A transition pathway for Germany's industry: which role for energy efficiency?

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eceee Industry Summer study 2016, Berlin

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Objective and approach

Objective

- **Modeling a -80% GHG reduction pathway for the German industry up until 2050 (compared to 1990) considering:**
  - Technology structure and technological change
  - Energy prices and technology costs
  - Policies
  - Availability of new technologies

-> What is the contribution of different technology options to achieving the reduction target?

System boundaries

- Technology options considered
  - **Energy-efficiency** improvement using BAT and optimization
  - **Fuel switch**
  - **Process innovations** using BNATs (e.g. low-carbon cement)
  - **Carbon capture and storage (CCS)**
  - **Material efficiency and secondary production routes**
- Inter-Sector considerations:
  - Only sustainable domestic **biomass** is used and most of it goes into transportation
  - Deployment of **industrial CHP** and use of **power-to-heat** is modeled in power sector
  - **Mitigation targets** in other sectors considered to arrive at a total of -80% (e.g. agriculture is less ambitious, while the power sector is more ambitious)
  - **Electricity** and **district heating** become substantially less CO2-intensive towards 2050

The model used: FORECAST-Industry
(see also http://www.forecast-model.eu/)

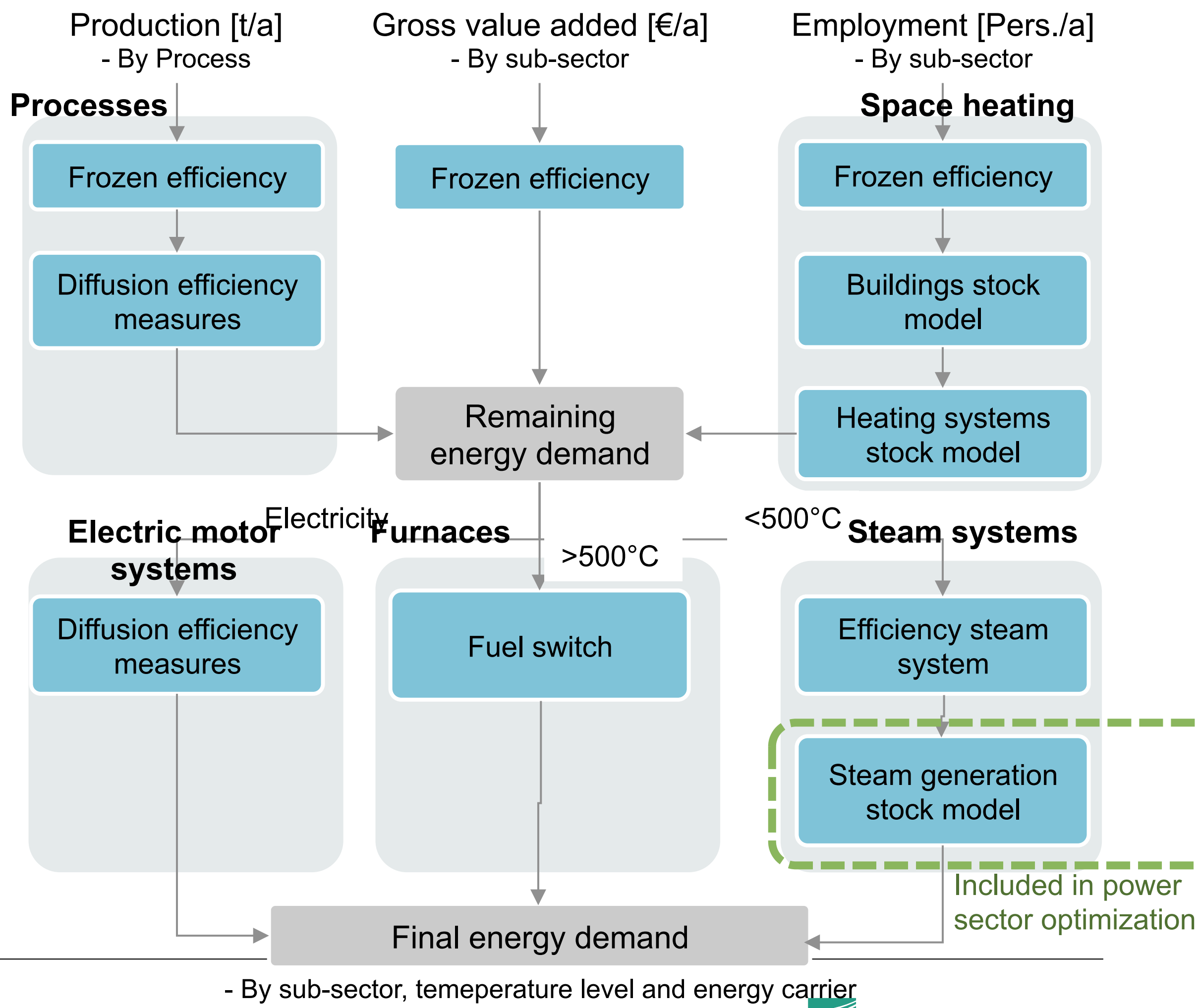
FORECAST
FORecasting Energy Consumption Analysis and Simulation Tool

Modeling approach

- Bottom-up simulation
- High technology detail
- Policy instruments:
  - EU ETS
  - Taxes/prices
  - Standards
  - Etc.

Level of detail

- 11 to 14 sub-sectors
- 64 processes
  + ~ 200 efficiency measures
- 2 building types
- > 20 technologies for heat generation incl. CHP
- 7 motor systems and lighting
  + >100 efficiency measures



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Scenario definition

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

Dimension	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	
Energy prices	Continously increasing prices	

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Assumptions and policies

Assumptions / economic framework

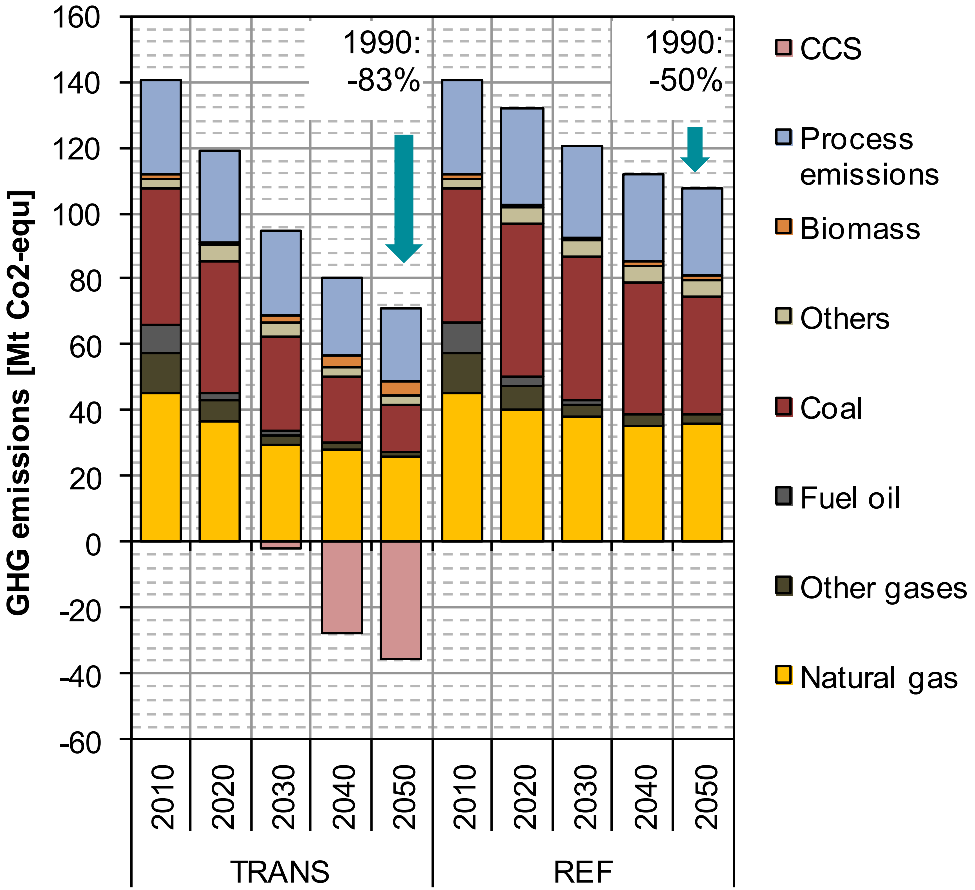
Parameter	TRANS and REF scenarios
Value added [$€_{2010}$/a]	• Industry total: 0.7%/a • Machinery and transport equipment: >1%/a • Energy-intensive industries: <0.5%/a
Production [t/a]	• Continuous slow increase for most products
Energy prices	• Fossil energy prices increase by 63 to 77% from 2010 to 2050 • Electricity increases by 28%

Policies / technology availability

Policy/technology	TRANS scenario
EU ETS: EUA price	2030: 35€; 2050: 100€ Plus 5-year ahead foresight
CO2 tax	Implementation for non-ETS
Appliance standards	According to LLCC
Building standards	Little more ambitious than REF
Energy mgmt and audits	Substantial increase
Subsidies	Increase
Material efficiency	More ambitious than REF
CCS	Available after 2030 (not available in REF)
Innovation	New process technologies enter market around 2020

Results

Results: GHG emissions up until 2050



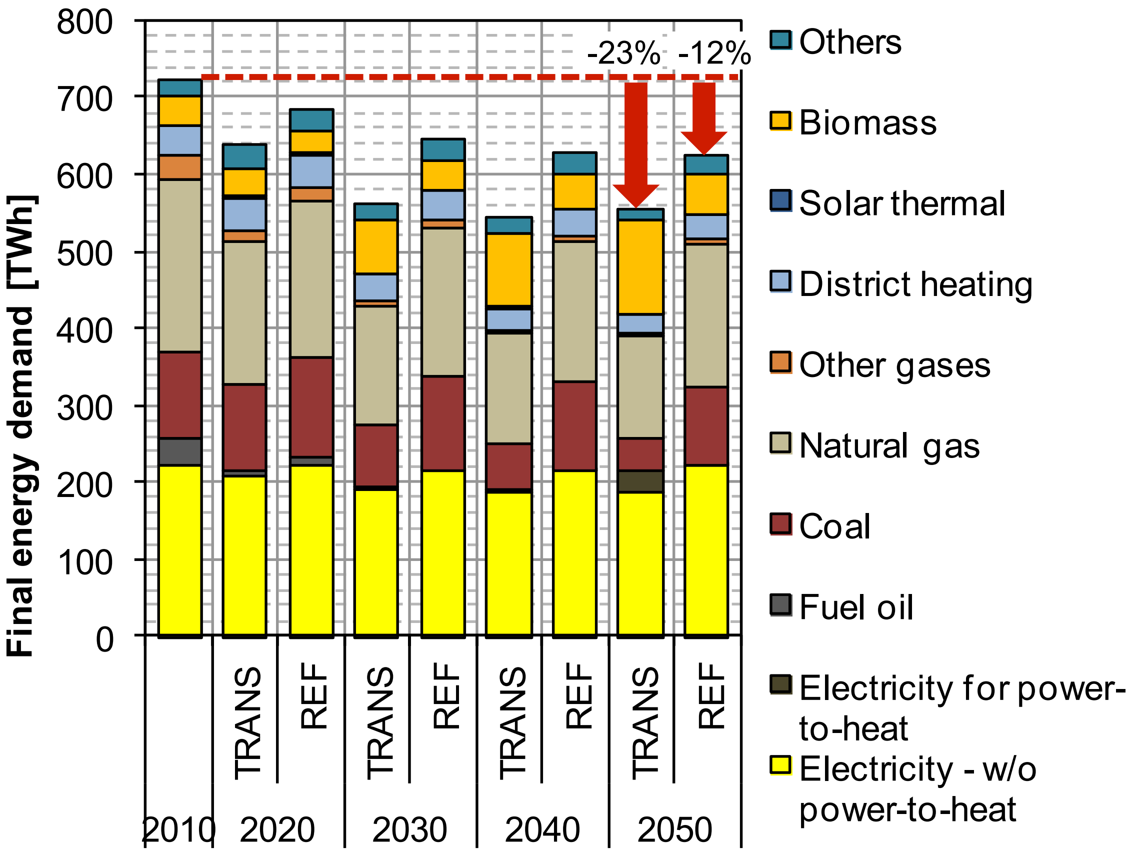
GHG balancing:

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

Results TRANS scenario:

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

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

Conclusions

Conclusions for TRANS scenario

- **Industry in 2050: high efficiency, minimum coal use, no fuel oil, much biomass, still 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 diffusion of new BNAT for basic materials processes
  - Reduction in **coal** use by 64% since 2010 (only partly remaining in steel production); quick phase out of **fuel oil**
  - **Material efficiency and secondary production** increasing: e.g. electric steel increases from 29% (2010) to (57%) – assuming only domestic scrap sources
  - **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 1990 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 production potentials remain in 2050.
- **Policy conclusions**
  - Impulses from CO2-price come too late (2030: 35€, 2050: 100€), because long-living capital stock and long innovation time required
  - Early market introduction of BNAT process technologies (including CCS) important
  - CCS prevents a more radical change in basic materials production
  - Incentive for fuel-switch in non-ETS needed

Further research and discussion

- **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**
  - Role of **carbon leakage** and **international competition**

- **Discussion:**
  - What are alternative industry sector mitigation pathways?
  - Are important mitigation options neglected?
  - How realistically do you judge the implementation of such a transition path?
  - ….

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Thank you for your attention!

More information: http://www.forecast-model.eu/

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Backup

Diffusion of process innovations in basic materials industries

EEM	Scenario	2010	2020	2030	2040	2050
Chemical pulp: black liquor gasification	REF	0	2	3	6	9
	TRANS	0	4	19	41	50
Steel: waste heat recovery from rolling	REF	0	8	24	34	37
	TRANS	0	12	39	51	53
Cement: low-carbon cements	REF	0	4	7	14	23
	TRANS	0	6	18	44	64
Aluminium: wettable cathodes	REF	0	0	3	16	26
	TRANS	0	1	8	45	72
Steel: thin slap or strip casting	REF	0	7	18	21	22
	TRANS	0	10	28	33	34
Aluminium: inert anodes	REF	0	1	3	5	7
	TRANS	0	4	26	56	65
Steel: coke dry quenching	REF	0	1	1	2	3
	TRANS	0	3	14	36	45

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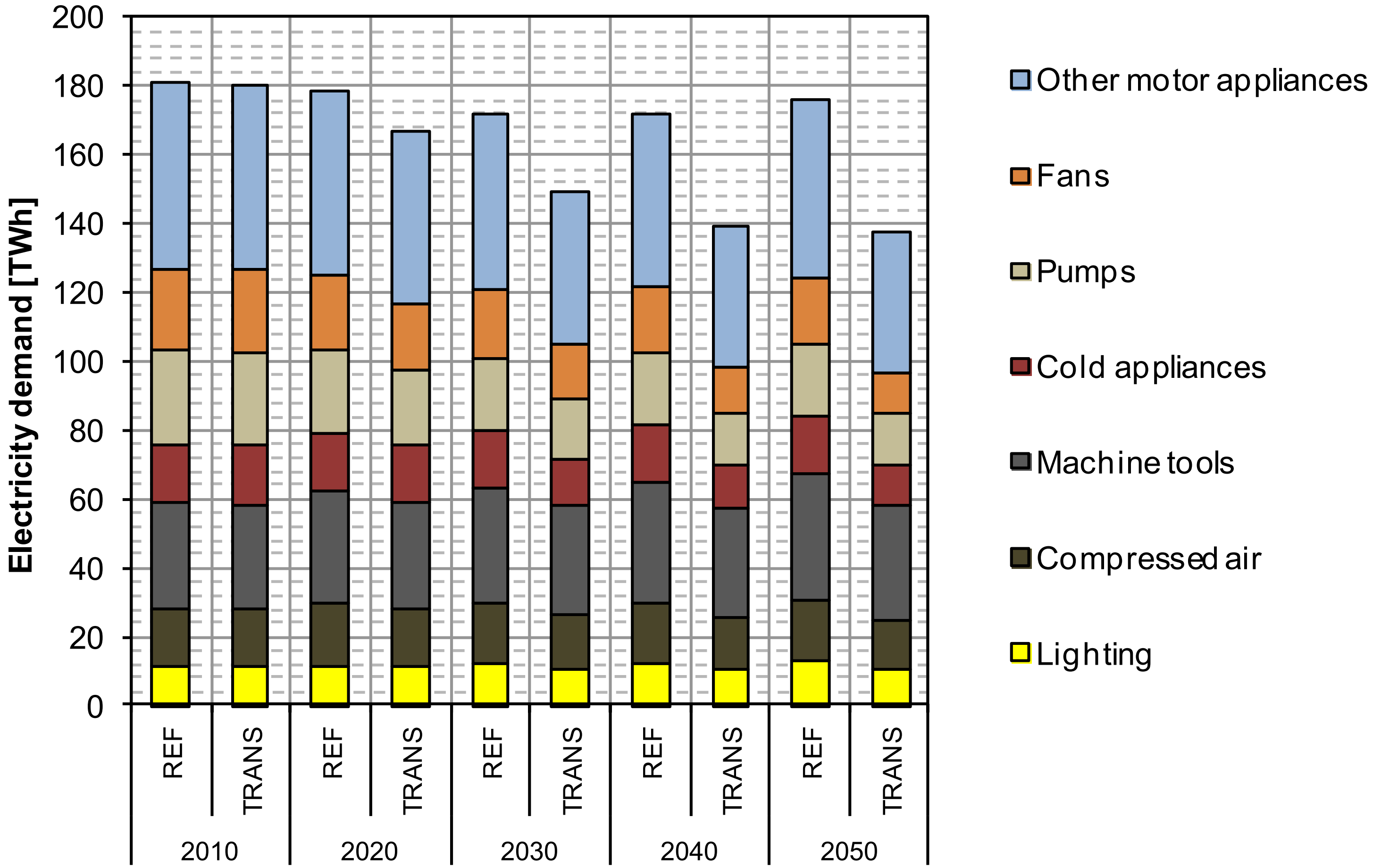
Electricity demand for cross-cutting technologies by scenario



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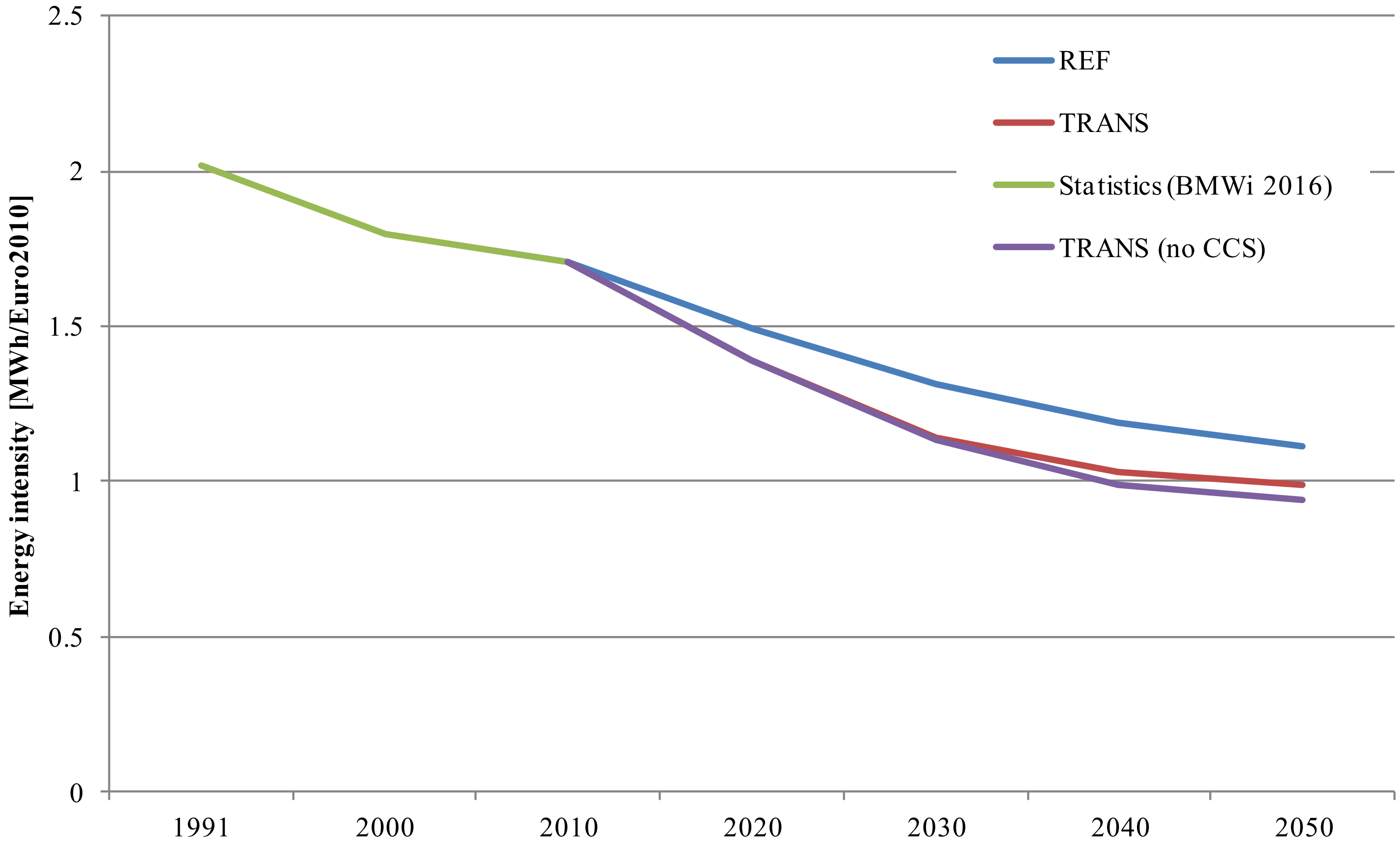
Energy intensity by scenario



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