Silicon Carbide in Steelmaking: Why Not?

Price history, common doubts and real results vs FeSi

Kymera® INTERNATIONAL

Kymera International – Performance Ceramics

Kymera International acquired Fiven in July 2024.
Performance Ceramics is Kymera's silicon carbide business – the former Fiven.

- **Full SiC portfolio**
  from metallurgical grade (SIKA® MET) to 99.999% purity
- **Own Acheson production**
  plants in Brazil and Norway
- **R&D and technical support**
  teams in Norway and Brazil

Certified

ISO 9001 | ISO 14001 | ISO 45001 | EcoVadis

1912
SiC production since (Arendal, Norway)

400+
employees in Performance Ceramics

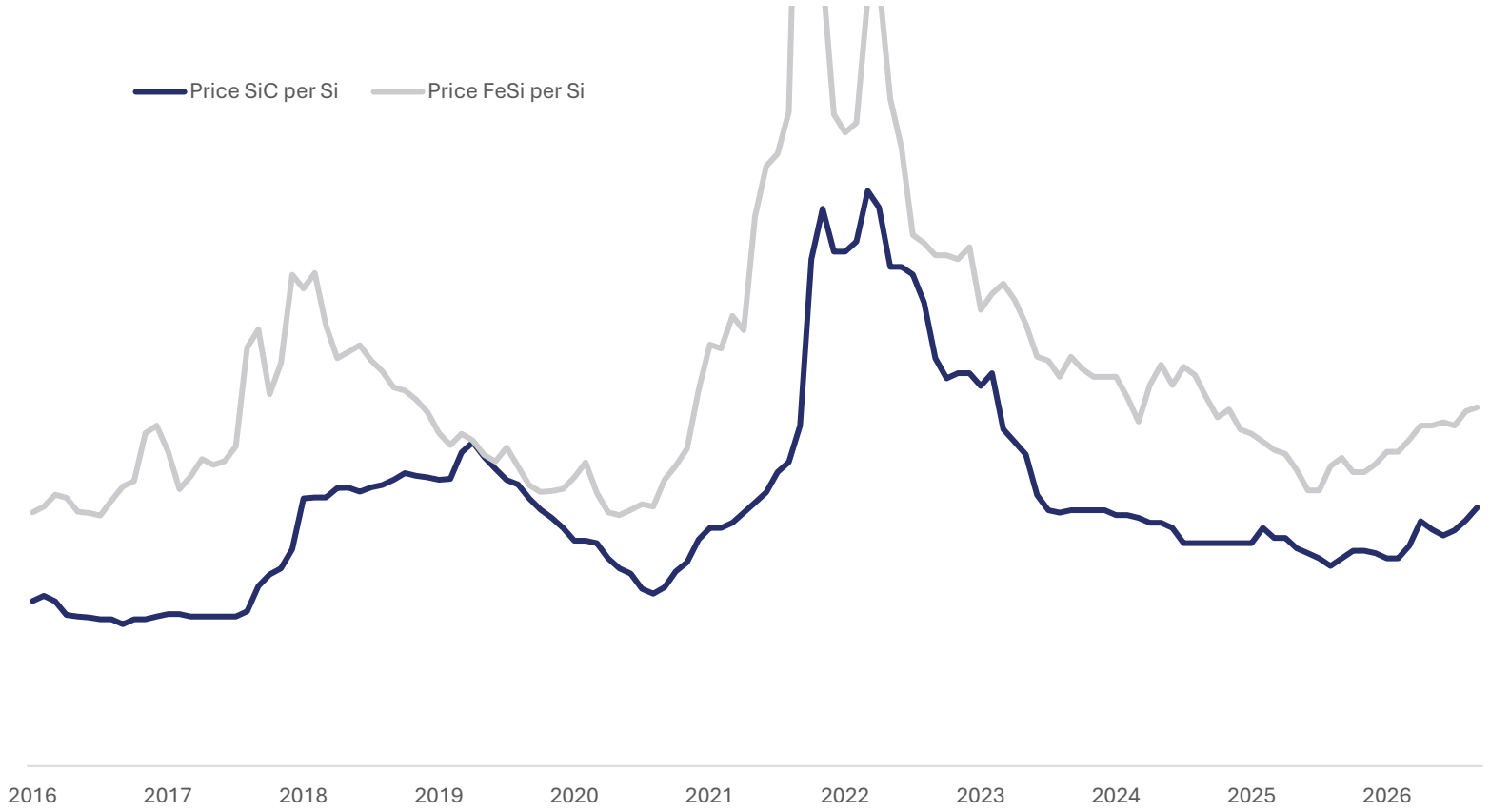
2
SiC plants: Brazil · Norway

21
Kymera sites in 12 countries

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SiC vs FeSi: Never More Expensive per Unit of Si



2016 – 2026, monthly · same Si basis*

129 / 129

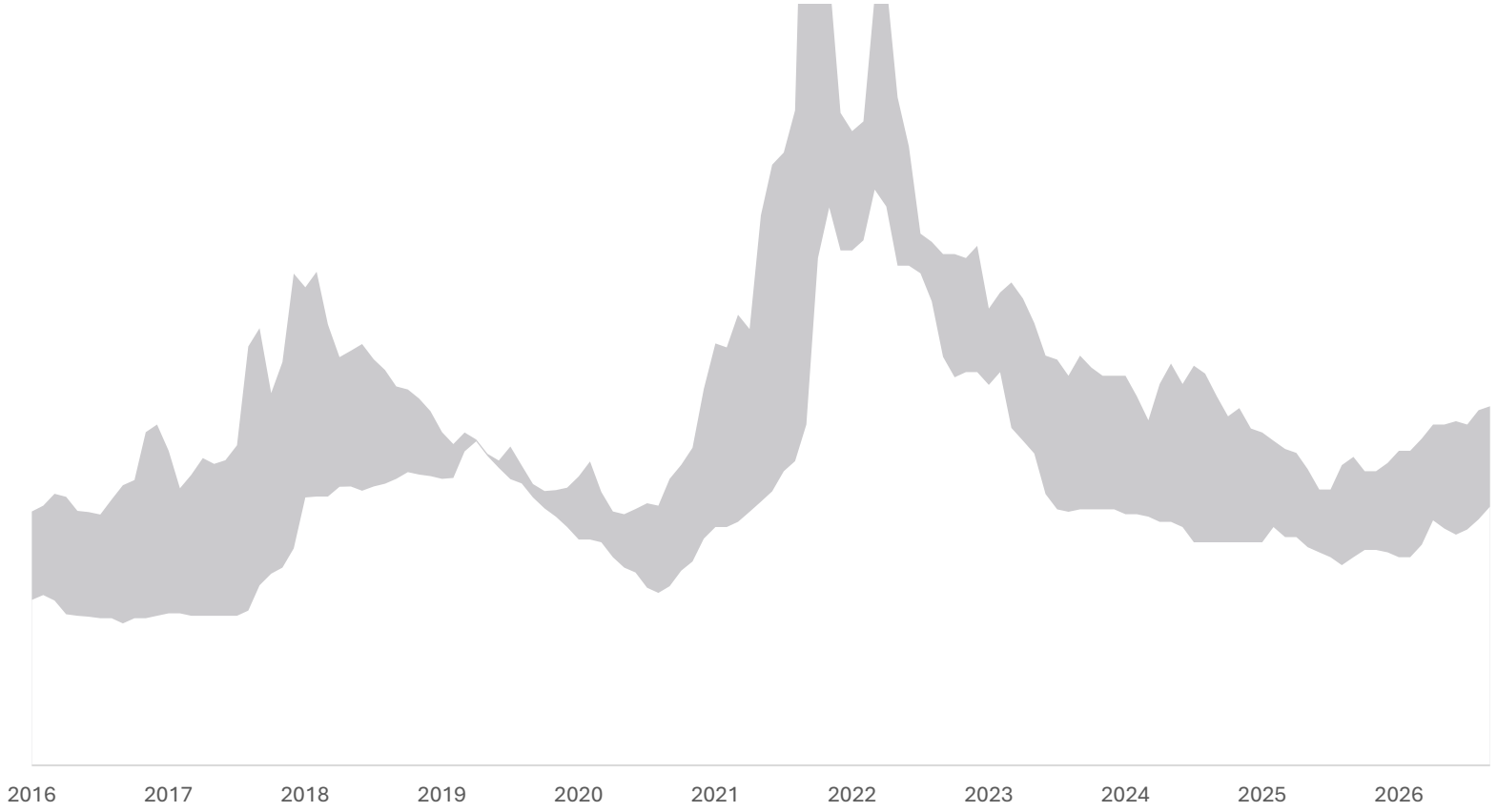
months with SiC below FeSi on the same silicon basis

*Same silicon basis: SiC ≈ 60% Si (SiC 85%) vs FeSi ≈ 75% Si (FeSi 75). Relative values only – no absolute prices.

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The Gap: Sometimes Narrow, Sometimes Wide



2016 – 2026, monthly · same Si basis*

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months with SiC below FeSi on the same silicon basis

0.4 – 59%

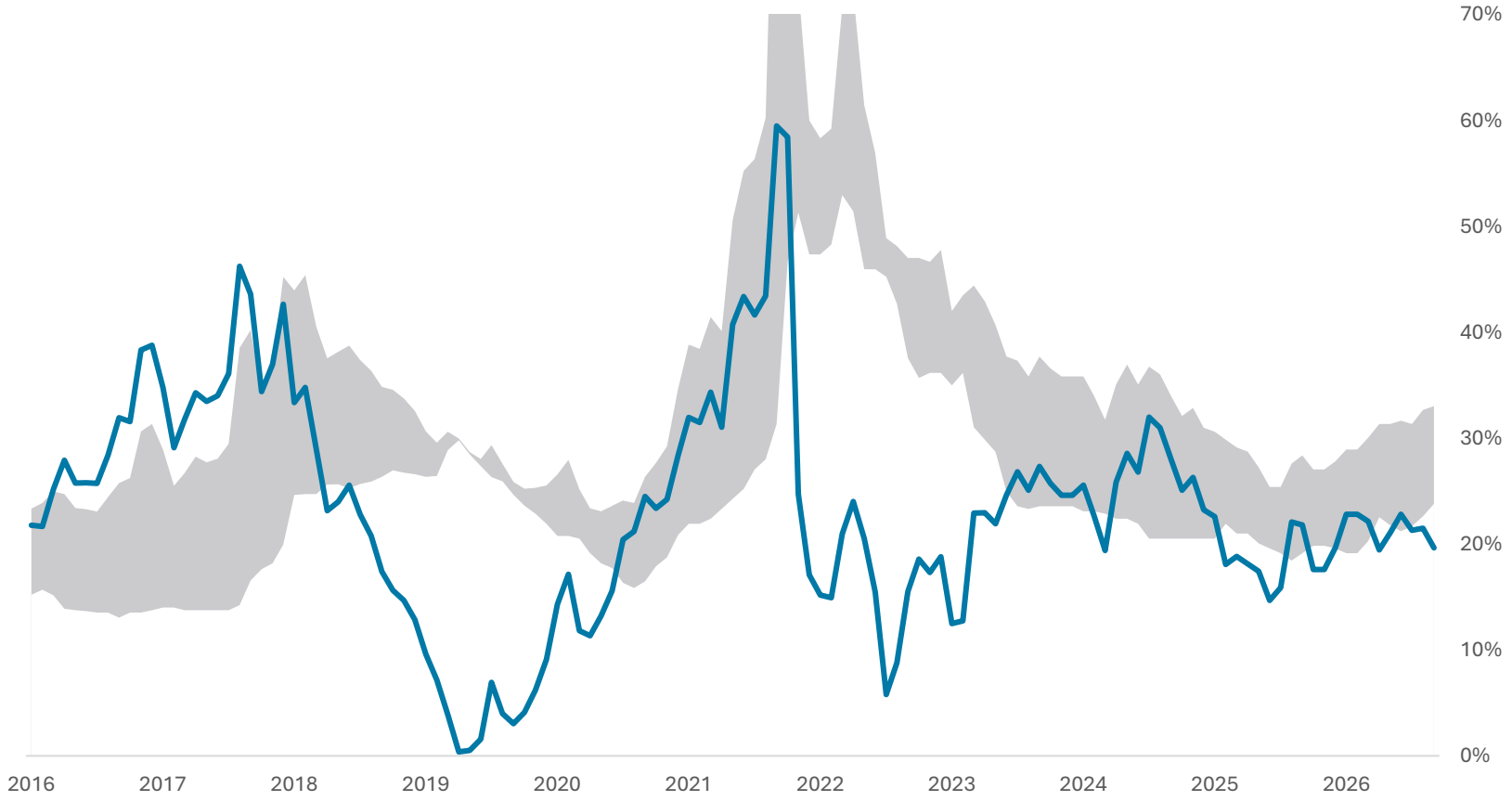
range of the discount: it narrows and widens, but never closes

*Same silicon basis: SiC ≈ 60% Si (SiC 85%) vs FeSi ≈ 75% Si (FeSi 75). Relative values only – no absolute prices.

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The SiC Discount vs FeSi, Month by Month



2016 – 2026, monthly · same Si basis*

129 / 129

months with SiC below FeSi on the same silicon basis

0.4 – 59%

range of the discount: it narrows and widens, but never closes

~40%

average SiC discount vs FeSi

~23%

average SiC discount vs FeSi per unit of Si

Never more expensive in a decade…
so why is SiC still a niche in steel?

*Same silicon basis: SiC ≈ 60% Si vs FeSi ≈ 75% Si. Blue line: SiC discount vs FeSi per unit of Si (right axis). No absolute prices.

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If it's ~40% cheaper… why not?

The five doubts we hear most when steelmakers consider replacing FeSi with SiC

1

"SiC is a ceramic – will it dissolve in liquid steel?"

"Is it abrasive – will it wear the refractory?"

Answered in:
SiC production & types

2

"Does it bring impurities like Al, N, H or S?"

Answered in:
Chemical composition

3

"Is SiC as effective as FeSi?"

Answered in:
Kinetics & real results

4

"What about the carbon pickup?"

Answered in:
Carbon pickup & mass balance

5

"Does it really pay off?"

Answered in:
Where the value comes from

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How SiC Is Made: the Acheson Process

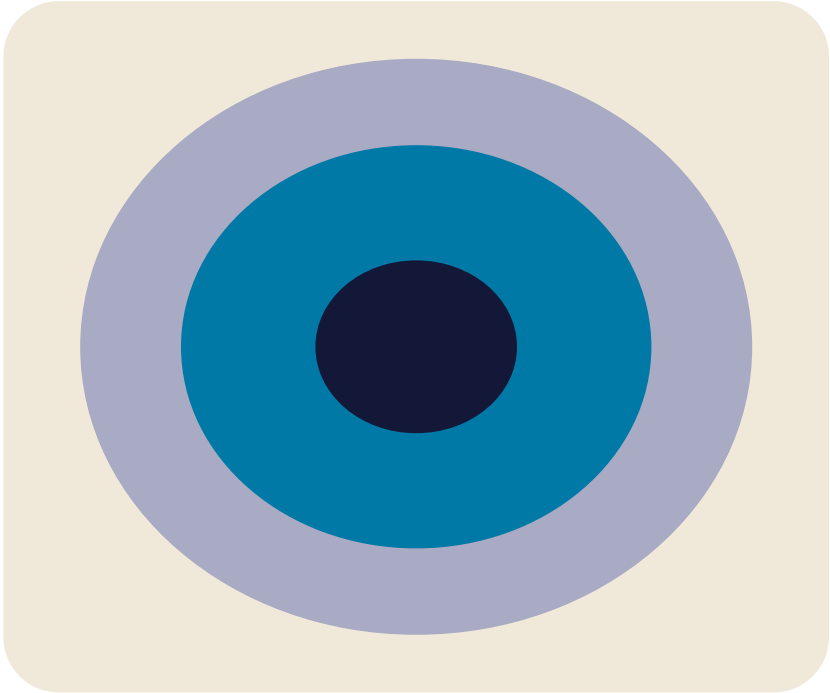
Quartz sand
SiO_2

+

Petroleum coke
C

+

Electric power
resistance heating



Furnace cross-section (simplified)

Graphite core
electric resistor – up to ~2,800 °C

Crystalline SiC
large, dense crystals · >97% SiC → abrasives, refractories, ceramics

Metallurgical SiC
outer zone · 70–90% SiC → steel & foundry

Unreacted mix
recycled into the next furnace

$$SiO_2 + 3C \rightarrow SiC + 2CO$$

Same furnace, same reaction: metallurgical SiC is the outer, less crystalline part of the ingot – chosen for reactivity, not for hardness.

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Crystalline vs Metallurgical SiC

	Crystalline SiC	Metallurgical SiC
SiC content	> 97%	70 – 90%
Structure	Large, dense crystals	Small crystals, porous, free C
Hardness	High	Low
Refractoriness	High	Low
Main markets	Abrasives, refractories, technical ceramics	Steel & foundry

SIKA® MET grades: 90 · 85 · 80 · 70% SiC – 0–10 mm, 1–10 mm, 10–60 mm, briquettes and pellets

MYTH

"SiC is a hard ceramic: it won't dissolve in steel and it will wear the refractory."

FACT

SiC does not need to melt: Si and C both dissolve in liquid iron.

SiC (s) → [Si] + [C]

Like graphite: it never melts, yet it alloys the steel.

Not abrasive in the ladle: metallurgical SiC is the low-hardness grade and dissolves quickly in the melt.

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Product Chemistry: SiC vs FeSi vs Graphite

Chemical Composition

Element	Silicon Source		Carbon Source		Silicon and Carbon Source	
	FeSi 75%		Grafite 90%		SiC 85%	
Si (%)	70	75	0	0	60	65
Ca (%)	0.8	1.5	0	0	0	1.5
Al (%)	1.0	2.0	0	0	0	0.8
C (%)	0	0.3	60	90	28	30
P (%)	0	0.05	0	0	0	0.002
S (%)	0	0.01	0	0.1	0	0.05
N (PPM)	0	0	0	800	0	300
H (PPM)	0	0	0	1300	0	100

THE PURITY ADVANTAGE:
Significantly lower Nitrogen & Sulfur pickup and no addition of Aluminium

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Where to Add SiC: EAF Tapping & Ladle Furnace



Electric Arc Furnace (EAF)

SIKA® MET ADDITION

...and other alloys

TAPPING STREAM

SiC serves as a simultaneous source of carbon and silicon with low level of impurities.



Final adjustments
- **SiC or FeSi**
- **Other alloys**
- **Graphite**

Ladle Furnace



Casting

STEEL DEOXIDATION DURING THE TAP

Silicon Oxidation (Deoxidation):
$<Si> + (O_2) = <SiO_2>$

Carbon Oxidation:
$<C> + (O_2) = (CO_2)$

SLAG DEOXIDATION IN LADLE FURNACE

$SiC\ (s) + FeO\ (l) \rightarrow SiO_2\ (slag) + CO\ (g) + Fe\ (l)$

Add SiC during EAF-to-ladle tapping. This stage is operationally safe, as the carbon in SiC presents no safety or process-related risks

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Deoxidation Kinetics: Technical Papers

DOUBT 3 · AS EFFECTIVE AS FeSi?

1 Kinetics

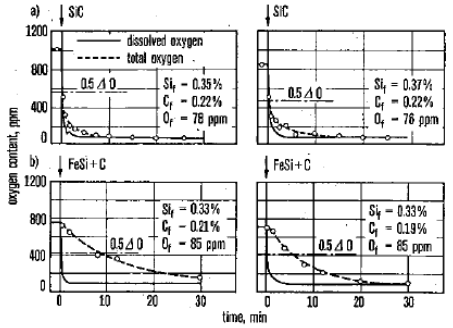


Figure 8. Progression of the oxygen content during deoxidation a) with metallurgical silicon carbide and b) with ferrosilicon plus graphite

SiC: Similar rate deoxidation comparing FeSi

2 Thermodynamics

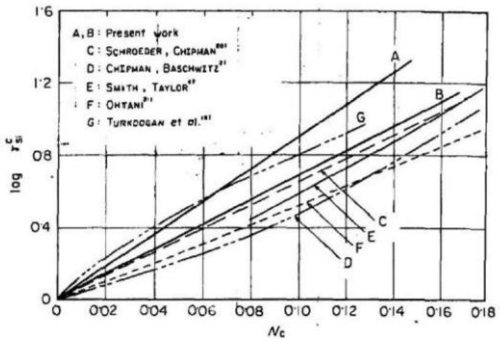


Figure 1. Effect of carbon molar fraction (N_c) on silicon's coefficient activity (γ_{Si}^{C})[14].

More carbon in the melt raises the activity of silicon

3 Simulation (FactSage)

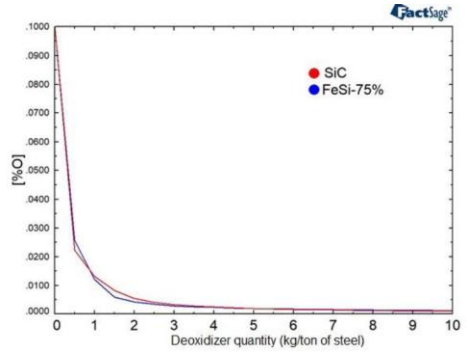


Figure 3. Steel deoxidation behavior as per varying deoxidizer quantities.

Same deoxidation curve for SiC and FeSi 75 at a 1:1 ratio

Separate addition: FeSi + carbon

- **Different dissolution rates** → reactions happen in different melt zones
- **FeSi** dissolves and forms solid SiO_2 or liquid silicates
- **Carbon** dissolves in the melt or reacts with oxygen to form CO
- **Aluminium** from FeSi forms alumina that stays in the melt (total O, dashed line)

SiC addition: faster and cleaner

- **Si and C released together** in the same micro-volume
- **Carbon raises the activity of Si** → more effective deoxidation (fig. 2)
- **Same oxygen level** despite the lower Si content (fig. 3)
- **Low level aluminium** lead more clear with no inclusion Al2O3. inclusions to the slag

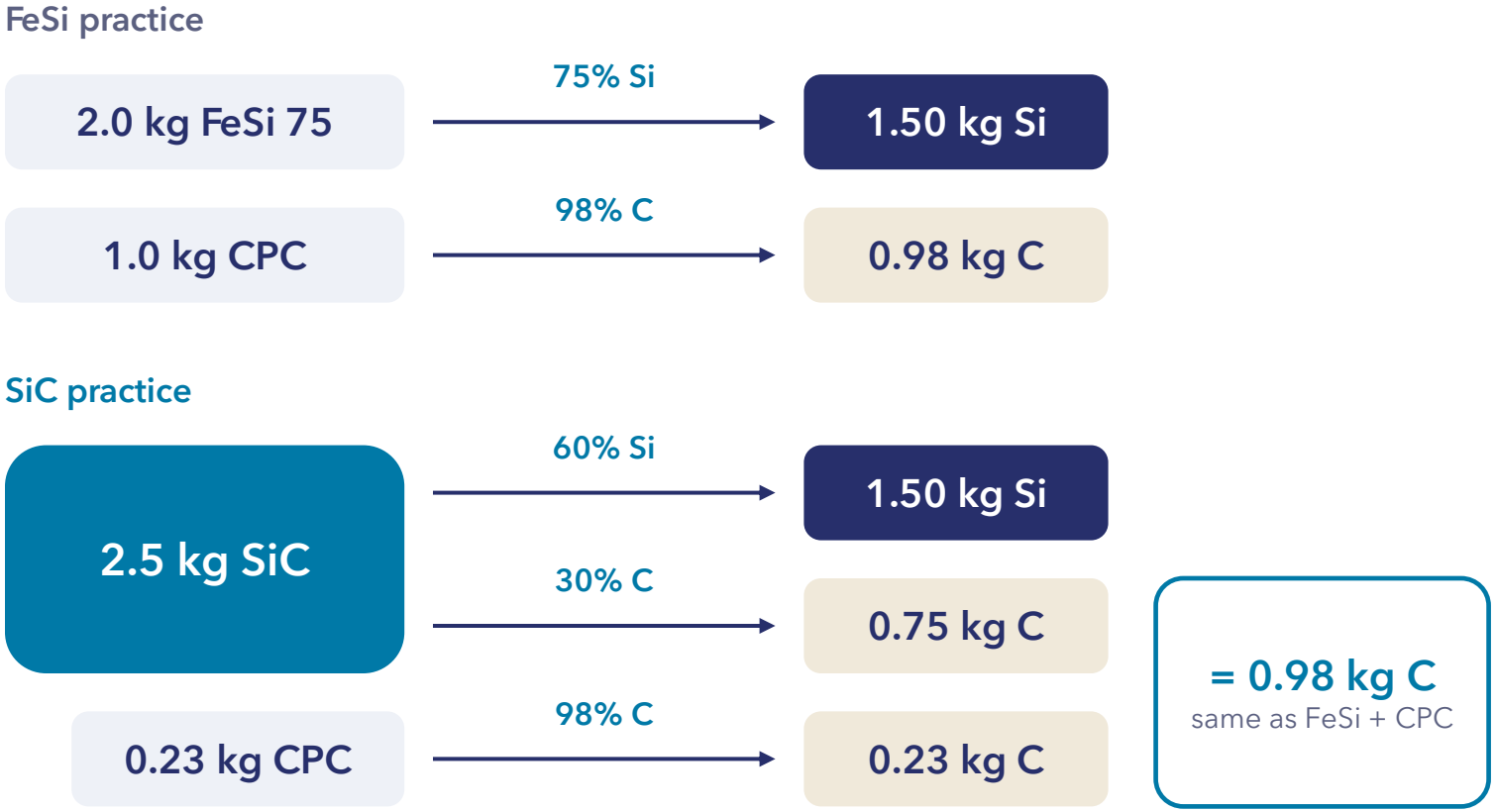
Fig. 1: Benecke, Th.; Defays, J. et al., Deoxidation of liquid steel with metallurgical silicon carbide, Metallurgical Plant and Technology, 1981 · Fig. 3: FactSage simulation

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Alloying Element: Mass Balance Simulation

DOUBT 4 · CARBON PICKUP?



Same result
1.50 kg Si + 0.98 kg C in both practices

–77% CPC
1.0 → 0.23 kg: the carbon in SiC replaces most of the recarburizer

~23% cheaper Si
historical SiC price per unit of Si vs FeSi (2016–2026)

Two direct savings:
a cheaper silicon unit and most of the recarburizer.

Simplified mass balance; full recovery assumed. SiC ≈ 60% Si / 30% C · FeSi 75 ≈ 75% Si · CPC ≈ 98% C.

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Real Results: Deoxidation + Alloying, AISI 1020

DOUBT 3 · AS EFFECTIVE AS FeSi?

kg / t steel	FeSi practice	SiC practice	Change
FeSi 75	2.30	0.59	**−74%**
SiC	–	**2.11**	new
CPC (recarburizer)	1.05	0.23	**−78%**
FeSiMn	8.36	8.36	=
Total alloys	**11.71**	**11.29**	**−0.42**
Delivered to the steel			
Silicon	2.77	2.76	=
Carbon	1.24	1.07	−0.17
Manganese	5.48	5.48	=

373 heats with FeSi · **393 heats** with SiC · same grade AISI 1020

766 heats
Average plant data – 373 with FeSi, 393 with SiC

Same Si, Mn
2.76 vs 2.77 kg Si/t: the same alloying result

−78% CPC · −74% FeSi
SiC supplies Si and C in one addition

In daily operation, SiC replaced ~75% of the FeSi silicon and most of the recarburizer. With low level of impurities

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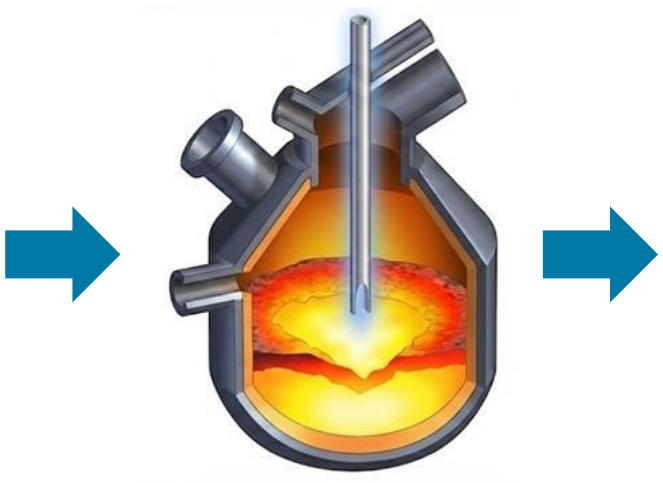
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SiC as Exothermic Agent in the BOF

Hot metal in

1300–1400 °C

C **4.70%**
Si **0.2–1.5%**
Mn **0.2–0.5%**
P **0.06–0.12%**



Steel out

1620–1720 °C

C **0.05%**
Si **0.00%**
Mn **0.10%**
P **0.01–0.02%**

Energy from SiC: two fuels in one addition

$Si + O_2 \rightarrow SiO_2$

−902 kJ/mol

ΔH · strongly exothermic

$C + O_2 \rightarrow CO_2$

−393 kJ/mol

ΔH · strongly exothermic

When to use SiC in the converter

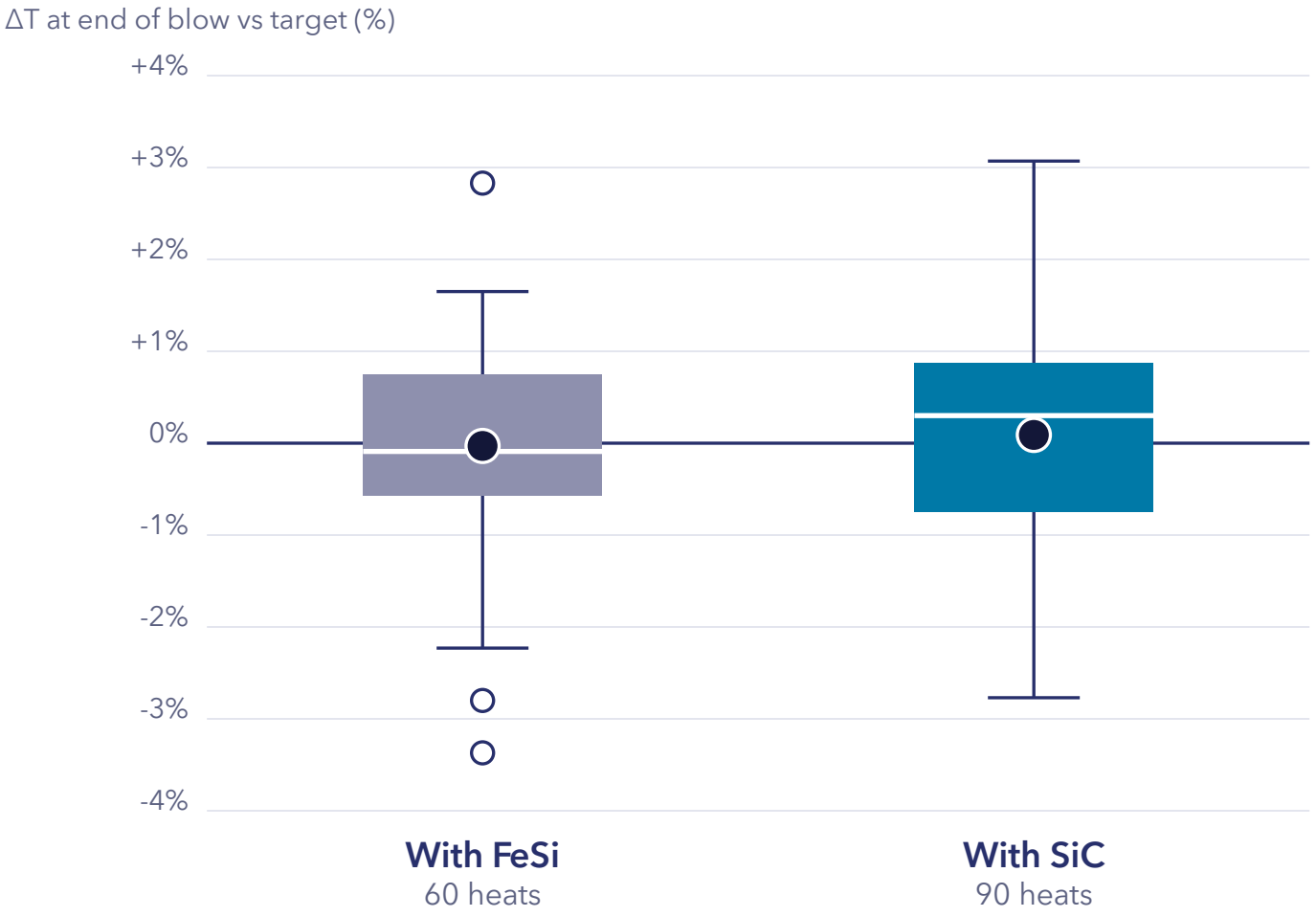
1. **Hot metal low in silicon**
   not enough Si to reach the target temperature
2. **Hot metal at low temperature**
   compensates the thermal deficit of the heat
3. **More scrap in the charge**
   less hot metal per tonne → lower CO_2 footprint

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Real Results: SiC as Exothermic Agent in the BOF

DOUBT 3 · AS EFFECTIVE AS FeSi?



Box: 25–75% of heats · white line: median · dot: mean · whiskers: range without outliers

Same temperature hit

1:1 replacement – average SiC addition = average FeSi addition

Mean ΔT: FeSi −0.03% · SiC +0.09%

Less silica → less lime

−19% lime

1 kg FeSi 75	→ 1.6 kg SiO_2	→ **4.8 kg CaO**
1 kg SiC	→ 1.3 kg SiO_2	→ **3.9 kg CaO**

Basicity CaO/SiO_2 = 3. Part of the heat from SiC comes from its carbon, which leaves as gas – no silica, no lime.

At 1:1, SiC gives the same heat as FeSi – **at a historically ~40% lower price per kg, and with ~19% less lime.**

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The Carbon Pickup Question

DOUBT 4 · CARBON PICKUP?

SiC can use for **70% of world steel**

Each kg of SiC per tonne of steel adds ≈ 0.03% C to the melt



≈ 30% · no SiC in the ladle

up to ~70% · SiC can replace FeSi in the ladle

up to ~70%

Deoxidation + alloying

Medium and high C: rebar, wire rod, sections, plates, engineering steels. SiC carbon replaces recarburizer.

~30%

Not in the ladle

Low and ultra-low C: flat, IF, coated, stainless, electrical. Al-killed or carbon-critical.

Any grade

BOF exothermic agent

Carbon burns off in the blow, so SiC can heat the converter even for low-C steel.

World crude steel 2025: 1,849 Mt (worldsteel); split by carbon range: author's estimate. Bar widths proportional to tonnage. Technical compatibility based on carbon; actual substitution depends on C control and practice.

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Does It Pay Off? Savings by Application

Historical prices and plant results – same steel quality, lower cost

Deoxidation + alloying

EAF tapping & ladle furnace

−23%

Silicon cost

Historical price per unit of contained Si vs FeSi 75

−0.3 kg

Recarburizer per kg SiC

SiC carries ~30% carbon (−78% CPC in plant, AISI 1020)

Exothermic agent

BOF / LD converter · 1:1 replacement

−40%

Alloy price per kg

Historical SiC price vs FeSi 75, kg for kg

−19%

Lime consumption

3.9 vs 4.8 kg CaO per kg of alloy (basicity 3)

= Lower cost per tonne of steel – with the same Si, Mn and temperature hit

Historical averages 2016–2026. Same Si basis: SiC ≈ 60% Si / 30% C · FeSi 75 ≈ 75% Si. 1 kg SiC ≈ 0.3 kg C ≈ 0.3 kg less recarburizer.

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So, Why Not?

It dissolves – and is not abrasive
Si and C dissolve in iron; metallurgical SiC is the low-hardness grade

Low impurities
No aluminium; lower N, H and S than graphite

As effective as FeSi
More effective deoxidation · same BOF heat at 1:1

Carbon pickup is not a barrier
Fits ~70% of world steel; SiC carbon replaces recarburizer

It pays off
−23% Si cost, −0.3 kg CPC per kg SiC · BOF: −40% alloy price, −19% lime

One addition. Two elements.

A cost-effective complement to FeSi where it fits:

~70% of world steel in the ladle, any grade in the BOF.

Not for ultra-low-carbon or carbon-critical grades in the ladle.

Next step: a plant trial
with our technical support

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