

# Electrification of the industry:

## Hydrogen direct reduction of steel and the electricity system – a win-win combination

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# Energy-intensive industries decarbonization

## Industry is a major emitter of CO<sub>2</sub>

20% of carbon emissions in the EU

## New Industrial Strategy

climate neutrality and digital leadership

## Deep CO<sub>2</sub> emissions reduction

- Electrification
- CCS
- Biomass

Decline in the cost of renewable energy technologies



# Industry: Steel production



Other press releases

## HYBRIT: SSAB, LKAB and Vattenfall to start up the world's first pilot plant for fossil-free steel

AUGUST 31, 2020 15:30 CET

7 MIN READ

Today, SSAB, LKAB and Vattenfall are taking a decisive step toward fossil-free steelmaking with the start-up of HYBRIT's globally unique pilot plant for the production of fossil-free sponge iron. Swedish Prime Minister Stefan Löfven started up the plant together with Isabella Lövin, Minister for Environment and Climate and Deputy Prime Minister, Martin Lindqvist, President and CEO of SSAB, Jan Moström, President and CEO of LKAB and Magnus Hall, President and CEO of Vattenfall. SSAB, LKAB and Vattenfall aim to create a complete value chain for fossil-free steel.



Other press releases

## SSAB to be first to market with fossil-free steel

NOVEMBER 14, 2019 11:00 CET

5 MIN READ

Global steel company SSAB plans to be the first company in the world to get fossil-free steel onto the market. The plan for transitioning to iron-ore based fossil-free steel production was presented to more than 400 customers and key players in the industry, in conjunction with SSAB's Swedish Steel Prize seminars this week in Stockholm.



Other news

## SSAB to deliver fossil-free steel to Volvo Trucks

MAY 24, 2022 8:10 CET

3 MIN READ

Volvo Trucks will, as the world's first truck manufacturer, introduce SSAB fossil-free steel in its trucks. Small scale introduction of the steel in Volvo's heavy electric trucks will start already in the third quarter of 2022.

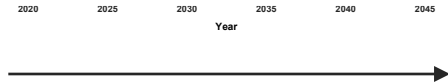


# CO<sub>2</sub> emissions development



## Pathway

Fossil-free steel production



## Steel production technologies

CO<sub>2</sub>



Conventional processes

Iron ore

**BF/BOF**

Blast furnace/basic oxygen furnace

scrap

**EAF**

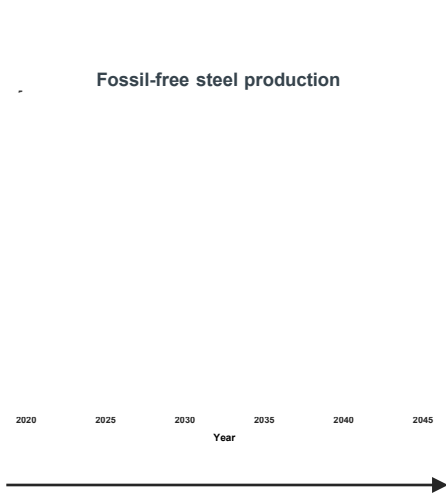
Electric arc furnace

# CO<sub>2</sub> emissions development

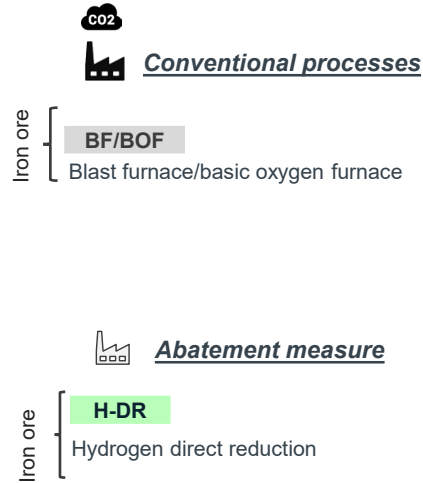


## Pathway

Fossil-free steel production



## Steel production technologies

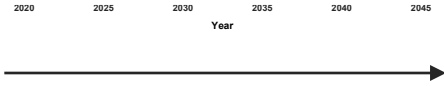


# CO<sub>2</sub> emissions development



## Pathway

Fossil-free steel production



## Steel production technologies

  Conventional processes

scrap { **EAF**  
Electric arc furnace

 Abatement measure

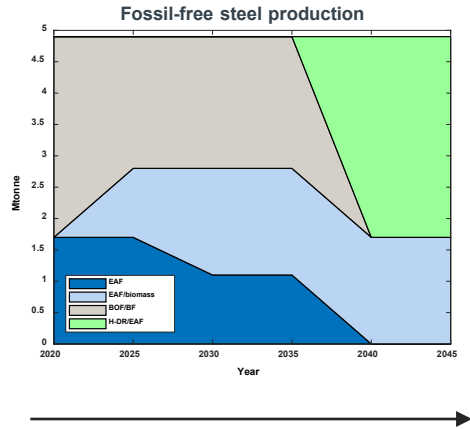
scrap { **EAF/Biomass**  
Electric arc furnace with biomass

# CO<sub>2</sub> emissions development



## Pathway

## Steel production technologies



CO<sub>2</sub>



Conventional processes

Iron ore [ **BF/BOF**  
Blast furnace/basic oxygen furnace

scrap [ **EAF**  
Electric arc furnace



Abatement measure

Iron ore [ **H-DR**  
Hydrogen direct reduction

scrap [ **EAF/Biomass**  
Electric arc furnace with biomass

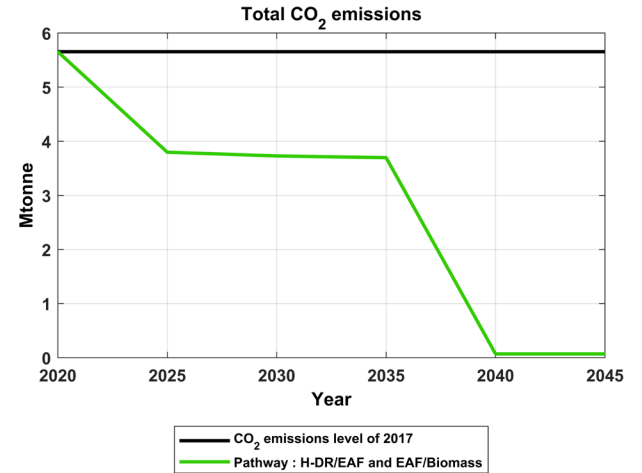
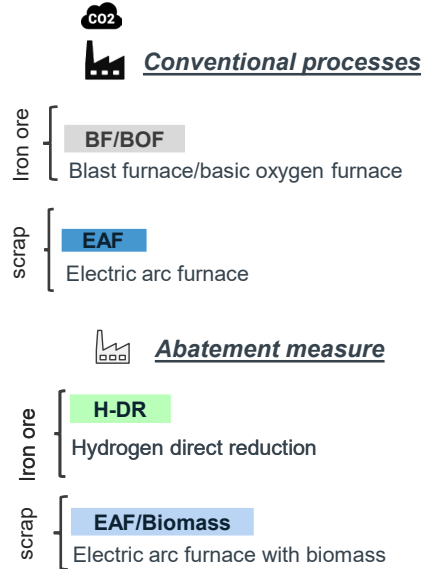
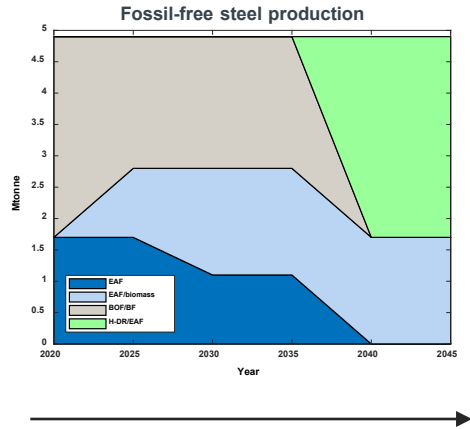
# CO<sub>2</sub> emissions development



## Pathway

## Steel production technologies

## CO<sub>2</sub> emissions level







# Energy-intensive industries decarbonization

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## New Industrial Strategy

climate neutrality and digital leadership

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- Electrification
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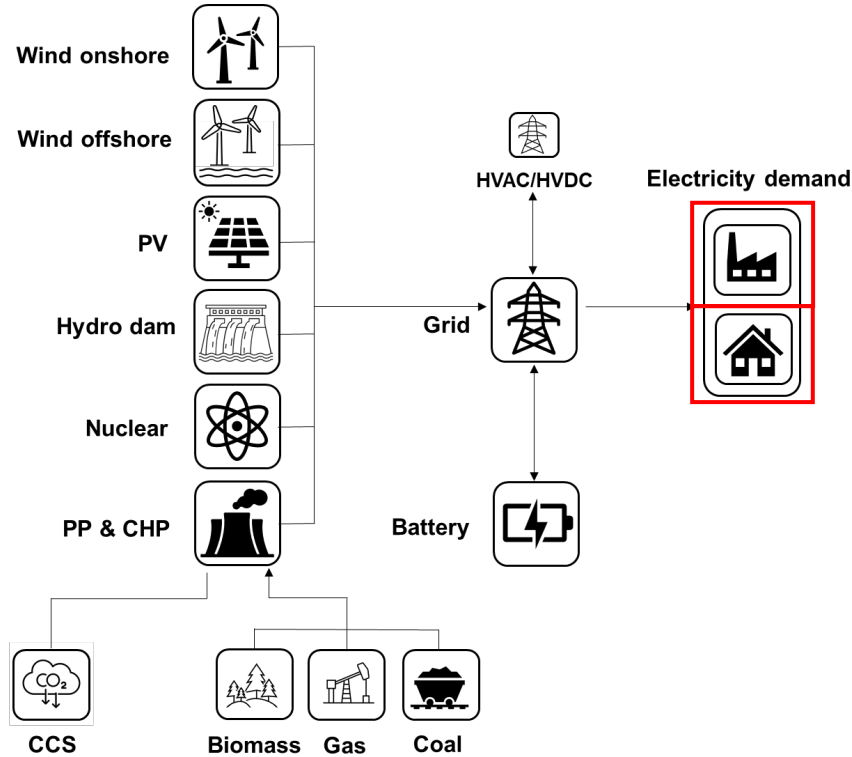
Decline in the cost of renewable energy technologies

## Global steel sector is at a crossroads

Before 2030, 71% of existing blast furnaces will reach the end of lifetimes



# Electricity system model



Technologies: electricity **generation**, energy **storage** and electricity **transmission**

**Cost-minimized** electricity supply and steel production for the given constraints

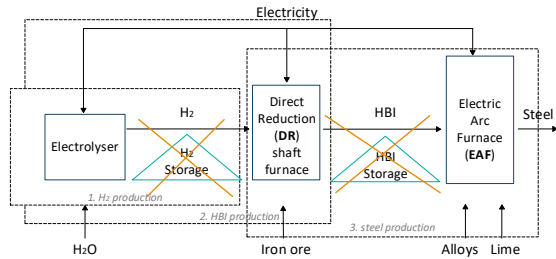
**Net-zero** CO<sub>2</sub> emissions

**Green-field** model

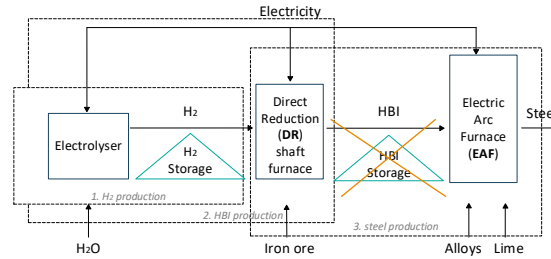
The **transmission network and hydro** power

# Flexible operation of the industrial consumers – steel production

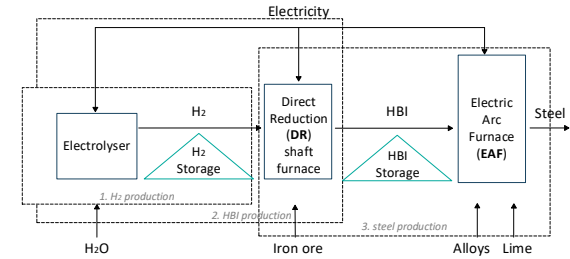
Inflexible



Partly flexible



Flexible



# Results:

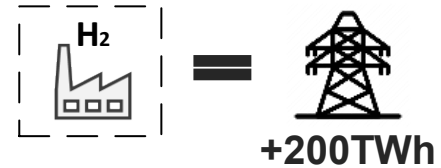
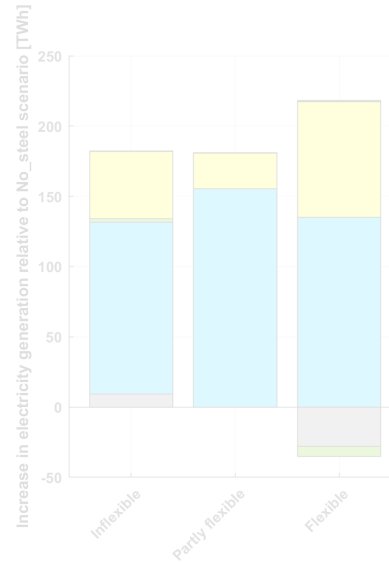
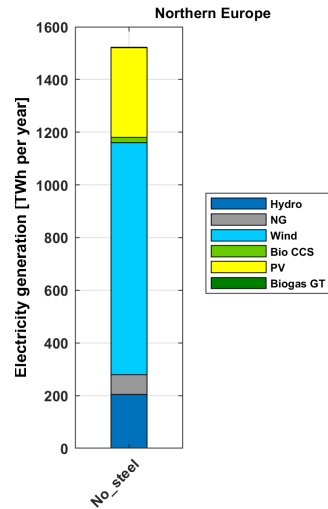
## Steel production cost



		Partly flexible	Flexible
Steel production cost	↓	6%	14%
Investment cost	↑	30%	48%
Total system cost	↓	2%	4%

# Results:

## Electricity system composition





# Results: Steel plants allocation



Locational determinant:

Availability of low-cost electricity generation

-  Current location of the steel production
-  Future location of the steel production



# Opportunities

- Emissions reductions
- Develop new 'green' markets
- Inter-firm collaboration

# Challenges

- Security of supply in the electricity grid
- Upscaling of hydrogen production, distribution, and storage infrastructure.
- Organizational changes across whole material value chains
- New climate and industrial policies



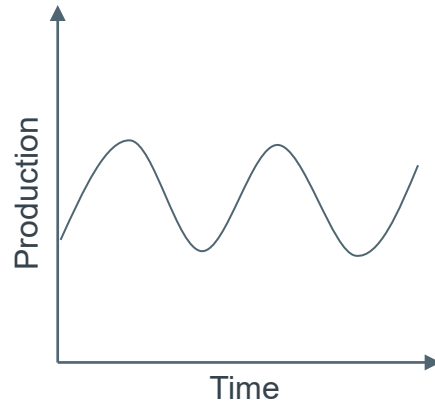


**CHALMERS**

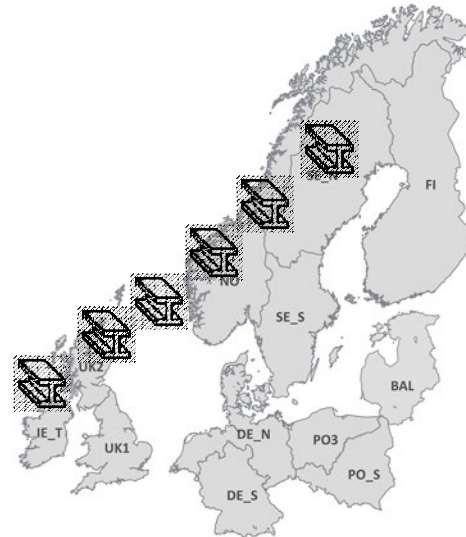
# Flexibility options



Flexibility in time



Flexibility in location



Iron ore  
HBI  
Steel

PRODUCTION OF IRON ORE PRODUCTS, Mt					
	2017	2016	2015	2014	2013
Northern Division <sup>1</sup>	16.0	15.2	13.8	-	-
Southern Division <sup>1</sup>	11.2	11.7	10.7	-	-
<b>Total</b>	<b>27.2</b>	<b>26.9</b>	<b>24.5</b>	<b>25.7</b>	<b>25.3</b>
Of which pellets	24.6	24.0	22.2	23.2	23.1
Of which fines	2.6	2.9	2.3	2.5	2.2

# Results: Electricity trade

