Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

CLIMATE NEUTRALITY AUSTRIA 2040 – CONTRIBUTION OF THE AUSTRIAN INDUSTRY

Final presentation of the scientific supporting study

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ENERGIEVERBUNDTECHNIK

ENERGIE INSTITUT an der Johannes Kepler Universität Linz

AUSTRIAN ENERGY AGENCY

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CONTENT

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- Background & objectives
- The Austrian industry in detail: status quo and international benchmark
- Technical decarbonisation potential for the sectors
  - Iron & steel
  - Non-metallic minerals
- Transformation costs
- Conclusions

Background and objectives

OBJECTIVES

1. Analysis Status Quo: how green is the Austrian industry in international comparison?
2. Transformation: Support for Austrian companies in the development of innovative transformation technologies

Status Quo

- Classification
- CO_2 - Footprint of the industry, future technologies
- International benchmarks

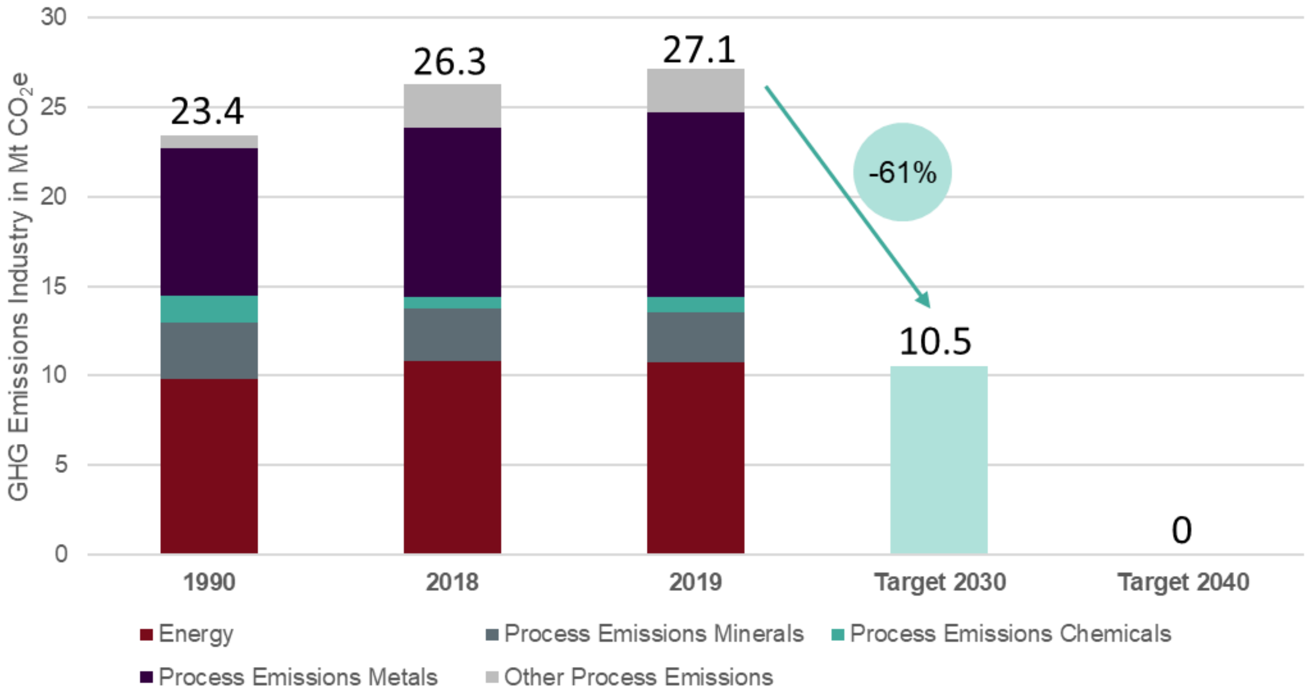
Austrian Industry 2040

Transformation

- Development of decarbonisation strategies
- Presentation of decarbonisation potentials
- Costs | Investments | Financing gaps

GOVERNMENT TARGET: CLIMATE NEUTRAL 2040

Target 2030: GHG-reduction -55 %



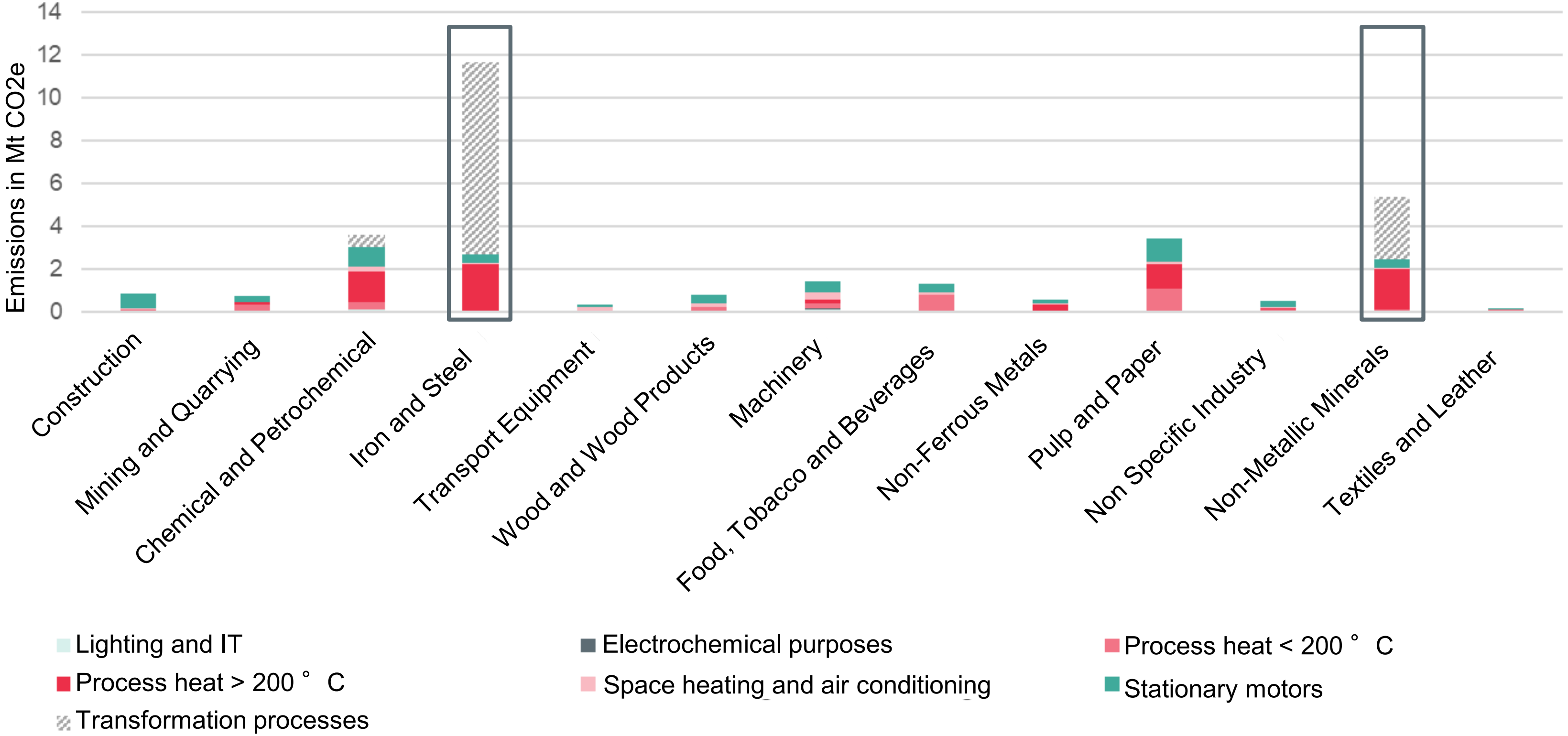
A reduction of 55% relative to 1990 corresponds to a reduction of 61% compared to 2019

Data sources: Umweltbundesamt, Austria‘s National Inventory Report 2021

The Austrian industry in detail: status quo and international benchmark

GHG-EMISSIONS OF THE AUSTRIAN INDUSTRY

Process-related emissions are responsible for a large share of emissions, followed by heat supply



Data sources: Statistik Austria Nutzenergieanalyse, own calculations; Data 2019

GHG-EMISSIONS OF THE AUSTRIAN INDUSTRY

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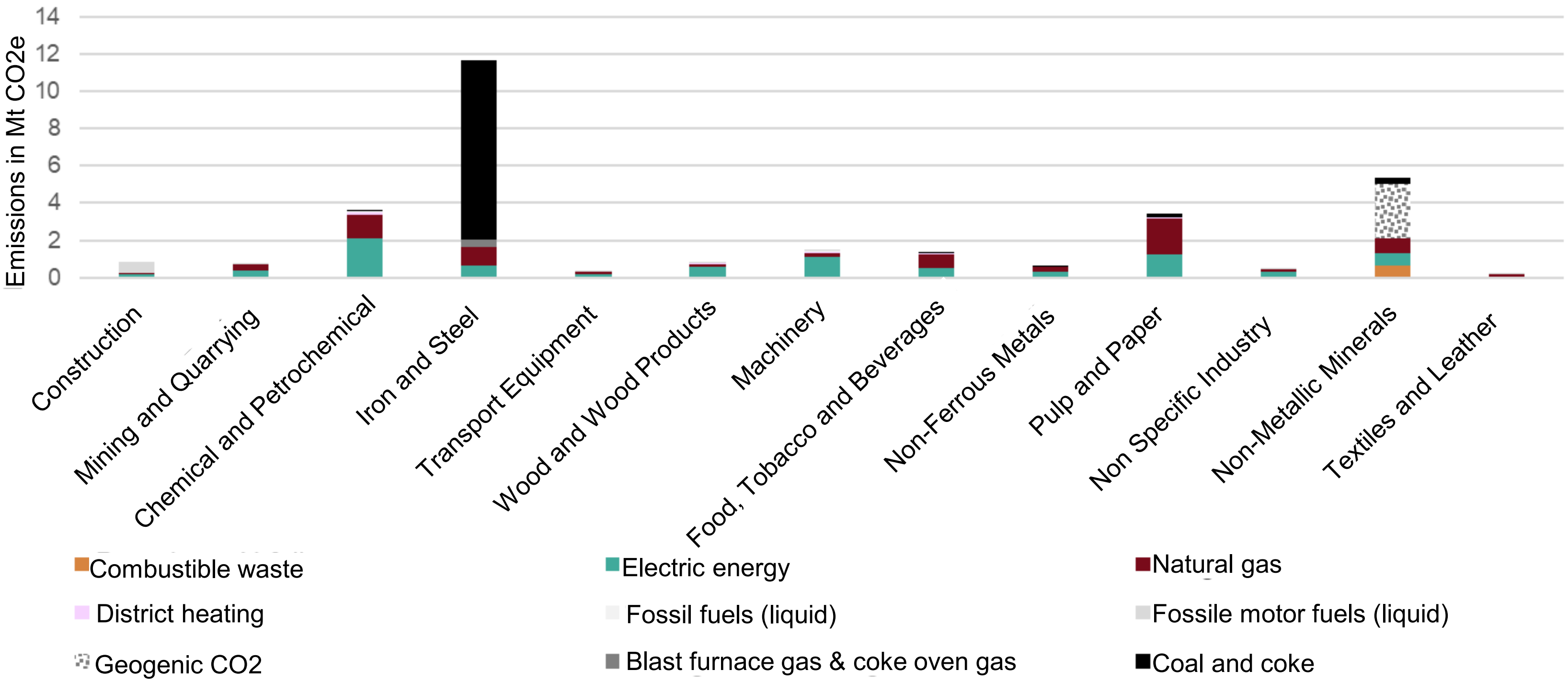
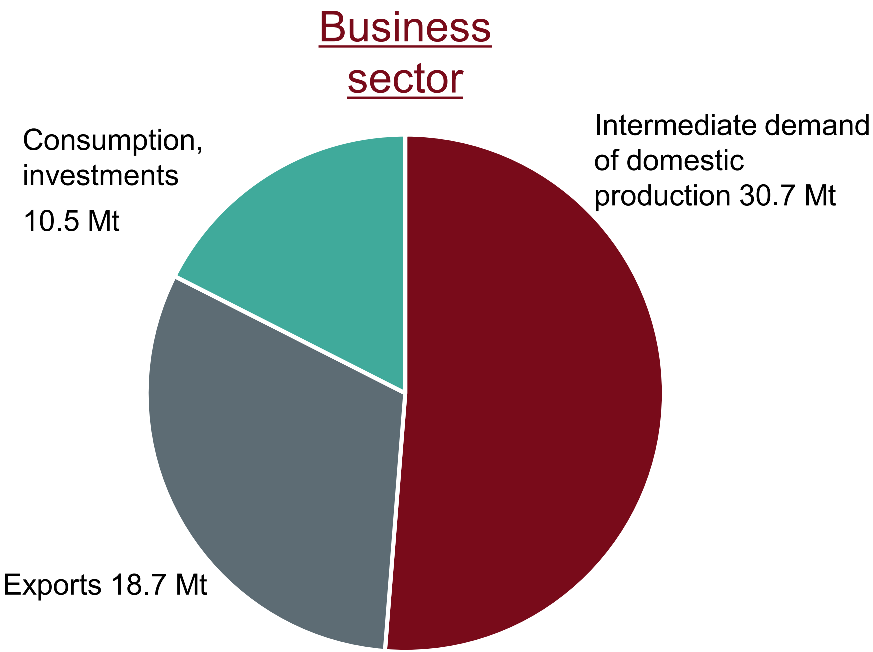
Most CO_2 is produced by burning coal, followed by electricity (indirectly) and natural gas

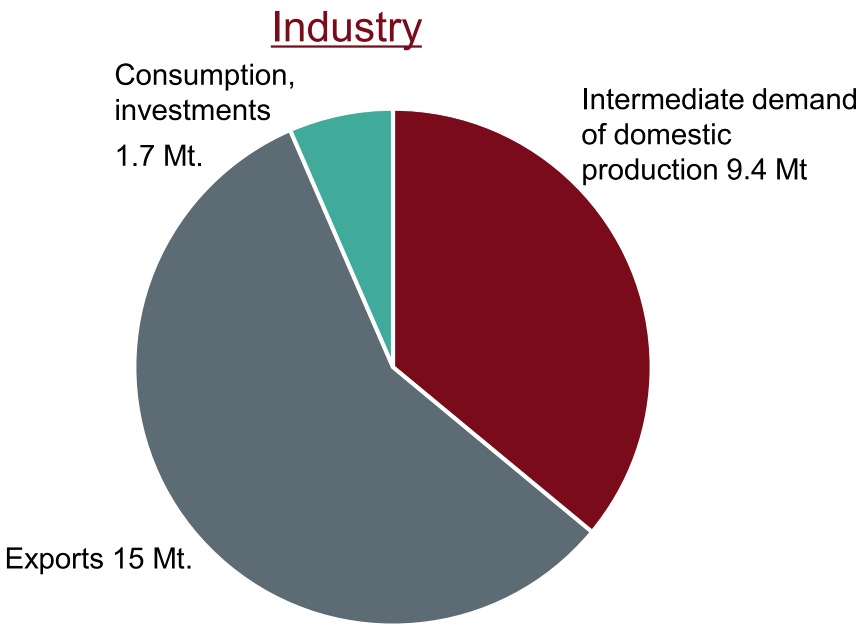


Data sources: Statistik Austria Nutzenergieanalyse, own calculations; Data 2019

WHERE DO THE EMISSIONS GO?

Strong link between domestic emissions and exports



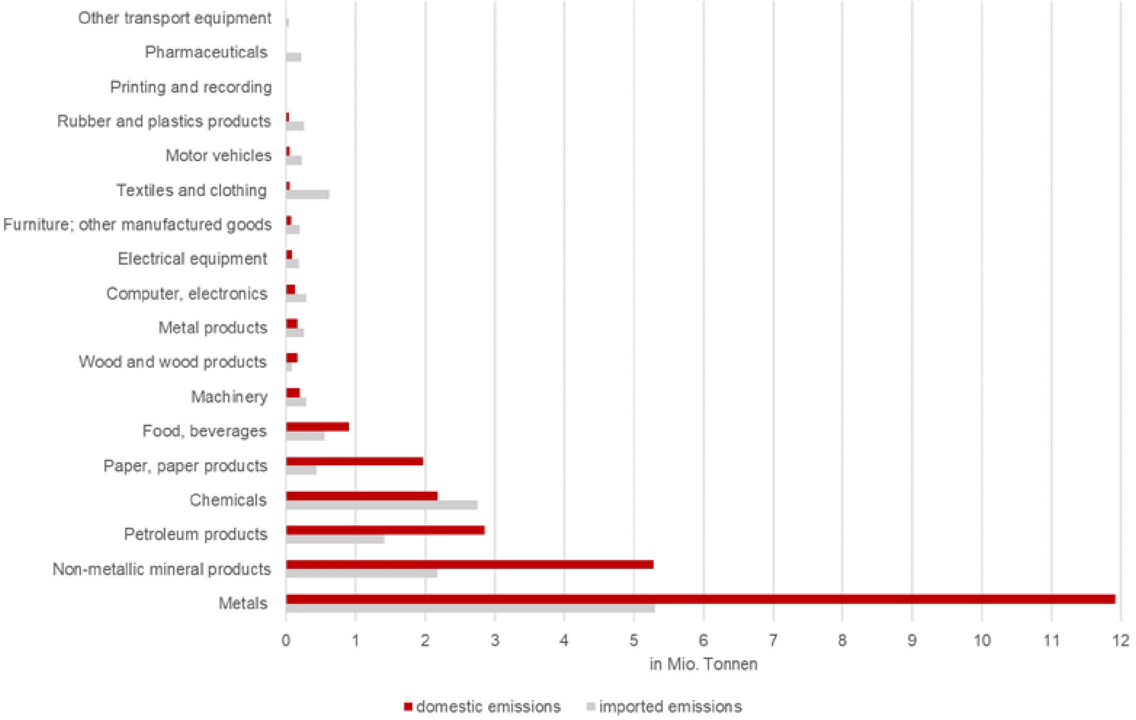


Quelle: EUROSTAT, Statistik Austria, own calculations

GHG-EMISSIONS EMBODIED IN IMPORTS

- Emissions embodied in imports can be estimated with import data and the emission intensity of the source industry in the source country.

- Emissions imported in manufacturing goods amount to 15.3 Mt.



Quelle: EUROSTAT, OECD, COMTRADE, eigene Berechnungen

INTERNATIONAL COMPARISON OF EMISSIONS INTENSITY

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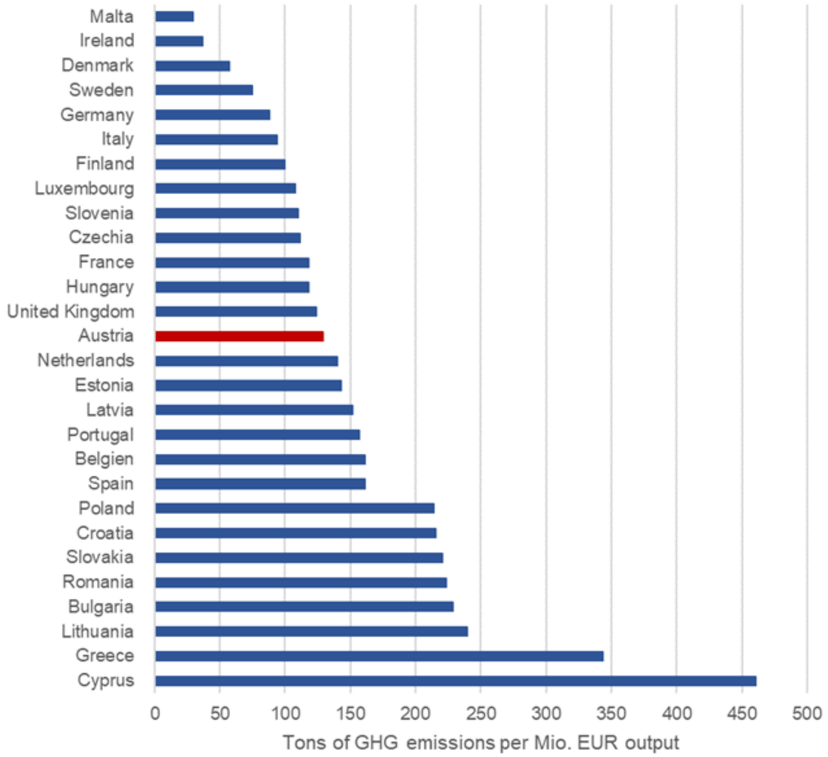
- Austria’s manufacturing sector reveals average emissions intensity compared to other EU member states.
- This is a result of Austria’s large basic materials industries
- Processes in primary production are mostly best technology according to international comparisons



Quelle: EUROSTAT, own calculations

SUMMARY STATUS QUO

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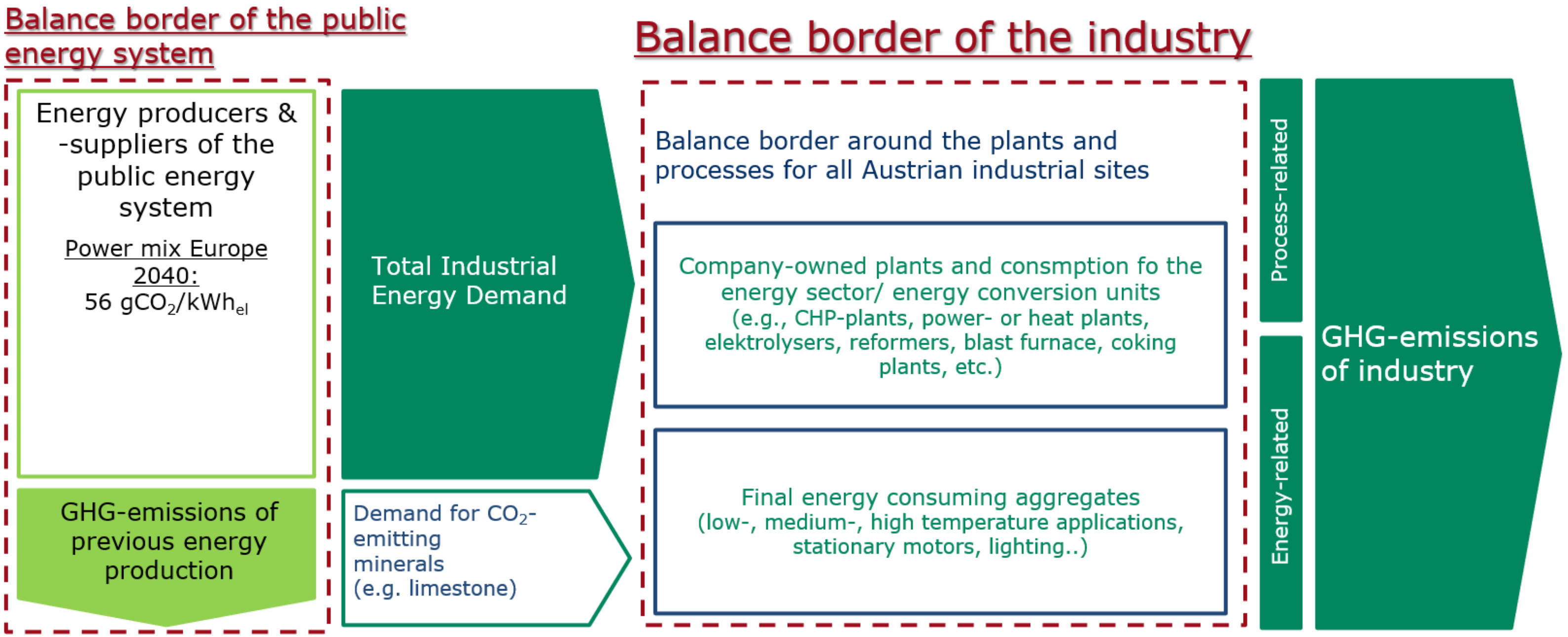
- GHG-Emissions should be reduced by **16.6 Mt** until **2030** and by **27.1 Mt** CO_2e until 2040.
- Large parts of the emissions are concentrated in the production of a few goods
- **Iron- & steel** production is by far the largest direct industrial emitter (~ 12 Mt), followed by **non-metallic minerals** (~ 5 Mt), chemical & petrochemical and pulp, paper & print.
- In a European comparison, AT is in the **midfield in terms of emissions per value added**, whereby the **industry structure has a significant influence** on comparisons here.
- While Austria imports15,3 Mt CO_2e via intermediate products, 15 Mt CO_2e of domestically generated emissions are exported via industrial goods.

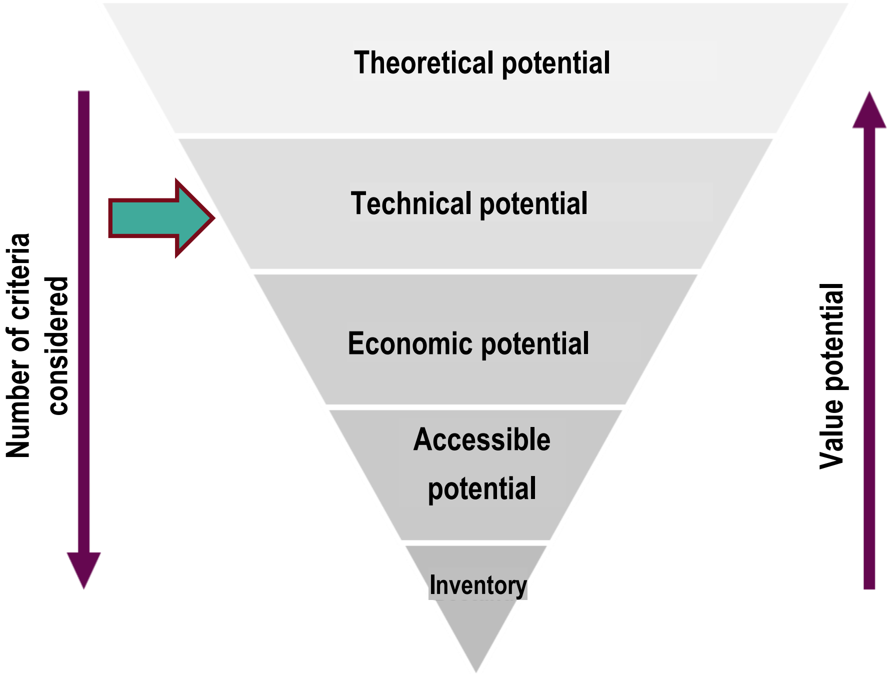
Technical decarbonisation potential

BALANCE BORDER OF THE INDUSTRY



DETERMINATION OF THE TECHNICAL DECARBONISATION POTENTIAL

- **Electrification**
  - Heat pumps
  - Stationary motors
- **CO_2-neutral Gas**
  - Hydrogen (from electrolysis or methane pyrolysis)
  - Bio-CH_4
- **Carbon Capture**
- **Circular economy**



IRON & STEEL

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Energy consumption & CO_2-emissions status quo (2018)

- ~6 Mt/a primary steel production (BF/BOF)
  - ~ 11 Mt CO_2e
  - Main driver: process-related emissions from reduction process (> 23 TWh coal & coke)

- ~1 Mt/a secondary steel production (electric arc furnace)
  - About half of the final energy use comes from natural gas

Data sources: Statistik Austria Nutzenergieanalyse, eigene Berechnung

IRON & STEEL
DECARBONISATION OPTIONS

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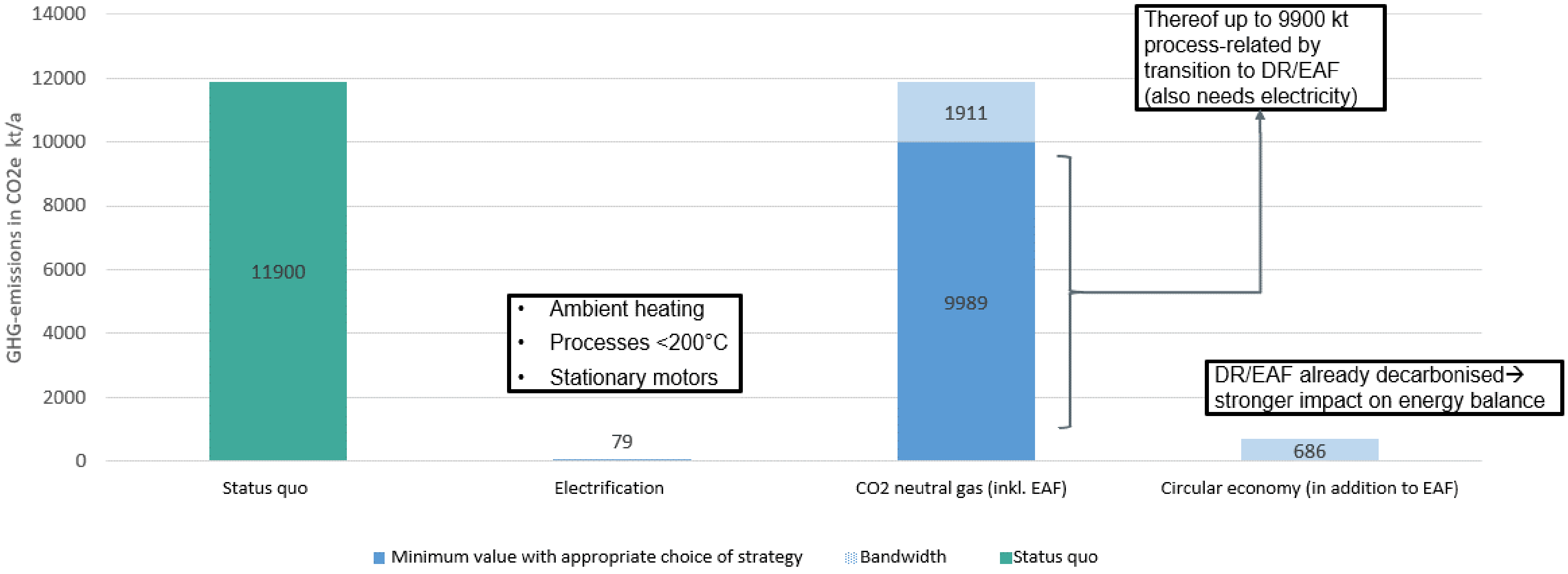
Decarbonisation strategy	Origin of emission		Technology	Scope of application
Electrification	*Energy-related emission*		Use of (high temperature) heat pumps	Ambient heating & cooling Process heat < 200 °C
	Energy-related emission		Electrification of stationary motors	Stationary motors
	In connection with DR route or increased use of scrap metal		Electric arc furnace (EAF)	Steel production in connection with scrap input and iron from direct reduction
CO_2-neutral Gas	***Process-related emission***		Direct reduction of iron ore with CO_2-neutral, green gas	Steel production in conjunction with electric arc furnace
	Energy-related emission		H_2 (from electrolysis or methane pyroloysis)	Ambient heating & cooling Process heat </> 200 °C
	Energy-related emission		H_2 (from methane pyroloysis)	Ambient heating & cooling Process heat </> 200 °C
	Energy-related emission		Bio-CH_4	Ambient heating & cooling Process heat </> 200 °C
Carbon Capture				
Circular Economy	***Process-related emission***		via electric arc furnace	Increased use of scrap in the EAF for steel production

Low transition effort *Medium transition effort* *High transition effort* *No option*

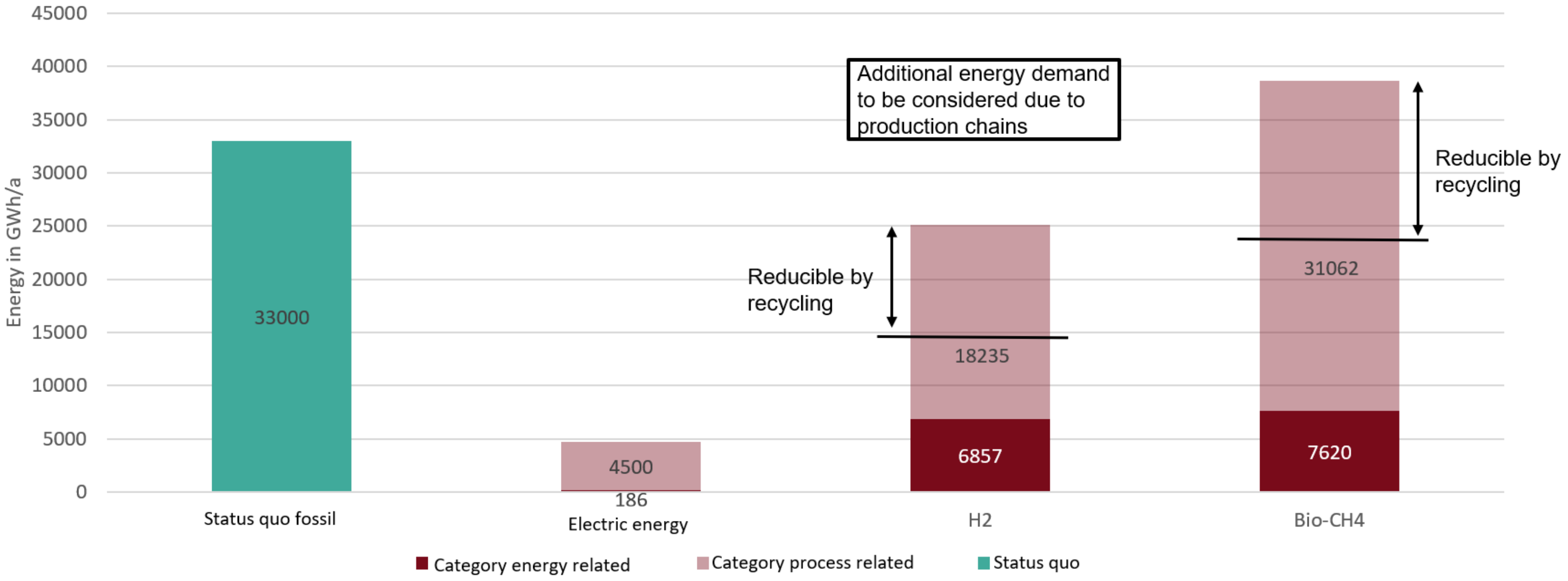
IRON & STEEL DECARBONISATION OPTIONS

Technical decarbonisation potential by decarbonisation strategy



IRON & STEEL DECARBONISATION OPTIONS

Possible change in the energy balance by energy source



SUMMARY IRON & STEEL

- Large savings potential due to process-related emissions
- By converting the blast furnace process to CO_2-neutral gases, around 10 Mt CO_2e can be avoided
- CO_2- and energy intensity of decarbonisation strategies and the effort required to establish them depend on upstream production chains
- Around half of the energy required for direct reduction could be saved through increased scrap recycling in the electric arc furnace

NON-METALLIC MINERALS

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Energy consumption & CO_2-emissions status quo (2018)

- GHG-emissions of the entire sector: 4 602 kt CO_2e
  - Thereof from minerals used (Expulsion process): 2 908 kt CO_2e (63 %)
  - Thereof energy-related: 1 694 kt CO_2e (37 %)

2018	**Cement**	**Lime**	**Magnesite**	**Glass**	**Bricks**	**Dolomite**	**Na_2CO_3**	**Sector Total**
Process-emissions in kt CO_2e	1 827	544	365	38	105	19	10	**2 908**
% pf sectoral process-emissions	63 %	19 %	13 %	1 %	4 %	<1 %	<0,5 %	**100 %**

Data source: Statistik Austria Nutzenergieanalyse, eigene Berechnung

NON-METALLIC MINERALS DECARBONISATION OPTIONS

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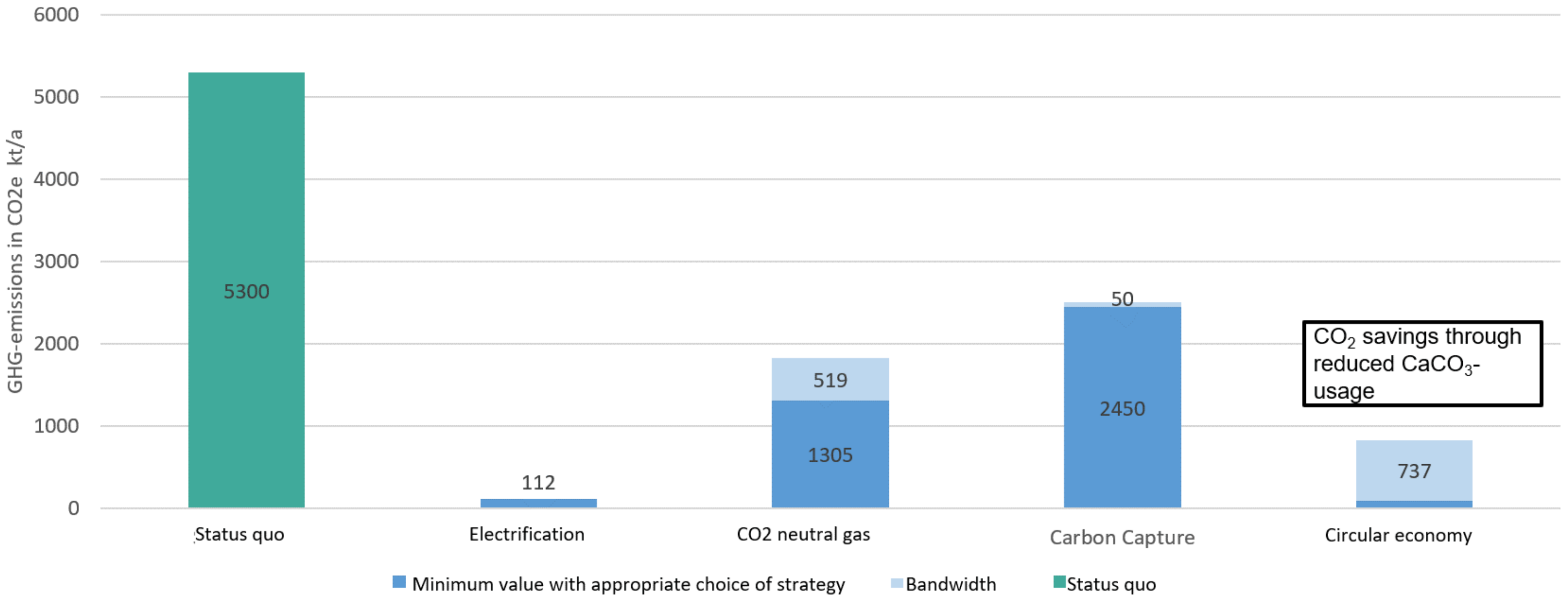
Decarbonisation strategy	Origin of emission		Technology	Scope of application
Electrification	***Energy-related emissions***	Medium	Use of (high temperature) heat pumps	Ambient heating & cooling Process heat < 200 °C
	Energy-related emissions	Medium	Electrification of stationary motors	Stationary motors
CO_2-neutral Gas	***Energy-related emissions***	Low	H_2 (from electrolysis)	Ambient heating & cooling Process heat </> 200 °C
	Energy-related emissions	Low	H_2 (from methane pyrolysis)	Ambient heating & cooling Process heat </> 200 °C
	Energy-related emissions	Low	Bio-CH_4	Ambient heating & cooling Process heat </> 200 °C
Carbon Capture	***Process-related emissions***	Medium	Oxyfuel combustion	Production process
	Process-related emissions	Low	Amine washing	Production process
Circular Economy	***Process-related emissions***	Low	Increased concrete recycling	Production process

Low transition effort *Medium transition effort* *High transition effort* *No option*

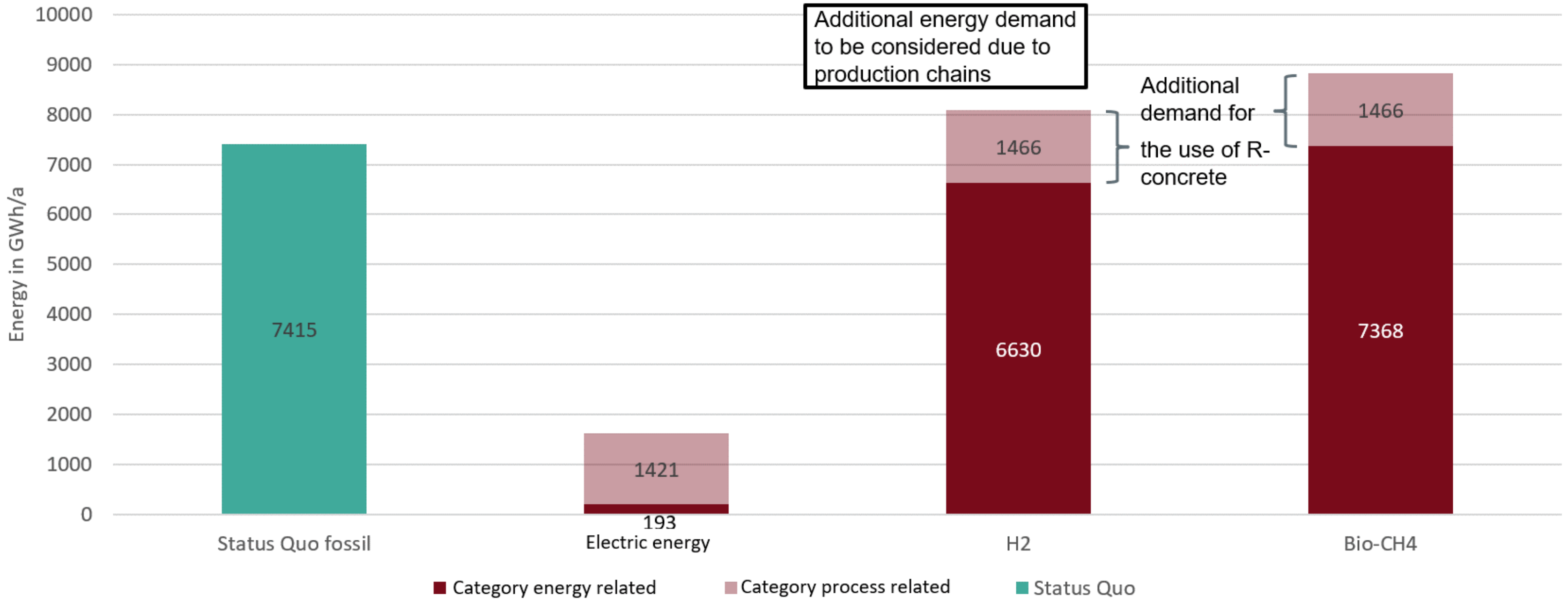
NON-METALLIC MINERALS DECARBONISATION OPTIONS

Technical decarbonisation potential by decarbonisation strategy



NON-METALLIC MINERALS DECARBONISATION OPTIONS

Possible change in the energy balance by energy source



SUMMARY NON-METALLIC MINERALS

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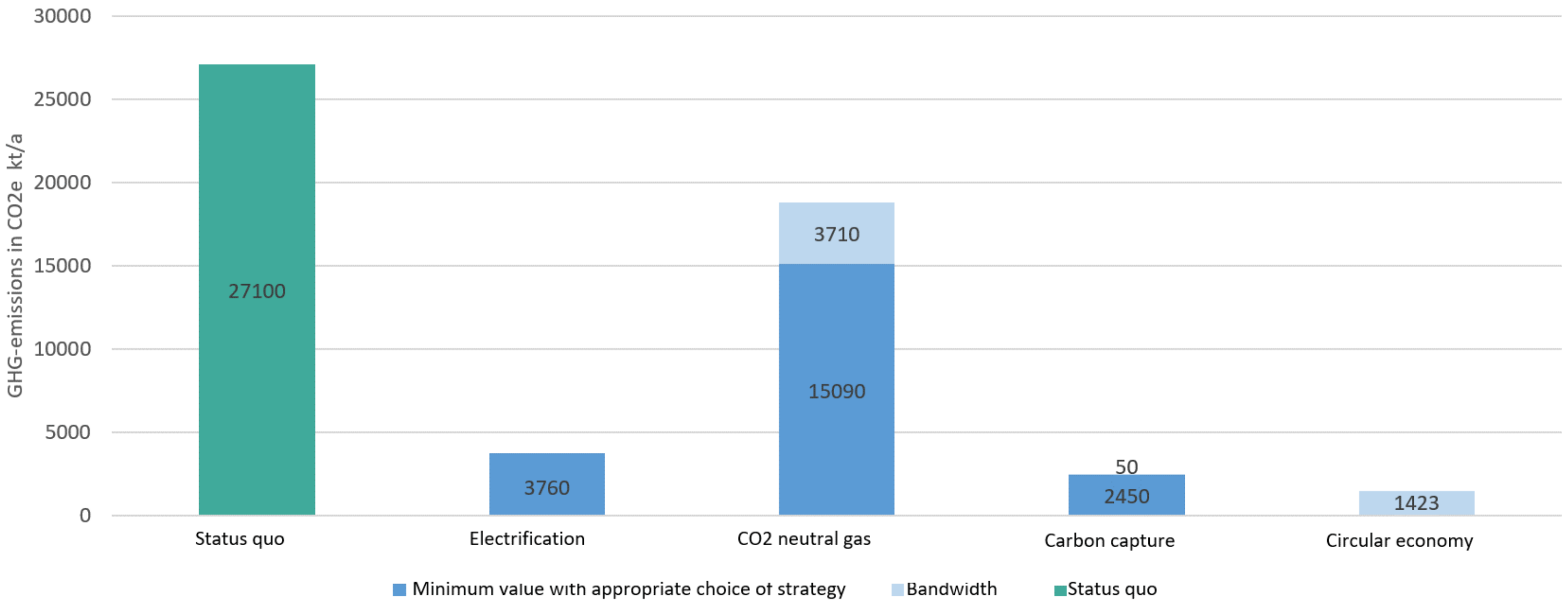
- Process-related emissions from the processing of the materials used cannot be avoided → CO_2-separation is necessary
  - Recycling of the captured CO_2 and the effort required to do so not considered
- GHG- and energy intensity of decarbonisation strategies and the effort required to establish them depend on upstream production chains

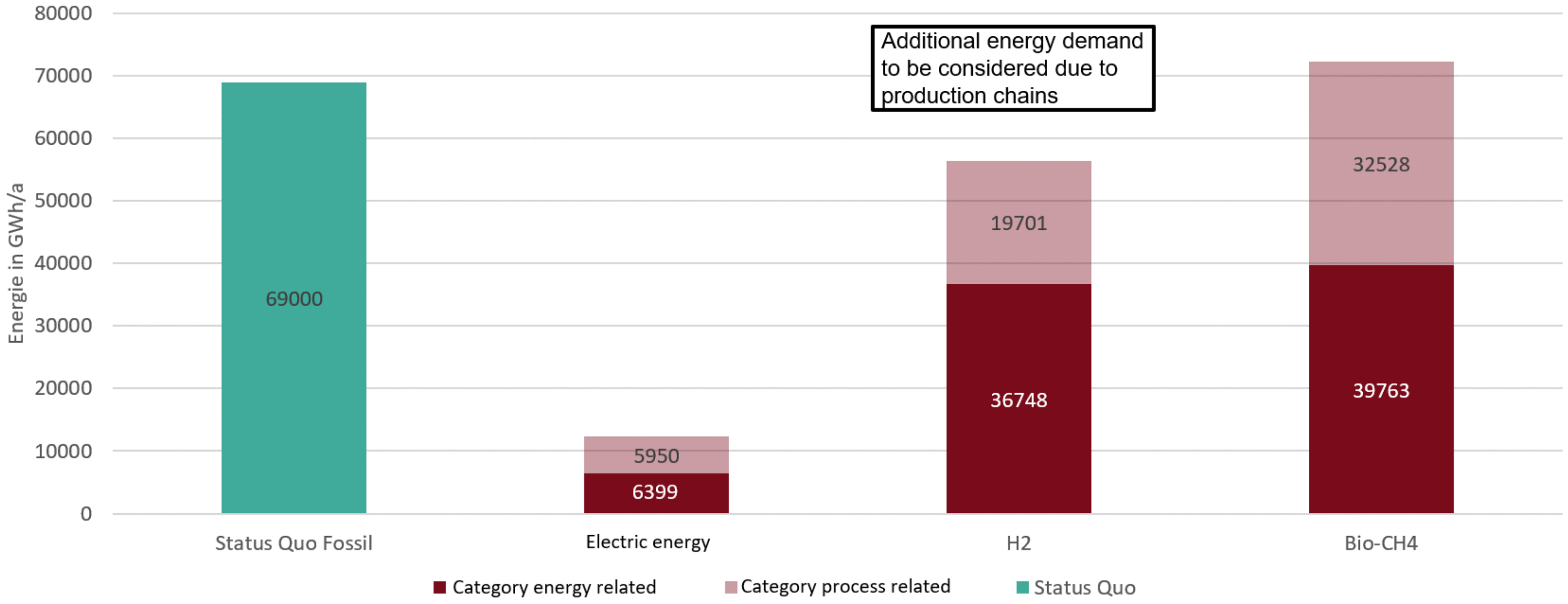
DECARBONISATION OPTIONS FOR AUSTRIAN INDUSTRY

Technical decarbonisation potential by decarbonisation strategy



DECARBONISATION OPTIONS FOR AUSTRIAN INDUSTRY

Possible change in the energy balance by energy source



SUMMARY DECARBONISATION OPTIONS

- Above all, the switch to CO_2-neutral gases as well as the use of carbon capture (in the sector non-metallic minerals) show a high technical decarbonisation potential
- **Electrification** (without electrolysis) allows a saving of up to 3,8 Mt.
- **CO_2-neutral gases** potentially save ~ 18 Mt
- **Circular economy** can reduce energy intensity in primary steel production by up to 10 TWh. In the cement industry, on the other hand, it primarily contributes to a GHG reduction through lower raw material use.
- **CCU** of process-related emissions in the minerals sector enables a reduction of approx. 2.4 Mt
- Consideration of the required upstream chains in the provision of CO_2-neutral gases and further use of the captured CO_2

Transformation costs

FRAMEWORK FOR THE ASSESSMENT OF COSTS

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- Scope of this study
  - Assessment of investments needed
  - No comparative analysis of total costs (incl. OPEX)
- Numbers give orientation of the **investment costs** associated with certain technical decarbonisation options in the industrial sector
- Investment costs of decarbonisation options cannot be added → consistent with analysis of technical decarbonisation potential
- Comparative assessment of total costs (including consistent assessment of OPEX) requires additional detailed analysis that includes
  - economic scenarios and
  - the involvement of relevant stakeholders (e.g. identification of typical investment cycles)

METHOD FOR THE DETERMINATION OF TRANSFORMATION COSTS

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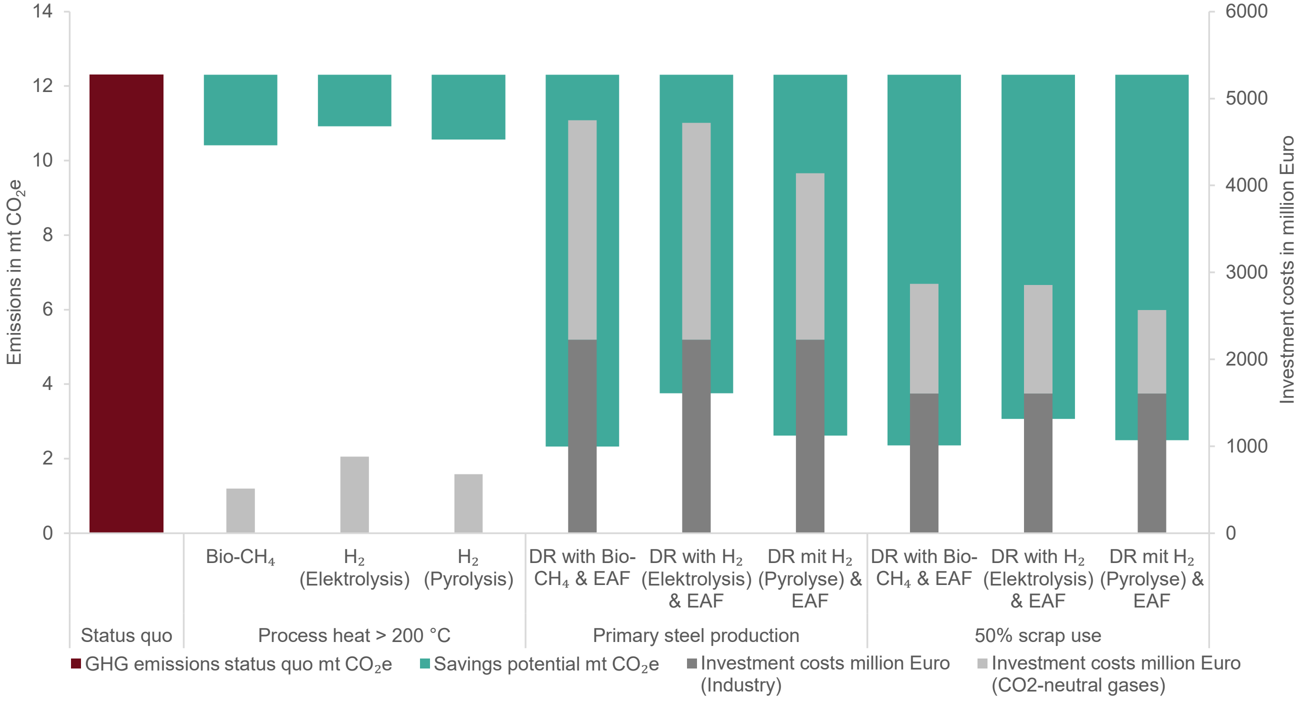
- Identification of costs based on existing literature
- No analysis of cost effectiveness
- Specific total costs (€/ton CO_2 reduced) are mentioned but not compared with each other due to different methods and assumptions in existing literature
- Concentration on direct investment costs
  - Represent immediate need for capital
  - Comparable between different sources
  - OPEX are not analysed ➔ task for future analyses
- Calculation of specific investment costs (per energy unit or product)
- Based on energy demand or production identified: Calculation of total investment costs until 2040 (including investment costs for the production of CO_2-neutral gases)

REFERENCE DATA FOR COSTS

- Challenge: No single source for the costs of all decarbonisation options: combination of different sources necessary
- Approach: As far as possible same source within a sector or within a family of measures and verification/plausibility check with other measures
- Main sources used
  - Klimaneutrale Industrie, Schlüsseltechnologien und Politikoptionen für Stahl, Chemie und Zement. Agora Energiewende.
  - Klimapfade für Deutschland. Boston Consulting Group und Prognos.
  - Net-Zero Europe, Decarbonization pathways and socioeconomic implications. McKinsey & Company.
  - Industrial Transformation 2050, Pathways to Net-Zero Emissions from EU Heavy Industry. Material Economics.
  - CEMCAP comparative techno-economic analysis of CO_2 capture in cement plants. CEMCAP Projekt
  - Roadmap Chemie, Auf dem Weg zu einer treibhausgasneutralen chemischen Industrie in Deutschland. Dechema, Futurecamp
  - Erneuerbare Prozesswärme, Integration von Solarthermie und Wärmepumpen in industrielle Prozesse. AIT et al
  - IEA G20 Hydrogen report: Assumptions. International Energy Agency
  - Closed Loop Economy: the Case of Concrete in the Netherlands. Universiteit Leiden & TU Delft

INVESTMENT COSTS IRON AND STEEL



- Main share of total investment costs for reduction of process related GHG
- Process related GHG: Approximately 50% of investment costs for the modification of the process and 50% for the production of reducing agents (CO_2-neutral gases)

INVESTMENT COSTS NON-METALLIC MINERALS

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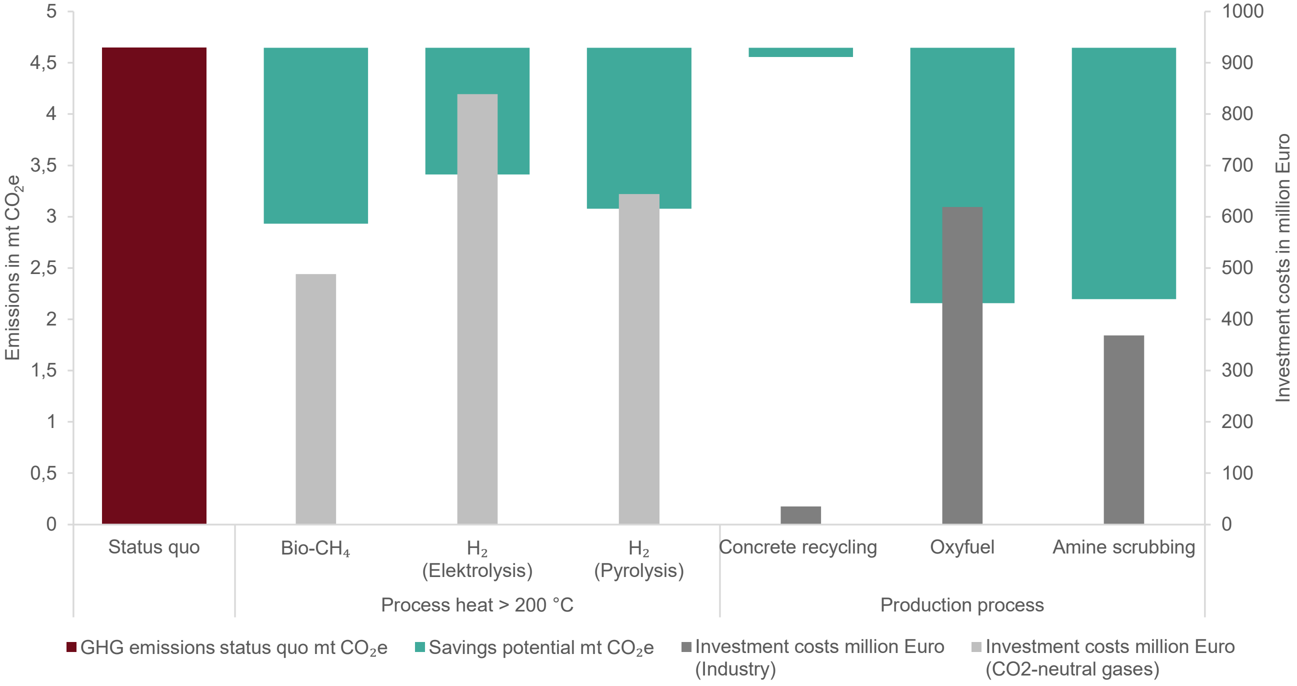
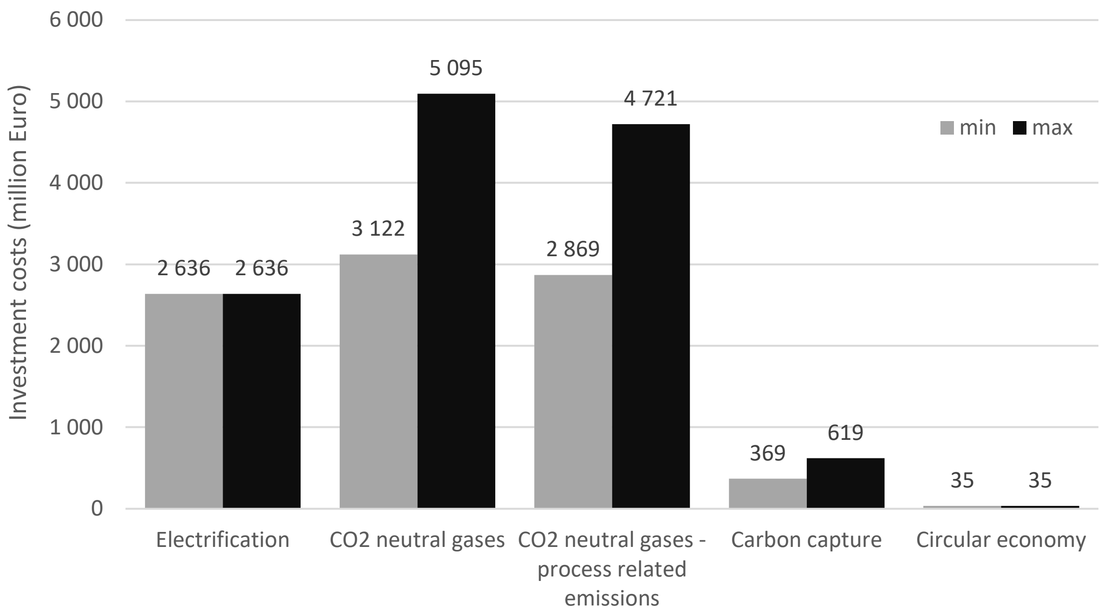


Fuel switch in process heat > 200° C triggers highest investment costs in the sector – provided the costs for the production of CO_2-neutral gases arise in the industrial sector.

OVERVIEW OF TRANSFORMATION COSTS

Large variation of investment costs for CO_2-neutral gas and for the reduction of process related emissions.



SUMMARY INVESTMENT COSTS

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- Total investment costs of the decarbonisation options analysed lie between 5.6 and 11.2 billion Euro (excl. OPEX) depending on the specific technologies chosen
- More than half of the 11.2 billion Euro are investment costs for the production of hydrogen
- Almost half of the 11.2 billion Euro arise in the steel sector (incl. investment costs for hydrogen production)
- Assessment of total costs (incl. OPEX) as well as the optimal combination of technologies and measures require further analyses which were not part of this study

Conclusions

CONCLUSIONS

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- The decarbonisation of Austrian industry is possible with the help of various technologies based on the strategies of *electrification*, use of *CO_2-neutral gases*, *carbon capture* and *circular economy* outlined in the study.
- Minimising process-related emissions is the biggest lever on the pathway to decarbonisation.
- Implementation requires a wholistic system analysis and measures derived from it that consider the challenges of the sectors in terms of energy and resource management, processes and spatial planning.
- Carbon capture technologies need to consider further usage or storage technologies
- A macroeconomic analysis of transformation costs requires further research

THANK YOU!

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