



Dissemination of the heating technology research results for emission minimization and process optimization towards today's fossil-free heating agenda

RFCS-2021

Grant agreement No 101057930

Presentations for dissemination

Deliverable 3.3

Authors

Oliver Hatzfeld (BFI), Filippo Avellino (CSM), Davide Ressegotti (CSM), Elsa Busson (IOB/RWTH-Aachen University), Gustav Häggström (Swerim), Joel Falk (Swerim), Andreas Johnsson (Swerim), Hugo Uijderbroeks (CRM)

Dissemination level: Public

Content

1	Presentations	3
2	Figure Index	10

1 Presentations

The presentation for dissemination is based on the State of the Art analysis performed in D3.2. The presentation was held in the final workshop on the future road map. Therefore, the highlights of State of the Art analysis were presented and a clear explanation of physical mechanisms, measuring systems, modelling techniques and results, safety issues, impact on CO2 emissions were given.

The presentations were additionally promoted via LinkedIn and are available on the Website as pdf-download.

The following presentation with slides of each Topic (1 to 5) were held on 14 December 2023:



Fig. 1: Presentation title

dissHEAT - SoA Highlights

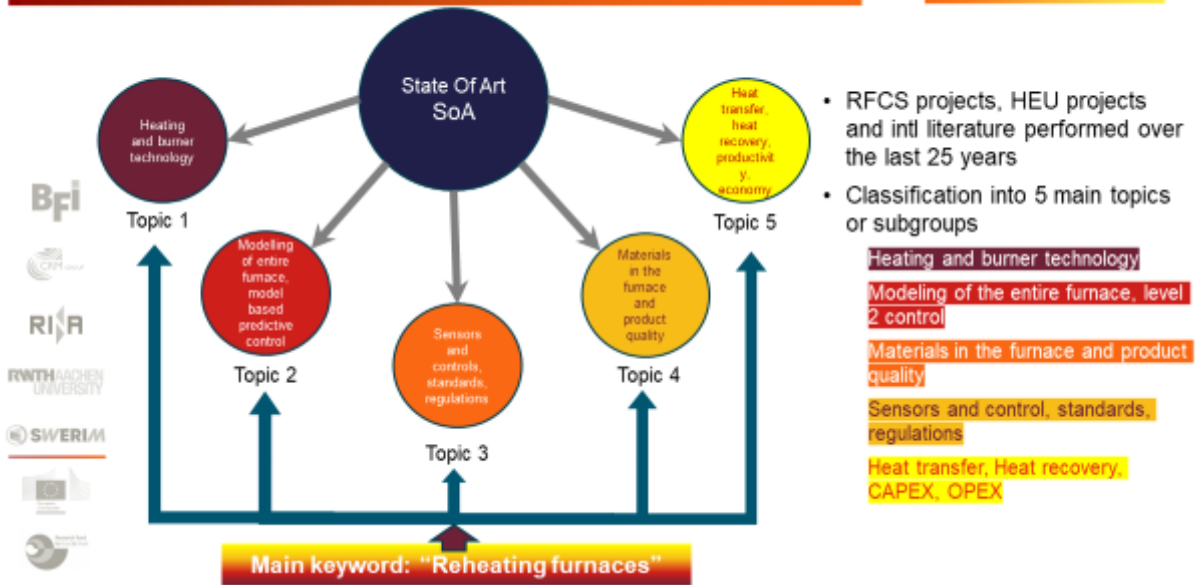


Fig. 2: Methodology and project topics

SoA - Relevant literature per topic

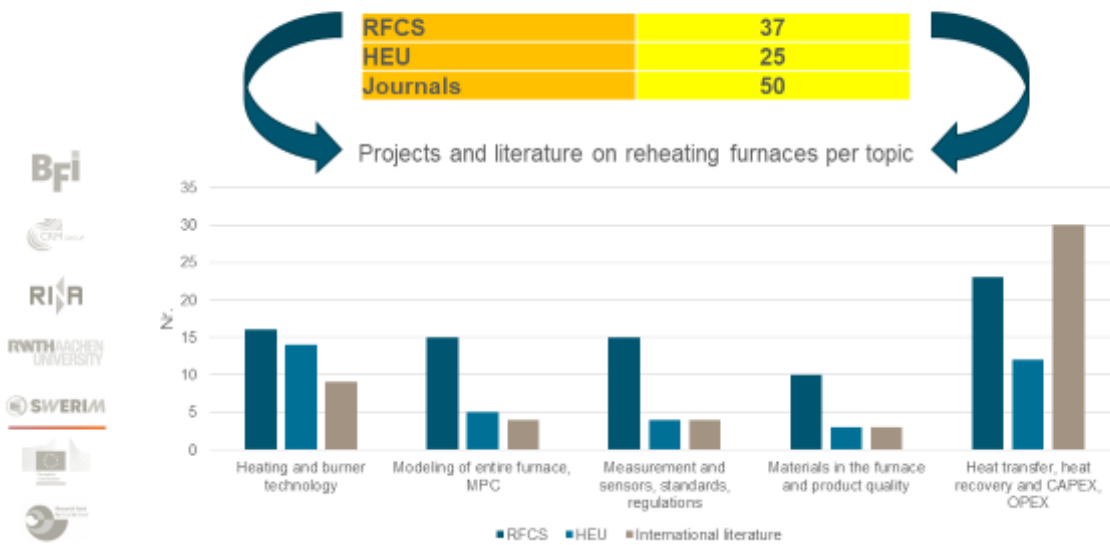
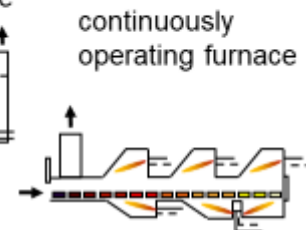
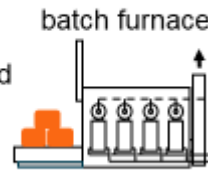


Fig. 3: Relevant reviewed literature per dissHEAT topic

SoA - Heating and burner technology



Key technologies to decrease **CO₂** and **NO_x emissions** of heating and burner technology for **reheating furnaces**:



Burner technology	Process gases	Efficiency by Heat recovery	Efficiency by process combination
NOx reduction - Flameless combustion - Ultra Low-NOx combustion	Substitution of natural gas in reheating furnace 100% or mixture with NG, oxidizer: air or OEC	Heat recovery form off gas by Combustion air preheating - recuperative - regenerative	Continuous casting not coupled rolling: warm charging Continuous casting coupled with rolling: direct charging

Fig. 4: Topic Heating and Burner technology – key technologies

SoA - Heating and burner technology

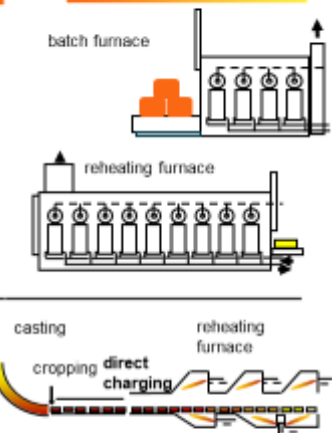
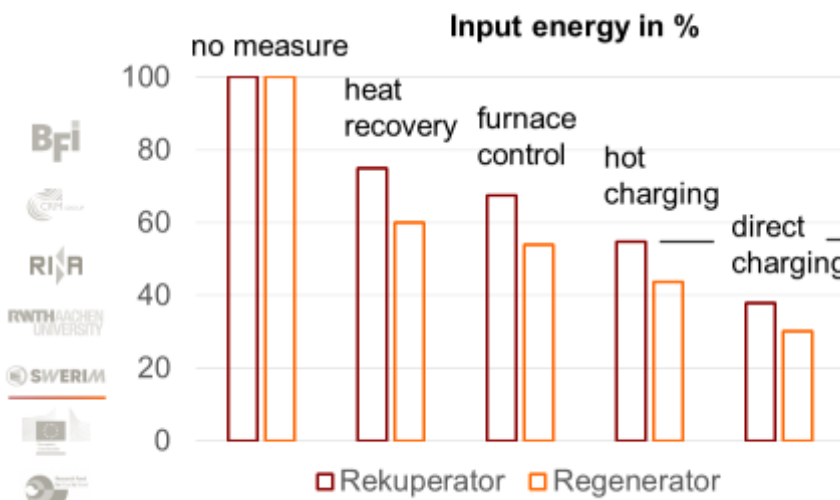


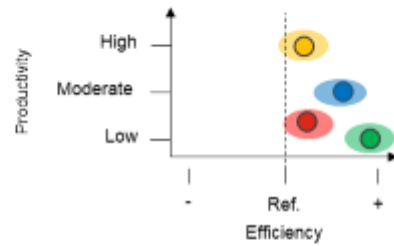
Fig. 5: Topic Heating and Burner technology – SoA saving potentials

State of the art 2023



Ref. Refers to a natural gas fired furnace with SoA recuperators

- Flameless regenerative burners ●
- Flameless oxyfuel combustion ●
- Electrical heating
 - Resistive radiative heating ●
 - Inductive heating ●



	Flameless regenerative burners	Flameless oxyfuel combustion	Resistive radiative heating	Inductive heating
CAPEX	Higher investment cost for burners	Higher investment cost for burners, need of oxygen infrastructure	Need new investment of entire furnace	Need new investment of entire furnace
OPEX	Lower specific fuel cost	Lower specific fuel cost, additional cost for oxygen	<ul style="list-style-type: none"> • Lower specific energy cost (highly dependent on elec. cost) • Uncertainties regarding longevity of heating elements 	Slightly lowered energy cost (highly dependent on elec. cost)

Fig. 6: Topic Heat transfer, heat recovery, productivity, economy, CAPEX, OPEX – Productivity and economy

Energy performance - example

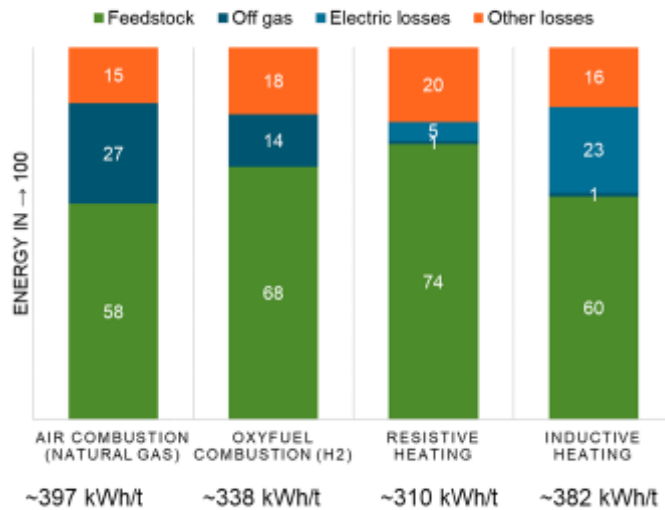


Fig. 7: Topic Heat transfer, heat recovery, productivity, economy, CAPEX, OPEX – SoA saving potentials

SoA - Sensors/controls, standards, regulations



The key technologies reviewed in topic 3 focus on **improving the energy efficiency of furnaces and enhancing product quality** using advanced measurement and control technologies.

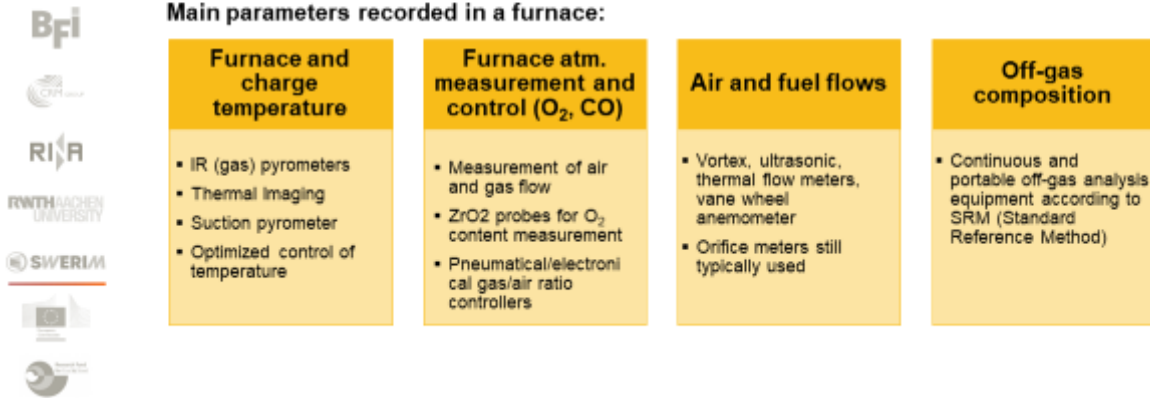


Fig. 8: Topic Measurement and sensors, measurement-based furnace control (level 1); standards, regulations – key technologies

SoA - Sensors/controls, standards, regulations

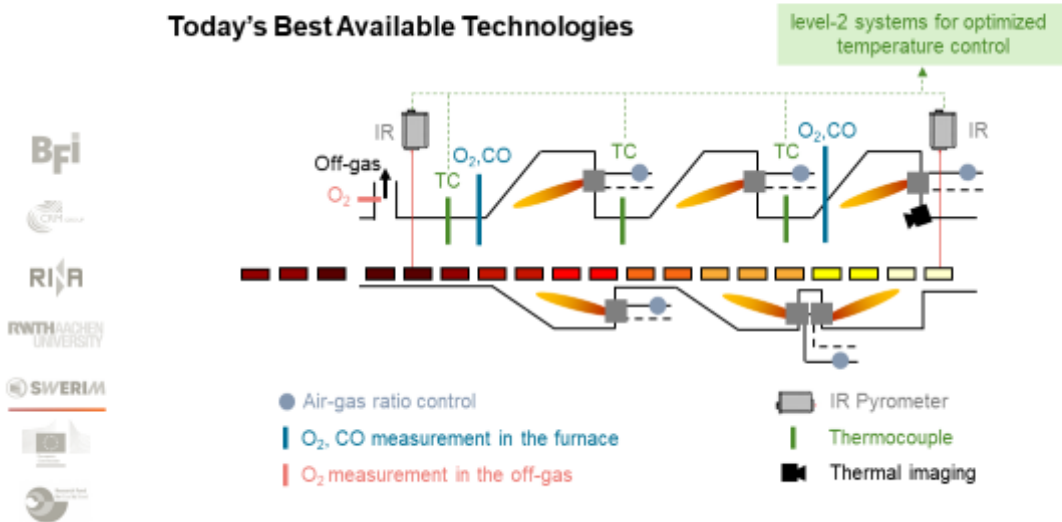


Fig. 9: Topic Measurement and sensors, measurement-based furnace control (level 1); standards, regulations – Best Available Technologies

SoA - Modelling of entire furnace, model based predictive control (Level 2)



The key technologies reviewed in topic 2 focus on **modelling of furnace and model based predictive control (level 2)** in order to:

- improve energy efficiency of the furnace
- minimize stop due to accidents
- enhance product quality

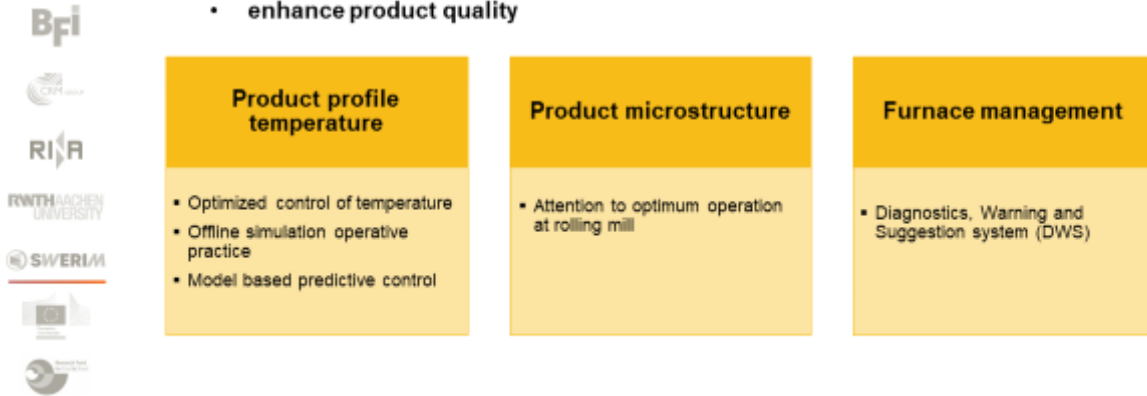


Fig. 10: Modelling of entire furnace, model based predictive control (level 2) – key technologies

SoA - Modelling of entire furnace, model based predictive control (Level 2)

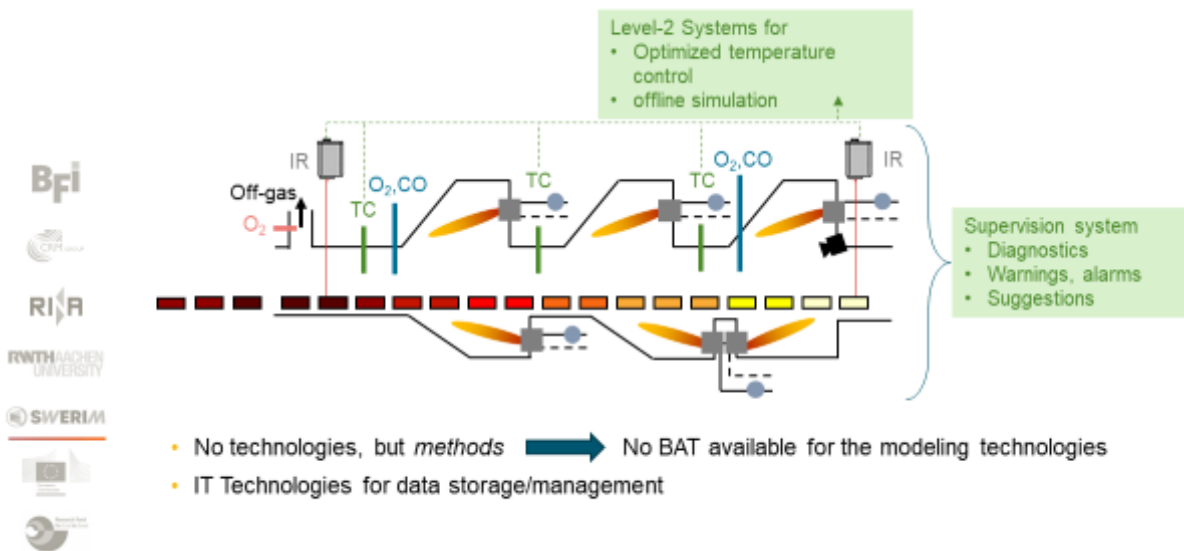


Fig. 11: Modelling of entire furnace, model based predictive control (level 2) – current methods

SoA - Materials in the furnace and product quality



- Focus of investigations in reviewing *Materials in the furnace and product quality* : Surface properties: decarbonization + scale + interface + Defects
- Success-story:
 - Definition of critical parameters (e.g. atmosphere, chemistry)
 - Interaction with descaling
 - Possible application of coatings



Scale growth	Descaling	Application of coatings
<ul style="list-style-type: none"> • Constox • Oxmapro • ScaleControl 	<ul style="list-style-type: none"> • Hides • ReduHeatLoss 	<ul style="list-style-type: none"> • Hiperscale

Fig. 12: Materials in the furnace and product quality – focus of investigations

SoA - Materials in the furnace and product quality



- Limit alloying elements (e.g. Al, Si, P, B, Cr, Mo, Ti, Nb, Cu, Ni, Sn, As, Sb)
- Limit reheating temperature
- Limit duration in the furnace, especially at high temperature
- Limit oxygen content
- Limit humidity
- Limit transfer time between furnace and descaler
- Assure an optimum descaler performance related to the rolled grade
- Apply coating to avoid decarbonisation depending on product and grade. Higher scale formation rates are beneficial for reducing decarburization, as decarburised regions are removed by the oxide layer. For some materials decarburization was not detectable when Stopoxy was used.



Fig. 13: Materials in the furnace and product quality – Best Available Technology

2 Figure Index

Fig. 1: Presentation title

Fig. 2: Methodology and project topics

Fig. 3: Relevant reviewed literature per dissHEAT topic

Fig. 4: Topic Heating and Burner technology – key technologies

Fig. 5: Topic Heating and Burner technology – SoA saving potentials

Fig. 6: Topic Heat transfer, heat recovery, productivity, economy, CAPEX, OPEX – Productivity and economy

Fig. 7: Topic Heat transfer, heat recovery, productivity, economy, CAPEX, OPEX – SoA saving potentials

Fig. 8: Topic Measurement and sensors, measurement-based furnace control (level 1); standards, regulations – key technologies

Fig. 9: Topic Measurement and sensors, measurement-based furnace control (level 1); standards, regulations – Best Available Technologies

Fig. 10: Modelling of entire furnace, model based predictive control (level 2) – key technologies

Fig. 11: Modelling of entire furnace, model based predictive control (level 2) – current methods

Fig. 12: Materials in the furnace and product quality – focus of investigations

Fig. 13: Materials in the furnace and product quality – Best Available Technology

Acknowledgement



This project has received funding from the Research Fund for Coal and Steel under grant agreement No 101057930.

This report reflects only the authors' view. The European Commission is not responsible for any use that may be made of the information it contains.