phase 4)
  - New DR plants with integrated pellet plants
  - US pellet plants researching shift from BF to DR grade (UMD/NRRI project)
  - Others?
- **Shift of BF pellets to DRI for BF/BOF consumption**



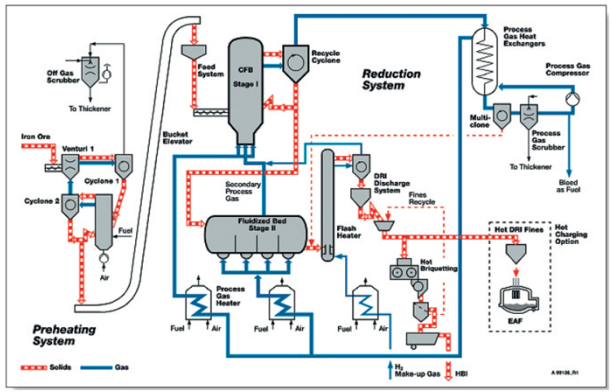
Fines-based DR processes

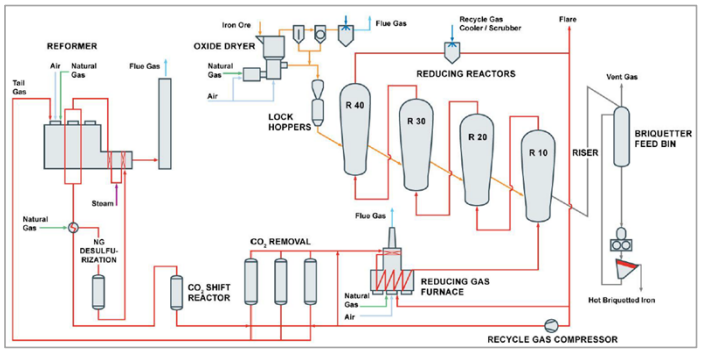
CIRCORED (Outotec)
fines/concentrates 0.1 – 2 mm

FINORED (Primetals)
fines up to 8 mm



HYFOR (Primetals)
(under development)
concentrates
up to 0.15 mm (150 µm)





Current merchant high grade pellet feed supply

- **Minas Rio, Brazil (Anglo American)**
  - 25-27 mt from 2023 (of which ±8 mt ≥67% Fe / ≤2% gangue)
- **Champion Iron, Canada (Bloom Lake)**
  - FY 2020 8 mt production, 66.5% Fe (Phase 2: 15 mt)
  - Two recent concentrate shipments to MENA totaling 0.34 mt with 67.98% and 67.8% Fe with combined SiO_2 + Al_2O_3 of 2.57% and 2.68%
- **Kaunis Iron, Sweden**
  - 2 mt >68% Fe
- **CMP, Chile**
  - El Romeral, Planta Magnetita (copper mining by-product) 66-68% Fe
- **Metalloinvest, Russia**
  - BF/DR grade concentrate (≤ 70% Fe, ≤ 2.6% SiO_2) - 6 mt from 2021
  - DR grade concentrate ((≤ 71% Fe, ≤ 1.0% SiO_2)) - 4 mt from 2024

Potential future suppliers of DR grade pellet feed

- **Eurasian Resources' Bamin project, Brazil:** 16-18 mt 67-68.5% Fe concentrate, start-up potentially 2021
- **SAM's' Projeto Bloco 8, MG Brazil:** 27.5 mt pellet feed 66.2% Fe
- **Strike Resources' Apurimac project in Peru:** base case is 20 mt magnetite concentrate >66% Fe, dependent on new railway with completion 2028, now updating PFS prior to BFS, now mining DSO
- **Nordic Iron Ore Ludvika mines, central Sweden:** plans to produce up to 4.4 mt high grade concentrate in three phases (66.5-70.5% Fe)
- **Tacora Resources' recently acquired Sydvaranger mine in Kirkenes, Norway:** first operated in 1910, mine last operated 2009-2015, 20 mt ore mined and 8 mt magnetite concentrate sold, specification 68% Fe (5% SiO_2)
- **FMG's Ironbridge project in WA Australia:** 22 mt 67% Fe magnetite concentrate (to be blended with lower grade FMG products?)
- **Carpentaria Resources' Hawsons Iron project in NSW, Australia:** aims to produce 70% Fe magnetite concentrate at initial rate of 10 mt from Q4 2022 - now undertaking financing for BFS
- **Magnetite Mines' Mawson Iron project in South Australia:** could produce 8.2 mt magnetite concentrate with up to 68.8% Fe
- Many other magnetite-based iron ore projects in Australia: **Southdown (Grange Resources), Mt. Ida (Jupiter Mines), Australian Resources' Balmoral South project**, etc.
- **Zanaga Iron Ore's project in Republic of Congo:** Phase 1: 12 mt (66% Fe) and Phase 2: +18 mt (67.5% Fe) pellet feed
- **Black Iron's Shymanivske project in Krivyi Rih, Ukraine:** Phase 1; 4 mt. Phase 2: 8 mt 68% Fe magnetite concentrate

Some key messages

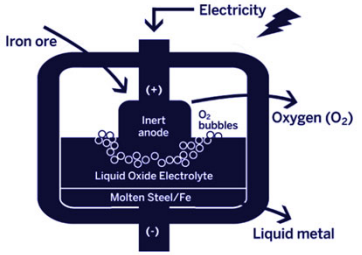
- **First and foremost, the iron ore status quo is not an option if carbon-neutral steelmaking is to become a reality in the prescribed timescale.**
- **The iron & steel industry and its technology suppliers have already started the journey, as have major iron ore producers around the world.**

Iron ore majors and scope 3 emissions

- **Rio Tinto:**
  - **Partnership with China Baowu Steel Group and Tsinghua University - establishment of Low Carbon Materials Preparation R&D Centre**
  - **MOU with Nippon Steel to jointly explore, develop and demonstrate technologies to transition to a low-carbon emission steel value chain**
  - **MOU with SHS Saar and Paul Wurth – H_2-based HBI production in Canada**
- **BHP**
  - **Partnership with JFE Steel to jointly study technologies and pathways capable of making material reductions to greenhouse gas emissions from the integrated steelmaking process**
  - **Partnership with China Baowu Steel Group to share technical knowledge to help address the challenge of reducing greenhouse gas emissions facing the global steel industry.**
  - **Partnership with HBIS Group – examine technology to reduce GHG in steel industry: H_2-based DRI technology, recycling of steelmaking slags, the role of lump ore utilisation**
- **Vale and BHP**
  - **Investment in Boston Metal – Molten Oxide Electrolysis**

Molten Oxide Electrolysis (MOE)

Better quality, easier process, no hazardous waste, pure metal output.



Iron Ore Electricity Iron Oxygen

$$Fe_2O_3 + e^- \rightarrow 2\,Fe + {}^3/_2\,O_2$$

Reducing Agent	Electrons
Feedstock	Concentrates or pure oxides
Electrolyte	Molten oxides (CaO, MgO, etc.)
Containment	Refractory or frozen ledge
Temperature	Up to 2,000°C
Product	Pure metals or alloys

Some key messages

- First and foremost, the iron ore status quo is not an option if carbon-neutral steelmaking is to become a reality in the prescribed timescale.
- The iron & steel industry and its technology suppliers have already started the journey, as have major iron ore producers around the world.
- **These two inter-dependent industries must co-operate closely to ensure that iron ore of the right type and quality is available on a timely basis - this is not a one-way street.**
- **In the long run, iron ore of the type and quality needed is not going to become cheaper to produce, given the need for higher levels of beneficiation in many cases.**
- **Whilst at industry level these challenges are increasingly well understood, it is essential that they be communicated to policy makers.**

Thanks for your attention!

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www.metallics.org

Health warning: a forecast (or even a scenario) is not a prophecy!