A transition pathway for Germany's industry up until 2050
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Results form a bottom-up modeling study

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Objective

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- Modeling an 80% GHG reduction pathway for the German industry up until 2050 (compared to 1990)
- Assessing the role of different mitigation options in a comprehensive analysis

Technology options considered

- Energy-efficiency improvement using BAT and optimization
- Fuel switch
- Process innovations using BNATs
- Carbon capture and storage (CCS)
- Material efficiency and secondary production routes

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Scenario definition

Two scenarios are defined: a reference (REF) and a transition (TRANS) scenario

	REF scenario	TRANS scenario
Policies	Current policy implementation	New policies and technologies to achieve at least 80% GHG reduction
Economic framework	Continous development; No substantial structural break Basic materials mostly constant production	
Energy prices	Continuously increasing prices	

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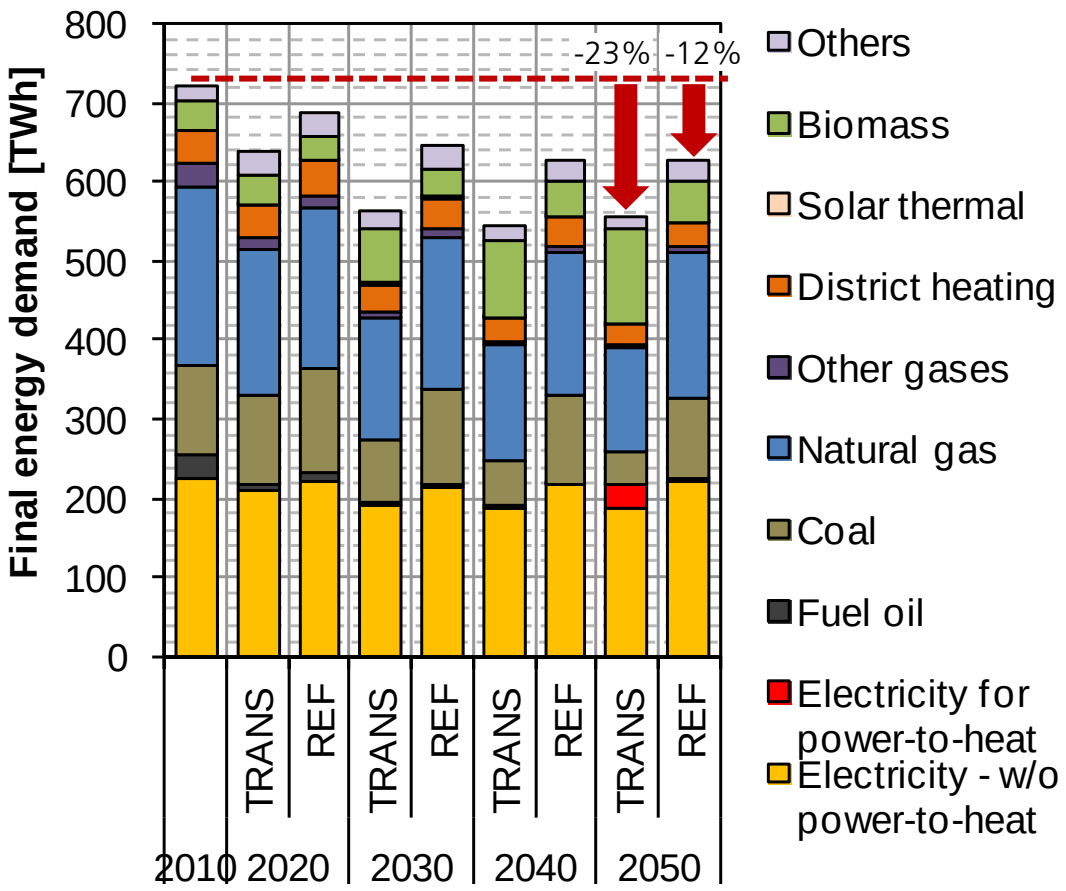
Results: Final energy demand up until 2050



Results TRANS scenario:

- **Demand reduction by 23% from 2010 to 2050**
- **FED** increases slightly after 2030, due to
  - 28 TWh demand for CCS in 2050
  - Reduction of CHP after 2030
  - Saturation of efficiency potentials
- **Fuel mix**:
  - Electricity demand constant, due to 29 TWh power-to-heat
  - Biomass use tripples
  - Natural gas falls by ~50%
  - Coal falls by 64%
  - Fuel oil phase out

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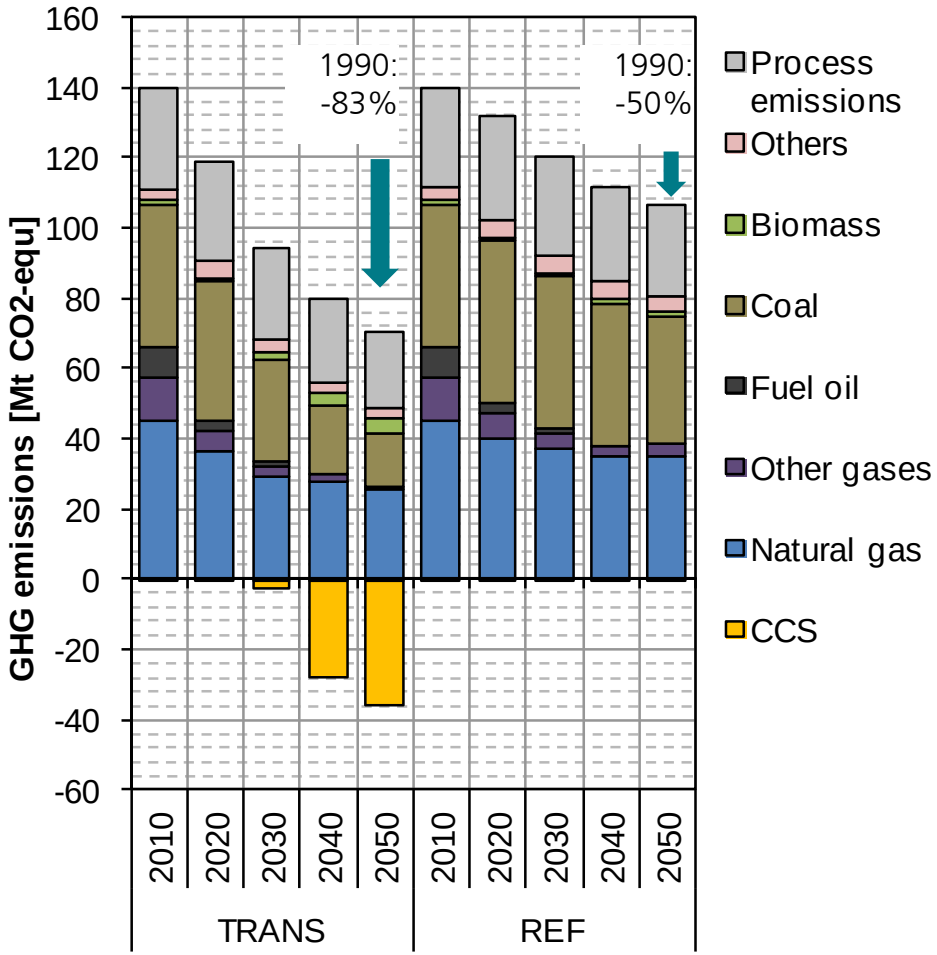
Results: GHG emissions up until 2050



Results TRANS scenario:

- TRANS uses substantiall less **coal** than REF (only where technically required for steelmaking)
- Still ~25 Mt CO2 emissions from **natural gas** in TRANS
- **CCS** important: 83% VS. 63% reduction versus 1990, particularly for process emissions

GHG balancing:

- Only direct emissions
- Emissions from electricity and DH not included
- CHP: energy use only for heat accounted

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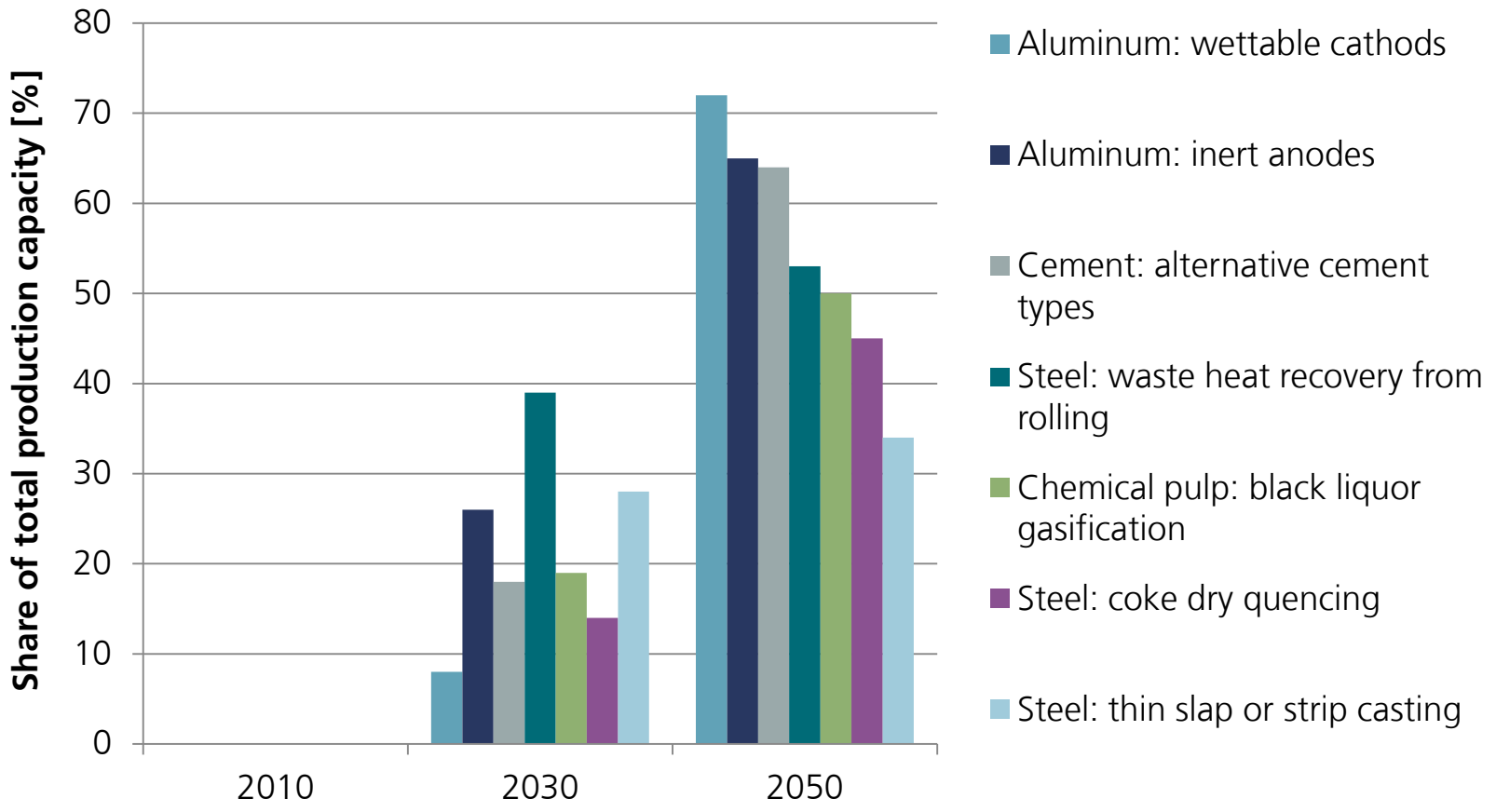
Diffusion of selected process innovations from basic materials in the TRANS scenario



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Summary of results for TRANS scenario

Industry in 2050: high efficiency, minimum coal use, no fuel oil, much biomass, much natural gas and CCS

- **83% GHG reduction** compared to 1990 achieved via:
  - 23% **reduction in final energy demand** (compared to 2010) via
    - ambitious system optimization in cross-cutting technologies and
    - fast diffusion of new BNAT for basic materials processes
  - **Material efficiency and secondary production** increasing: e.g. electric steel increases from 29% (2010) to 57% (2050)
  - Fuel switch:
    - Reduction In **coal** use by 64% since 2010; quick phase out of **fuel oil**
    - **Power-to-heat** increases to 29 TWh electricity use in 2050; it becomes relevant after 2030 and replaces CHP
    - Biomass increases by 211% compared to 2010 and reaches 120 TWh in 2050, solar thermal and ambient heat also increase, but on a low absolute level
    - Total **natural gas** demand falls by 49%, still it remains the second most important energy carrier
  - **CCS** contributes with 35 Mt CO2 sequestration and reaches maximum diffusion in steel, lime, ammonia, ethylene and methanol. In clinker it remains below maximum.

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Further research

- Role of **RES-H2**, e.g. for steel production but also in chemical industry in ammonia and methanol production?
- **Sector coupling** in general: electricity, H2, biomass (also bio-based materials)
- Status-quo and possible market introduction of **low-carbon process innovations** (e.g. low-carbon cement)
- Comprehensive modeling of mitigation potentials through **circular economy and material efficiency**
- **....**

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Thank you for your attention!

More information:

Fleiter, Rehfeldt, Pfluger (2016): A transition pathway for Germany's industry – what role for energy efficiency? Eceee industrial summer study 2016, Berlin

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