Technical and Industrial Developments in Ferro-alloys in Southern Africa

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INFACON XIV

KYIV, UKRAINE

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INTERNATIONAL COMMITTEE ON FERRO- ALLOYS

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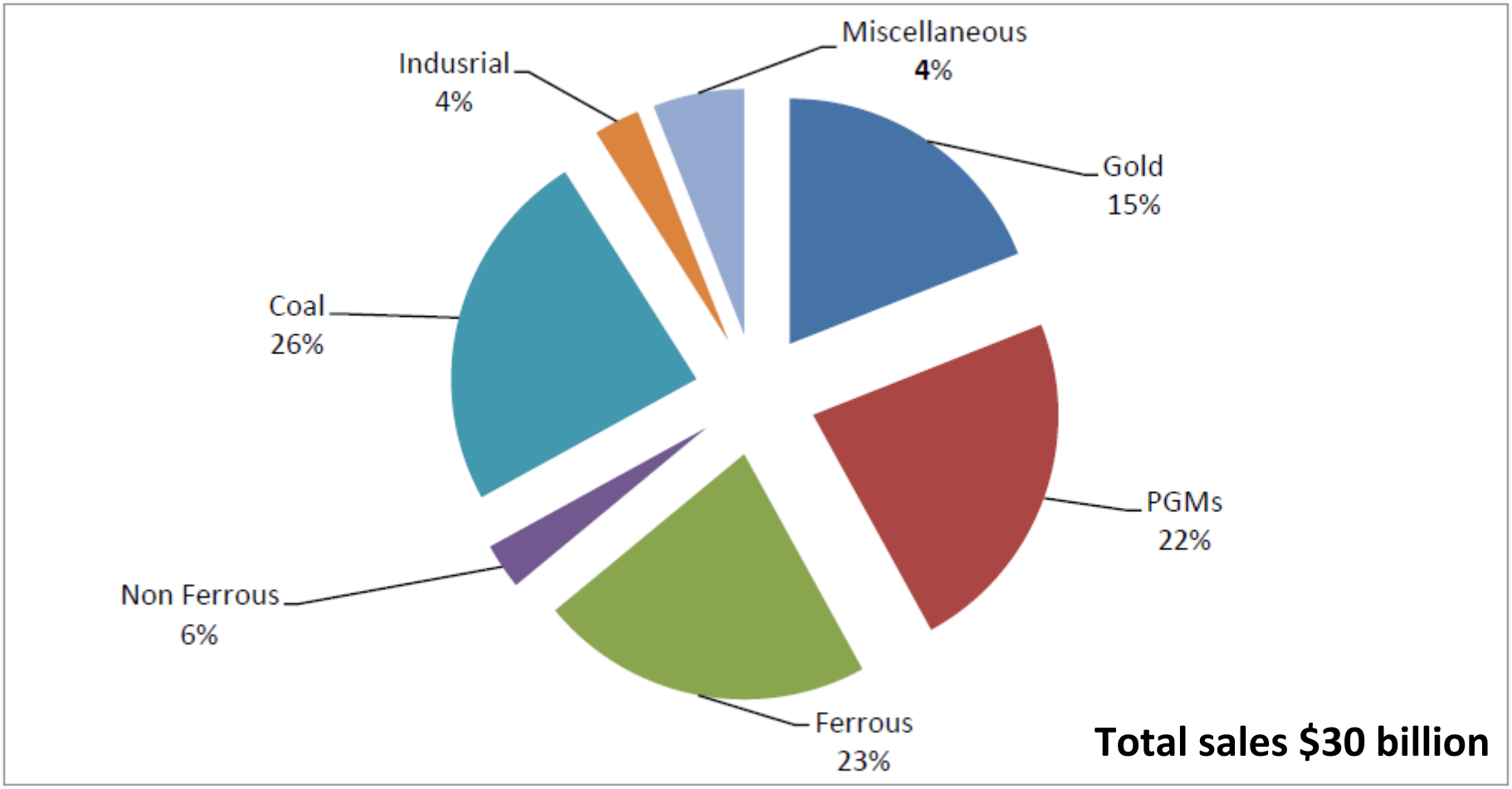
South Africa's Minerals sales (2013)



Source: Department of Mineral Resources, Directorate Mineral Economics

South Africa's Ferrous ore sales (2013)

COMMODITY	YEAR	PRODUCTION	LOCAL SALES		EXPORT SALES		TOTAL SALES	
		kt	kt	R million	kt	R million	kt	R million
CHROME ORE	2013	13 653	8 473	5 866	4 168	5 891	12 641	11 758
	2012	11 310	6 685	4 683	2 470	3 594	9 155	8 277
IRON ORE	2013	71 534	9 259	5 746	58 202	57 385	67 461	63 131
	2012	67 100	8 393	4 448	57 110	48 193	65 503	52 642
MANGANESE ORE	2013	11 056	3 425	1 569	7 631	12 513	11 056	14 082
	2012	8 943	1 445	1 135	7 498	9 686	8 943	10 821
TOTAL	**2013**	***96 243***	***21 157***	***13 181***	***70 001***	***75 789***	***91 158***	***88 971***
	2012	**87 373**	**16 524**	**9 133**	**67 094**	**51 800**	**83 618**	**60 933**

Source: DMR, Directorate Mineral Economics

Total $9 Billion sales

(*Rand 10 = 1 US $)

South Africa's FeCr and FeMn Ferro-alloy sales (2013)

COMMODITY	YEAR	PRODUCTION	LOCAL SALES		EXPORT SALES		TOTAL SALES	
		kt	kt	R million	kt	R million	kt	R million
CHROMIUM ALLOYS	2013	3 219	360	2 983	2 802	25 552	3 162	28 535
	2012	3 063	443	3 402	2 745	22 290	3 188	25 693
MANGANESE ALLOYS	2013	681	58	496	493	4 113	551	4 609
	2012	706	33	263	523	3 961	556	4 224
TOTAL	2013	3 900	418	3 479	3 295	29 665	3 713	33 144
	2012	3 852	533	4 104	3 301	22 731	3 834	26 836

Source: DMR, Directorate Mineral Economics

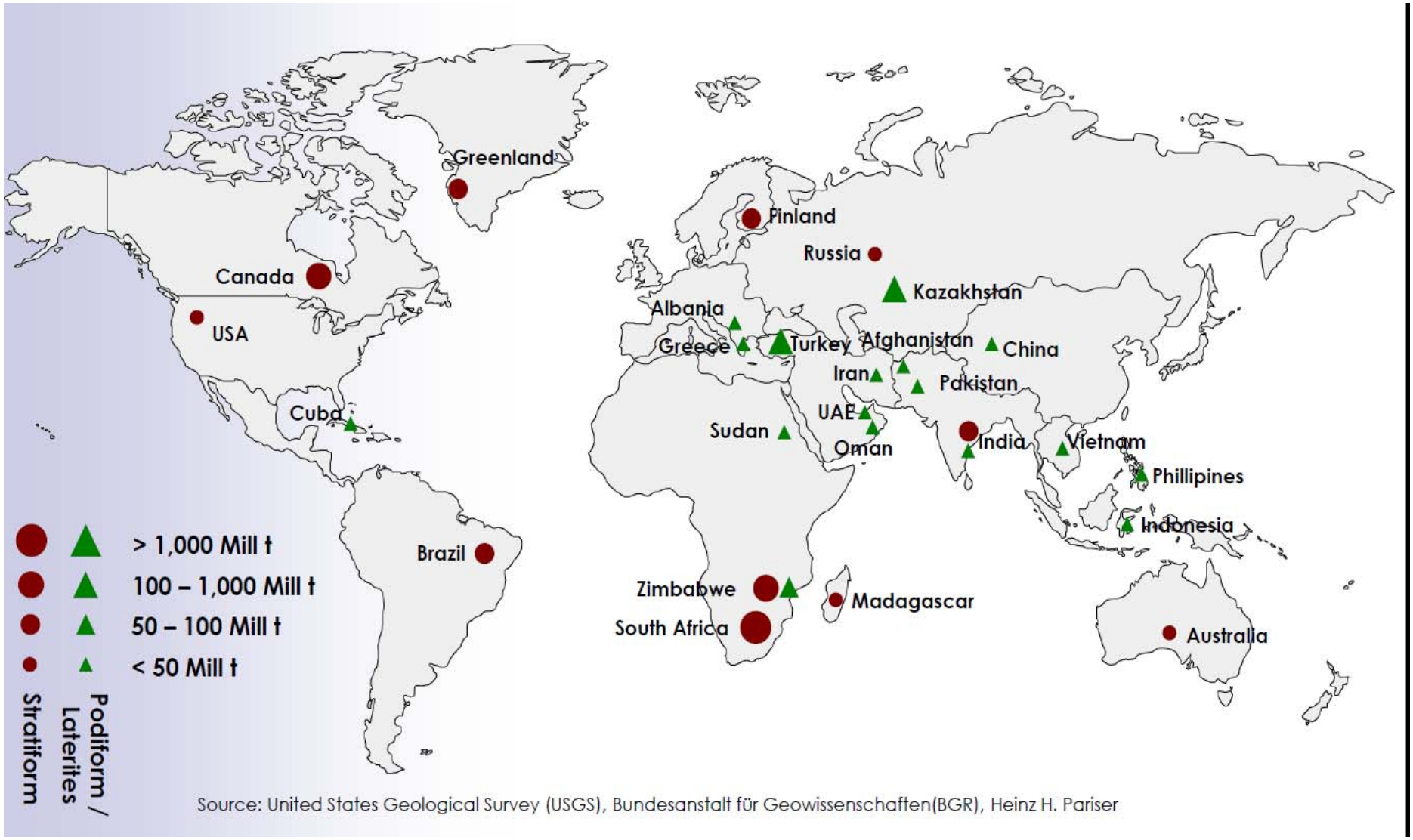
Total $3 Billion sales

(*Rand 10 = 1 US $)

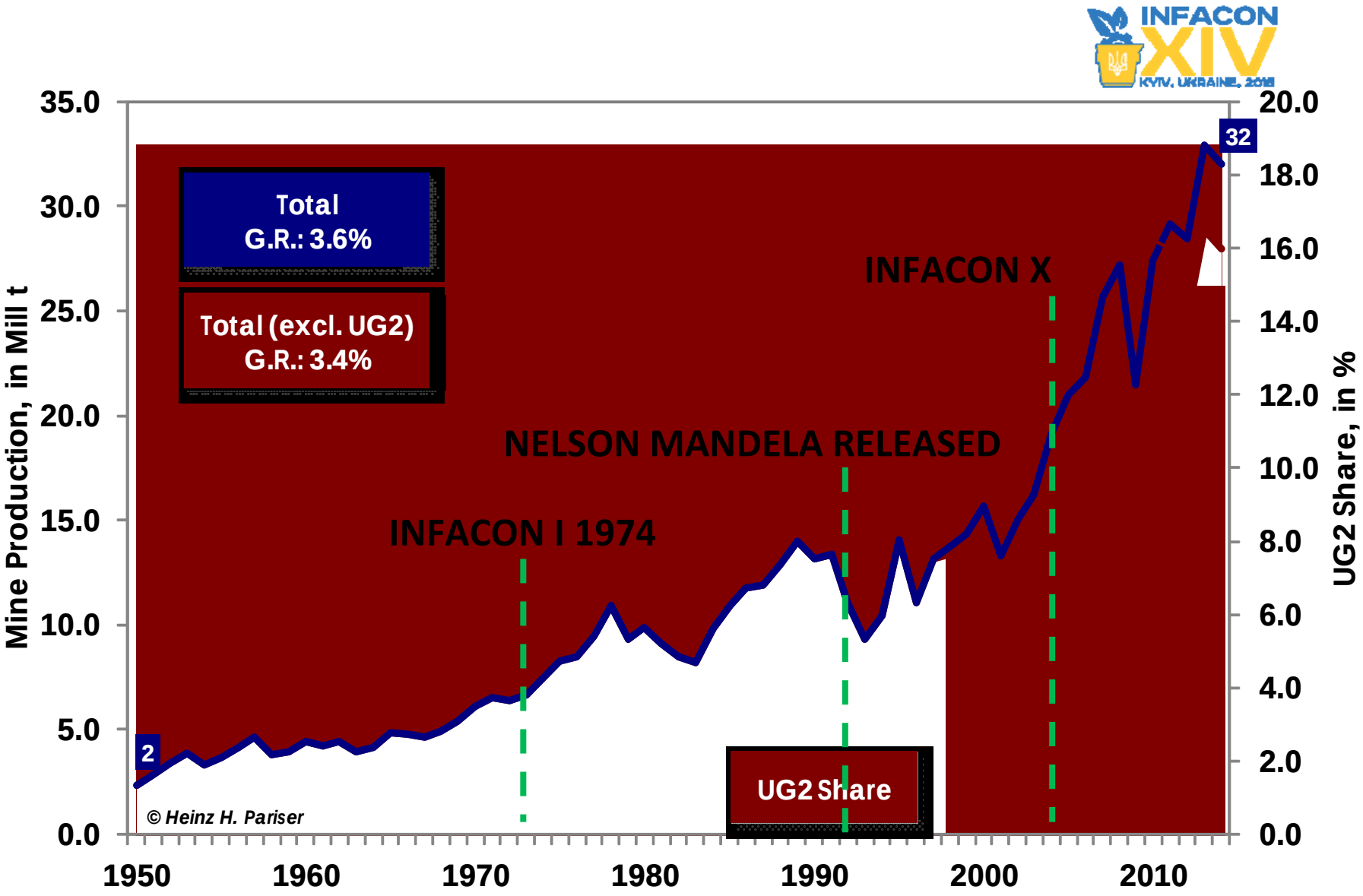
Chromite and FeCr growth trends over past 40 years

- Growth of RSA chromite FeCr production from 1970s to 2015 including growth in China, India and Kazakhstan.
- Historical and future trends in chrome ore supply from RSA (UG2 contribution) and demand
- Decline in FeCr production in Europe, Japan and North America
- Forecast of FeCr trends in next five to ten years

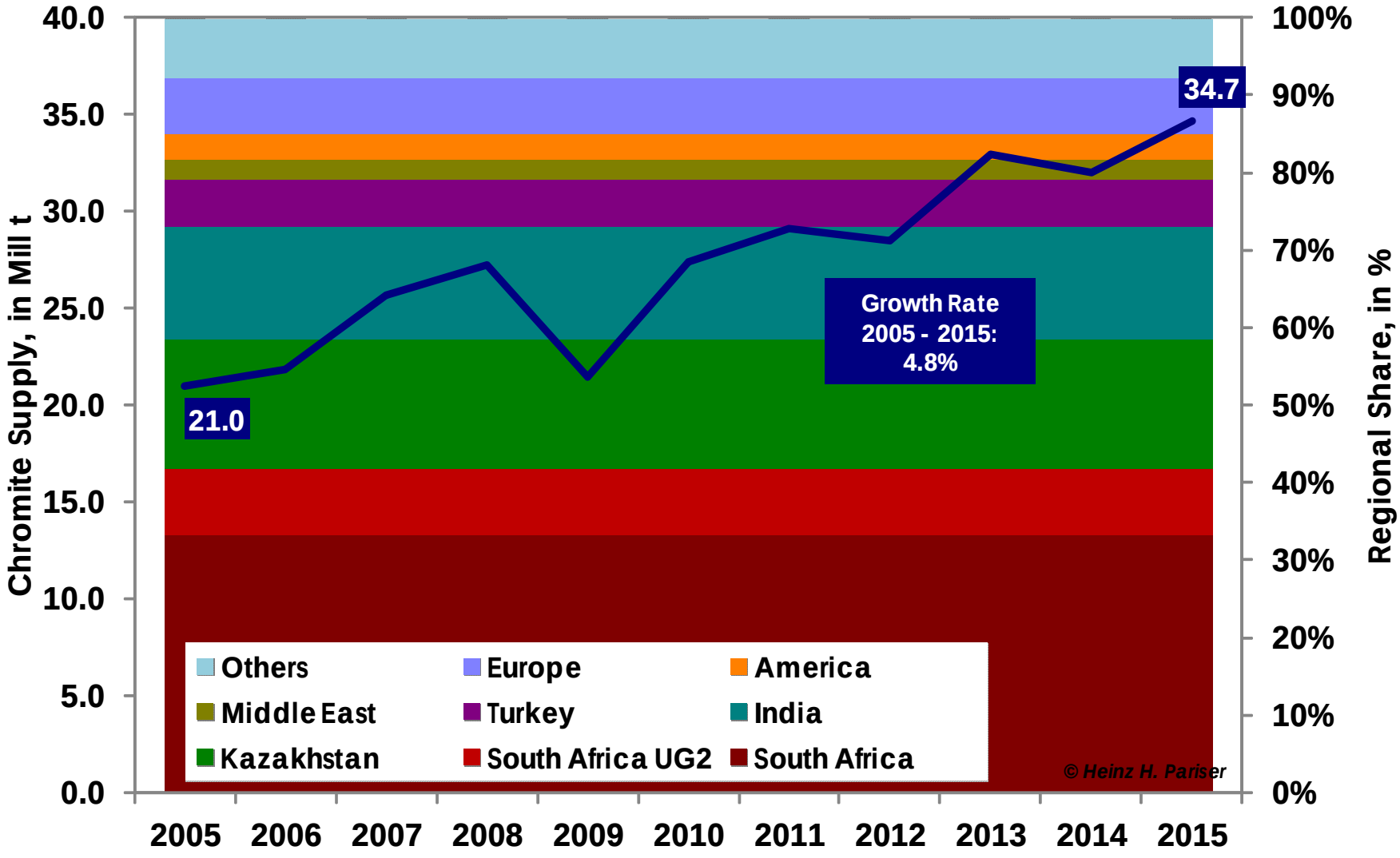
Global chromite resources



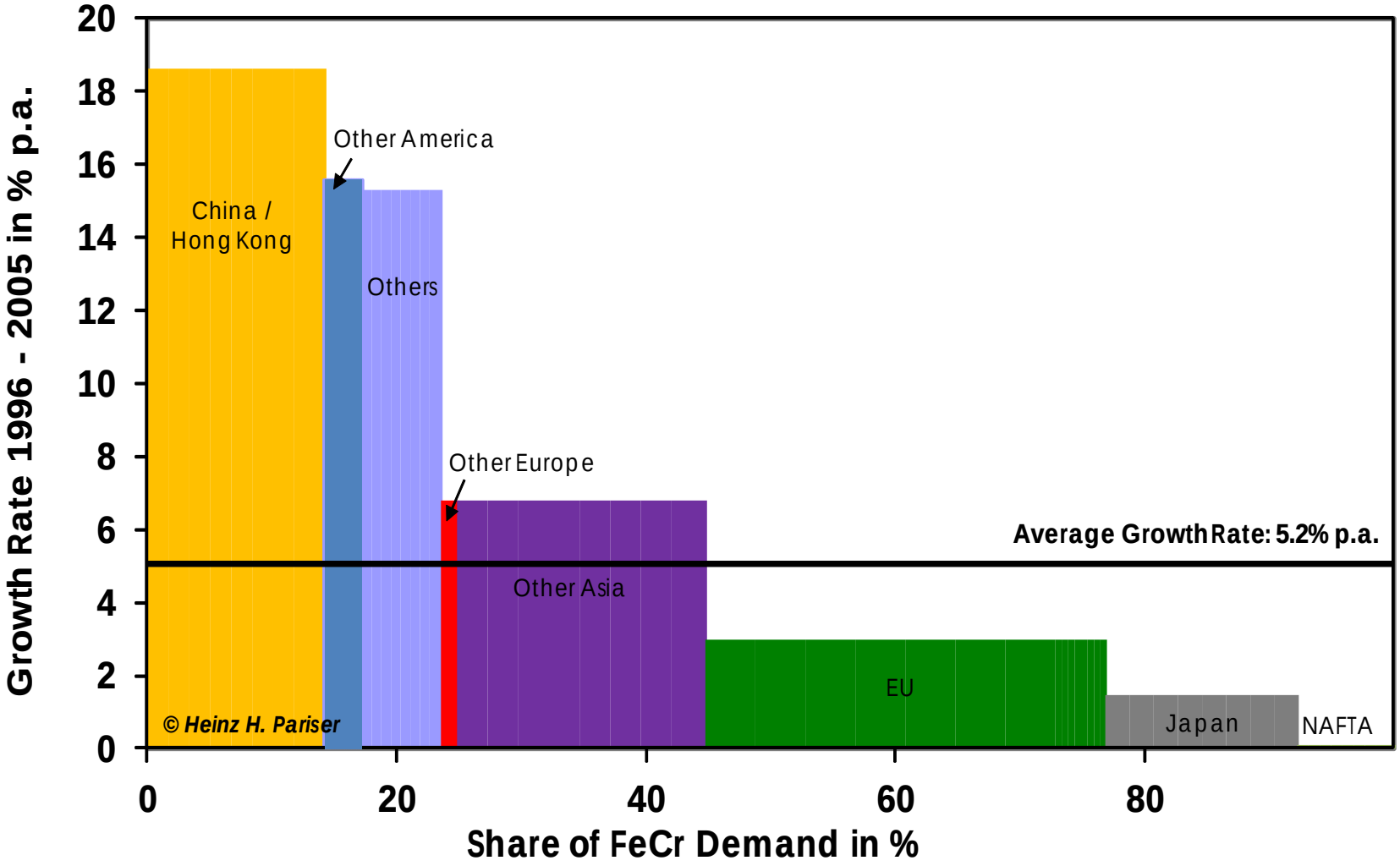
Growth of chromite supply from 1950s



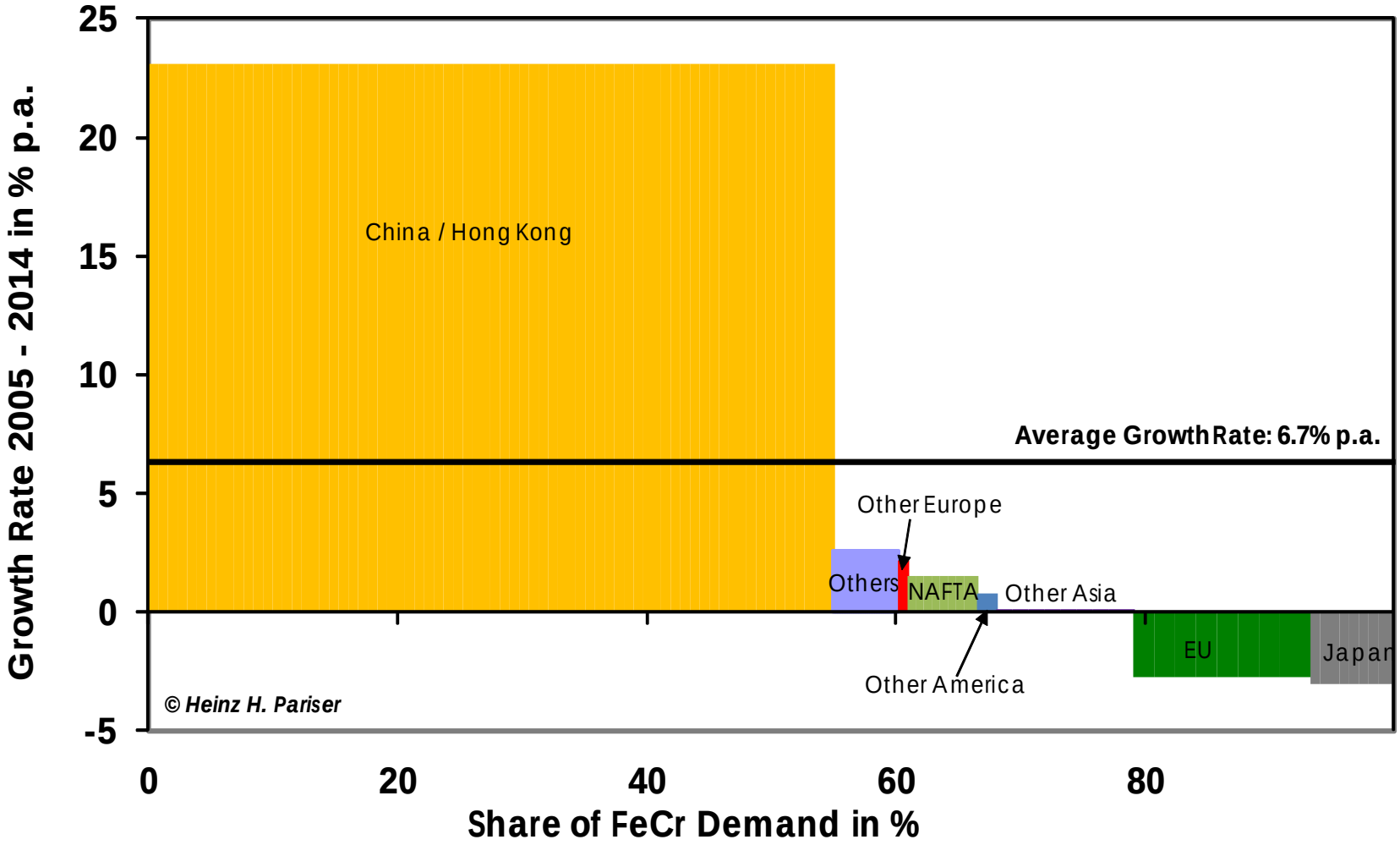
➢ Diversity of chromite supply from 2005



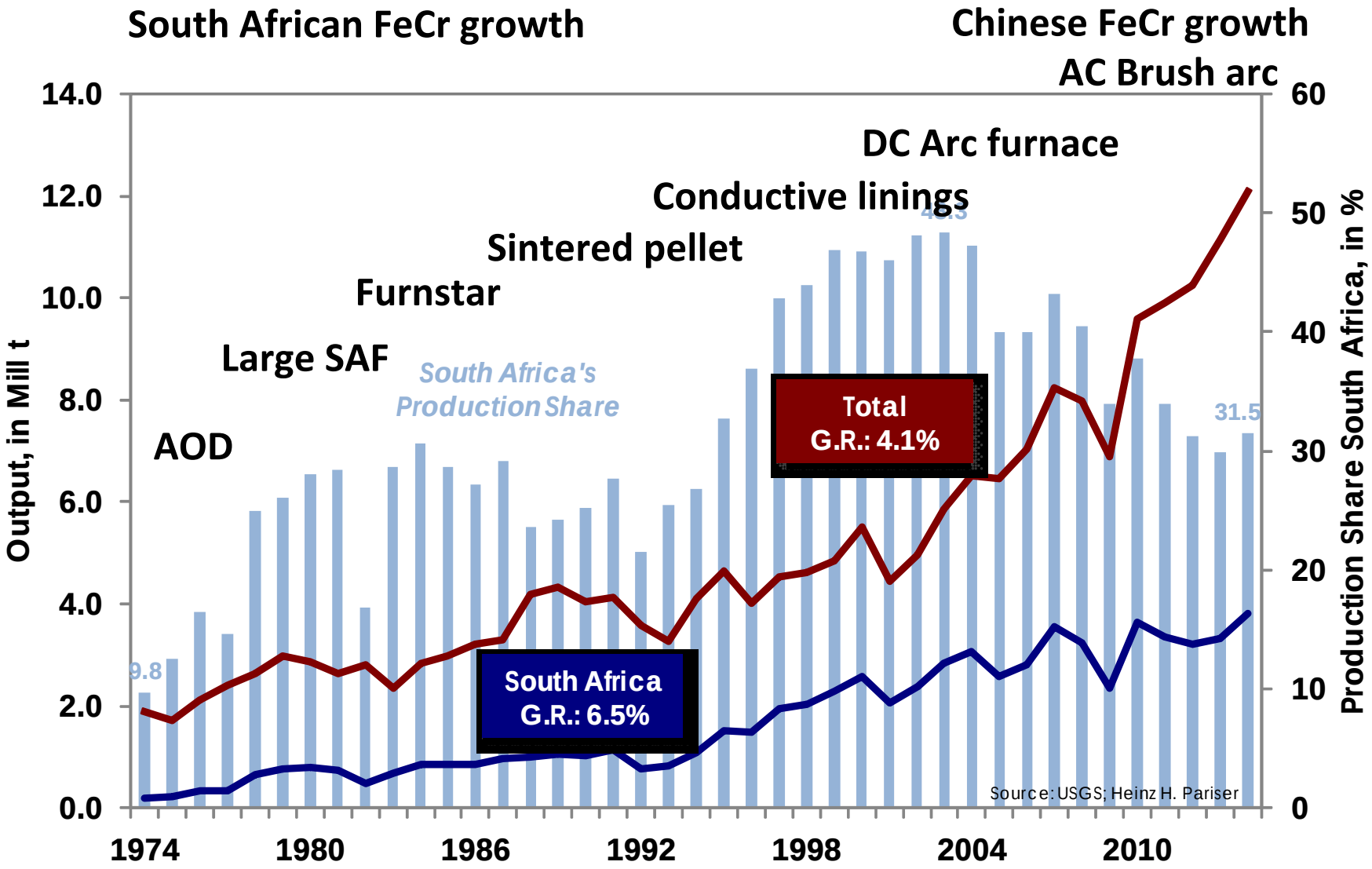
FeCr demand > 15% by China 2005
(6.1 Mt)



FeCr demand > 55% by China 2014
(11.3 Mt)



The growth in the FeCr industry since INFACON 1, 1974



Technologies that impacted the FeCr Industry in the past 40 years

- AOD in 1970s on charge chrome production from RSA in 1970s
- Development of large SAF furnaces for FeCr over 30MW in 1975
- Improvements in furnace control (Mintek Furnstar) increasing MW to over 40 MW 1980
- Sintered chrome ore pellet process (Outotec) increasing MW to over 50 MW 1990s
- Conductive SAF lining (carbon and graphite) allowing freeze line control with lower basicity ratio slags

Technologies that impacted the FeCr industry in the past 40 years

- DC arc furnace technology to smelt fines directly (Mintek/Samancor Cr) to over 60 MW 2000s and Kazchrome 4 x 72 MW furnace installation

- Sintered pellet furnace technology (Outotec/Outokumpu) to over 100MW 2012

- Refined Low to Medium Carbon FeCr alloys

60 MW DC arc FeCr smelting furnace
Middelburg Ferrochrome South Africa

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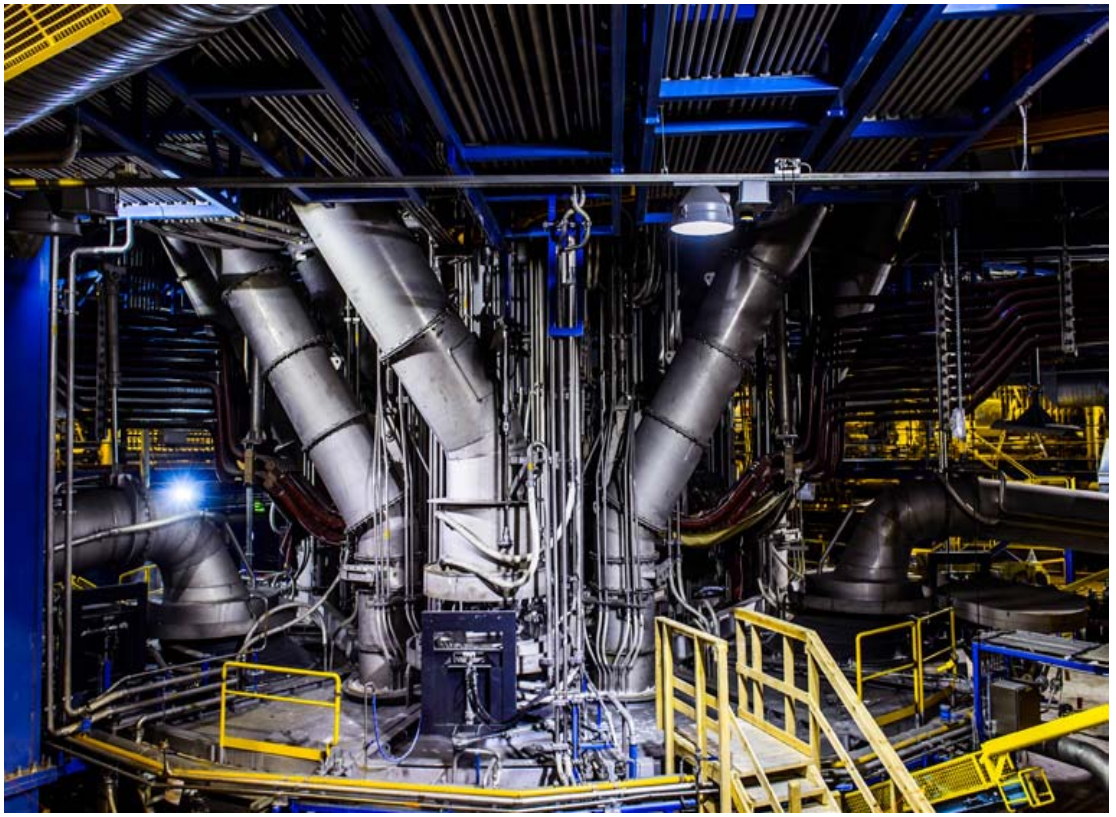
4 x 72 MW DC arc FeCr smelting furnaces
Kazchrome, Kazakhstan

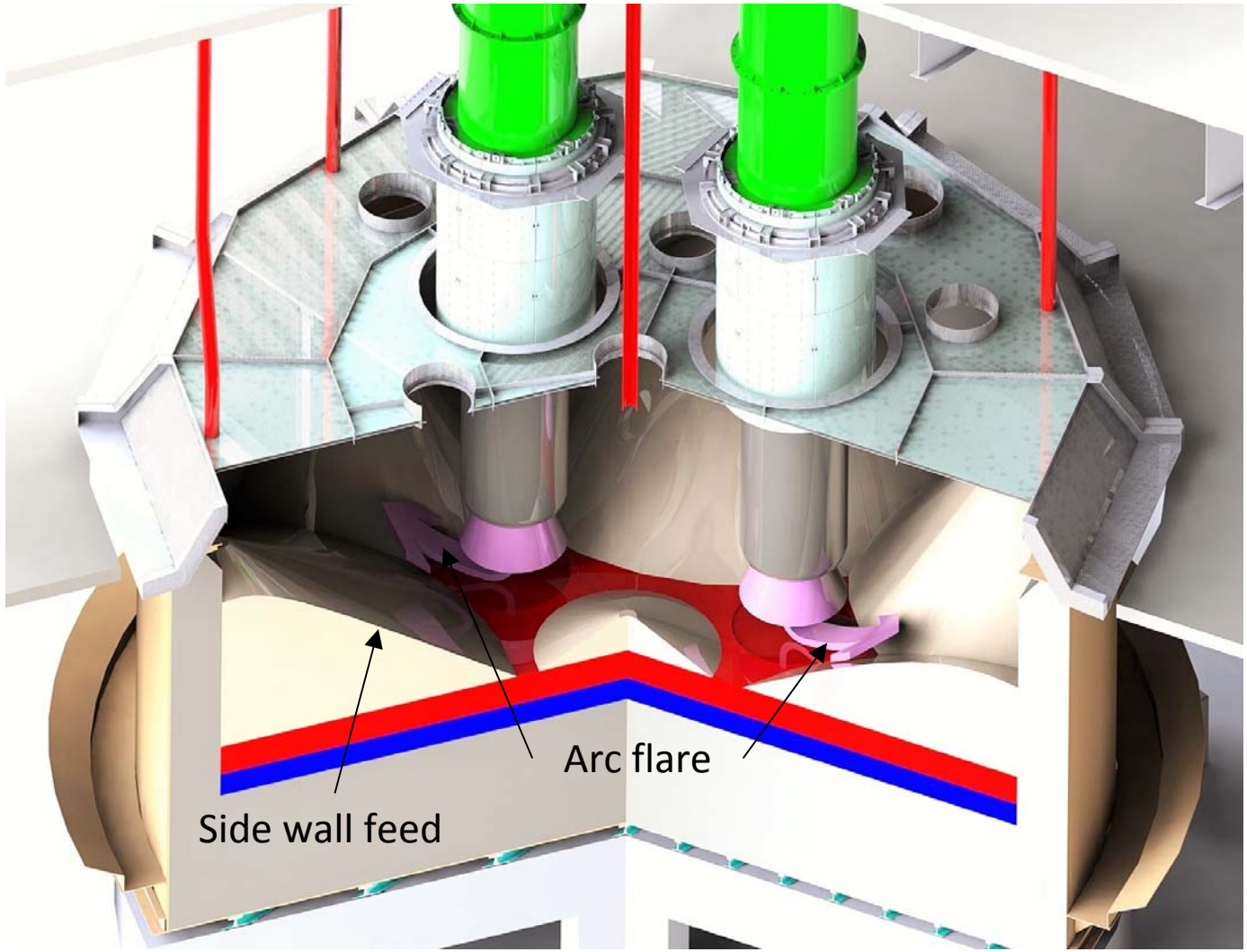
SMS SIEMAG

Preheated sintered chrome pellet FeCr smelting furnace technology up to 100 MW



Outotec

GLPS AC Brush arc FeCr smelting technology



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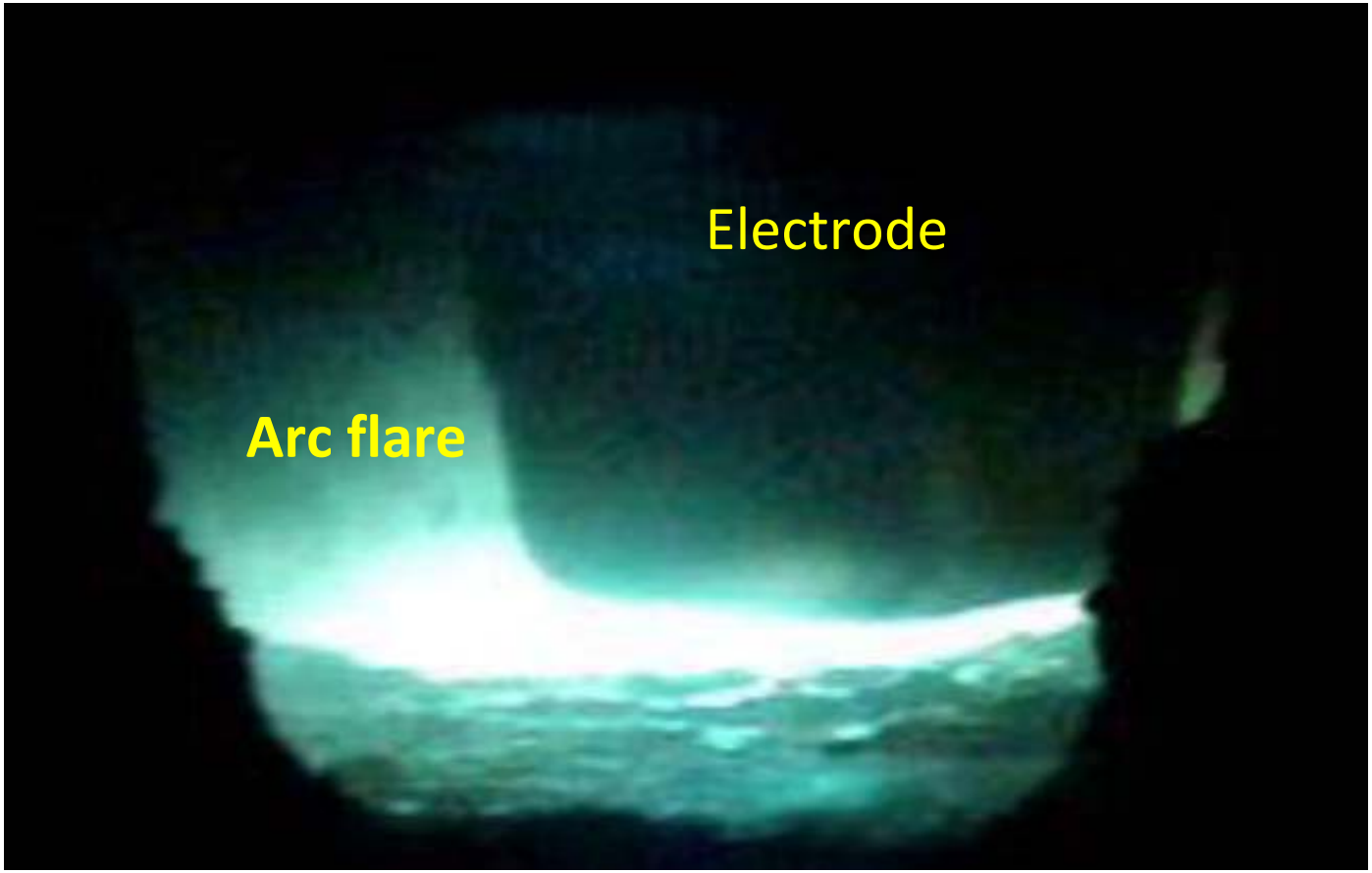
Arc flare from DC and AC electrodes



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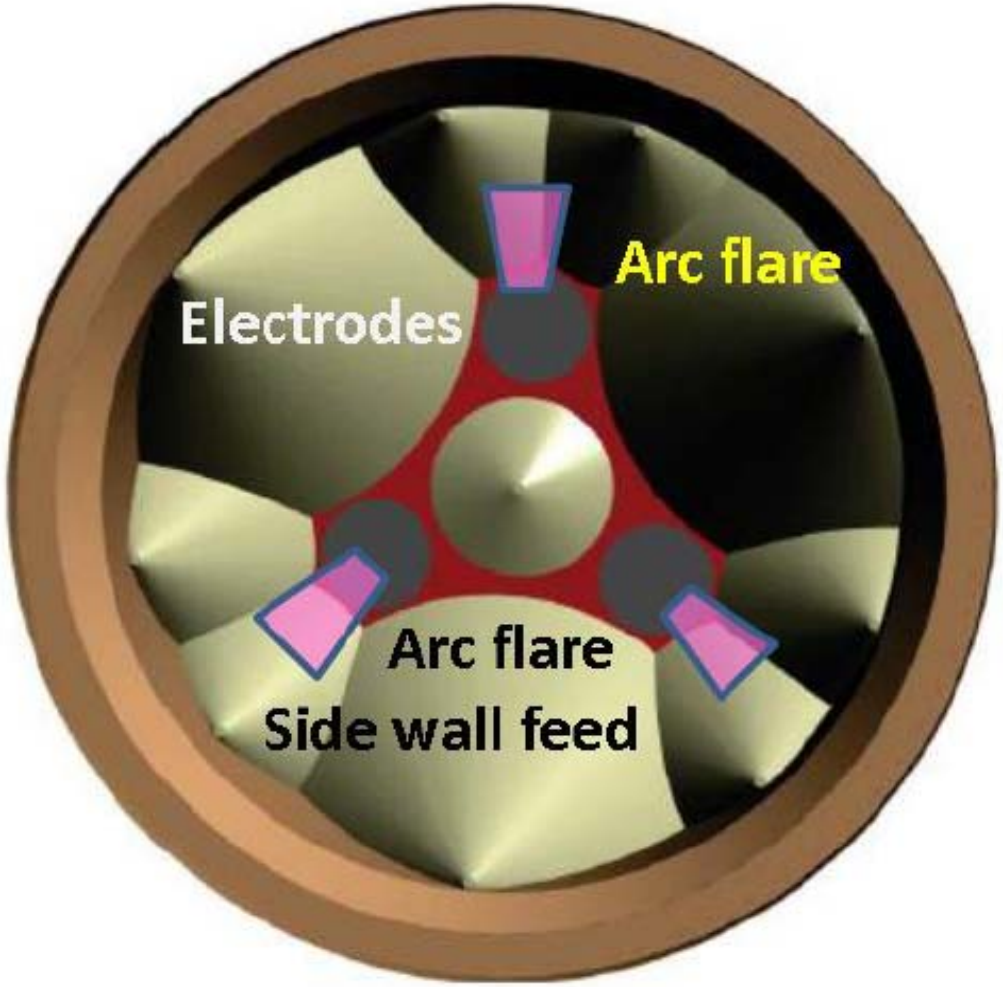
GLPS AC Brush arc FeCr smelting technology



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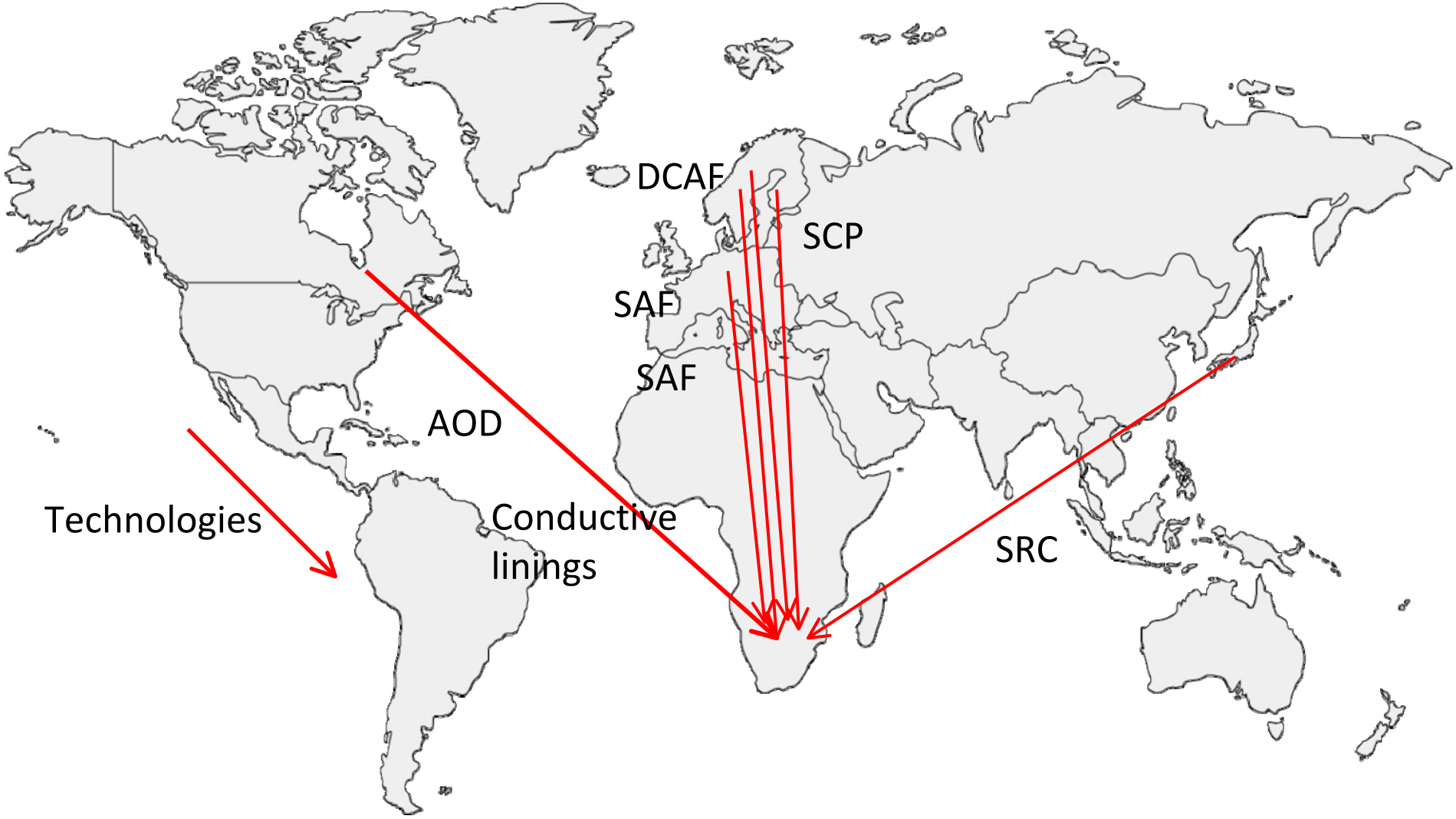
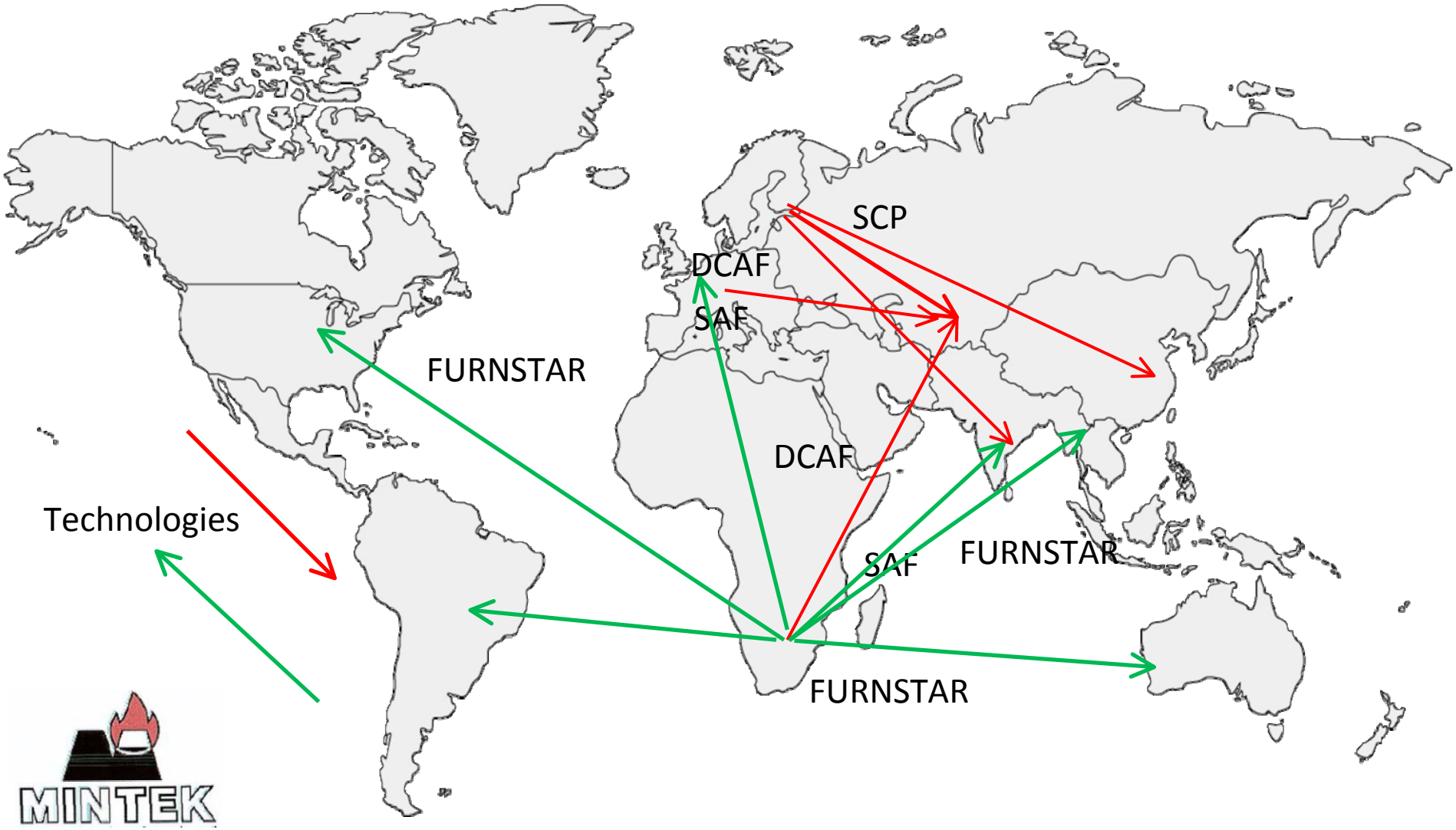
FeCr technology transfer from Europe Scandinavia and the USA



FeCr technology transfer from Europe, Scandinavia and from South Africa



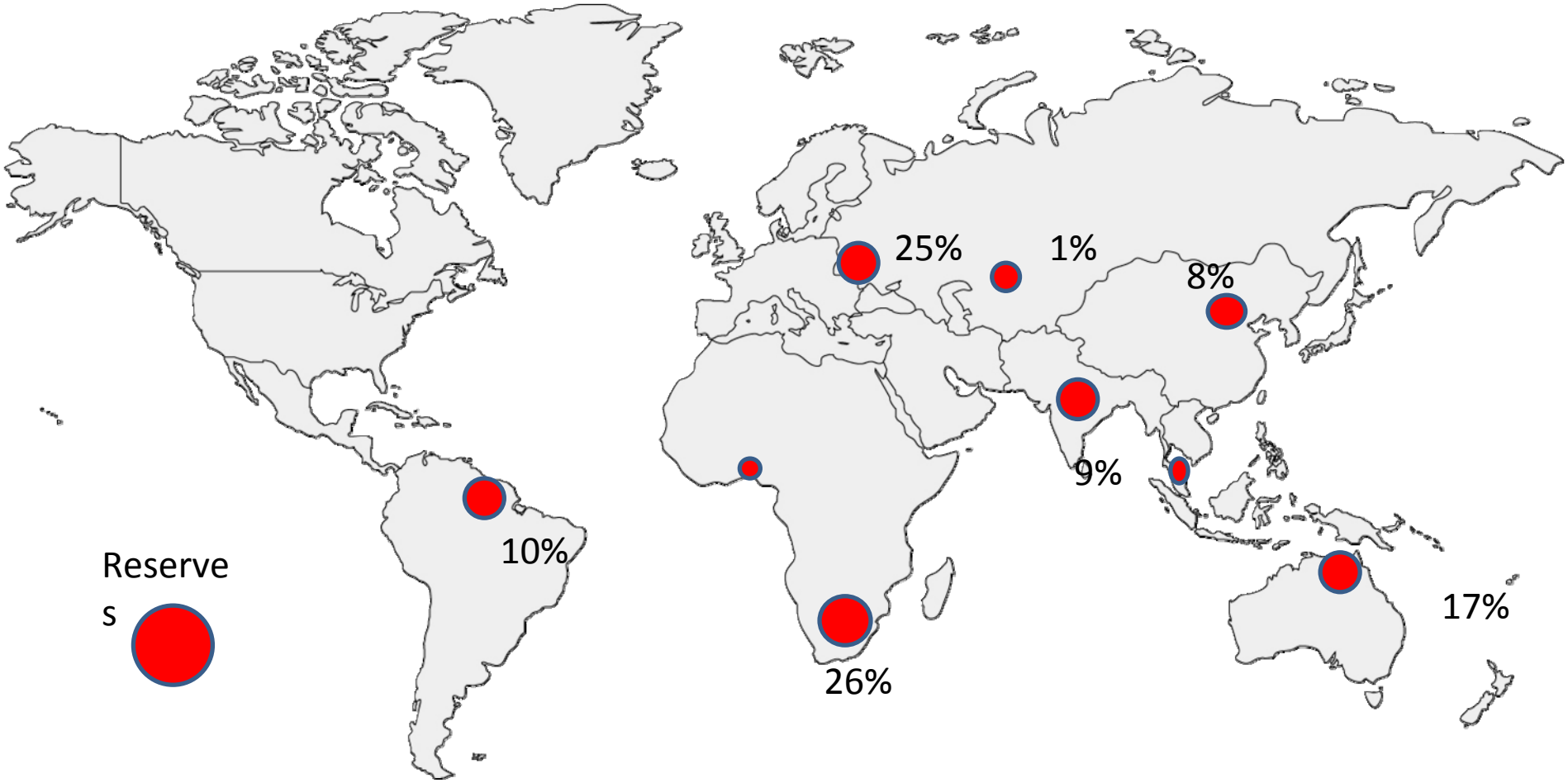
FeMn Trends over the past 40 years

- Growth in RSA FeMn alloy production from 1970 to 2015 including other major producers

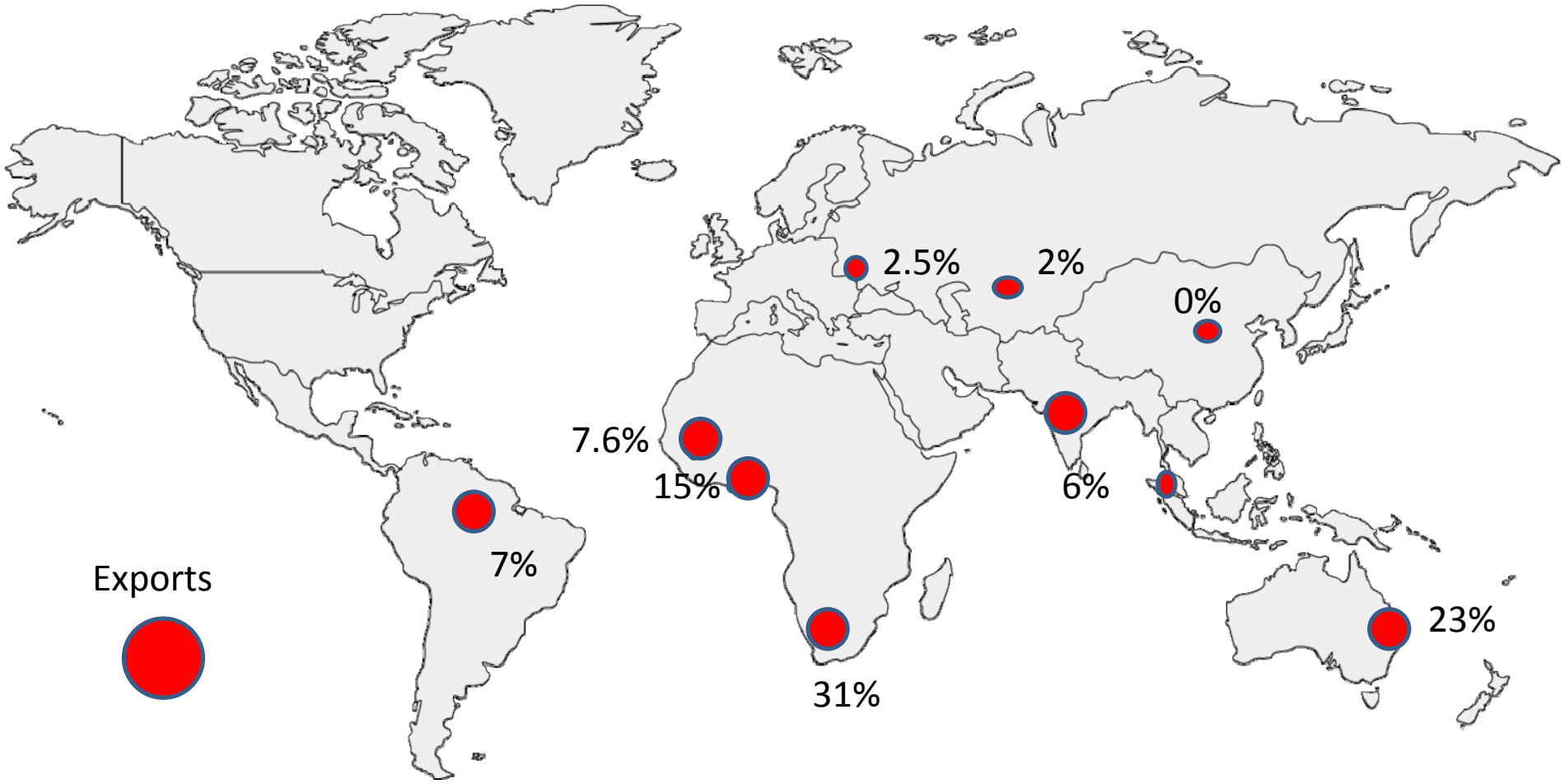
- Historical and future trends in manganese ore supply from RSA vs other regions and demand

- Forecast of FeMn production trends (recent developments (eg FeMn alloy project in Malaysia)

Mn ore reserves (570 Mt Mn contained)

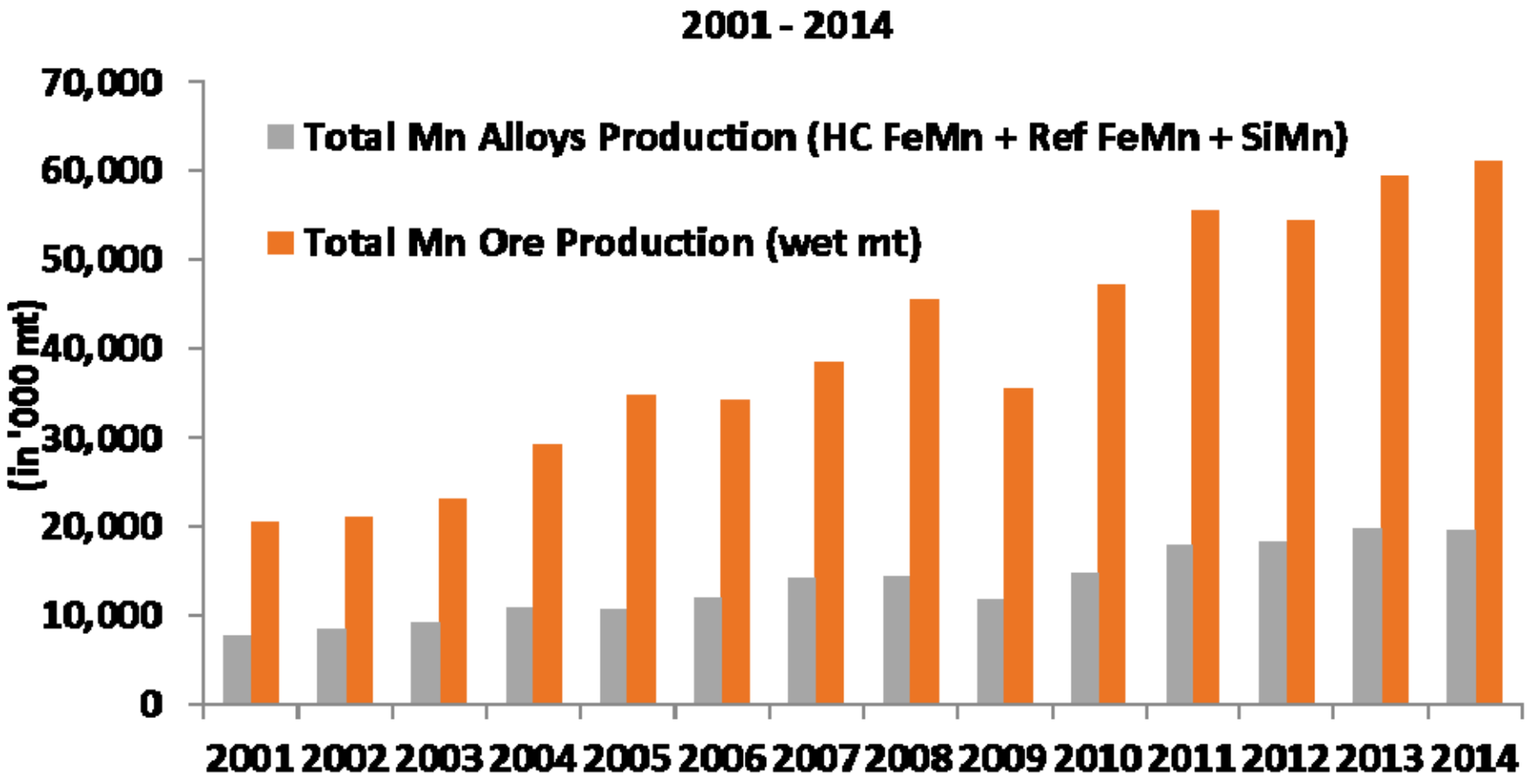


Mn ore exports (26 Mt 2013)



FeMn alloy production (18 Mt)

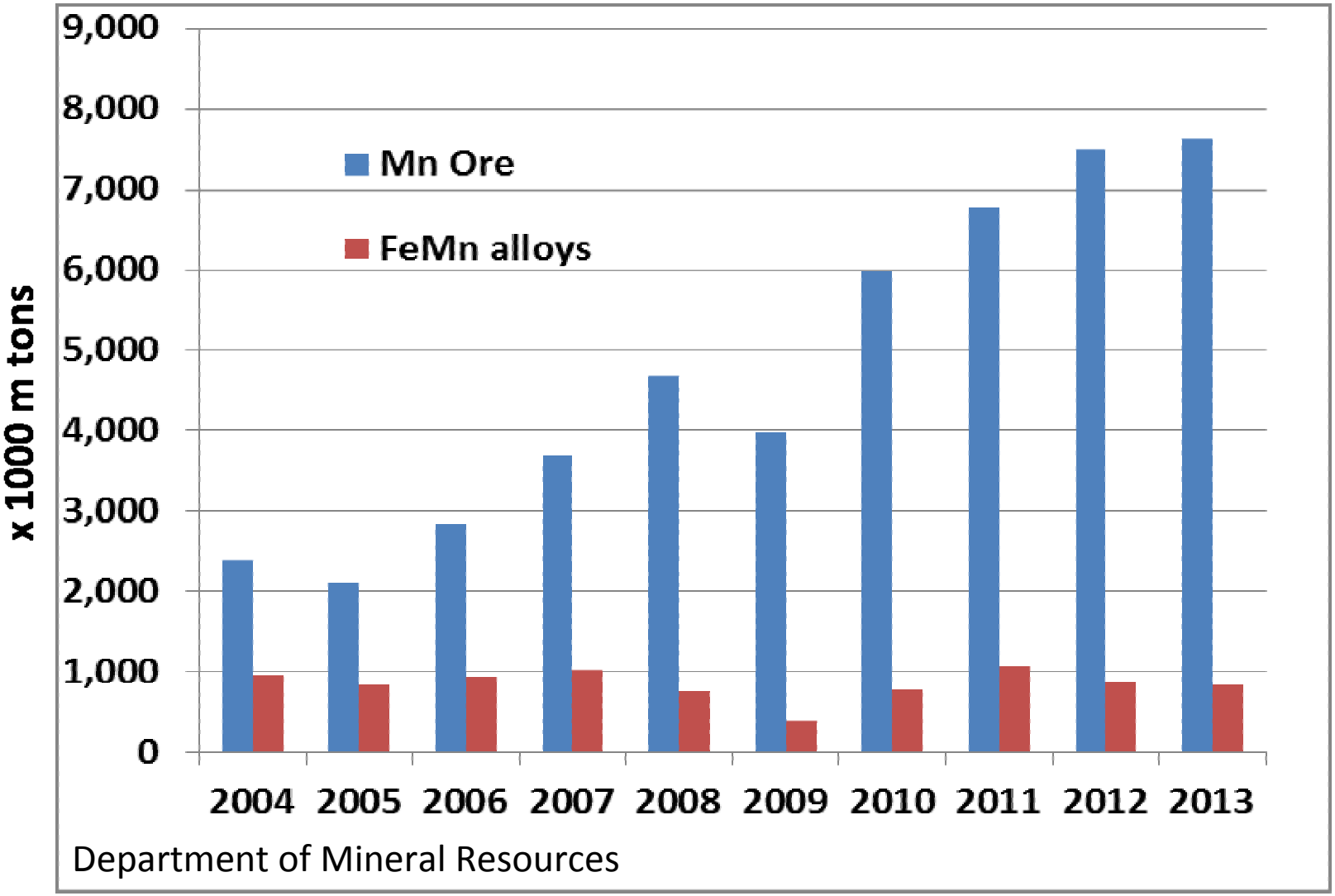
Global Mn Ore & Mn Alloys Production



Source: IMnI

IMnI INTERNATIONAL MANGANESE INSTITUTE

Manganese ore and all alloy sales
(South Africa 630 kt 2004 to 2013)



Technologies that impacted the FeMn Industry over 40 years

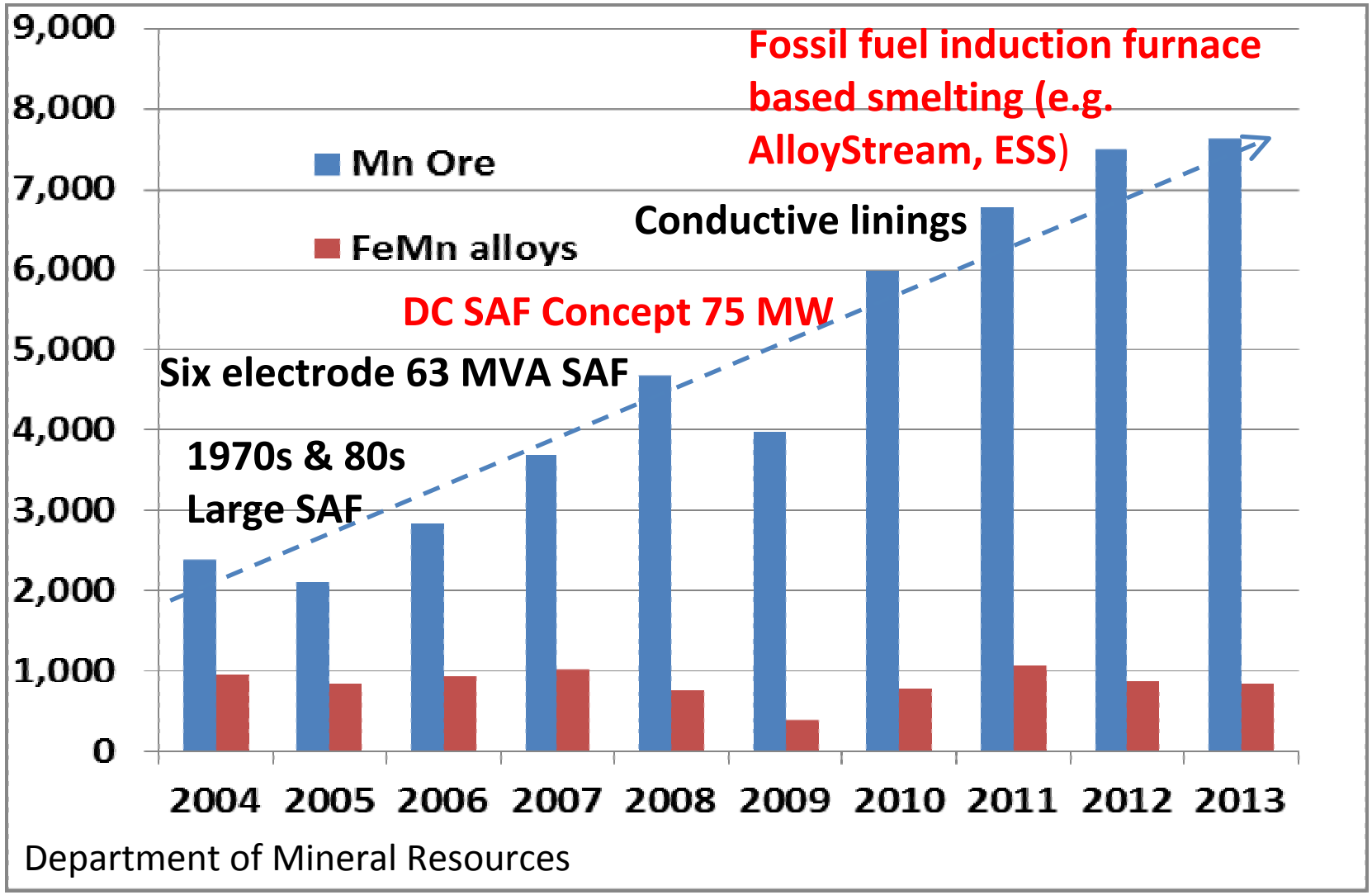
- Development of large SAF furnaces for FeMn over 30MW in 1970s
- Improvements in furnace control (Mintek Furnstar) increasing MW to over 40MW 1980
- Sintered manganese ore technology to improve furnace operation 1980/1990s

Technologies that impacted the FeMn Industry over 40 years

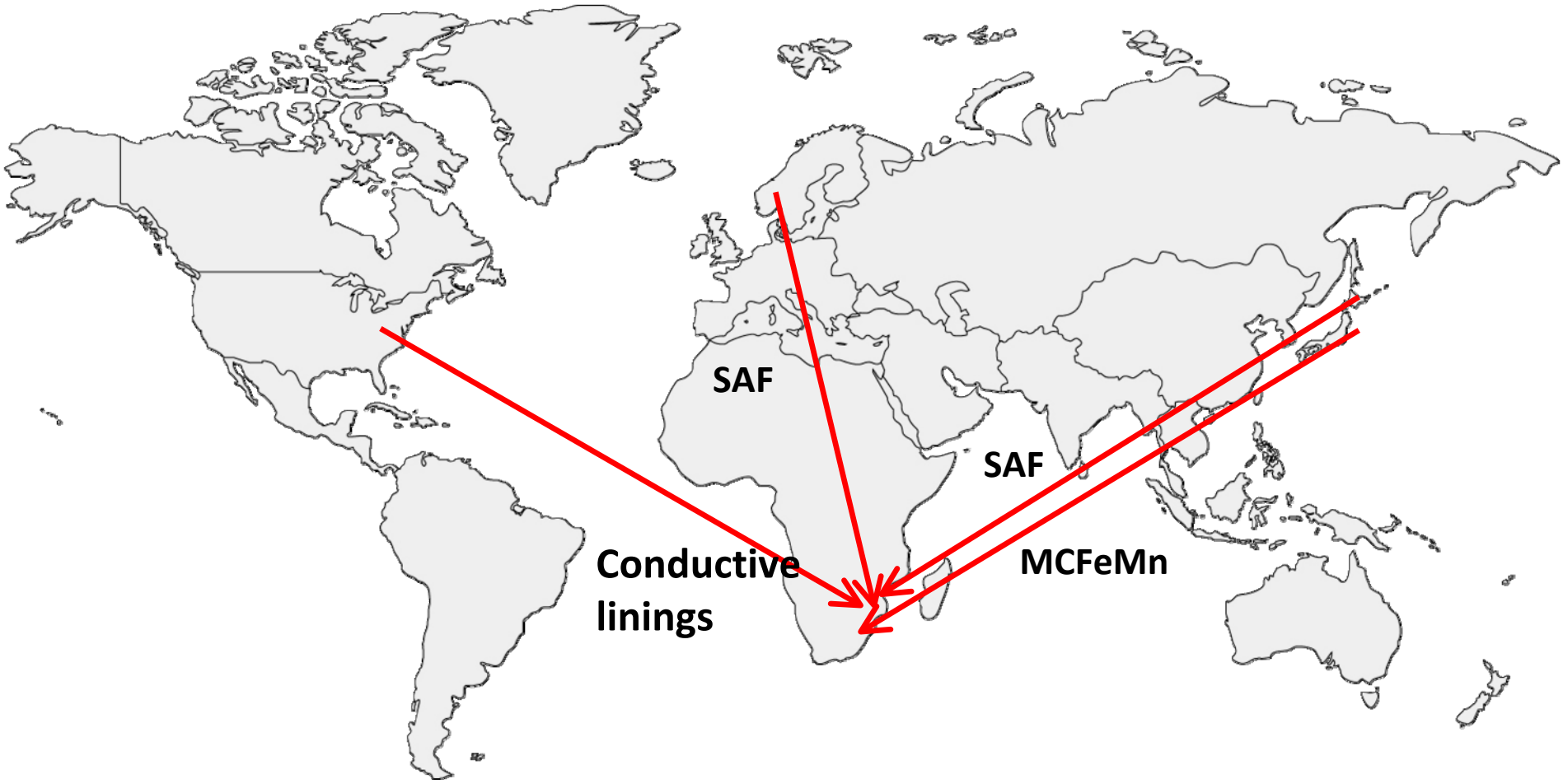
- Challenging developments in DC arc furnace technology to smelt FeMn (Samancor Manganese) 1980s
- Further improvements in furnace control increasing power up to 50 MW 1990s
- DC SAF Concept to increase SAF power to 75MW
- Challenging development to date on combustion induction furnace technology for FeMn alloys 2010s

Manganese ore and all alloy sales from RSA

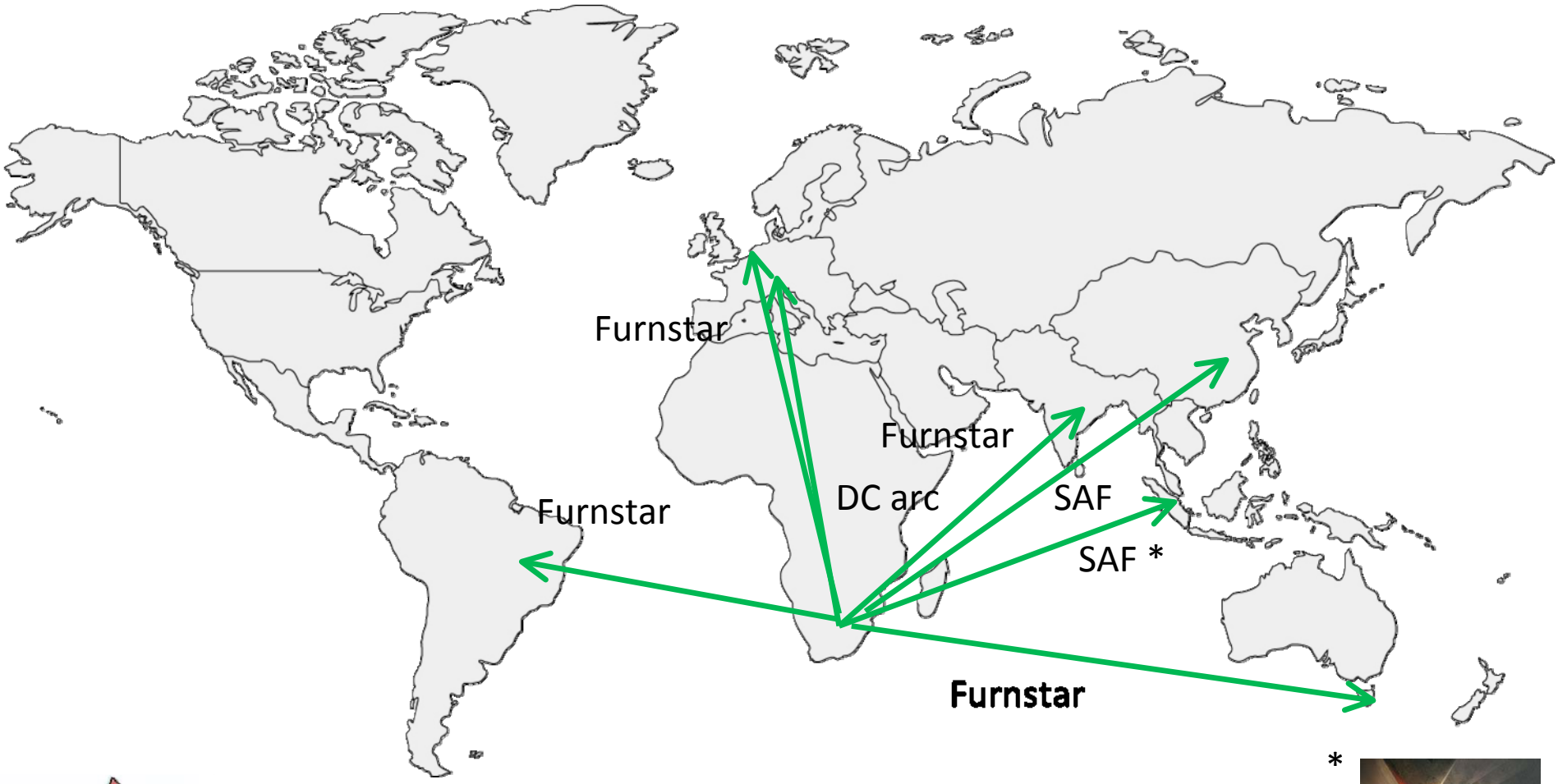
(New technologies)



Manganese technologies to South Africa

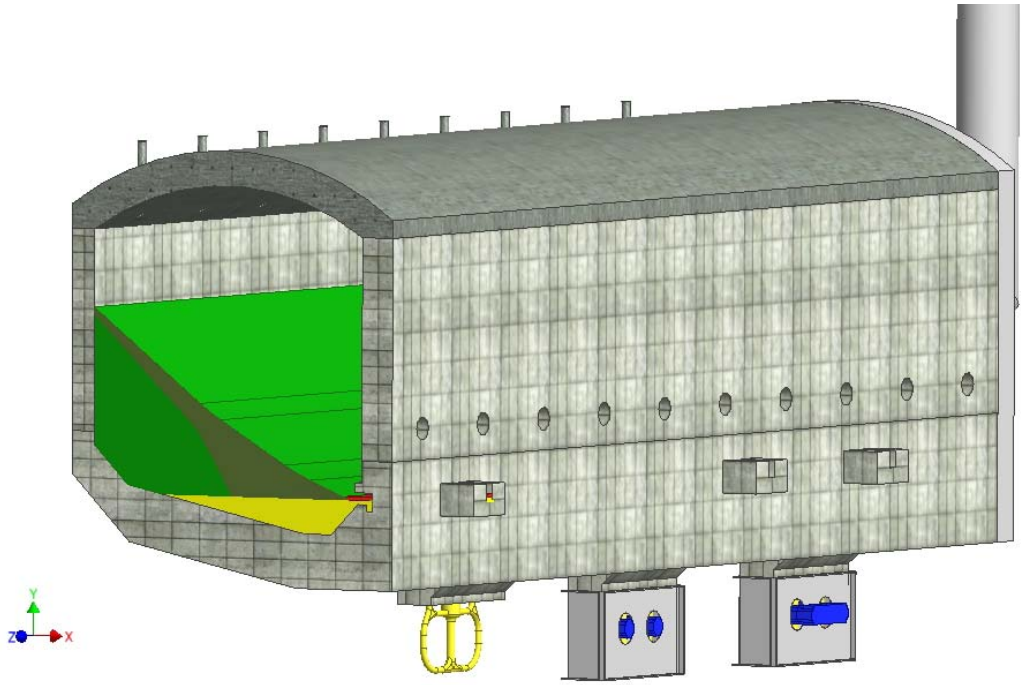


Manganese technologies from South Africa



Manganese ore (and FeNi) smelting technologies for the future

(ESS Process)

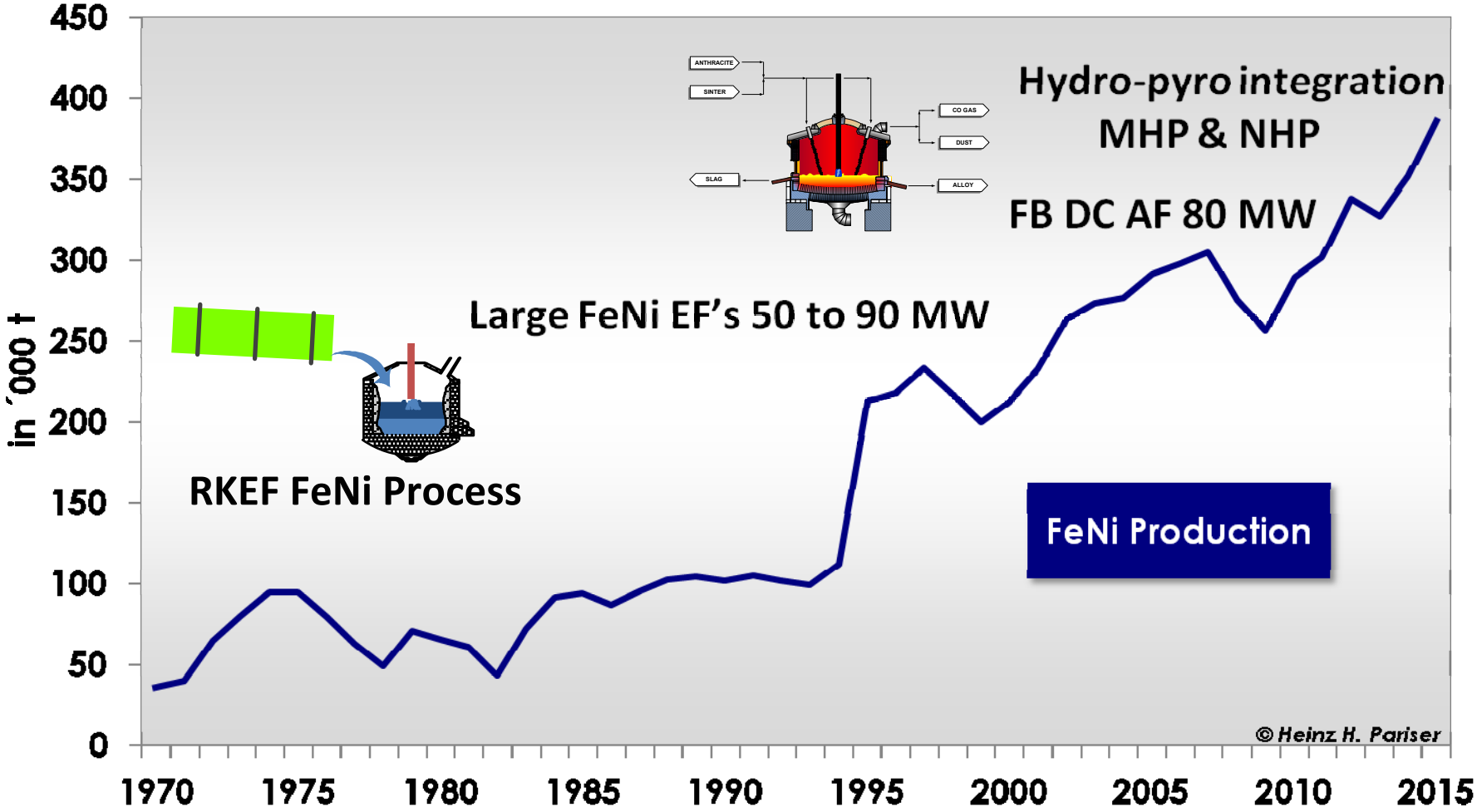


“Energy saving Smelting”

Technologies that impacted the FeNi industry in the past 40 years

- Development of large EF furnaces for FeNi over 50 MW in 1990
- Improvements in furnace control (Hatch, SMS Siemag) increasing MW to over 90 MW 2010
- DC arc furnace technology to smelt fines directly (Mintek) to potentially > 80 MW 2000's
- Hydro-pyro integration using MHP/NHP as feed to RKEF and DC AF processes

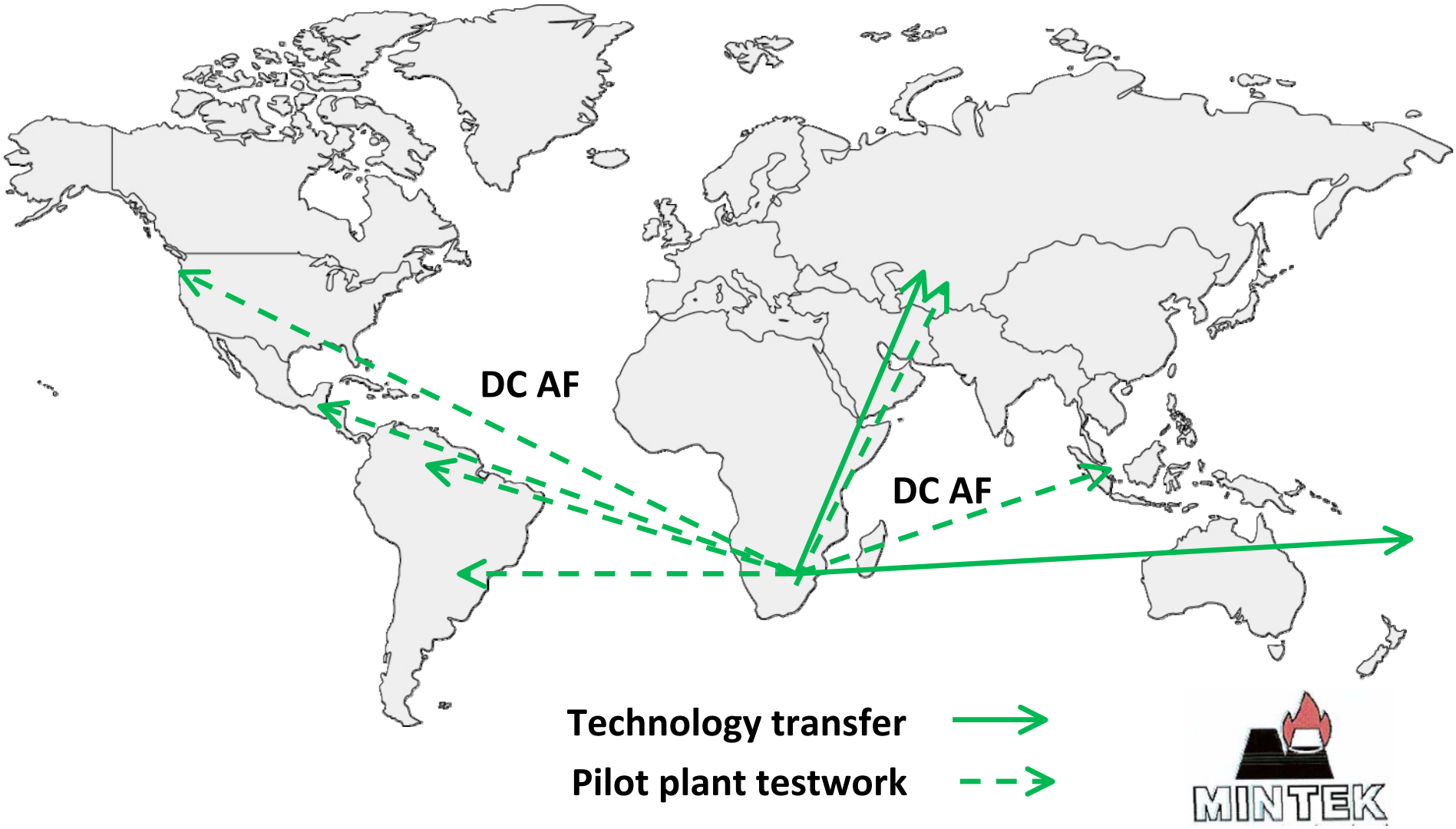
FeNi production (excluding NPI) 1970 - 2015



FeNi alloy production (400 kt)

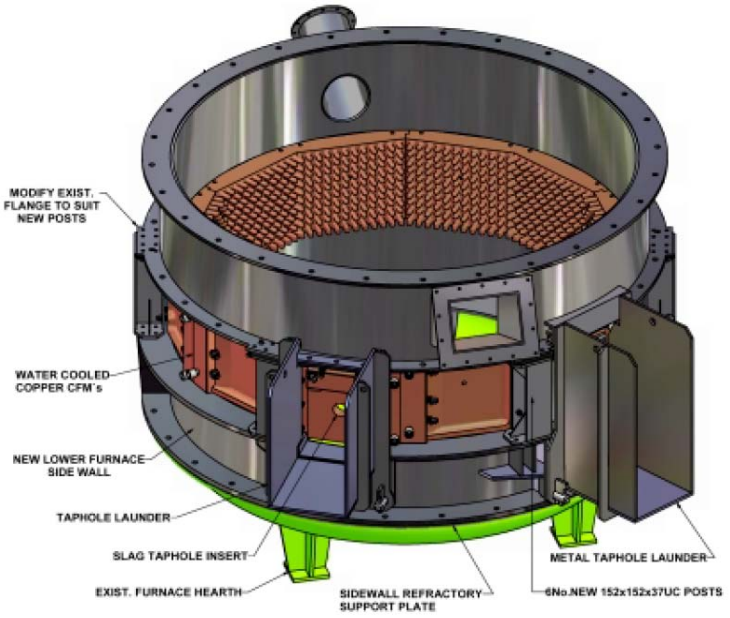
(NPI ~100 kt/a)

DC FeNi technologies from South Africa



Ferronickel technology
(Mintek twin electrode DC arc furnace)

Copper-coolers



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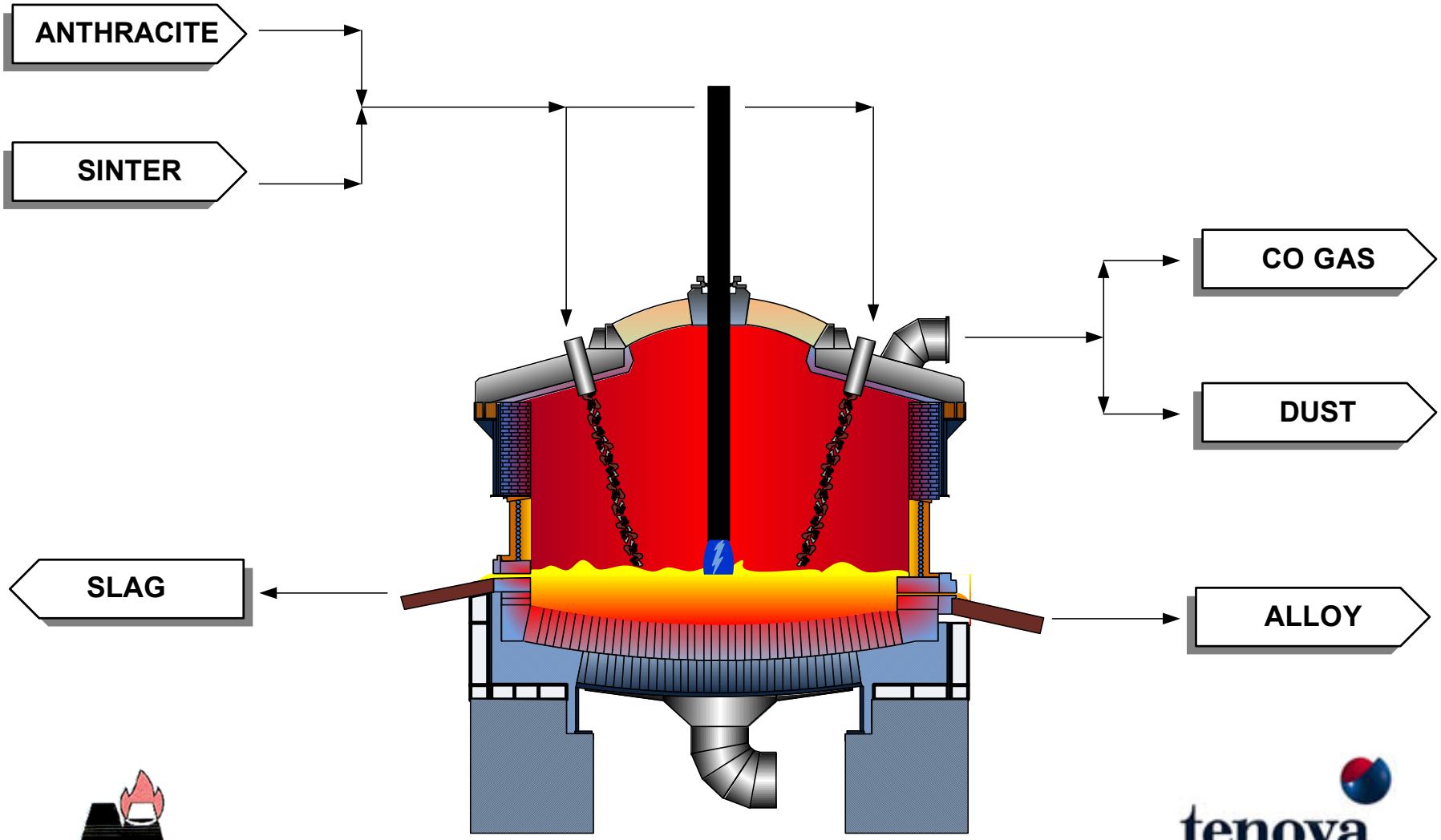
12 MW FeNi DC arc furnace (SUNP)



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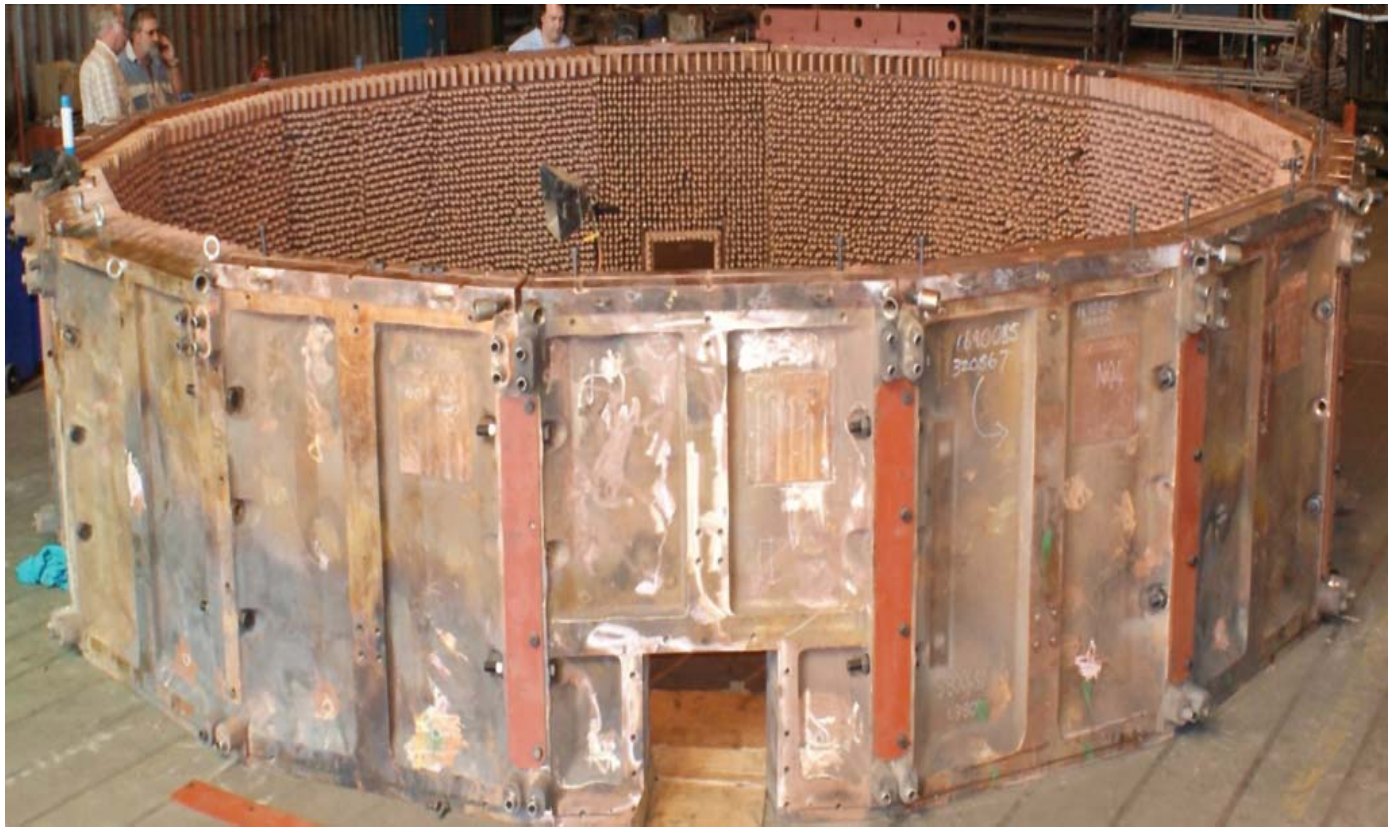
Copper-coolers for 12 MW DC arc FeNi furnace (SUNP)



Koniambo 2 x 80 MW DC FeNi furnaces
New Caledonia

HATCH

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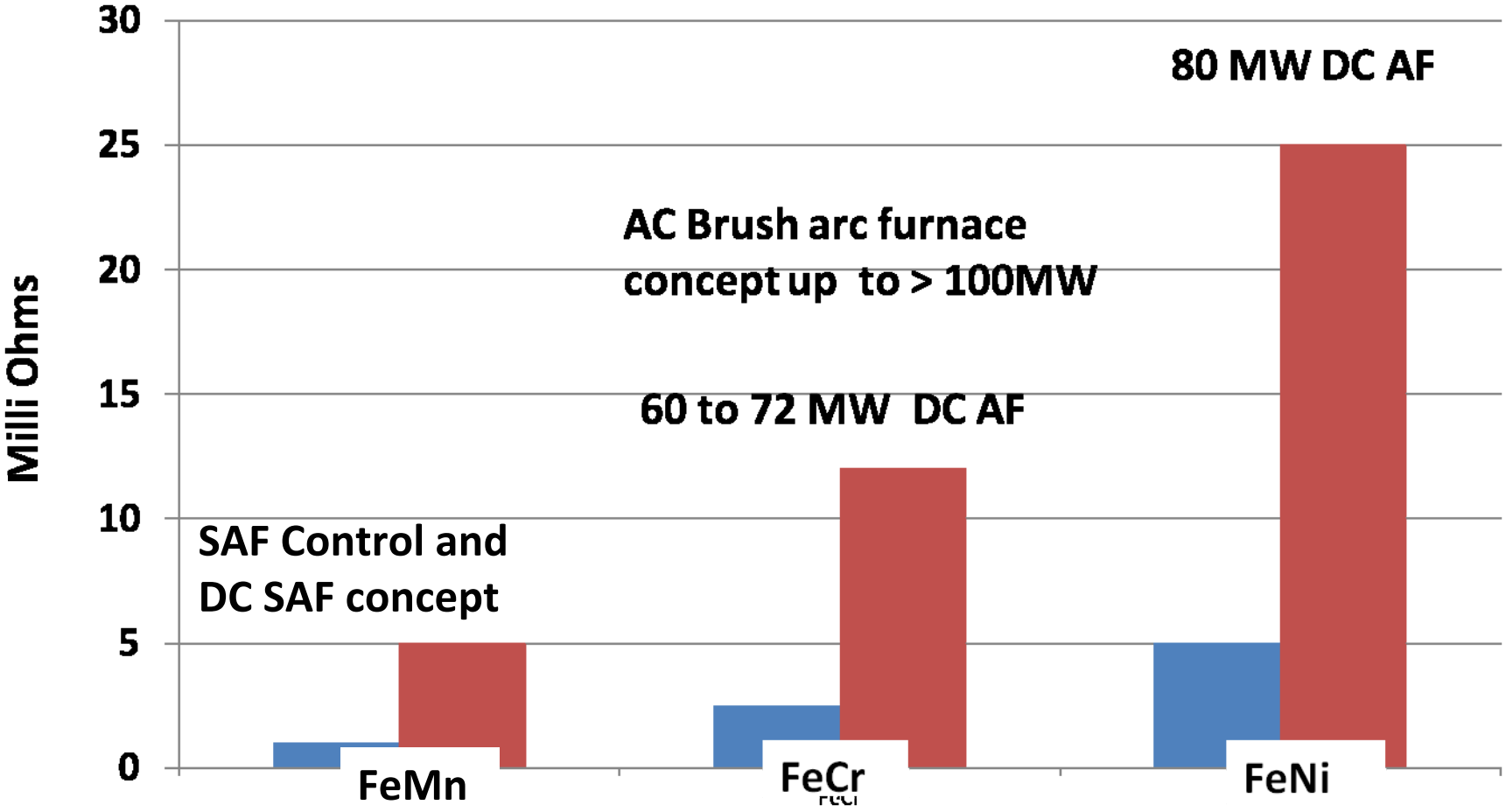
South Africa's role in technology demand and supply internationally

- Furnace control for most ferro-alloy smelting processes
- Applications of advanced furnace technology in particular DC arc furnaces for FeCr and FeNi
- Applications to special ferro-alloys LCFeCr, Mn slag from dry cell batteries, FeNb, FeV others
- Extensive metallurgical testwork on smelting chromite and nickel laterite ores in support of feasibility studies and the implementation of FeCr up to 70 MW and FeNi up to 80 MW scales.

Relative operating resistances for FeMn, FeCr and FeNi furnaces for SAF and DC AF configurations



Conclusions:
Developments, challenges, sustainability and what lessons have been learnt?

- Driven by regional and market forces
- Sustainability depends on longer term competitiveness
- Raw material and energy availability and supply costs are critical factors
- The global pattern is driven by regional developments and security of supply considerations but not necessarily by competiveness.

Conclusions:
Developments, challenges, sustainability and what lessons have been learnt?

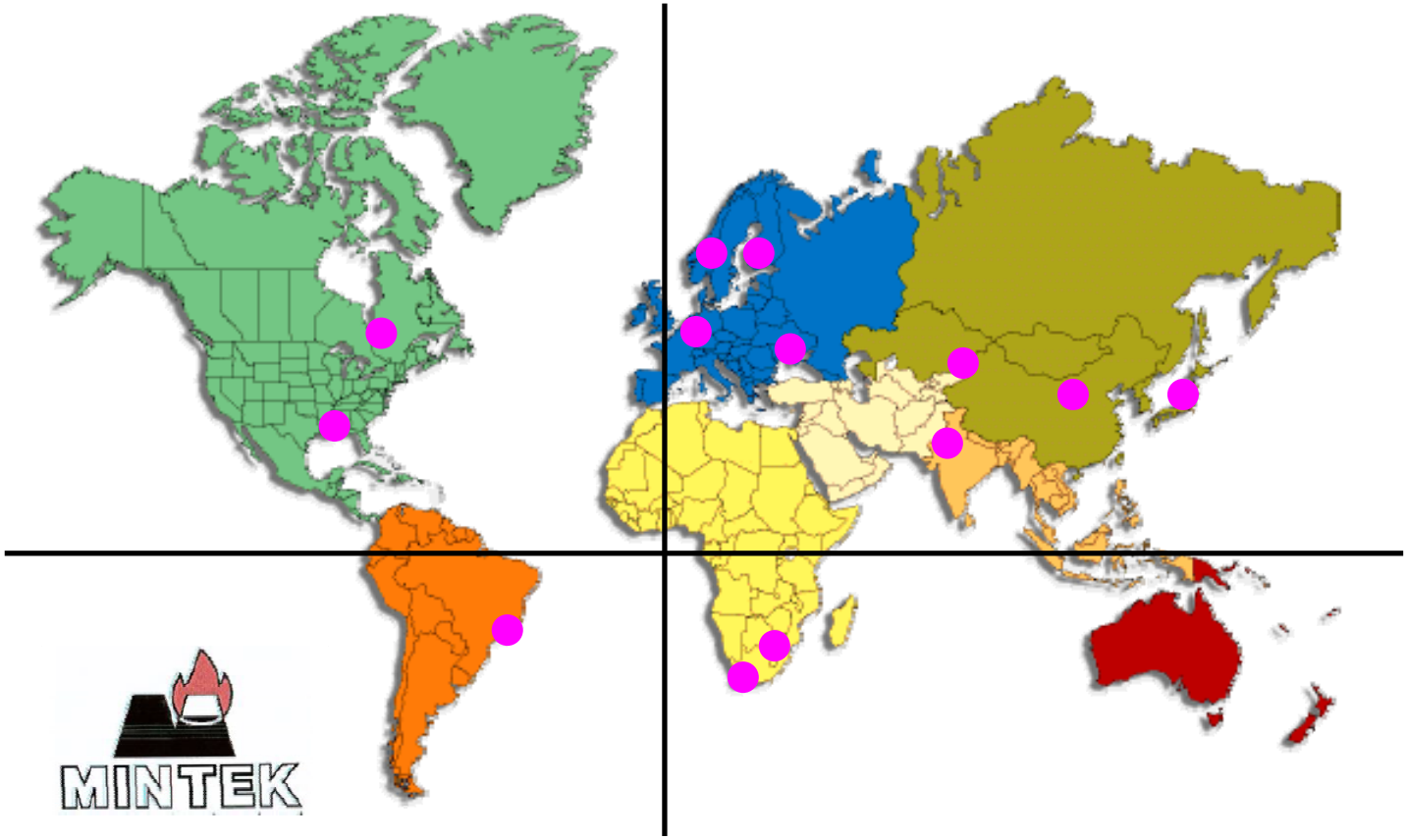
- Longer term sustainability shifts the balance to regional supply with sustainable competitive cost structure

- South Africa needs to recognise this and position itself accordingly

- Lessons learnt – INFACON XV

Thank you

Acknowledgements:-
Heinz H. Pariser-chrome and nickel data



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