Technology orientated analysis of the emission reduction potentials in the industrial sector in the EU-27

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Overview

- Introduction
- Approach
  i. TIMES PanEU model
  ii. CO_2 price variation
- Results and key effects (EU-27)
  i. General overview scenario results 2000-2050
  ii. Emission reduction potentials in the industrial sector at varied CO_2 prices
- Conclusion and outlook

Introduction (I)

Energy and climate policy in the EU-27

- Current energy and climate policy discussion about overall **emission reduction** targets and **burden sharing**
- Cost optimal burden sharing between countries and **sectors** has to consider different potentials and **abatement costs**
  - Different potentials/costs of the single sectors (conversion/production + end use sectors) and countries have to be analysed and known for the political discussion about targets
  - Focus of this paper: analysing the reduction potentials of the industrial sector
  - Construction of emission reduction potential curves

Introduction (II)

Emission reduction in industrial sector

- Key role concerning overall CO_2 emissions (about 22%) and ETS emissions (about 25%)
- Certificate allocation in industrial sector important for competitiveness (carbon leakage)
- Emission reduction possibilities differ from other sectors:
  i. Fuel switch / renewables / efficiency improvements
  ii. Changes in industrial **production processes** (additional dimension)

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TIMES PanEU – model description (I)

General model characteristics

- Energy system model
- Technology oriented bottom-up model
- Perfect foresight
- Objective function: Minimization of total costs (optimisation model)
- Multiregional model with trade processes (electricity, bio fuels)
- Starting point: EU-Project NEEDS
- Further development: IER (developed to TIMES PanEU)

TIMES PanEU – model description (II)

Specification: **TIMES PanEU**

- Modelling horizon 2000 – 2050
- 12 time slices (4 seasonal, 3 day level)
- 30 region model (EU 27 + IS, NO, CH)
- Country specific differences (characterisation of new power plants, load curves, availability factors for renewable energy sources, ...)
- Detailed electricity exchange balances
- Emissions: Greenhouse gas emissions and Pollutants
- Sectors: Public and industrial electricity and heat supply, conversion, industry, residential, commercial, transport and agriculture

Industry sector in TIMES PanEU (I)

Industry

energy intensive industries

- Iron&Steel
- Aluminium
- Copper
- Cement
- Ammonia
- Chlorine
- Lime
- Glass
- Pulp&Paper

non-intensive industries

- Other non-ferrous metals
- Other chemicals
- Other non-metallic minerals
- Food&Tobacco
- Other Industries

Industry sector in TIMES PanEU (II)

Industry

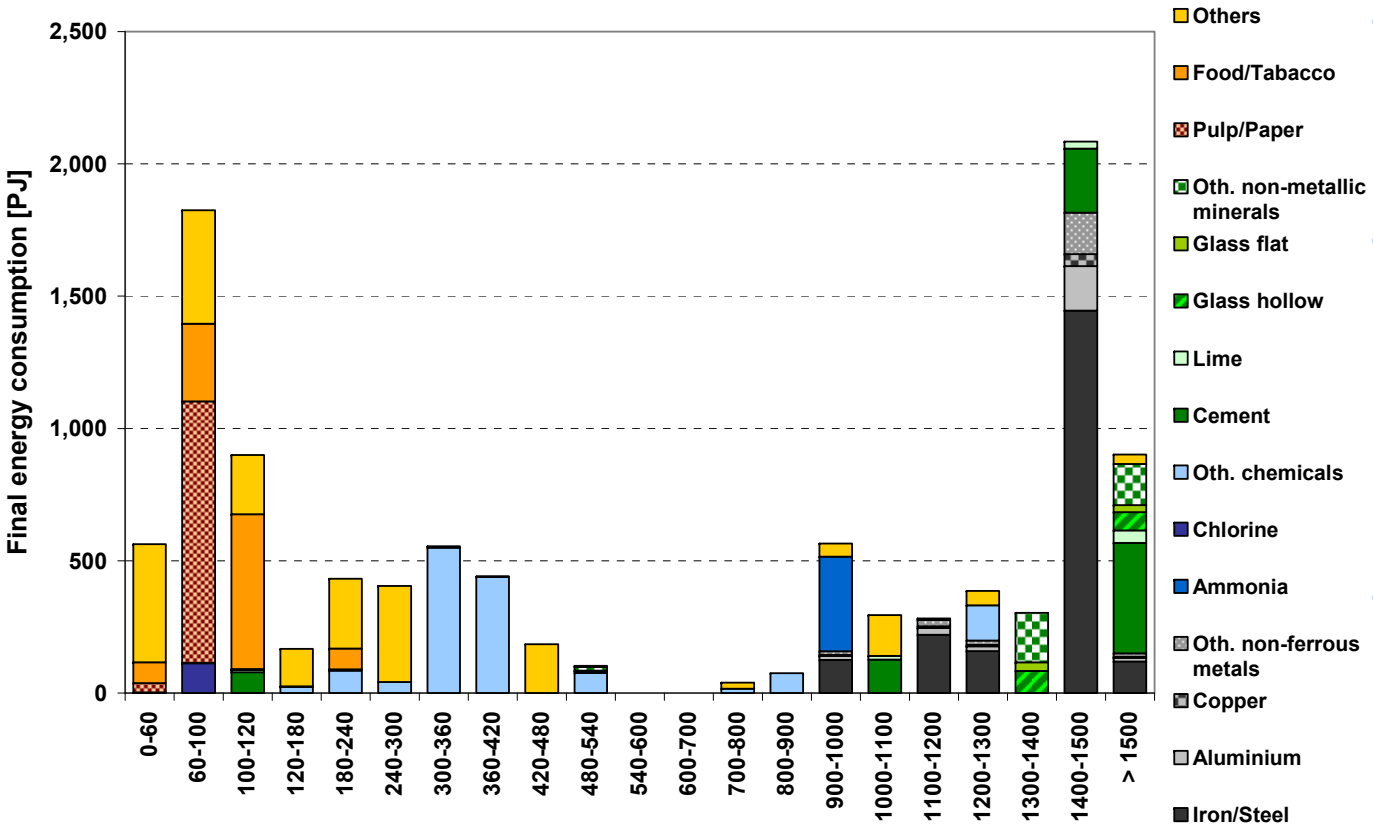
energy intensive industries

- Process orientated Reference Energy System
- Demand for final products in natural units (Mt)
- Demand based on a link with general equilibrium models (NEWAGE)

non-intensive industries

- Standard structure
- mix of 5 main energy uses (Steam, Process heat, Machine drive, Electro-chemical, Others)
- Food&Tabacco + Others: additional energy uses like space heat, hot water, cooling, pumps
- Demand for energy uses (PJ)

Heat demand of industrial sector (EU-27)



- Heat demand on different temperature levels
- Supply technologies and potential use of renewables depend on temperature levels
- Different roles of countries depending on the structure of their industrial sector

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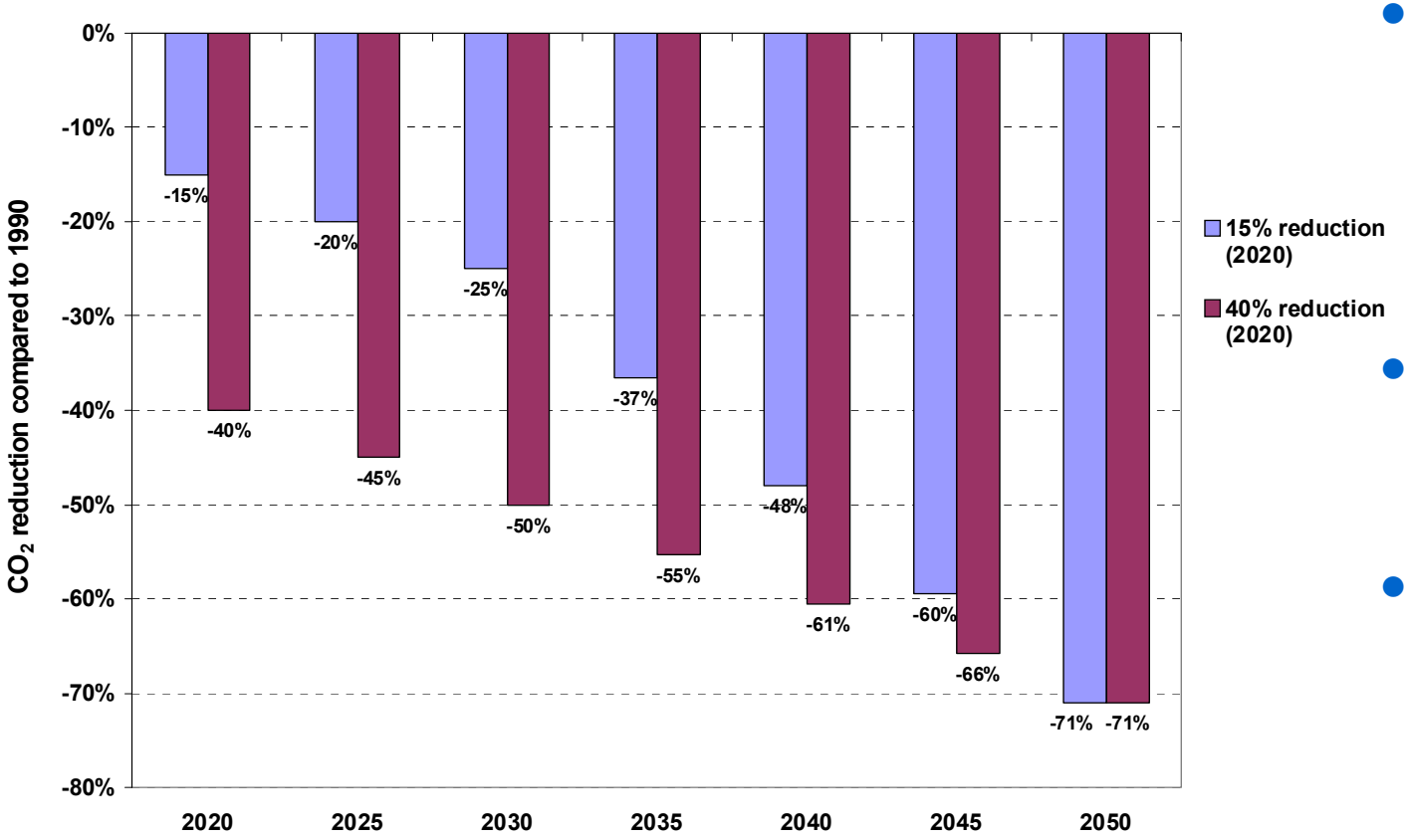
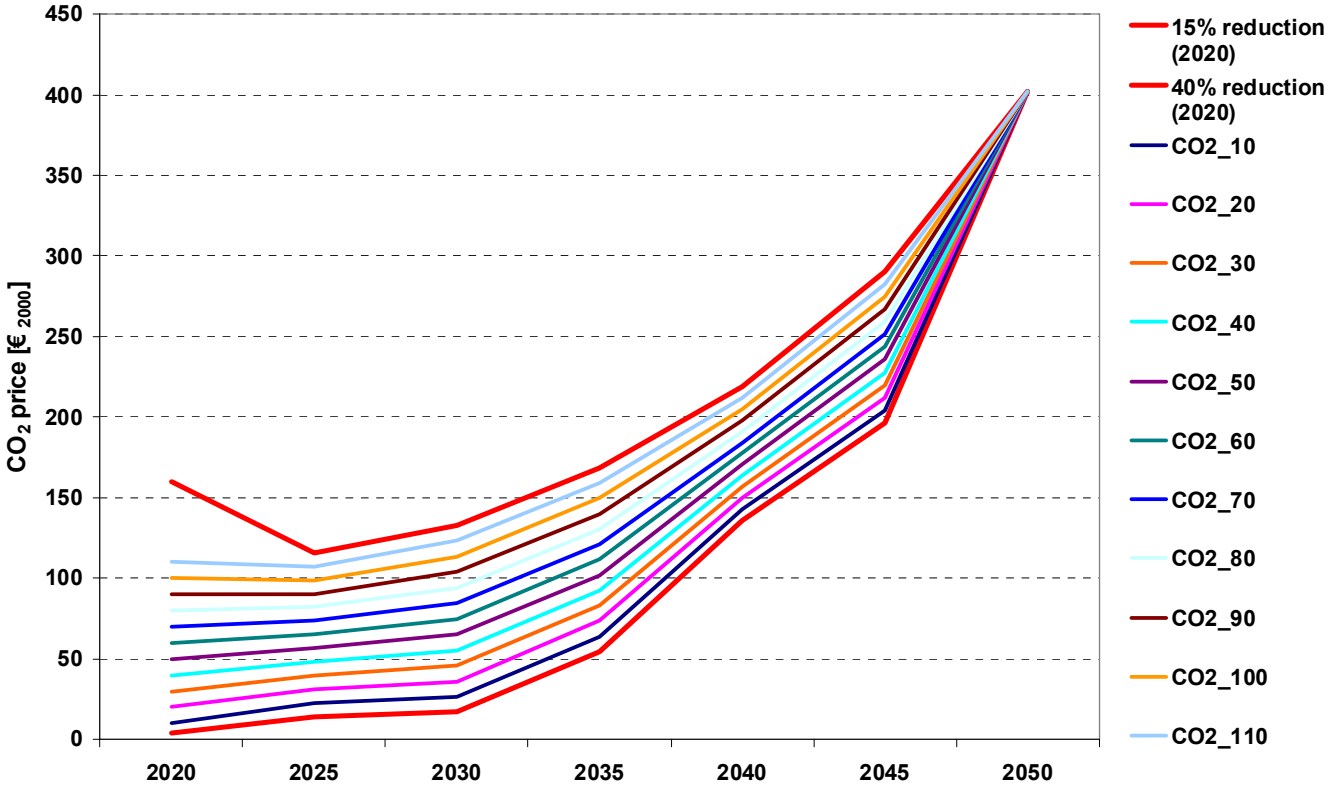
CO_2 price variation and scenario definition (I)



- setting two reduction pathways of -15% (to Kyoto base) and -40% in 2020
- 450ppm target (-71%) in 2050 in both scenarios
- Evaluating resulting CO_2 prices from these two scenarios

CO_2 price variation and scenario definition (II)



- CO_2 price as a result of *-15% (2020)* and *-40% (2020)* scenarios as lower and upper bound
- variation of the CO_2 price within this range of the two scenarios in equal steps
- in 2020: variation from 10€/t CO_2 to 110€/t CO_2
- Constructing reduction potential curves at a point of time

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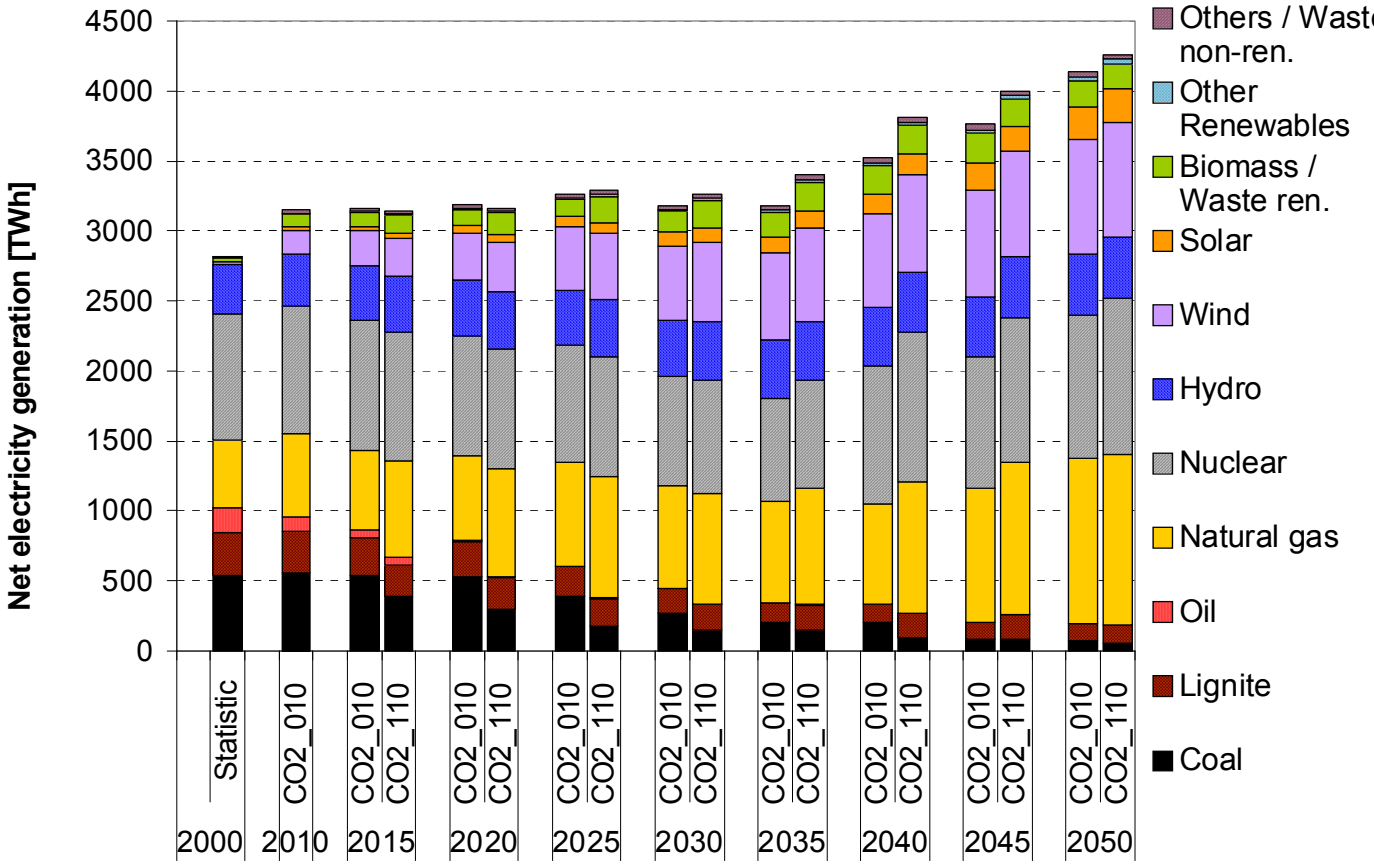
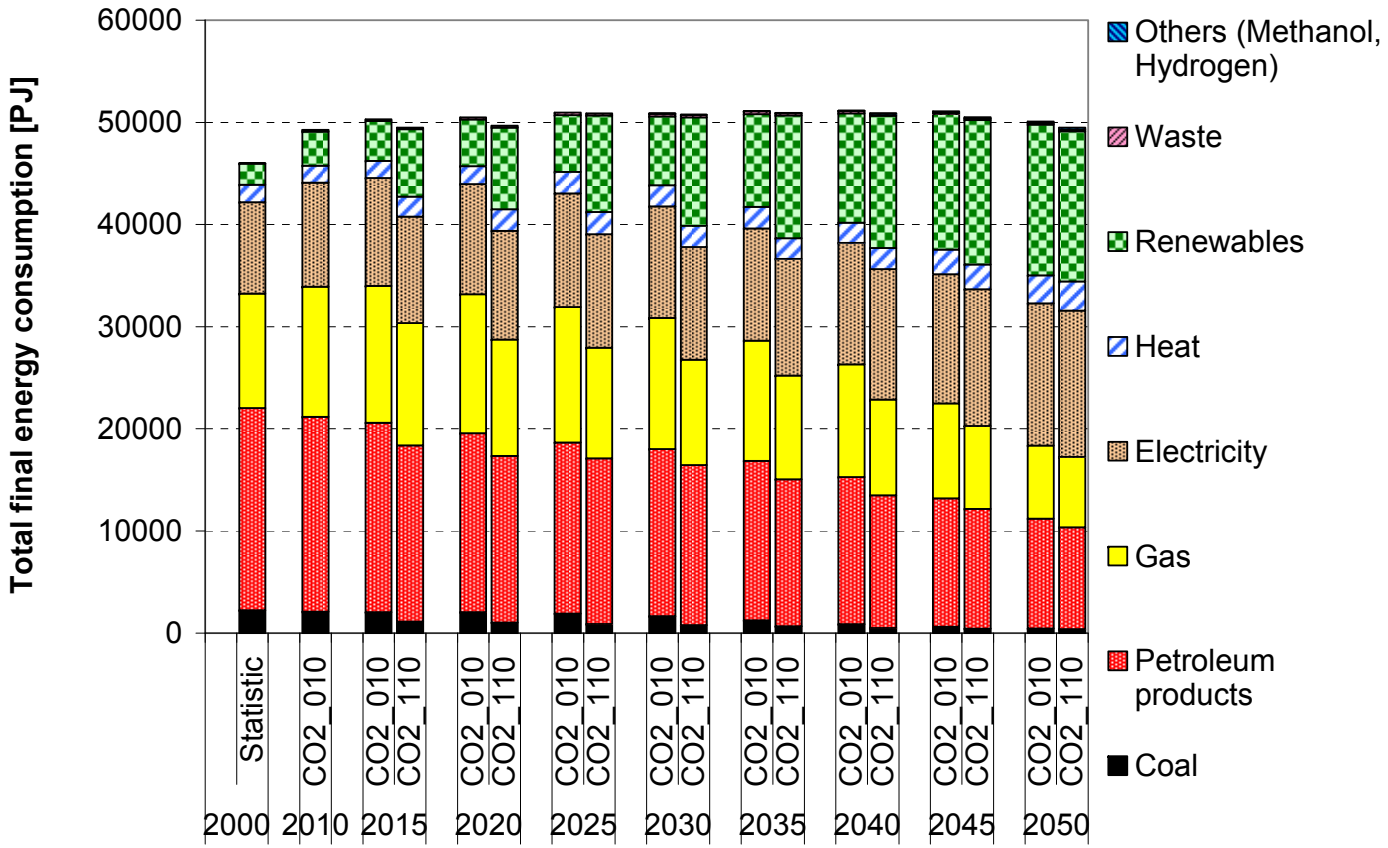
2000-2050: Electricity Generation EU-27



- Results of lowest (10€/t CO_2 in 2020) and highest (110€/t) CO_2 price
- differences in the mid term periods
- Higher electricity generation at later periods with stricter targets (450ppm)
- 2030: higher use of nuclear, renewables and CCS at higher carbon price

2000-2050: Final Energy Consumption EU-27



- Decreasing FEC in the long run
- Higher use of electricity and biomass in the long run
- Almost same FEC at varying CO_2 prices with different shares of energy carriers
- Higher price: reduced intensity (2020) + more biomass (2030)

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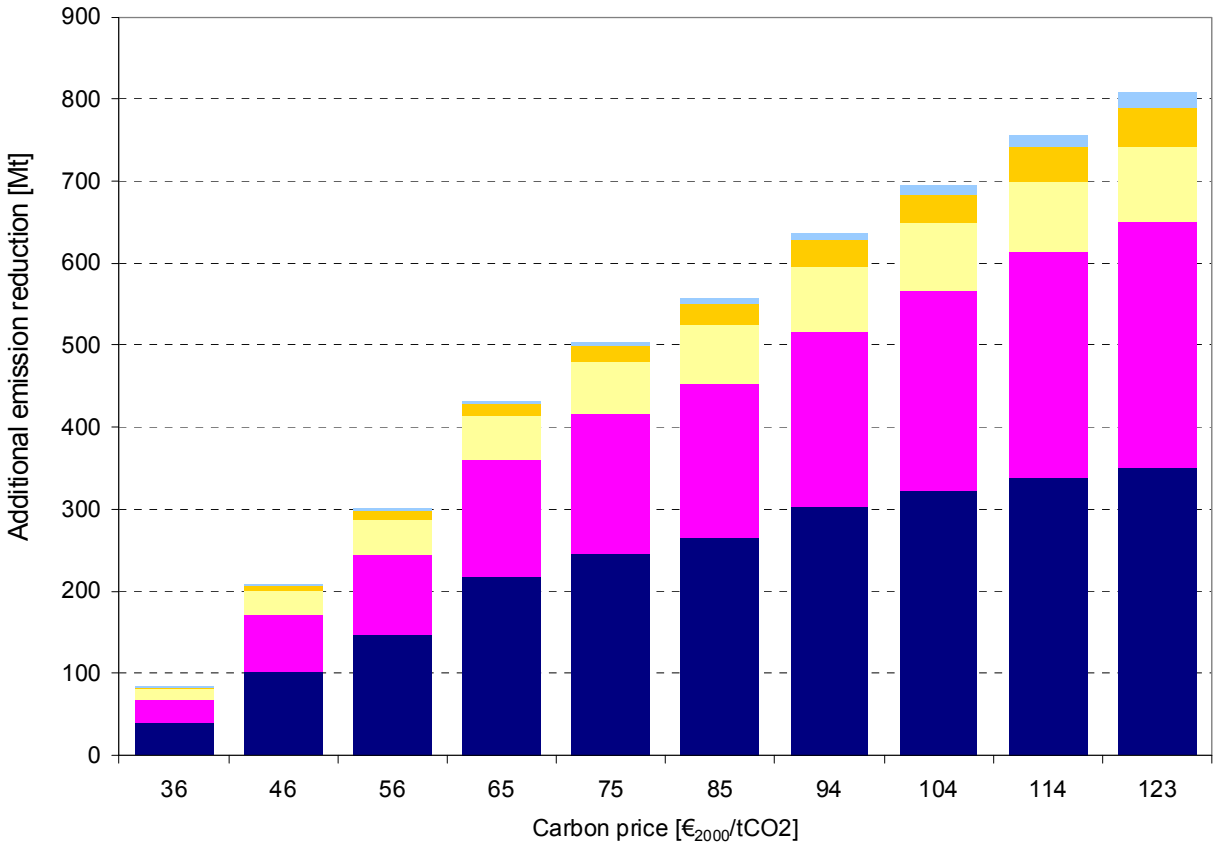
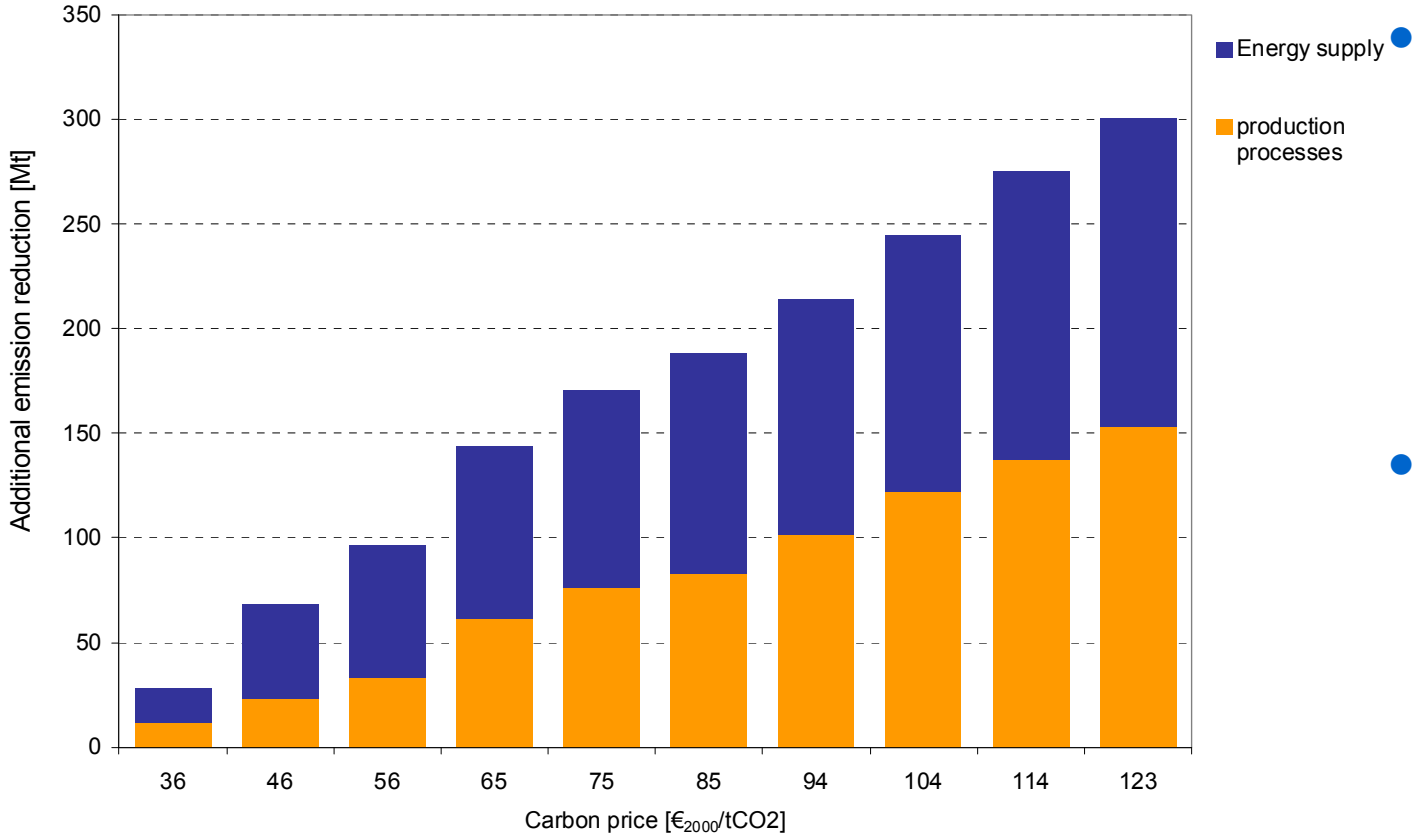
Additional emission reduction (2030) by sector



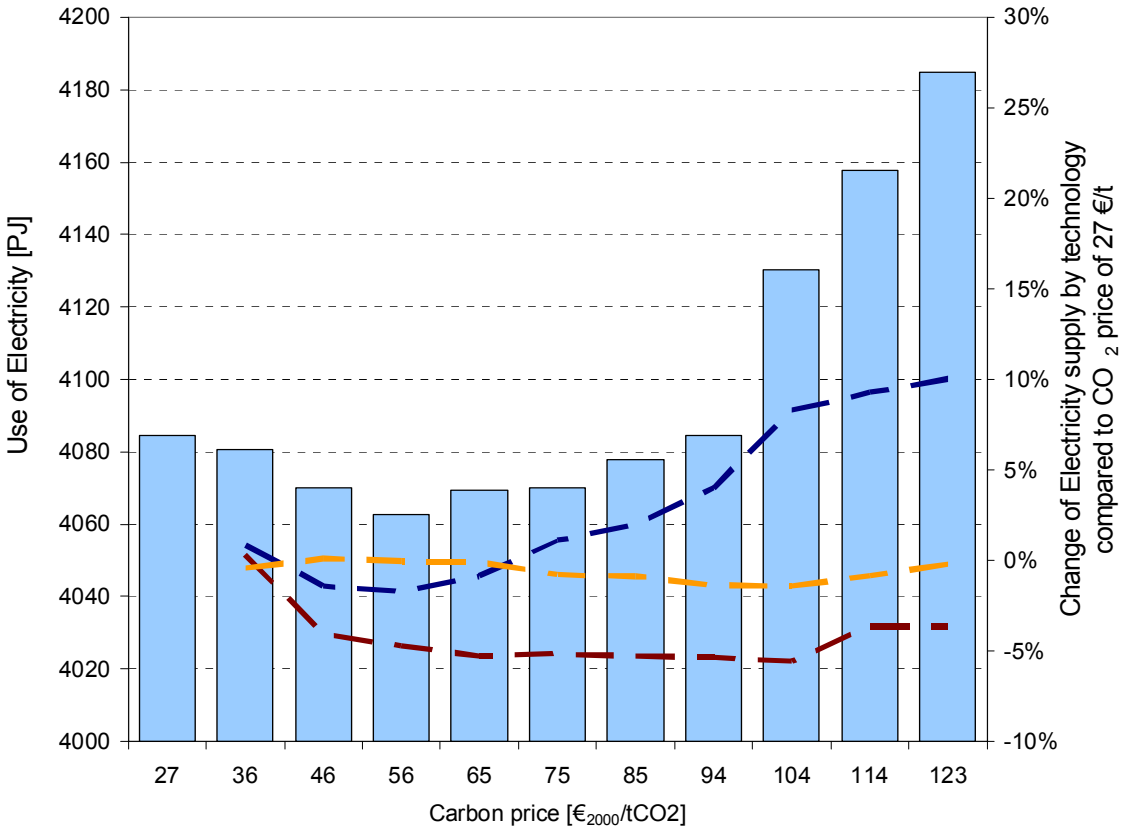
- Additional CO_2 reduction in 2030 compared to reduction at lowest CO_2 price (27€/t CO_2 in 2030)
- Key role of conversion/ production and industrial sector
- Additional reduction of 301 Mt. CO_2 in industrial sector at highest CO_2 price

Additional reduction in industrial sector (2030)



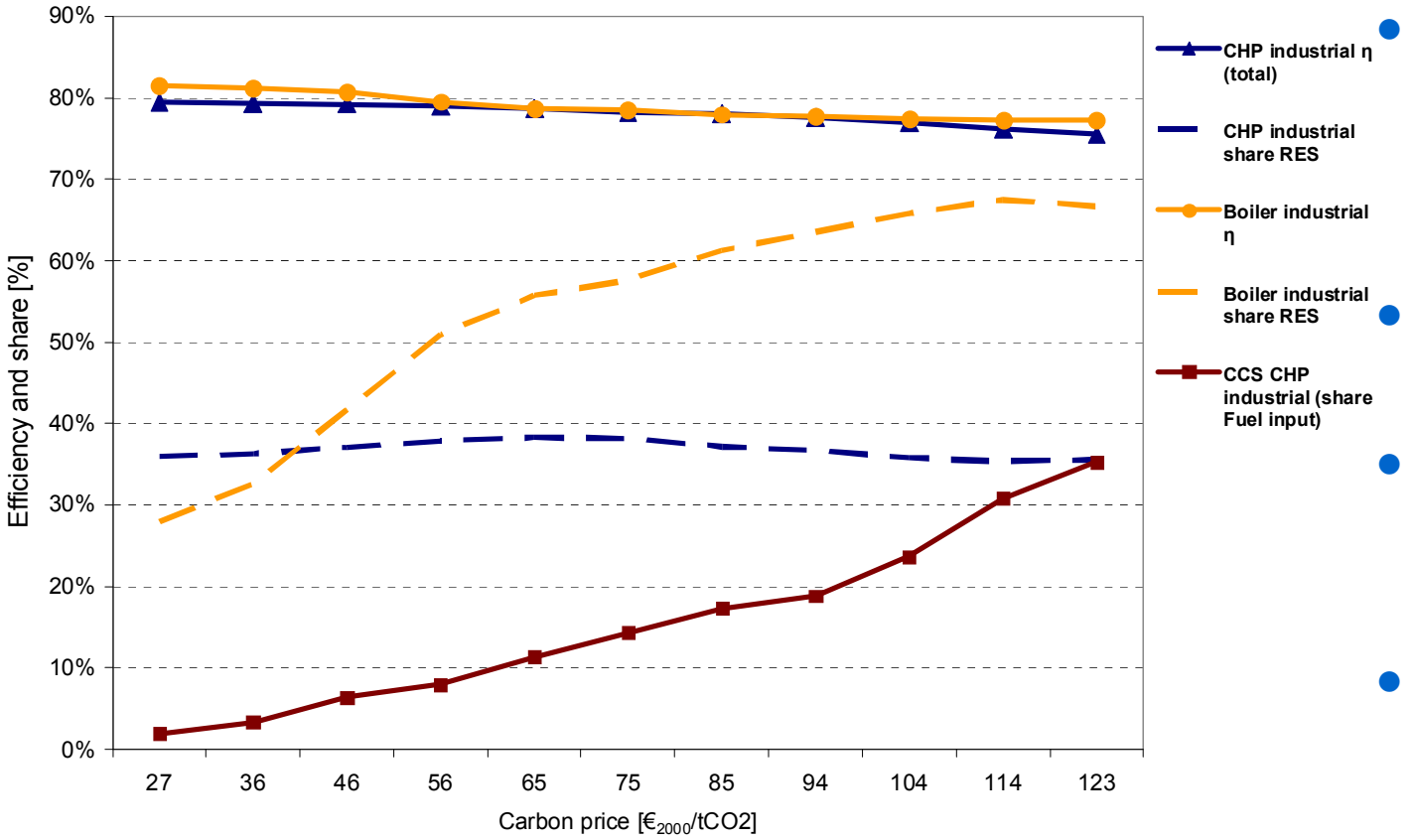
- Both clear emission reduction by supply (electricity/ heat) [147 Mt] and production processes [154 Mt]
- at lower prices higher additional reduction at supply processes (66% at 46€/t)

Electricity in industrial sector (2030)



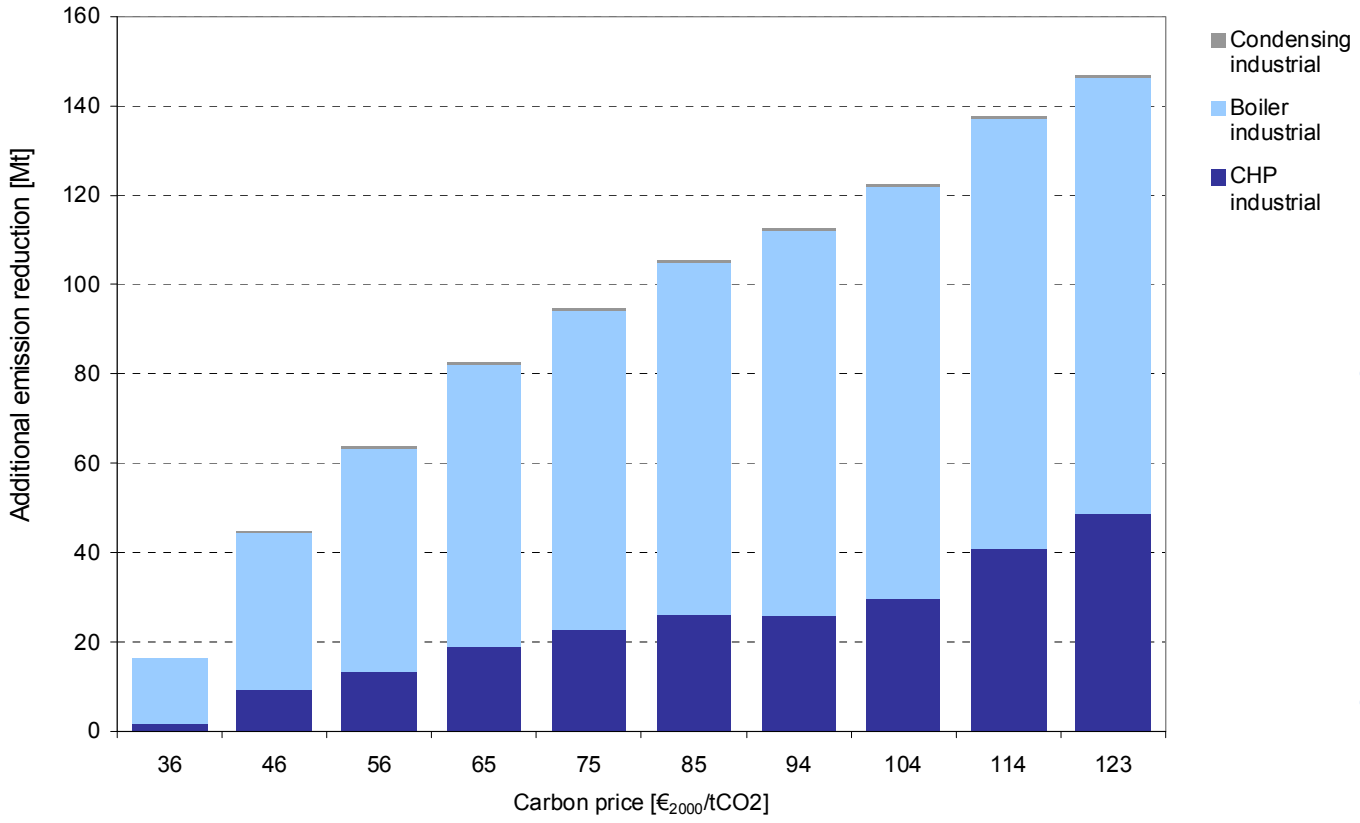
- Higher use of electricity at higher prices (mechanical appliances, higher end use efficiency, iron&steel and cement)
- Increasing generation at industrial auto producer, mainly from CHPs, constant use from public generation

Heat generation by technologies (2030)



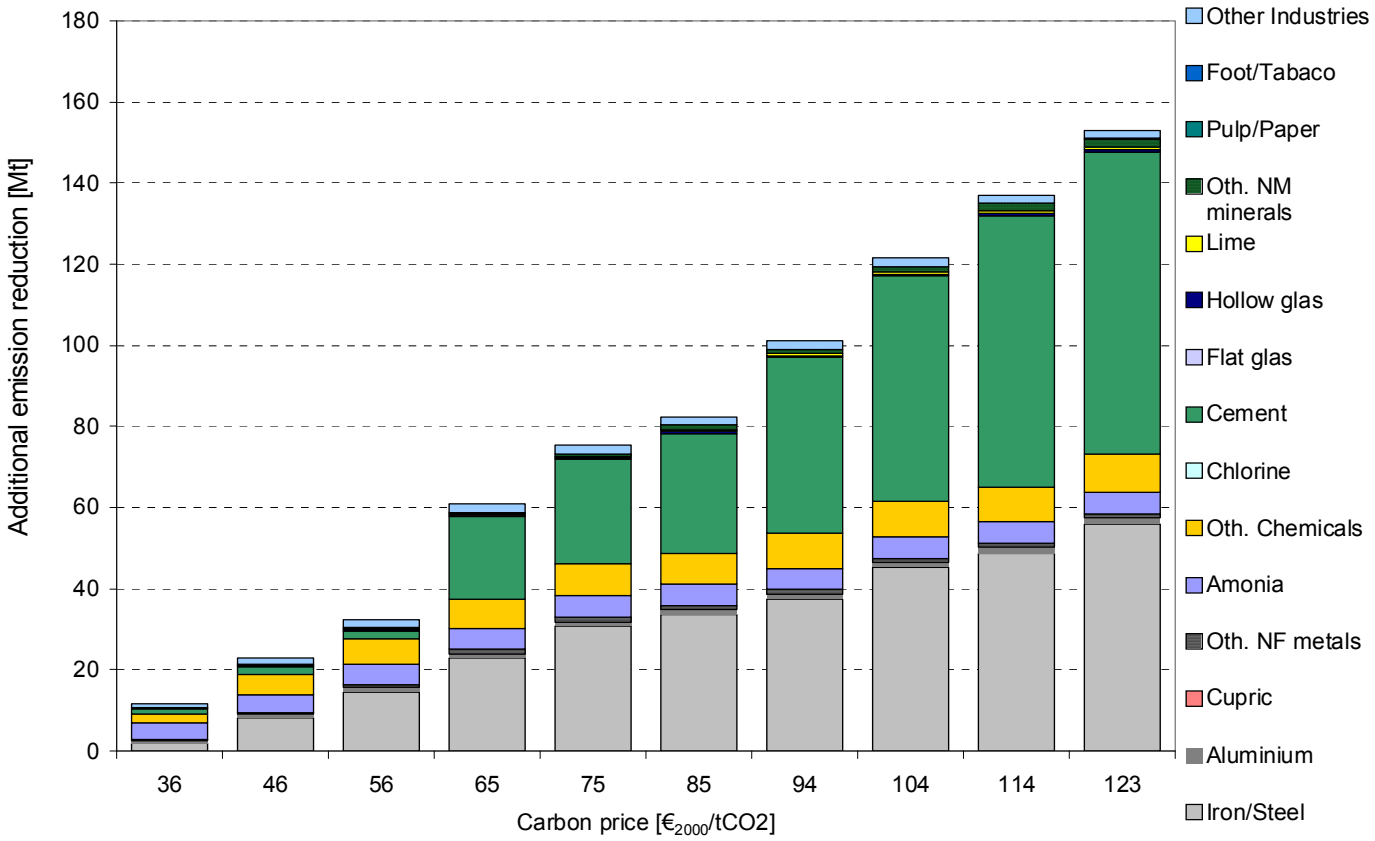
- Increasing share of renewables used in boilers from 36 to 65 €/t
- Thus, reduced thermal efficiency
- CHPs: increasing share of renewables till 75 €/t
- Afterwards: Higher share of CCS (gas-fired) / reduced efficiency in CHPs

Additional reduction by industrial supply side (2030)



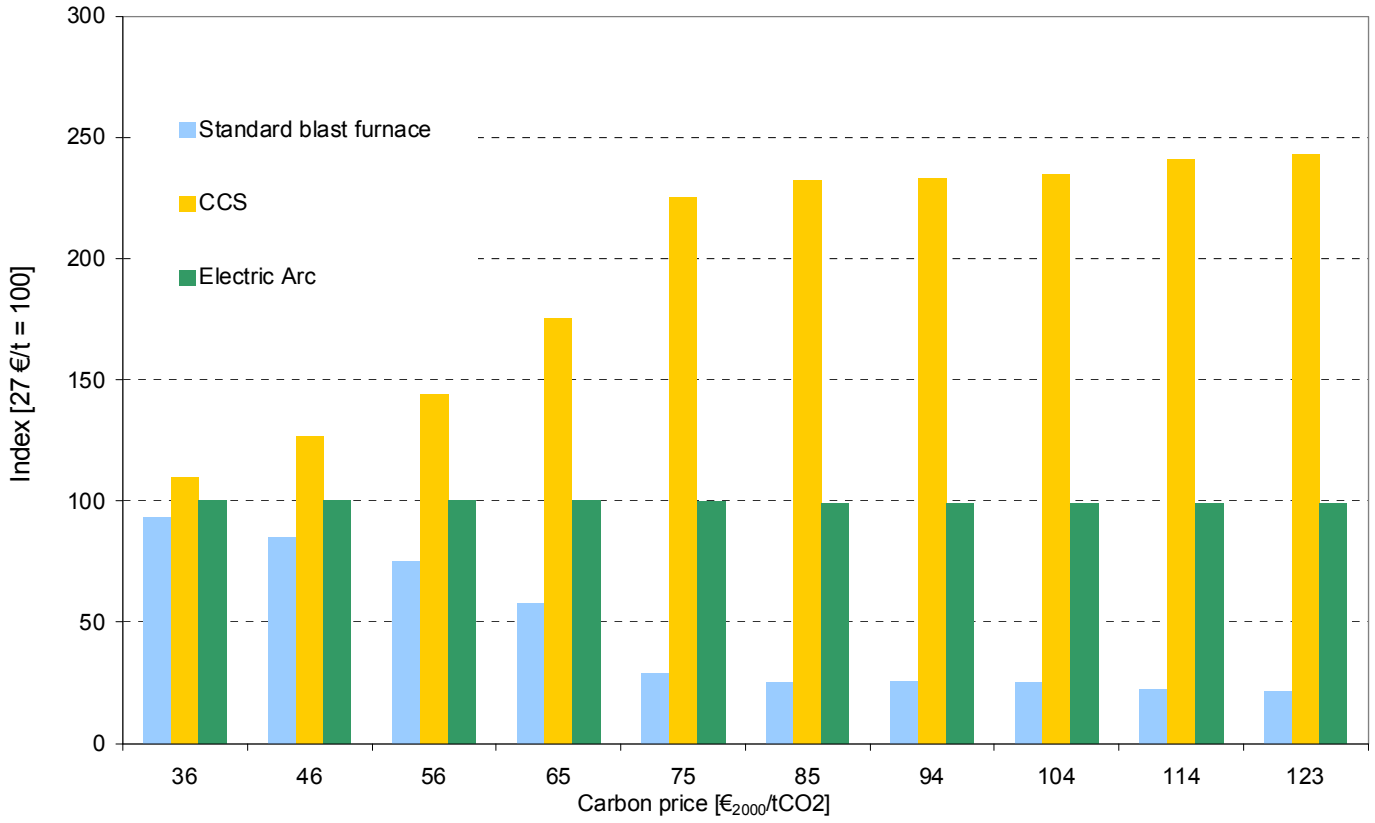
- At lower carbon prices reduction of emissions from boilers caused by extended use of renewables
- At higher carbon prices: switch from use of boilers to CHPs (less heat from boiler)
- CHP: constant level at medium prices due to extended use
- CCS use at CHPs at above 94€/t

Additional reduction by production processes (2030)



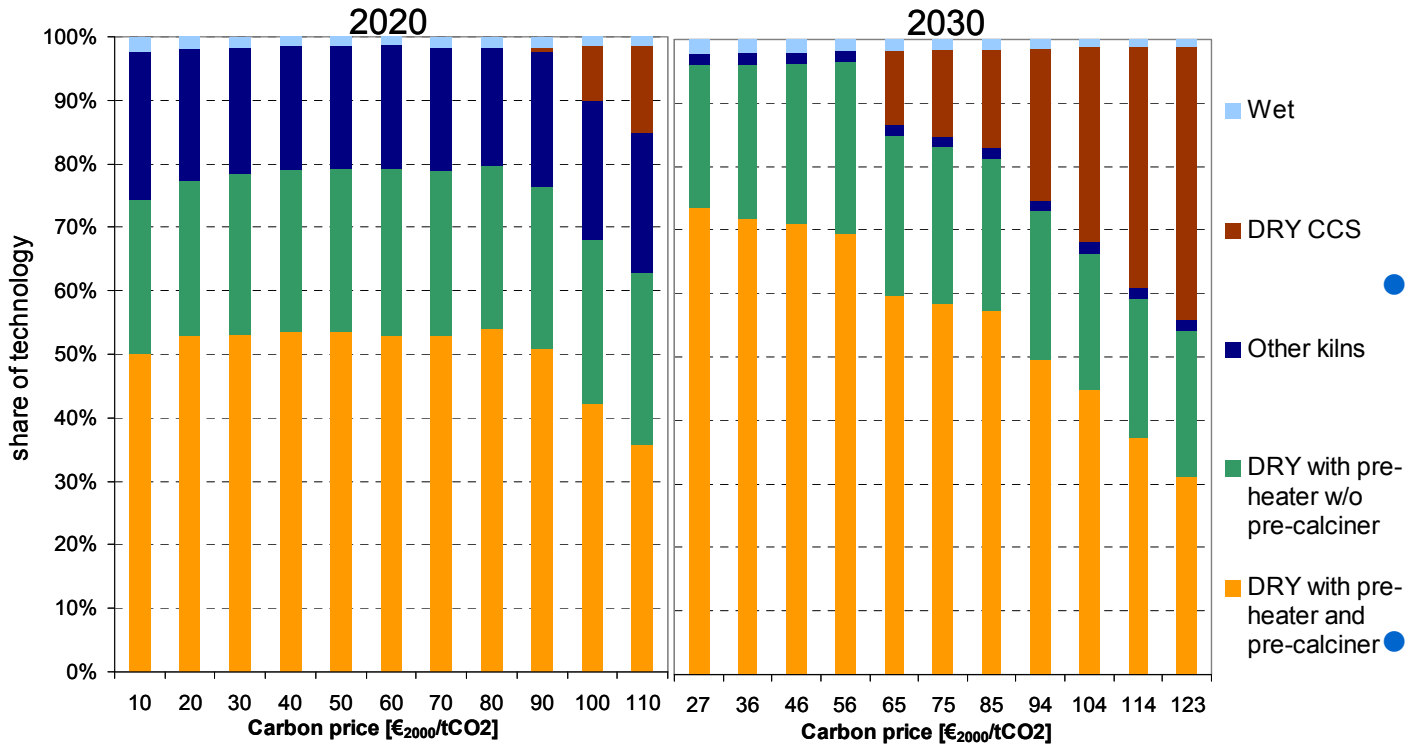
- Additional reduction at highest carbon price of 154 Mt. (123€/t to 27 €/t)
- Key sub-sectors: Cement, Iron&steel, chemical industry

Technology use in iron/steel industry (2030)



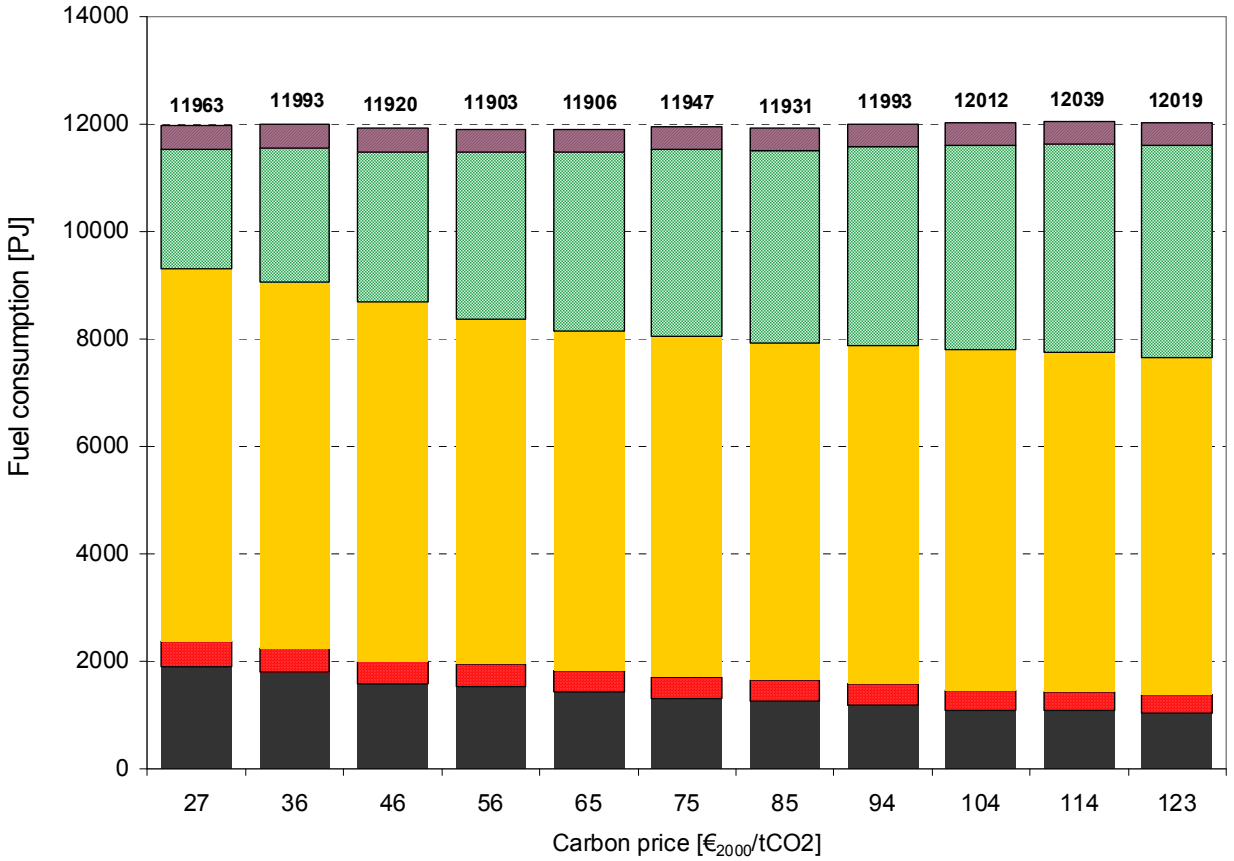
- Reduction possibilities: process improvements or changes, fuel switch, CCS
- High use of Electric Arc Furnace in 2030 even at low prices
- Above 56/65 €/t: higher share of CCS and reduced use of standard blast furnace

Technology use in cement industry (2020/2030)



- Reduction possibilities: efficient kilns, CCS, clinker substitution, alternative fuel use
- 2020: at higher CO_2 price switch to more efficient kilns, above 90 €/t early investment in CCS
- 2030: investment in CCS even above 65 €/t (instead of more efficient standard kilns)

Fuel consumption of industrial sector (2030)



- In total, constant consumption of fuels (fossils, renewables, waste)
- Different effects of efficiency improvements and use of renewables and CCS balance out
- Increasing share of renewables and CCS at higher prices

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Industrial emission reduction potential

- Both **industrial supply and production** processes have high potentials for emission reduction (necessary for ambitious targets)
- Clearly **different ways to reduce emissions** between supply and production processes
- Key driver **production**: efficiency improvements due to technology changes (focus: cement and iron&steel)
- Key driver **supply**: increased use of renewables
- **CCS**: important role both at production level (iron&steel, cement, ammonia) and supply side (mainly gas fired CHP)

Outlook

Industrial emission reduction potential

- All **emission reduction pathways** (renewables, efficiency improvements, CCS) are necessary at ambitious climate targets
- Even an **increasing** final **energy consumption** (industrial supply side: higher consumption due to renewables and CCS) and especially primary energy consumption (increasing use of electricity, CCS) could be necessary at ambitious climate targets
- **EU energy efficiency target** on general, non energy carrier specific energy consumption (20% reduction of PEC) could block one of the emission reduction pathways

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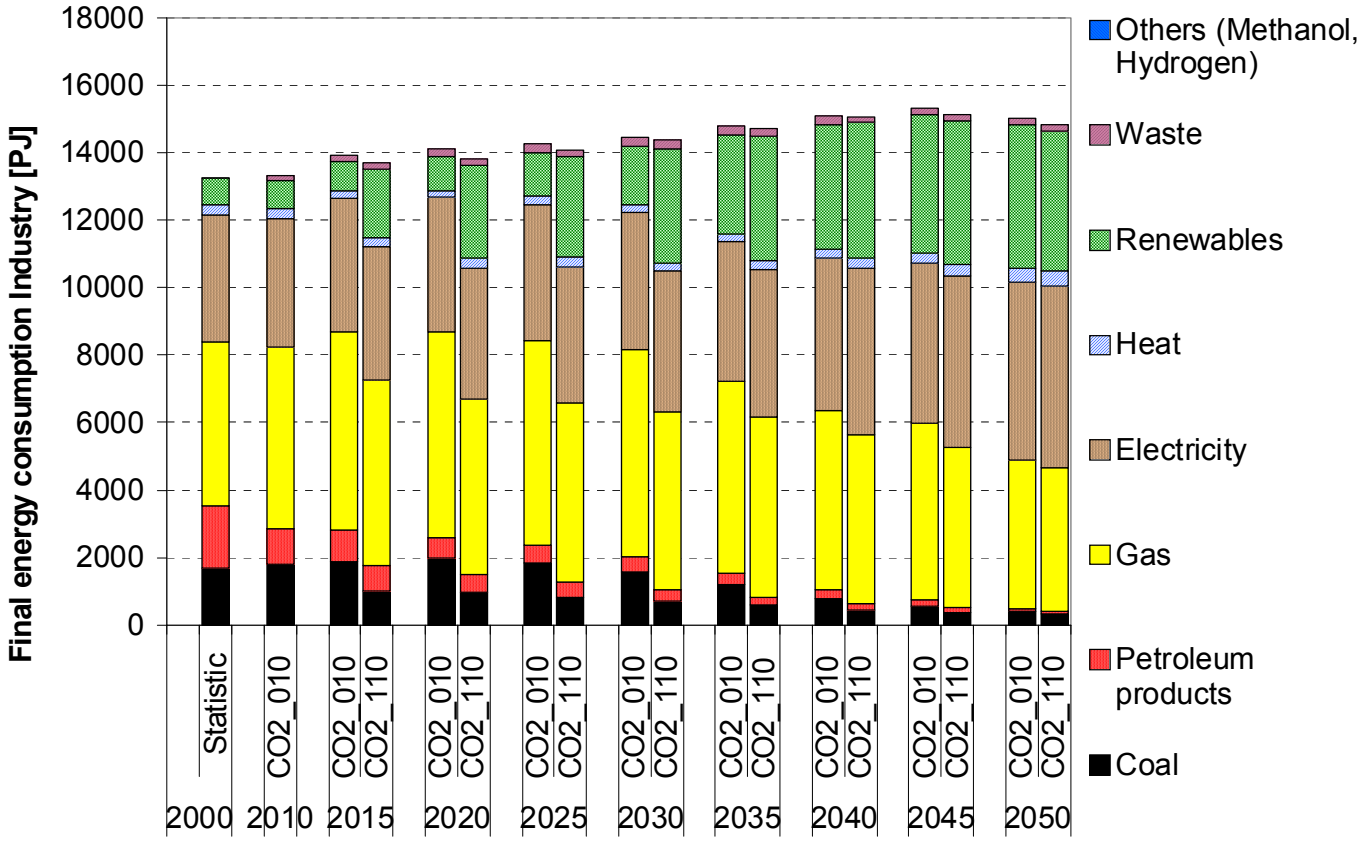
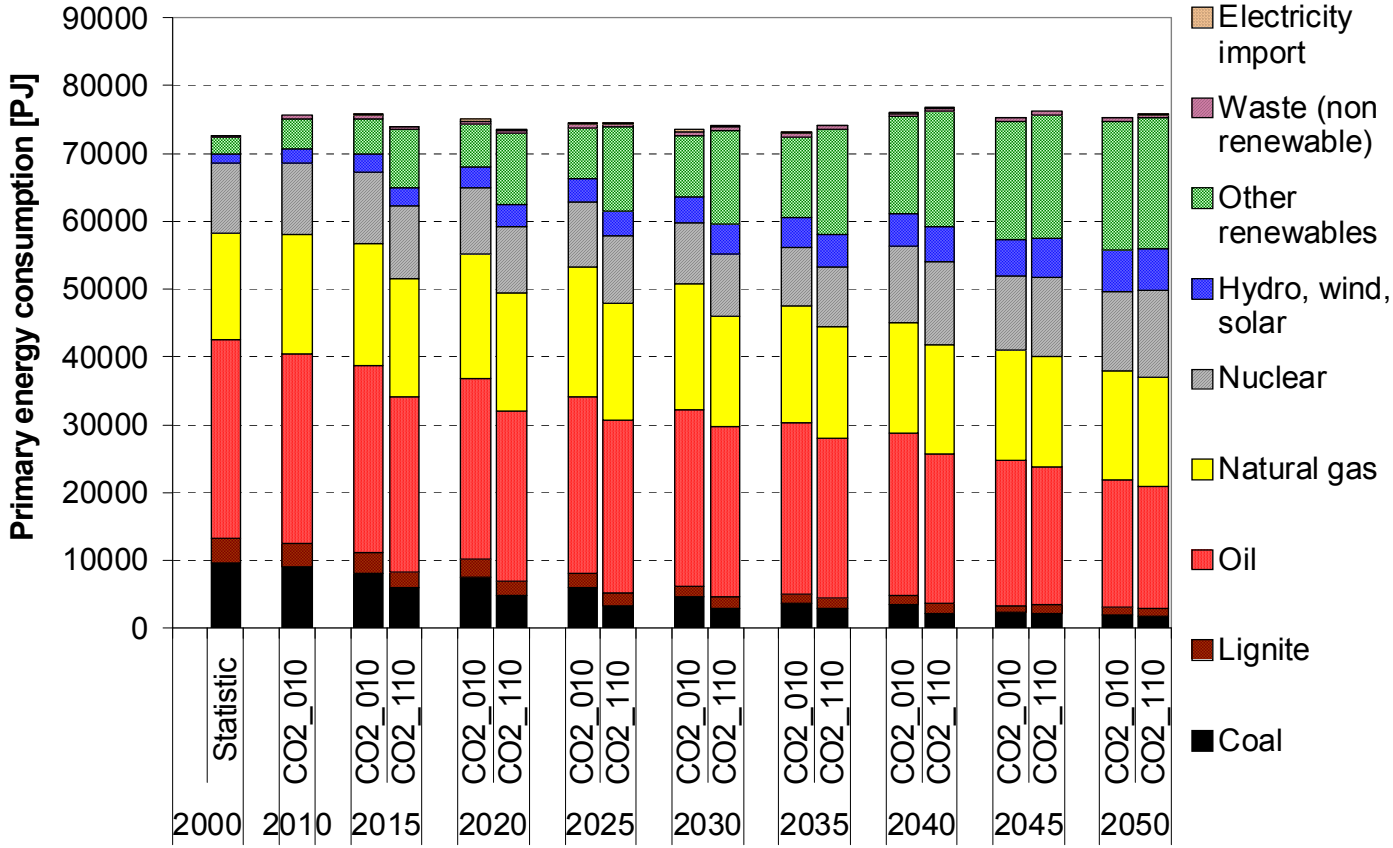
BACKUP

2000-2050: FEC Industrial Sector EU-27



- rise of FEC till 2045 mainly driven by NMS
- higher share of electricity and renewables in the long run in both scenarios
- Differences in the mid term: higher use of renewables instead of coal (mainly for heat production)

2000-2050: Primary Energy Consumption EU-27



- In total almost constant
- lower FEC, but higher conversion losses due to higher electricity generation (+CCS, renewables)
- decreasing role of fossil fuels
- At higher carbon price higher use of renewables, less oil