New horizons - Decarbonisation within the steel industry for a sustainable future

K1 MET
metallurgical competence center

Coordinated by

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tirol Standortagentur

Partner of UAR INNOVATION NETWORK

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Das Land Steiermark

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upper austria

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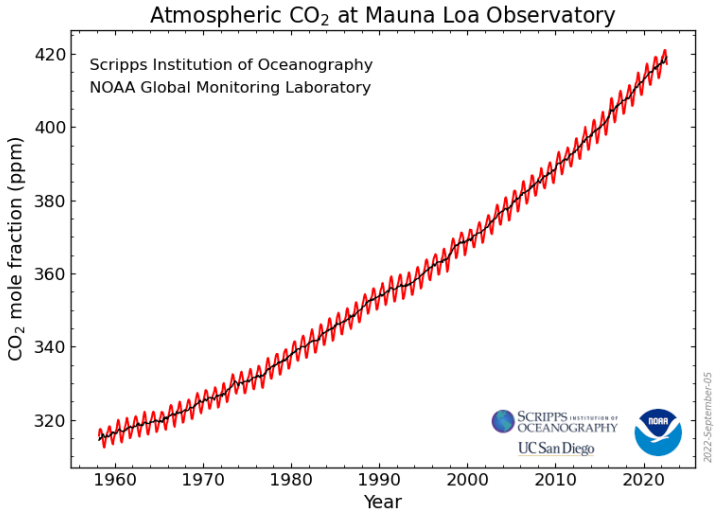
INTRODUCTION

CO_2 EMISSIONS AND AMBITIOUS TARGETS

CO_2 emissions

Concentration trends in the atmosphere

Mauna Loa (Hawaii) holds the longest continuous record of direct atmospheric CO_2 measurements



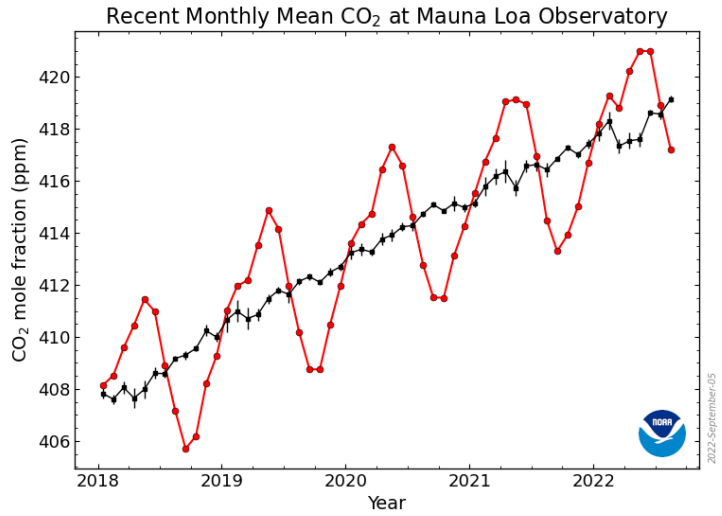
CO_2 measurements (started in 1958 by Charles David Keeling and Roger Revelle) clearly show the increasing use of fossil fuels

Full record of data

ATMOSPHERIC CO_2 MEASUREMENTS

Monthly average (last 5 years)

Annual CO_2 trends arise from the vegetation distribution on the earth's hemisphere and from the seasons



Reference: https://gml.noaa.gov/ccgg/trends/

Global temperature change

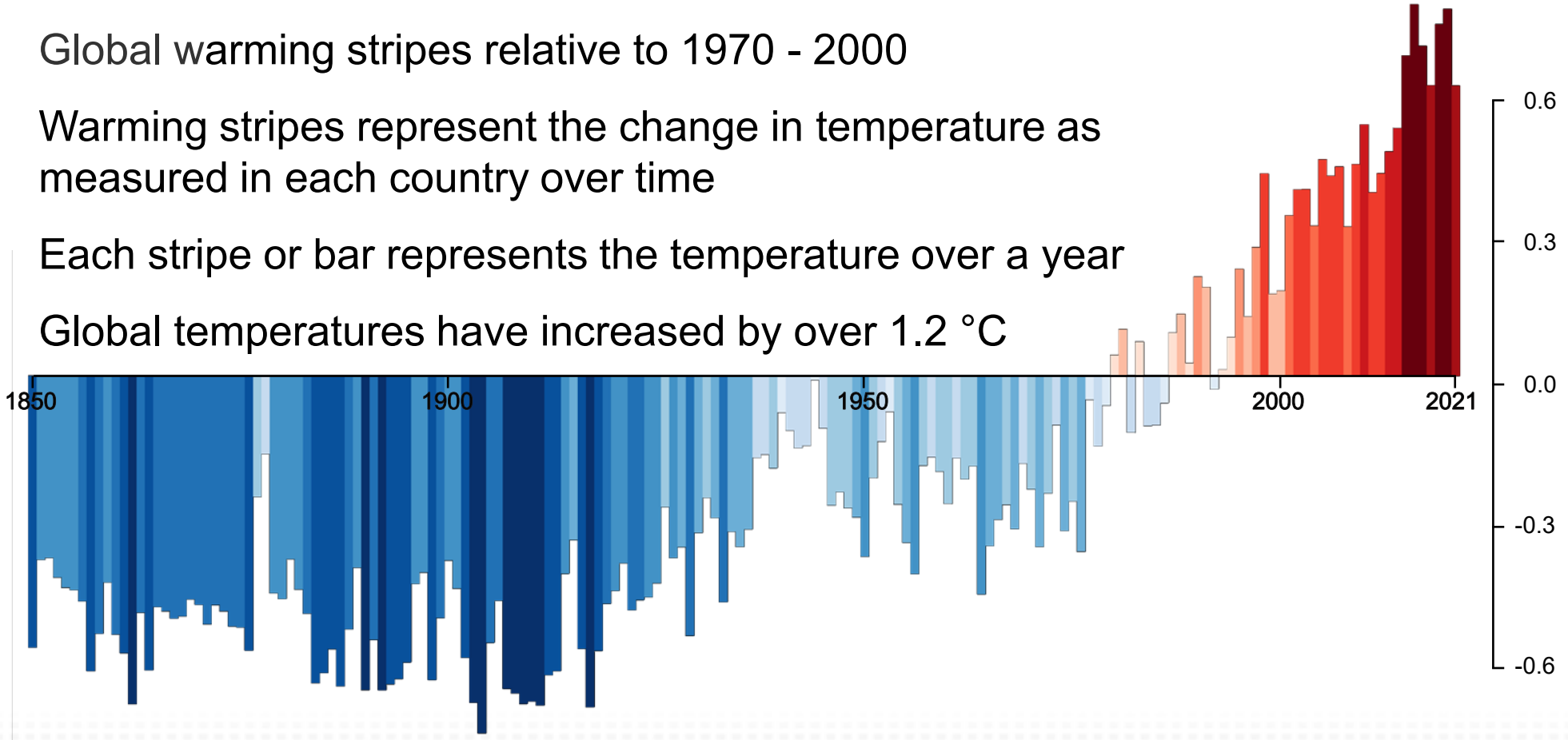
Warming strips

Global warming stripes relative to 1970 - 2000

Warming stripes represent the change in temperature as measured in each country over time

Each stripe or bar represents the temperature over a year

Global temperatures have increased by over 1.2 °C



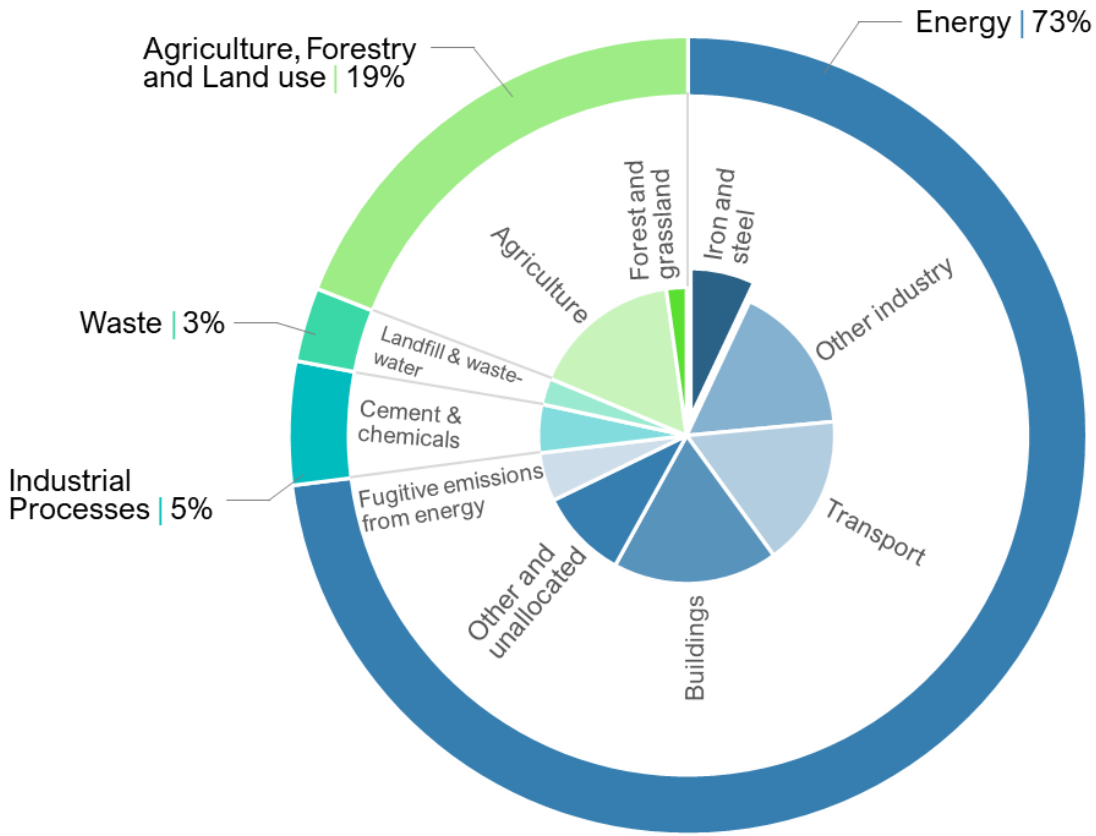
Reference: https://showyourstripes.info/; Professor Ed Hawkins (University of Reading)

Taking actions

Climate targets

Environmental and climate change regulation

- **Paris Agreement** (2015)
  Max. global temperature increase
  of 2.0 (+1.5) °C at 2100 compared
  to levels before industrialization
- **European Green Deal** (2019)
  Zero net emissions of greenhouse gases by 2050
- **Austrian government program** (2020)
  2030: 100% renewable electric energy
  2040: climate neutrality



Reference: missionpossiblepartnership.org/

Iron and steel industry

Steel production routes

Primary routes

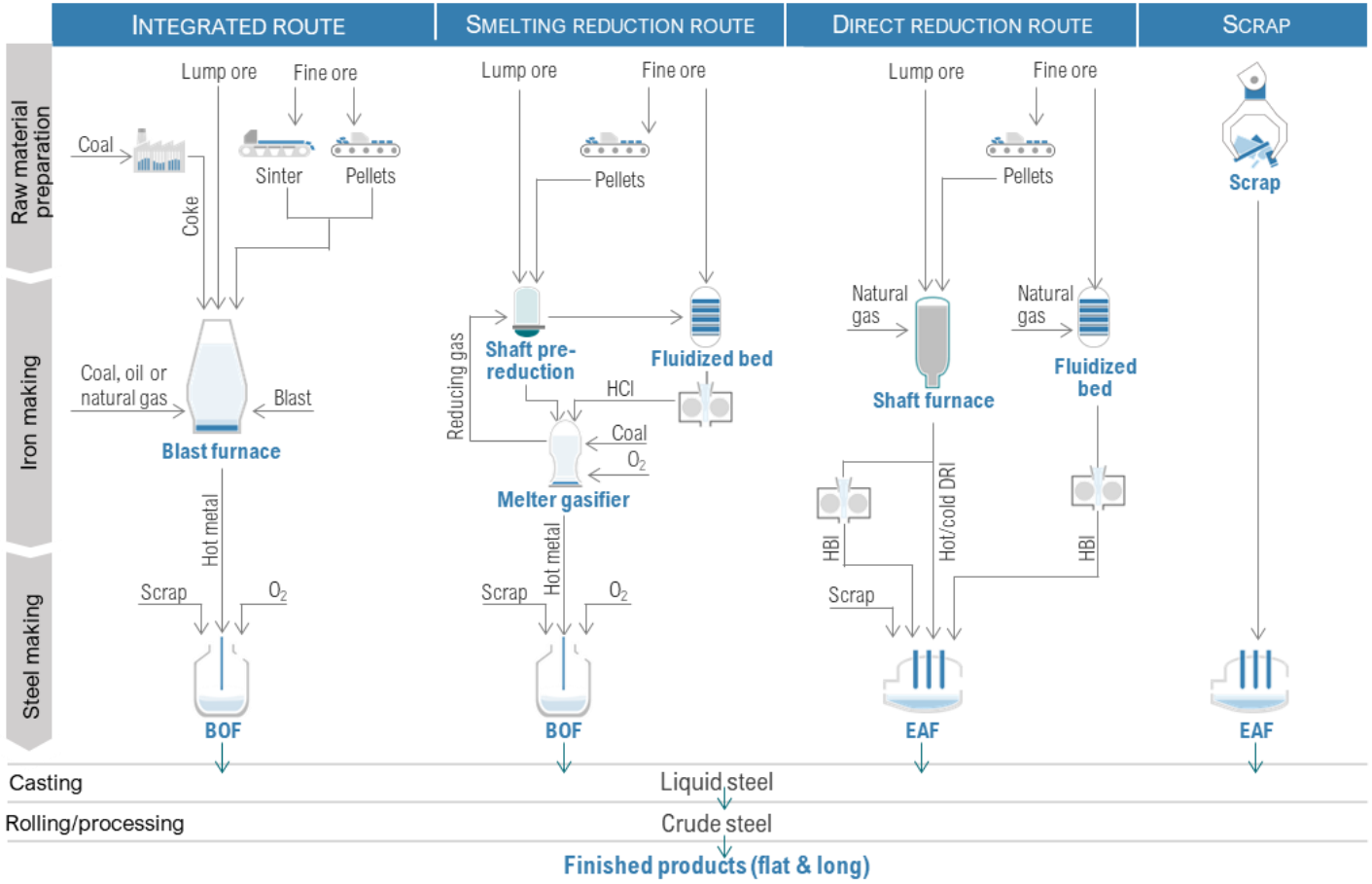
Conversion of iron ore into crude steel

- Blast furnace - basic oxygen furnace (BF-BOF)
- Smelting reduction - BOF
- Direct reduction - electric arc furnace (DR-EAF)
- Potential use of H_2 as reducing agent replacing natural gas

Secondary route

Recycling of iron and steel scrap

- EAF



Reference: Stahlinstitut VDEh

PATHWAYS TOWARDS CO_2 NEUTRAL STEELMAKING

CO_2 MITIGATION TECHNOLOGIES

CO_2 mitigation technologies

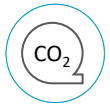
3 Pathways

SMART CARBON USAGE (+CCS)

Process modifications designed to be integrated in conventional steel plants

Process integration

- Iron bath reactor smelting reduction
- Gas injection into the blast furnace
- Alternative carbon sources
- Increased scrap usage



Carbon capture and usage

- Carbon oxide conversion

CO_2 mitigation technologies

3 Pathways

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Carbon Direct Avoidance

Production of steel from virgin iron ores without direct release of carbon emissions by replacing of current fossil fuels with renewable electricity or green hydrogen produced from renewable electricity

Hydrogen-based metallurgy

- Hydrogen-based direct reduction
- Hydrogen plasma smelting reduction

Electricity-based metallurgy

- Alkaline iron electrolysis
- Molten oxide electrolysis

CO_2 mitigation technologies

3 Pathways

Circular Economy

Circular economy as overlapping pathway focusing on increased material recovery from residues and scrap recycling

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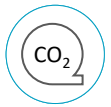

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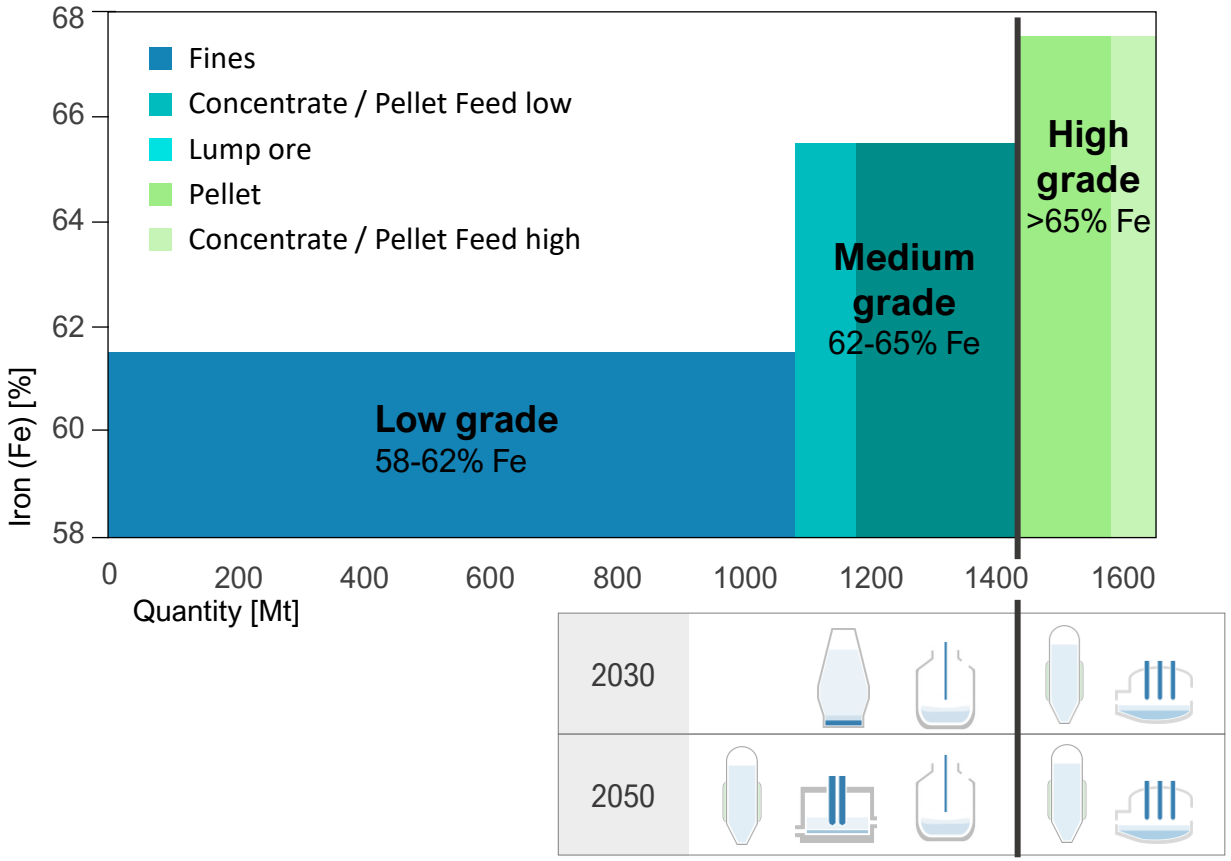
Sustainable steelmaking

Iron ore qualities

Global iron ore market is dominated by low and medium grade iron ores

The replacement of blast furnace – basic oxygen furnace process route (BF-BOF) by direct reduction – electric arc furnace (DR-EAF) process route requires development of an adapted metallurgical concept for steelmaking from low/medium grades

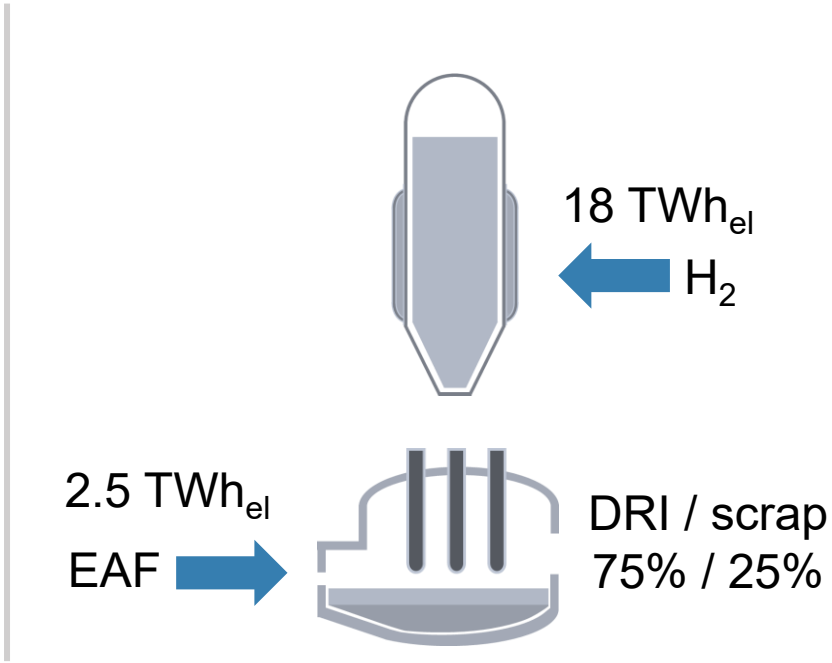


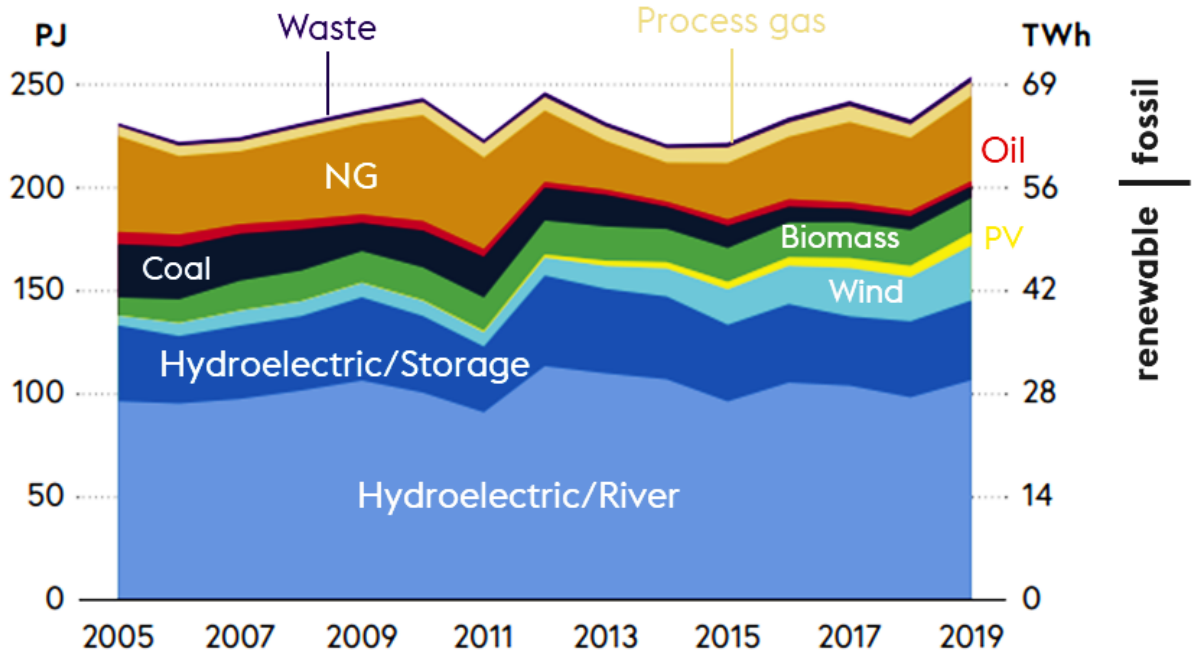
Reference: RtM (2021)

Transformation scenario

Electric energy production in Austria

Electric energy demand for 6.0 Mt steel/year





Downstream processes 7.5 TWh$_{el}$

Reference: https://www.bmk.gv.at/themen/energie/publikationen/zahlen.html

Hydrogen production

H2FUTURE

One of the biggest PEM electrolyser units in the world with 6 MW power and 1.200 m^3/h H_2 production at voestalpine Linz for full scale demonstration of H_2 production and grid balancing

- Ambitious efficiency target at nominal power
- W_{el} = 48 - 51 kWh/kg
- h_{System} = 82% - 77%

Dynamic response suitable for all kind of grid services

Breakthrough technology

Hydrogen plasma smelting reduction

SuSteel – Sustainable Steelmaking

- Direct steelmaking of iron ores with hydrogen plasma smelting reduction
- Avoidance of CO_2 emissions
- Testing facility at the Donawitz site in Styria

Demo plant is located at voestalpine Donawitz site

Partner

- voestalpine
- K1-MET
- Montanuniversität Leoben

Reference: voestalpine, K1-MET

Breakthrough technology

Hydrogen-based fine ore reduction

HYFOR – Hydrogen based fine ore reduction

- Direct reduction of magnetite/hematite iron ores in fluidized bed with hydrogen as main reducing gas (metallization degree of 97%)
- No agglomeration process required
- Pilot plant in Donawitz

Partner

- voestalpine
- Primetals Technologies
- Montanuniversität Leoben

Reference: voestalpine, Primetals

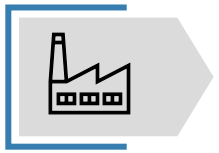
What's Next

Summary and Conclusion

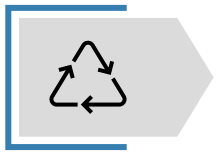
Roadmap towards climate neutral steelmaking

Summary and conclusion

Austria's steel industry is focusing to gradually increase the share of green electricity and green hydrogen in steel production in order to achieve climate-neutral and sustainable production by 2050



Hybrid technology with electric arc furnace process additional to blast furnace – direct reduction – basic oxygen furnace production at integrated sites until 2030



Up to 30% CO_2 reduction independent from green hydrogen and high potential for further CO_2 decrease as soon as green hydrogen is economical available

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Das Land Steiermark Wirtschaft, Tourismus, Regionen, Wissenschaft und Forschung

tirol Unser Land

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