Decarbonization solutions for the steel industry: an update

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FOR GREEN STEEL

3rd INTERNATIONAL CONFERENCE

meets





ESTEP 2024 Annual Event

AR ECONC

BY THE EUROPEAN STEEL





European Steel Technology Platform

voestalpine



20 years together

Green or blue hydrogen?

last?

What will be electrolyser costs in 2030? 2050?

Is it wise to invest in a DRI plant relying on NG feed?

What will be the European CBAM (Carbon Border Adjustment Mechanisms) impact?

Where will DRI be produced?

Which is the best electrolyzer technology?

What will be green hydrogen price?

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CCS (Carbon Capture and Storage) or hydrogen?

Are subsidies certain? Are they forever?

Are green steel premiums realistic? Will they

Which is the best carbon capture technology?

Is section 232 in steel in the US forever?

Will there be enough DRI-compatible iron ore?

When will green hydrogen be available?

What will be CO2 emissions cost in 2030? in 2050?

Air Liquide



Transition to low carbon steel making



Switch to DRI

Blast Furnace Decarbonization



Hydrogen and CCS solutions are two cornerstones of the decarbonization of the steel industry





Air Liquide techno mapping for CO₂ capture



ESTEP - H2 for Green Steel meets A Circular Economy driven by the European Steel - October 2024

Development of CO2 capture & liquefaction has started 15 years ago...



Industrial scale production of Electrolysers with up to 1GW in 2023 and 3GW in 2025



PEM multi-Gigafactory

- Joint Venture Manufacturing with Siemens Energy in Berlin
- Industrial scaling up to 1GW in 2023 and 3GW in 2025 (1 GW expansion each 12 month)
- Highly automated PEM manufacturing according to latest production standards



Product development

- R&D for electrolysis technology
- Joint product development and capitalization



Array

Electrolyzer Packaging

- Internal and external partners for final assembly to prepare for optionality acc. Market trends
- Packager will be established locally in main markets to facilitate local value add
- First workshops established in France, Germany and Czech Republic







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ESTEP - H2 for Green Steel meets A Circular Economy driven by the European Steel - October 2024

Air Liquide supplies H2 solution to Midrex DRI plant in Canada



- ArcelorMittal has tested green hydrogen co-firing in a natural gas-based <u>Midrex DRI plant</u> in Contrecoeur, Quebec
- 6.8% of NG was replaced by green hydrogen for 24 h
- Air Liquide supplied the hydrogen solution







Air Liquide supports its customers in steel energy transition all around the globe providing low carbon gases and technologies for decarbonization

- **Air Liquide and ArcelorMittal** <u>are working together</u> on reducing 2.85 mtpa CO2 emissions at Dunkirk steel plant. Considered solutions:
- Hydrogen supply to a DRI+EAF integrated plant
- Implementation of carbon capture technologies.



Air Liquide is performing a DoE-funded FEED study on Midrex carbon capture for ArcelorMittal plant in Corpus Christi, USGC





Combustion: Expertise all along the process



4 Combustion Platforms (Delaware, Paris, Shanghai, Tokyo) 3 Combustion product Lines : Cleveland, Paris, Shanghai



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Hydrogen Combustion in a Glass Furnace: Industrial tests roadmap





H2/O2 combustion - Impact on heat transfer Industrial scale tests

R&D Pilot scale





CFD modeling : **+2%** heat transfer to the load for H2-based mixtures



HYREX: approx. 5% decrease in specific energy consumption with 47%vol H2 in fuel mix



Key Takeaways





- Low carbon steel is possible with low emission electricity EAF, but depends on scrap availability
- More economical to capture and store CO2 emitted from a blast furnace, than to inject H2.
- Low carbon H2 in DRI Ironmaking can be the final goal to decarbonize steelmaking

Air Liquide is accompanying its customers in this journey with a comprehensive portfolio of technologies for Hydrogen and Carbon Capture



Air Liquide

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