Research developments during the last 20 years and todays State-of-the-Art

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Review process and focus

Topic 5: Heat recovery, heat transfer, productivity and economy

- 20 articles, 13 RFCS and 6 HEU reports, technology provider reports and webpages, state of the art documents

→ TRL, efficiency, productivity, CAPEX, OPEX, CO_2 emissions

Research & Development drivers:

- Profitability and legislative limits of SO_2, NO_x, and GHG emissions

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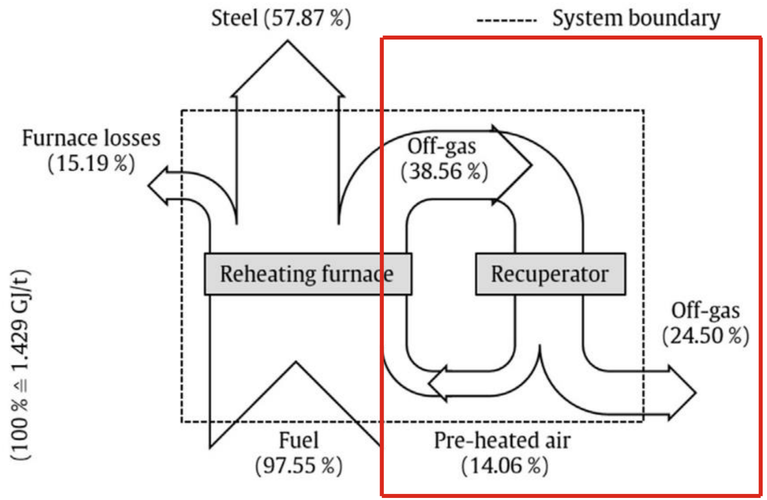
Heat recovery/efficiency – combustion

<u>Heat recovery/efficiency</u>
Increases profitability and reduces emissions

<u>Recovery potential</u>
- Off gas temperature and flue gas load

<u>Primary measures</u>
- Air preheating
- Feedstock preheating
- Decrease or eliminate flue gas load

<u>Secondary measures</u>
- Waste heat boiler
- Organic Rankine cycle
- Thermoelectric generators



"Towards CO2-neutral process heat generation for continuous reheating furnaces in steel hot rolling mills – A case study, 2021"

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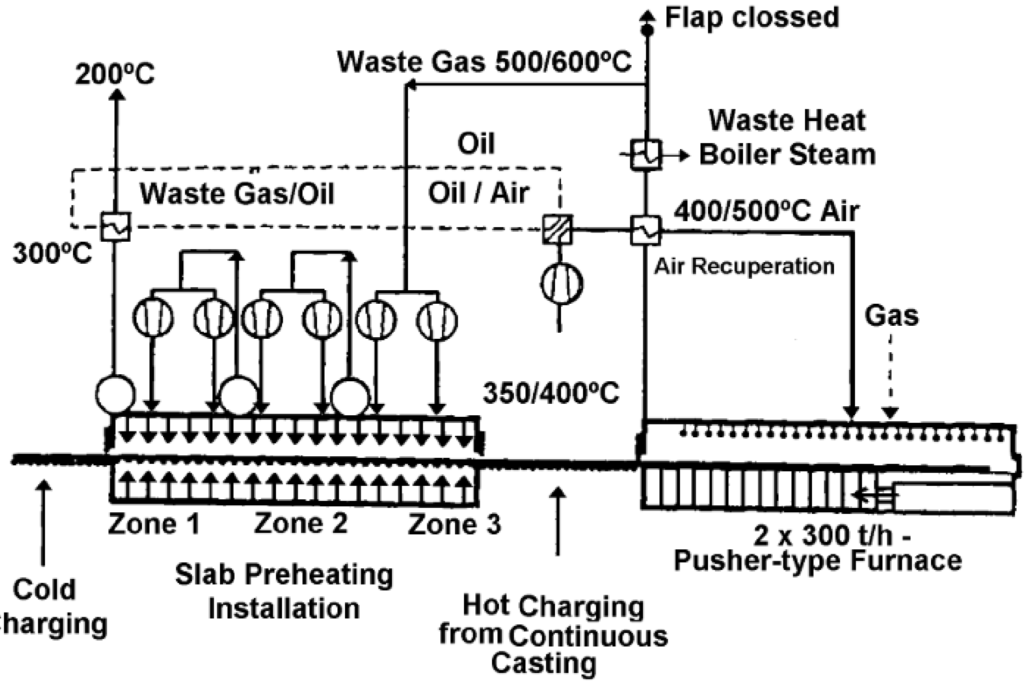
State of the art 2001



Limitations
- Air preheating < 600 °C
- Cold charging
- Continuous furnaces

Reference Document on Best Available Techniques in the Ferrous Metals Processing Industry 2001

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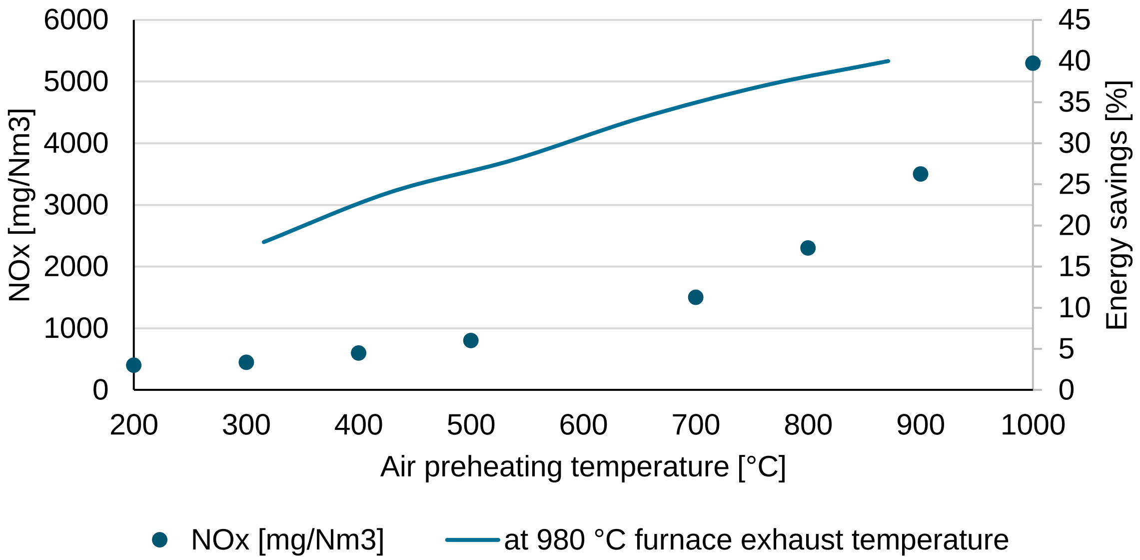
Development in heating technology

Trade off between energy efficiency and NO_x emissions
→ combined heat recovery approaches necessary



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Development in heating technology

Flameless combustion

- Low or ultralow NO_x emissions

Regenerative systems

- T_{air} > 1000 °C

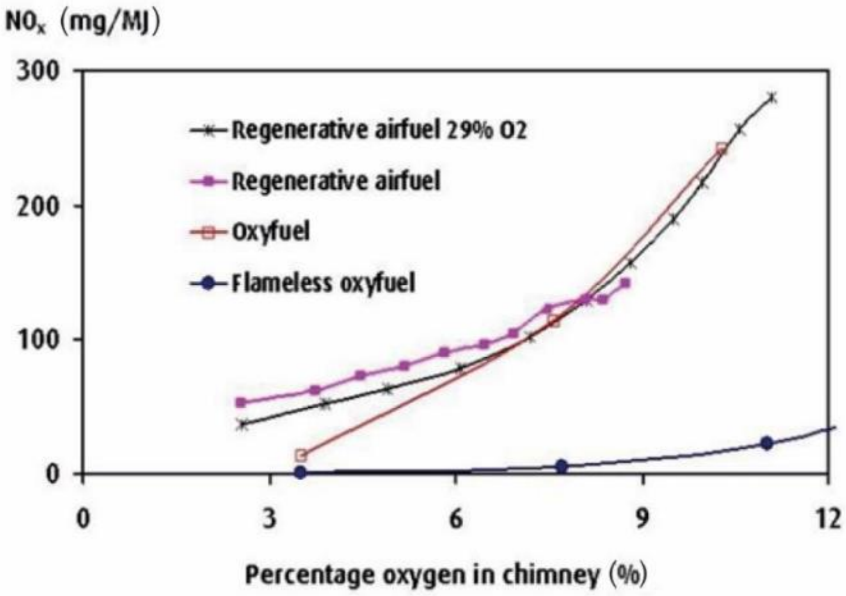
Oxyfuel combustion

- Reduced flue gas load

✓ Hot/direct charging

✓ Batch processes

- More options available to reach high efficiency



Successful use of flameless oxyfuel in steel reheating, 2020

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Development in heating technology

Technology	Fuel savings*	Productivity*
Recuperative/regenerative burners	<30 %	<15 %
Oxygen enriched combustion	<30 %	<30 %
Flameless regenerative burner	<40 %	<30 %
Flameless oxyfuel combustion	<65 %	<50 %

*Compared to combustion of natural gas with cold air.

Upgrading/retrofitting an old furnace is generally possible

Dissheat: State of the art report

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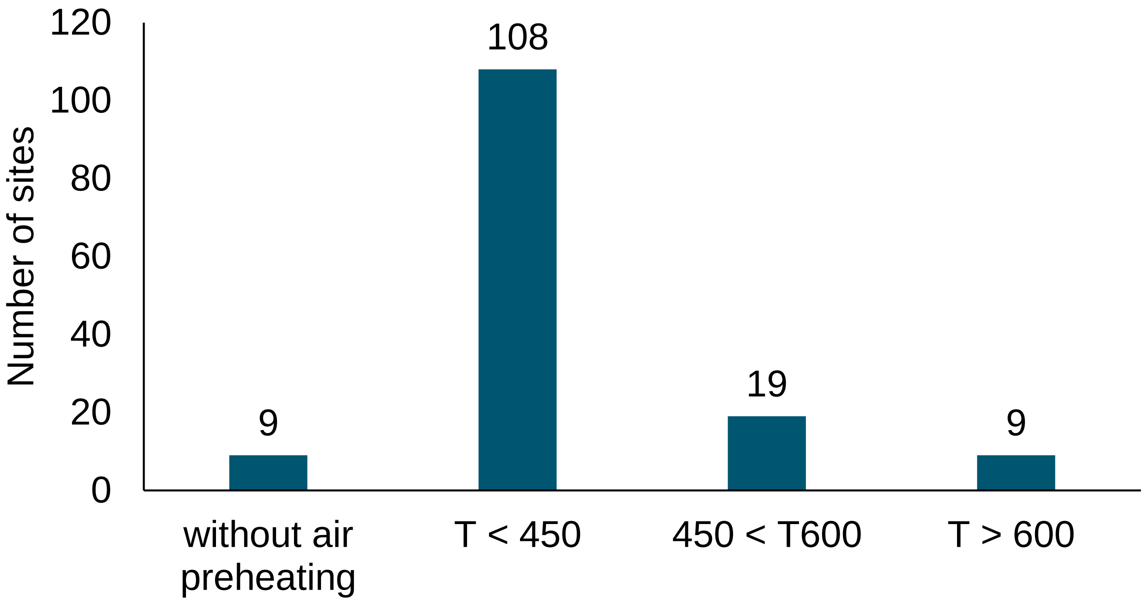
Situation in industry



Reference Document on Best Available Techniques in the Ferrous Metals Processing Industry 2022

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Development in electrical heating

<u>Electrical heating</u>

- Resistive heating
  - Direct
  - Radiative
  - Convective
- Inductive heating
- Plasma heating
- Rotodynamic heating
- Hybrid heating

Technology	Heat recovery/ Efficiency	Heat transfer/ productivity
Combustion	Low to high	Moderate
Inductive heating	Low to high	High
Indirect radiative heating	High to very high	Low
Direct resistive heating	Moderate to very high	Very high

Typically requires a new furnace installation

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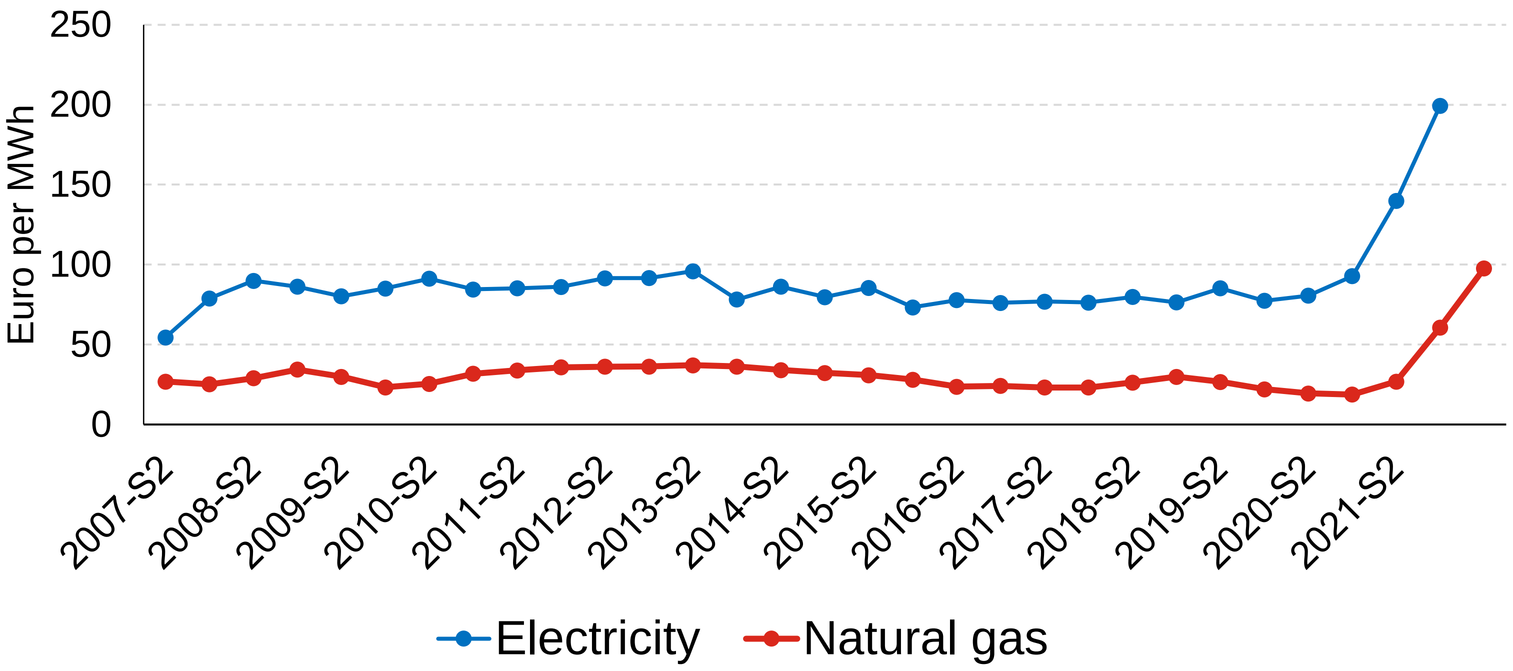
Electricity and natural gas cost – EU27



Eurostat – prices of natural gas and electricity in EU27 2007-2022 (large consumers)

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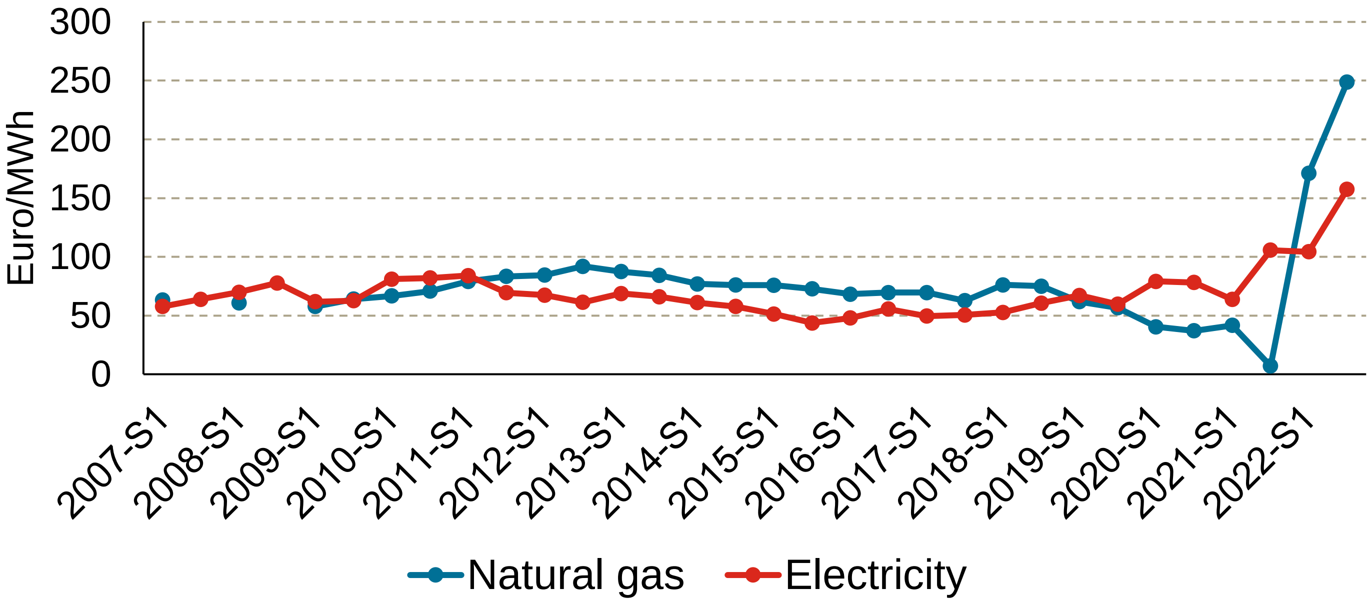
Price variability

<u>Electrical heating</u>

Feasibility depends on local electricity price and electricity mix (fossil-free share)



Eurostat – prices of natural gas and electricity in Sweden 2007-2022 (large consumers)

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Electrofuels in reheating furnaces

Electrofuels
- Does not require major modification to conventional heating furnaces
- Less efficient than electrical heating or conventional heating
- Can be stored and transported

→ Can utilize regional and daily variation in electricity price

Fuel	η_{syn} (LHV)	η_{tot} (50 % < η_{com} < 75 %)
Hydrogen (H_2)	~50-70 %	~25-52.5 %
Ammonia (NH_3)	~55-65 %	~27.5-48.8 %
Methane (CH_4)	~49-65 %	24.5-48.8 %

“Process efficiency simulation for key process parameters in biological methanogenesis”
“Current and future role of Haber–Bosch ammonia in a carbon-free energy landscape”
“Current status of water electrolysis for energy storage, grid balancing and sector coupling via power-to-gas and power-to-liquids: A review”

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Thank you for the attention!

Stay informed

www.dissheat.eu

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