# ZEP-studie av kostnadseffektiv reduksjon av CO2-utslipp i Europa

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CenSES Energi- og klimakonferanse
3.12.2015 Oslo

# Report available now


http://www.zeroemissionsplatform.eu/library/publication/258-ccsforindustry.html

# ZEP – Zero Emission Platform

- European Technology Platform for Zero Emission Fossil Fuel Power Plants
- Coalition of stakeholders united in their support for $CO_2$ Capture and Storage (CCS) as a key technology for combating climate change

- Three main goals:
  1. Enable CCS as a key technology for combating climate change
  2. Make CCS technology commercially viable by 2020 via a EU-backed demonstration programme
  3. Accelerate R&D into next-generation CCS technology and its wide deployment post-2020

# Participants in the study

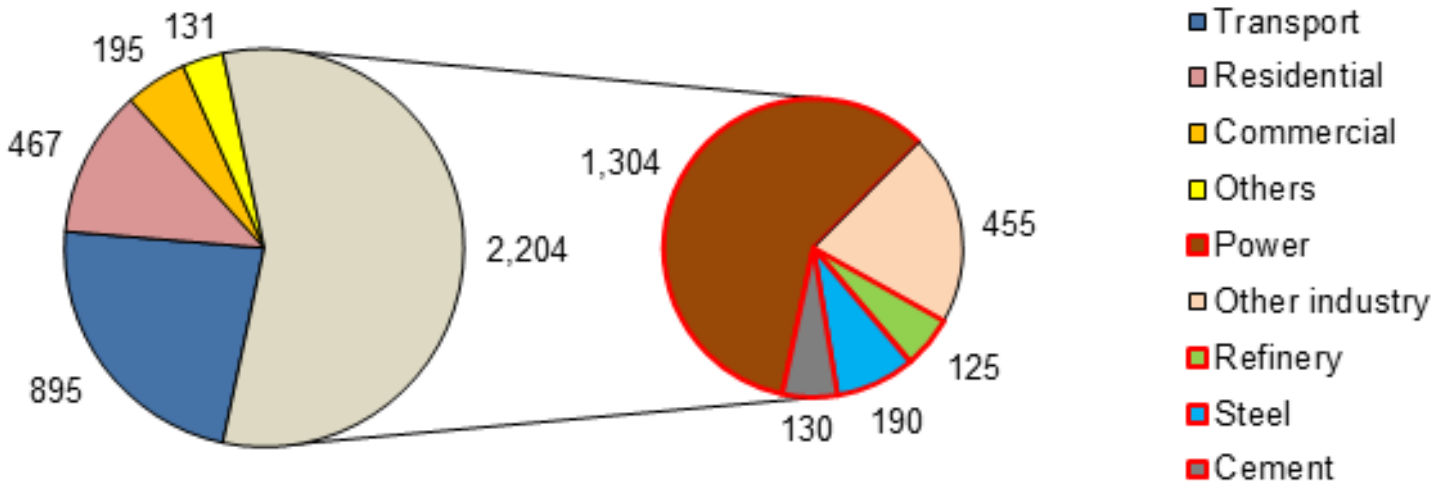
| Name | Country | Organisation |
|---|---|---|
| Bruce Adderley | UK | Sheffield University |
| Gian Luigi Agostinelli | Switzerland | General Electric |
| Heinz Bergmann | Germany | IZ Klima |
| Karl Buttiens | Luxembourg | ArcelorMittal |
| Umberto Desideri | Italy | University of Pisa |
| Niall Mac Dowell | UK | Imperial College |
| Mark Downes | UK | Shell |
| Paul Fennell | UK | Imperial College |
| Ward Goldthorpe | UK | Crown Estate |
| Lily Gray | The Netherlands | Shell |
| Gianfranco Guidati | Switzerland | General Electric |
| Jonas Helseth | Belgium | Bellona Europa |
| Zoe Kapetaki | Belgium | Global CCS Institute |
| Nicolas Kraus | Belgium | EPPSA |
| Ian Luciani | UK | BP |
| Wilfried Maas | The Netherlands | Shell |
| Kjetil Midthun | Norway | SINTEF |
| Theo Mitchell | UK | CCSA |
| Hans Modder | The Netherlands | ZEP Secretariat |
| Magnus Moertberg | Germany | General Electric |
| Tim Peeters | The Netherlands | Tata Steel |
| Peter Radgen | Switzerland | Swiss Federal Office of Energy (SFOE) |
| Alan Reid | Belgium | CONCAWE |
| Christian Skar | Norway | Norwegian University of Science and Technology (NTNU) |
| Charles Soothill | Switzerland | General Electric |
| Katrin Stoetzl | Belgium | EUTurbines |
| Kazimierz Szynol | Poland | PKE S.A. |
| Asgeir Tomasgard | Norway | SINTEF |
| Robert van der Lande | The Netherlands | ZEP Secretariat |
| Rob van der Meer | The Netherlands | HeidelbergCement |
| Ralf Wezel | Belgium | EUTurbines |
| Keith Whiriskey | Belgium | Bellona Europa |

# Background

- SINTEF was asked to use the EMPIRE model to perform analysis on behalf of ZEP
- Data gathering and analysis requests made by ZEP
- All data and assumptions are provided in the ZEP-report
- Model runs performed by SINTEF

# Scope

- $CO_2$ emissions and mitigation options for power and large industrial emitters – Steel, Refineries and Cement
- Chemical industry not considered due to high diversity
- Represent 50% of Europe's 2010 emissions of 3.8 $Gt_{CO2}$/a
- Time horizon from 2010 to 2050

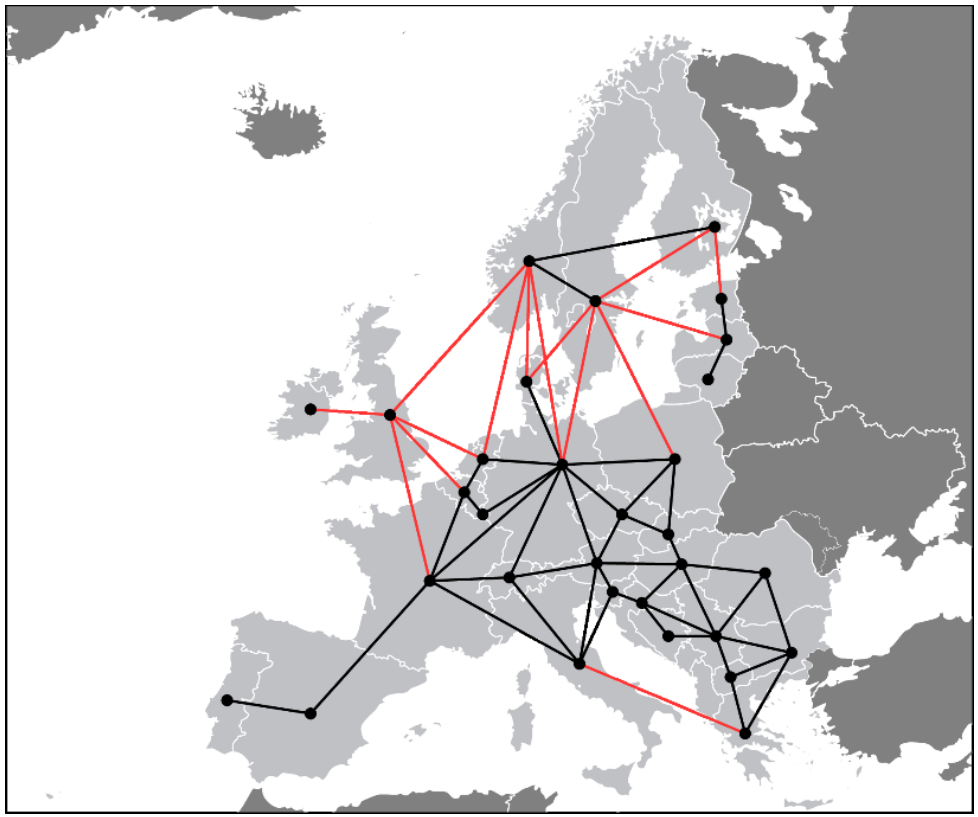


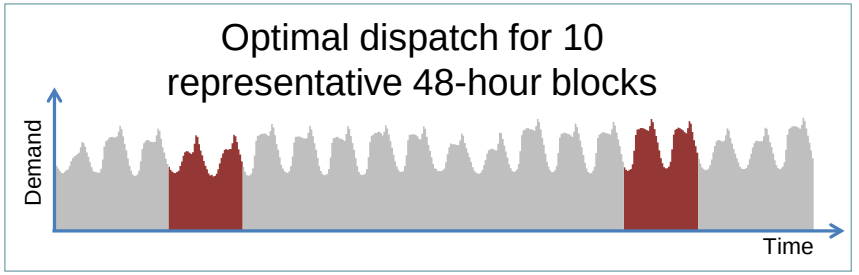
# Objectives

- Quantify costs of decarbonization
- Compare different options (CCS, RES)
- Show the impact of delayed deployment of CCS
- Highlight the role of Transport & Storage (T&S) costs and the value of clusters to push CCS
- Determine necessary supporting measures to accelerate CCS deployment

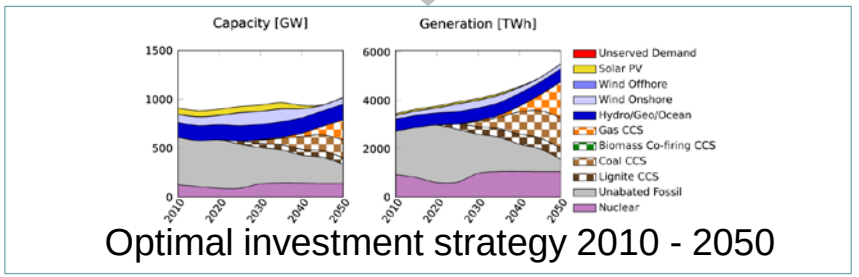
- **EU objective: reduce CO2 emissions for power and large industry by 80-95% by 2050 (ref 1990)**

# EMPIRE Model - Determine cost optimal investment strategy until 2050 for each European country





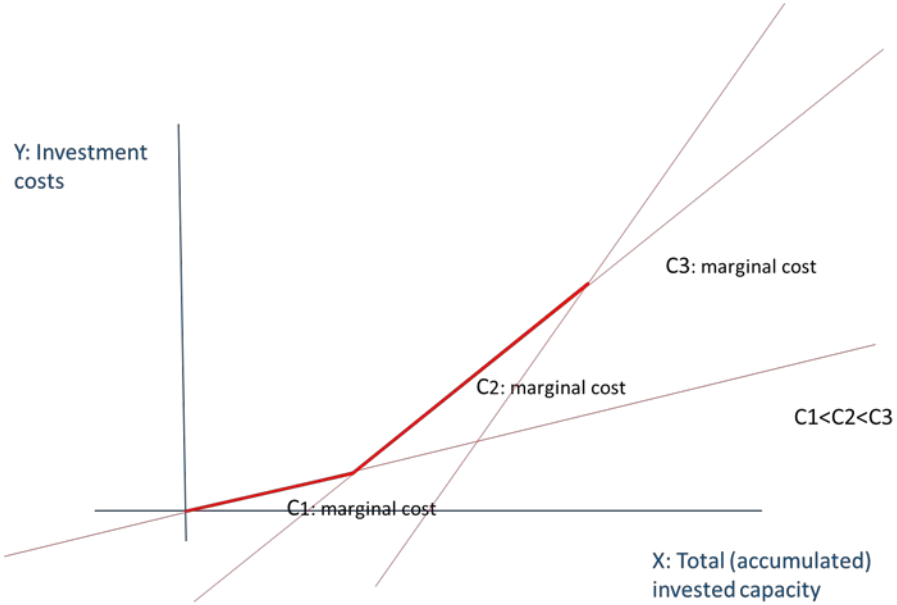

Coupled optimization problem to minimize total system costs

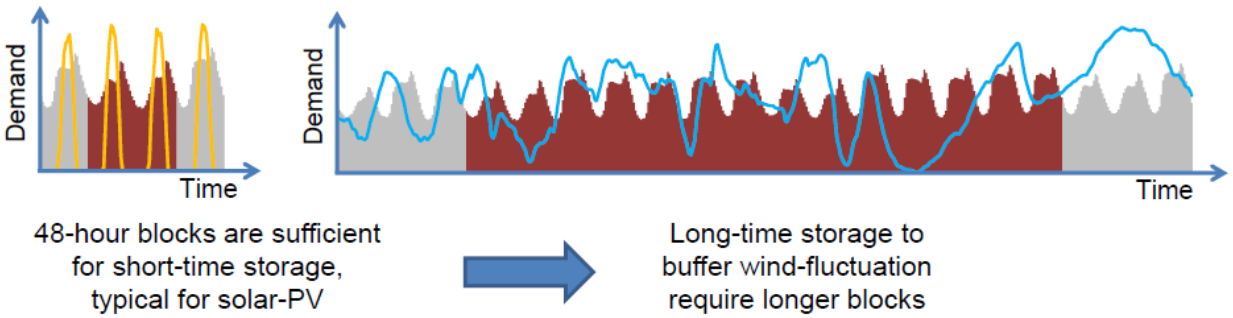



Optimal investment strategy 2010 - 2050

# Model developments

- Industrial emitters
- Longer time horizons
- New storage technologies
- Clusters for transport and storage



# Industry emitters - refineries

- About 80 refineries operating in EU in 2015
- Accounts for approximately 14% of EUs direct industrial emissions

- Numerous $CO_2$ emission points
  - Fired heaters for distillation columns
  - Fluid catalytic crackers

- Reduction options
  - Improve energy efficiency
  - Fuel switching
  - CCS

- CCS expected to be important when first two options are fully utilised
- Different technology solutions required
- Need for retrofitting leads to high costs

# Industry emitters - steel

- Two main routes: from iron ore and scrap

- EU accounts for approximately 10% of global steel production
- About 21% of EUs industrial $CO_2$-emissions comes from the steel industry

- Continuous process improvements has reduced the CO2 emissions. Potential for further reductions:
  - Higher level of scrap recycling
  - Increased utilization of the off-gases available on site
  - Energy efficiency improvements
  - CCS

- CCS is recognised by the global steel community as an important option for reducing $CO_2$ emissions

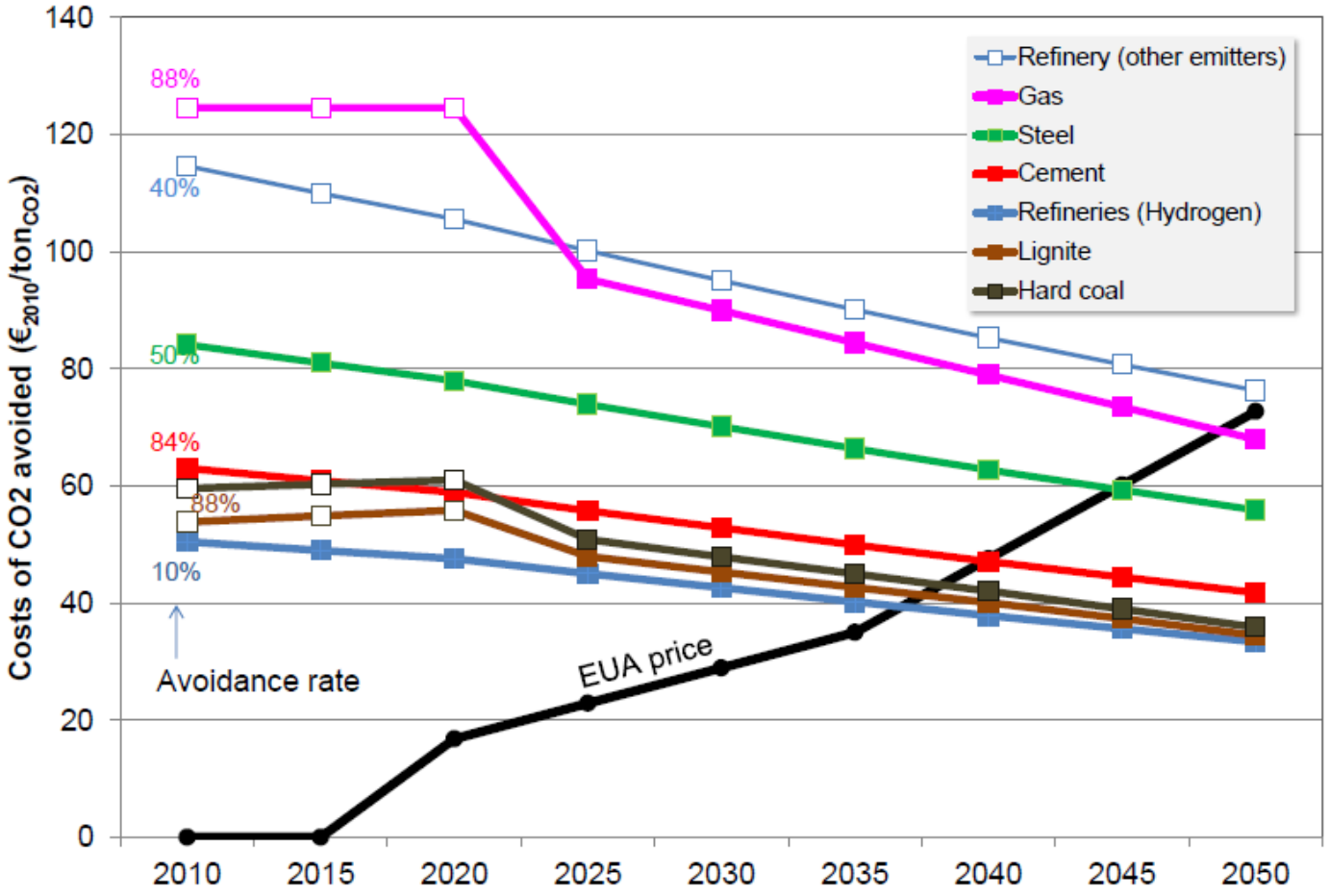
# Industry emitters - cement

- The cement industry in EU has been negatively affected by the economic crisis
  - From 2007 to 2010 the production dropped from 270 Mt to 190 Mt
- There are approximately 270 cement production plants in EU

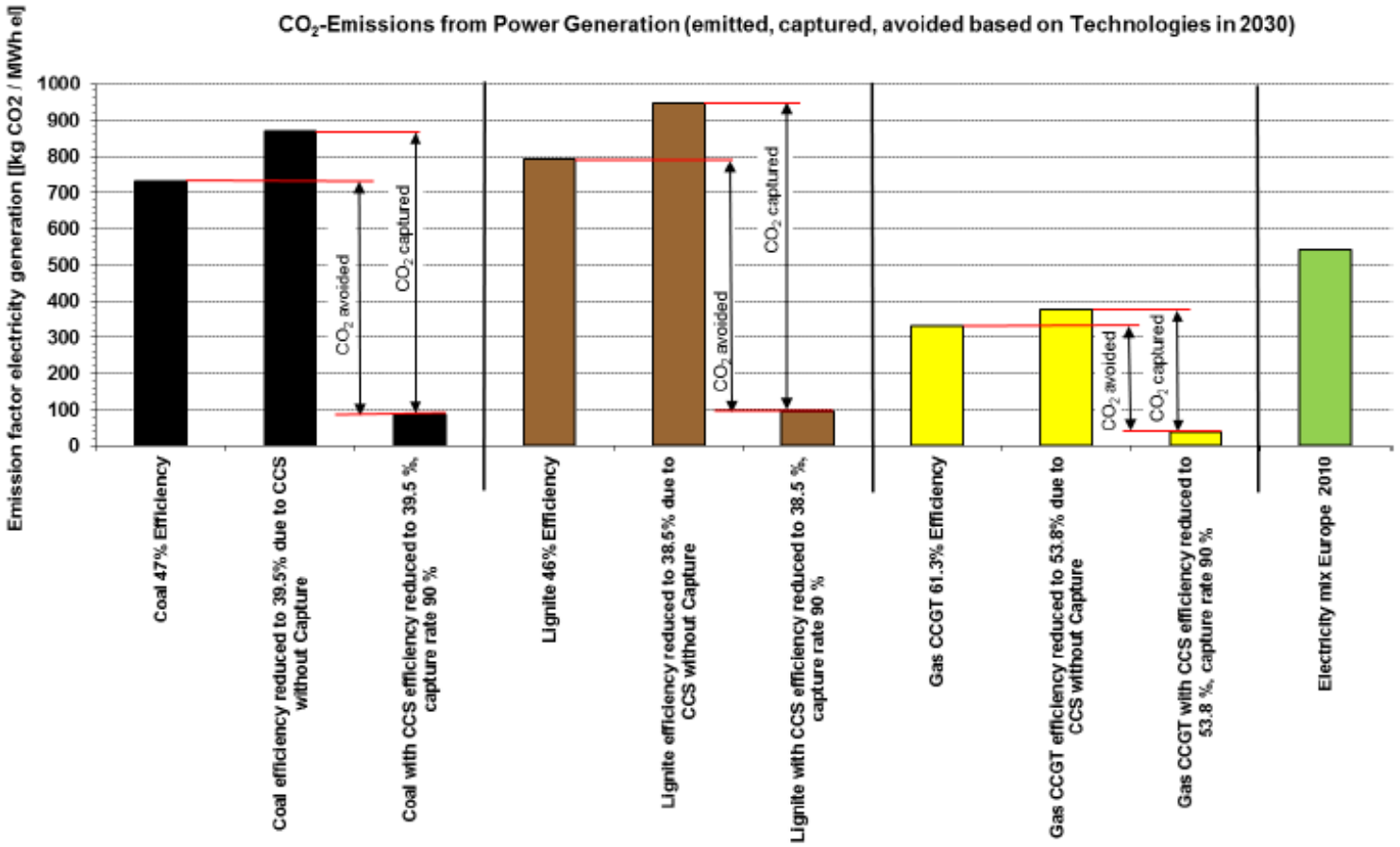
- The $CO_2$ emissions from the cement industry represents about 14% of EUs total industrial emissions

- Reduction options
  - Large parts of the emissions are inherently unavoidable
  - Energy efficiency
  - Fuel switching
  - CCS

# Cost assumptions



# $CO_2$ avoided versus $CO_2$ captured



# Model considerations

- Electricity generation
  - Cost-efficient satisfaction of electricity demand
  - Technology choice
  - Avoidance cost versus emission cost

- Industry emitters have three options
  - Emit $CO_2$ and pay the $CO_2$ price (
  - Deploy CCS
  - Shift production outside the EU

  - The industry has free allowances that are reduced linearly towards 2050

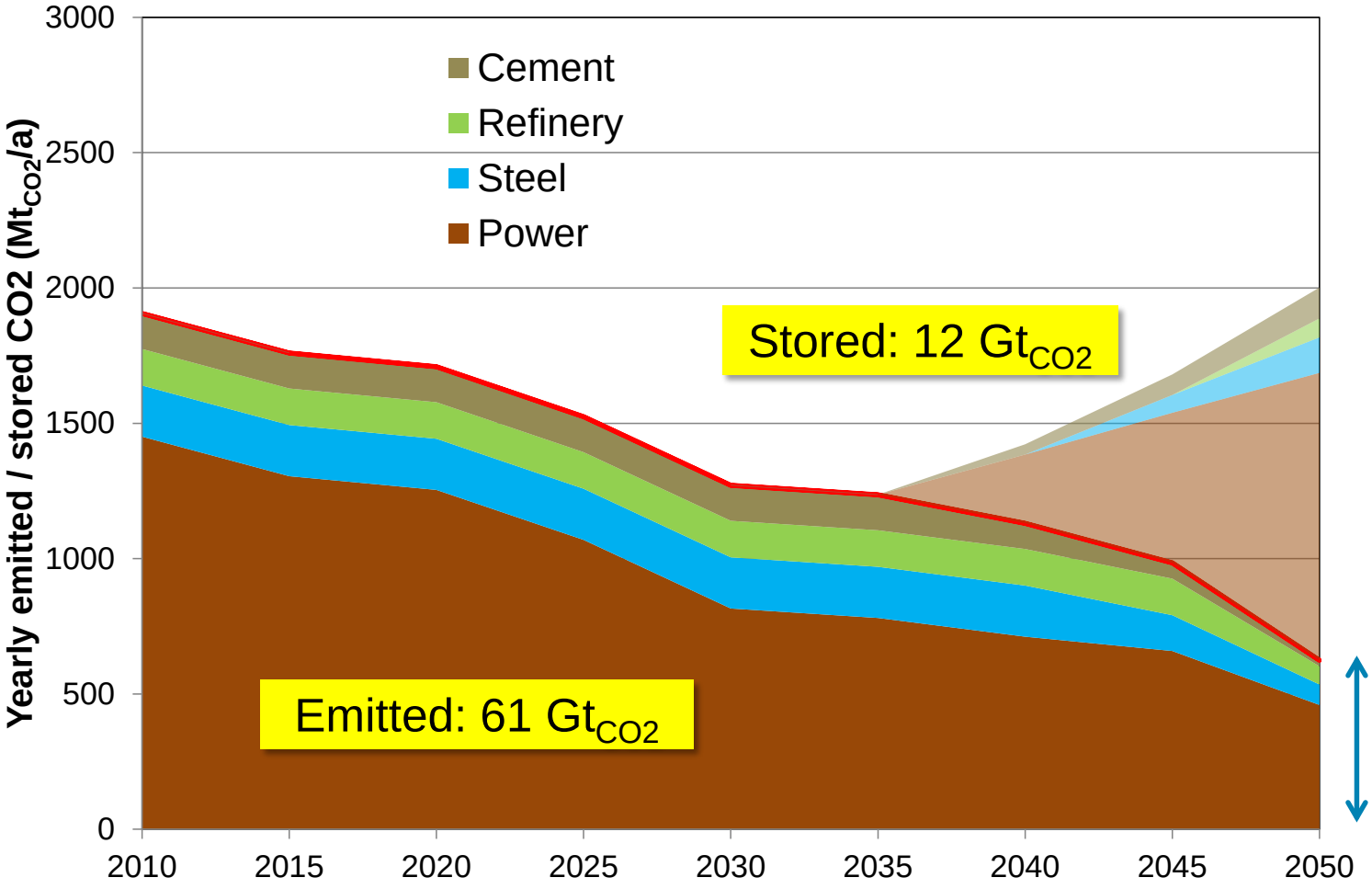
# Analysis results

The results are based on the GCAM 450 ppm scenario

- Increase in electricity consumption of 60% from 2010 to 2050
- Reduction in carbon emissions obtained with a carbon price (some runs also with limits on emissions)
  - Leads to electrification

# Yearly emitted/stored CO2

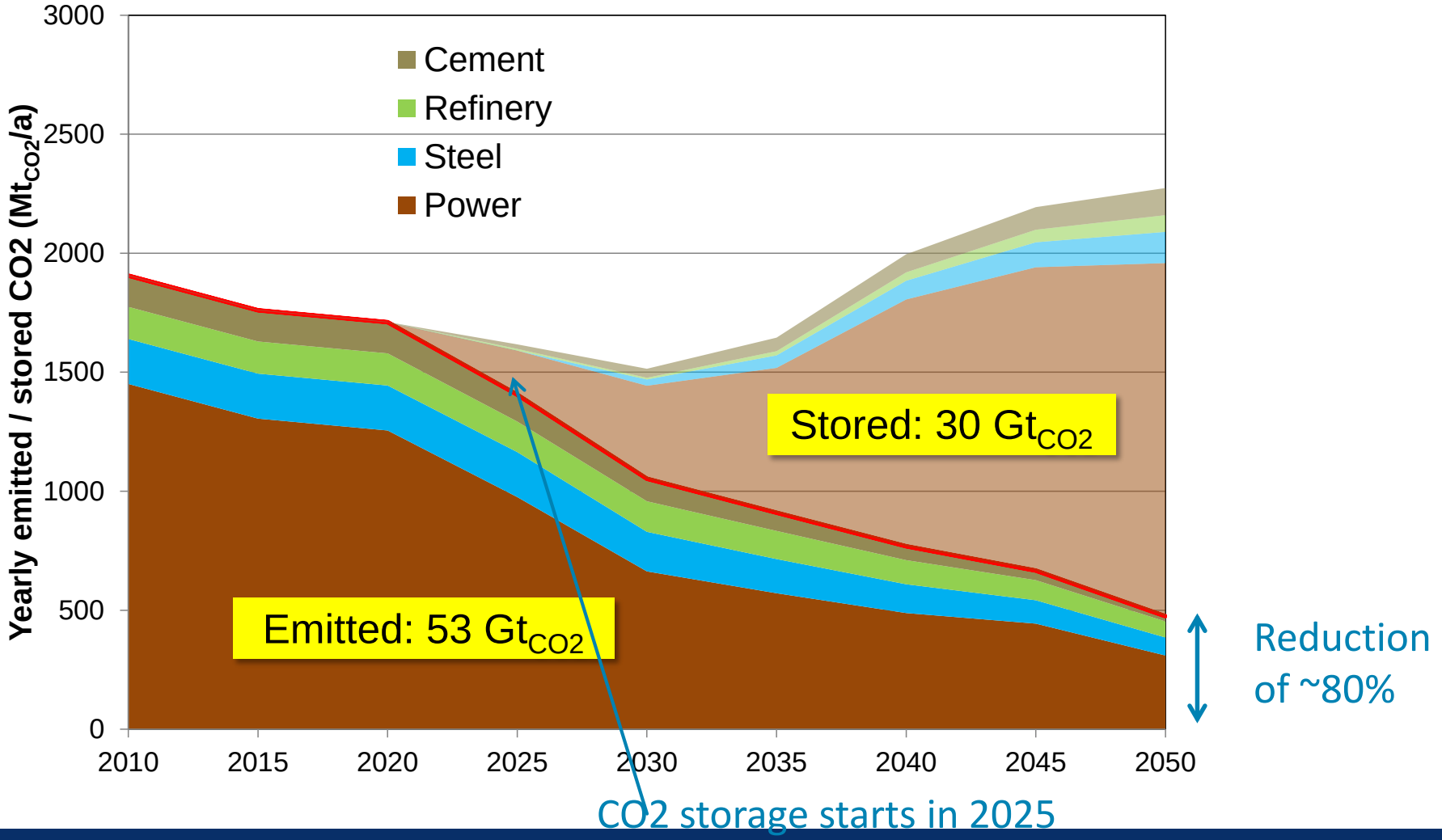
## No supporting measures




Only 68% reduction can be achieved

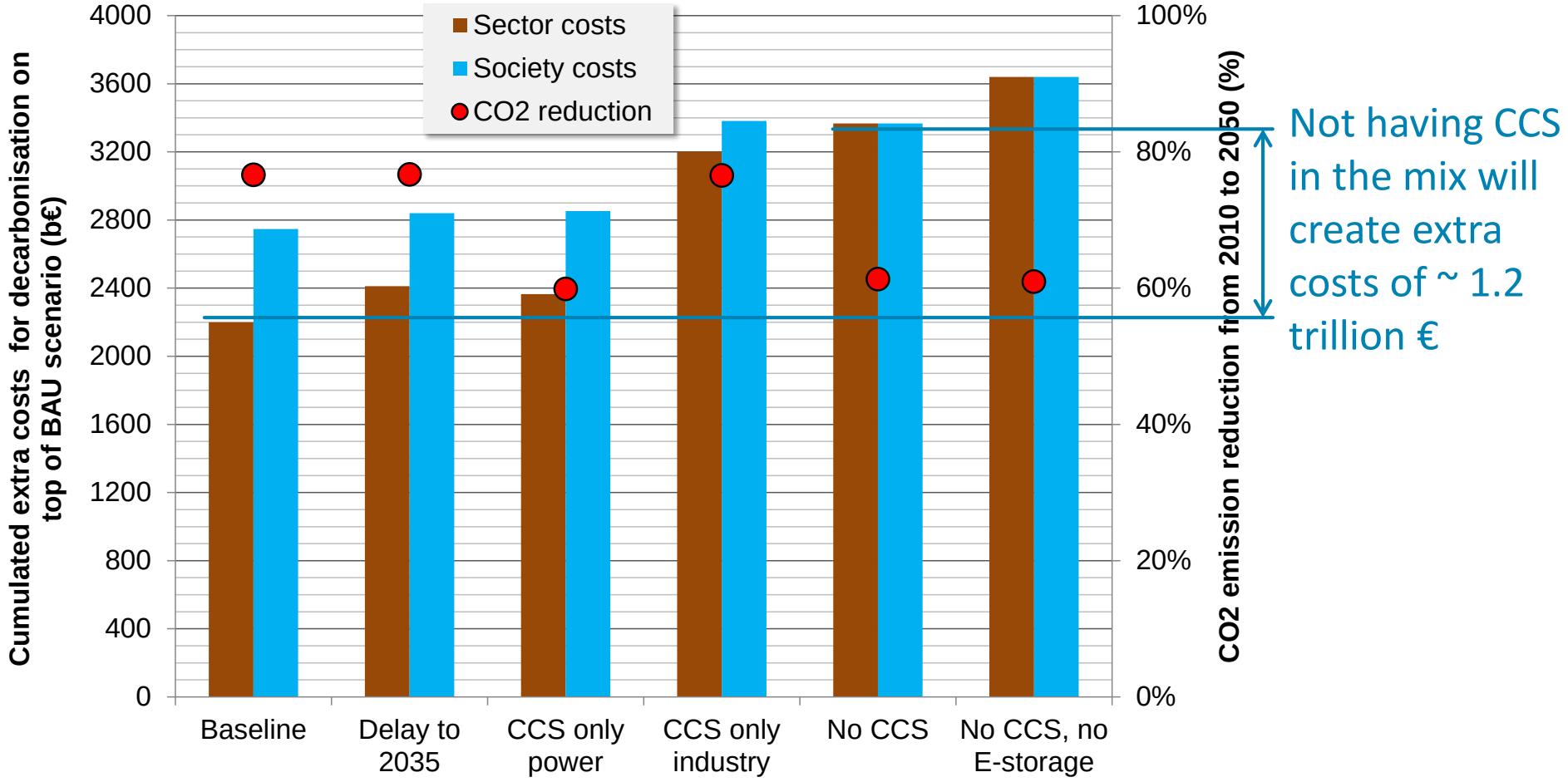
# Yearly emitted/stored CO2 (Baseline)

## Upfront public investment in T&S infrastructure + support to industry



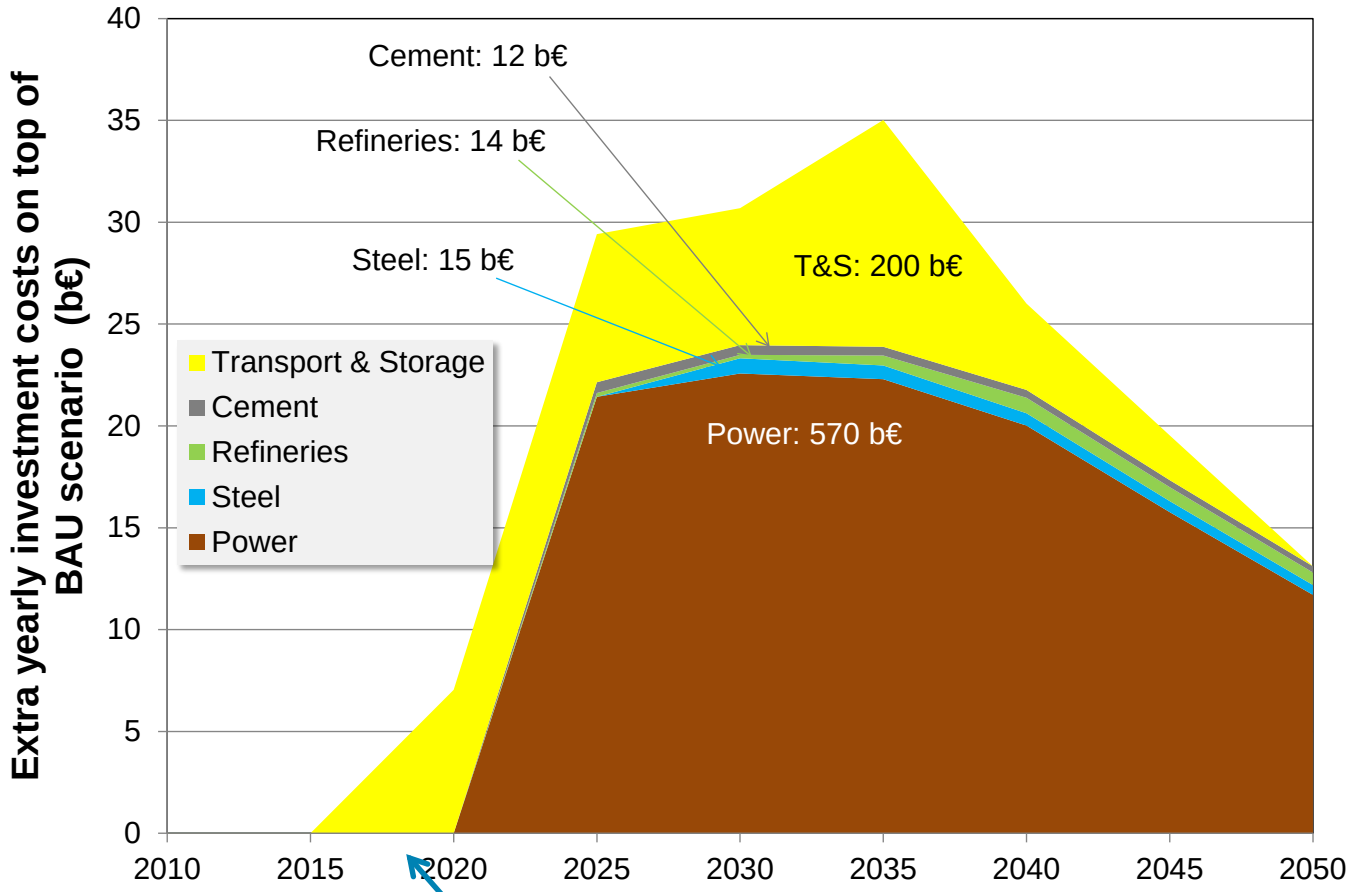
# Costs of decarbonization

## On top of business-as-usual, cumulated from 2010-2050



# Yearly investment costs for CCS

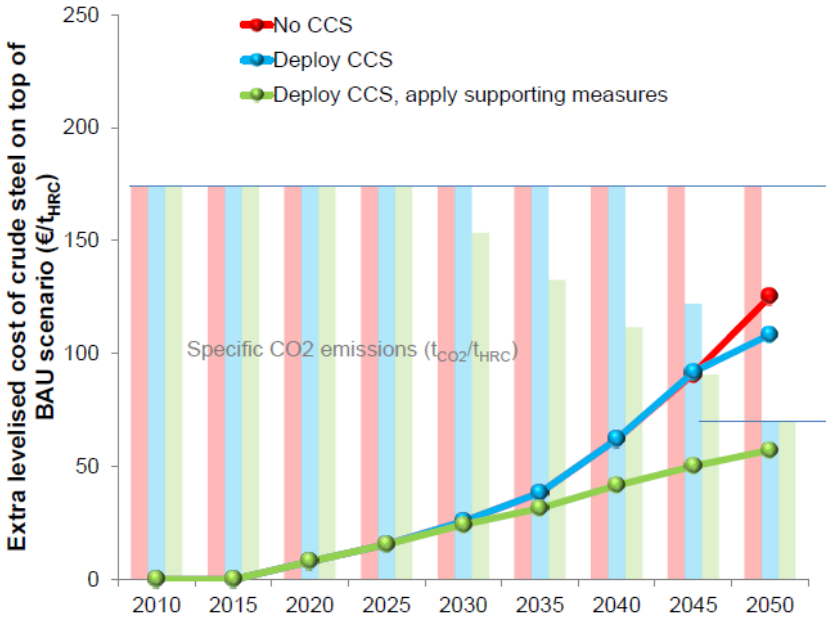
## On top of business-as-usual



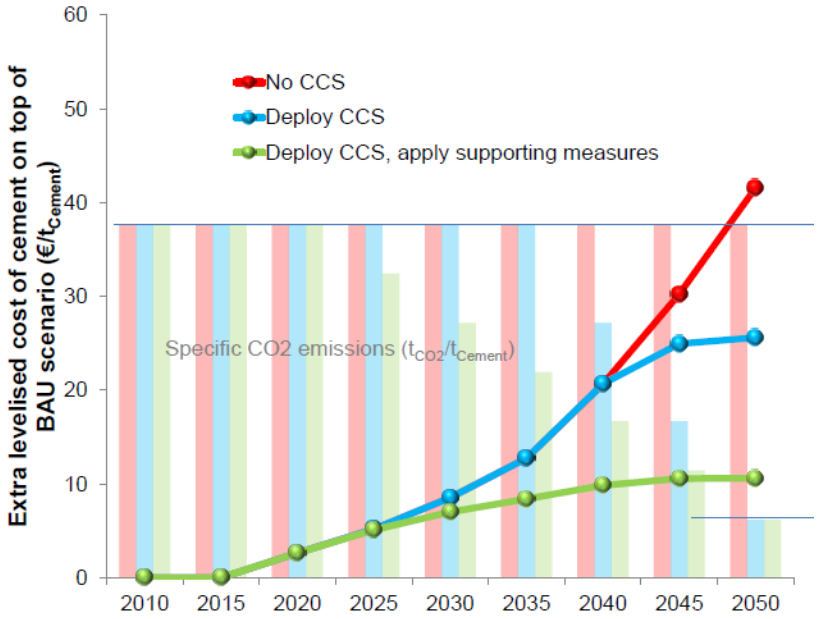

Investment into CO2 transport & storage infrastructure must start now

# Extra levelised cost on top of BAU scenario

Steel




Cement



# Summary of the analysis

- Yearly $CO_2$ emissions from power and large industrial sectors can be reduced by 80% in 2050
- CCS is an important part of the mix – total cumulative costs of de-carbonization can be reduced by 1.2 trillion $€_{2010}$ for the same emission reductions
- In order to be ready for CCS in 2025, investment into $CO_2$ clusters sharing transport & storage infrastructure is important (3-6 20 $Mt_{CO2}$/y clusters for approx 6-12 b€)
- CCS will increase product costs for industry – appropriate measures have to be taken to avoid a de-industrialization of Europe
- A reliable and stable $CO_2$ price signal is required for long term investments in CCS to become reality