Smart Choice of Metallurgy and Technology for the Production of New Generation Single Phase, High Strength High Formable Sheet Steels towards Low Carbon Steel Production

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Big River Steel – Changing the Landscape of Steel Production

LEED Certified by DOE, USA

'Responsible Steel' certified

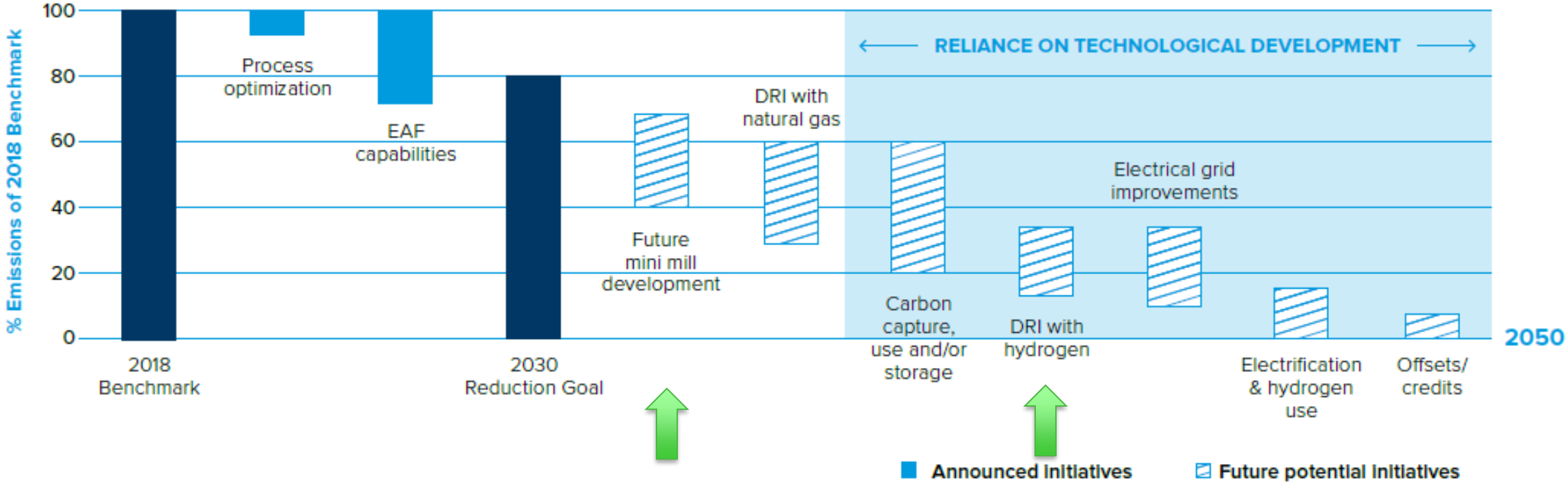
Traditional

Newer Technologies

Big River Steel – Right Step Towards Greener Steelmaking

Our Path to Net-Zero

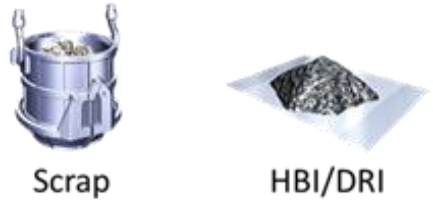
Roadmap to 2050 net-zero goal while incorporating the interim 2030 target of a 20% reduction in GHG emissions intensity for our Scope 1 and Scope 2 emissions.

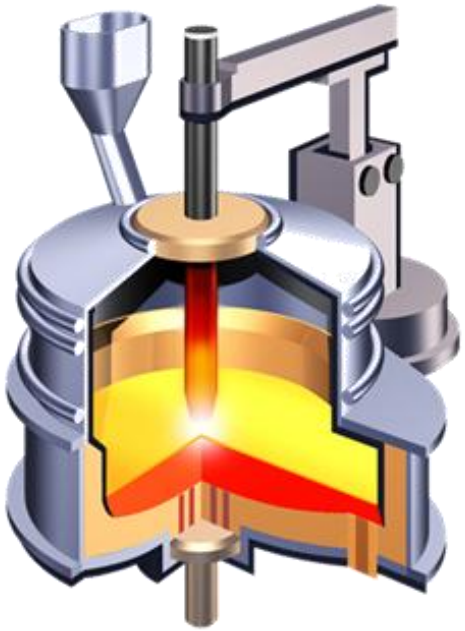


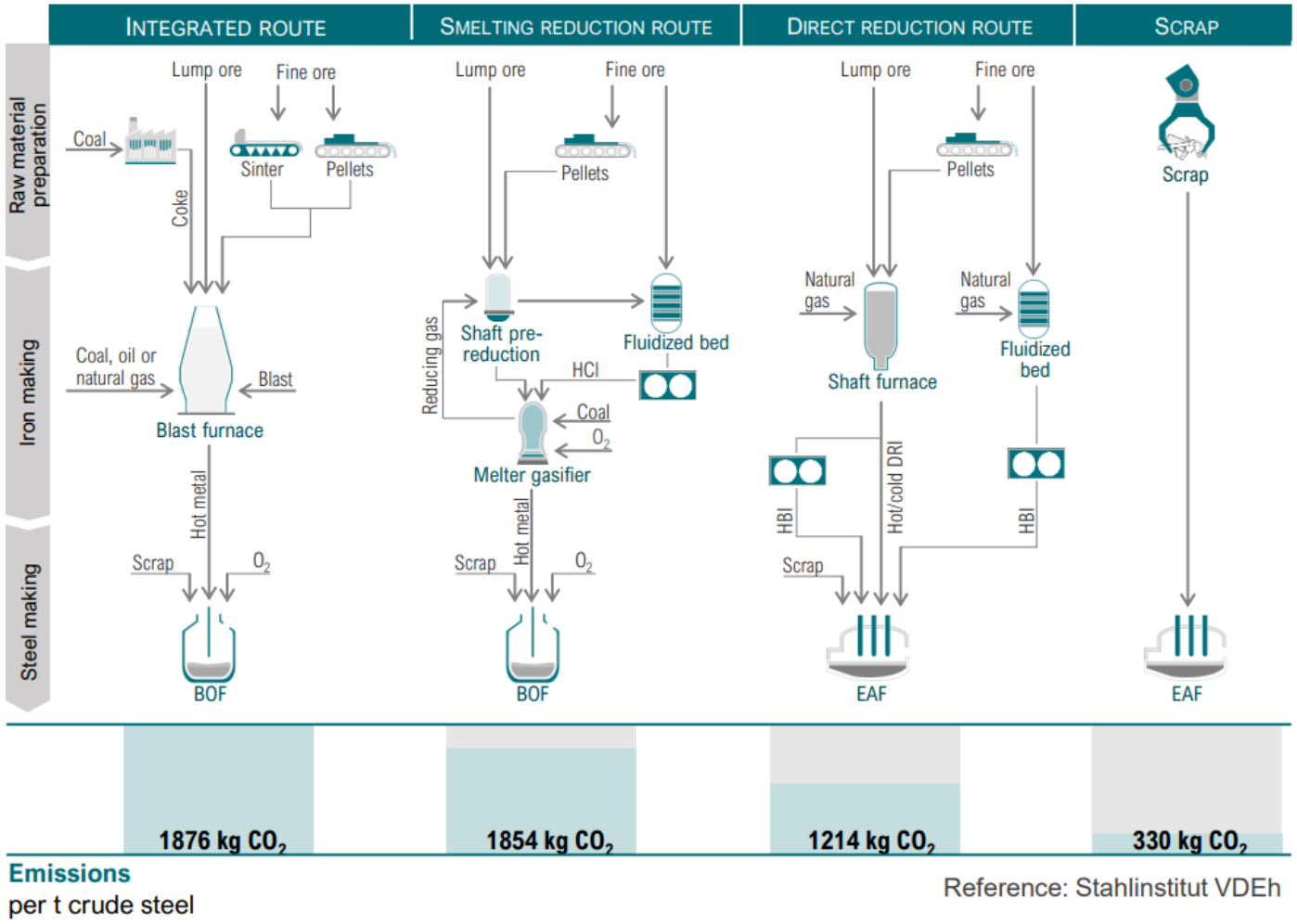
USS Climate Strategy Report 2023

Big River Steel – EAF Steelmaking and CO_2 Reduction

A Total of 6MT of Steel Production
All through EAF







Emissions from EAF almost 1/6th of Integrated Route of Steelmaking

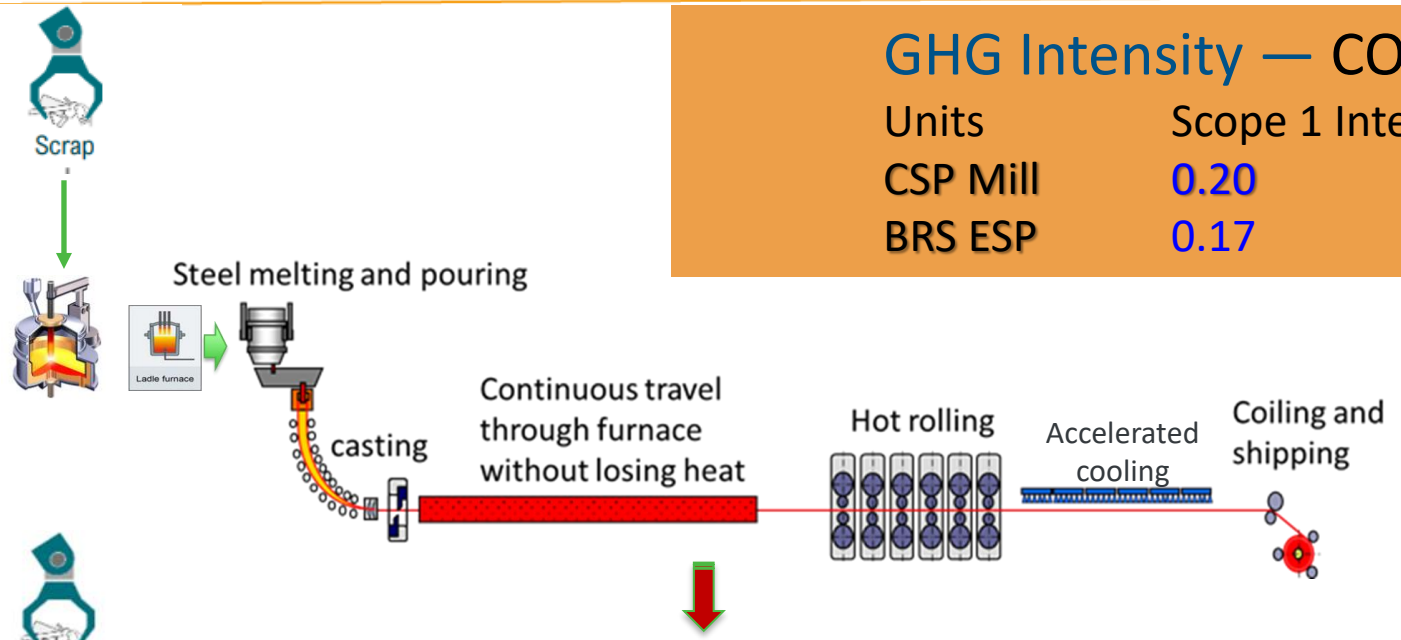
Steelmaking Technologies and CO_2 Reduction

GHG Intensity — CO_2 /metric tons raw steel

Units	Scope 1 Intensity	Scope 2 Intensity	Total
CSP Mill	0.20	0.13	0.33
BRS ESP	0.17	to be calculated	

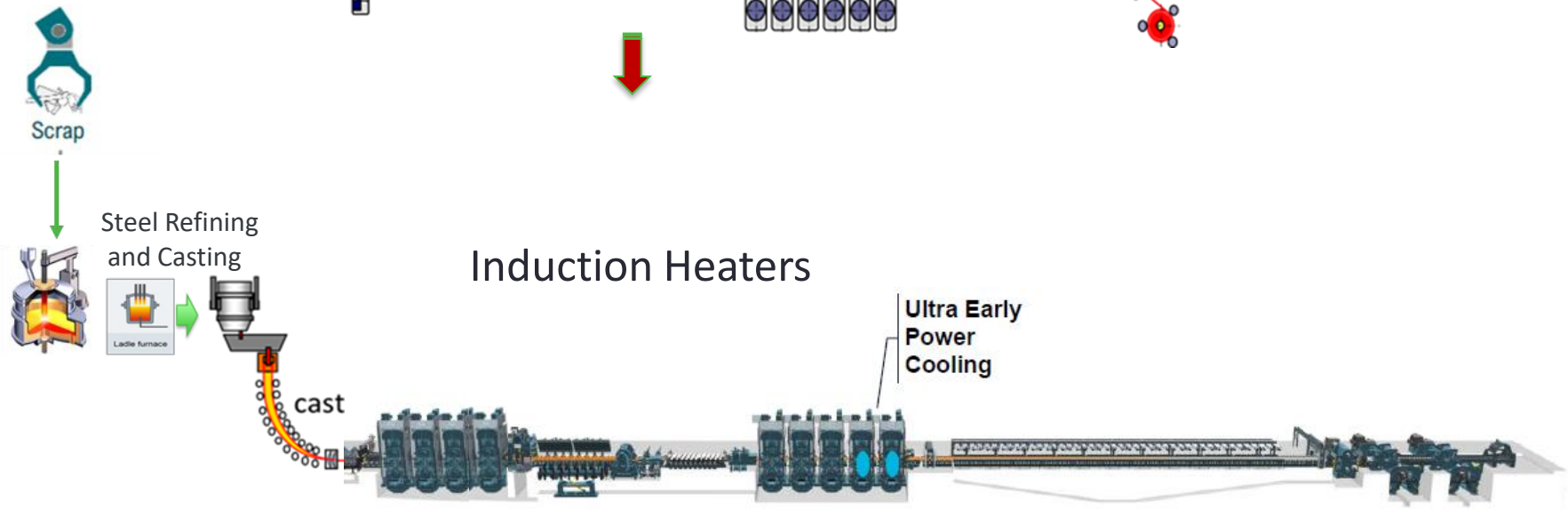
CSP

BRS1
(3.0MT)



ESP

BRS2
(3.0MT)



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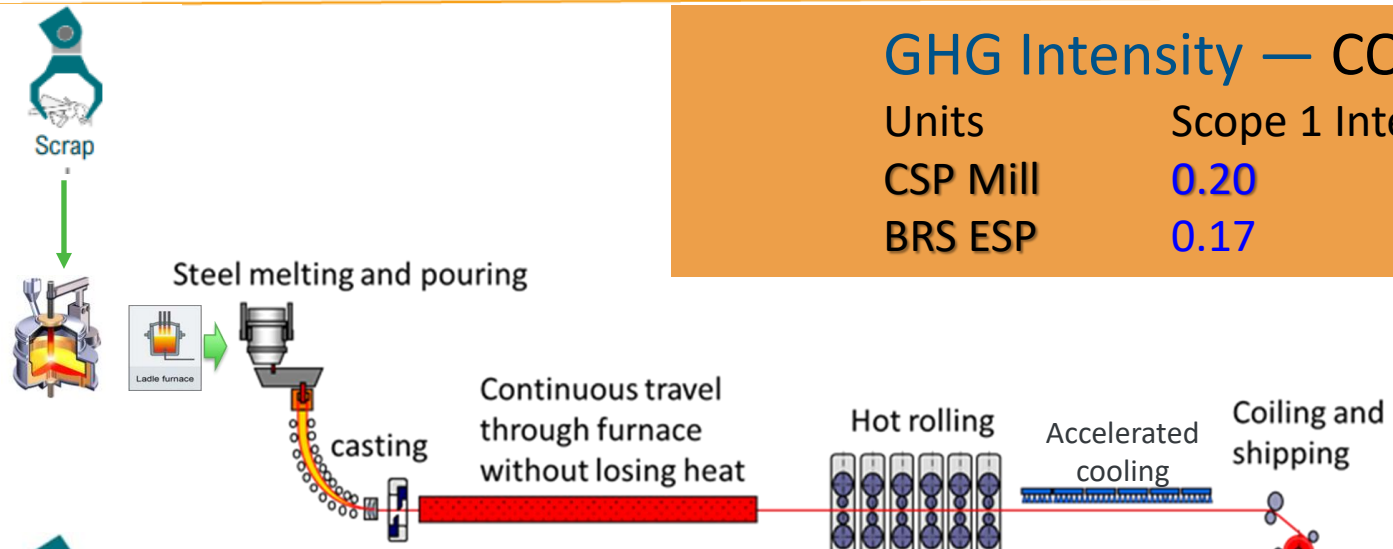
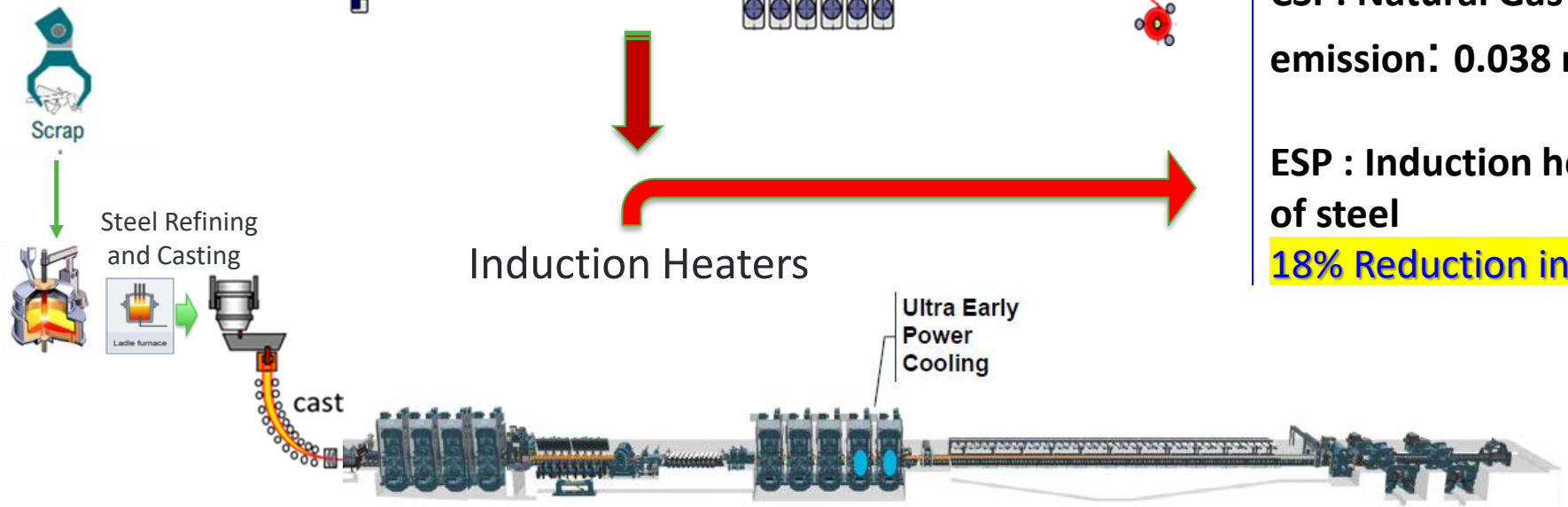


ESP

BRS2
(3.0MT)



CO_2 emission Reduction:

CSP: Natural Gas Tunnel furnace emission: 0.038 mt CO_2 / ton of steel

ESP : Induction heating : 0 mt CO_2 /ton of steel

18% Reduction in Scope 1 Emission

hot rolling to 0.8mm

Product Innovation Breakthroughs: Single-Phase (SP) Steel

Further Downstream Emission Reduction/Elimination can be possible using

- New Product Innovations,
- Technological Breakthroughs,

Example:

Development of a Lean, Single Phase (SP), Nano-precipitate Strengthened SP590/780 Sheet Steel with Outstanding Formability: A DP590/780 Alternative?

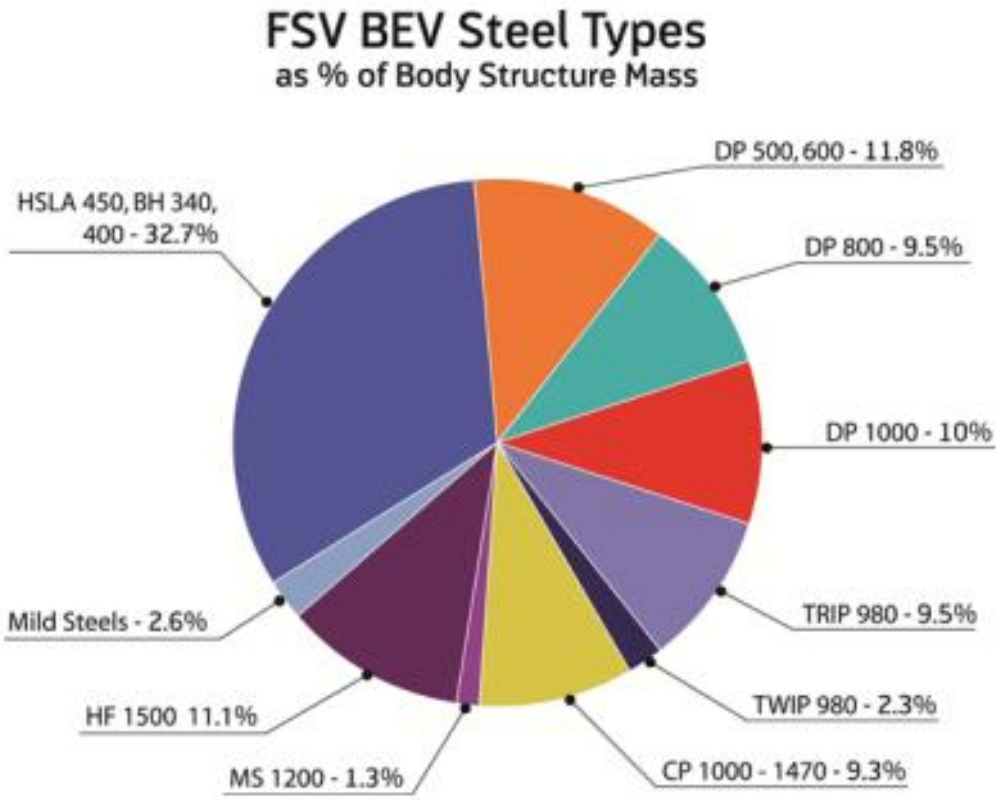
Product Innovation Breakthroughs: Single-Phase (SP) Steel

Steels with 450MPa and above > More than 54% of Lightweighting

25% with HSLA/AHSS steels with Tensile Strength up to 800MPa

Catered by

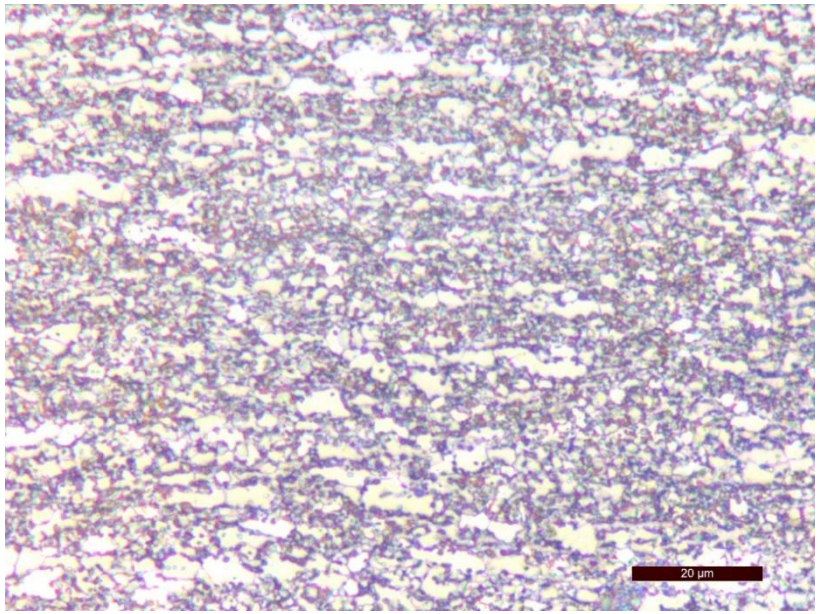
- HSLA, Dual-phase steels, MP (Multi-phase)/Complex phase steel,
  FB (Ferritic-Bainitic steels)



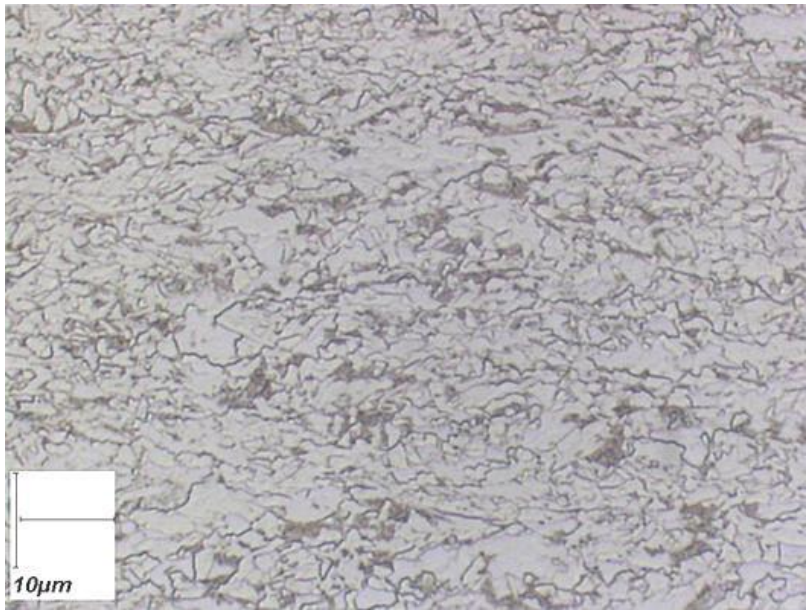
Worldautosteel.org

Product Innovation Breakthroughs: Single-Phase (SP) Steel

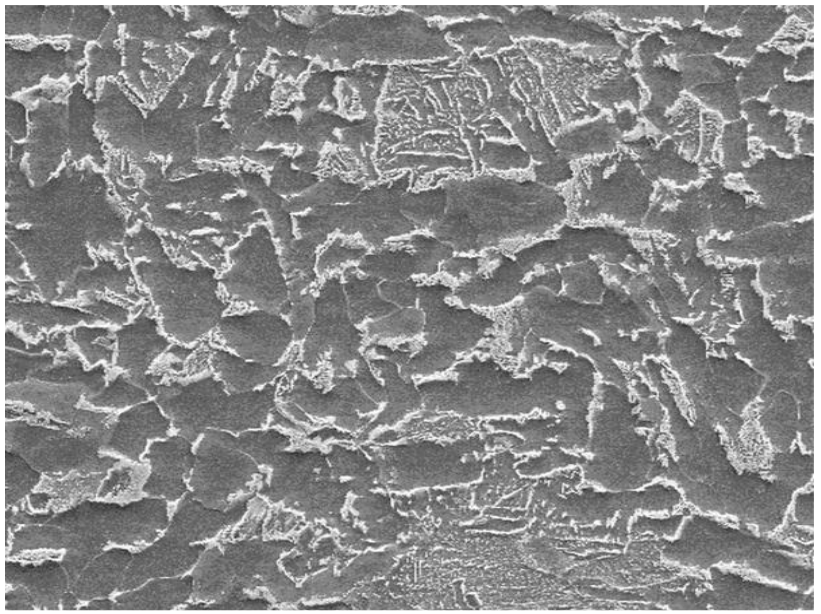
Steels with Tensile Strength of 800MPa and less



Dual-Phase (F+M)



Complex phase (F/B/M/RA)



Ferritic-Bainite (F+B)

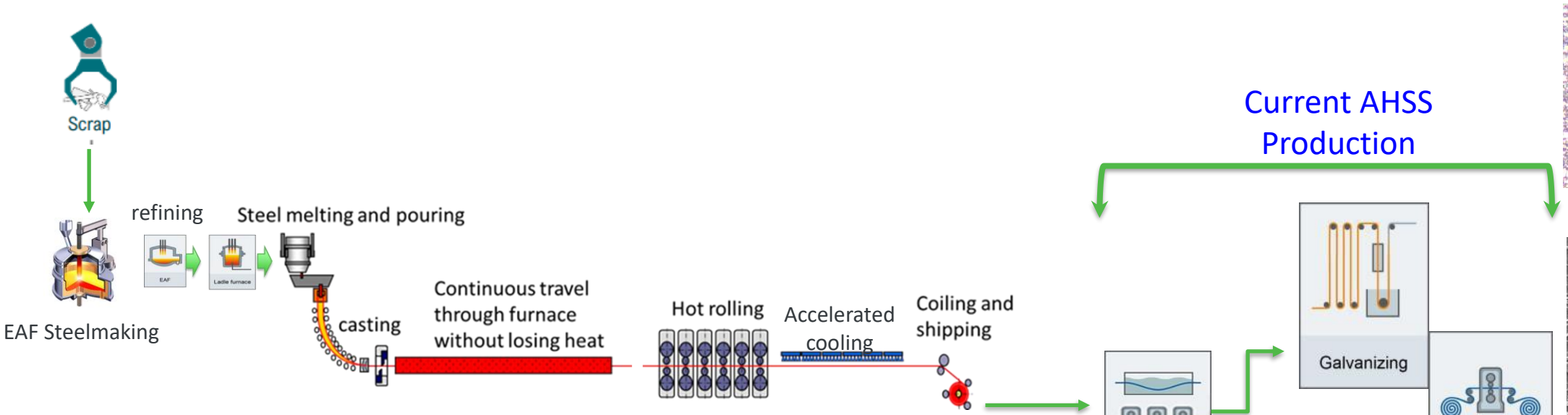
Offered significant weight savings but

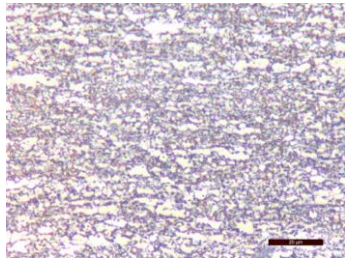
High Cost of Alloying -

High Cost of Production – secondary processing

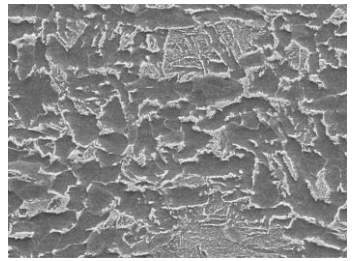
High Maintenance Steels – HIC resistance, LME

Product Innovation Breakthroughs: SP Steel

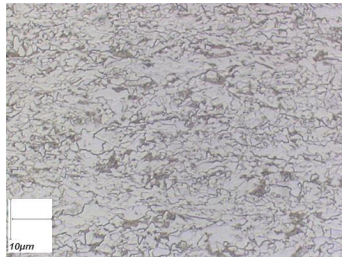




DP

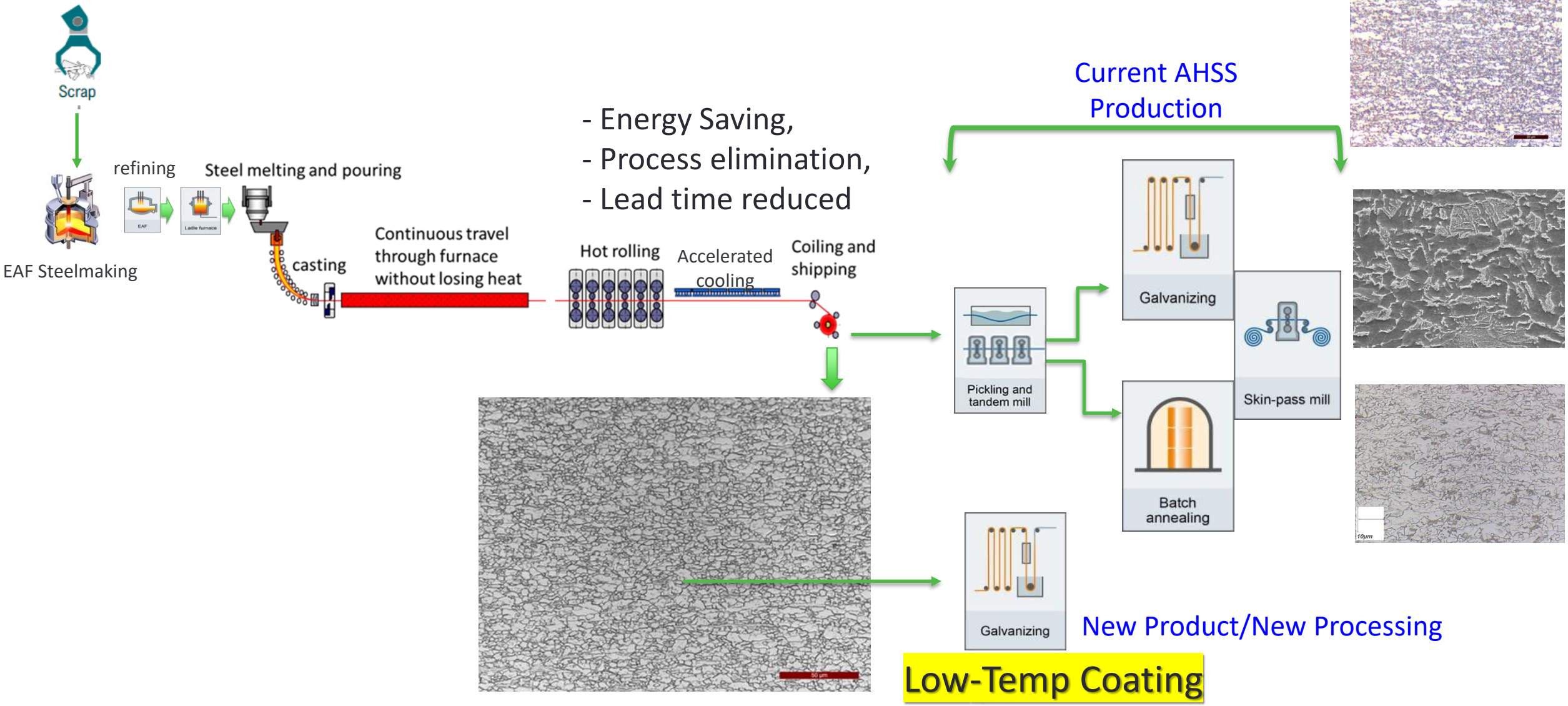


FB

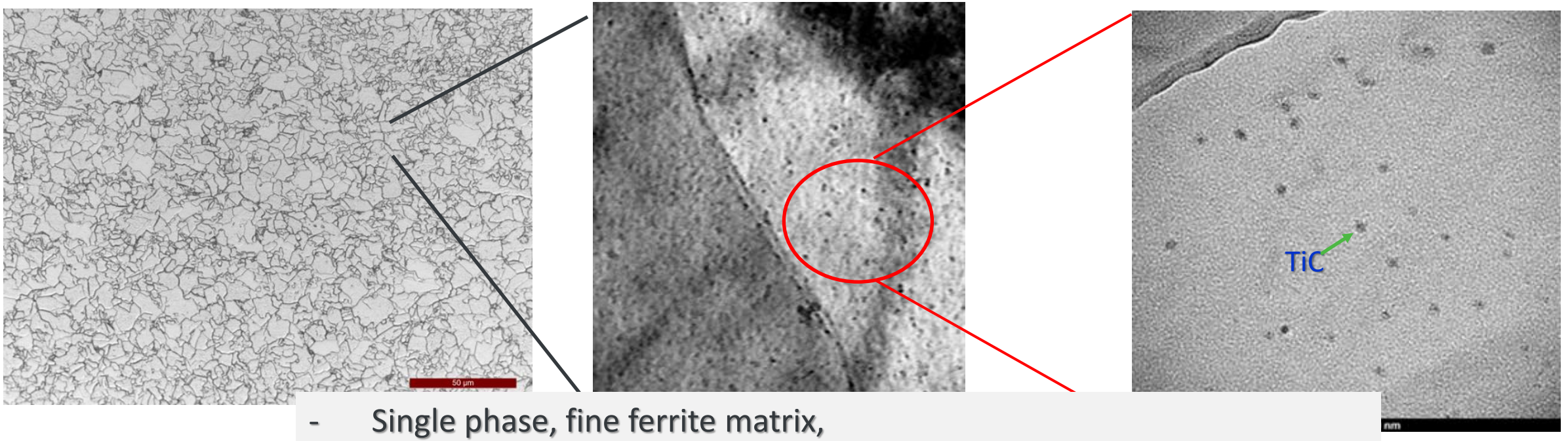


CP

Product Innovation Breakthroughs: SP Steel

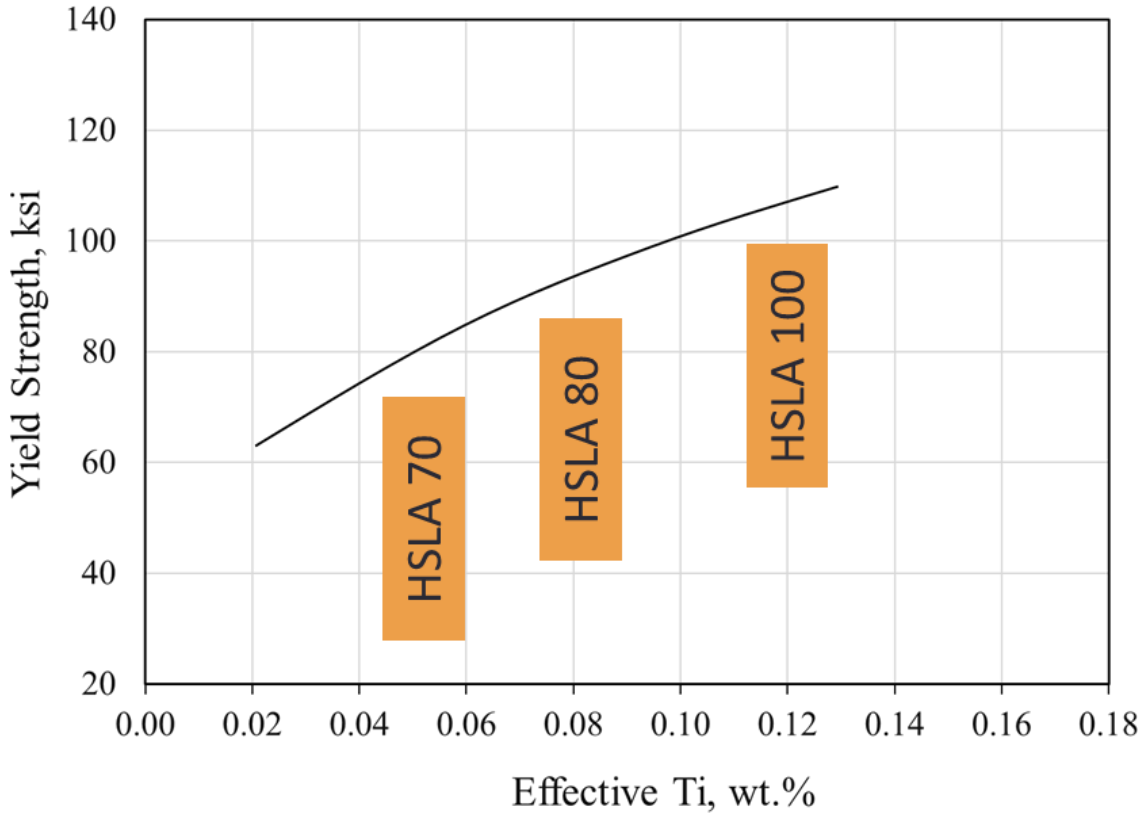


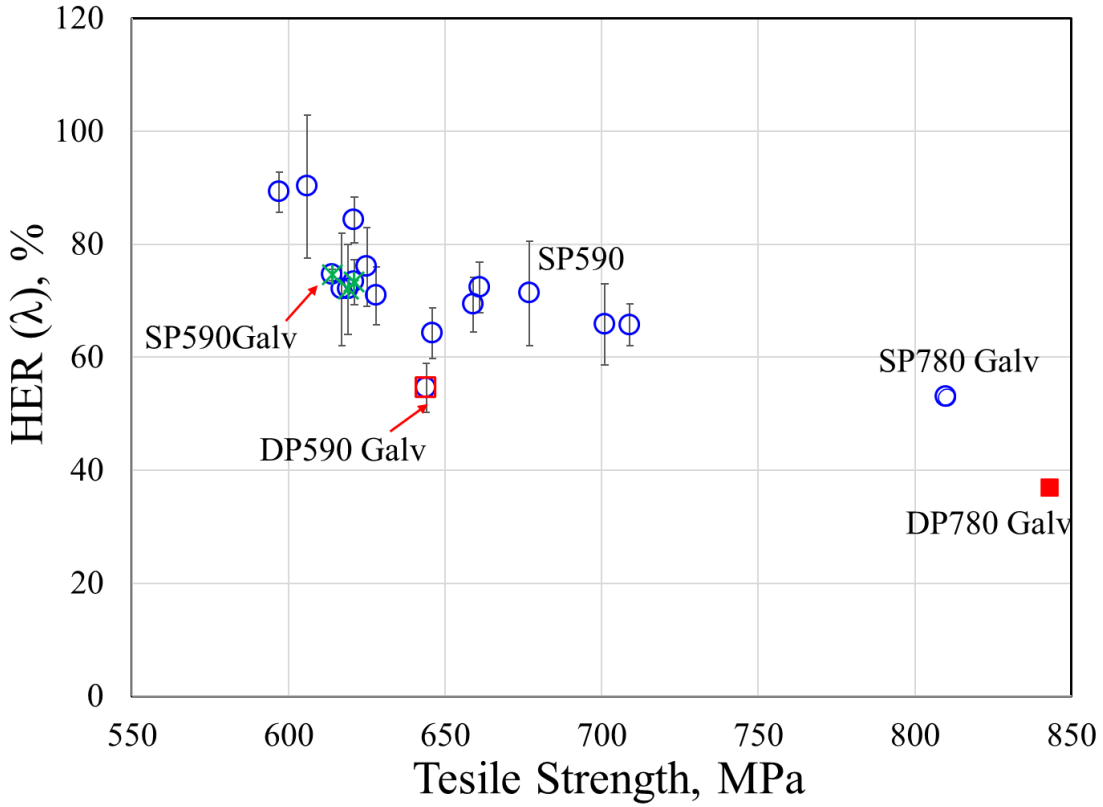
Product Innovation Breakthroughs: Single-Phase (SP) Steel



- Single phase, fine ferrite matrix,
- Very low-carbon chemistry (<0.055C)
- Ultra high Strength by TiC Nano precipitates (<4nm),
- Leanest alloy with Ti-microalloying only,
- Outstanding Formability as evidenced by
  - HER values
  - Forming Limit Strains,
  - bendability
- Excels over DP steel with similar strength.

Product Innovation Breakthroughs: SP Steel





SP Nano-Precipitate Strengthened Steel

Outstanding Stretchability

Steel	C	Mn	P	S	Ti	N
SP590-SP780	0.050	1.10-1.50	0.015	0.003	0.10 -0.15	0.009

Axial Crash Behavior of SP Steel

- 515-kg drop weight
- 7.3-m/s impact velocity
- 13.7-kJ applied energy
- Measure load, acceleration @ 50 kHz
- Crush distance, Original height (12”) –Final Height
- 5 transverse specimens, tapered hexagonal geometry
- Press brake forming and MIG welding
- All specimens received 177°C/30-min paint bake simulation after fabrication

Axial Crash Behavior of SP Steel

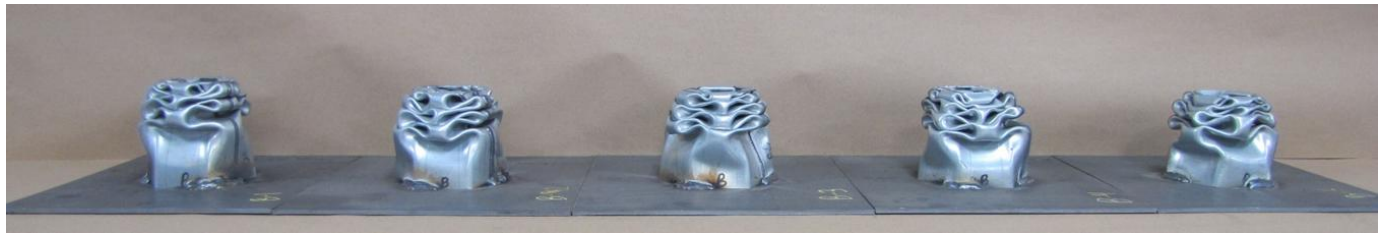
Performance Evaluation: current 590-class AHSS

- 1.4-mm CR 590SP
- 1.4-mm GA 590R
- 1.4-mm GI 590DP
- 1.5-mm GI 550LA

Material	Average Crush Load (kN)	Crush Distance (cm)
1.4mm CR 590 SP	70.5	19.2
1.4mm GA 590R	72.0	19.3
1.4mm GI 590DP	72.2	19.4
1.2mm GI 980CP	84.2	16.8
1.5mm GI 550LA	87.9	15.7

1.4mm CR 590SP,
CD = 19.2 cm

1.4mm GI 590DP,
CD = 19.4 cm



SP Steel – Hydrogen Induced Cracking Resistance

Hydrogen-induced Cracking Resistance

Hydrogen-Induced Cracking (HIC) Testing

Specification: NACE TM0284-2016

Test Conditions:

Solution Type:	Solution A	Test Duration (hrs):	96
Initial pH:	2.67	Temperature (°C):	24
pH at Start of Test:	2.75	[H_2S] at Start of Test (mg/L):	2506
pH at End of Test:	2.93	[H_2S] at End of Test (mg/L):	2624

Test Results:

Specimen ID	HT #	Section	CLR (%)	CTR (%)	CSR (%)
231-1	24145262-03	A	0	0	0
		B	0	0	0
		C	0	0	0
		Average	0	0	0
231-2		A	0	0	0
		B	0	0	0
		C	0	0	0
		Average	0	0	0
231-3		A	0	0	0
		B	0	0	0
		C	0	0	0
		Average	0	0	0
Overall Average			0	0	0

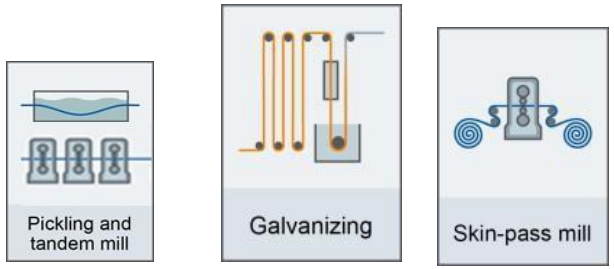
Note: Acceptance criteria per NACE MR0175/ISO 15156-2 2021: CLR - 15% maximum; CTR - 5% maximum; CSR - 2% maximum.

Conclusion: The heat of steel pass the acceptance criteria of the above standard.

Product Innovation Breakthroughs: Environmental Impact

Current AHSS Production

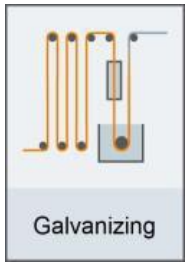
Anneal T 780-830C



- CO_2 emission for High Temperature (~820C) Annealing:
  2.96 metric tons per hr of runtime

New Product/New Processing

Anneal T 550-625C



Low-Temp Coating

- CO_2 emission for Low Temperature (~620C) Annealing:
  1.61 metric tons per hr of runtime

- **Emission Reduction:**

2.96-1.61 =1.35 metric ton/hr of CGL line operation.

SP Steel – Applications Demonstrated

Structurals and Machinery:
UHSS 100, Gauge 4.5mm-10mm
Product Successfully commercialized and used in structural, machinery applications

Automotive

SP780 : Component of a Car Seat Retractor

SP 600 : Component of a Car Seat
CR500LA

SP 650 : Front Link
CR550LA

Summary

- Breakthrough Technology
  - Technology offerings is successful when one can make use of its potential in reducing process costs, performance and sustainability.
  - The development of Lean, Singel Phase Low-Carbon **Nano precipitation-strengthened,** Ferritic Steel to produce steels up to 780MPa tensile Strength is an example where downstream processing can be substantially reduced or eliminated
  - There is significant energy savings and lesser CO_2 reduction for the new products developed offering a Greener and better performing steel.
- The New Steel has the Potential to replace medium-strength DP steels, CP and MP steels up to 780MPa tensile strength in both coated and uncoated condition. Hopefully, we will present the stamping performance review against DP steels in the next technical meeting.

Thank You

For more details contact

ade@bigriversteel.com