Sectoral Mitigation Potentials
Bottom Up and Top Down Comparison

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This study has been performed within the framework of the Netherlands Research Programme on Scientific Assessment and Policy Analysis for Climate Change (WAB). The study results in three products for further reading: a background report describing the bottom-up approach, two workshop reports on the comparison of the bottom –up and top-down approaches for respectively the energy sector and the forestry sector, and an executive summary with main results and conclusions. All products can be downloaded from the WAB website at www.pbl.nl.

Scientific Assessment and Policy Analysis (WAB) Climate Change

The Netherlands Programme on Scientific Assessment and Policy Analysis Climate Change (WAB) has the following objectives:

Collection and evaluation of relevant scientific information for policy development and decision–making in the field of climate change;

Analysis of resolutions and decisions in the framework of international climate negotiations and their implications.

WAB conducts analyses and assessments intended for a balanced evaluation of the state-of-the-art for underpinning policy choices. These analyses and assessment activities are carried out in periods of several months to a maximum of one year, depending on the complexity and the urgency of the policy issue. Assessment teams organised to handle the various topics consist of the best Dutch experts in their fields. Teams work on incidental and additionally financed activities, as opposed to the regular, structurally financed activities of the climate research consortium. The work should reflect the current state of science on the relevant topic.

The main commissioning bodies are the National Environmental Policy Plan departments, with the Ministry of Housing, Spatial Planning and the Environment assuming a coordinating role. Work is also commissioned by organisations in society playing an important role in the decision-making process concerned with and the implementation of the climate policy. A consortium consisting of the Netherlands Environmental Assessment Agency (PBL), the Royal Dutch Meteorological Institute, the Climate Change and Biosphere Research Centre (CCB) of Wageningen University and Research Centre (WUR), the Energy research Centre of the Netherlands (ECN), the Netherlands Research Programme on Climate Change Centre at the VU University of Amsterdam (CCVUA), the International Centre for Integrative Studies of the University of Maastricht (UM/ICIS) and the Copernicus Institute at Utrecht University (UU) is responsible for the implementation. The Netherlands Environmental Assessment Agency (PBL), as the main contracting body, is chairing the Steering Committee.

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This report in pdf-format is available at www.pbl.nl

1. Research Question and Context

Sectoral Mitigation Potential

Key question in climate policy:
"How much GHG emissions and energy can be reduced and at what costs?"

Two approaches:

- Bottom Up: focus on separate technologies, aggregating measures, sectors, regions
- Top Down: focus on economies as a whole, historical behaviour, response to prices (elasticity), structural changes

Both approaches: reductions compared to a baseline

IPCC WGIII AR4

- Emission reduction potentials short term, 2030
- Bottom Up and Top Down approach used
- Reinforcing message on the potential

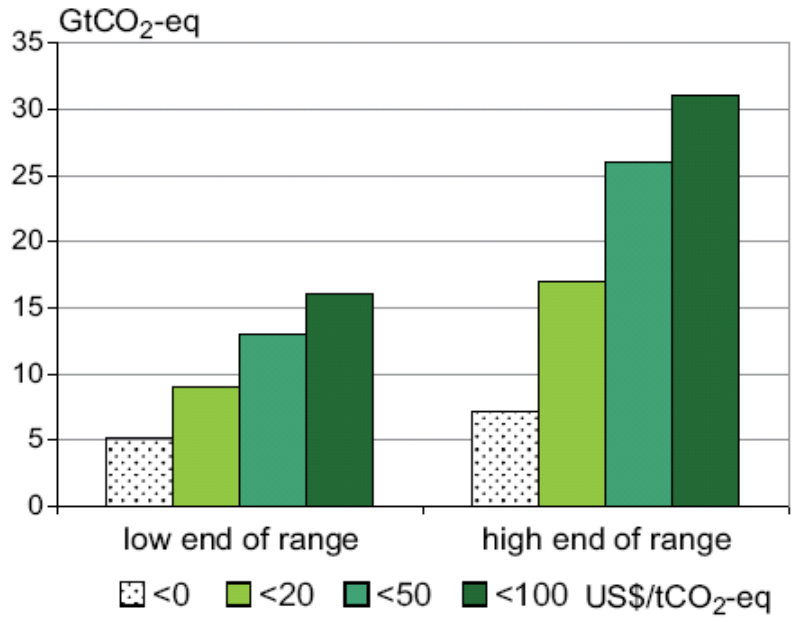


Figure SPM.5A: *Global economic mitigation potential in 2030 estimated from bottom-up studies (data from Table SPM.1)*

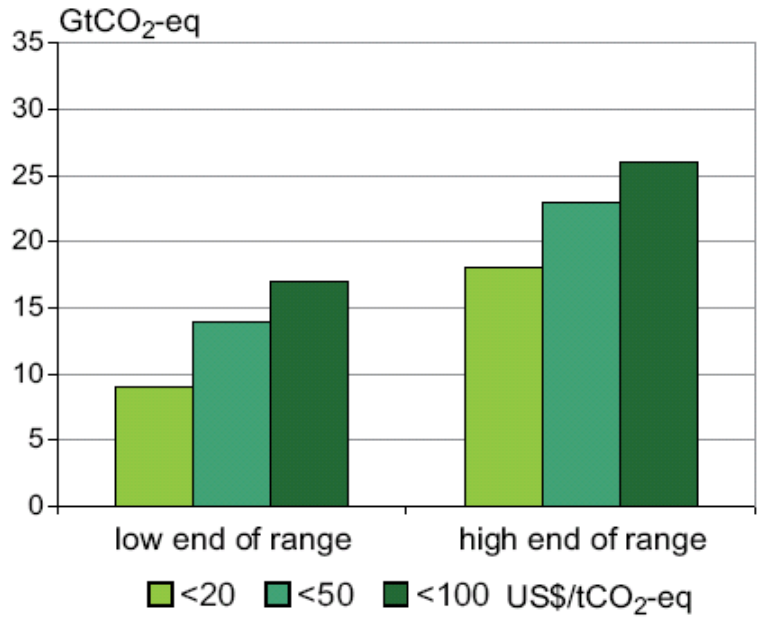


Figure SPM.5B: *Global economic mitigation potential in 2030 estimated from top-down studies (data from Table SPM.2)*

This project: Aim

- Understand difference between bottom up and top down approaches.
- Derive robust numbers on the sectoral and regional emission reduction potentials at cost levels.
  - How can the studies be compared?
  - For what sectors are differences small, for what large?
  - Can we explain the differences or the similarities between the approaches?
  - What can we learn for the coming Fifth Assessment Report?

This project: Team

Team:

Ecofys (PM); ALTERRA; Cambridge University, 4 CMR; CPB; CEU; PBL; IIASA; LBNL; NIES; OECD.

Commissioned by:

Ministry of Housing Spatial Planning and Environment (VROM) as part of WAB funding: Wetenschappelijk Assessment Beleidsanalyse (policy assessment)

2. Bottom Up and Top Down Methodologies

Characterising methods

	Top-down model	Bottom-up model
Technologies	By use of production function	Explicit
Calibration	Historic behaviour (assumed to continue)	Estimates of future/ present technology detail
Economic feedback	Central	Mostly not included

Pros BU

- Detailed technology description and data
- Possible link to variety of policies
- Easy verifiable, transparent. Direct link with actual data possible.

Pros TD

- Modelling total economy, including interactions
- Based on historic behaviour if economic inter-relationships are being explicitly estimated
- Inclusion of different feedbacks and spillover effects.

Cons BU

- No interactions between economic sectors
- Future costs of technologies in isolation
- No incorporation of market barriers
- Various options already in baseline
- No feedbacks on e.g. energy prices

Cons TD

- Based on historic trends, extrapolation of trends to future
- Mostly based on monetary values rather than physical indicators
- Technology data representation is poor

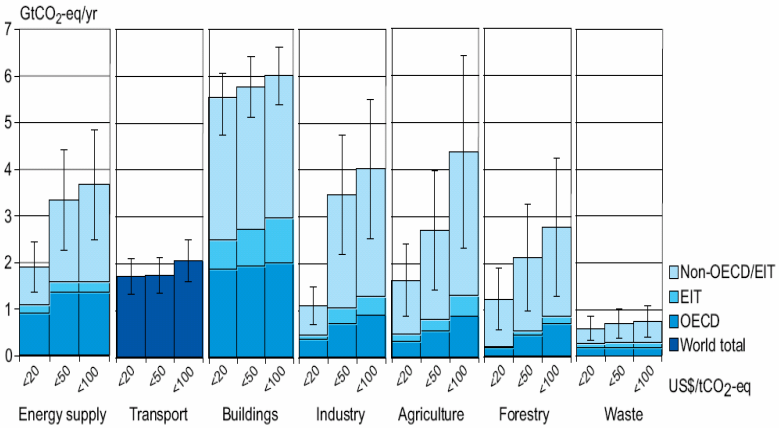
Bottom up

- Sectoral assessment per chapter
- Integrated in Chapter 11
- Different baselines
- Not all options included

Top Down

- 35 studies that reported c-tax and reductions
- Statistical analysis to derive "responses"
- Black box

At sectoral level no good comparison possible



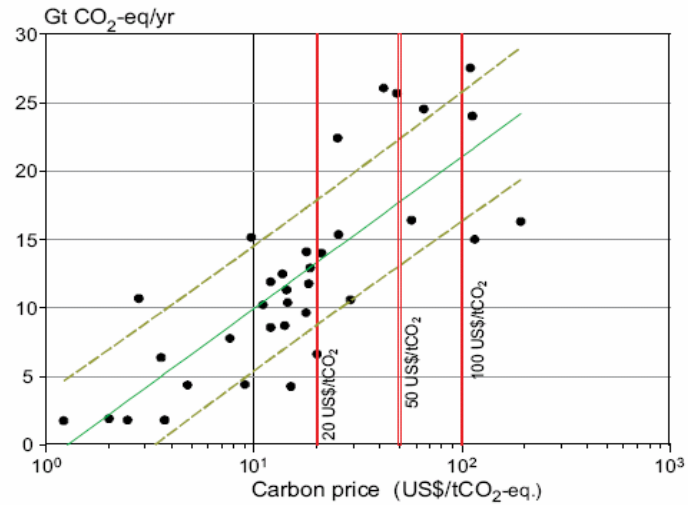


Figure 3.40: *Permit price versus level of emission reduction – total economy in 2030 (the natural logarithm of the permit price is used for the x-axis). The uncertainty range indicated is the 68% interval.*

3. Activities Within the Project

This project: Tasks

- TD models 7 runs one baseline and 6 experiments
- BU assessment extension to IPCC AR4 work
- Workshop energy sectors
- Additional runs and information
- Analyses and hypothesis
- Further discussions
- Workshop forestry
- Final report, scientific publications

Bottom Up Approach

- Individual sectoral estimates
- WEO baseline (except buildings)
- Baseline constructed for activity indicators
- Reductions compared to activity indicators (energy savings)
- Substitution to carbon free technologies
- Correct for double counting power supply and end use sectors
- For a detailed description: Hoogwijk et al., 2008

Updates Compared to AR4 per Sector

- Energy Supply
  - The ranges were extended
- Transport
  - HDV and MDV were included and biofuels included at regional scale
- Residential and Service
  - Frozen efficiencies were excluded from the baseline
  - Energy baseline and savings included
- Industry
  - Figures updated with new literature
  - Split between electricity and fuel savings
  - Energy baseline and savings included

Top Down Models Included

Worldscan: Muliti-region, multi-sector CGE model

MESSAGE –MACRO: Dynamic systems engineering optimization model MACRO is a macroeconomic model to reflect the energy demand response

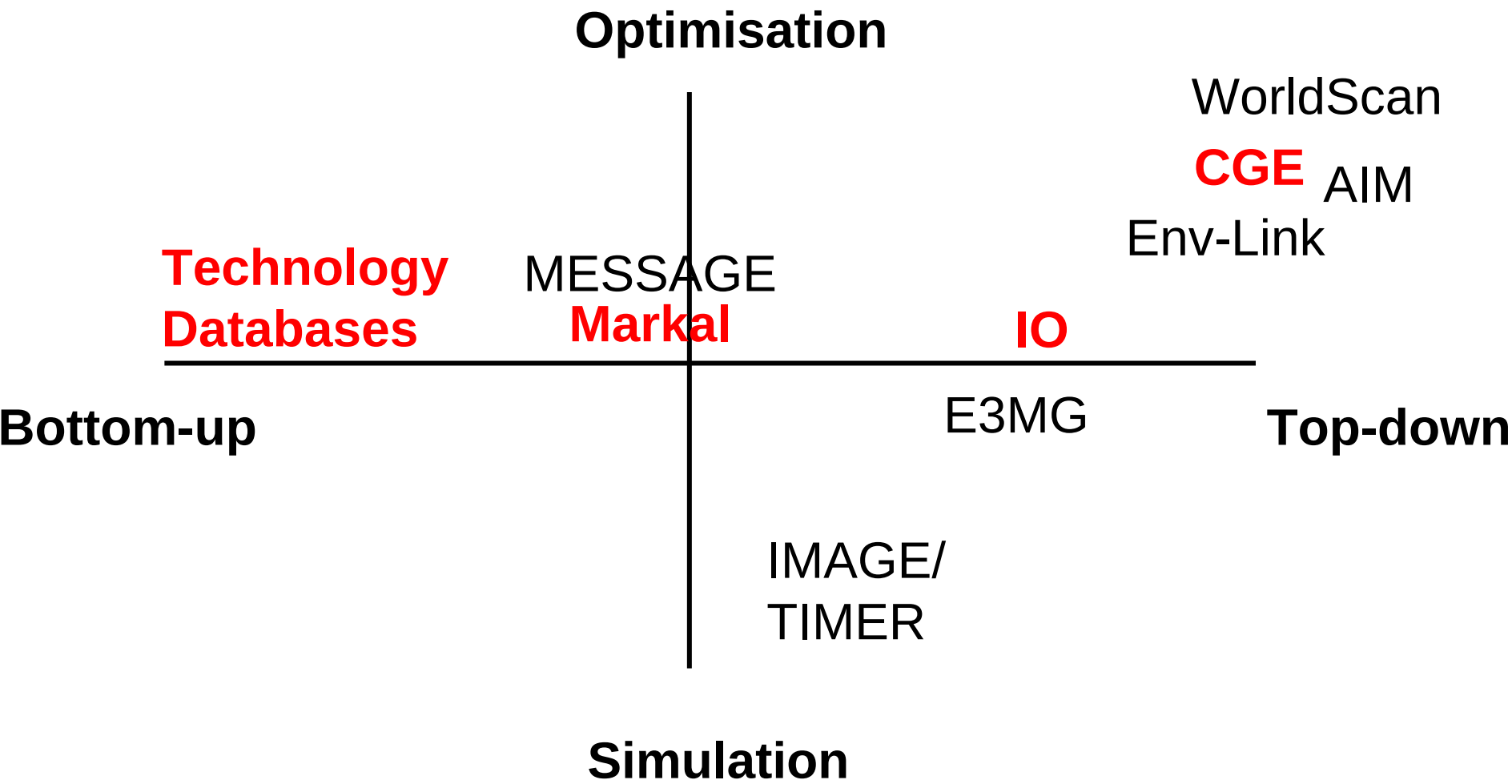
E3MG: macro-econometric simulation hybrid (TD-BU) model of the global energy environment-economy system

AIM/GCE: Global CGE with recursive dynamics

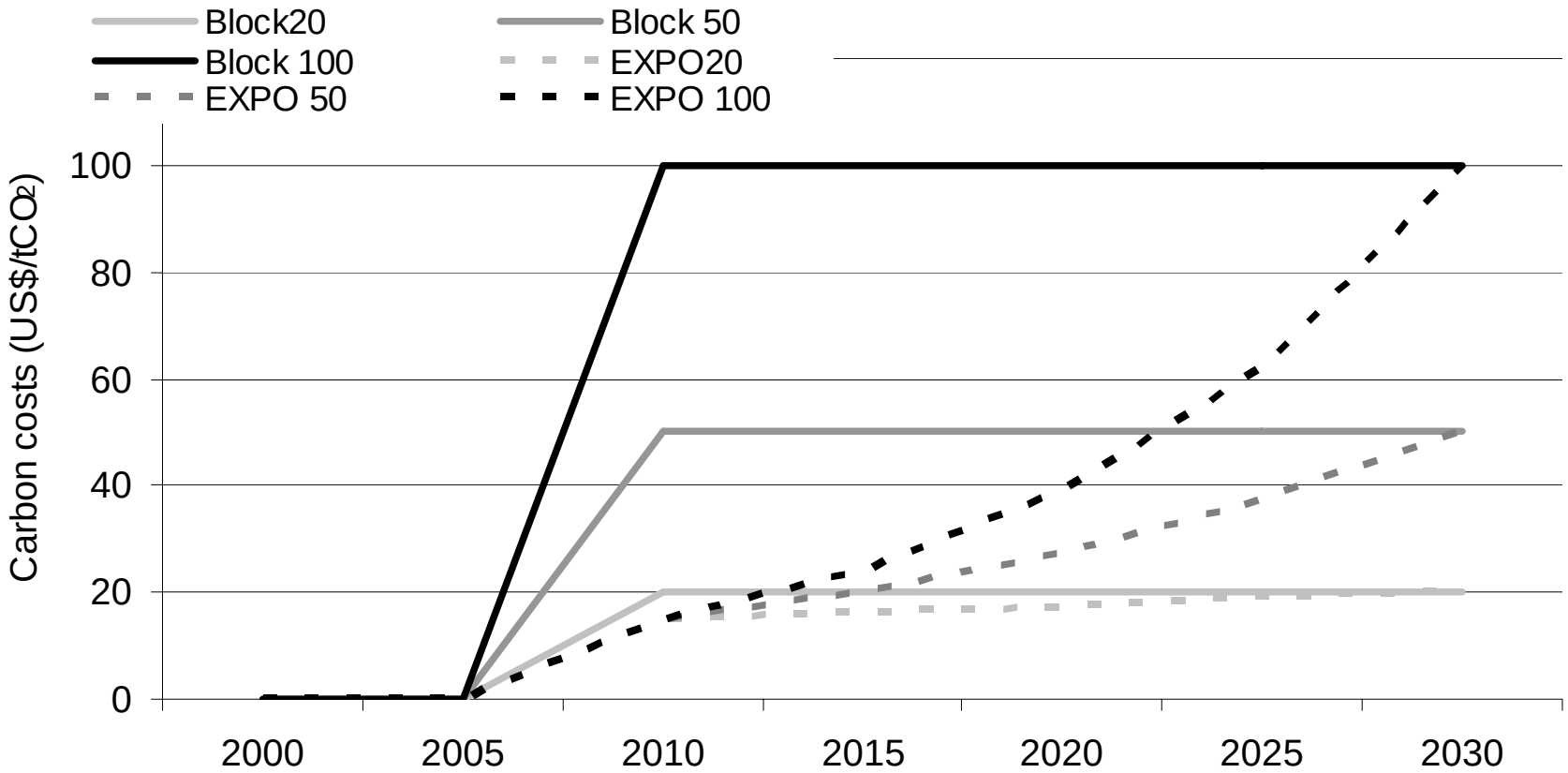
IMAGE: IAM with. TIMER is a dynamic systems engineering simulation model

Env Linkage: Muliti-region, multi-sector recursive dynamic neo-classical general equilibrium model with vintage capital stocks.

Characteristics of TD Models Included



Top Down Experiments



Starting Points for Comparison

- Baseline, B2 and WEO
- Sectoral definition
  - refineries
  - district heating
  - extraction and distribution
  - sectors included
- Emission allocation
  - Point of emissions (TD)
  - End use sectors (BU)
  - This project we use point of emission.
- Comparison first only for the energy related sectors

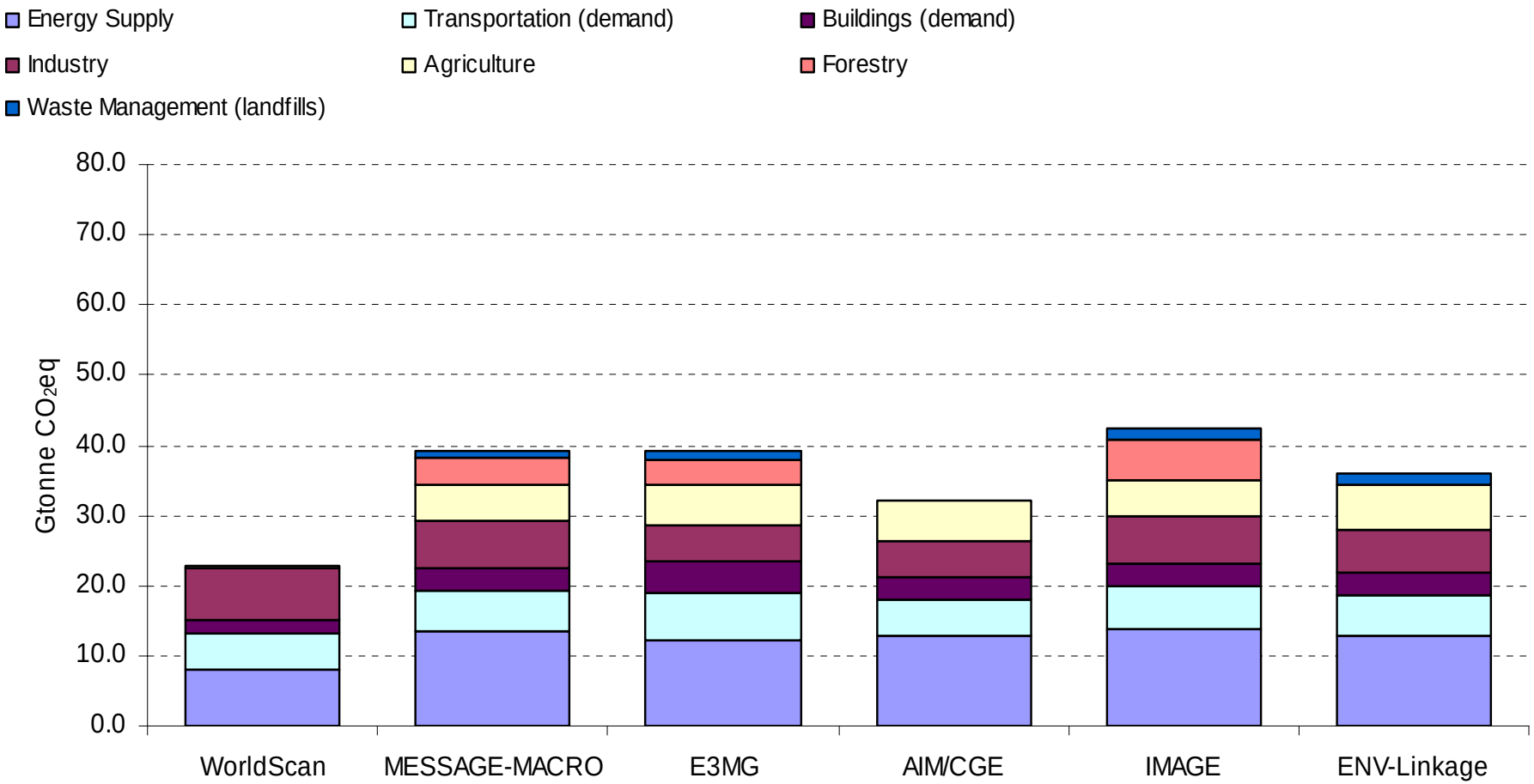
Potential Assessed: Economic Potential

- Bottom up:
  - Physical and technical constraints and size of the market
  - A low and a high range is included
  - Costs are technical cost parameters
  - Discount rate in the order of 5 – 10 %.
  - Social costs not included.

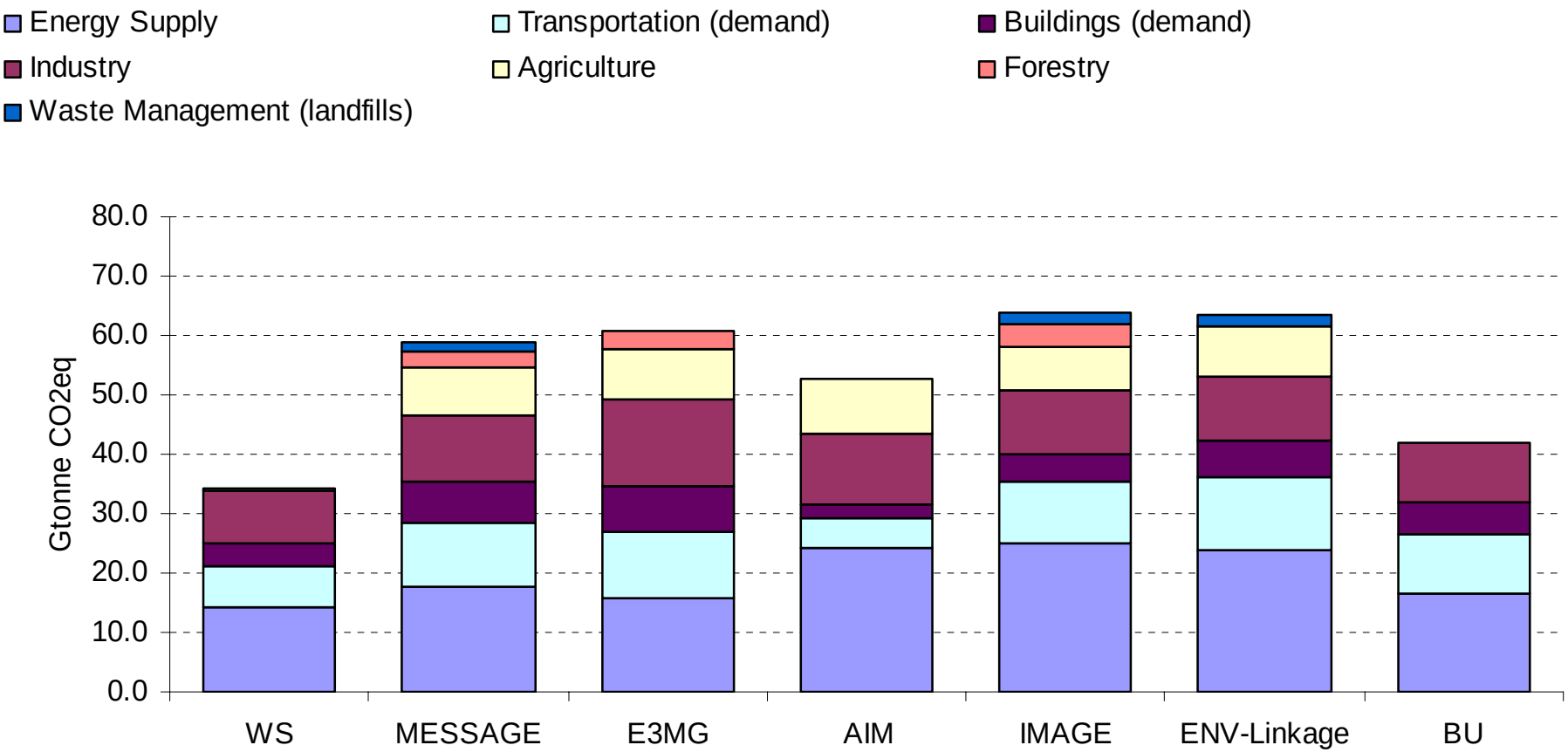
- Top-down:
  - Market constraints and size of the market
  - Some technical constraints included
  - Price responses or market
  - Social costs not included

4. Results

Baseline Emissions per sector (2000)

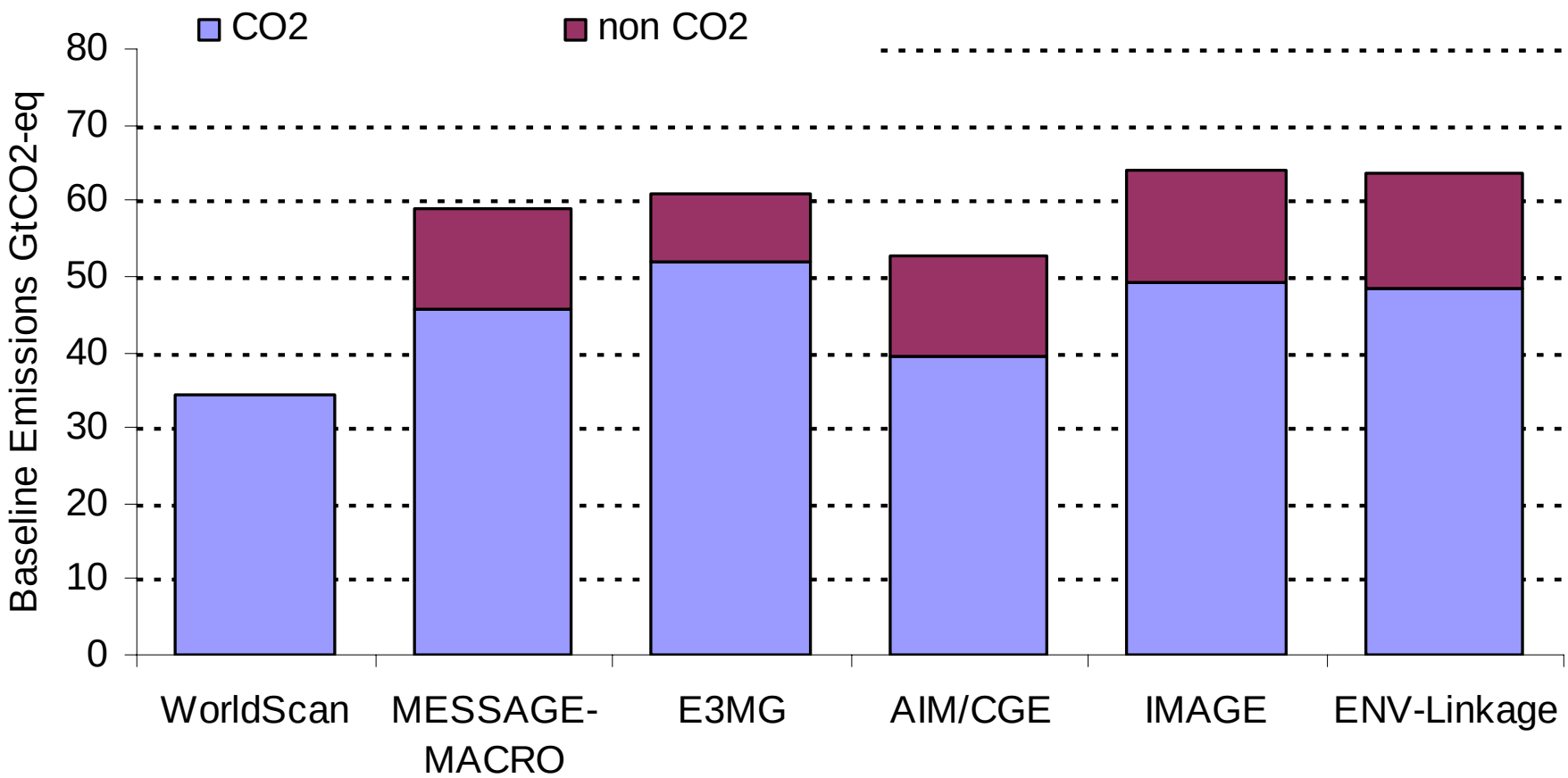


Baseline Emissions per Sector (2030)

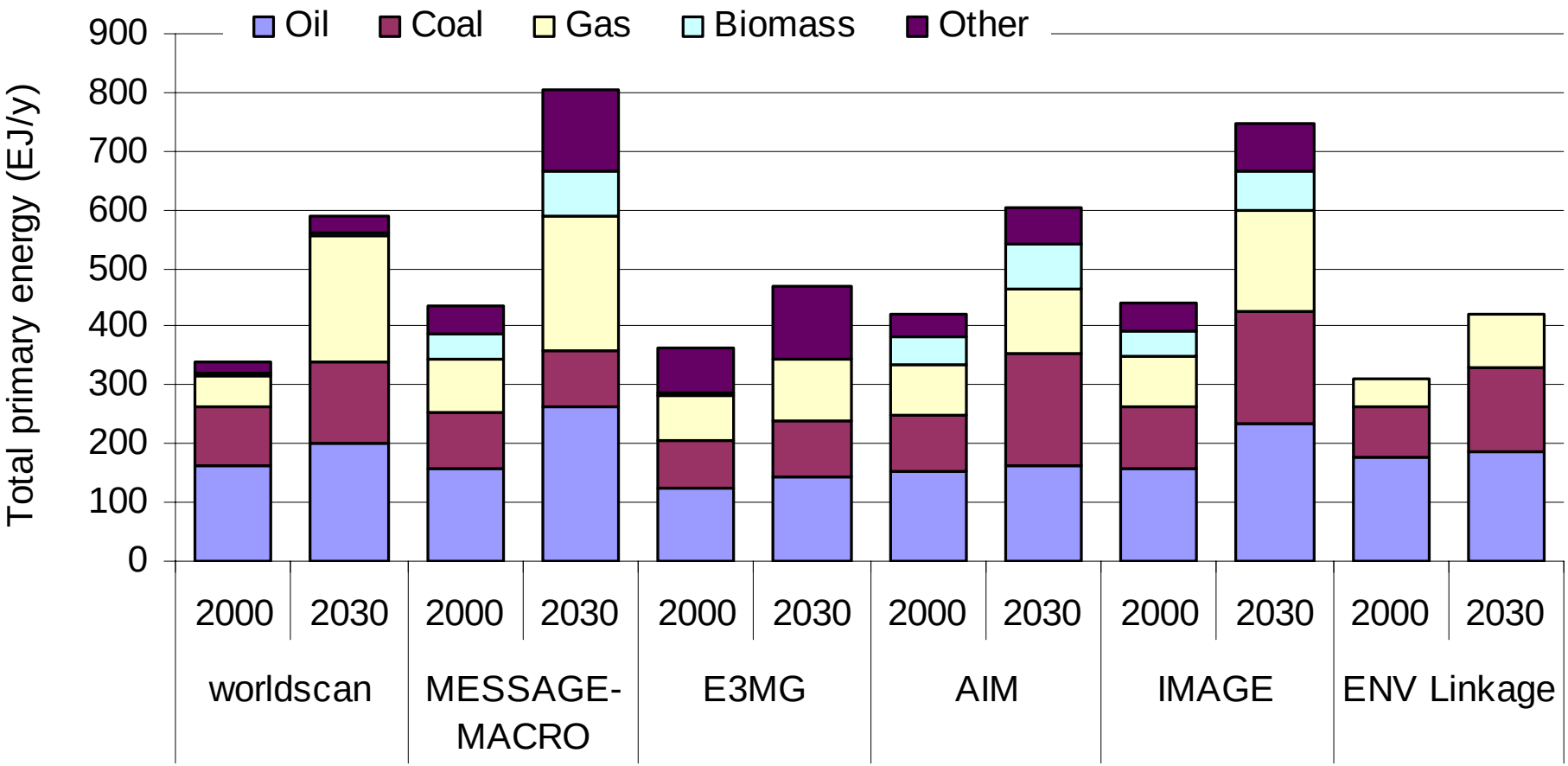


Please note that for the BU analyses only the energy sectors are represented. Where data are given, the TD figures include agriculture, forestry or waste management.

Baseline Emissions per emission type (2030)



Baseline Energy Use per Fuel



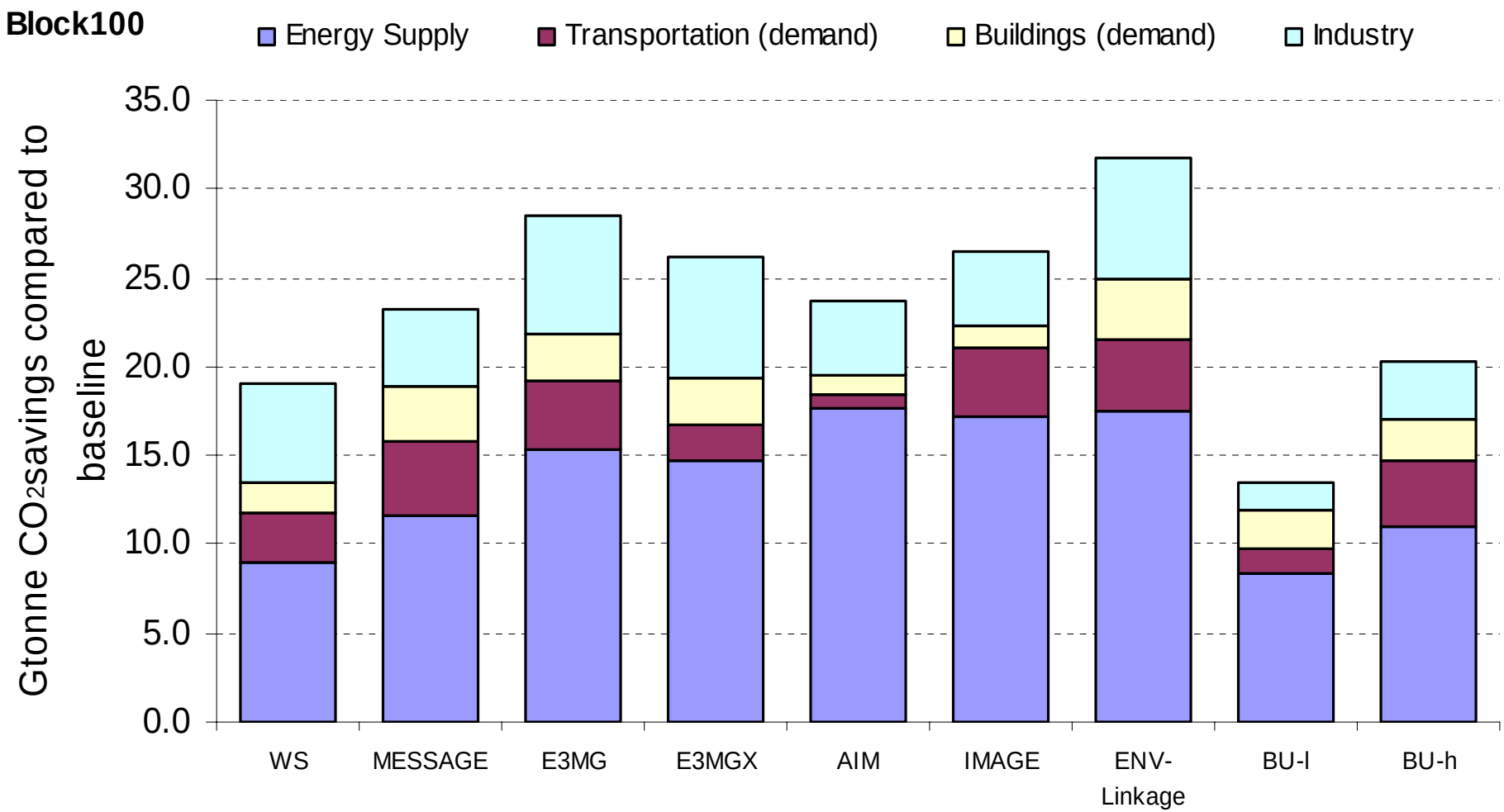
Note that for ENV Linkage only fossil fuels are reported

Responses to Increased Carbon Cost

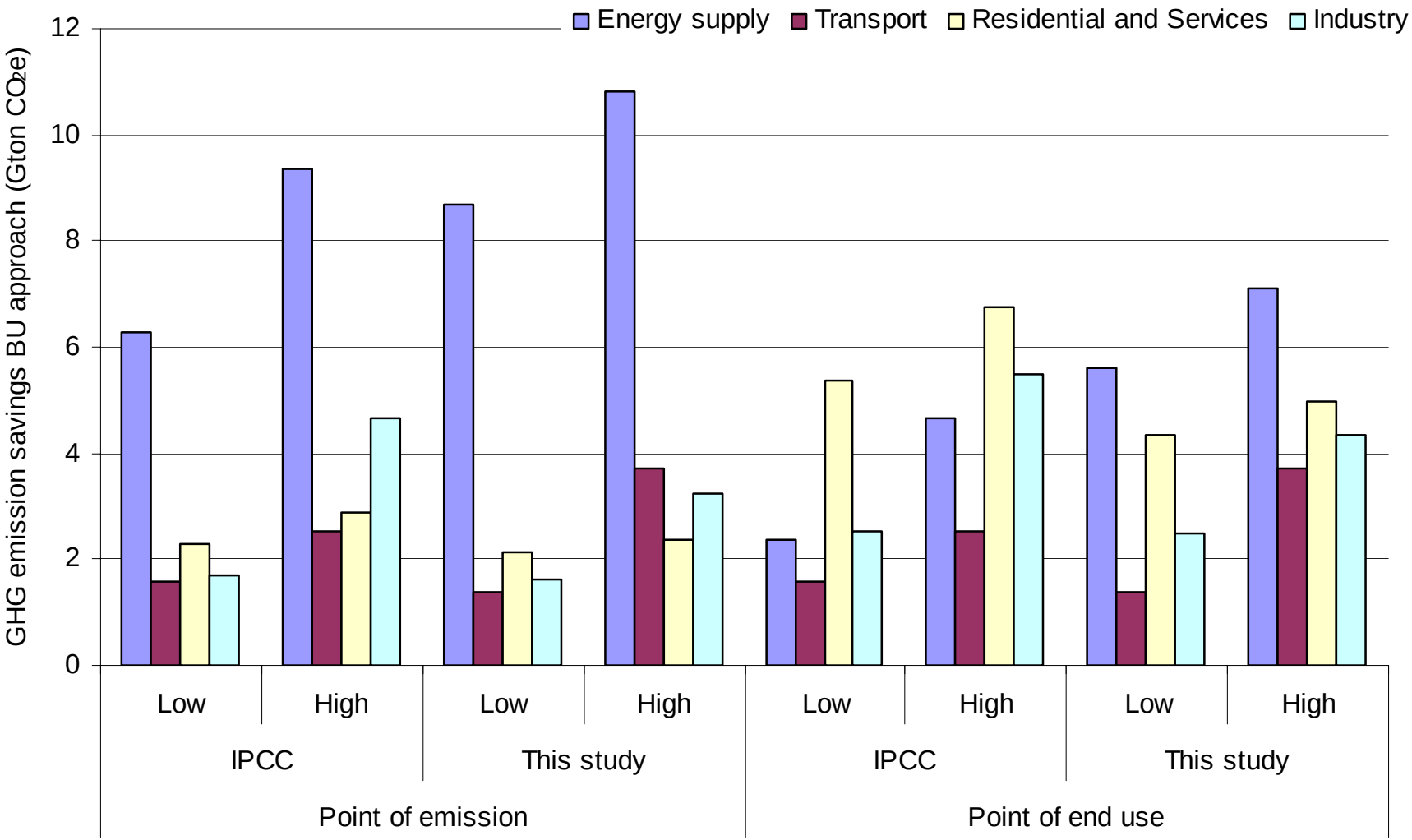
Different responses to increased carbon costs

- Fuel switch to low(er) carbon technologies (ALL)
- Energy efficiency improvement (ALL)
- Reduction of output (TD except IMAGE)
- Structural changes (TD except IMAGE)

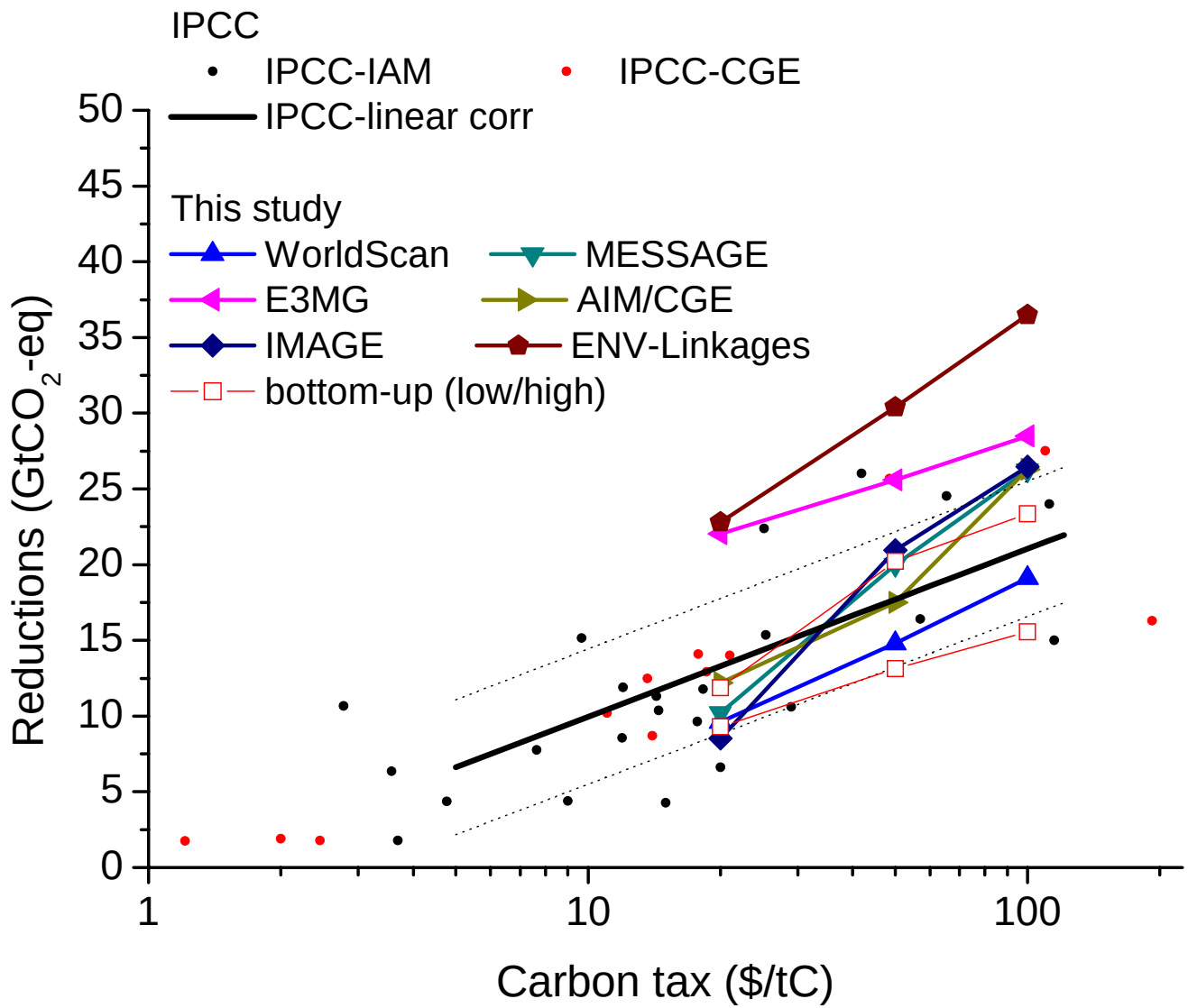
Absolute Savings per Sector



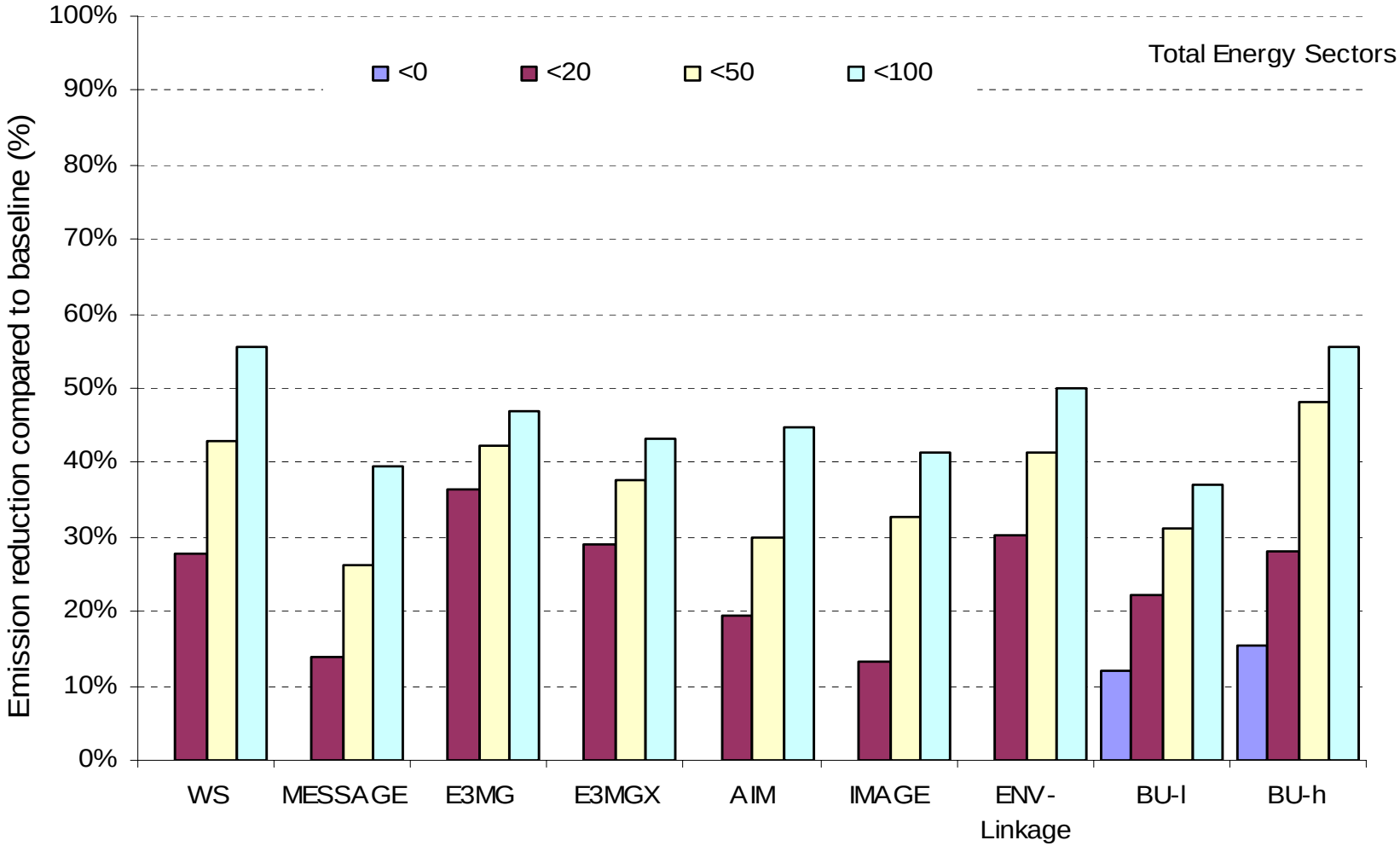
Savings Bottom Up Compared to IPCC AR4



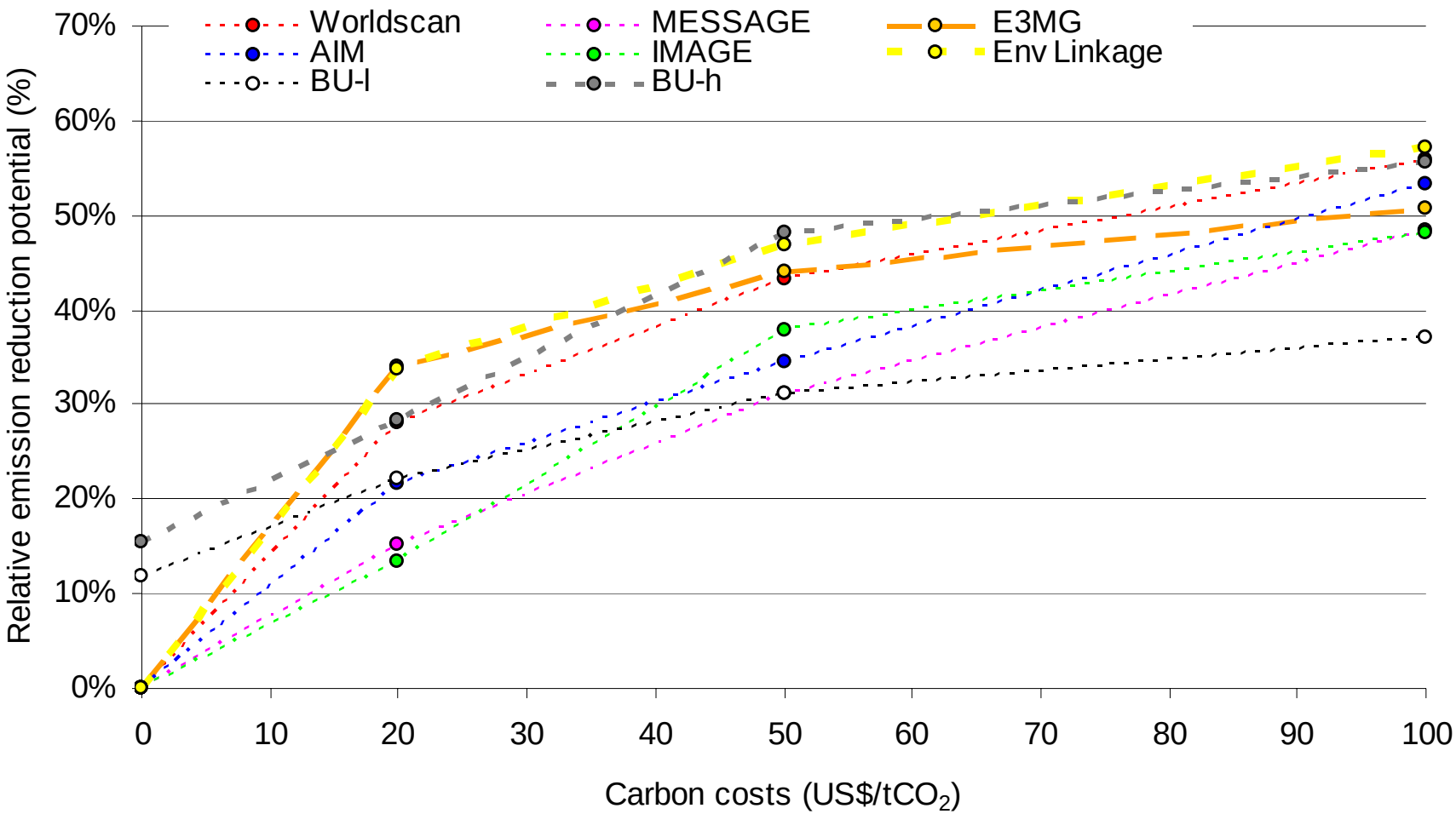
Savings Top Down Compared to IPCC AR4



Relative Emission Reduction in 2030 (1)

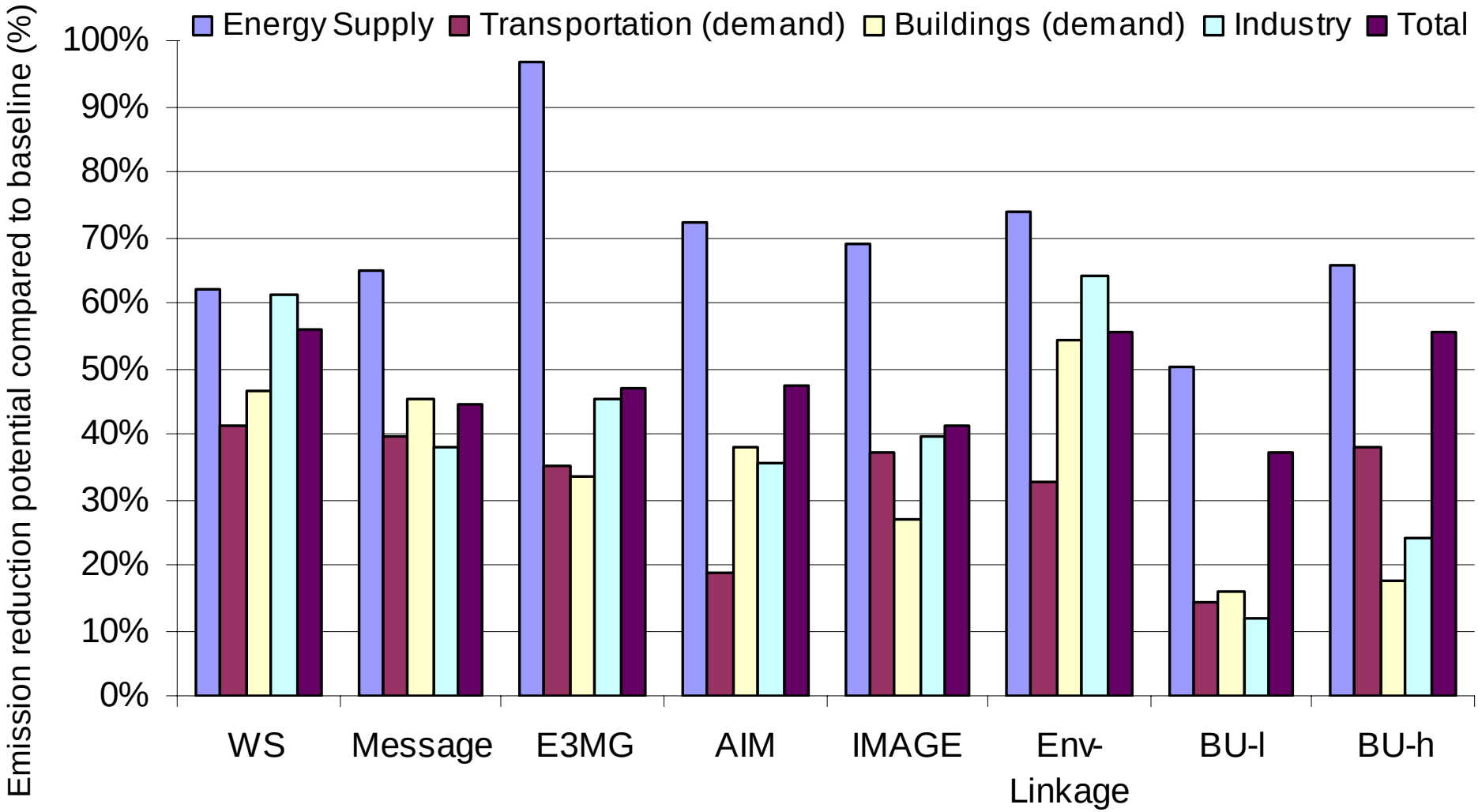


Relative Emission Reduction in 2030 (2)

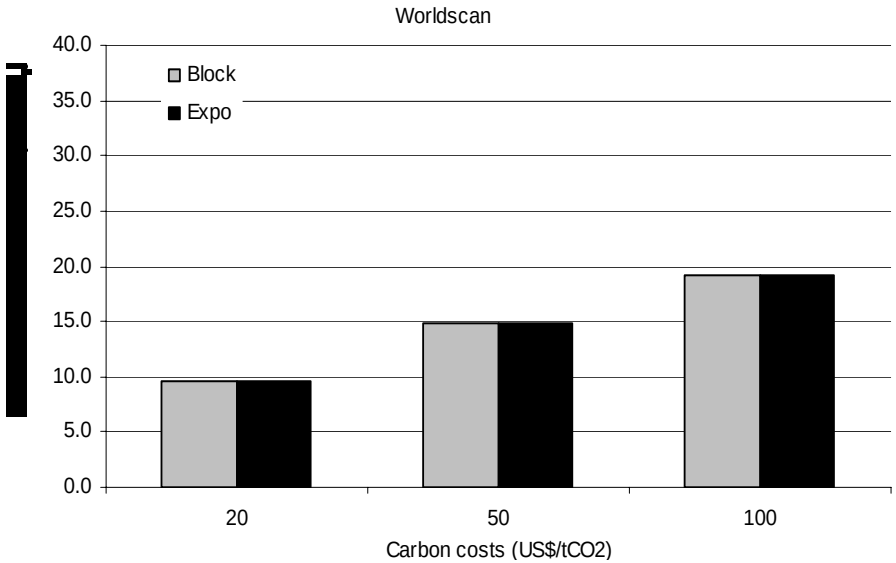


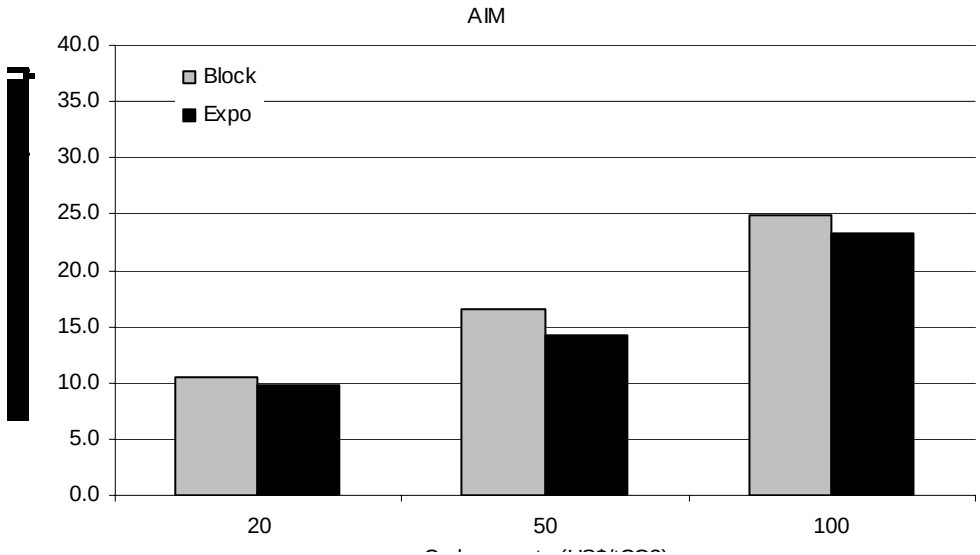
BU-h and BU-l are low and high range of the BU estimates.
The TD estimates indicated include the Block experiments with a continued carbon cost

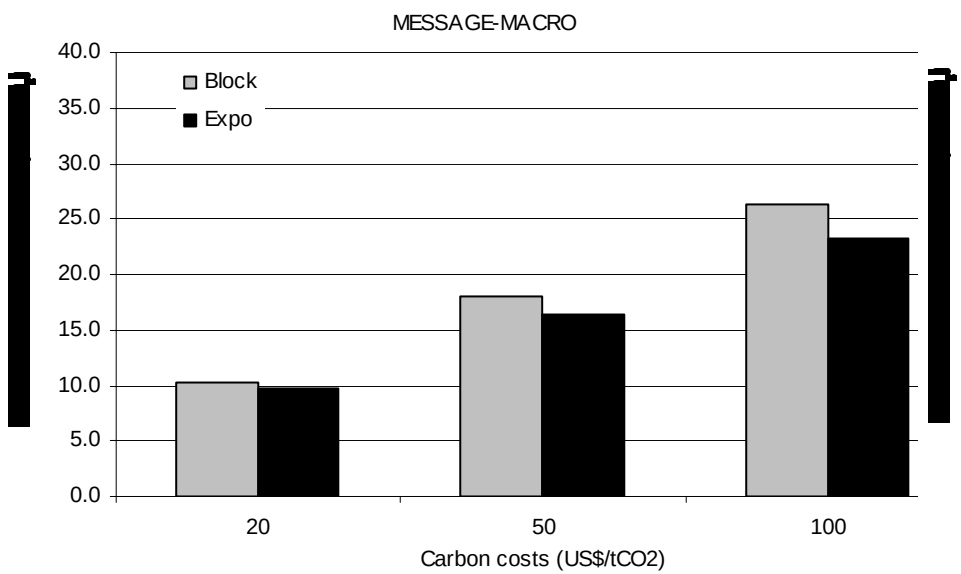
Relative Emission Reduction per Sector

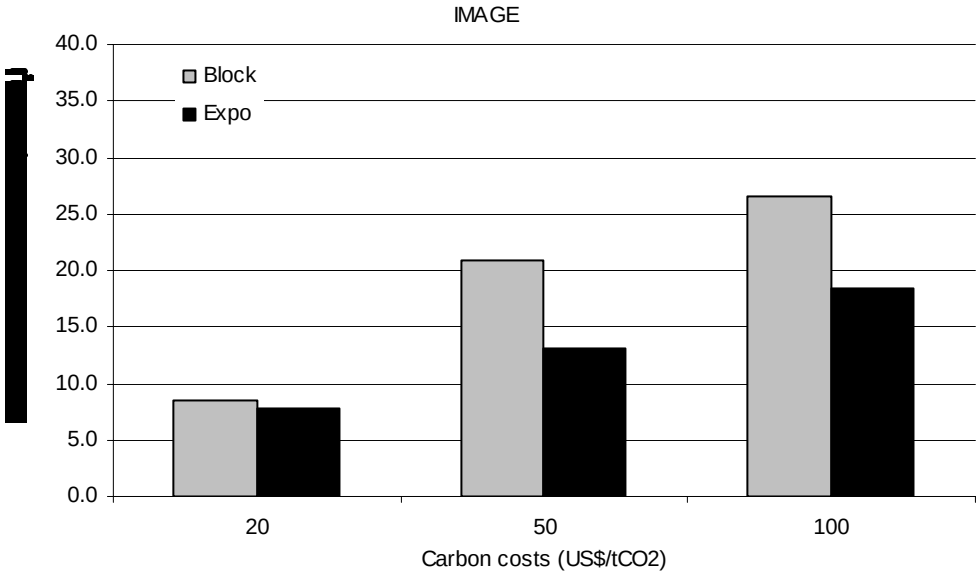


Block versus EXPO experiment (1)

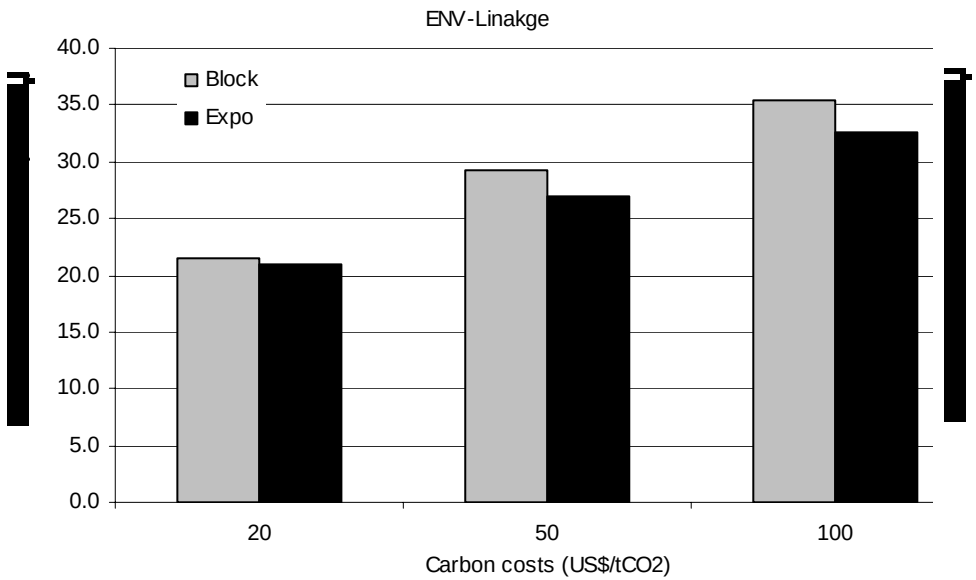


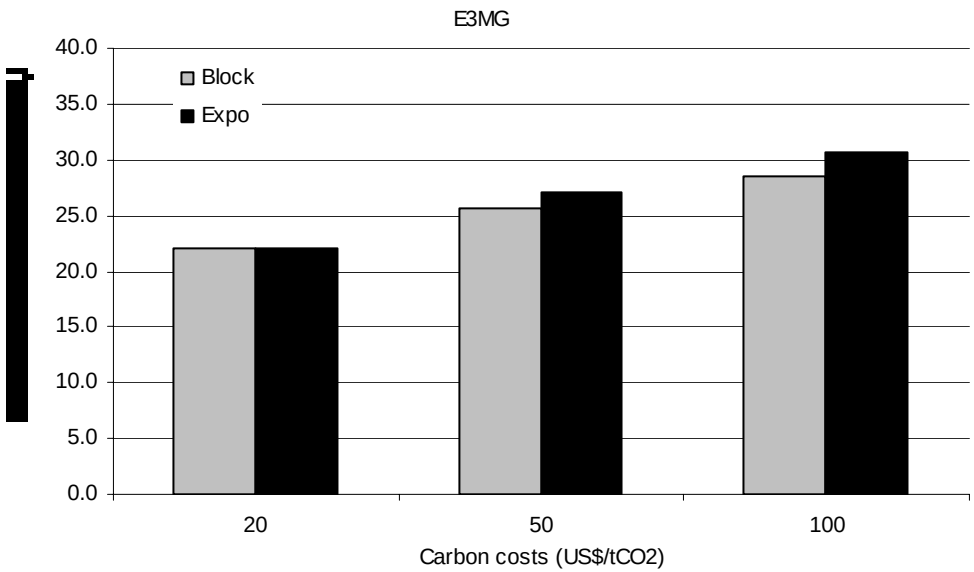


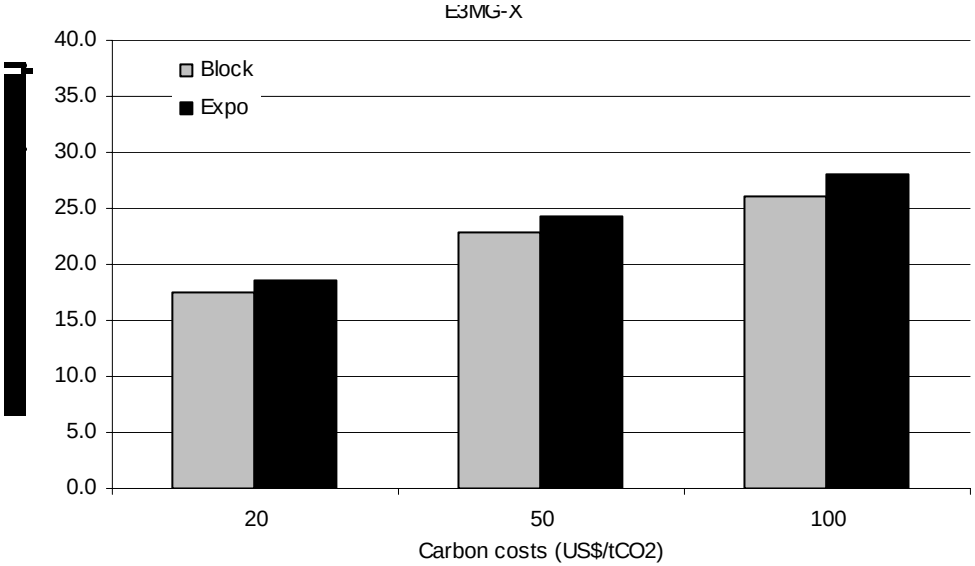




Block versus EXPO experiment (2)



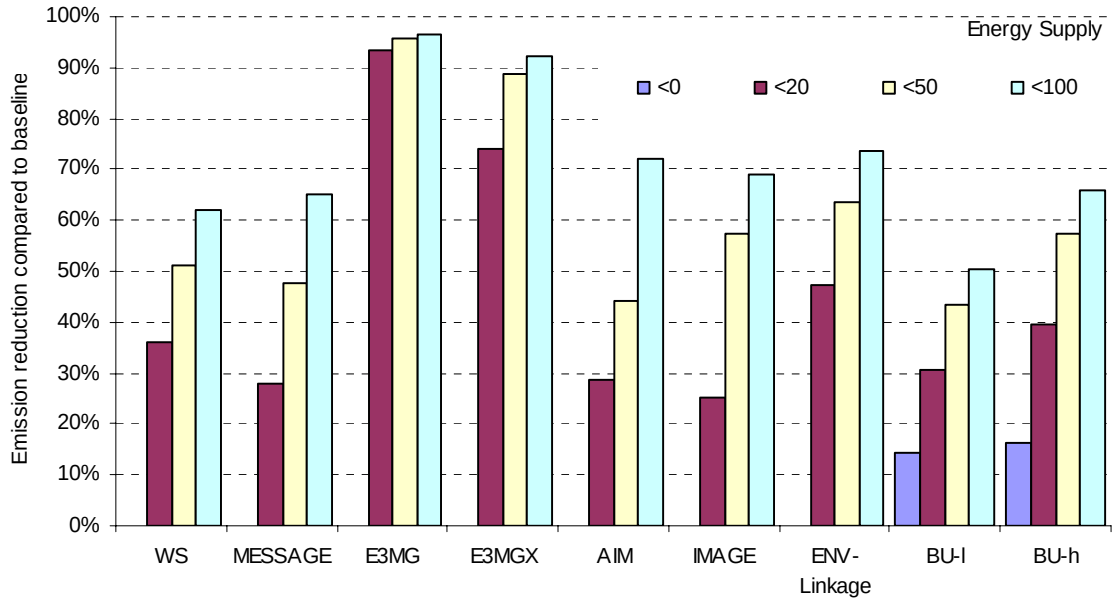




Sector: Energy Supply

Large reductions both models and BU and TD

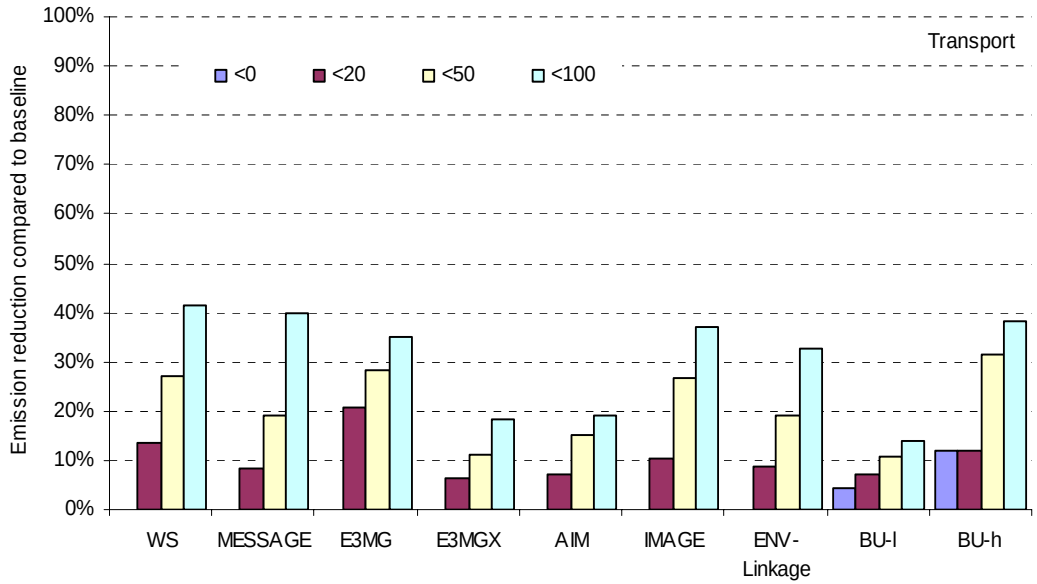
- Sector with centralised and rationale decision making
- Mostly reduction emission factor (fuel Switch) and electricity savings



Sector: Transport

Comparable results among models and BU and TD

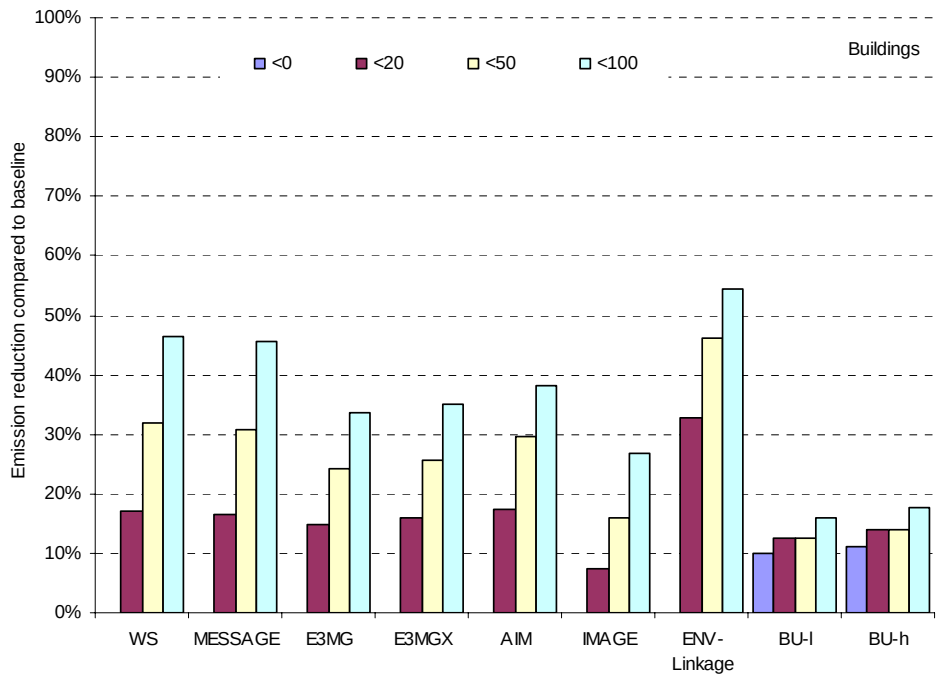
- Sector with relatively low (technical) potential and slow response on prices



Sector: Residential and Services

Comparable results among models but NOT for BU

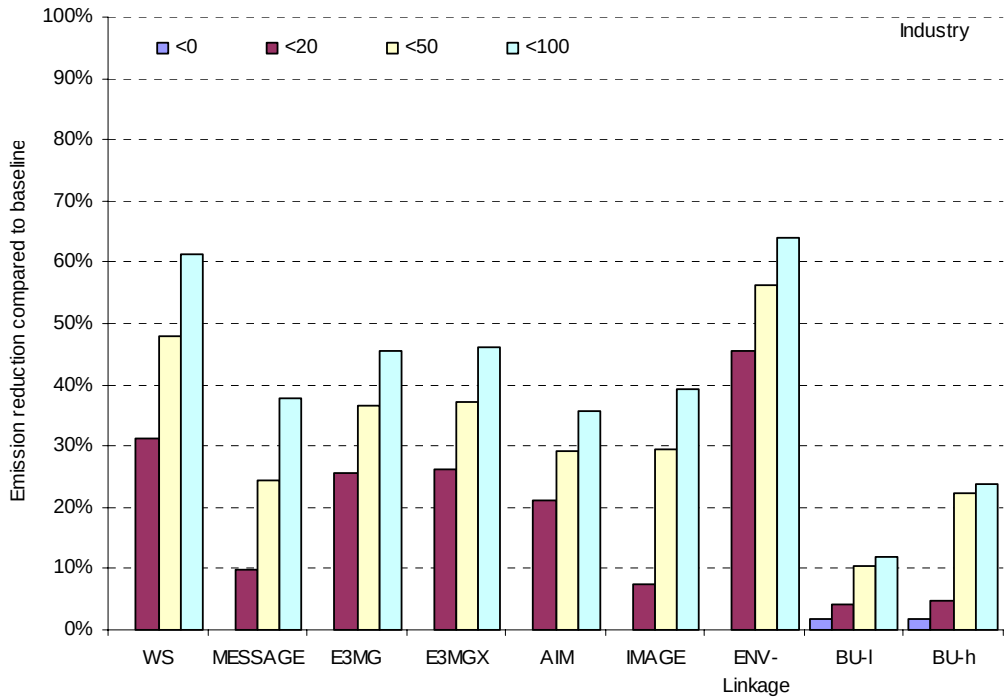
- Large uncertainties mainly in non OECD region (also baseline)
- Top down more options are included.



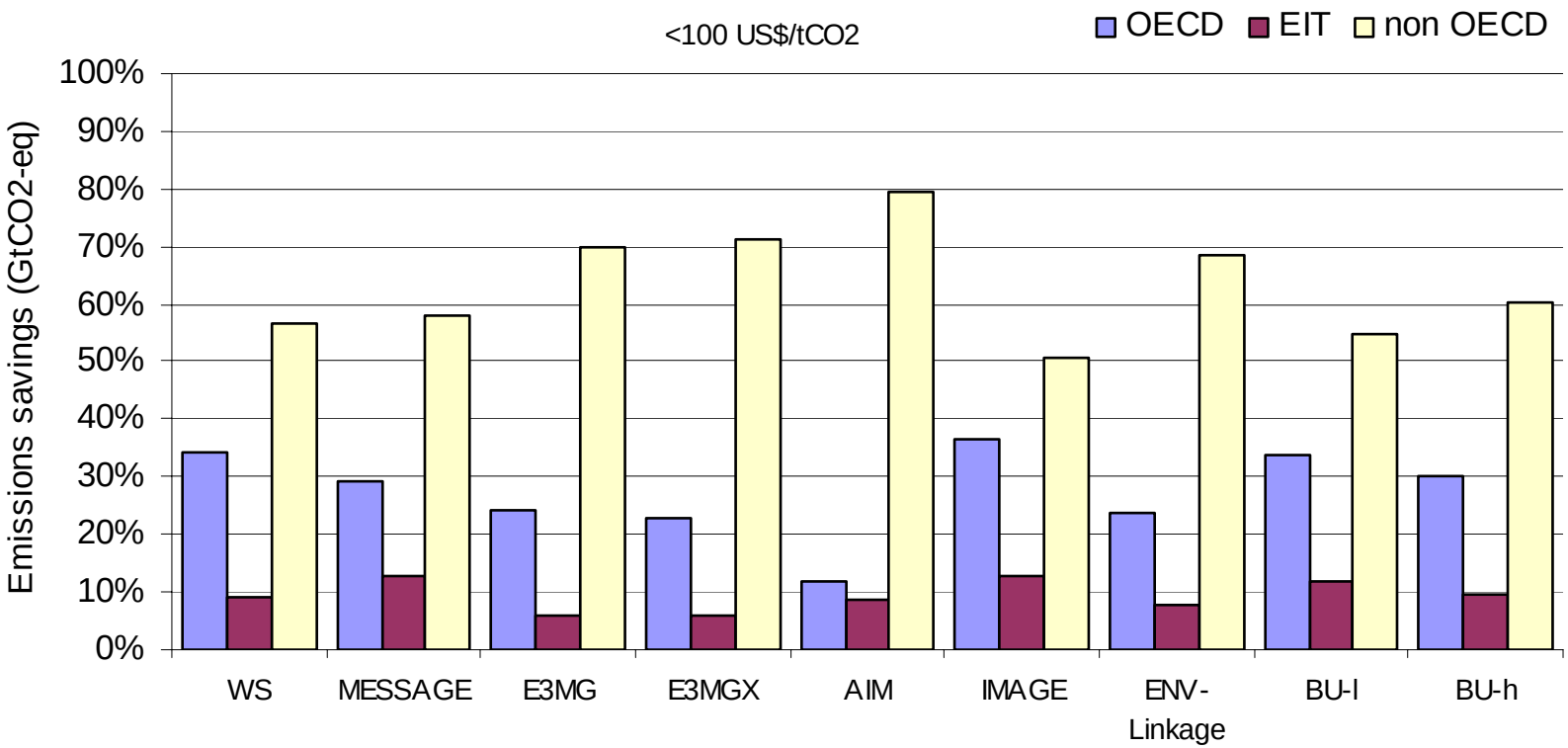
Sector: Industry

Comparable results among models but NOT for BU

- Data are uncertain: elasticity not available, BU data not always available
- BU mainly efficiency improvement.
- Top down models do include more options than BU: recycling, dematerialisation.

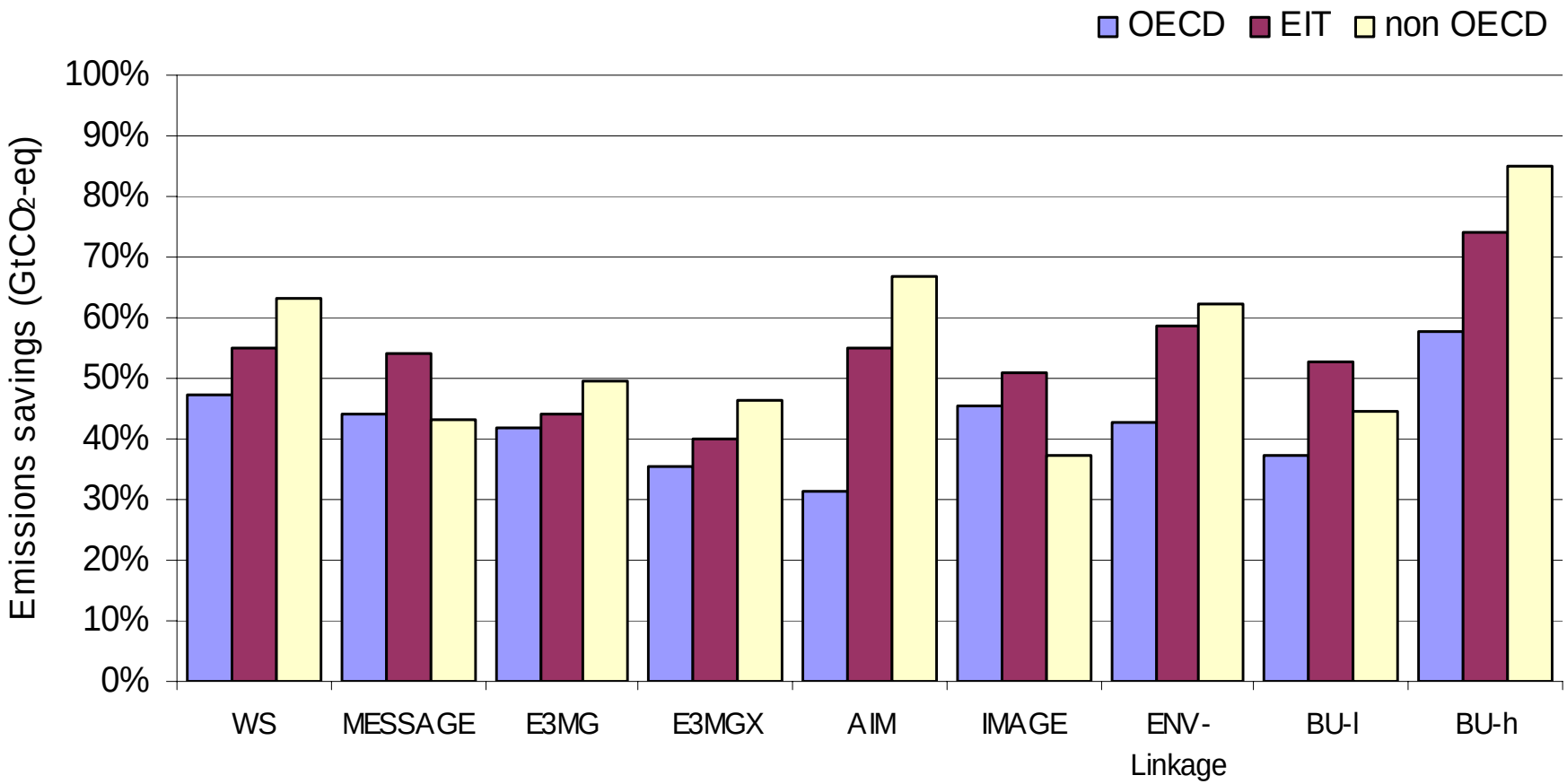


Regional Savings Contribution

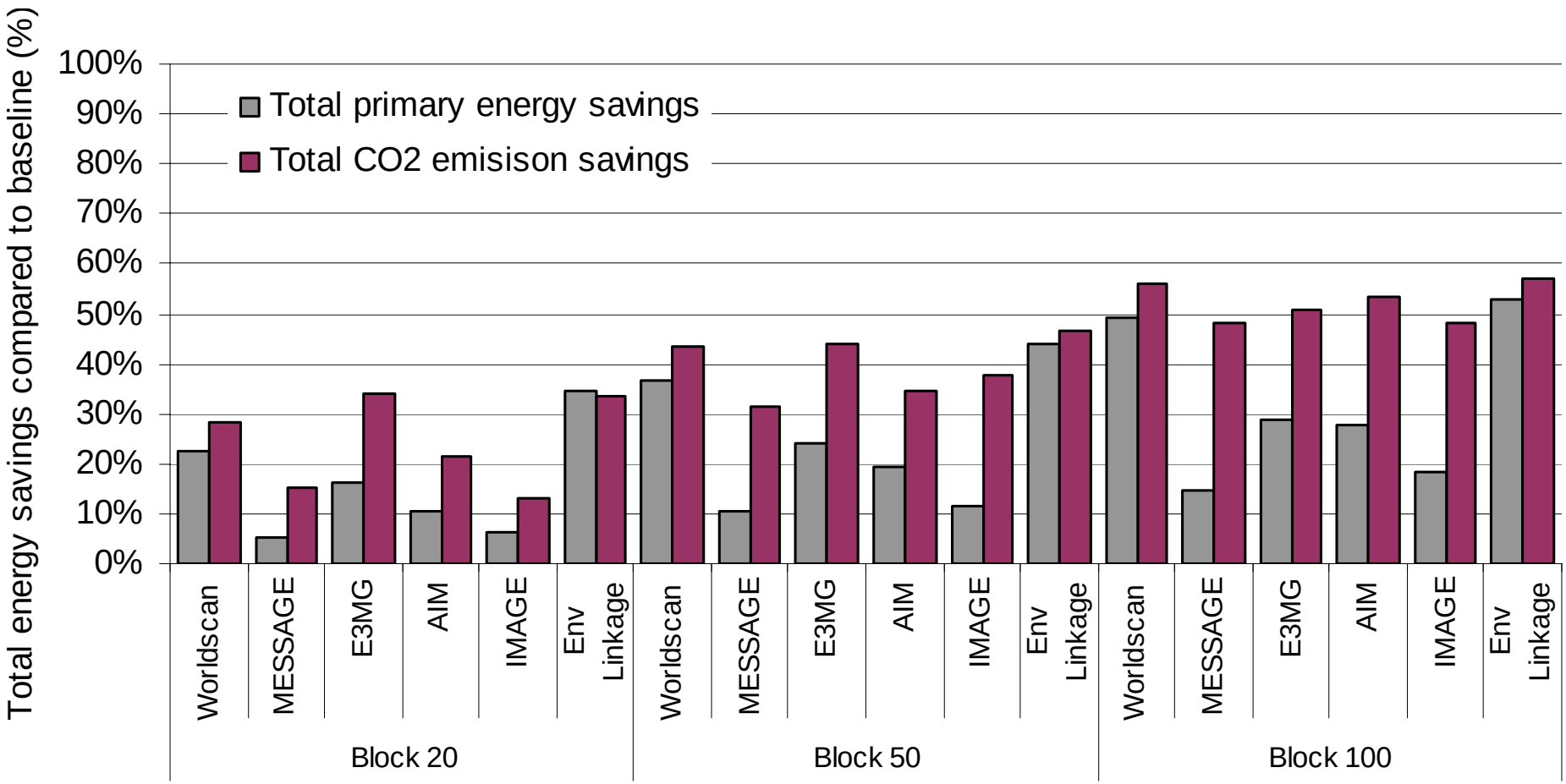


- Large varieties no specific BU and TD differences
- more analyses needed

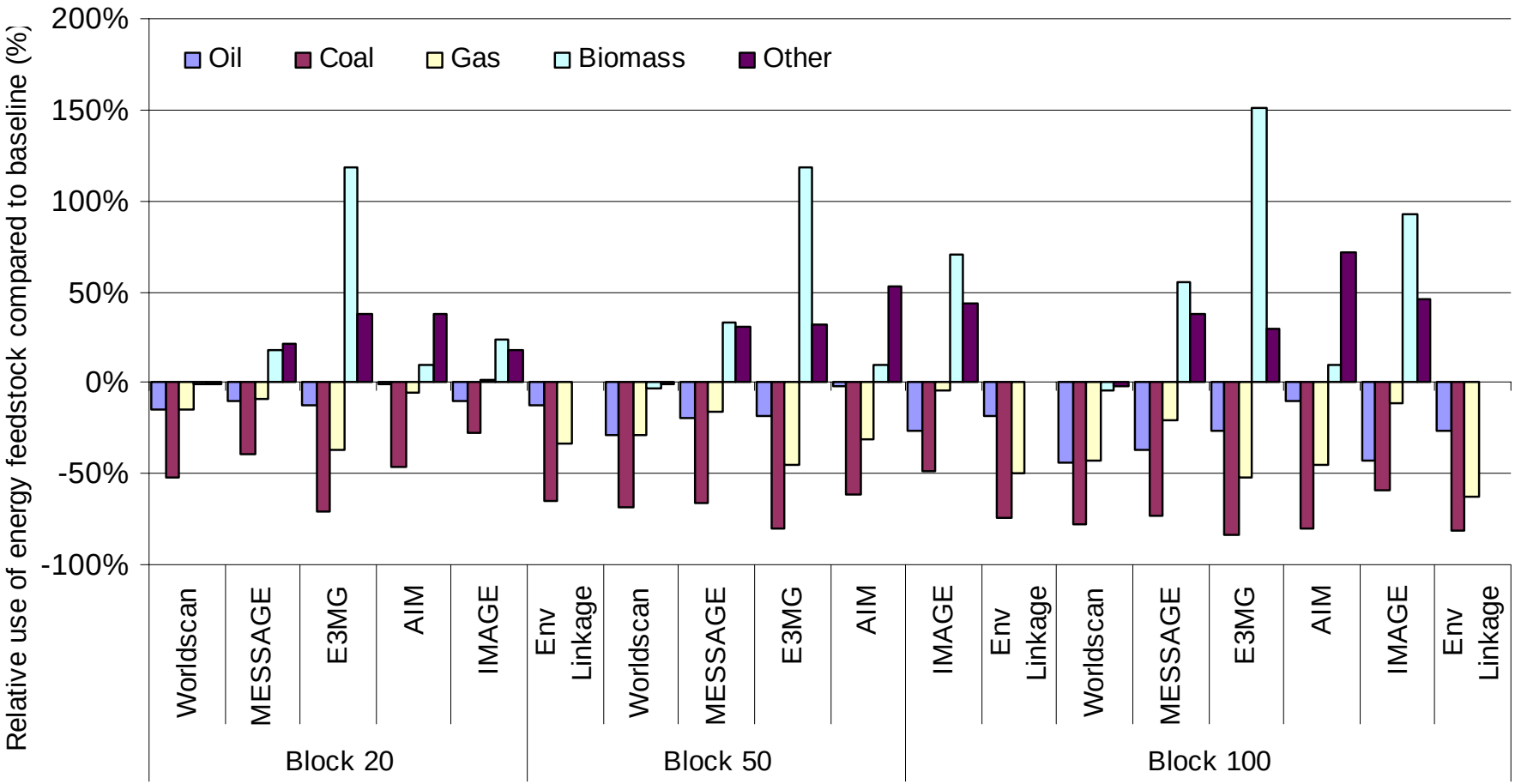
Regional Savings Relative to Baseline



Comparison Energy and Emission Savings



Global Differences in Fuel Consumption



Forestry Sector

- Uncertainties of the mitigation potential from forestry sector are large, complicating the comparison between different modelling approaches.
- Rather than a difference between BU and TD, a difference was found between sectoral and cross sectoral modelling approaches.
- Main differences between modelling output originate from differences in system boundaries, in basic modelling approach (economic versus engineering) and treatment of reference situation.
- Comparison should be made on the cumulative level, whether currently most data are presented on the annual level.
- Bottom up analyses for REDD are not possible and there should always be modelling analyses.

Agricultural Sector

- Many emission models do not include the non CO_2 emissions and reductions from the agricultural sector.
- There is a large problem with the baseline scenario when comparing between TD models and with BU assessment.
- Specific agricultural models are needed to compare the mitigation potentials. In this study this was not possible due to time constraints.
- Specific runs under standardised conditions and references are required for further investigation. Both with emission and agricultural models.

5. Discussion and Conclusion

Fundamental Differences Between BU and TD

Bottom up and top down approach are completely different approaches making it difficult to compare results:

- Most bottom up approaches do not quantify barriers to overcome negative costs.
- For bottom up, the baseline is mostly used as reference for activity data and emissions, no consistent analyses is done with the baseline.
- Most top down approaches include macro economic feedbacks.
- Because of the inclusion of macro economic feedbacks, in most top down studies output reduction and structural changes are included in the mitigation potential.
- The bottom up approach allocates emissions and reductions to end use sectors. Top down models use an allocation to point of emission.

Main Findings on BU and TD

- Significant work is needed for AR5 to improve the mitigation potentials and comparison
- Guiding is required to compare the different approaches, even between TD
- The energy and transport sector have the most comparable results between BU and TD
- The buildings and industry sector show comparable results among TD models but NOT for BU.
- The data for energy efficiency improvements are most uncertain.
- TD models include more options than BU for the industry sector for instance recycling and use of different materials

Mitigation Potential – Robust Findings

- The ranges between the results at sectoral and regional scale are large.
- The results reinforce the message from the IPCC AR4
- Reductions compared to baseline in 2030: 40 – 55%
- Reductions compared to baseline in 2000: 60 – 100%
- Most reduction originate from the energy supply sector
- Transport sector low potential
- Building sector has the reductions at the lowest costs
- Largest uncertainties:
  - building sector
  - non OECD region
  - low carbon costs

Guidance For Using Sectoral Mitigation Potentials

- Only consider ranges, never one single number or study for policy decisions.
- Ensure the consistency in allocation of emissions and the definition of sectors when comparing data.
- Only use relative numbers when comparing mitigation potentials.

Further work needed for AR5 (1)

- Develop guidelines on reporting bottom up and top down studies regarding:
  - Baseline
  - Sectoral definitions
  - Emission and energy allocation principles
  - Inclusion of mitigation options
- Disaggregated baselines for bottom up analyses
- Improve BU estimates by:
  - harmonizing the methodology of the residential and service sector
  - identifying reduction measures that have not been included in AR4 (Combined Heat and Power (CHP), use of recycling material in the industry sector, non CO_2)
  - better representing developing countries

Further work needed for AR5 (2)

- Conduct studies specifically on behavioural changes
- Improve the representation of top down models by:
  - Conduct additional studies to improve data in top down models
  - Check differences in original databases (GTAP and IEA)
  - Include physical parameters in economic models to improve comparability
- Improve the consistency on modelling and reporting forestry sector