Impacts of deep decarbonization pathways on the Italian energy intensive industries

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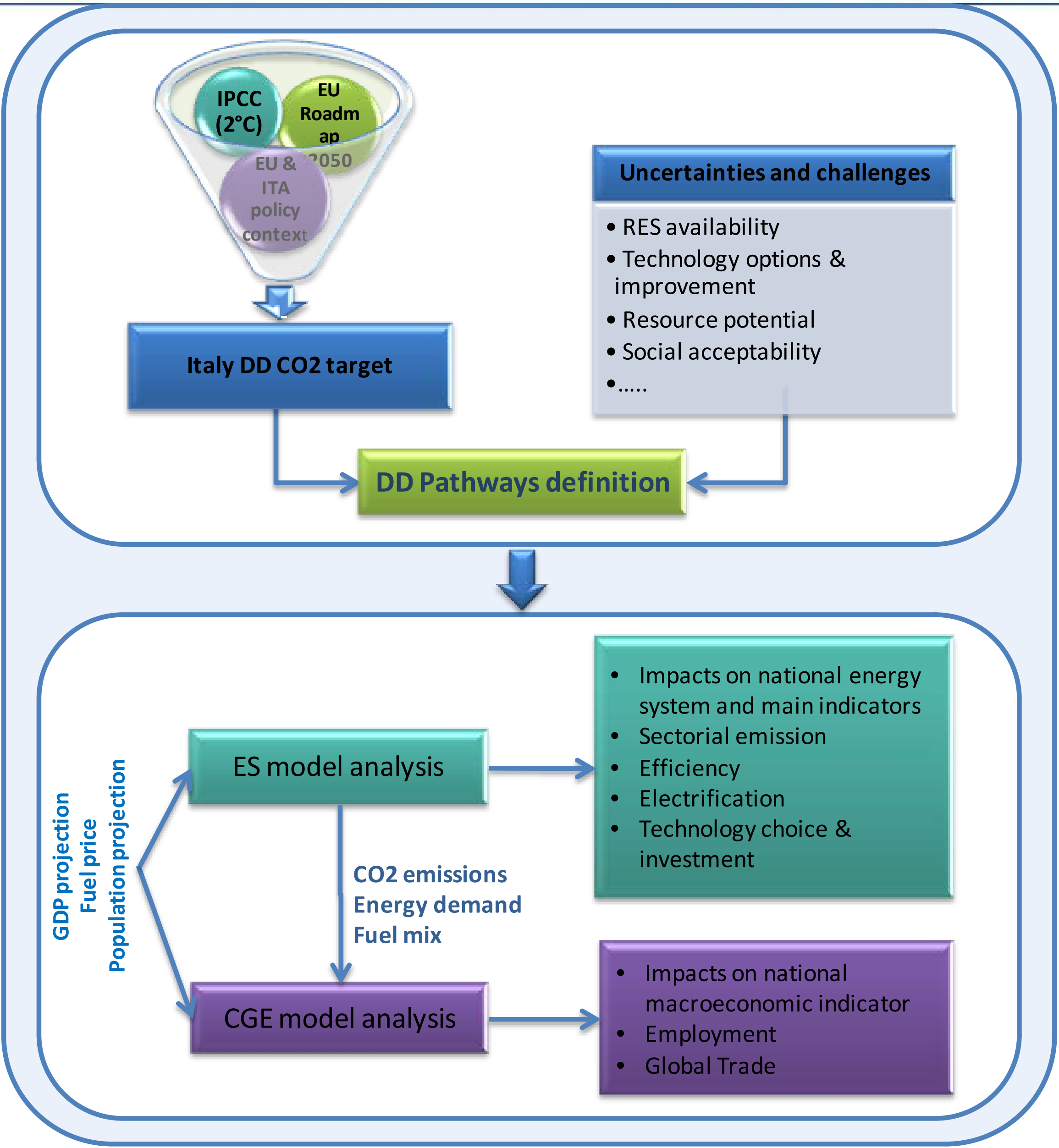
Background and objectives

- Work carried out in the framework of the DDPP project (led by IDDRI and the UN Sustainable Development Solutions Network) and in collaboration with FEEM. Results presented here based only on ENEA work.
- Objective: to explore the impacts of three different decarbonization pathways to 2050 for Italy. Scenarios consider 80% CO2 emissions reduction by 2050 w.r. to 1990.
- The focus is on the role of CCS and energy efficiency in CO2 emissions reductions, assuming different levels of penetration of CCS and different effort in energy efficiency.
- Special attention paid to energy intensive industries.
- The response strategies of the system analyzed with a linear optimization model (TIMES-Italy) under different technological hypotheses.
- Two alternative economic assumptions: exogenous energy service demand and price elastic energy service demand.
- The second case explicitly considers output reduction in energy intensive industries as a response strategy in a scenario where industrial CCS options are limited.
- The same scenarios are assessed also from a macroeconomic perspective using a CGE model (GDyn-E).

Methodological approach



- **Stage 1: Analysis of the Italian energy system to identify key uncertainties, challenges & build consistent storylines.**
- **Stage 2: Definition of reference macroeconomic drivers and CO_2 emissions for the REF and DDP scenarios.**
- **Stage 3: Quantification of the main energy trends for the chosen scenarios using the energy system model TIMES-Italy;**
- **Harmonization of drivers defined in Stage 2 with the output produced by TIMES Italy in Stage 3 (primary energy supply by source, emission reduction targets etc.) in the CGE model GDyn-E**
- **Stage 4: Top-down, macroeconomic evaluation of the decarbonization scenarios with the CGE model.**

Key Challenges and uncertainties

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No Nuclear	- The nuclear option excluded(referendum in 2011). This could result in an increase in the generation costs for greater use of other options.
RES	- Intermittent renewables require suitable network infrastructure (smart grid, electric batteries and storage etc ...) -> investment and O&M costs increase. - Resource availability (in particular for bioenergy)
CCS	- R&D and commercialization - CO_2 storage sites and social acceptability

ELECTRIFICATION	- It is promoted by low electricity prices. - Lack of one or more decarbonisation factors of the electricity system reduces the role of electrification in the end-use sectors - EV and heat pumps deployment.
RES in end-use sectors	- Resource availability (in particular for bioenergy). - Air quality (for biomass).
TRANSPORT	- Infrastructure costs for modal shift and attitudes towards public transport. - R&D and costs of hydrogen and electrical storage.
Energy efficiency	- High buildings retrofitting costs and availability of financing.
Industry	- CCS R&D and commercialization - CO_2 storage sites and social acceptability - High energy prices could influence the shift towards a less energy intensive industry

Scenario overview

The three scenarios are characterized as follows:

The **CCS scenario (CCS):**

- High public acceptance of key low carbon generation technologies.
- Abundant renewable sources, capture technology and CO_2 storage sites allow to decarbonize the electricity system ➡ high electrification of heating and transport ;
- Large amount of electricity from renewables and fossil fuel technologies coupled with CCS.

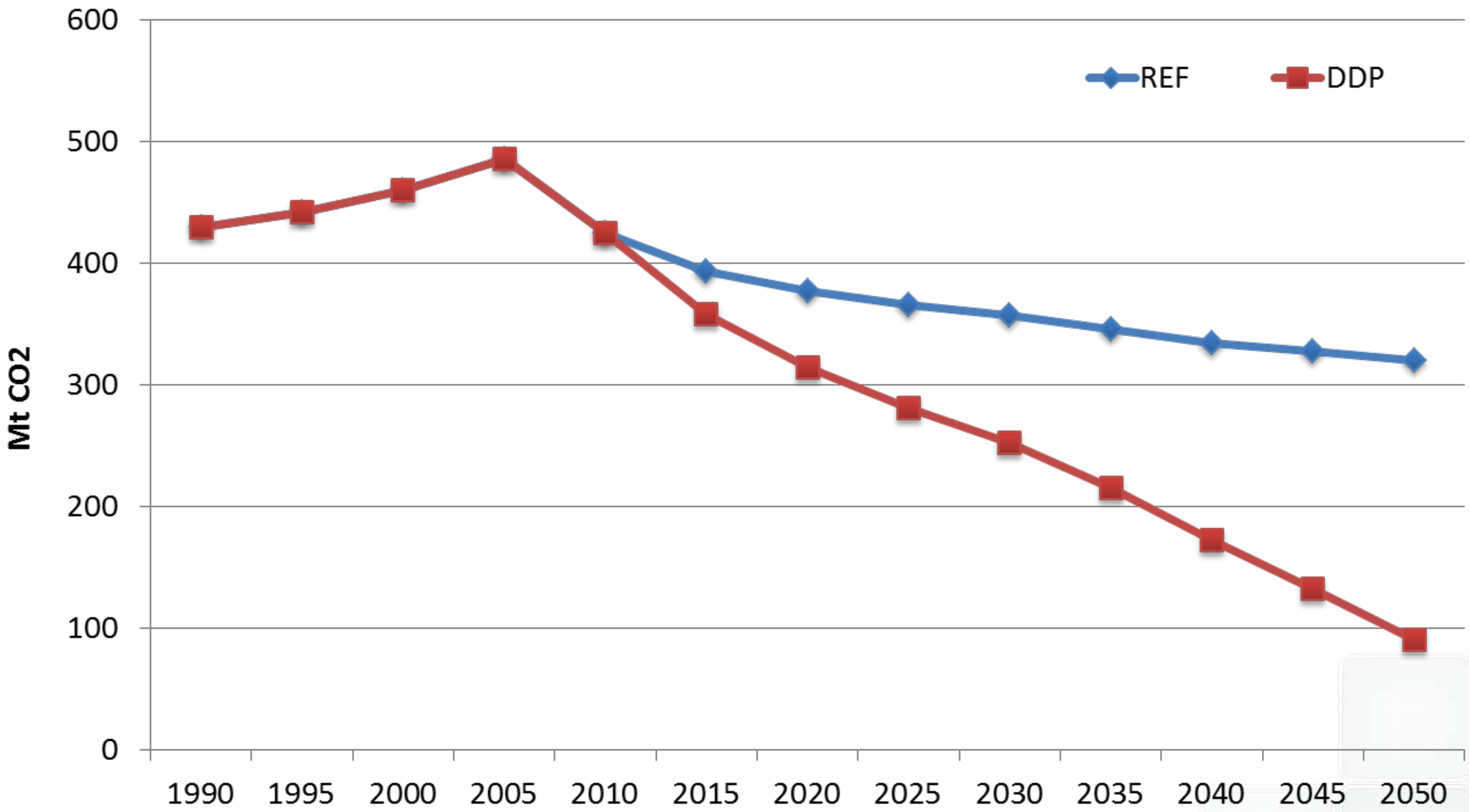
- The **EFF scenario (EFF):**
  - Lower availability of options to decarbonize the electricity system, results in relatively higher costs and a reduction of the electricity consumed in end-use sectors.
  - This is compensated by an increased reliance on advanced energy efficiency technologies and a greater renewable energy use for heat and transportation.
  - A lower sectoral discount rate stimulates a higher penetration of new and advanced energy efficiency technologies
- The **DMD_RED scenario (DMD_RED)**
  - Limited availability of CCS (especially in the industrial sector) and high cost of decarbonization.
  - Low public acceptance of CCS, in part due to insufficient policy effort.
  - Simulated using the TIMES-Italy model in the version with price elastic demand:
  - the demand drivers of end-use sectors are influenced by high fuel and energy carrier prices.

Scenario overview

	CCS	EFF	DMD_RED
Generation decarbonization			
Nuclear	-	-	-
RES	+++	++	++
CCS	+++	++	+
Electrification			
Heat pumps, EV and PHEV	+++	++	++
Fuel switch to electricity	+++	+	+
End-use sectors			
Building retrofit	++	+++	+++
Advanced eff. technologies	++	+++	+++
RES for heat and transportation	+++	+++	++
Fuel switch in final sectors	++	+++	+++
CCS in Industrial sector	+++	++	+
Service demand in final sectors			
Transport modal shift	+	+	++
Reduction in Industry production	-	-	++

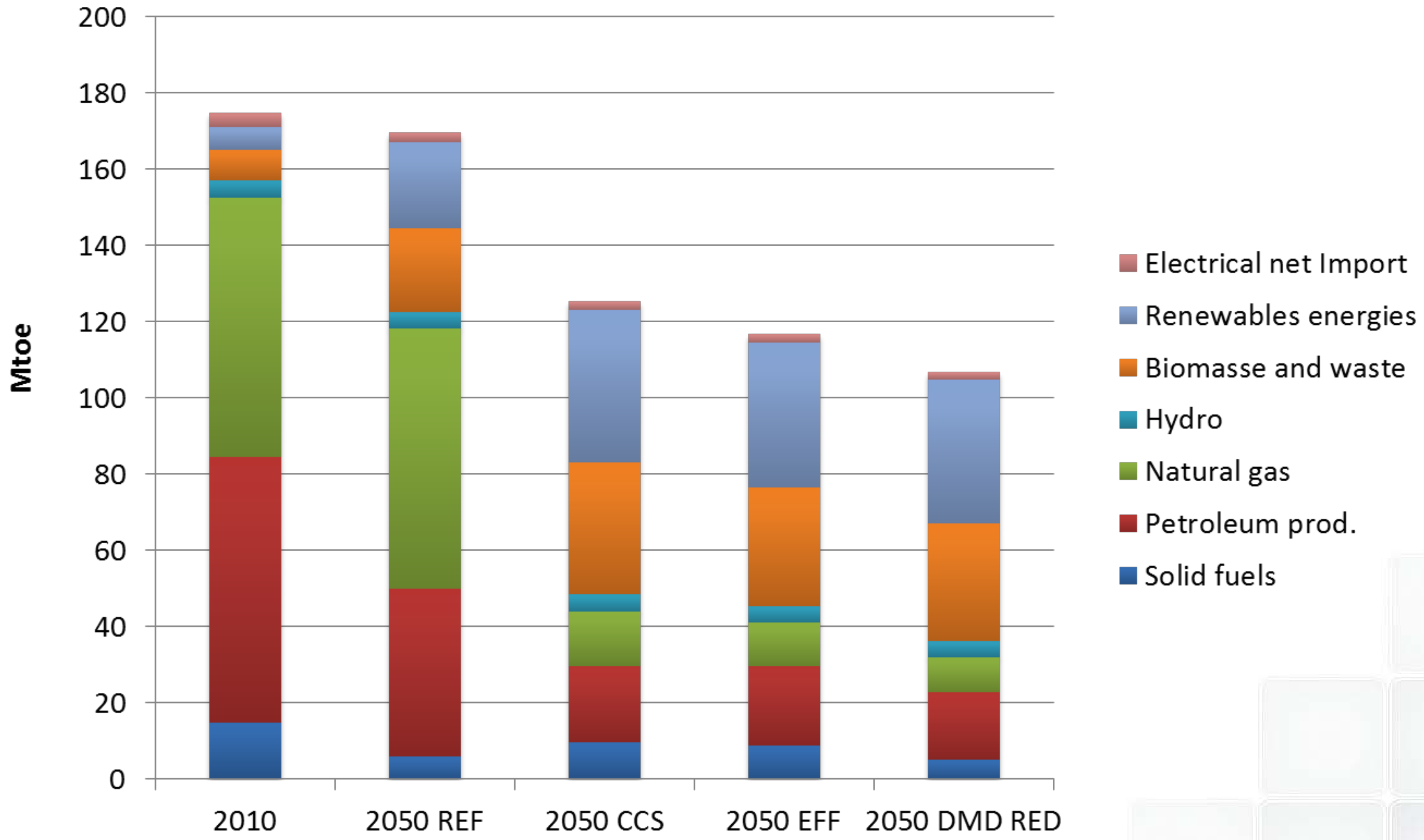
Results

Energy-related and process CO_2 emissions in Reference Scenario and Deep Decarbonization Pathways – $MtCO_2$.



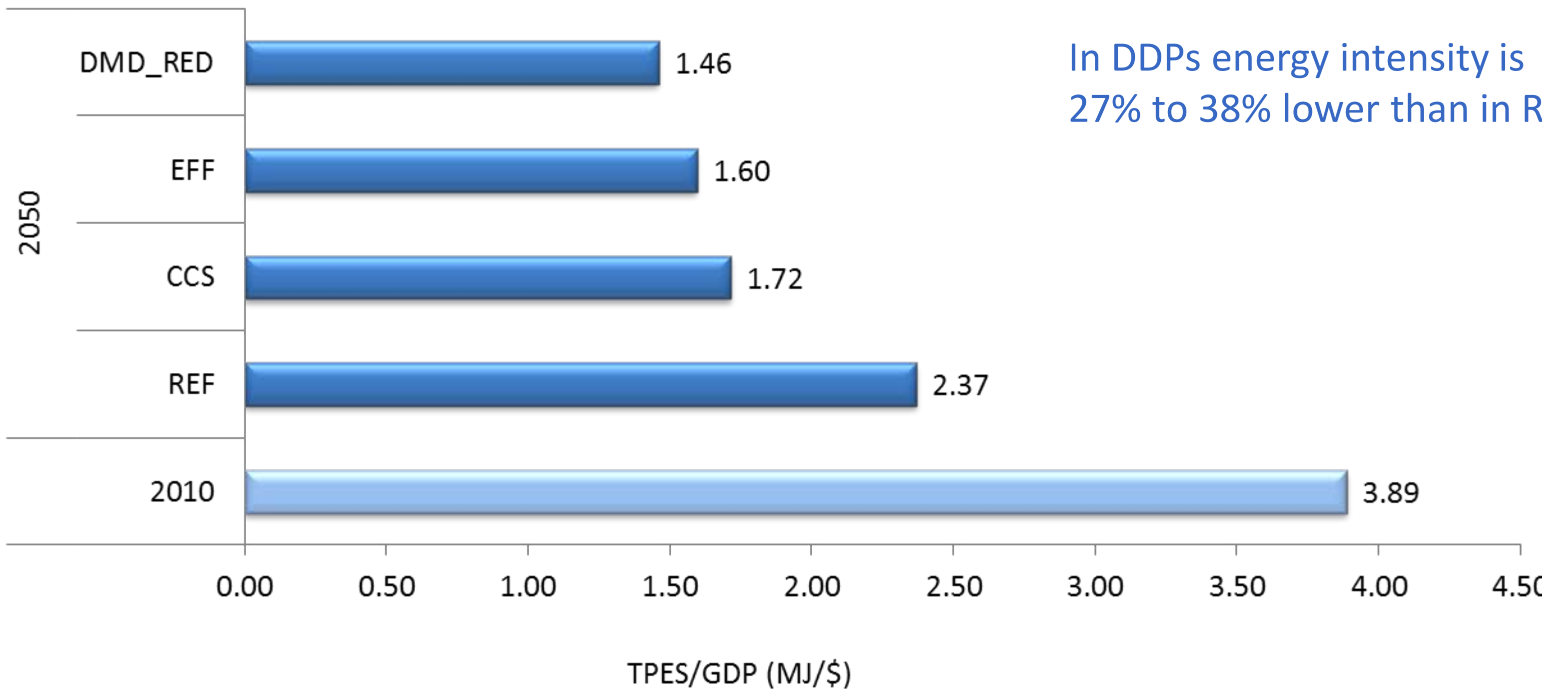
Results

Total Primary Energy Supply by energy source in three scenarios – Mtoe



Results

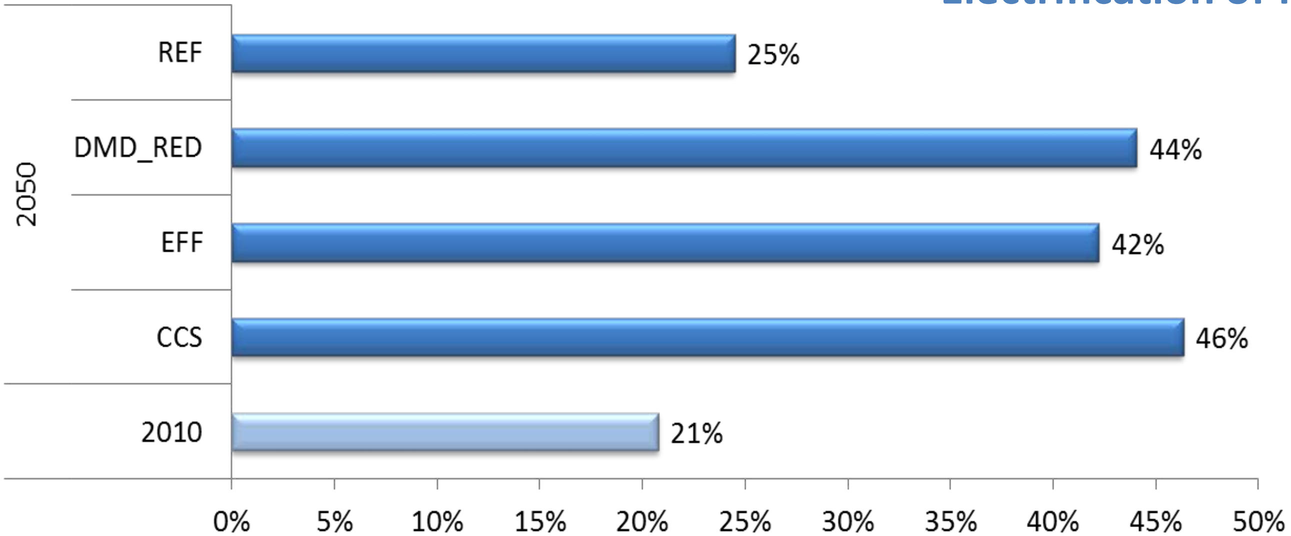
Energy intensity of GDP – MJ/$2005



In DDPs energy intensity is 27% to 38% lower than in REF

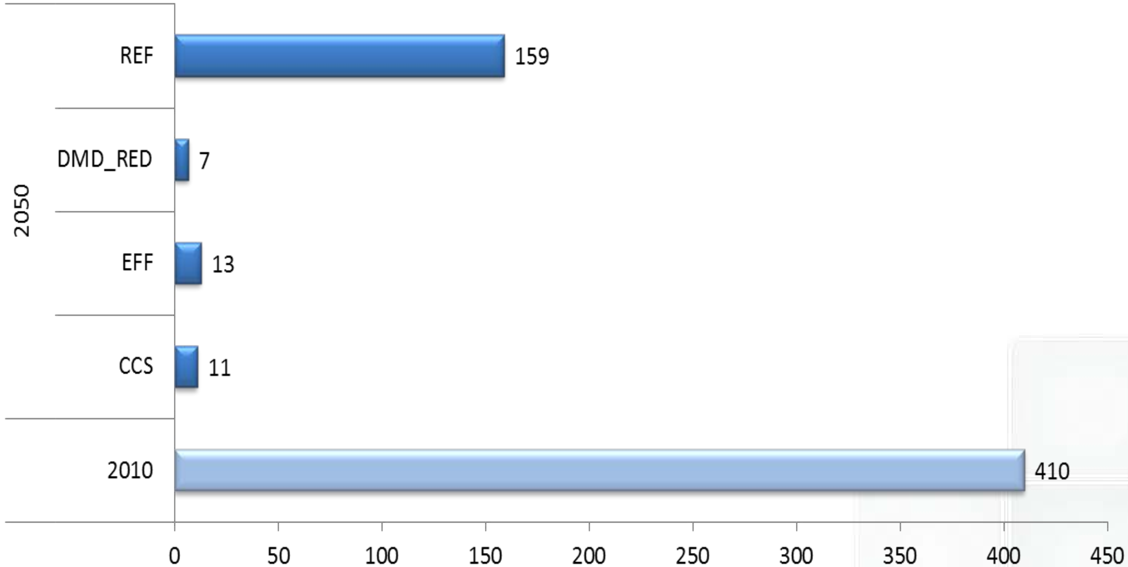
Results

Electrification of final energy consumption



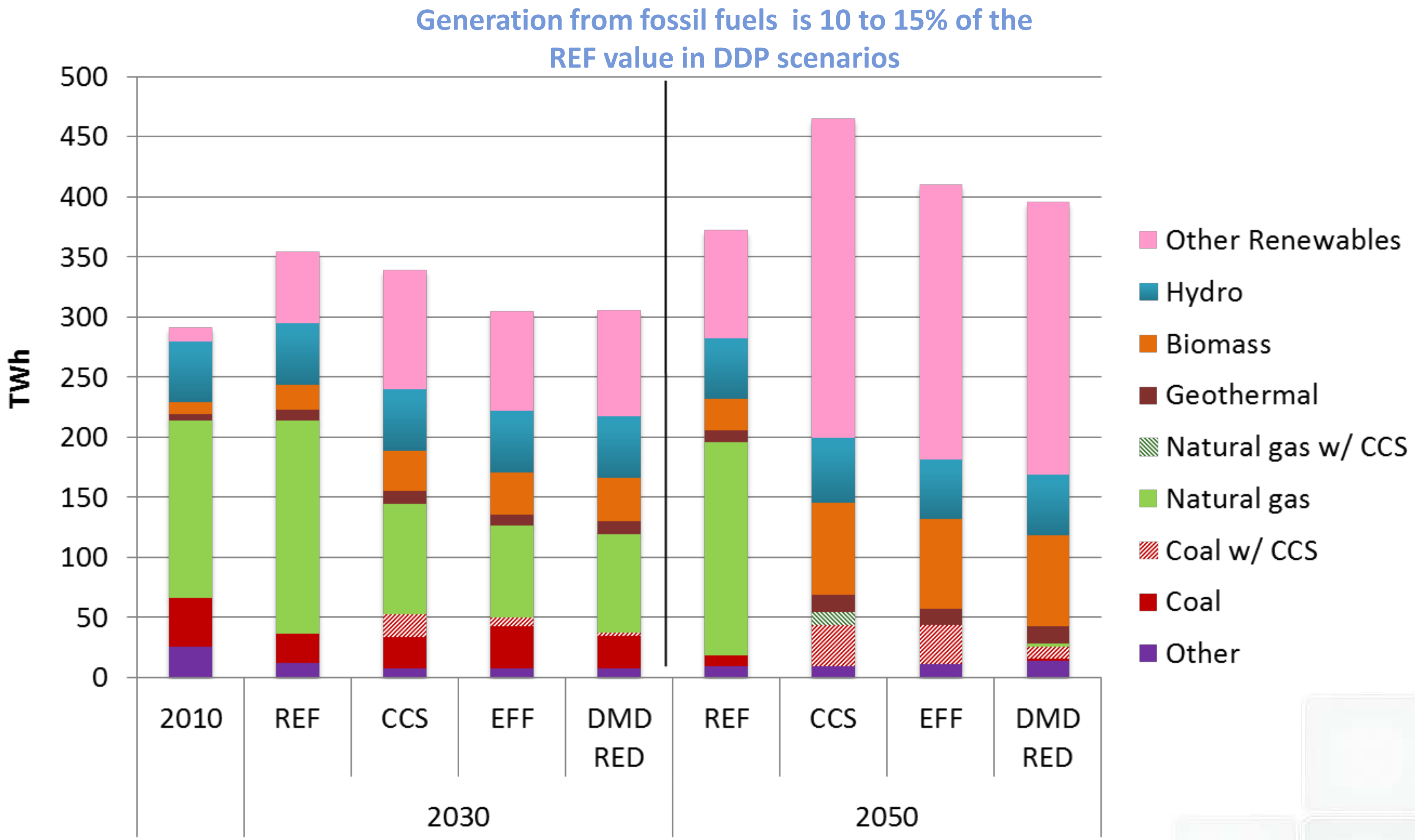
Electricity emissions intensity, g CO_2/kWh

Emissions are less than 3% of the 2010 value



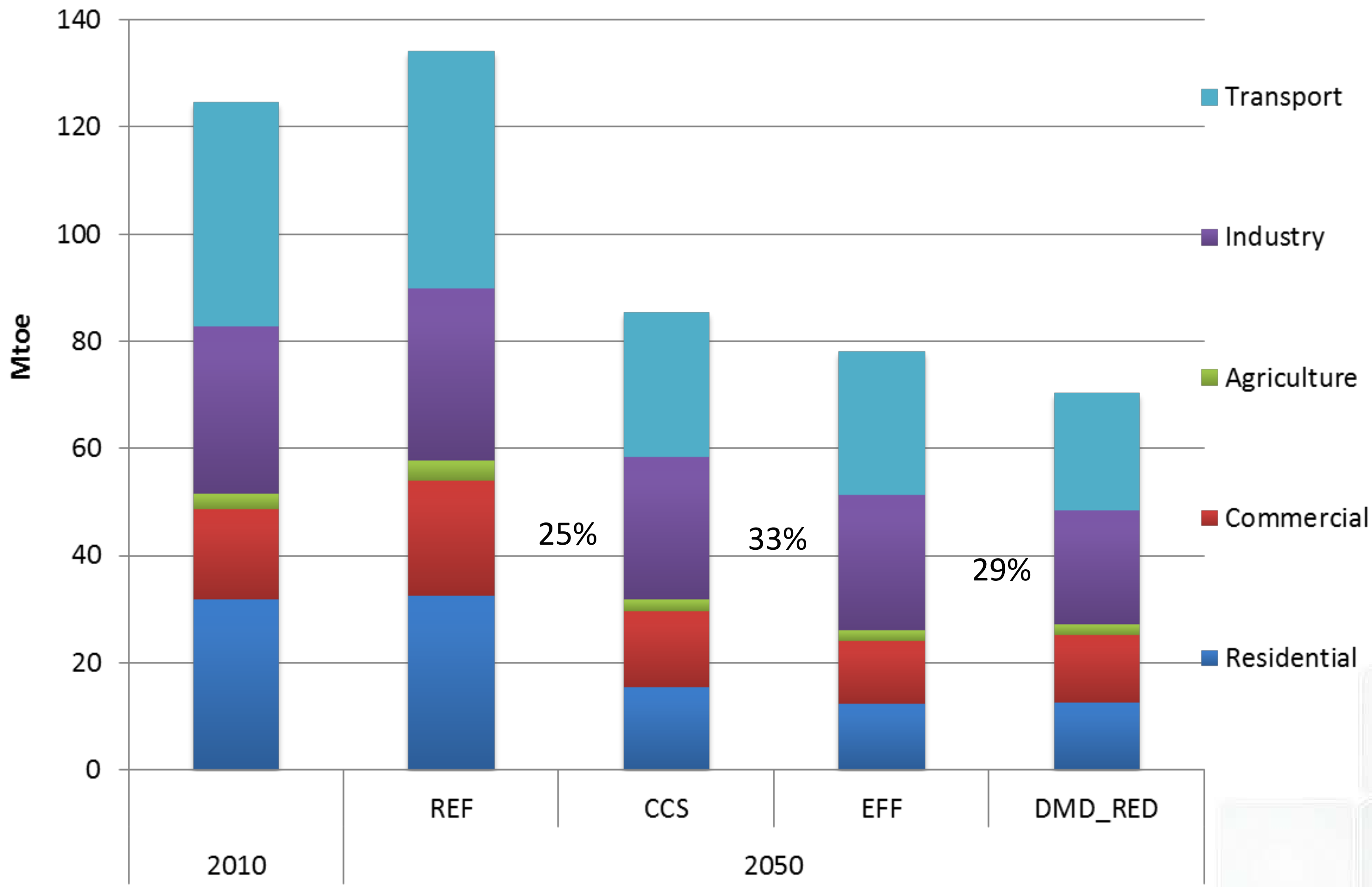
Results

Power generation



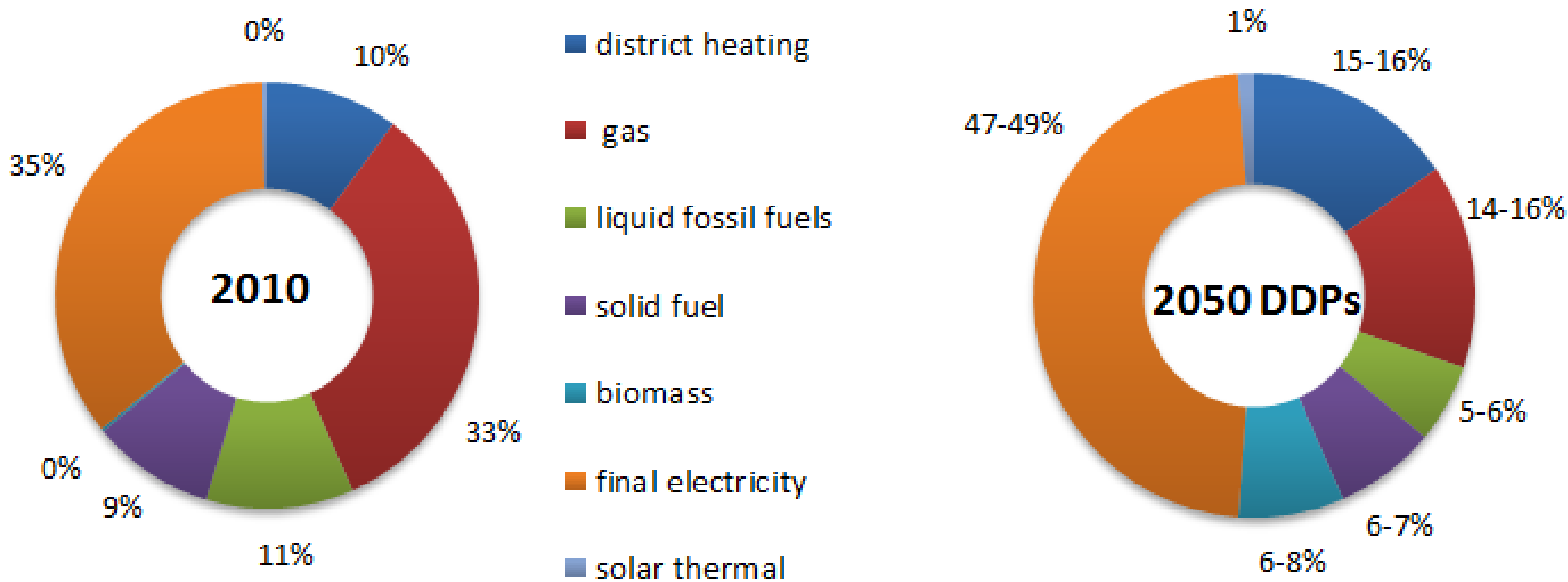
Results

Final Energy consumption



Results

Energy mix in industry sector

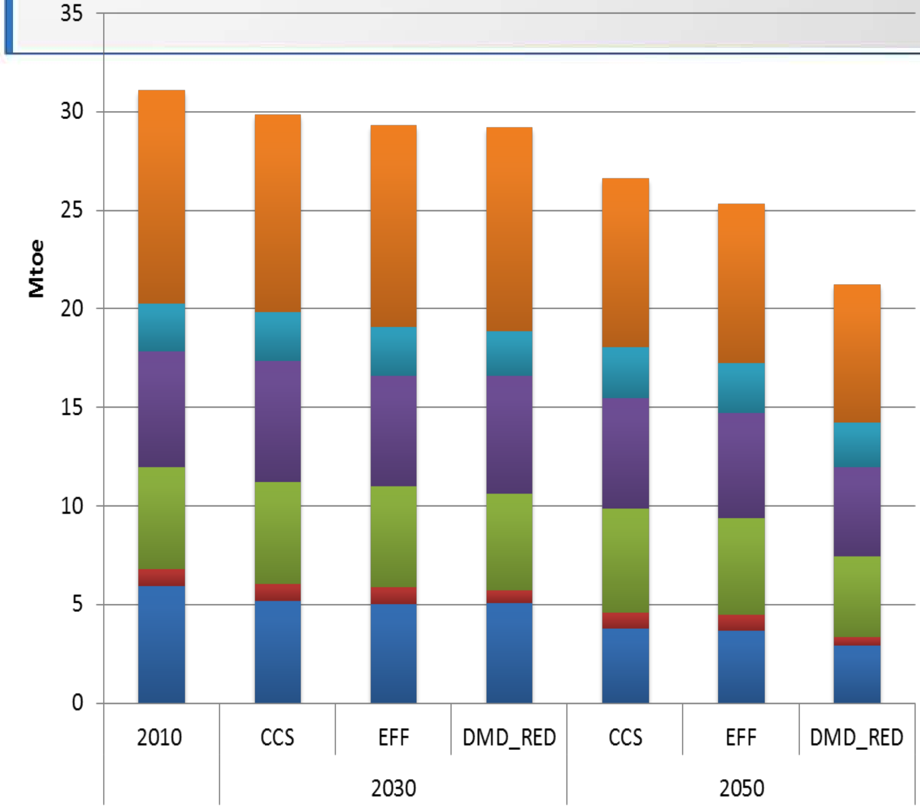


Source: ENEA

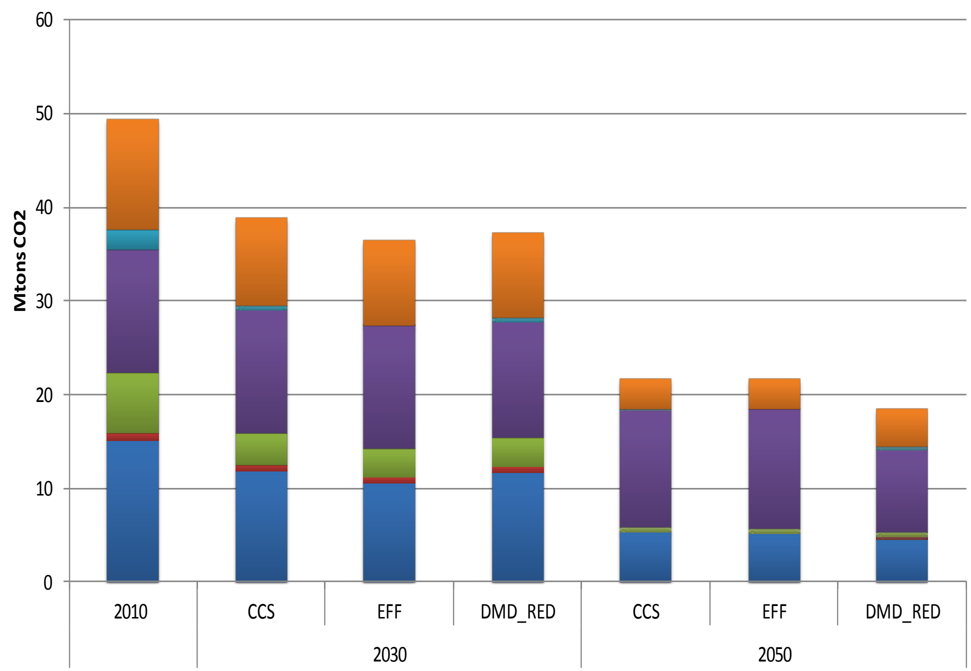
Results

Industry Final Energy Use by sectors

- Final energy use highest in the CCS scenario
- In DEM-RED scenario, iron and steel, non ferrous metals, chemicals and non metallic minerals reduce consumption more visibly

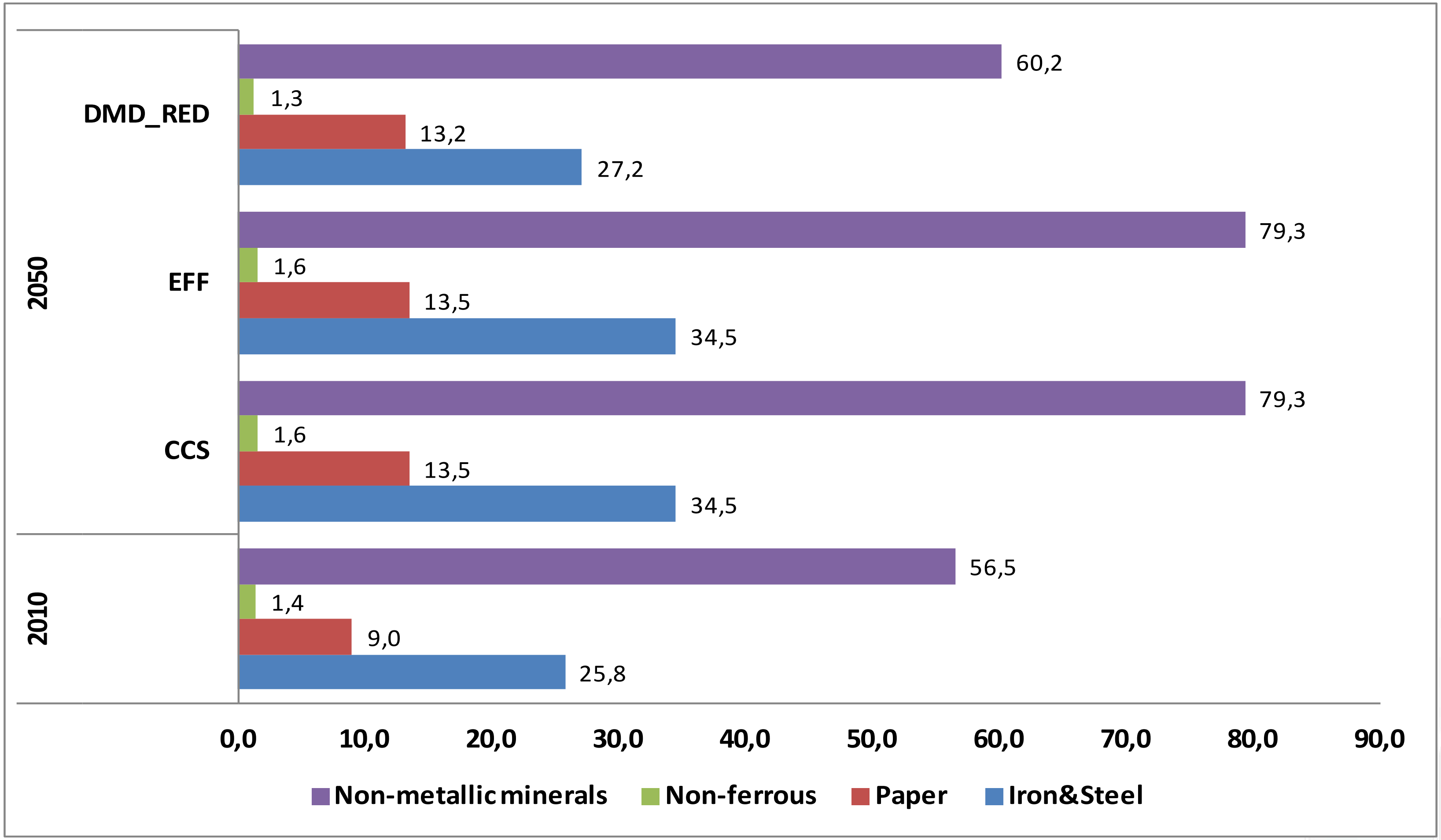


Energy-related CO2 emissions by sector



Results

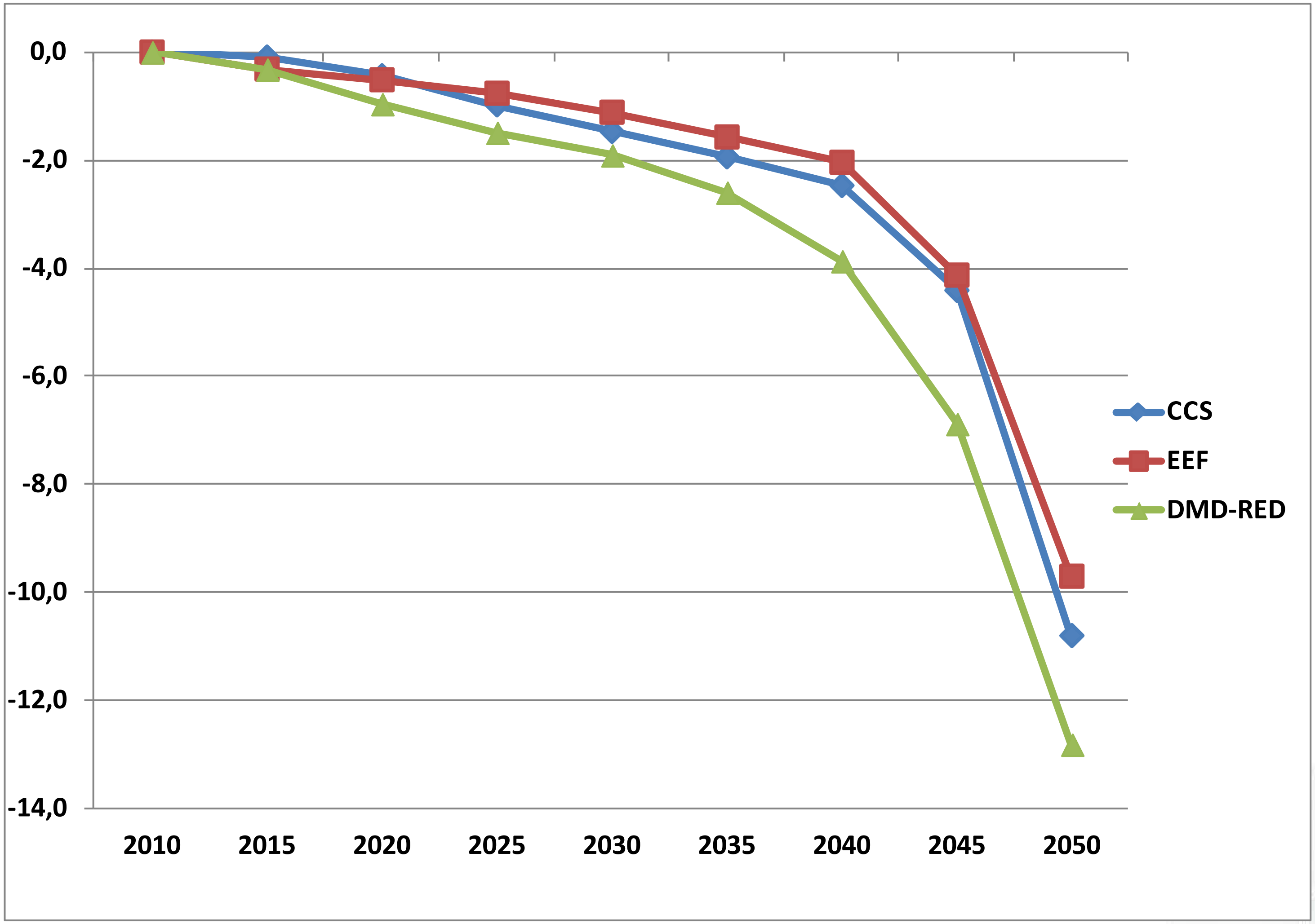
Output levels for selected energy intensive products, Mt



Output grows least in the DMD-RED scenario, especially cement, iron and steel and non ferrous metals

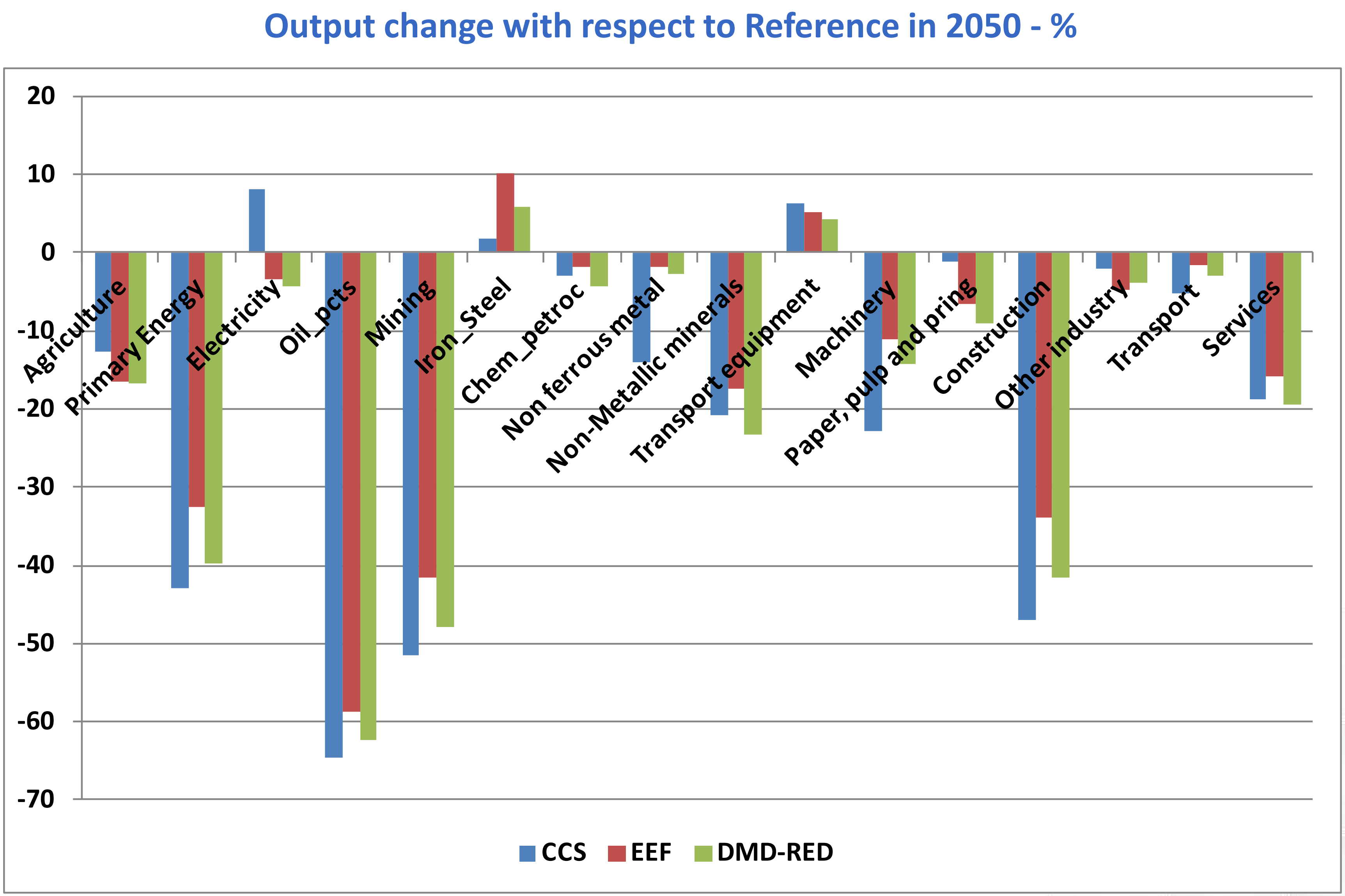
Macroeconomic analysis: Results

GDP change relative to Reference in 2050 - %



Dramatic GDP drop after 2030, but within the range seen in the CGE literature (Knopf et al. 2014)

Macroeconomic analysis: Results



Macroeconomic analysis: Results

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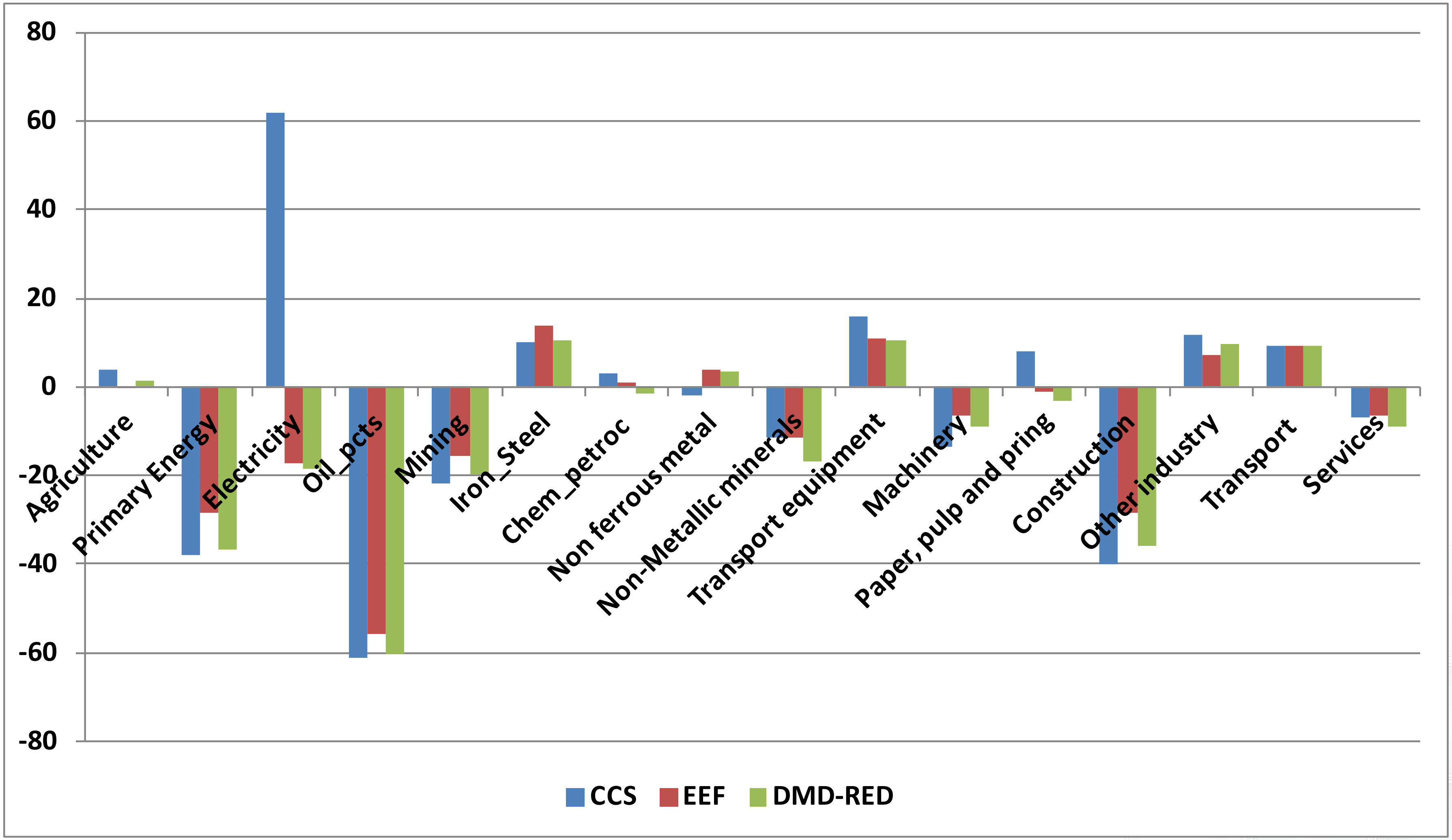
Change in value added with respect to Reference in 2050 - %



Macroeconomic analysis: Results

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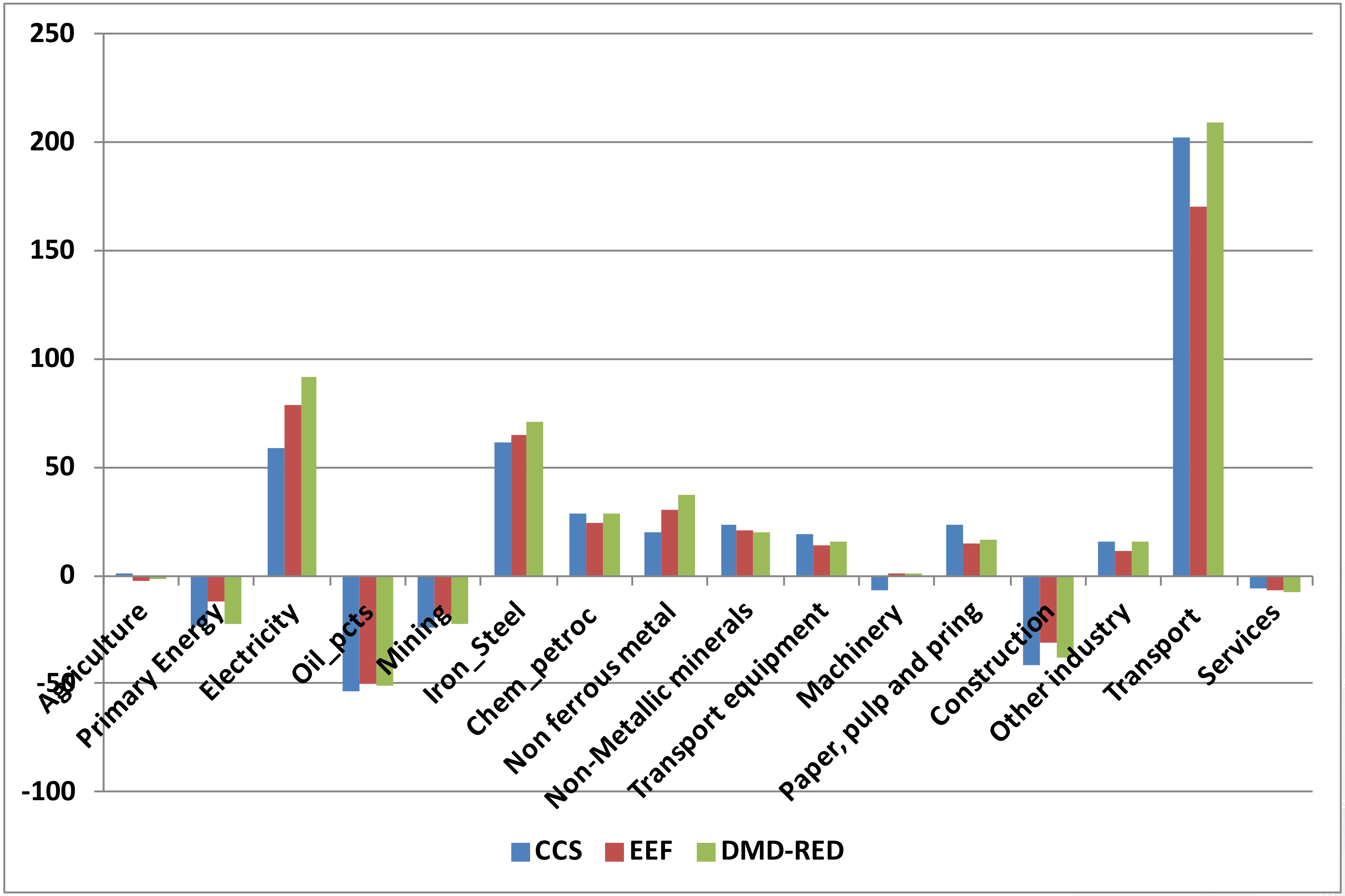
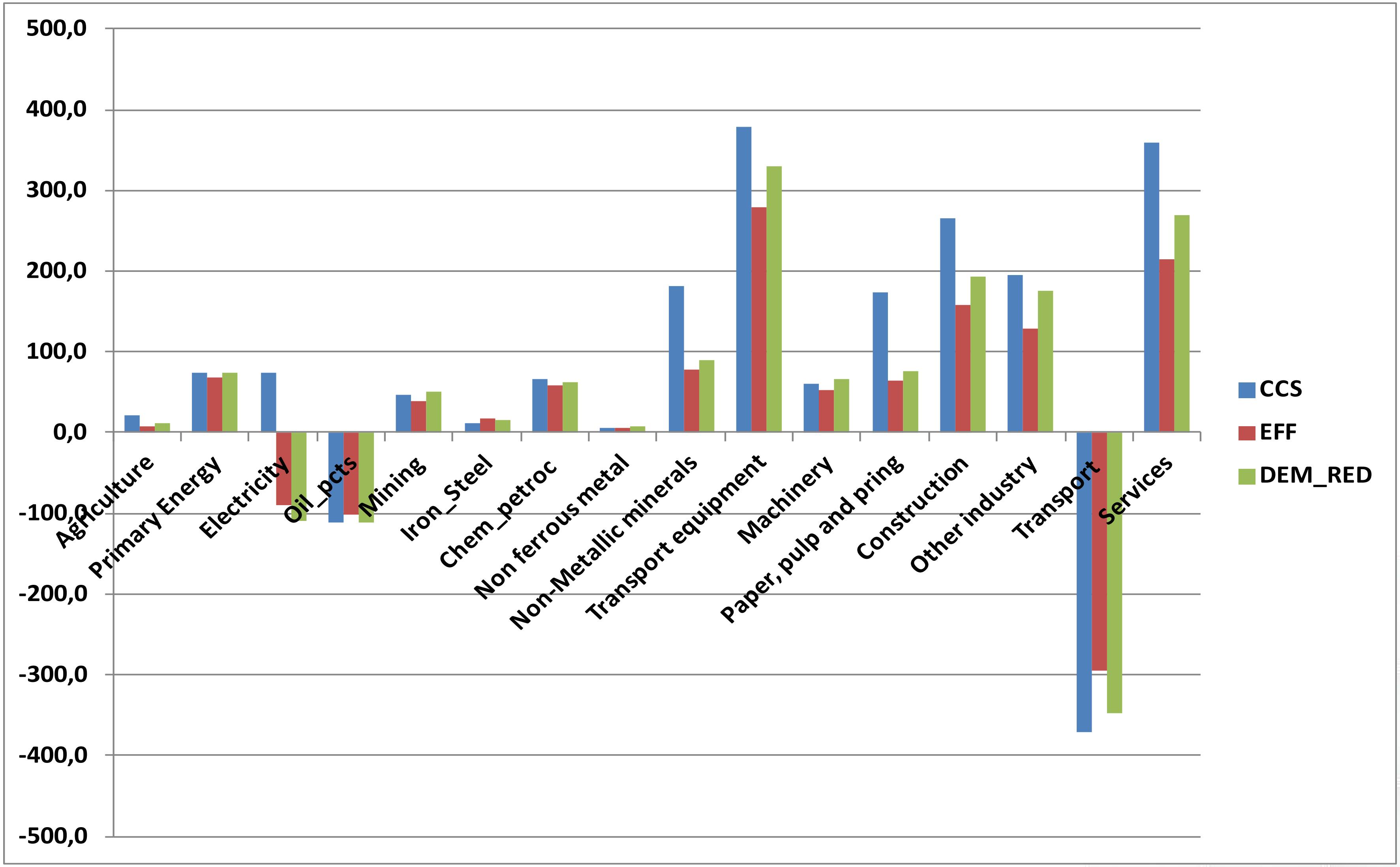
Change in employment with respect to Reference in 2050 - %



Macroeconomic analysis: Results

Trade balance with respect to Reference in 2050 - %



Conclusions

- CCS, RES and EE are key elements of Italian decarbonization scenarios
- Final energy use highest in the CCS scenario. Electricity will be 47-49% of the final energy mix in industry by 2050.
- In DEM-RED scenario, iron and steel, non ferrous metals, chemicals and non metallic minerals contract energy consumption more visibly
- Macroanalysis shows a dramatic GDP drop in all scenarios after 2030, but within the range seen in the CGE literature. Biggest drop in the DMD-RED scenario. More mitigated impacts in the Energy efficiency scenario.
- For DDP the biggest output and value added contraction occurs in extractive activities (oil&gas, other mining), oil refining, non-ferrous metals and non-metallic minerals. Employment impacts for the same sectors are also negative
- Positive impacts in less energy intensive industries
- Trade impacts are mostly positive (large reduction in oil and gas imports, improvement of energy dependence) except for the oil refining sector.
- If CCS is not a viable option and other enabling technologies are unable to reduce signicantly energy demand and CO_2 emissions in energy intensive industries, the result could be delocalization and further downsizing. This calls for policy intervention.

Thanks