Summary of current project state Estep Dissemination Event 2024, Brussels 14.3.2024

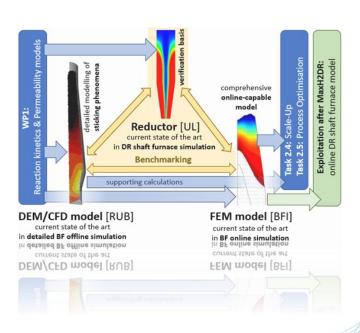
Dr. Thorsten Hauck



VDEh-Betriebsforschungsinstitut GmbH





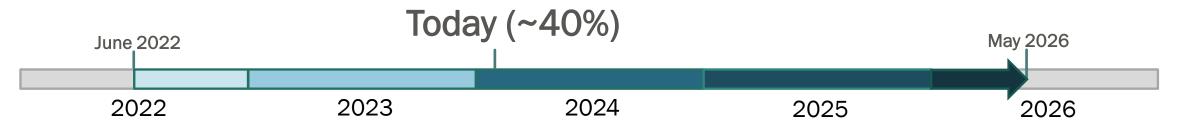






This project has received funding from the European Union under grant agreement NUMBER – 101058429 – MaxH2DR

OVERVIEW OF CURRENT PROJECT STATE





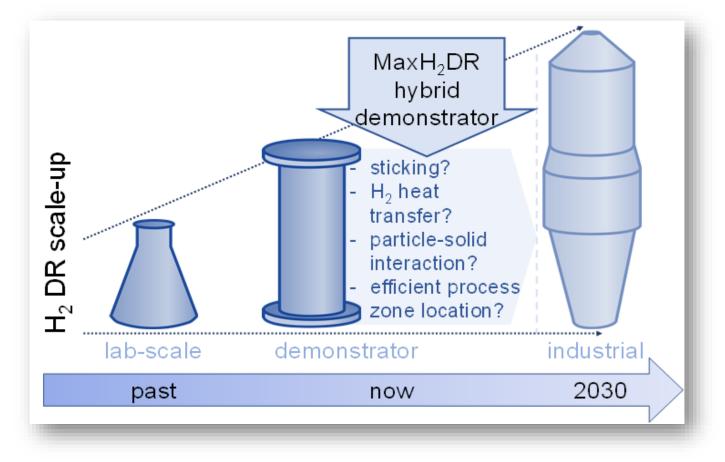
Maximise H2 Enrichment in Direct Reduction Shaft Furnaces

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MAXH2DR OVERVIEW: WHAT AND WHY?

- Key facts:
 - HORIZON-IA: 4 years from June 2022 to May 2026, budget: 4.5 million Euro
 - Financial & formal coordination: SSSA Technical coordination: BFI
- Background:
 - Natural gas based direct reduction industrially established
 - Hydrogen based direct reduction is ground-breaking technology for climate neutral steelmaking
 - No industrial experience with DR using >80% H₂ content
 - Operational problems and needed
 process optimisations unknown yet





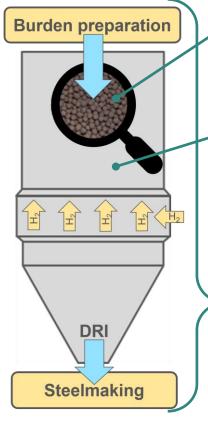
MAXH2DR OBJECTIVES:

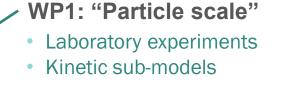
- Crucial aspects:
 - Cinetics and material properties at H_2 enrichment > 80%
 - Flow of gas and burden
 - Process stability and efficiency issues
 - ... and in particular the corresponding impact of H_2 enrichment > 80%
- MaxH2DR objectives:
 - ... provide missing physical and chemical data
 - ... close the current knowledge gaps
 - ... exploit new knowledge+data into comprehensive models ("hybrid demonstration")
 - ... deliver the tools needed for process optimisation and investment planning

MAXH2DR OVERALL CONCEPT

- Approach: hybrid demonstration of steelmaking via H₂ based direct reduction
 - validating and fusing DR furnace models with physical demonstration into a "hybrid demonstrator"

Three perspectives of investigation:



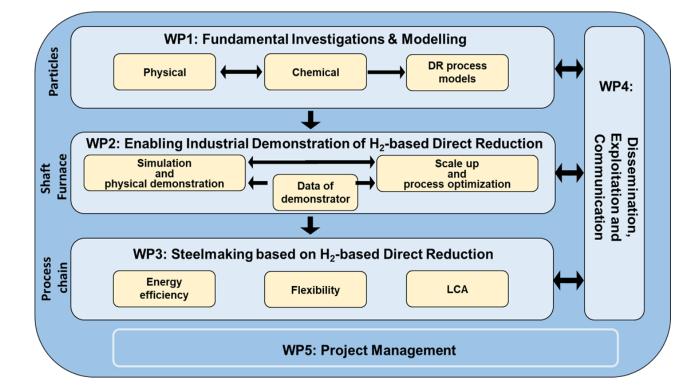


• WP2: "Furnace scale"

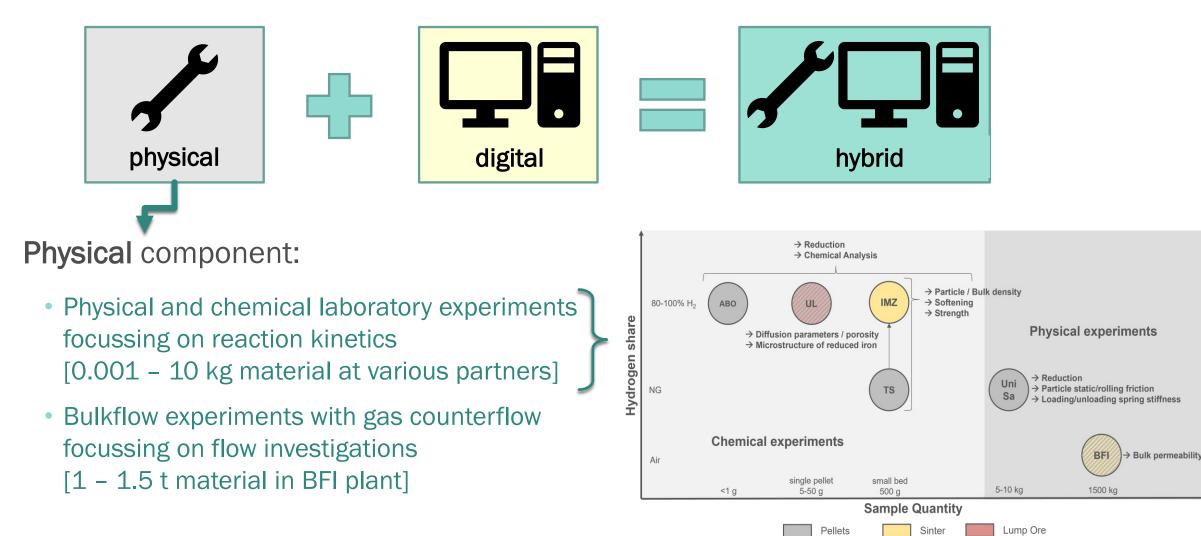
- Bulkflow demo experiments
- 3 detailed shaft furnace models
- Validation & process optimisation

WP3: "Process chain scale"

- Stationary scenario analyses
- Dynamic investigations (flexibility)
- LCA, LCC, social impacts

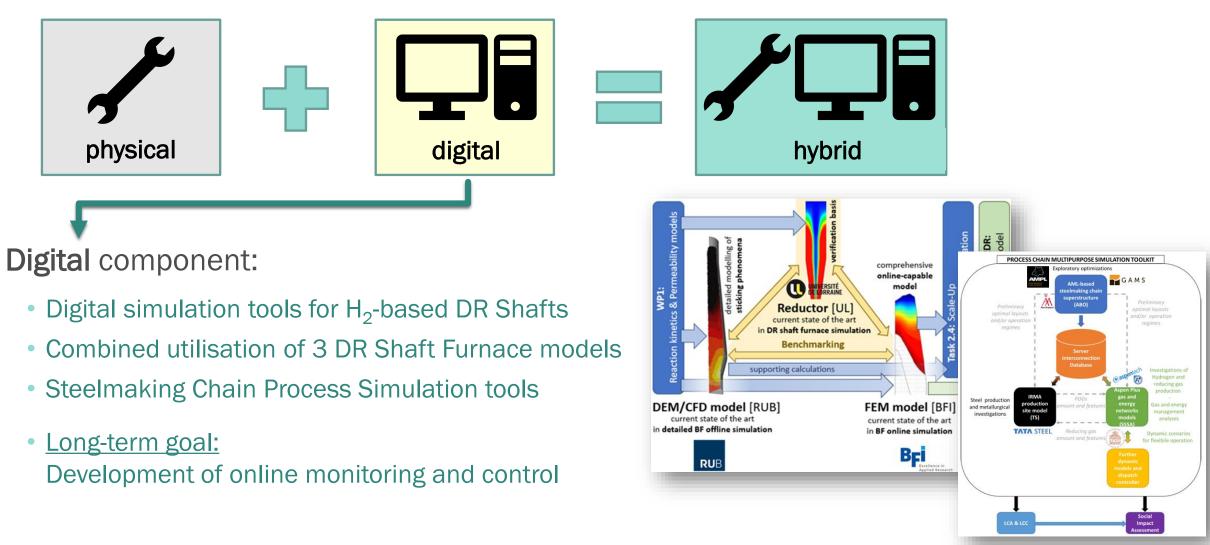


MAXH2DR HYBRID DEMONSTRATION APPROACH





MAXH2DR HYBRID DEMONSTRATION APPROACH



Max H2 DR

MAXH2DR OVERALL WORK PLAN

Horizon Europe Proposal MaxH2DR			2022			2023						+		2024				2025					2026		
		Year	and add	2022			> <u>∞681118119</u>				x 0.0		V m	State of the second					1				- N ²⁰ 0	1000	
WP 1	WP 1 New fundamental knowledge and sub-models		- 14	140	,			1 -1				200	100	200	900		mmr	n m r	200	000	44	44.	ব ব ব	3 4 4	
T1.1	Experimental investigations of reduction kinetics in different scales											C								++		HT	\pm	+++	
T1.2	Experimental investigations of physical properties of raw materials, intermediates and products	-			+	T	++				M		D						D	++	++	HH	++	+++	
T 1.3	Development of kinetic sub-models for H2-enriched DR	1	\square				\square					C			Π							HT	T	TH	
T 1.4	Implementation of new kinetic sub-models into DR shaft process					\square						D.	0	VI	D				\square			H	T		
WP 2	Enabling Industrial Demonstration of Hydrogen-enriched Direct Reduction																								
T 2.1	Physical Demonstration of linked solid and gas flow in DR shaft furnace												1	VI						D		Ш			
T 2.2	Coupled DEM/CFD simulation of moving granular particles and gas flow in DR model shafts													1	>				T			\square			
T 2.3	Development of validated hybrid demonstrator by synergetic combination of models with physical demonstra	ation															M			D					
T 2.4	Scale-up towards industrial scale DR shaft reactors																		T	TT					
T 2.5	Process optimisation for industrial scale DR shaft reactors																							D	
WP 3	Efficient and flexible steelmaking process chains based on H2-enriched DR																								
T 3.1	Adaptation and extension of available models and interconnection development	l.			M						D	N					I	N							
T 3.2	Stationary scenario analyses for transitional pathways																					D			
T 3.3	Dynamic investigations for flexible operation of new integrated steelworks with H2-enriched DR for high RES integration																							D	
T 3.4	Life Cycle Assessment and Cost																					D			
T 3.5	Social impact assessments																							D	
WP 4	Dissemination, Exploitation and Communication																								
T4.1	Website and Project Branding Toolkit				D																				
T 4.2	Dissemination and Communication Strategy				D																				
T 4.3	Stakeholder consultations				M																	D			
T 4.4	Compliance / IPR Checks and concepts	(П								1					T	TT		\square	П	D	
T 4.5	Exploitation and transfer of results to recommendations	1			D																		T		
T 4.6	Exploitation to the market				D						D					D			П						
WP 5	Project Management														\square				T	T					
T 5.1	Contractual Management	0																							
T 5.2	Technical and administrative project management				D																				
T 5.3	Reporting to the EC																								
T 5.4	Quality and Risk Management		D	D'										DI	n i									M	
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End of 1° reporting period





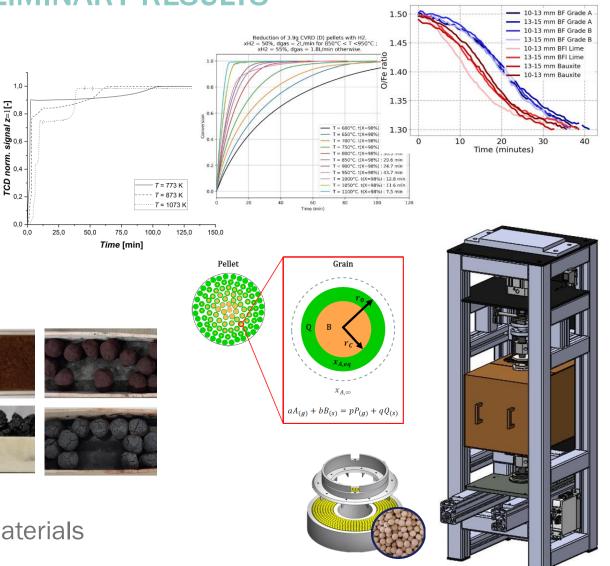
WP1: SELECTED OBJECTIVES AND PRELIMINARY RESULTS

Key-Objectives:

- Reduction <u>experiments</u> for H₂-enriched DR and new sophisticated kinetic <u>model</u>
- World-first <u>test rig</u> for adhesive forces of pellet bulks at industrial conditions

Planning tests & construction:

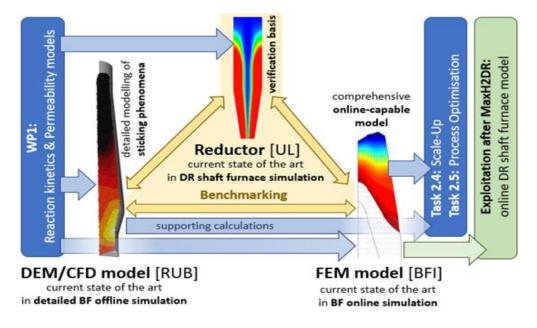
- Coherent materials & conditions for tests with <u>powder</u> (AAU), single <u>pellets</u> (UL) and <u>bulk</u> material (TS, IMZ)
- Preliminary cold tests and concept development of world-first test rig for <u>adhesive forces of moving bulk</u> materials



WP2: SELECTED OBJECTIVES AND PRELIMINARY RESULTS

Key-Objectives:

- Demonstration scale test rig for solid+gas flow
- Synergistic combination of DR shaft models

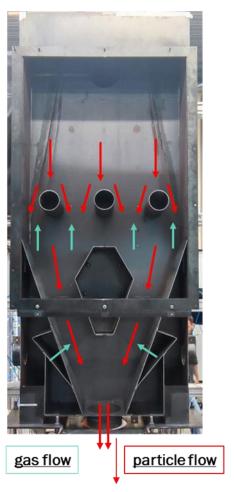


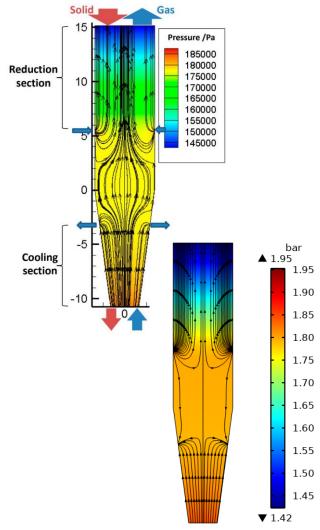
State of work:

Max^[H2]DR

Preliminary tube tests, demo test rig ready

First model versions ready and benchmarking started





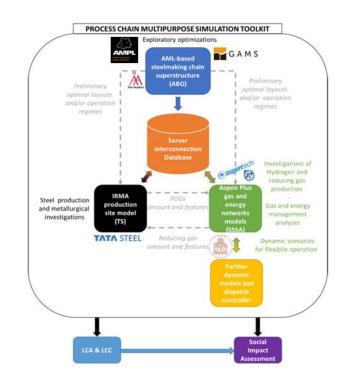
WP3: SELECTED OBJECTIVES AND PRELIMINARY RESULTS

Key-Objectives:

- Process chain simulation toolkit combining AML, IRMA and ASPEN
- Promising future plant states including H₂-enriched DR
- State of work:

Max[']H2[']DR

- Simplified prognosis of transition routes using AML
- Benchmarking of models for standard integrated steelworks
- Database and IT architecture available and interconnection demonstrated



Electricity

Oxygen Lime

BOF

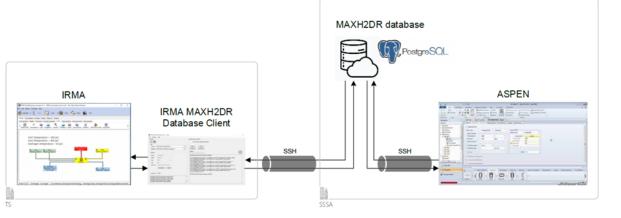
Electricity Oxygen

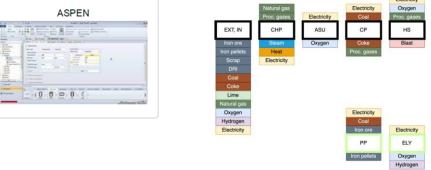
> Lime Coal DRI Scrap

Hydrogen

Oxygen

LT, CC, RM





CONCLUSIONS

- MaxH2DR integrates ...
 - investigations on different <u>scales</u> from powder to steel plant
 - ... different <u>model</u> approaches for maximum <u>synergy</u>
 - digital with physical-chemical investigations for <u>"hybrid-demonstration</u>"
- MaxH2DR provides ...
 - ... a lot of new data and knowledge
 - ... world-first test rigs and models

Project website via estep.eu

Follow us on Twitter and LinkedIn

Stay tuned for upcoming results !



THANK YOU FOR YOUR ATTENTION!



THANKS TO THE COLLEAGUES FOR THE GREAT COOPERATION !

Max H2 DR