Analysis of costs and benefits of CO2 emission reduction strategies

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The Institute for Prospective Technological Studies (IPTS)

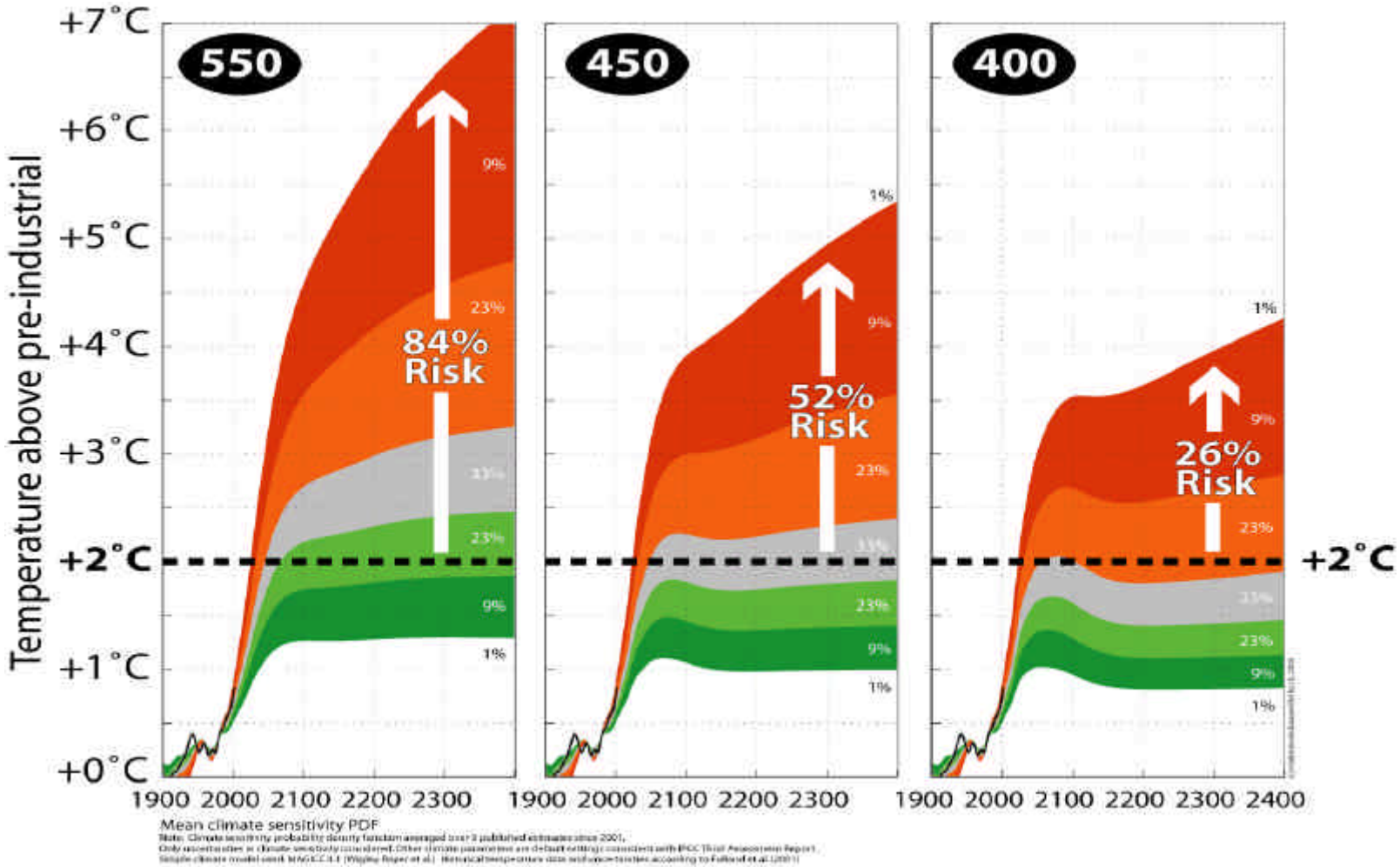
- The IPTS, based in Sevilla, is one of the 7 scientific institutes of the European Commission's Joint Research Centre (JRC)
- Its mission is to provide customer-driven support to the EU policy-making process by researching science-based responses to policy challenges that have both a socio-economic and a scientific or technological dimension

- European Spring Council 2005: Commission invited to "prepare a cost benefit analysis which takes account both of environmental and competitiveness considerations"
- Commission launched a web-based stakeholder consultation
- The Commission's Communication on action on climate change post 2012 (9 February 2005)

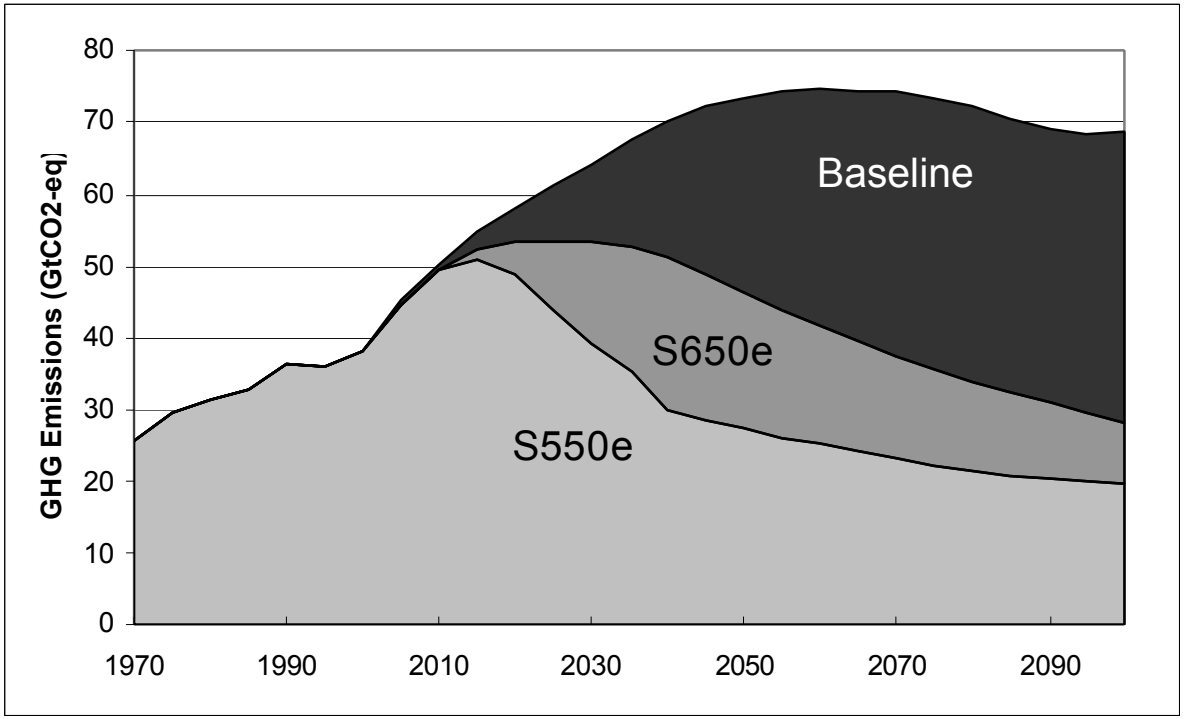
"Action on climate change post-2102"

(http://europa.eu.int/comm/environment/climat/future_action.htm)

The Risk to overshoot 2°C



The 2°C challenge and cut in global emissions



Source: GCNRS/LEPII-EPE/RIVM/MNP/ICCS-NTUA/CES-KUL study

- By 2025, global reductions of 15 to 30 % from baseline are required, respectively in S650e and S550e
- By 2050, these reductions reach 35 to 65 %

Model-based analysis

Energy Modeling Activities at IPTS

Sustainability in Industry, Energy and Transport (SIET) Unit

- **Energy and Climate Change Group (htttp://energy.jrc.es)**
  - POLES Model: partial equilibrium model of the energy system
    - Power generation sector
    - Energy-intensive sectors individually modeled (steel, cement, refineries, pulp & paper, transport)
  - GEM-E3 Model: general equilibrium model

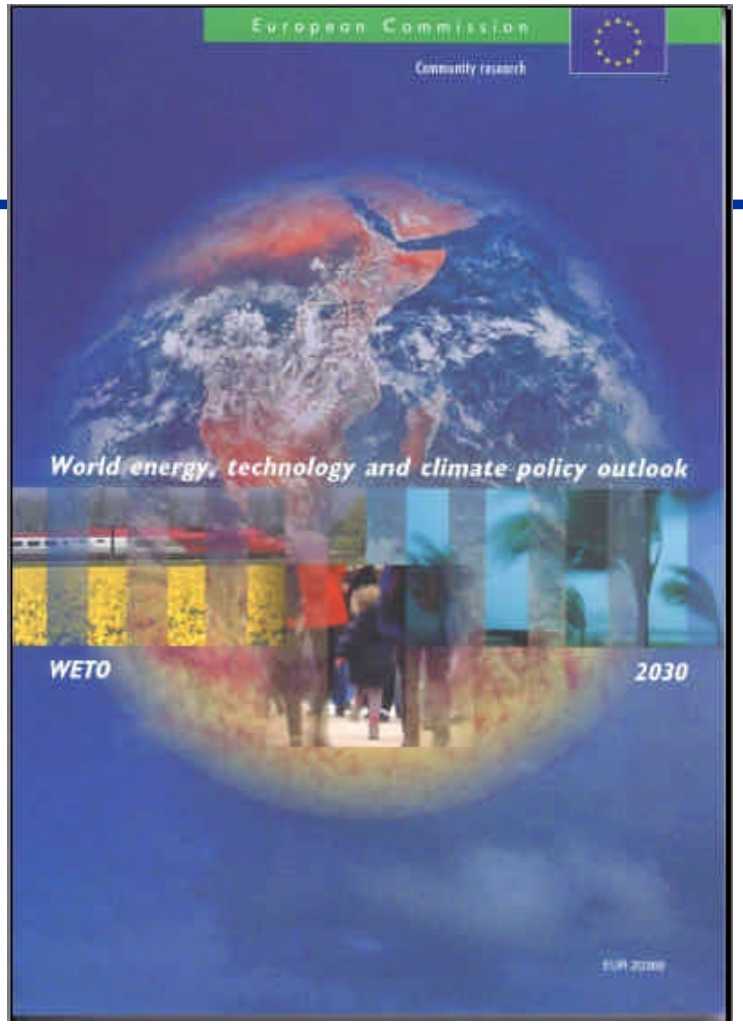
The POLES Model

A world simulation model for the analysis of energy systems and their global environmental impacts to 2010 and 2030 :

- **scenarios and projections for energy demand, supply and prices**
- **analysis of CO_2 emission reduction options in an international perspective**
- **impacts of technological change and R&D strategies**

WETO 2030

World Energy, Technology and climate policy Outlook

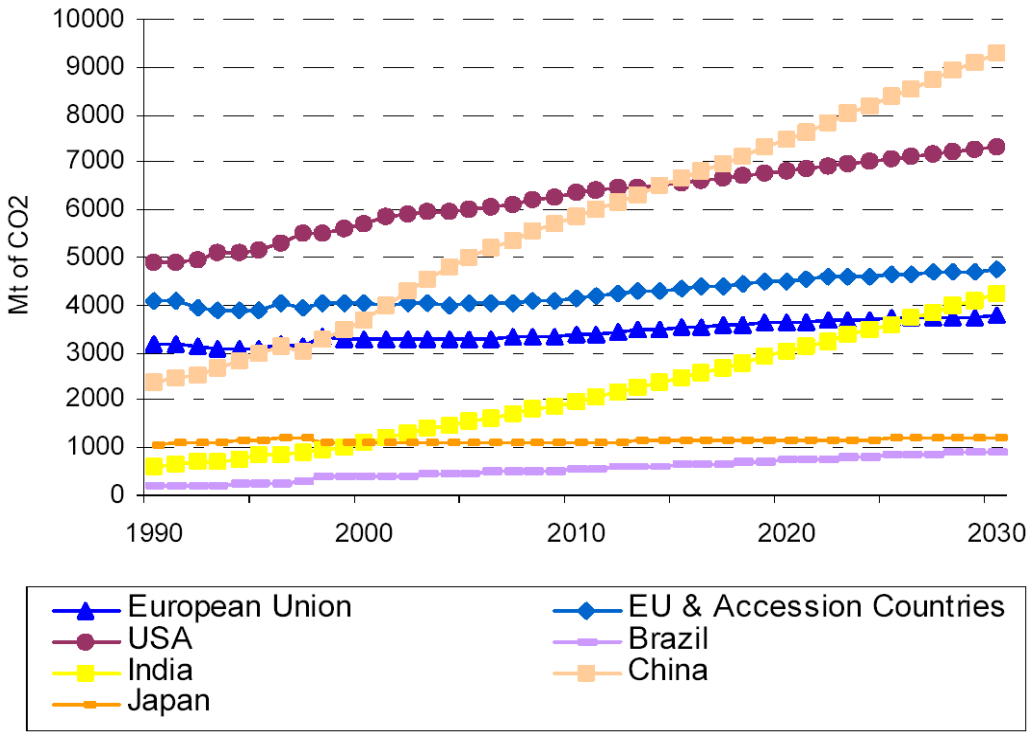


EUR/20366/EN

http://energy.jrc.es/

http://europa.eu.int/comm/research/energy/pdf/weto_final_report.pdf

Energy-related CO_2 Emissions



Impact of Alternative Technology Cases

- Defined as technological breakthroughs affecting alternative sectors (power generation, transportation, end-use) Imply changes in costs, efficiency, potential.
- Addressing the impact of them into the basic variables: energy dependency, GHG emissions, etc.

Conclusions:

Technological breakthroughs do not offer definitive solutions for the climate change problem. They are not likely to induce stabilization of GHG emissions unless:

1. **Active climate-protecting policies are implemented (via economic incentives)**
2. **These climate-protecting policies involve the major global actors**

The GEM-E3 Model: General Equilibrium Model for Energy-Economics-Environment interactions

- Developed in mid 1990s by
  - Core team: NTUA, ZEW, KUL
  - Contributors: University Toulouse, University of Strathclyde, Stockholm School of Economics, Erasme, CORE and Middlesex University
- Partly financed by DG RTD
- Complementarity with other E3 models: POLES and PRIMES
- Extensively used in energy and environmental policy assessments

GEM-E3 Characteristics

- GEM is a computable general equilibrium model: simultaneous equilibrium (optimality) in all markets (endogenously determined)
- World version: 21 regions
- EU version: 15 + outer regions
- 20 sectors: focus on energy and energy-intensive sectors
- GTAP database
- Formulated in Mixed Complementarity (zero profits, equilibrium conditions and balance constraint; complementarity conditions)
- GAMS/PATH solver
- Dynamic version: working on a 5-year basis, from 1995 to 2030

The GEM-E3 model: model overview

The model considers an economy with:

- **multiple sectors, each producing a homogeneous commodity**
- **a single representative Firm operates in each sector**
  - minimizing cost under CRTS technology
  - deriving optimal demand for production factors (including all other commodities, labour and capital)
- **a single representative Household**
  - maximizing utility
  - allocating revenues to consumption of commodities and savings
  - determining labour supply
- **and a Government ensuring transfer distribution and applying policy through**
  - taxes, consumption, investments etc.

The GRP Study
Greenhouse gas Reduction Pathways (GRP) in the UN-FCCC process up to 2025

see http://europa.eu.int/comm/environment/climat/future_action.htm

Partners:

LEPII-EPE (coord.), RIVM-MNP, ICCS-NTUA, and CES-KUL

Study performed for DG Environment

Using the POLES, GEM-E3 and IMAGE models

GRP Scenarios of interest

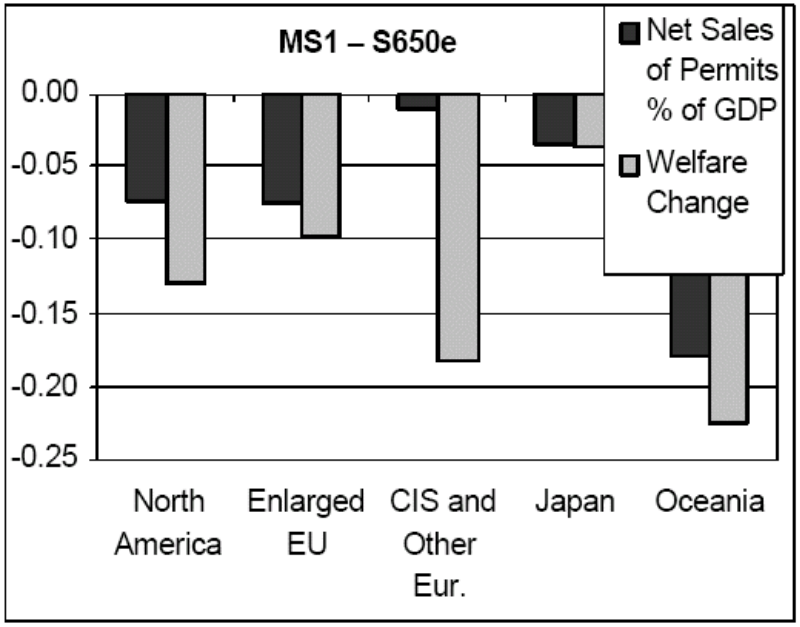
Two "reduction profiles", related to the 2°C, have been defined, for the set of the 6 Kyoto gases:

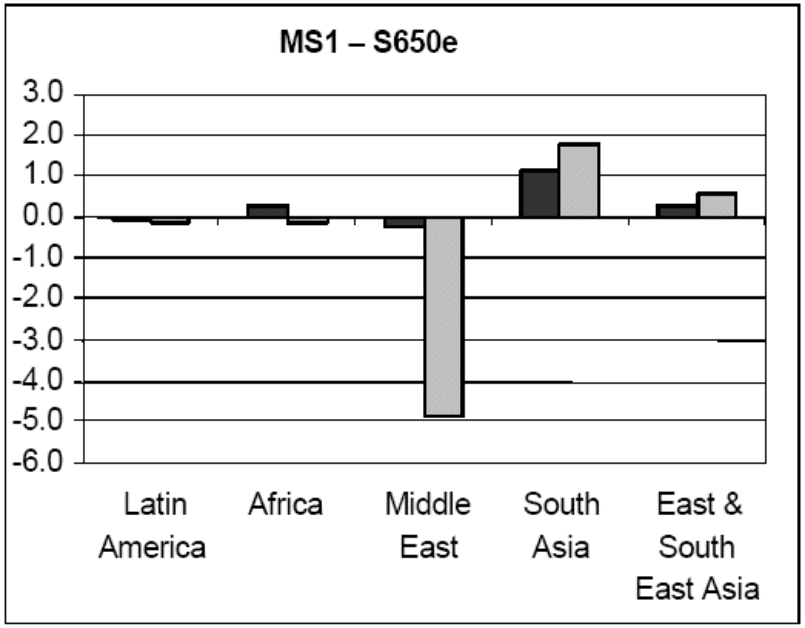
- **S550e for a stabilization of concentrations at 550 ppmv CO2e for the 6 Kyoto GHGs (corresponding to 450 ppmv for CO2 only)**
- **S650e for a stabilization at 650 ppmv CO2e**

Assumptions of the GEM-E3 model runs

- Economic assessment is performed under the assumption of international emission trading schemes that allow for least-cost options to be implemented in all parts of the world
- Grandfathering principle for permit allocation
- Revenues/losses recycled in the economy (to firms and households)
- Perfect market for emission quotas
- Welfare analysis, based on utility of households derived from consumption and leisure

Change in Welfare and Net Sales of Quotas as % of GDP (relative to the baseline)





Source : GEM-E3

Summary of GEM-E3 Results

The General Equilibrium approach allows to account for indirect macroeconomic costs, in addition to the 'direct' costs

- **For each region, the impacts on welfare are strongly correlated to emission trading, except for fossil fuel exporting regions, which are also affected by changes in their exports**
- **In 2025, the total cost of achieving reductions represents 0.7-0.9% of world GDP in S650e and 1.9-2.8% in S550e**

The GRP follow-up Study

IPTS

Study performed for the post-2012 Communication

Using the POLES and GEM-E3 Models

GRP follow-up: Three Limited Participation Scenarios

(1) "Annex I freeze"

- EU-25 reduces emissions by 2025 to 8% below 1990 level,
- while all other Annex I countries continue to be restricted to the Kyoto target by 2025
- The US, by 2025, stabilizes absolute emissions at the 2012 level resulting from compliance with the intensity target
- JI and CDM, are available beyond 2012

(2) "EU freeze"

- EU-25 reduces emissions by 2025 to 8% below 1990 level, and no other countries take on commitments beyond 2012
- Two cases: whether JI and CDM are available beyond 2012

(3) "EU reduce"

- EU-25 reduces emissions by 2025 to 20% below 1990 level, and no other countries take on commitments beyond 2012
- Two cases: whether JI and CDM are available beyond 2012

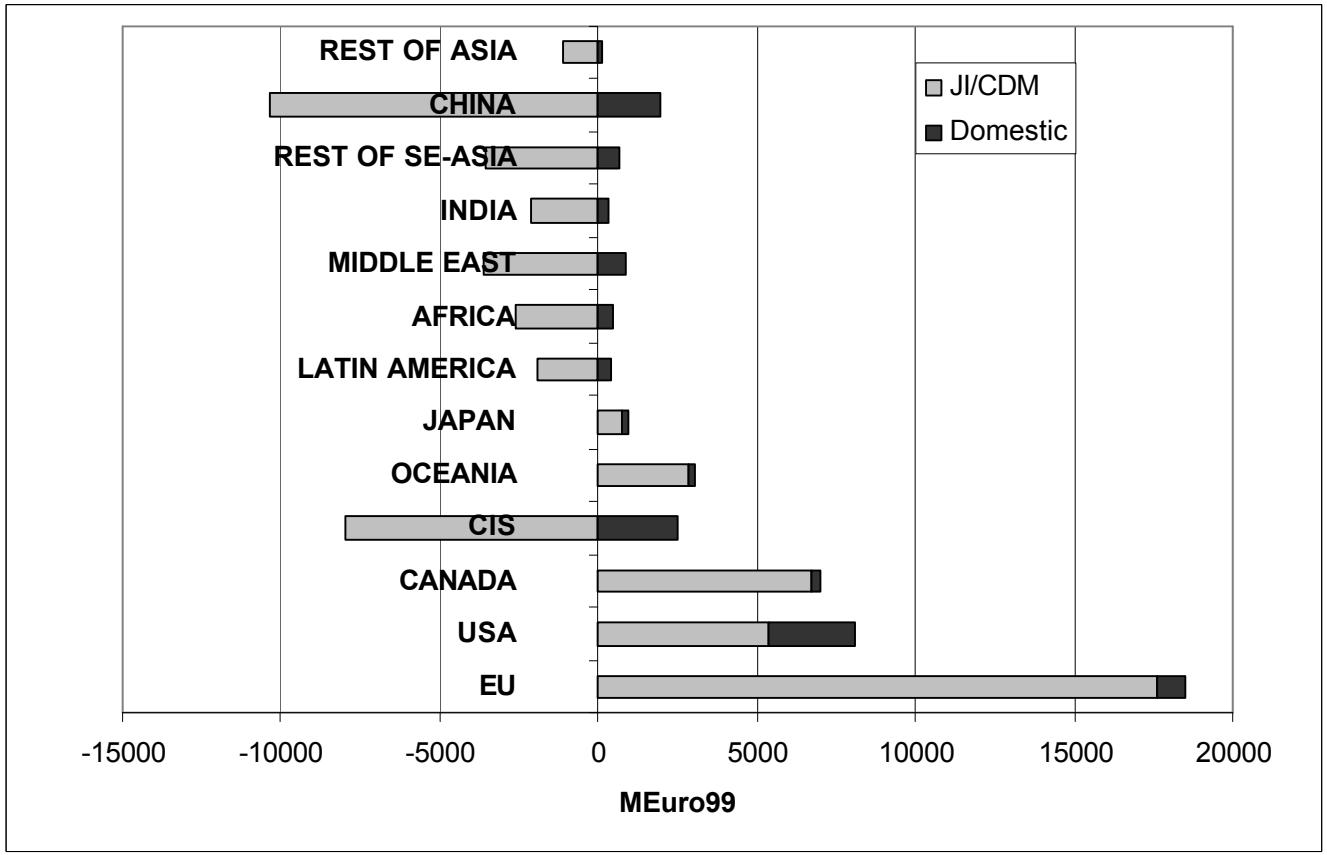
Results of Limited Participation Scenarios: POLES and GEM-E3 models

	Annex I freeze	EU freeze		EU reduce	
		With JI/CDM	*Without JI/CDM*	*With JI/CDM*	*Without JI/CDM*
Global reduction (compared to baseline)	7.3 %	3.3 %		3.9 %	
EU reduction (compared to 1990)	8 %	8 %		20 %	
Costs for the EU in % of 2025 GDP (partial equilibrium)[1)]	0.023 %	0.008 %	0.020 %	0.013 %	0.036 %
Costs for the EU in % of 2025 GDP (general equilibrium)[2)]	0.045 %	0.015 %	0.780 %	0.023 %	1.672 %

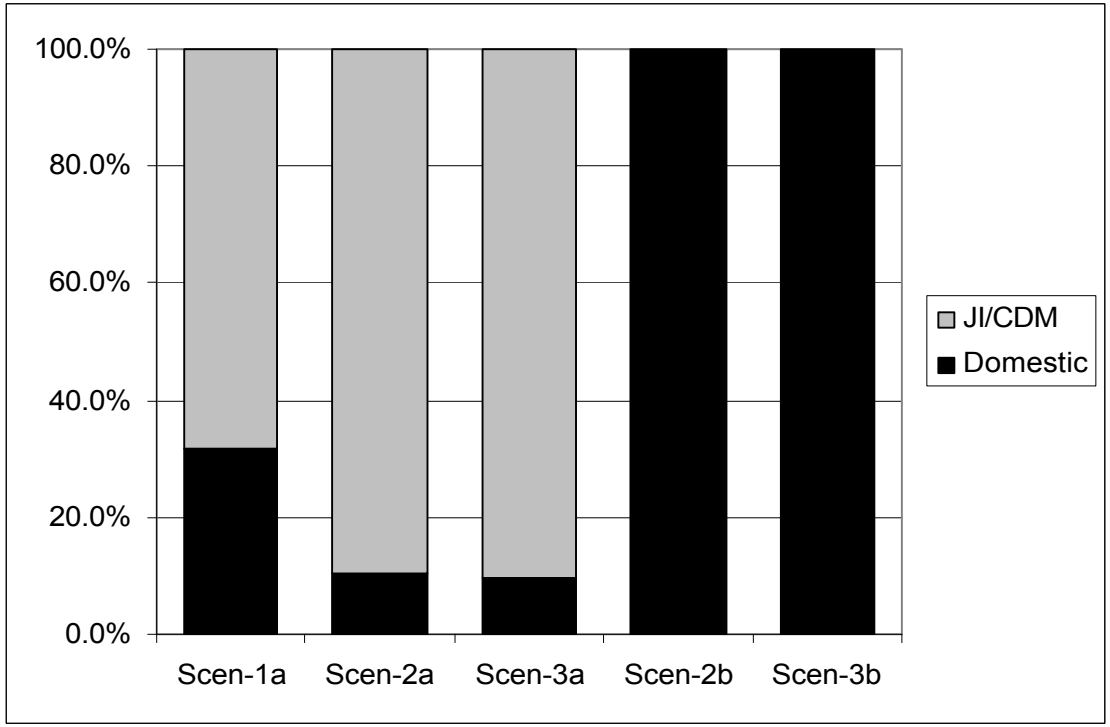
Source: IPTS, POLES and GEM-E3 models.

Note: 1) POLES model 2) GEM-E3 model

Cumulated reduction cost (Scen. 1a)



Domestic action vs. flexibility mechanisms



Carbon value (POLES)

	Carbon Value
Scen-1a	7.22
Scen-2a	1.39
Scen-3a	2.00
Scen-2b	23.08
Scen-3b	54.43

- **Euro99/tCO_2eq**

The most important links

For more information on the Commission's activities related to post 2012 climate policies see

http://europa.eu.int/comm/environment/climat/future_action.htm

For information on modelling activities at the IPTS related to climate change please see

http://energy.jrc.es