New technologies: H2 combustion, electrical heating and flexifuel from an industrial and system point-of-view

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Introduction

- Fossil-free agenda and carbon neutrality
- Electrification of processes
- Power generation
- Demand flexibility
- Synthetic fuel production
  - PtX
  - Biomass origin
- Reheating furnaces in the system

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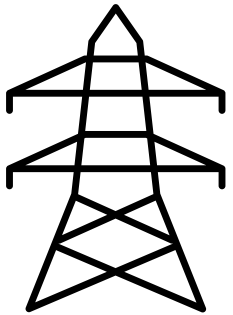
Electrification

”Processes that can be electrified, should be, for the most cost-efficient transition to carbon neutrality”

In industries with the possibility to go for direct electrification, it is the preferred option.

For reheating furnaces, the existing infrastructure is not easily converted for direct electrification



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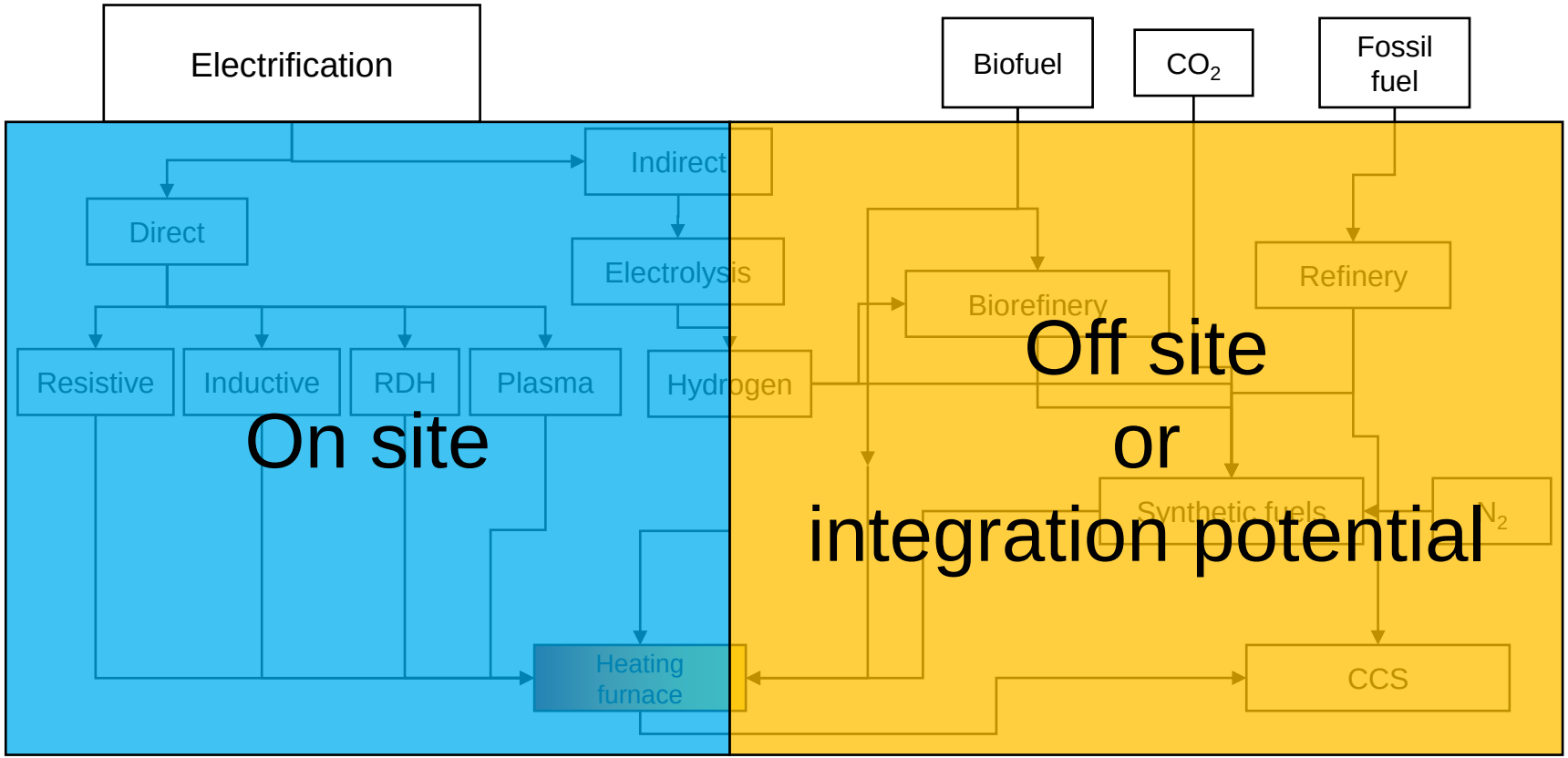
“National Energy System Modelling of Industry: Optimising the Transition Towards Carbon Neutrality”, PhD thesis, Erik Sandberg, Luleå University of Technology, 2022

New technologies



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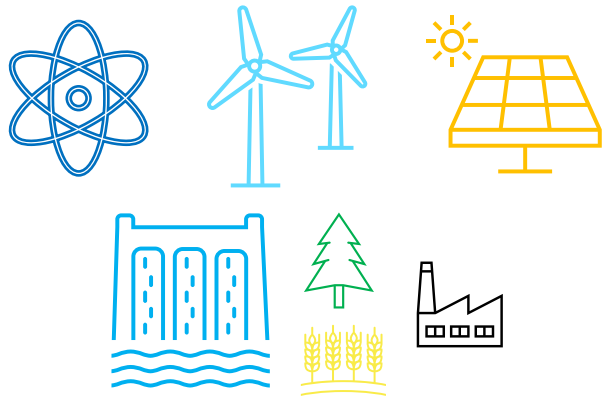
Power generation

Fossil free

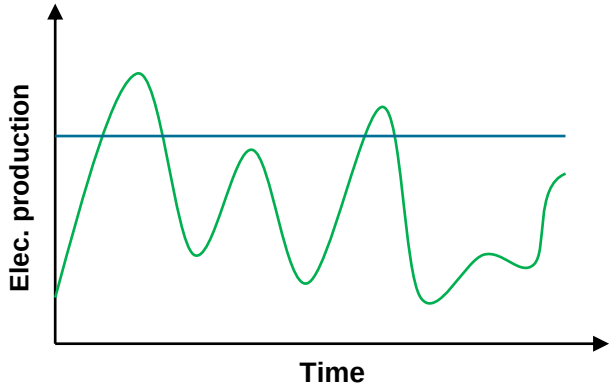
- Nuclear
- Wind
  - Land or sea
- Solar
- Hydropower
- Biomass



- Uncertain costs for new production and storages
- Power market in EU currently heavily linked to natural gas market by electricity production

Intermittency

- Needs storage, regulating power production or demand flexibility



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Hydrogen production

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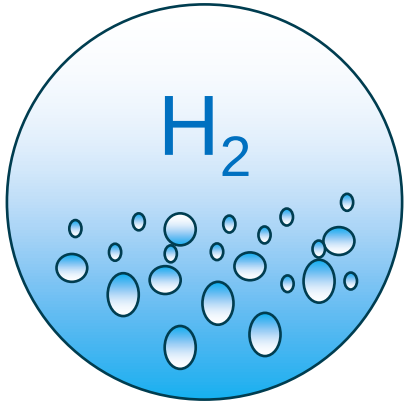
Electrolysis
Alkaline – Commercially deployed, scaling up
PEM – Commercially deployed, scaling up
SOEC – maturing, need high temperature source

Steam methane reforming + CCS
- Widely available
- Conventional technology

Hydrocarbon pyrolysis + CCS

Gasification
- Biomass
- Fossil + CCS

Thermochemical cycles
- Future technology
- Need very high temperature source of heat



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Electrical heating from industrial PoV

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Greenfield installations

- New electrical furnace
- Induction furnace pre-heating for productivity
- Resistive for soaking
- Possible to use shielding atmosphere

Retrofitting of existing furnaces

- Induction heating, but with relatively large losses
- Due to power density of resistive heating, only partial replacement of fuel possible
- RDH possible future market competitor with higher power density

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Hydrogen combustion from industrial PoV

- Most simple retrofitting option, can preserve current infrastructure to a large degree
- Needs investment in electrolyzer or bought from market, preferably through gas grid
    - Electrolyzers currently undergoing upscaling to levels matching reheating furnaces
    - Gas grid a possible H_2 storage

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Fuel flexibility

Hydrogen/methane/LPG/Ammonia/other synthetic fuel

- Using existing furnace and sometimes burner installation
- Possibility to install electrolysers on site
    - Power requirement
- Storage or gas grid dependency
- Need a fossil-free backup-fuel or CCS in the future for carbon neutrality

Hydrogen/electrical heating

- Requires investment in parallel infrastructure
- Co-interact with power availability needs

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Reheating furnaces from a system perspective

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Swedish perspective

- Combustion solutions
  - Biomass-based hydrogen production the most cost effective
  - Oxyfuel combustion if possible use of excess oxygen from electrolysis.
- Electrical solutions
  - Resistive heating the best option

- In biomass-limited scenarios, the most cost-effective solution is resistive heating for the case where daily electricity price variation is low.
  - For cases where the daily price variation is ± 45 %, electrolysis based H_2 production + storage becomes competitive.

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“Flexible solutions to decrease greenhouse gas emissions from heating furnaces in the steel industry”, Larsson et al, 2019

System integration possibilities

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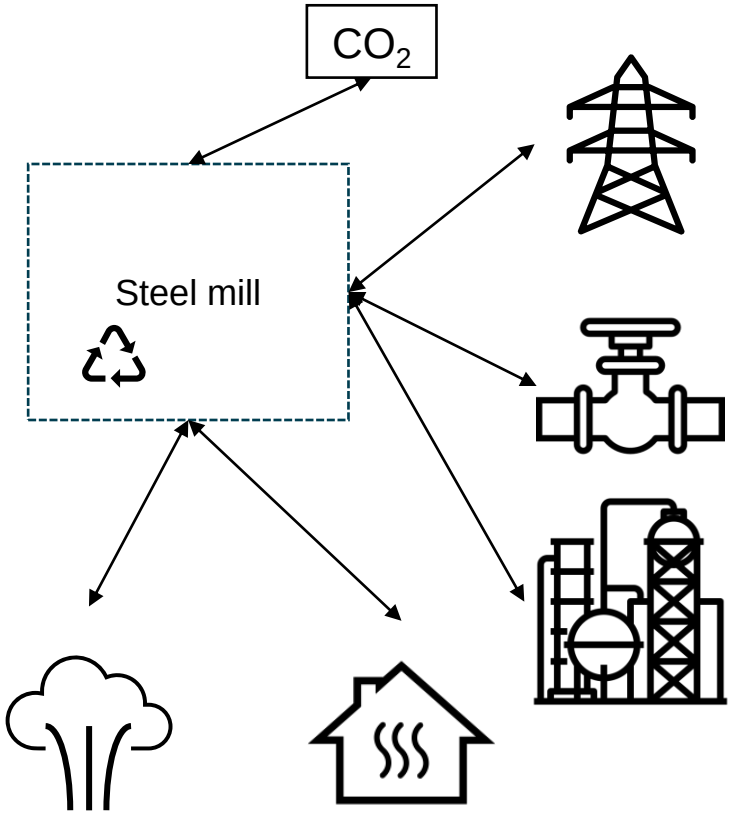
Fuel production

- H_2 on- or off-site, natural gas grid interaction
- Synthetic fuel production

Site specific

- EAF heat recovery
- Hot-charging
- Steam or hot water production
- Oxygen production
- Provide power grid services
- CCS/CCU



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