ESTEP 2025 Annual Event
28-30 October 2025
Udine (ITALY)

How decarbonisation, digitisation and circular solutions forge the sustainable European steel future?

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EU-Project H2Loop

Decarbonizing the EU steel industry through innovative carbon dioxide separation and hydrogen production from metallurgical gases

Project ID: *101193354*

H2loop

Research Fund for Coal & Steel

Co-funded by the European Union

AMBARTEC
HyCS-TECHNOLOGY

ESTEP

DIGIMET

DANIELI AUTOMATION

UNIVERSITÀ DEGLI STUDI DI UDINE
HIC SUNT FUTURA

EU-Project H2Loop

Project Brief - Targets

Sustainable decarbonization of integrated steel plants by hydrogen production from chemical looping

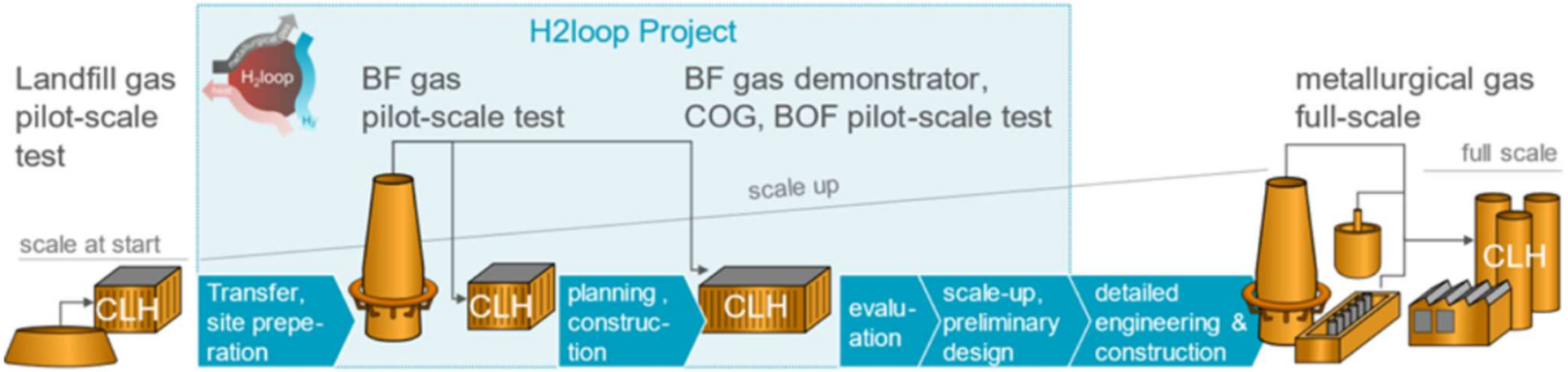
1) Tests of modular oxygen carriers to enable chemical looping (H2Loop) in industrial scale

2) Demonstration of emission-free H2Loop-plant directly connected to the blast furnace duct

3) H2Loop demo plant with 24/7 operation in closed-loop control

4) Engineering of process integration in steel plants including energy efficiency evaluation and LCA

5) Scale-up design and business plan for full industrial roll-out in steel industry



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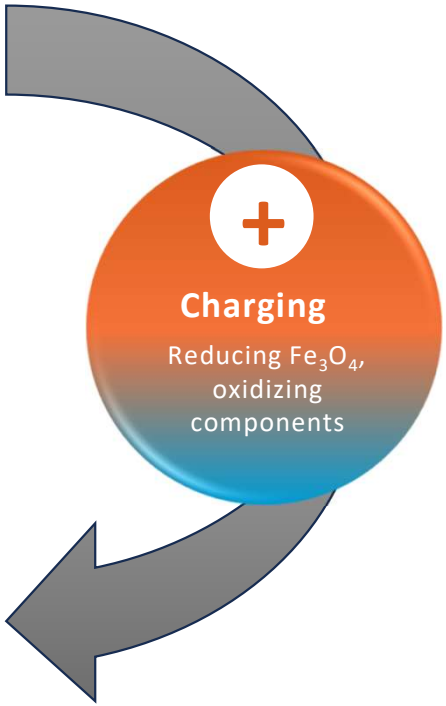
Iron Cycle for CO to CO_2-conversion and H_2-generation

Iron-nuggets performing in cycling processes for conversion and storage purposes.

Reducing Gases with
impure CO and/or H_2

- From gasification
- Steel mills
- Steam reforming
  - Landfills
  - Biogas
  - …

Impurities



Fe

Iron-nuggets.

Pure
Hydrogen

STEAM

Process synonyms: wet-iron-cycle / steam-iron-cycle / chemical looping / iron-redox-cycle

RG H2

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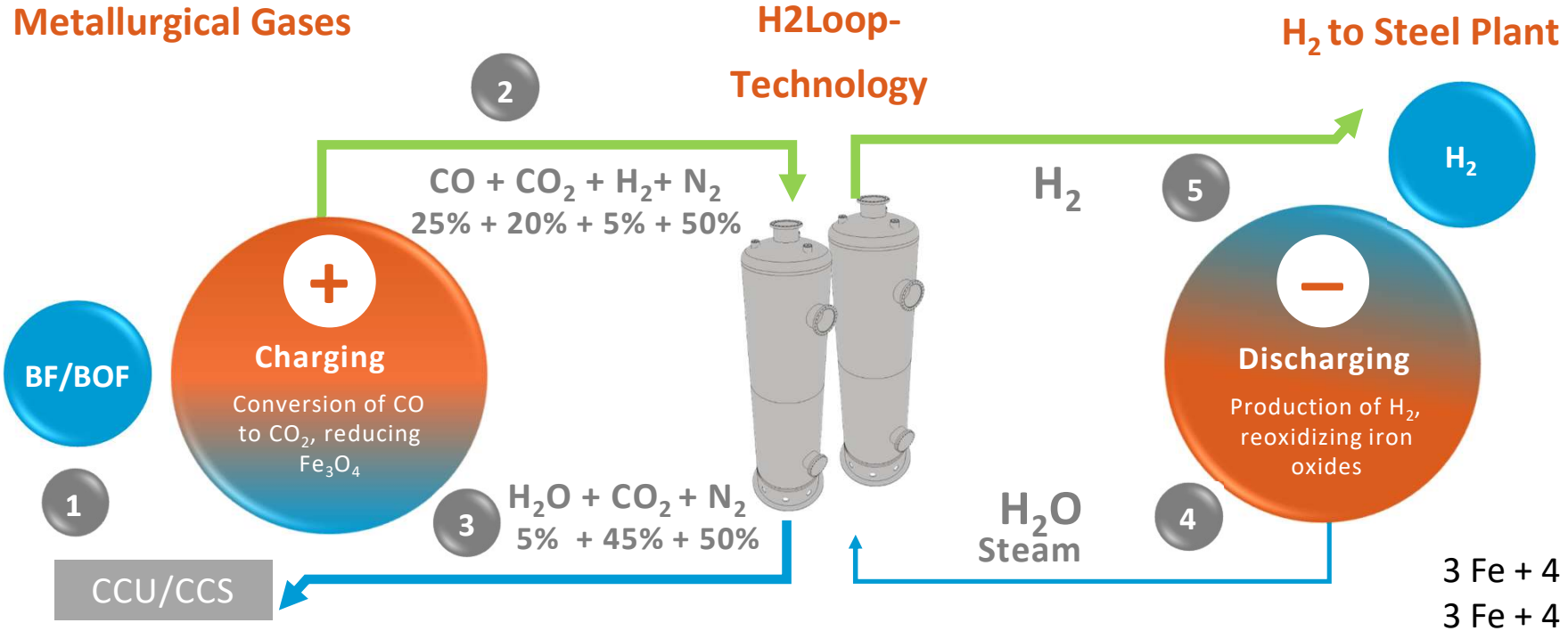
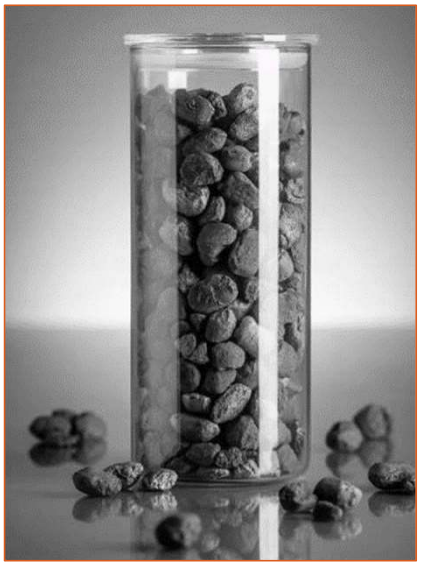
H2Loop-Technology: Hydrogen Production & CO_2 Separation

CO is converted into a CO_2 stream & H_2 produced with our iron-nuggets.





$3\ Fe + 4\ H_2O \leftrightarrow Fe_3O_4 + 4\ H_2$

$3\ Fe + 4\ CO_2 \leftrightarrow Fe_3O_4 + 4\ CO$

1. Dust removal and heating of metallurgical gases;
2. Conversion of CO into CO_2 ,reducing the iron oxides (loading) doubling/tripling CO_2 concentration
3. Separation of the concentrated CO_2 for to CCU/CCS-technologies, decarbonizing the steel mill
4. Supply of steam to close the loop (discharging), reoxidizing the reduced iron oxides
5. Production of significant amounts of hydrogen for the steel mill and the power plant

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Applications

Nuggets

Bulk Carrier Ships

Containers up to
800 kg H2 / 25 MWh

Large Scale
Facilities

160 MWh
60 m3

Energy Transport

Stationar
Energy Stor

H2 to
Syngas

RG H2
Gas
Upgrading

Goal of H2Loop

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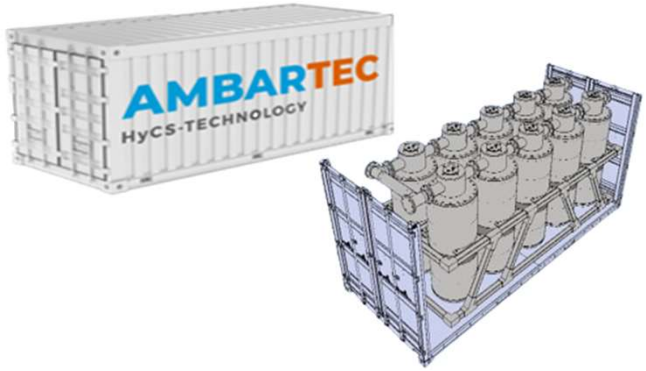
RGH2 & AMBARtec Combining Design- & Operating-Know-how

Iron-nuggets "bridge the missing link" between CO_2 and H_2O.

AMBARtec AG:

- Scale-up HyCS®-Vessels 10L → 100L → 1000L → 6000 L
- 1000L+6000L Liter CE-certified
- Larger Vessels (45.000 Liter) producing 10.000 m^3/h proven in 1972



RGH2: Operation Experience with Syngas:

	Time on stream	Gas composition / mol%						CO_2 intensity
	h	CH_4	CO	CO_2	H_2	H_2O	N_2	$t_{CO2}\ MWh_{LHV}^{-1}$
Synthetic BFG	1500+		24%	22%	4%		50%	0.90
Synthetic BOFG	100+		58%	14%	2%	12%	14%	0.66
Landfill gas reforming	4,000 (continuous)	1%	27%	4%	47%	8%	12%	0.26
	10,000 (various)	0%	23%	3%	39%	7%	28%	0.26
Wood gasification (steam)	Inital tests	5%	10%	12%	26%	30%	17%	0.34
		7%	16%	3%	41%	2%	28%	0.21
Wastewood gasification (air)	100	3%	18%	14%	21%	2%	42%	0.43
Steam reforming	10,000 (various)	2%	21%	2%	70%	6%		0.16

RGH2

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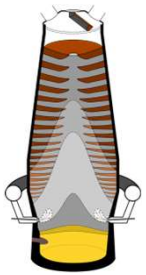
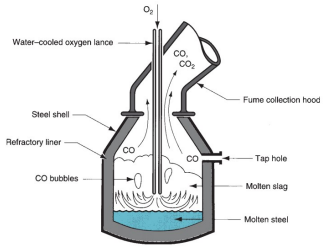
RGH2's & AMBARtec's way to get steel mills to net Zero

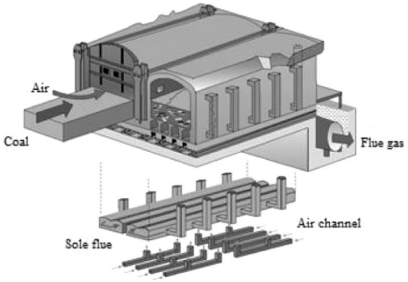
Decarbonising the integrated steel mill with 1,5 mt/a steel production



78%



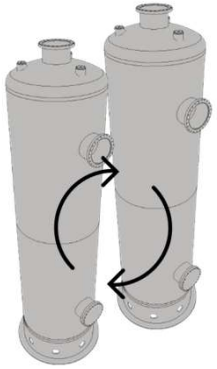
4 %



18 %

BFG/BOFG/COG Production: 2,950 Mm³/a

H2Loop-Technology Potential



CO_2: 2.148.000 t/a

91 % of all CO_2

CCU/CCS

H_2: 120.090 t/a

H_2

Buying ETS		Prices for ETS *(est.)*	
2025	0,00 Mio. ETS	60 € / ETS	0,0 Mio. €
2026	0,08 Mio. ETS	65 € / ETS	4,9 Mio. €
…	…	…	…
2030	2,01 Mio. ETS	85 € / ETS	170,2 Mio. €
…	…	…	…
2034	2,15 Mio. ETS	150 € / ETS	323,0 Mio. €

Amortisation in 7…10 years

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Roll-out

- **Phase 1:** (small) H2-Flow from BOFG to cover todays H2 demand for steel treatment
  - H2-Amount: 300 t/a (5% of the BOFG required)
  - 2x6000 l Container + Loading+Discharging unit, **CAPEX: 3 M€**
  - **Amortisation: ~ 1 year**
  - **Product ready => Sales ongoing**

- **Phase 2:** total BOFG converted to H2, H2 for own demand + sales to neighbour + CO2 for CCS/CCU
  - CAPEX: 25 M€
  - **Amortisation: ~ 2 years**
  - AMBARtec Product ready, CO2 separation to be developed

- **Phase 3**: 120 kt H2 for DRI + 2,1 mt CO2 for CCS/CCU
  - CAPEX: 200 M€
  - **Amortisation: ~7…10 years**
  - Product development to be completed

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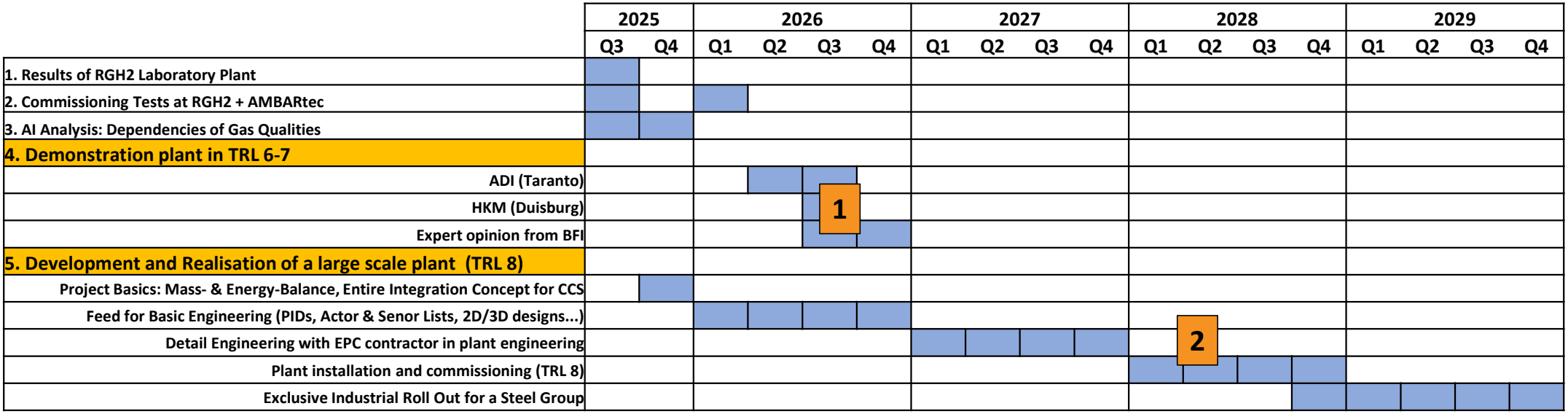
AMBARtec for Steel mills - Product Development & Roll-out

Execution mainly in EU-Project H2Loop – Partners still welcome



1 **Test plants in Taranto & Duisburg for BFG & COG & BOFG for production > 100 kg/day**

2 **Large Scale Plant for ~100 % BFG to produce H_2 for DRI**

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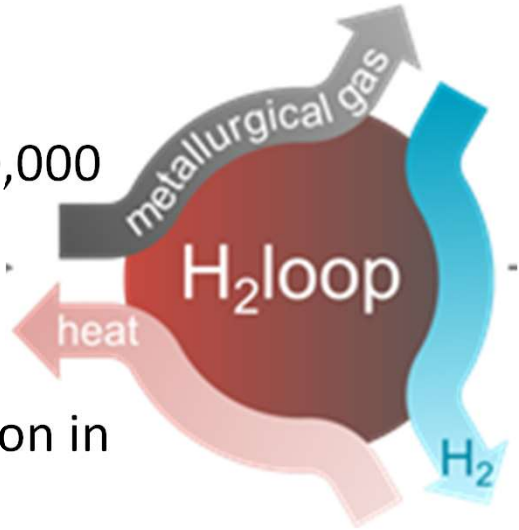
Summary

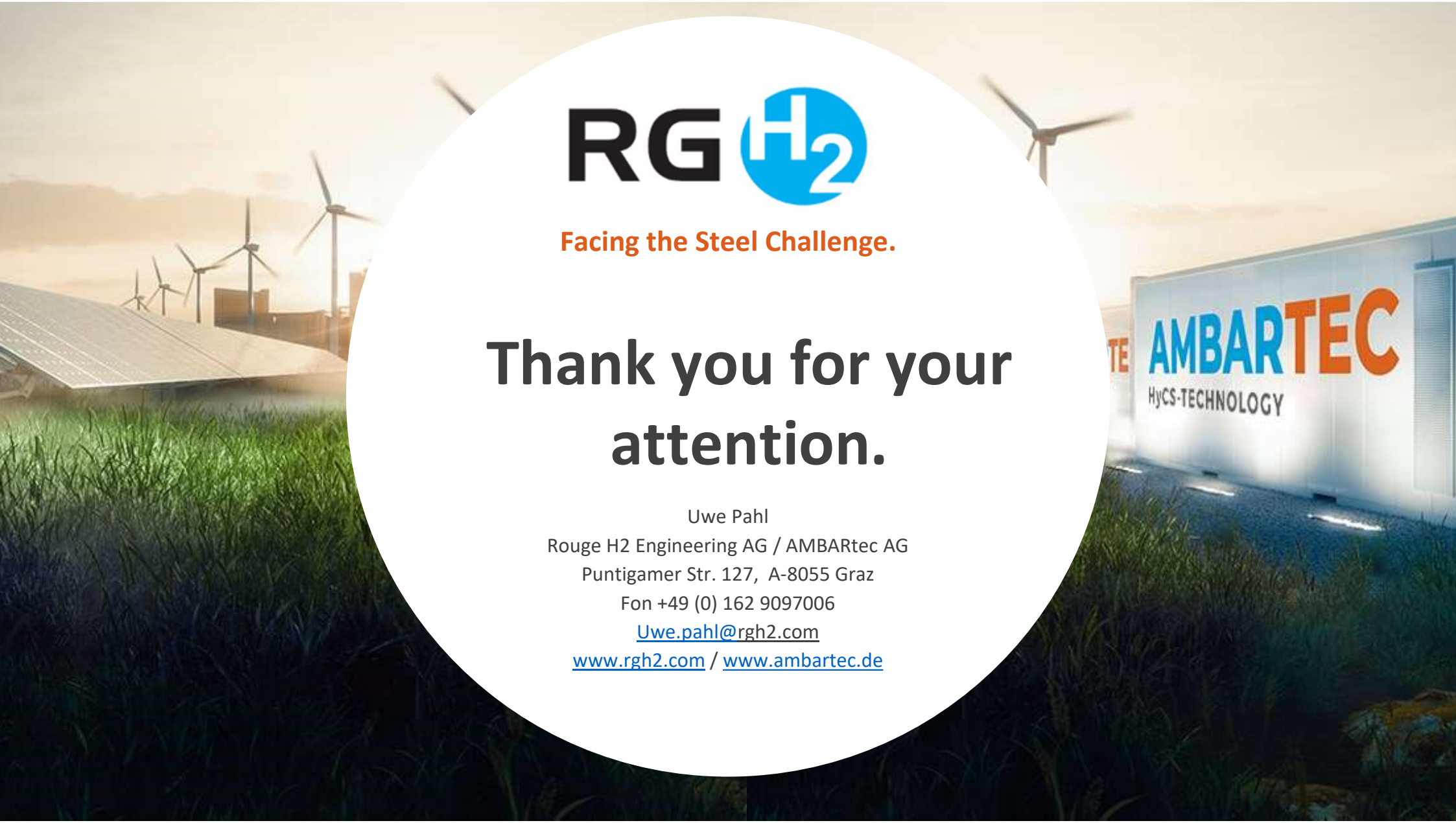
- Metallurgical gas treatment and CO_2 capture with the H2Loop process is a low-cost alternative or complementary solution to DRI to achieve green steel production.

- Referred to SALCOS®-Type-Project: 2 Mio. t/a DRI plant requires 150,000 t/a H2 → 80 % of the H2 amount can be supplied by one H2Loop integrated BF.



- H2Loop Technology is ready for small scale but commercial application in year 2026.

- RGH2 and AMBARtec are open for new partners for large scale deployment.



Facing the Steel Challenge.

Thank you for your attention.

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