Differences in regional marginal abatement cost curves: A global analysis

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International Energy Workshop

25 – 27 June 2007

Stanford University

Overview

- Motivation
- Global ETSAP-TIAM model and calculation method of marginal abatement cost curves (MACC)
- Results: Global and regional MACC curves
- Conclusions

Motivation & Issues

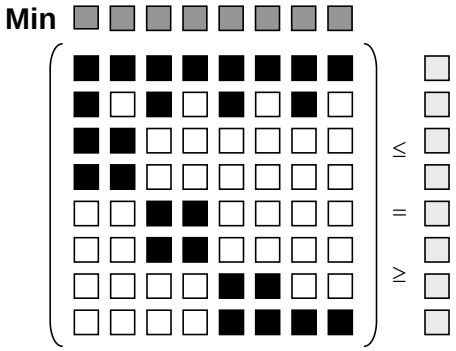
- Purpose of marginal abatement cost curves (MACC):
  i. Avoiding too restricted look at mitigation question
  ii. Ranking of different mitigation options in terms of costs
  iii. Estimation of benefits (costs) associated with cooperative (national) mitigation efforts
- Regional issues:
  i. Baseline development
  ii. Cost and potential of available mitigation measures
- Analysis issues:
  i. Reference conditions change with CO_2 price/mitigation target
  ii. Cross-sectoral linkages, e.g. electric heat pumps, hydrogen in transport etc.

ETSAP-TIAM model

- TIMES model
  i. Dynamic partial equilibrium model approach with inter-temporal objective function (perfect foresight) minimizing total discounted system costs
  ii. Technologically detailed „bottom-up“ model for each region
  iii. Covering energy flows from the useful energy demand over end-use sectors and conversion sector to the primary supply
- Time horizon 2000 – 2100
- 15 world regions with
  i. Bilateral trade in hard coal, pipeline gas, LNG, crude oil and petroleum products (distillates, gasoline, heavy fuel oil and naphtha)
  ii. Global trade in emission permits possible
- Emissions: CO2, N2O, CH4
  i. Carbon capture and sequestration (power generation and alternative fuel production)
  ii. Mitigation options for N2O and CH4
- Climate module (3-reservoir model for calculating atmospheric CO2 concentrations)
- Multi-stage stochastic programming (uncertainties in emission targets, demands, bounds)

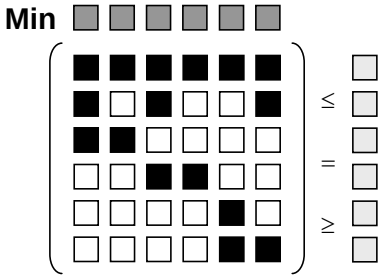
Methodology to derive MACCs

Original problem



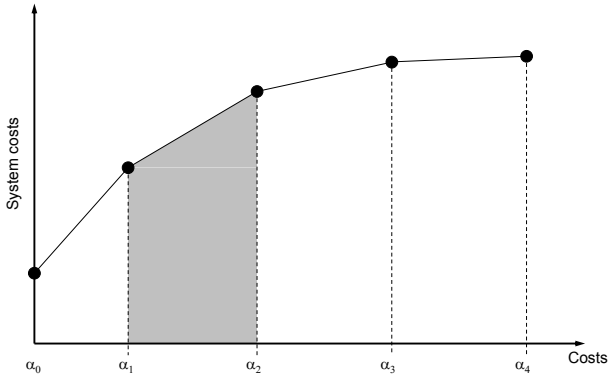
- Coefficient in objective function (e.g. import price for natural gas)
- Matrix coefficient (e.g. quota for electricity production from renewables)
- RHS constant (e.g. emission bound)

Reduced problem



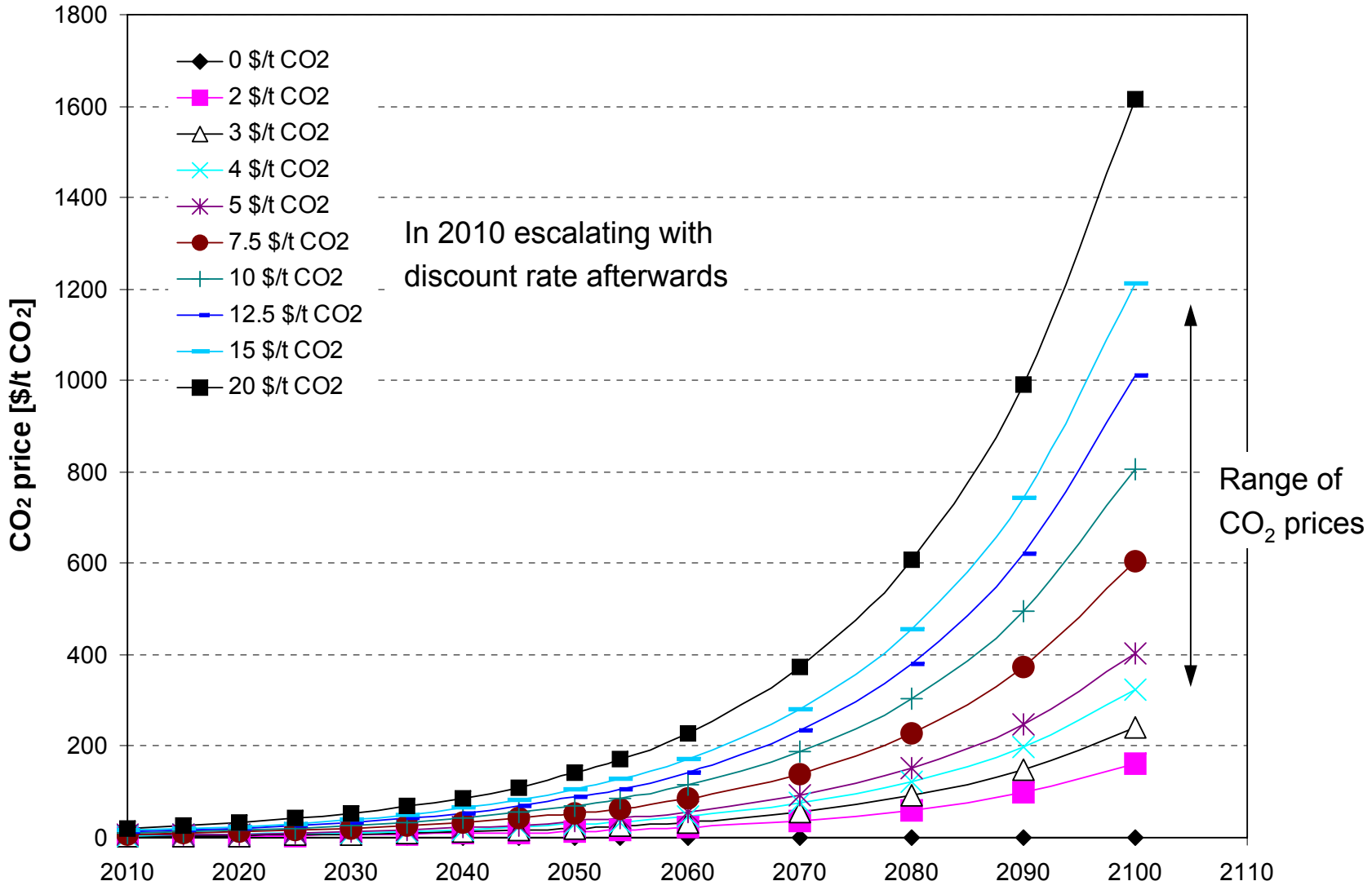
e.g. elimination of equations and variables by substitution

Sensitivity analysis

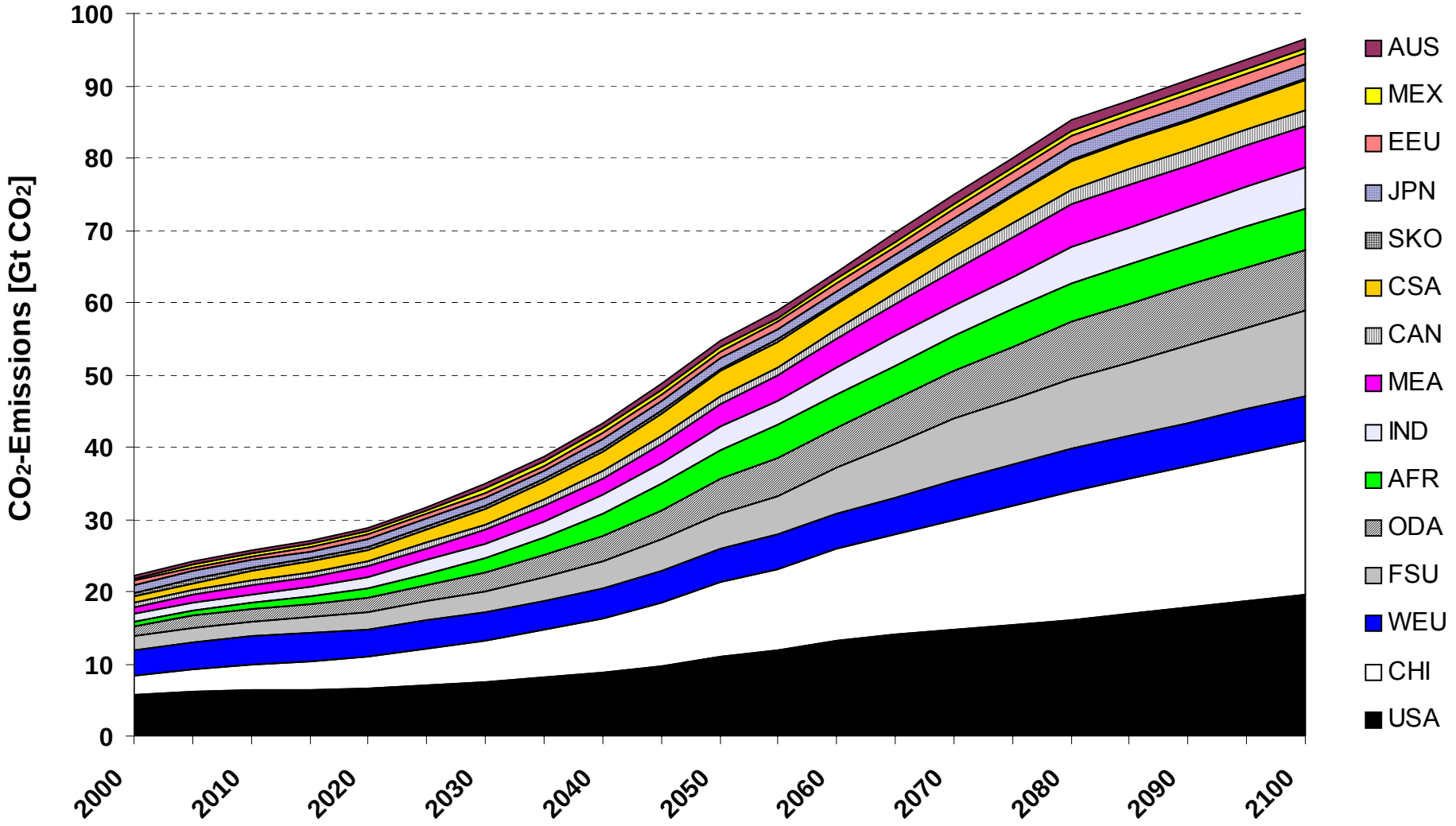


Iterative solution of reduced problem for different CO_2 prices

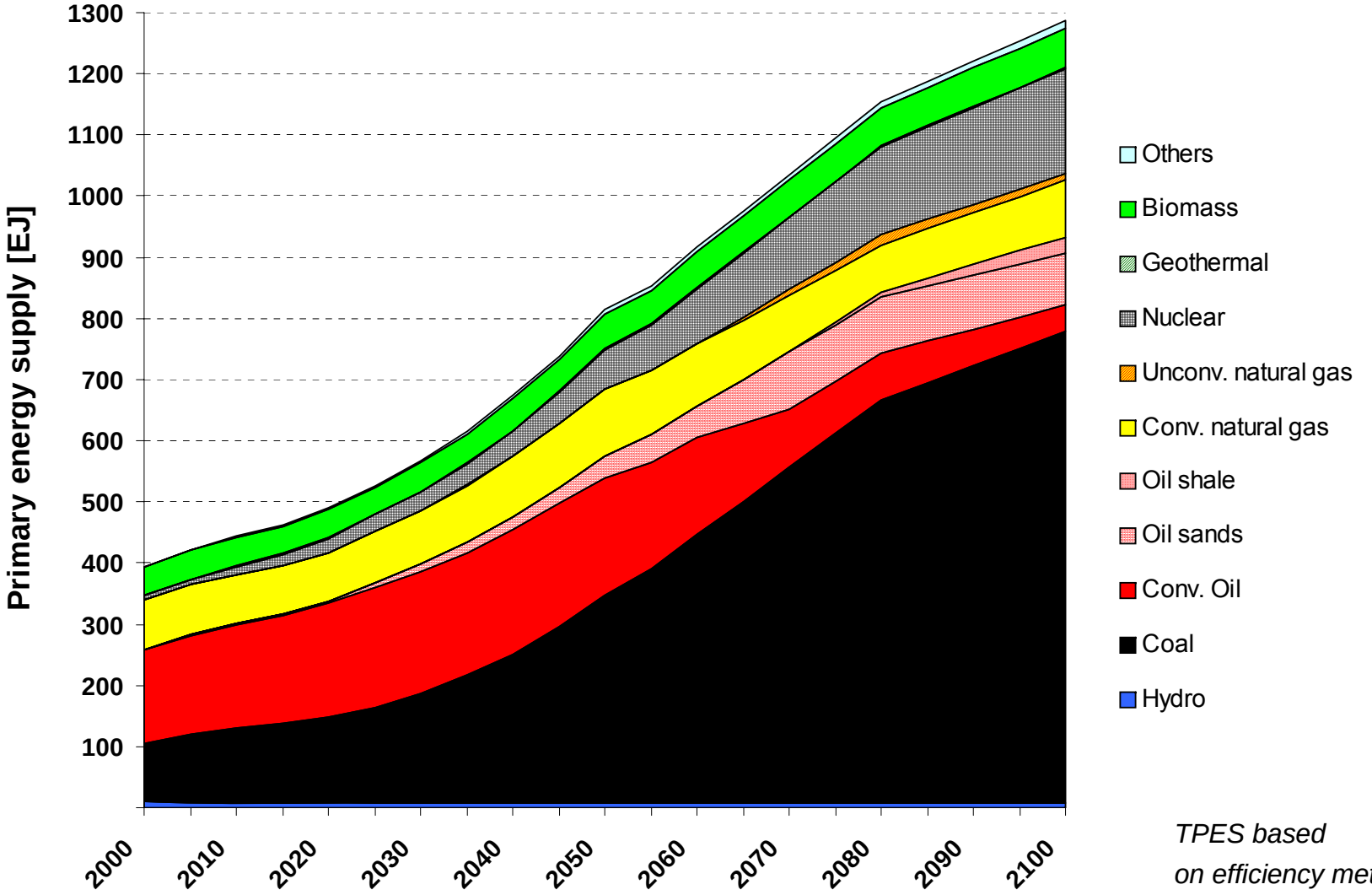
Variation of CO_2 prices



CO_2 emissions in base case

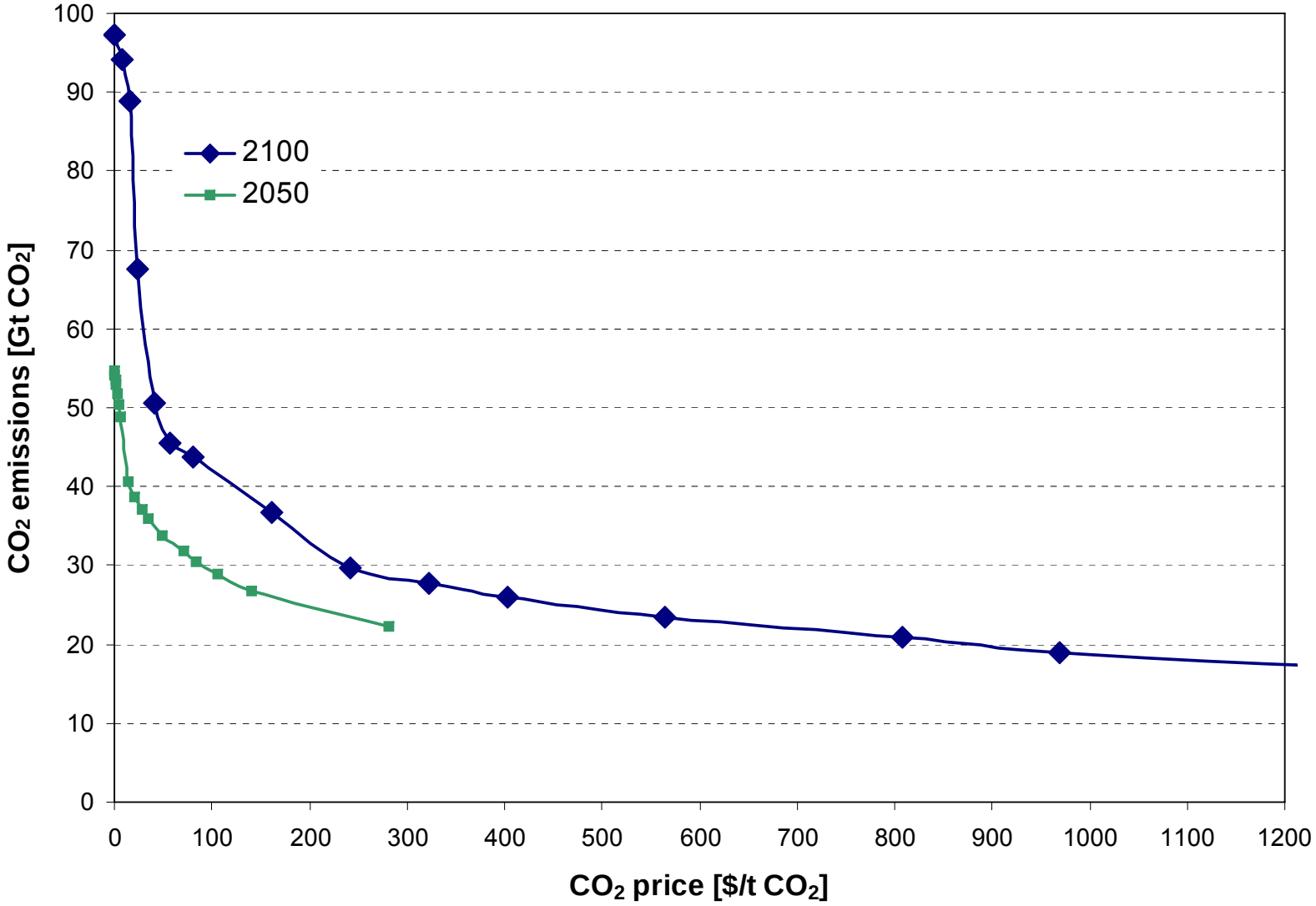


TPES in base case

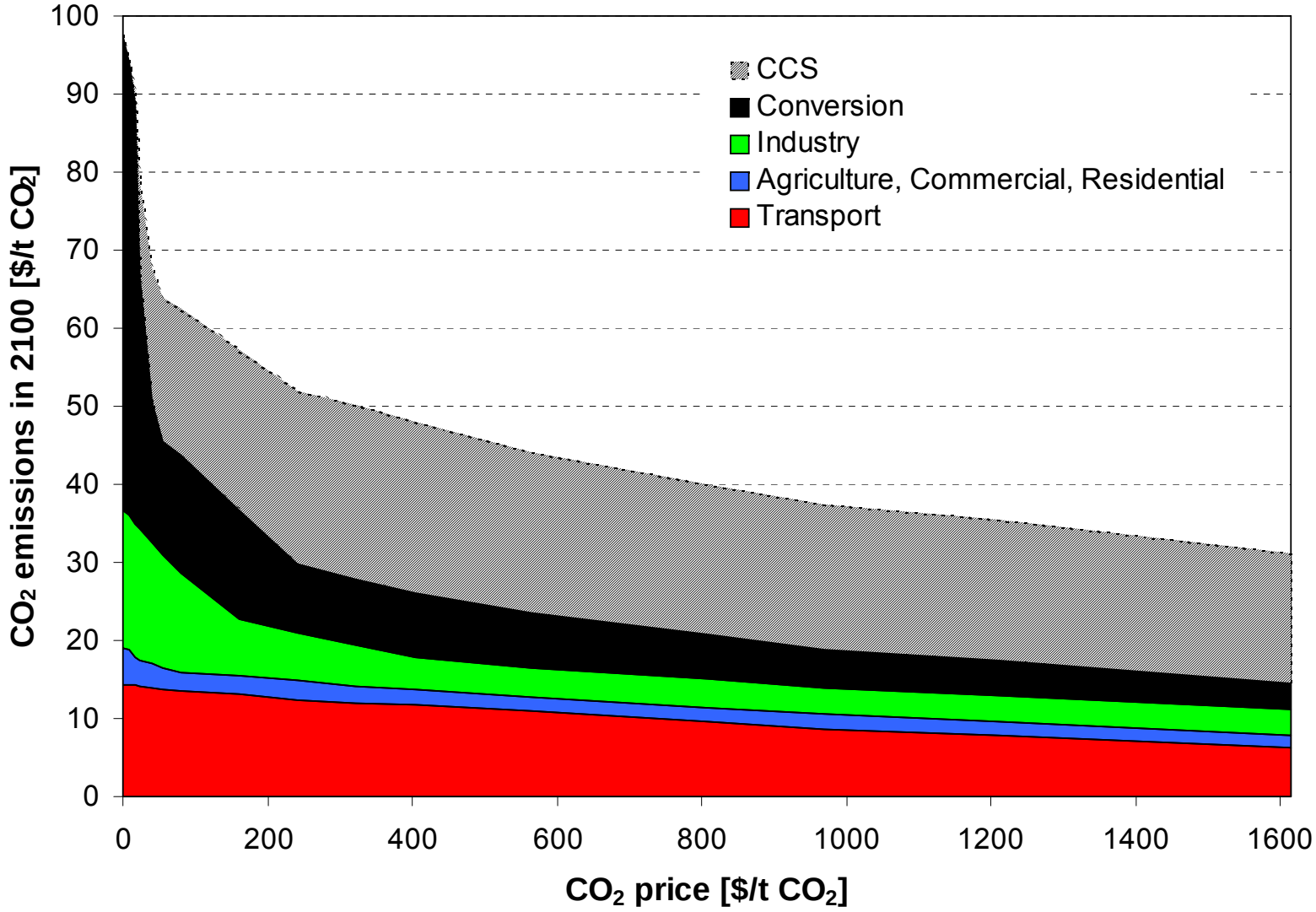


TPES based on efficiency method.

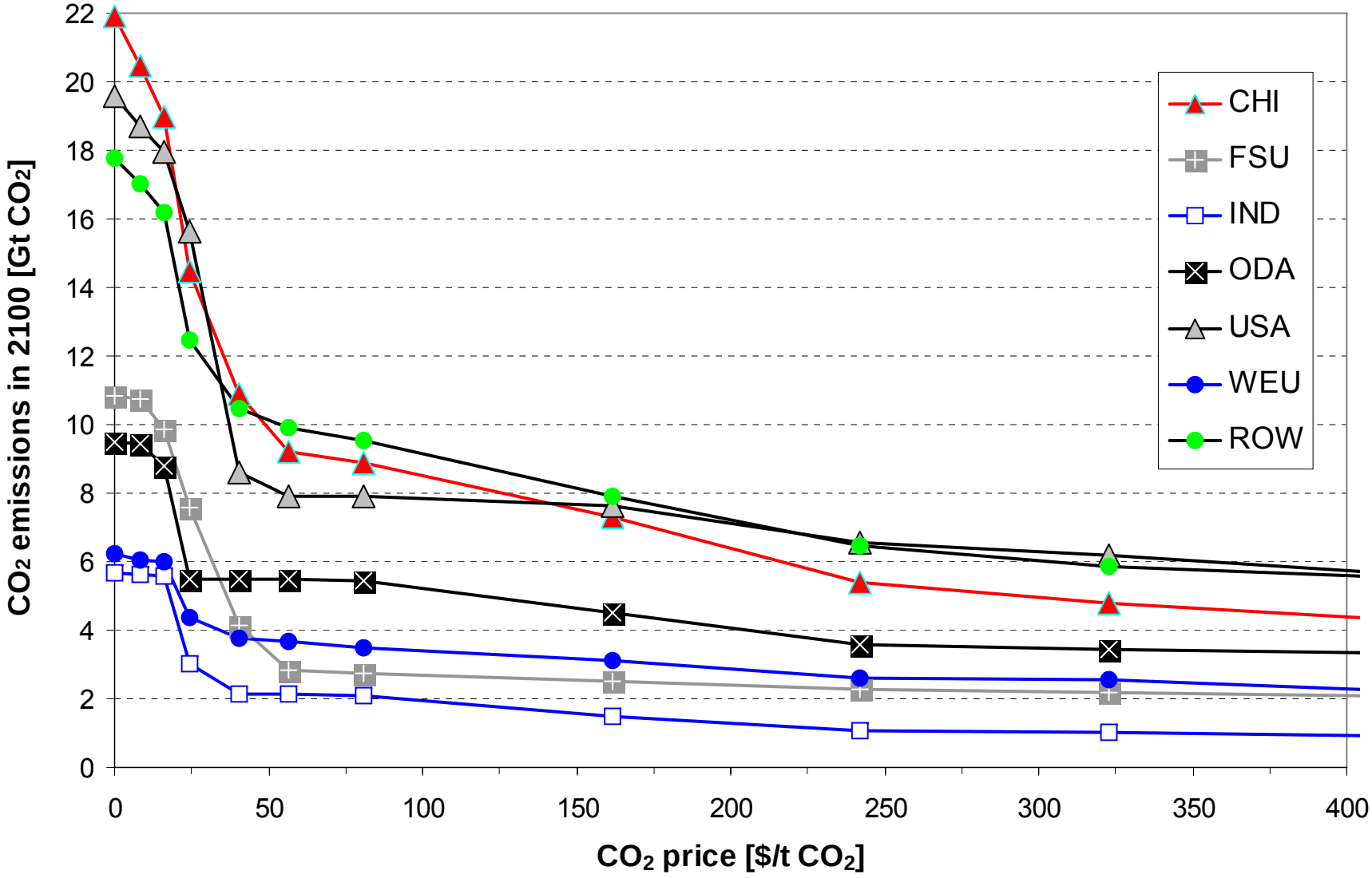
Global MACC curves



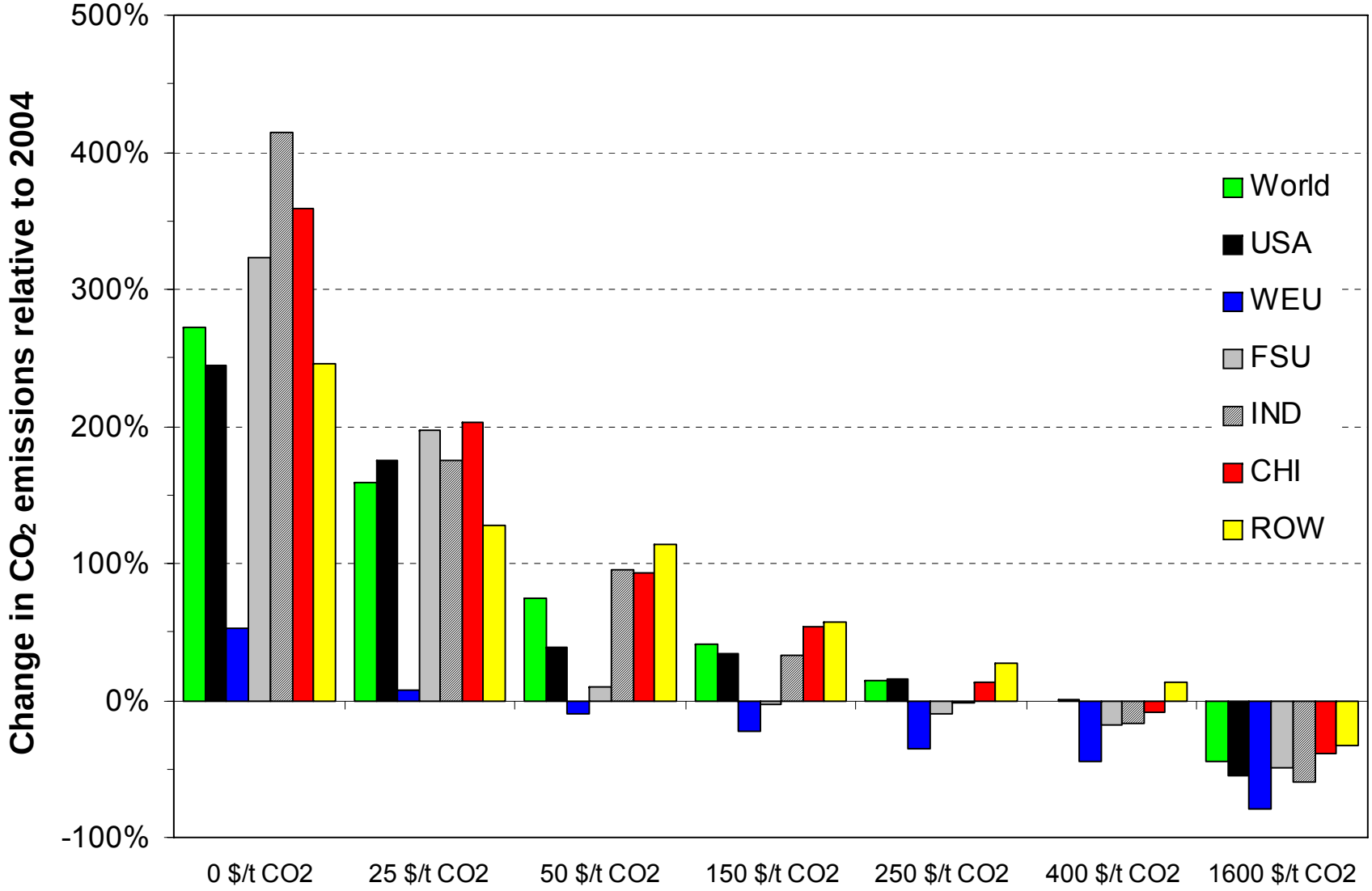
Sectoral CO_2 emissions in 2100



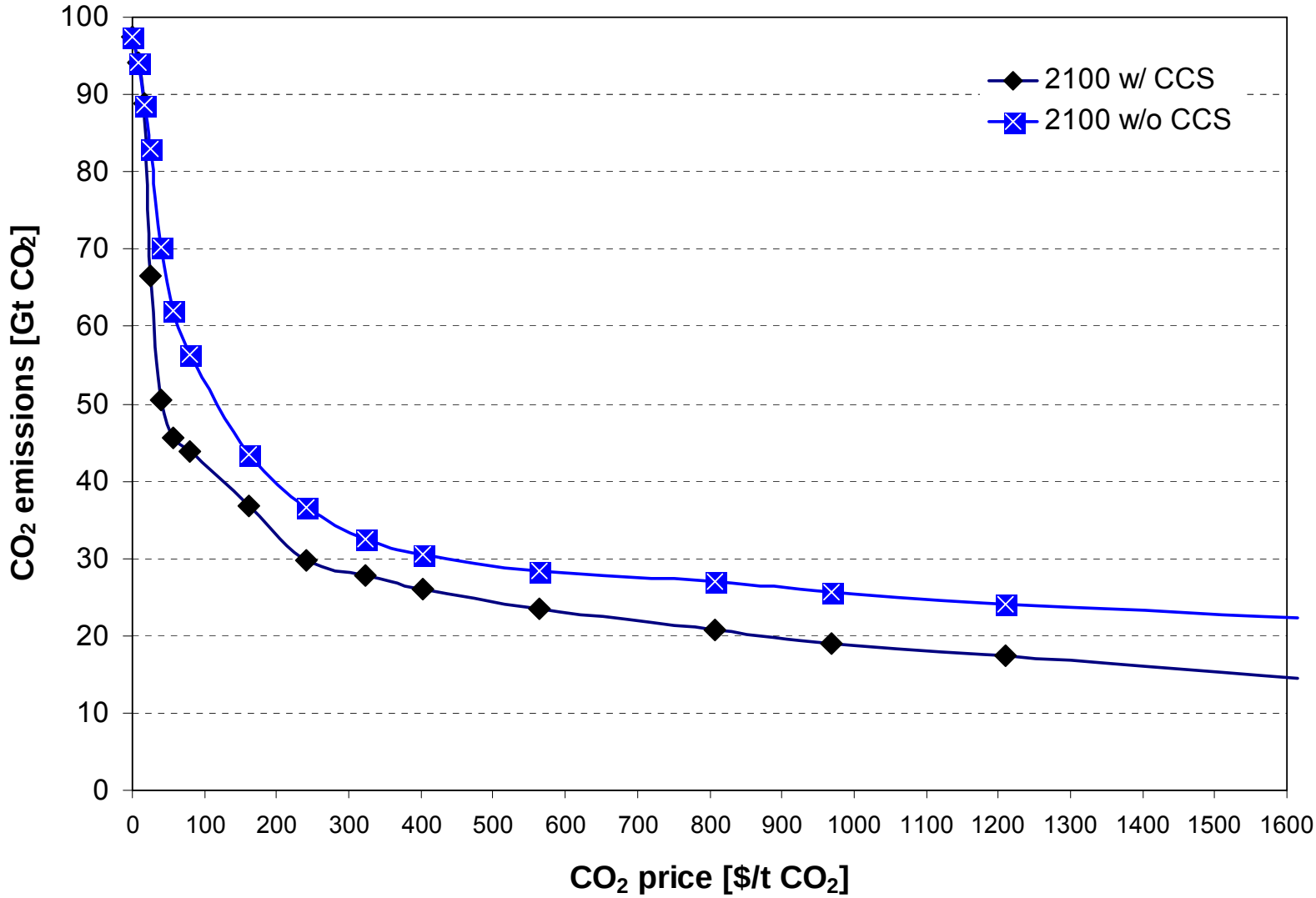
Regional MACC in 2100



Change in CO_2 emissions in 2100 relative to 2004



Role of carbon capture and storage



Conclusions

- Base case development without any intervention dominated by fossil fuels, namely coal in power generation and synfuel production
- Sectoral:
  i. Up to 400 $/t CO2 mainly reduction in power generation, industry, residential sectors
  ii. High costs for mitigation in transport sector (except FT with CCS and ethanol)
  iii. CCS: responsible for 1/3 of CO2 reduction relative to base case in 2100
  iv. CCS moves part of the wind, PV potential to higher marginal abatement costs
- Regional:
  i. Large reduction potentials in developing Asia (high base case emissions due to economic growth) and USA, FSU (due to CTL) at CO2 prices up to 50 $/t CO2
  ii. Necessary CO2 price to bring emissions in 2100 back to 2004 levels ranges from 50 (WEU) to 400 $/t CO2 (developing Asia)
- Future work:
  i. Review technology characterization (transport after 2050) and portfolio (end-use sectors, CHP) considered
  ii. MACC for more near-term years

Thank you!

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