Residual Emissions in the EU-ETS1 Sectors

Developing an estimate of residual emissions in 2040 and 2050



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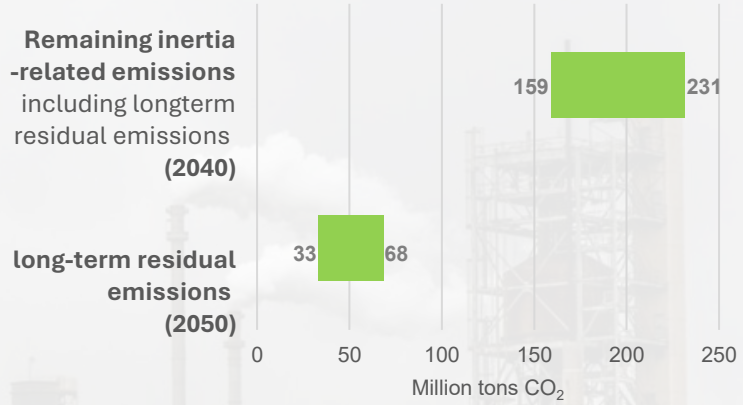
Study results at a glance

What could be the scale of residual emissions consistent with technological abatement potentials and ambitious decarbonisation pathways in the EU-ETS1?

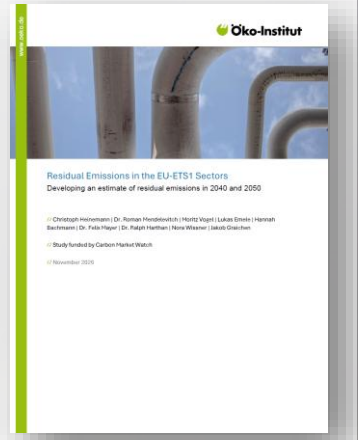
Long-term residual emissions 2050
- 33 to 68 Mt

Inertia-related emissions 2040
- 159 to 231 Mt

* Due to ramp up of new technologies and infrastructure
* Due to inertia in transforming existing installations



Publication available today



Sectors with highest emissions in 2050:

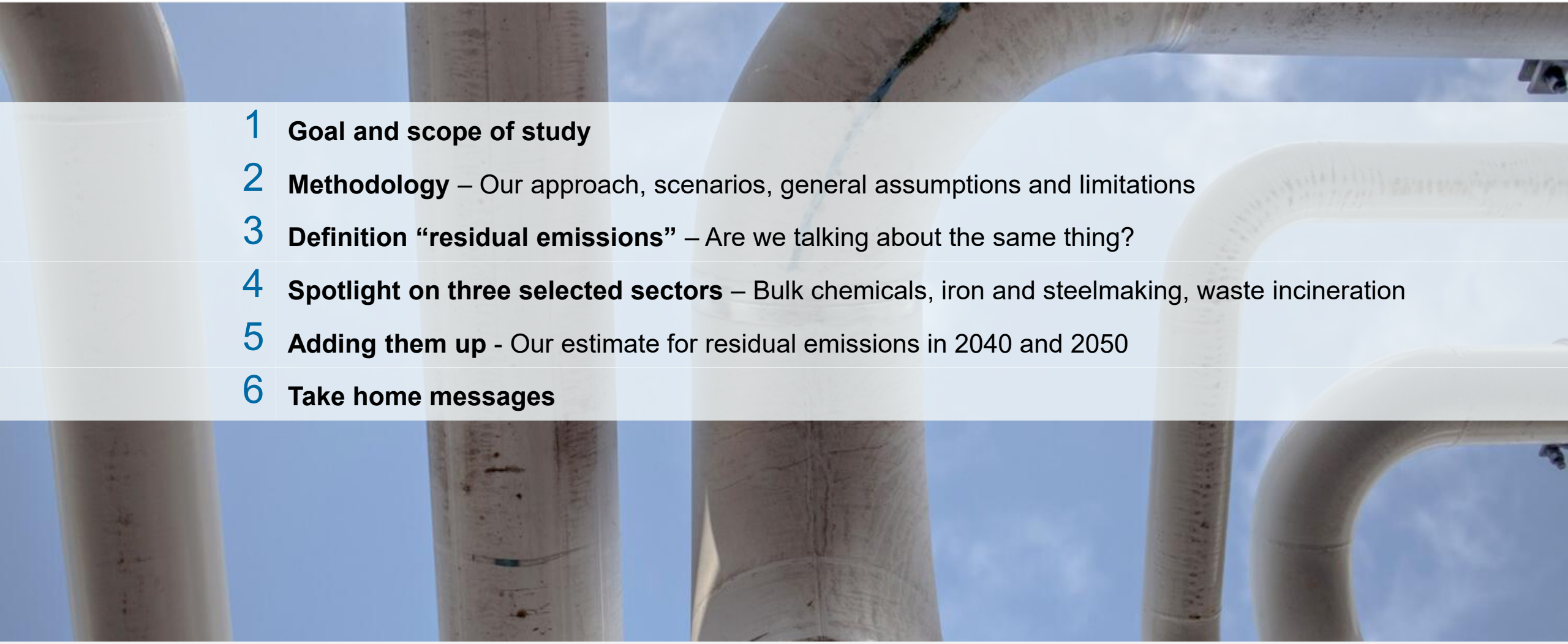
- ✓ Waste incineration
- ✓ Iron and steel
- ✓ Cement

Why are any emissions remaining in 2050?

- ✓ CO_2 that is not captured due to effective capture rate
- ✓ Installations that are assumed to be too small for CCS
- ✓ Consumption and burn-off of electrodes
- ✓ Required new technology is currently at a low TRL and might not be available in time

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Content



1. **Goal and scope of study**
2. **Methodology** – Our approach, scenarios, general assumptions and limitations
3. **Definition “residual emissions”** – Are we talking about the same thing?
4. **Spotlight on three selected sectors** – Bulk chemicals, iron and steelmaking, waste incineration
5. **Adding them up** - Our estimate for residual emissions in 2040 and 2050
6. **Take home messages**

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1 – Goal and scope of study

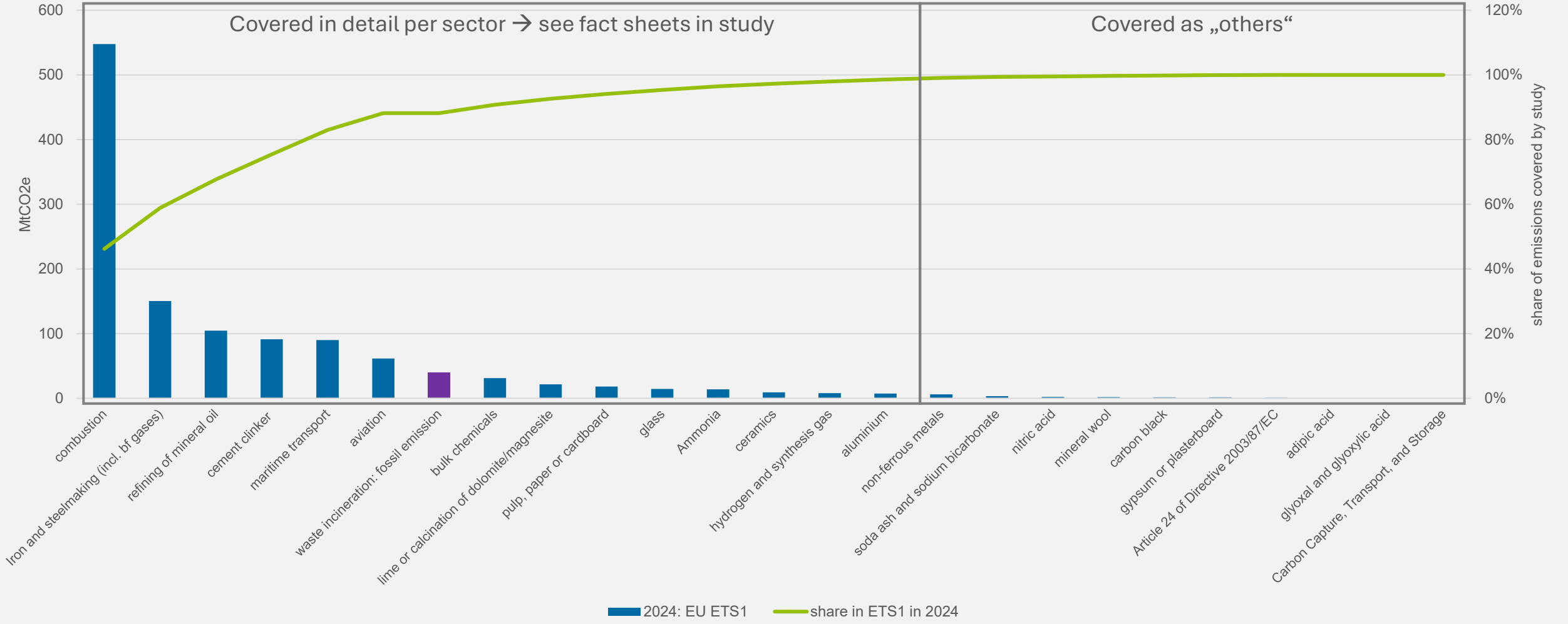


The goal of this study is to support the debate on residual emissions in the industries and sectors covered by EU-ETS1.

The main research question is:
What could be the scale of residual emissions consistent with technological abatement potentials and ambitious decarbonisation pathways?

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1 – Goal and scope of study: sector selection



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2 – Methodology: Approach and scenarios

Our approach: For each sector we **analyse current literature on transformation scenarios and technology roadmaps** and extract scenarios and assumptions that fit a medium- and a high-progress scenario.

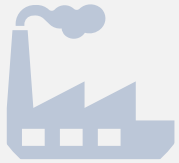
Medium-progress scenario	**High-progress scenario**
Based on existing scenarios from literature if available and authors' own assumptions to close data gaps	Based on existing scenarios from literature complemented with **additional assumptions for single parameters to reach minimal emissions** in 2040 and 2050
Central items of the story line per scenario	
✓ Increase or limited, demand-driven decrease of production volumes in many cases ✓ Medium availability of technologies, feedstocks and infrastructure connection taken from literature	✓ Reduction in product demand leading partly to lower production volumes for example due to increased use of alternative products and high product efficiency ✓ High availability of technologies, feedstocks and infrastructure connection

2 – Methodology: General assumptions to assess minimal emissions per sector



RES-E

Sufficient supply for electrification
Sufficient access to grid



CCS

- Effective capture rate: 85-90%
- Infrastructure access: >100kt CO2 in 2024



Production volumes

- No carbon leakage
- Only demand-driven changes



Circularity

- Literature-based potentials
- Take into account limitations due to volume and quality restrictions connected to recycled substances



Technology roll-out

- Literature-based assessment accounting for age structure of current installation fleet and TRL of transformation technologies
- No investment in fossil-based infrastructure where alternatives are available



Hydrogen

- Sufficient supply and access
- Checked resulting total demand against potential supply



Biomass

- No increase in share of biomass in specific energy or feedstock input
- Exception: aviation and maritime transportation, and bulk chemicals

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2 – Methodology: Limitations of our approach and potential next steps

No integrated modelling under consistent scenarios

- ✓ however, consistency created through
  - choice of decarbonisation scenarios and common set of general assumptions
  - checks on potential volume bottlenecks for biomass and hydrogen
- ❖ Potential next step: modelling consistent scenarios

No economic or site-specific assessment on the individual installation or industrial cluster level & no assessment on individual access to electricity, climate-neutral energy carriers or feedstock

- ✓ however, structural aspects included via use of proxies to assess decarbonisation speed and possibility for CCS connections
  - average fleet age
  - emission volume thresholds for CCS connection
- ❖ Potential next step: Analysis on installation level

No technology research beyond desk research

- ❖ Potential next step: Stakeholder involvement Interviews / discussions with other sector experts to substantiate the findings and identify crucial interdependencies or restrictions

3 – Definition of the term „residual emissions“

The term “residual emissions” is not defined consistently.

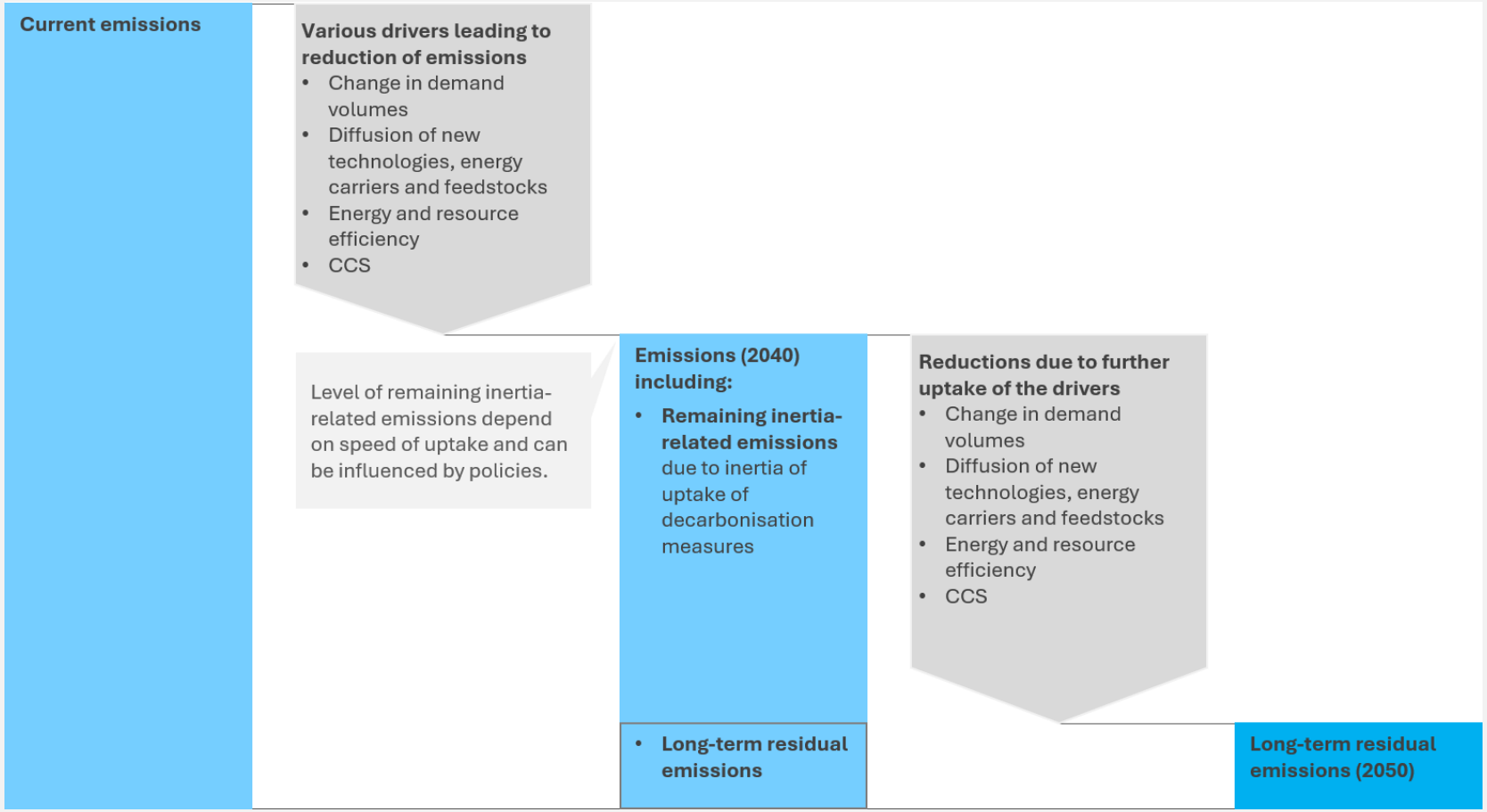
We differentiate between emissions that remain during the transformation process of the economy due to slow uptake:

✓ **Remaining inertia-related emissions**

and

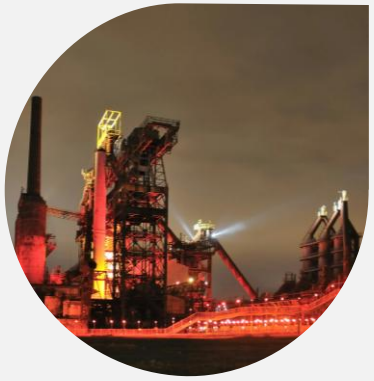
emissions that are expected to remain in the long term due to technical reasons:

✓ **Long-term residual emissions**



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4 – Spotlight on three selected sectors



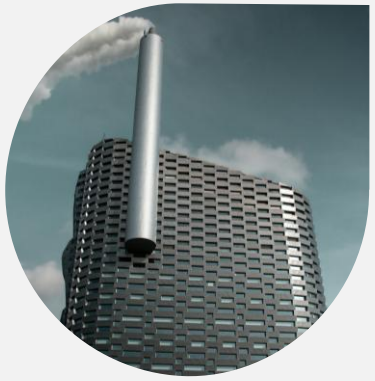
Iron & steelmaking

- Clear decarbonisation pathway
- Emissions from consumption of electrodes and other inputs
- Large amounts of hydrogen needed



Bulk chemicals

- Complete new production routes necessary
- New feedstocks
- Feedstocks are limited (hydrogen, biomass, CO2)



Waste incineration

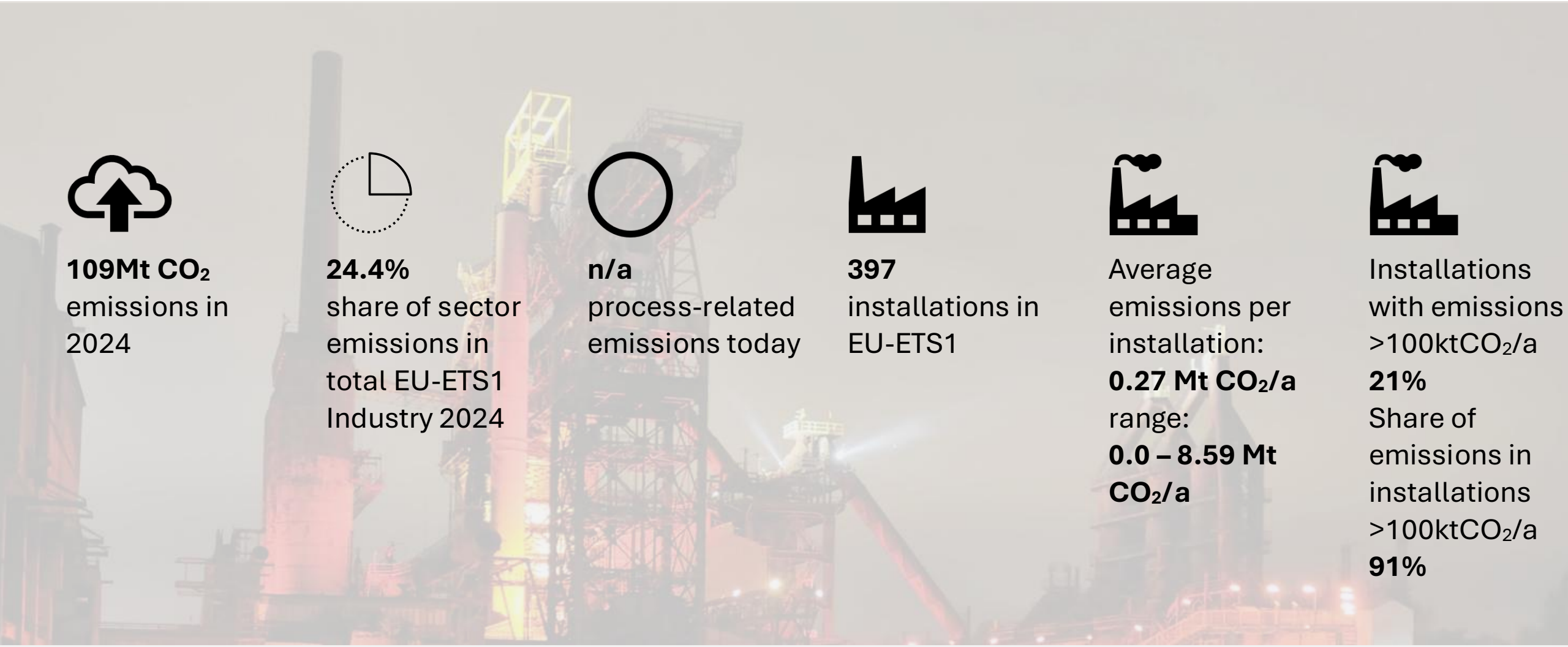
- Possibly largest residual emitting sector
- CCS necessary
- Different sizes of installations

Pictures: From left to right:
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4 – Spotlight on three selected sectors

Iron and steelmaking



109Mt CO_2
emissions in 2024

24.4%
share of sector emissions in total EU-ETS1 Industry 2024

n/a
process-related emissions today

397
installations in EU-ETS1

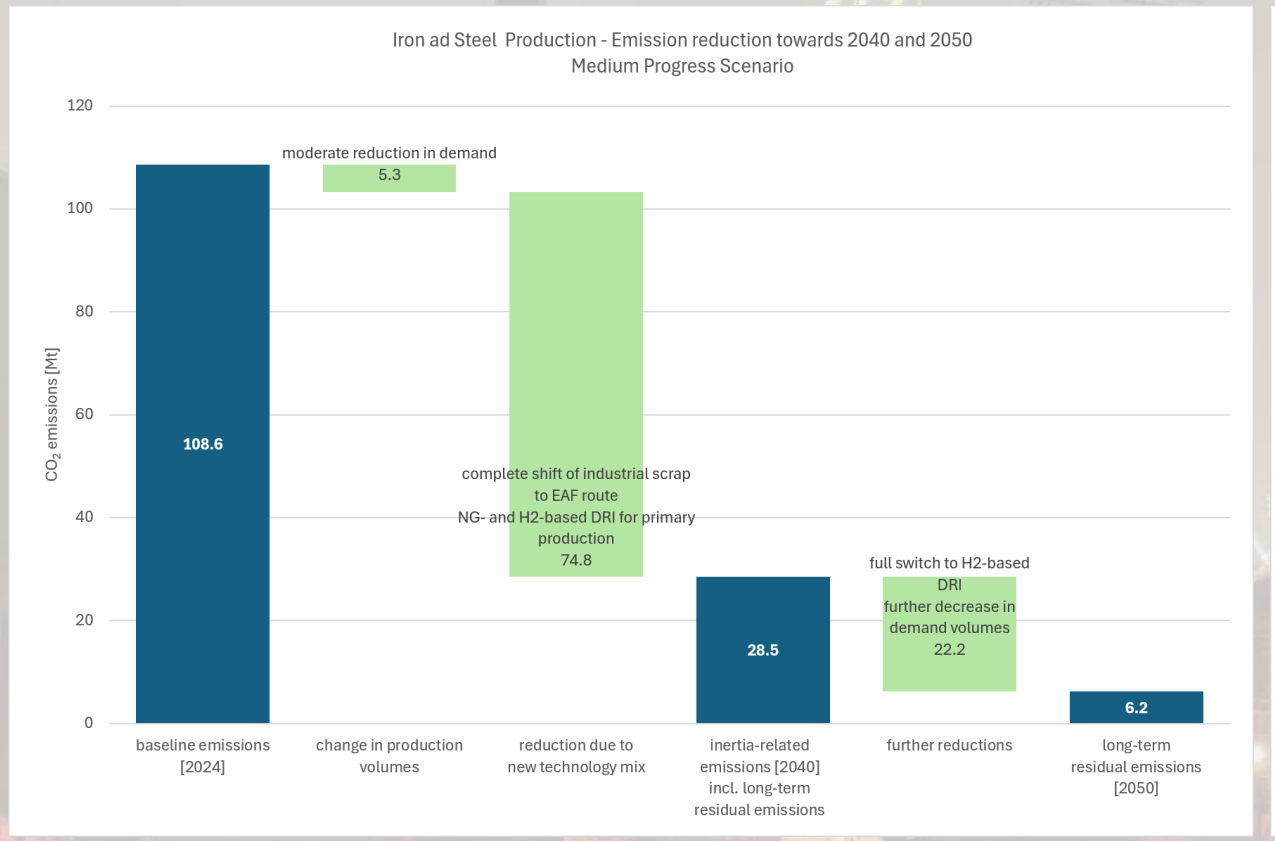
Average emissions per installation:
0.27 Mt CO_2/a
range:
0.0 – 8.59 Mt CO_2/a

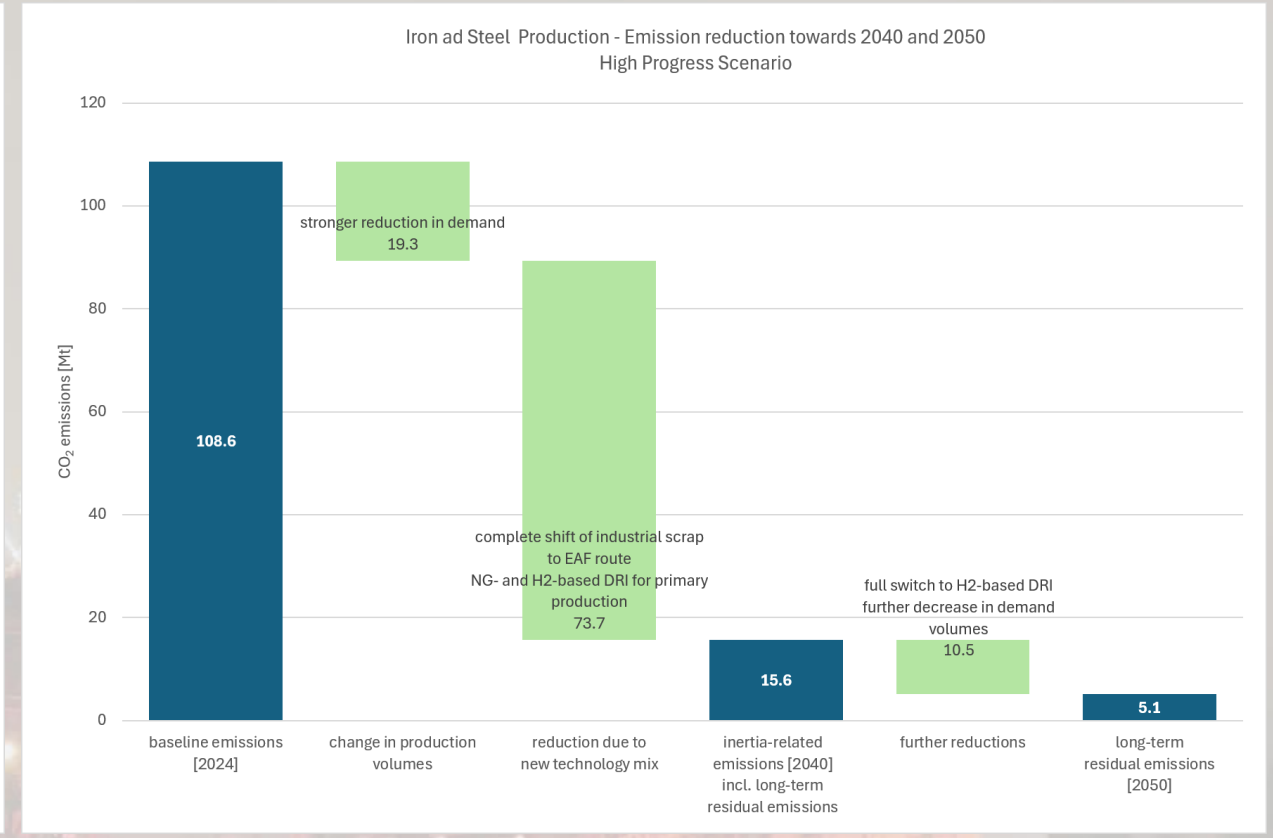
Installations with emissions >100ktCO_2/a
21%
Share of emissions in installations >100ktCO_2/a
91%

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4 – Spotlight on three selected sectors

Iron and steelmaking





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4 – Spotlight on three selected sectors
Iron and steelmaking

Major Requirements for deep decarbonization

Large-scale availability of low-cost renewable hydrogen

- ✓ Renewable energy uptake for renewable hydrogen production
- ✓ Investment in large-scale electrolysis capacities
- ✓ Investment in large-scale hydrogen transport infrastructure if relocation of current site shall be avoided

Large amounts of renewable electricity for the electric arc furnaces

4 – Spotlight on three selected sectors

Bulk chemicals

31.4 Mt CO_2 emissions in 2024

7.9% share of sector emissions in total EU-ETS1 Industry 2024

0-5% process-related emissions today

269 installations in EU-ETS1

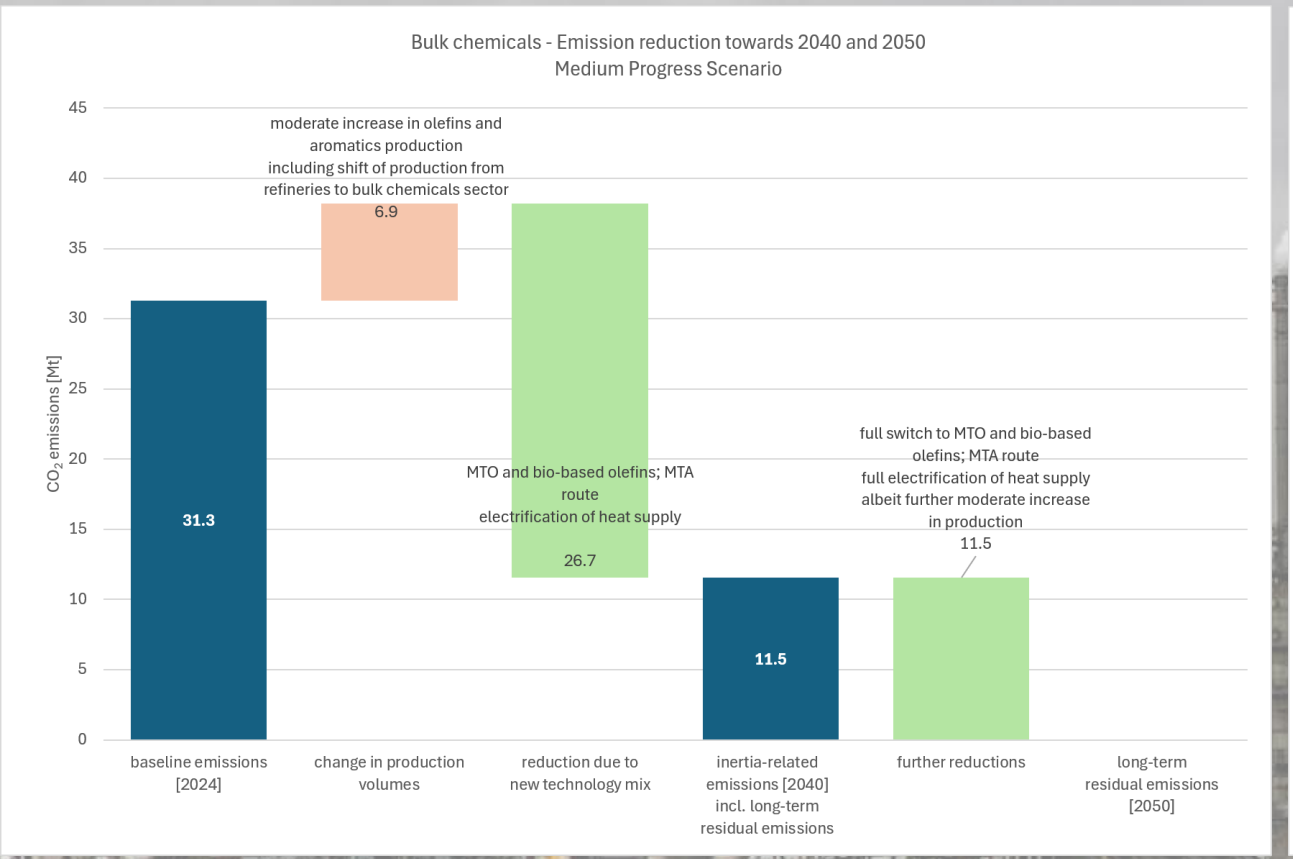
Average emissions per installation: **0.12 Mt CO_2/a** range: **0.0 – 3.31 Mt CO_2/a**

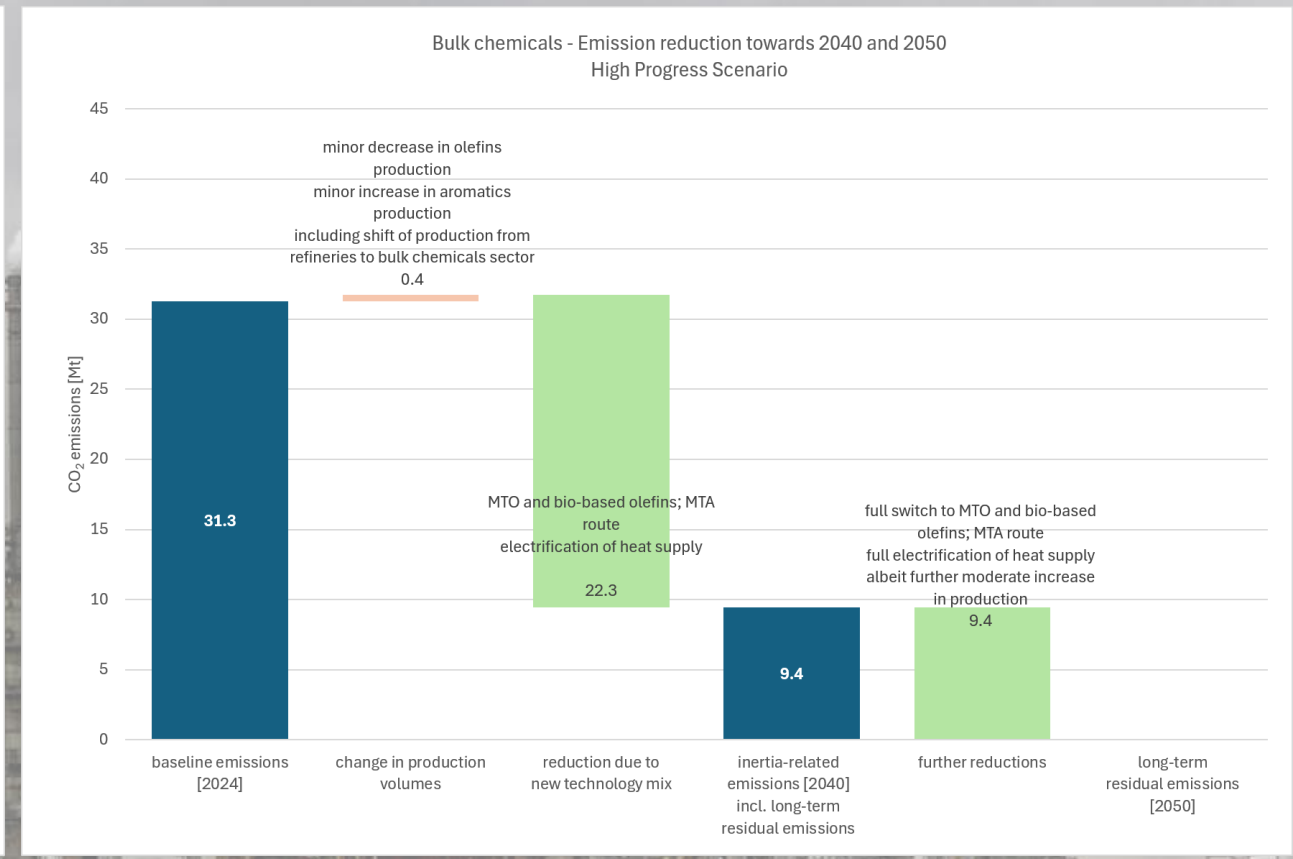
Installations with emissions >100ktCO_2/a **17%** Share of emissions in installations >100ktCO_2/a **85%**

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4 – Spotlight on three selected sectors

Bulk chemicals





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4 – Spotlight on three selected sectors
Bulk chemicals

Major Requirements for deep defossilization

Large-scale availability of low-cost renewable hydrogen

- Renewable energy uptake for renewable hydrogen production
- Investment in large-scale electrolysis capacities
- Investment in large-scale hydrogen transport infrastructure if relocation of current site is to be avoided

Large-scale availability of sustainable and climate-neutral CO_2 sources

- Availability of sustainable biomass for BECCU or BioCCU, or very low-cost electricity and further commercialization of DACCU
- Connection to large-scale CO2 transport infrastructure if relocation of current site is to be avoided

MTA-route need further R&D and commercialization efforts to become available in time and scale

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4 – Spotlight on three selected sectors

waste incineration

~53 Mt CO_2
fossil emissions in 2024

n/a
share of sector emissions in total EU-ETS1 Industry 2024

0%
process-related emissions today

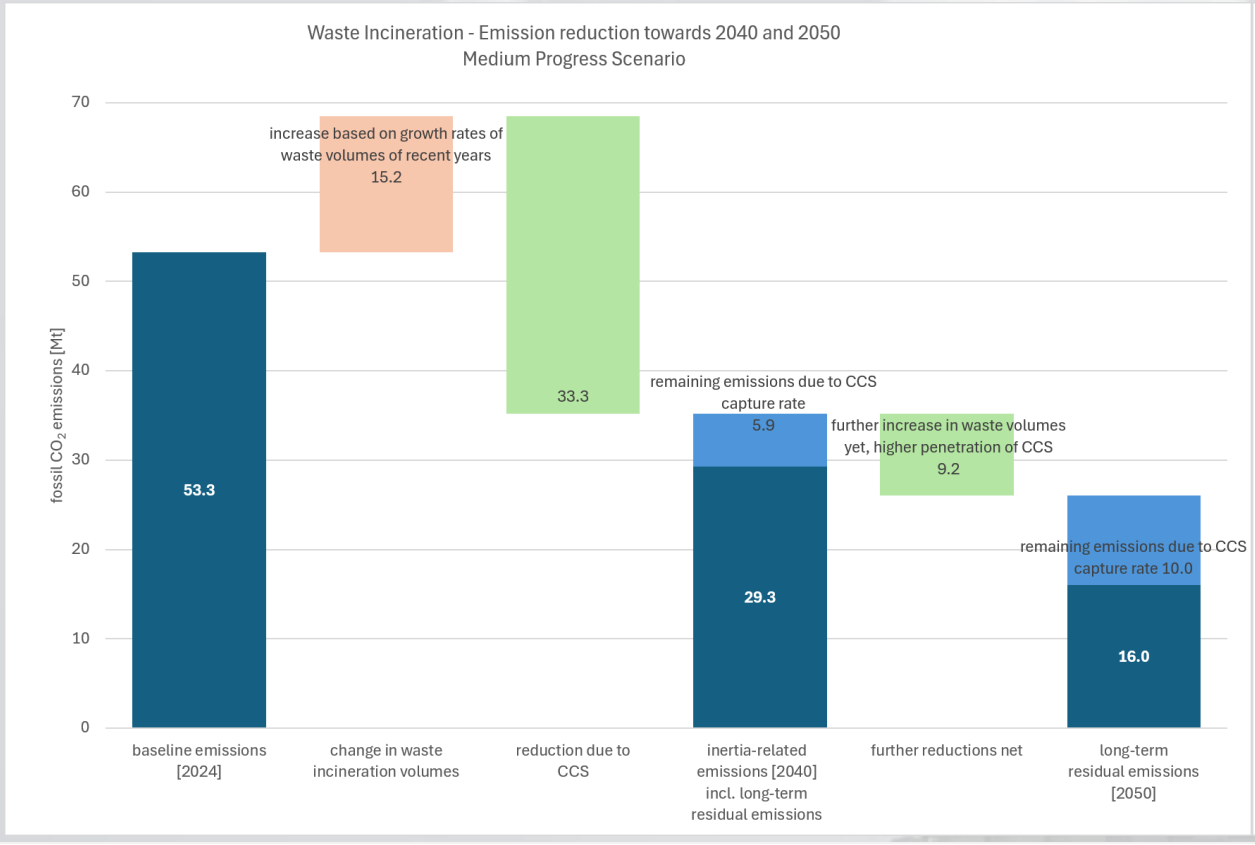
~500
installations in the EU

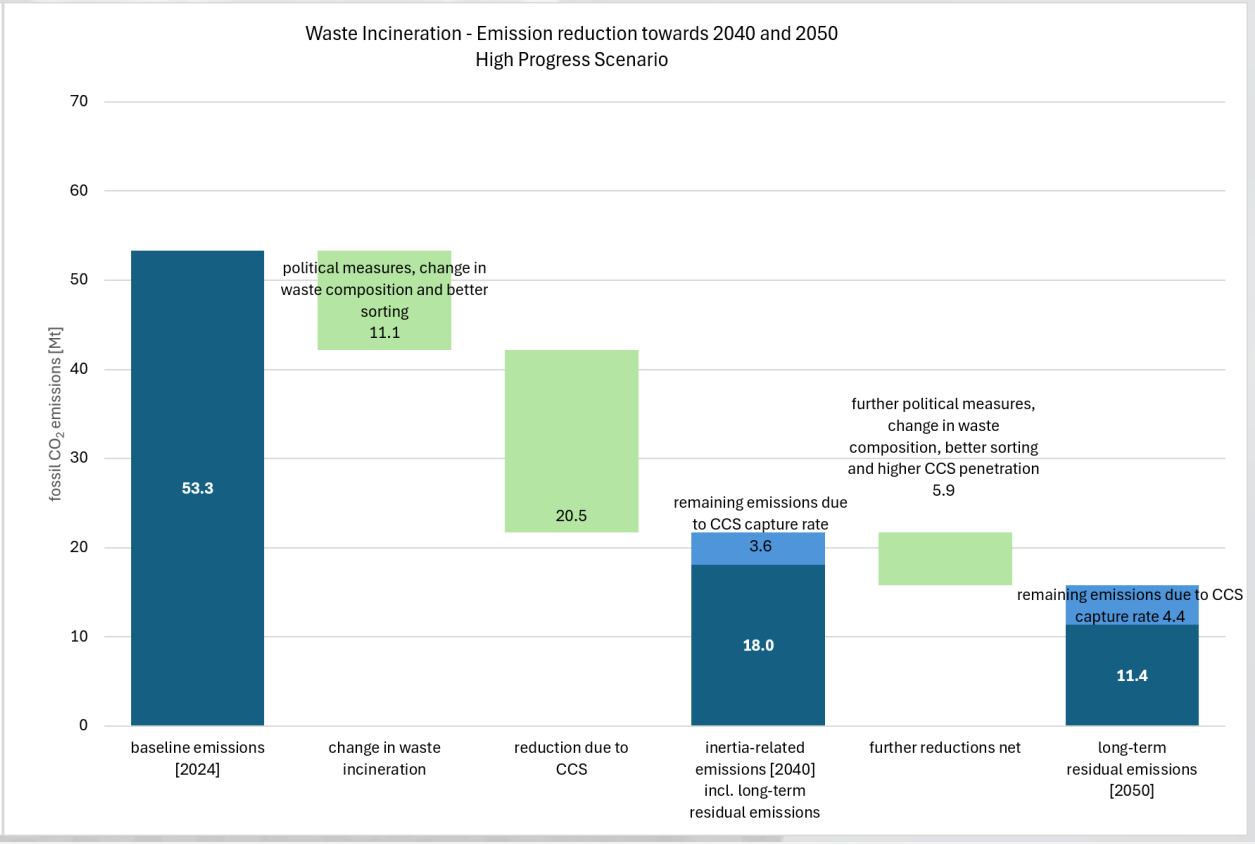
Average capacity per installation:
200kt waste/a
range:
9-1400kt waste/a

Installations with emissions >100ktCO_2/a
>50%
Share of emissions in installations >100ktCO_2/a
>80%

Picture: © Hoyoun Lee

4 – Spotlight on three selected sectors
waste incineration





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4 – Spotlight on three selected sectors
waste incineration

Major Requirements for deep decarbonization

Reduce overall volume of waste

- reduction in total demand for products that become waste, either through the use of alternatives or following broader degrowth trends
- enhanced circularity practices that extend the life of products
- enhanced recycling

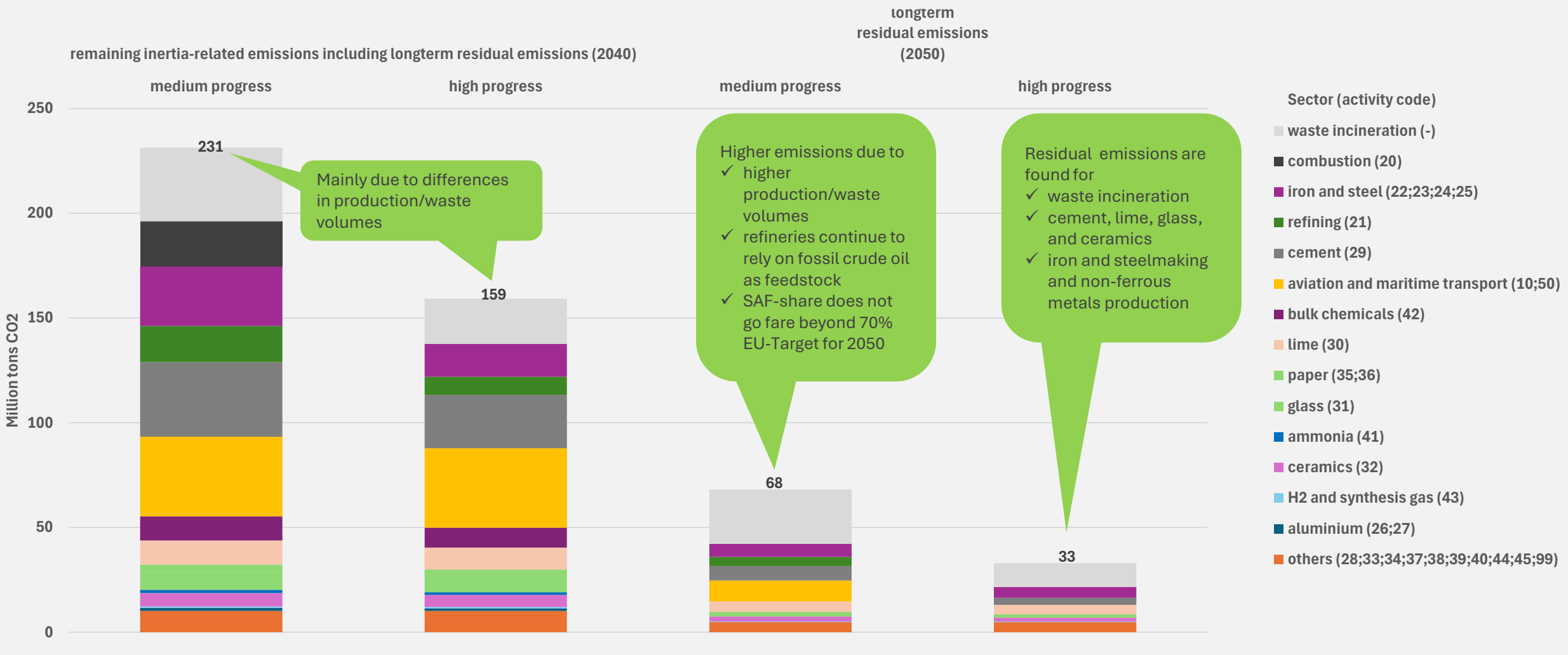
Reduce fossil emissions from incineration of plastics

- Increase recycling instead
- Increase share of non-fossil plastics used in the materials and products

Replace reduced electricity and heat output due to Carbon Capture with RES-E

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5 – Adding them up: Our estimate for residual emissions in 2040 and 2050



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6 – Take-Home Messages

Contributors to long-term residual emissions

- ✓ CO_2 that is not captured by carbon capture units (we assume a capture rate of 85% for waste incineration and 90% for all other applications).
- ✓ Emissions of installations that are assumed to be too small to be equipped with a carbon capture unit or to be connected to CO_2 transport infrastructure.
- ✓ Consumption and burn-off of electrodes in steelmaking and non-ferrous metals production.
- ✓ Emissions from few processes (including the ones mentioned above) that have a small share in total emissions, where the required new technology is currently at a low TRL and might not be available in time (e.g. alternative reducing agents in some non-ferrous metals production processes).

Risks leading to high remaining inertia-related emissions

- ✓ Slow or not focussed development and commercialisation of necessary technologies. Most importantly, this relates to electricity-based high-temperature technologies, direct synthesis of methanol and processes in the chemical industry such as methanol-to-aromatics.
- ✓ Lack of transmission/transport infrastructure (electricity, hydrogen, and CO_2) including grid connection of the installations.
- ✓ Low availability or high costs of necessary energy carriers and feedstocks, especially renewable electricity and hydrogen and its derivatives.
- ✓ Lack of financial capacity for industries to make large-scale investments into transformation technologies.

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