Energy and Climate Change Scenarios from a European Perspective

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Outline

- What is the problem?
- What have we done so far?
- Where do we go next: post-2012 Communication
- Model-based analysis

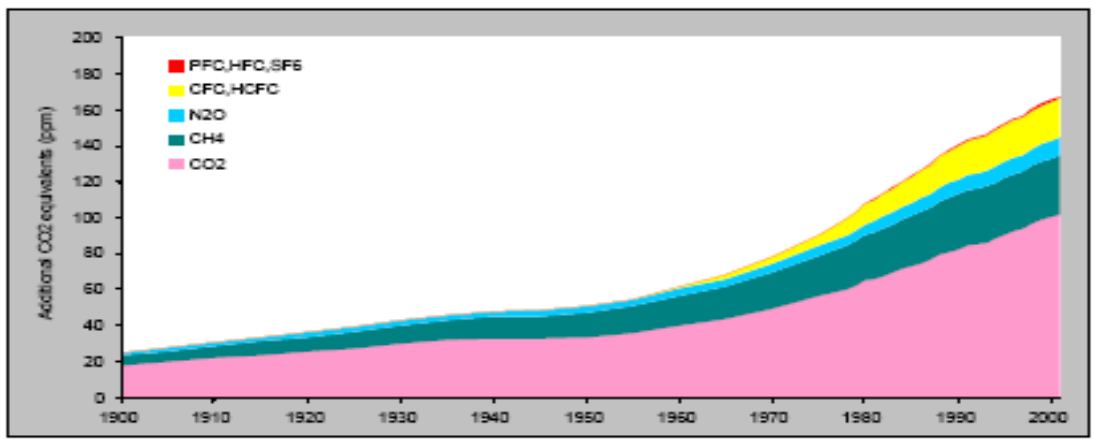
What is the problem?

What is the source of the problem?

Greenhouse gas concentration

past trends

- Concentration of CO_2 has increased by 95 ppm (34%) to 375 ppm (global + Europe)
- All greenhouse gases rose by 170 ppm CO_2-equivalent (61% CO_2, 19% methane, 13% CFCs and HCFCs, and 6% N_2O)



Rise of greenhouse gases (1900–2000) compared to the year 1750

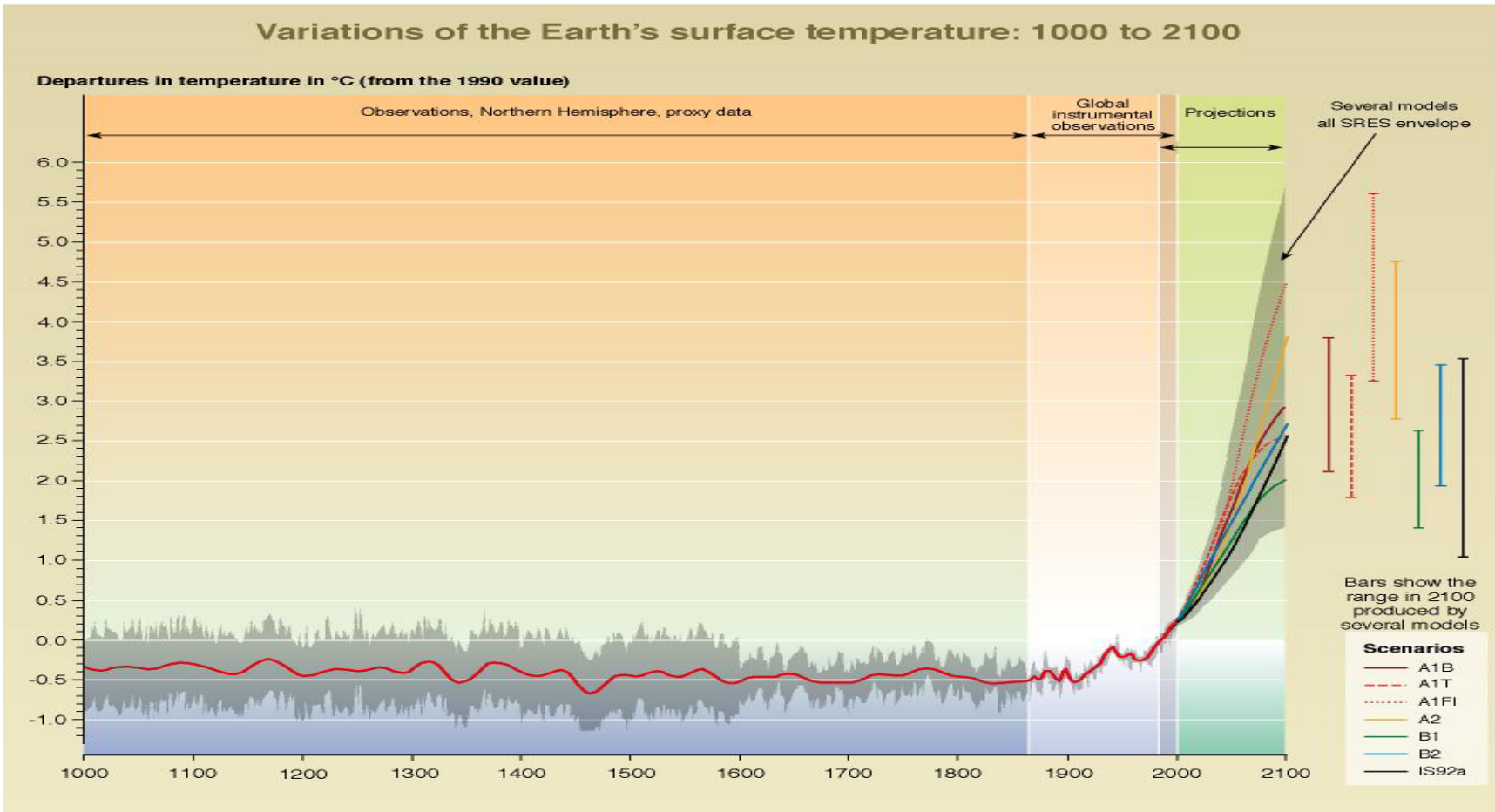
future projection

- Increase to 650 - 1215 ppm CO_2-equivalent is projected by 2100

Data-sources: IPCC

By 2100: global temperature will rise by 1.4 – 5.8 ° C and 2 – 6.3 ° C in Europe (EEA, 2004)

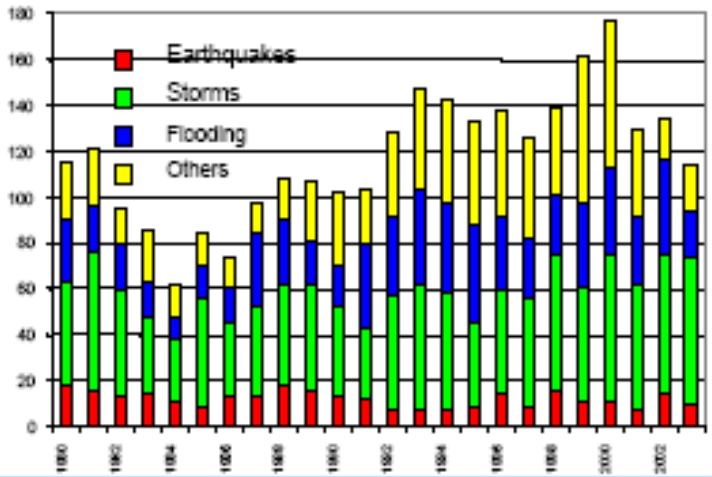
FIGURE 9.2
SPM - 10b

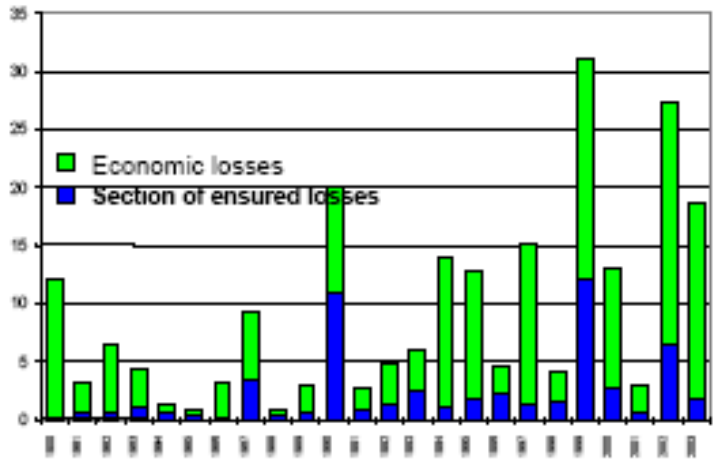


Extreme climate events lead to economic losses

past trends

- 64% of all catastrophic events and 79 % of economic losses since 1980 attributable to weather and climate extremes
- Doubling of annual disastrous weather climate related events over 1990s
- Economic losses increased from decadal average less than 5 in the 1980s to about more than 11 billion US$ in 1990s)





future projection

- Increasing likelihood of extreme events ⇒ higher losses

Data-sources: Munich-Re, Swiss-Re, EMDAT (CRED), ...

What have we done so far?

European Climate Change Programme (ECCP): main elements

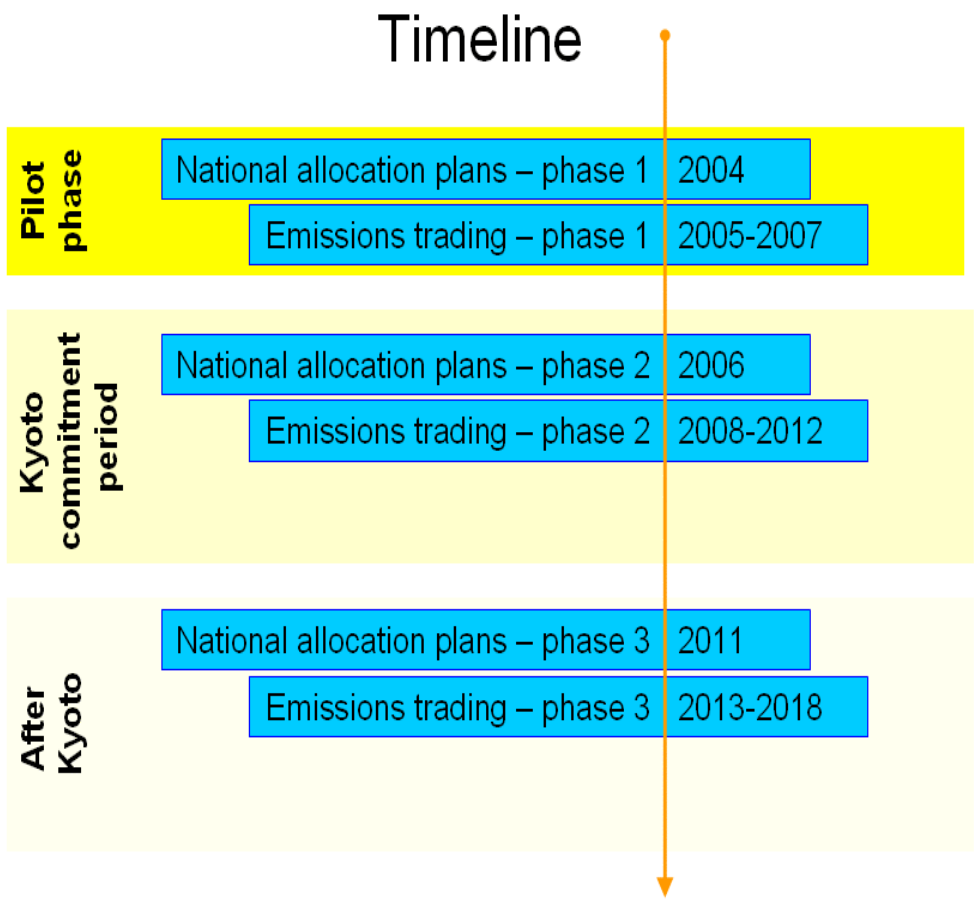
- **Objective:** Identify and develop cost effective elements of EC strategy to meet its -8% Kyoto objective
- **Major Milestones**
  - launch March 2000
  - October 2001: Commission Comm. on ECCP Action Plan
  - May 2003: second progress report
- **Total reduction potential of 578 - 696 Mt CO2eq./year = twice Kyoto '-8%' identified**
- **EU measures for 276 -316 Mt CO_2eq./year currently "in implementation"**

ECCP: Most important EU legislation in implementation relating to climate change

Policies and Measures	Reduction potential (Mt CO2-eq.)	Entry into force	Starting to deliver
EU emission trading scheme	-	2003	2005
Link JI/CDM to emission trading	-	2004	2005/ 2008
Revision of the Monitoring Decision	-	2004	-
Directive on the promotion of CHP	65	2004	2006
Directive on energy performance of buildings	35-45	2003	2006
Directive on the promotion of transport bio-fuels	35-40	2003	2005
Directive on the promotion of electricity from renewable energy sources	100-125	2001	2003
Landfill directive	41	1999	2000
ACEA voluntary agreement	75-80	1998	1999
Energy labelling directives	20	1992	1993

EU emissions trading scheme (EU ETS)

- a new, market based instrument to reduce emissions
- reduces compliance costs for the EU industry
- US: successful emissions trading for other pollutants
- the largest scheme ever implemented
- Community-wide recognition of & trade in allowances



EU ETS - how it works

- CO_2 emissions must be covered by allowances
- Community-wide trading of allowances
- *open:* might be linked to other schemes in the future
- *results-oriented:* companies decide how to reduce
- *scarcity* determined by total allocation across the EU

Where do we go next?
The post-2012 Communication

The international state of play

- Kyoto Protocol entered into force 16 February 2005, after it was ratified by the Russian Federation
- while the Bush administration has rejected the Protocol…
- Australia refuses ratify...
- the UNFCCC remains as the basis.

- Build on the Kyoto architecture
  - targets, timetables, market mechanisms, monitoring, compliance
- And let the architecture of the multilateral regime evolve further.

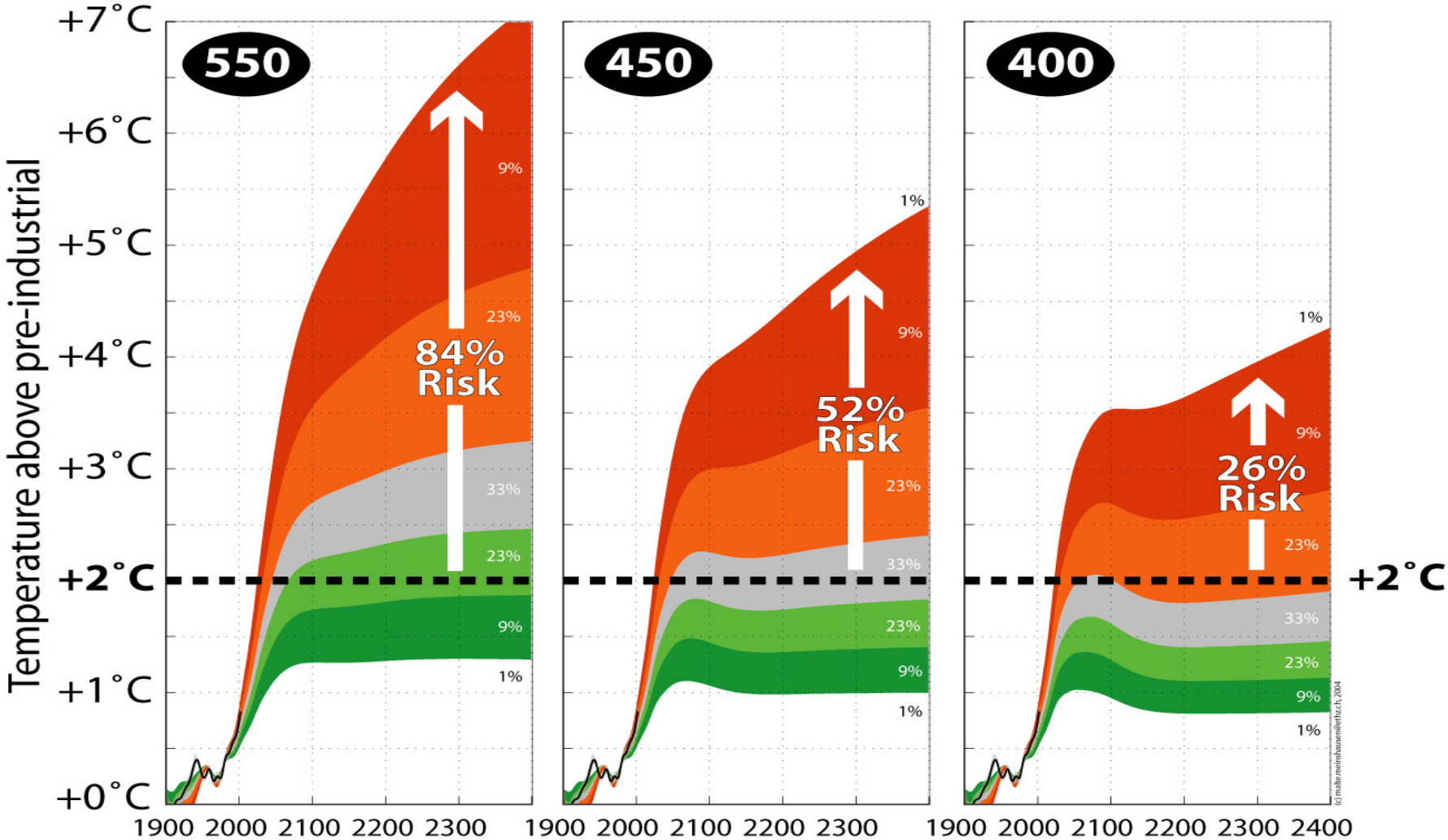
Post-2012: Why must the EU further develop its climate strategy?

- The Kyoto Protocol requires negotiations on the post-2012 regime to start in 2005
- European Spring Council 2005 wants to "consider mid and longer term strategies, including targets"
- Council has repeatedly operationalised this objective as no more than 2°C temperature increase
- Deep structural change requires a secure planning horizon to allow a smoother transition process for both the public and the private sector

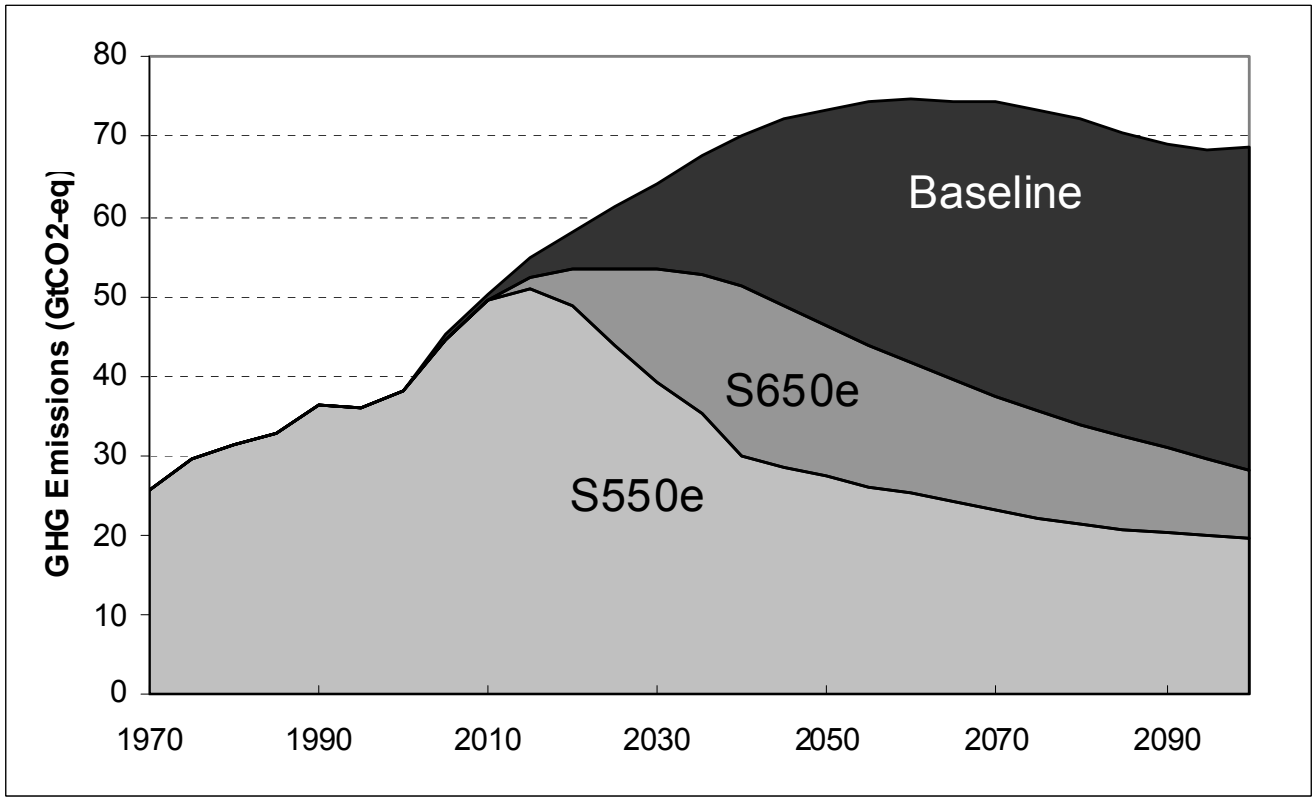
- European Spring Council 2005: Commission invited to "prepare a cost benefit analysis which takes account both of environmental and competitiveness considerations"
- Commission launched a web-based stakeholder consultation
- The Commission's Communication on action on climate change post 2012 (9 February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

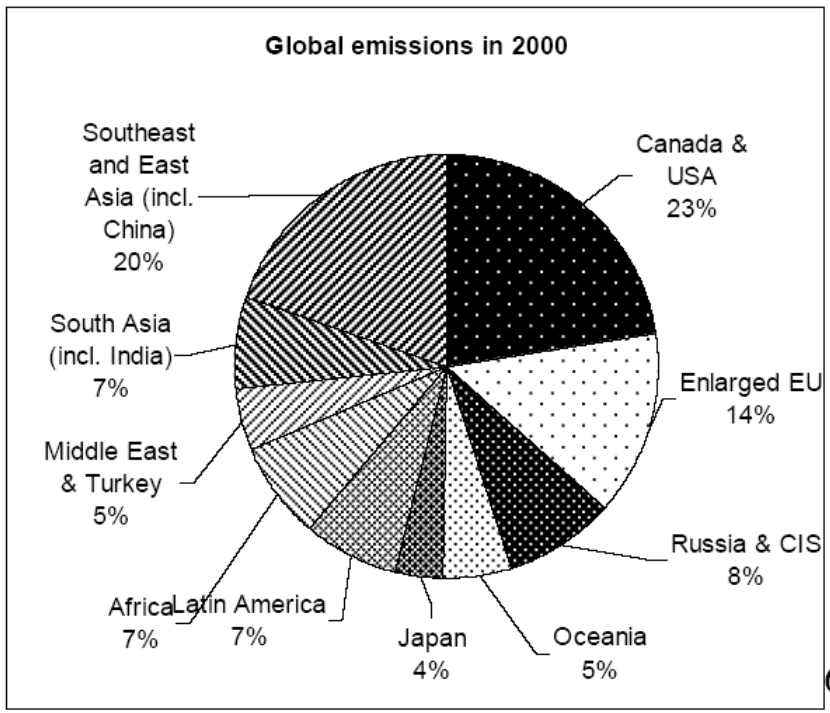


Source: GCNRS/LEPII-EPE/RIVM/MNP/ICCS-NTUA/CES-KUL study

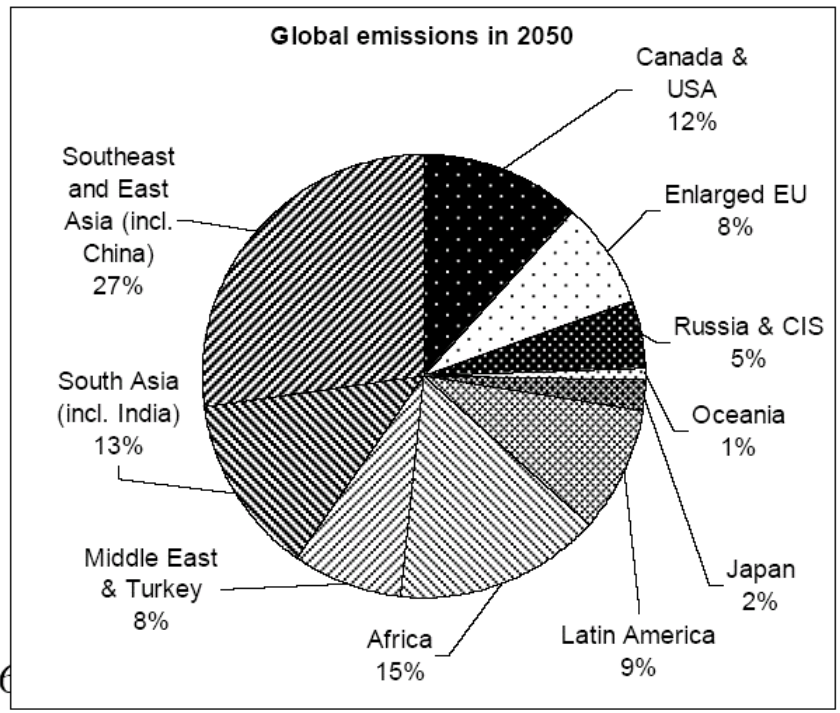
- By 2025, global reductions of 15 to 30 % from baseline are required, respectively in S650e and S550e
- By 2050, these reductions reach 35 to 65 %

The Participation Challenge

2000



2050



The Innovation and Adaptation Challenges

- **The Innovation Challenge**
  - Pulling technological change: price signals
  - Pushing technological change: RTD
  - Technology innovation and the EU competitive edge in a 'low carbon future'
- **The Adaptation Challenge**
  - Further research to predict the impacts and adapt
  - Early prediction of more frequent and damaging natural disasters

Model-based analysis

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

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

POLES Model Development

- Initially funded under the JOULE II programme of EU-DG Research
- Main contribution from the CNRS-IEPE, ECOSIM, JRC-IPTS and the support of Enerdata, CEPII, ETSU, FhG-ISI and other partners.
- Complementarity with other E3 models: PRIMES and GEM-E3
- 1993-1995, a first version
- Related research projects (e.g. TEEM, Technology Endogenisation in Energy Models)
- Related *application* projects: WETO 2030 (World Energy, Technology, and climate policy Outlook), ACROPOLIS

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**

POLES Characteristics

- The POLES model is a *recursive simulation* model at world level, working on a year by year basis, from 1998 to 2030
- It incorporates more than 60,000 variables
- Main exogenous variables are GDP and population. Energy prices are endogenous
- It is built of a system of >50,000 equations organised in *modules* for the different countries/regions and energy consuming sectors, activities and technologies

POLES Characteristics

- **Interconnected modules: international energy markets, national energy demand, new technologies, electricity production, primary energy production and CO_2 emissions, energy-intensive sectors**
- **Outcomes**
  - **Regularly updated Reference Case**
  - **World long-term energy scenarios or projections (*WETO*)**
  - **National-regional energy balance and CO_2 emissions simulation**
  - **Analysis of new energy technologies potentials, markets and diffusion**
  - **Test of energy policies and energy RTD strategies**

Technology Rich / Bottom-up Model: Electricity generation technologies

Conventional large size hydropower	HYD
Nuclear Light Water Reactor	LWR
New nuclear design	NND
Supercritical pulverised fuel combustion (coal)	PFC
Integrated coal gasification with CC	ICG
Advanced thermodynamic cycle (coal)	ATC
Lignite powered conventional thermal	LCT
Coal powered conventional thermal	CCT
Oil powered conventional thermal	OCT
Gas powered conventional thermal	GCT
Gas powered gas turbine in combined cycle	GGT
Oil powered gas turbine in combined cycle	OGT

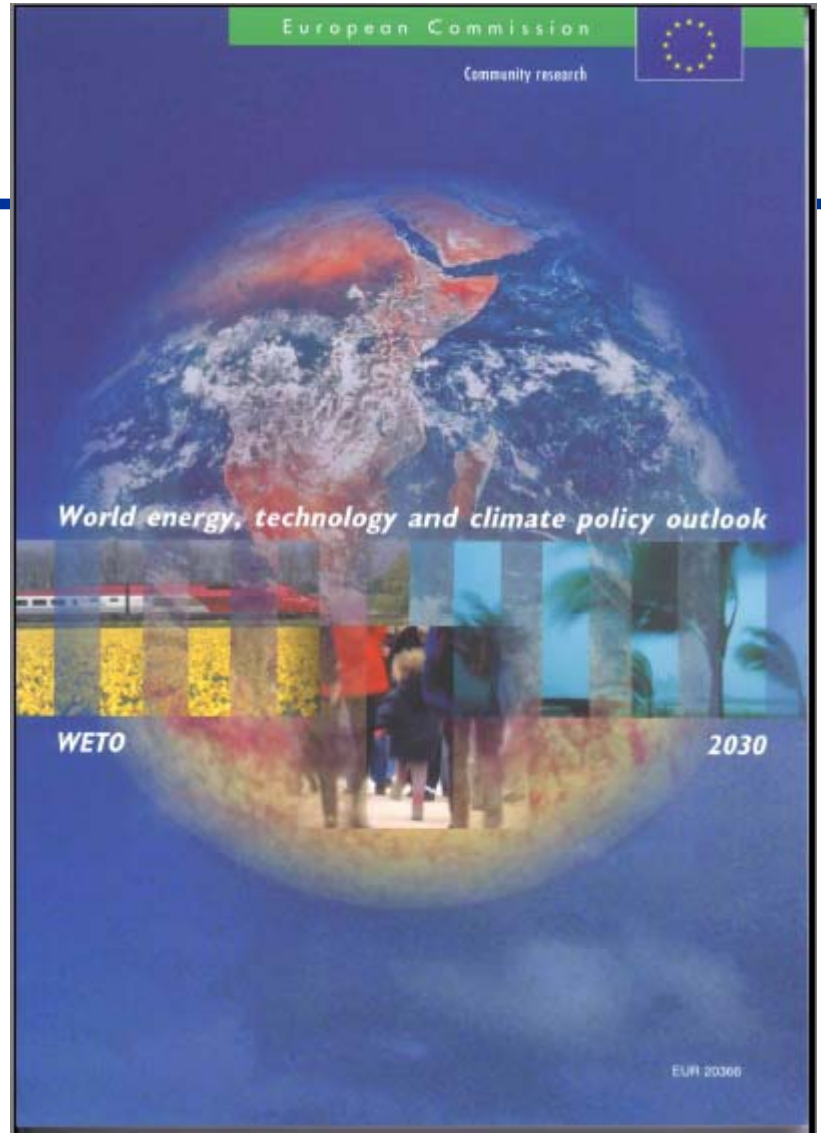
Techno-economic Characterisation of Technologies

For each technology and country, and time period:

- Costs (fixed –investment-, variable)
- Installed capacity
- Efficiency
- Emission factors
- Life time of plants
- Construction time

WETO 2030

World Energy, Technology and climate policy Outlook



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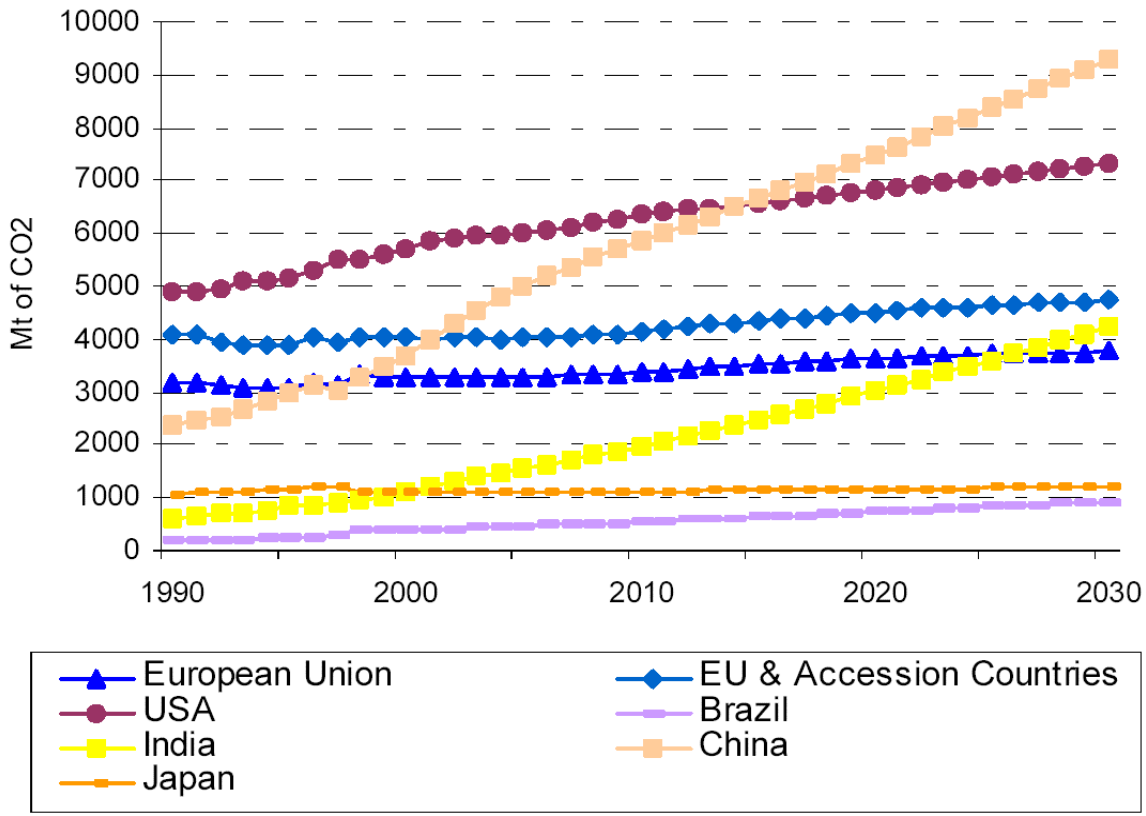
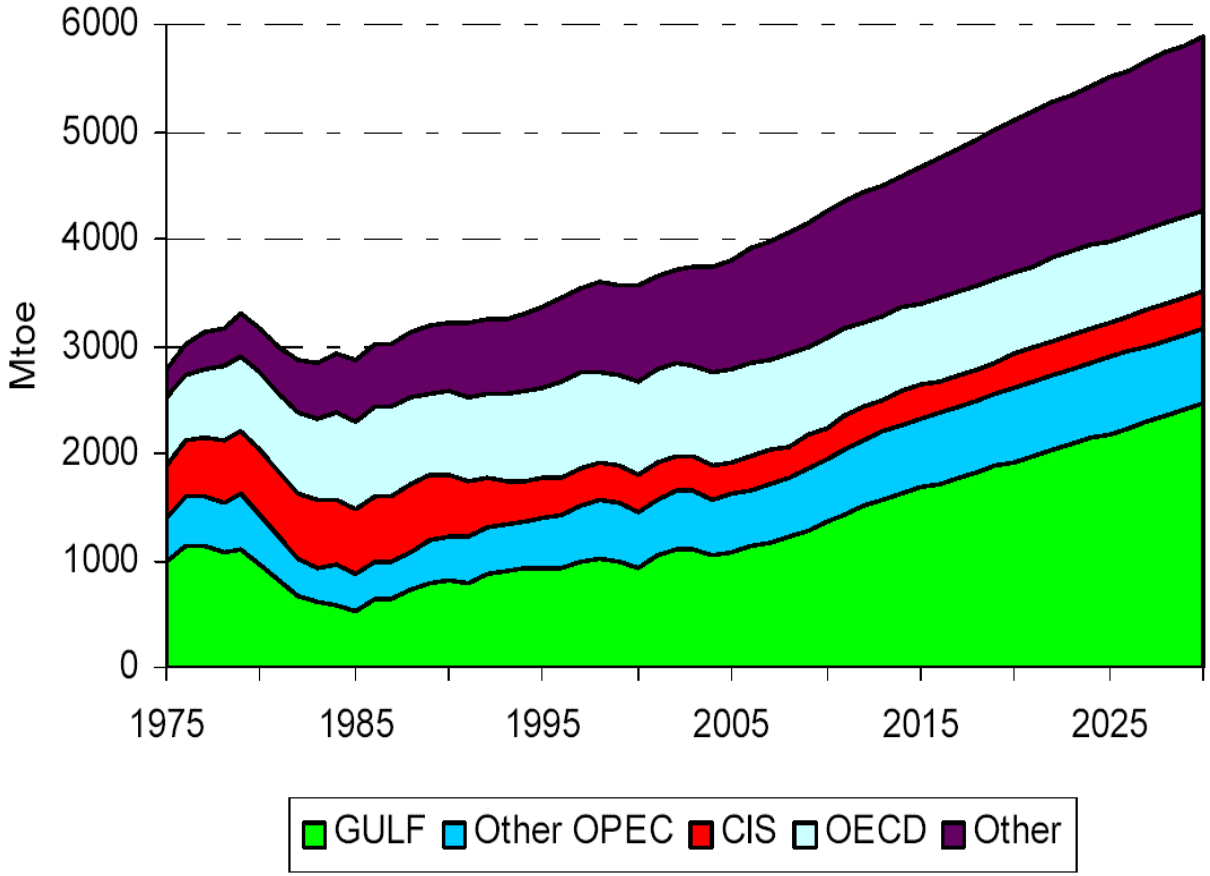
http://energy.jrc.es/

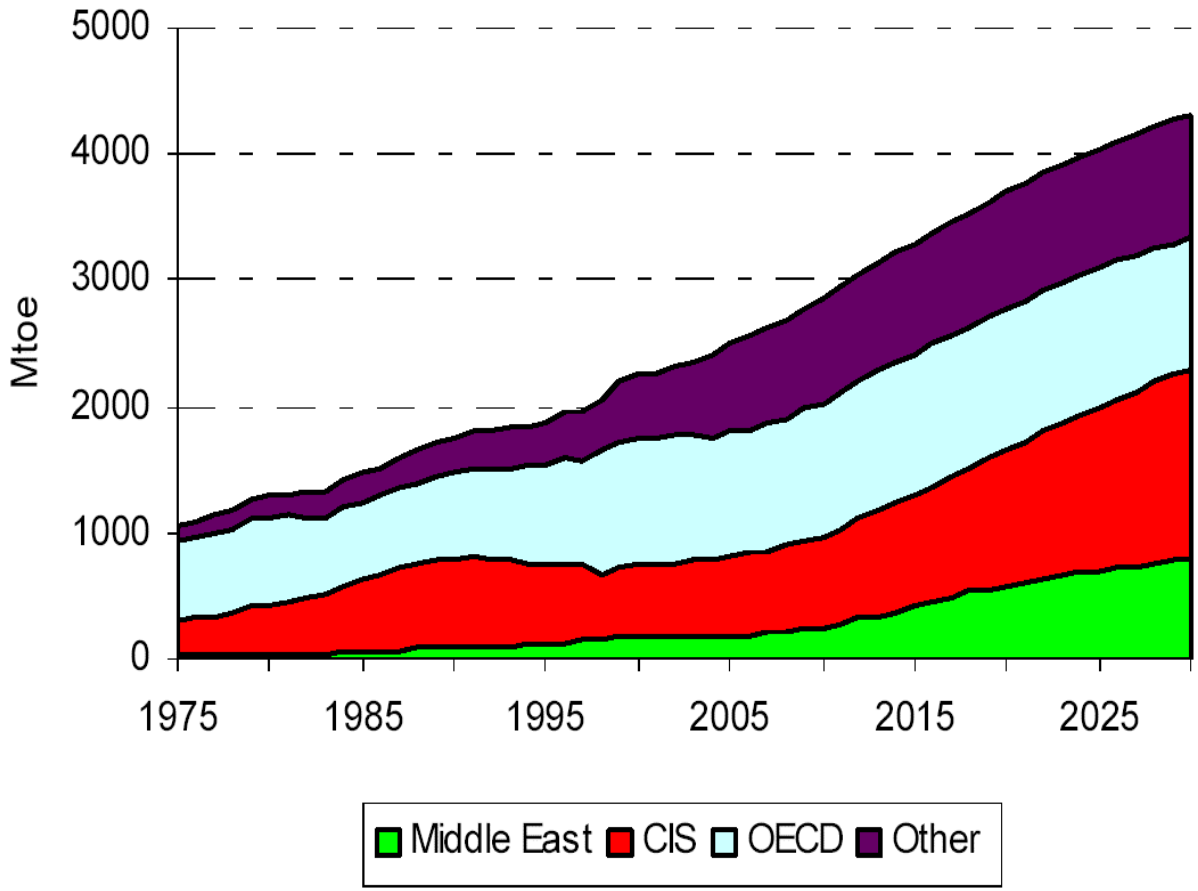
Energy-related CO_2 Emissions



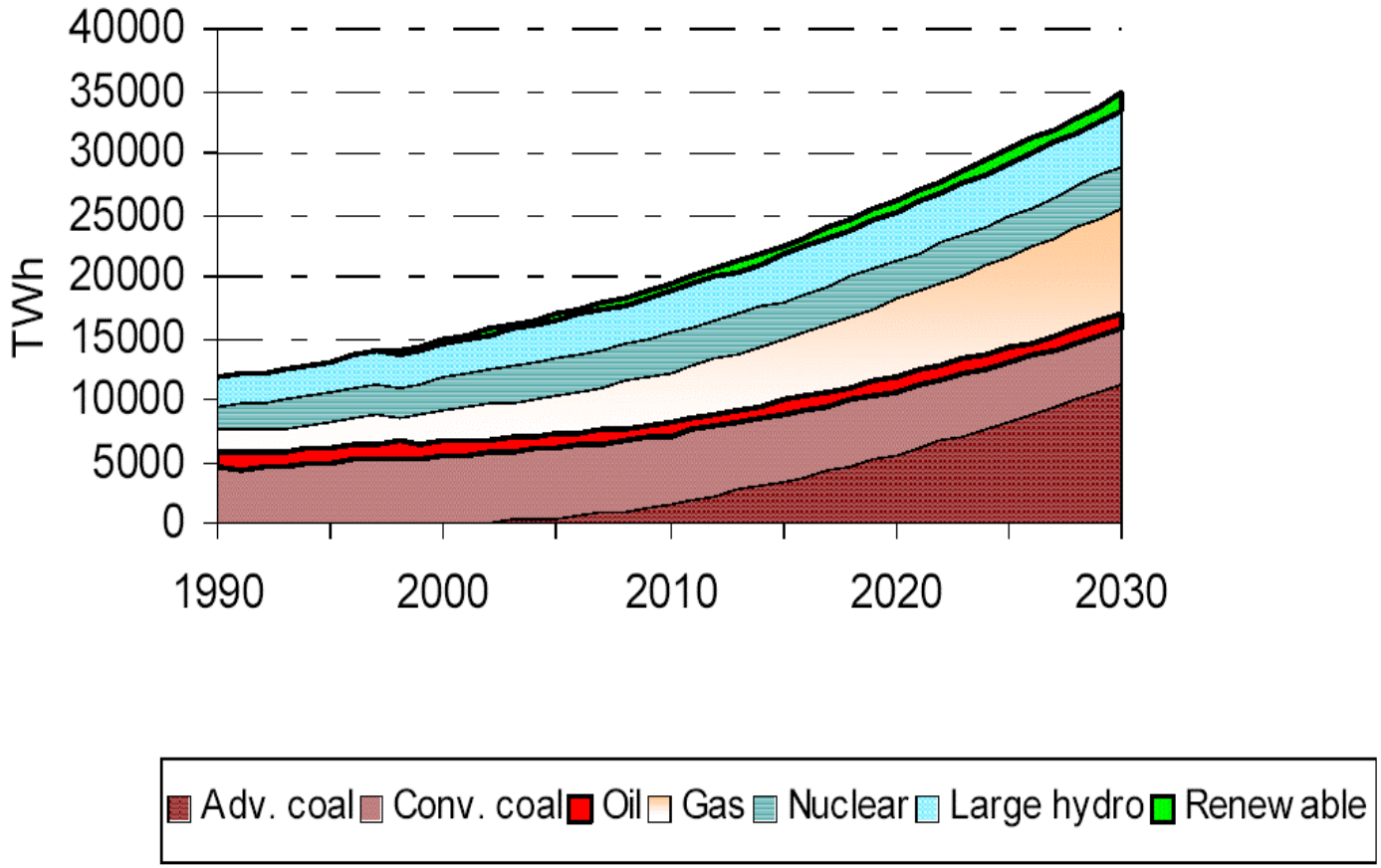
World Oil Production



World Gas Production



World Power Generation



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

Partners:

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

Study performed for DG Environment

Using the GEM-E3 Model

GRP Scenarios of interest

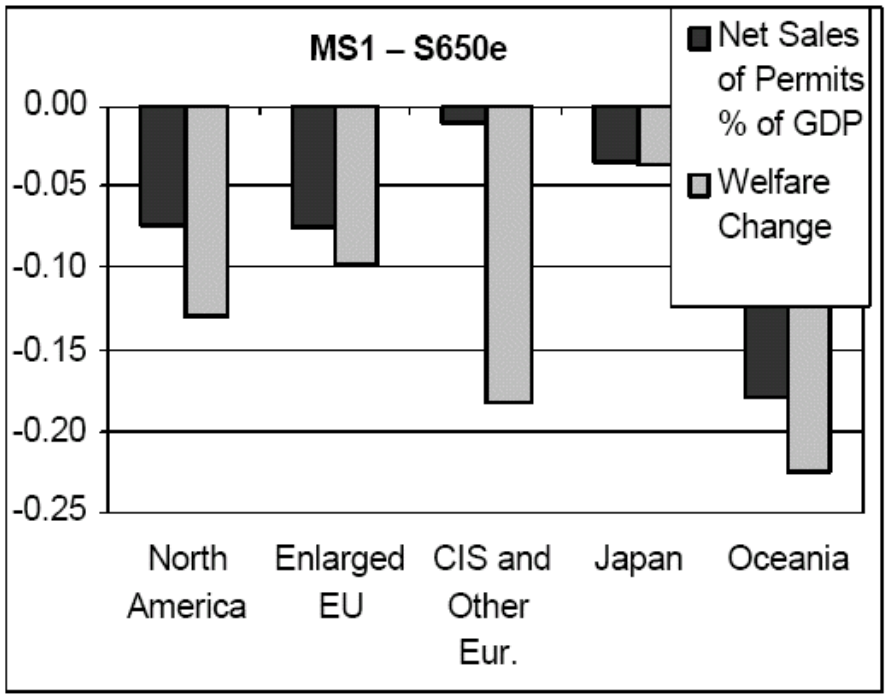
Two "reduction profiles", related to the 2°C, have been defined, for the set of the 6 Kyoto gases:

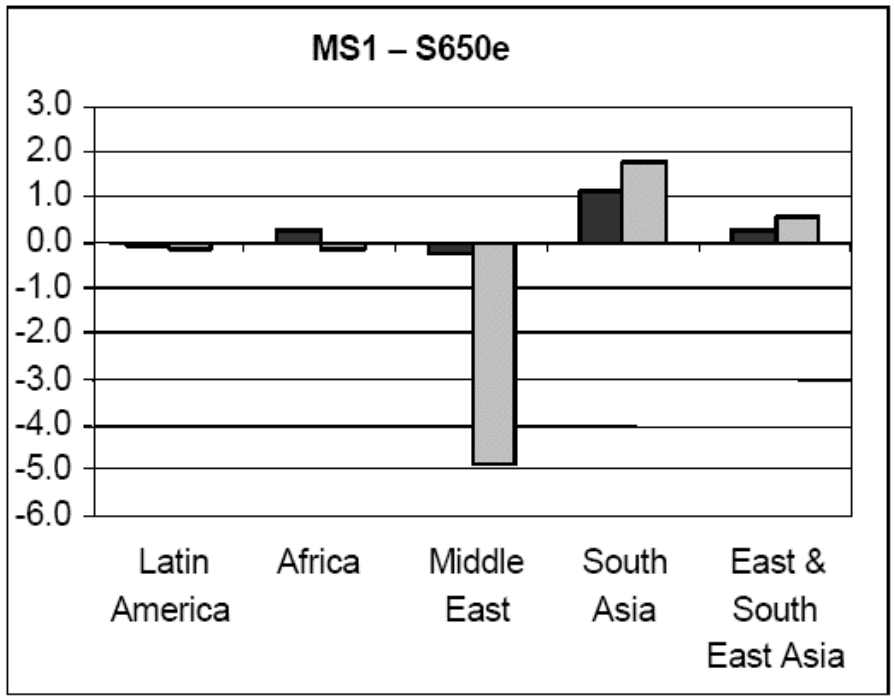
- **S550e for a stabilization of concentrations at 550 ppmv CO2e for the 6 Kyoto GHGs (corresponding to 450 ppmv for CO2 only)**
- **S650e for a stabilization at 650 ppmv CO2e**

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

The Challenges Ahead

- Depending on the risks we are willing to accept, global emissions will have to peak between 2015 and 2025…
- Build a broad coalition among developed and developing countries
- Do we need a mix of mitigation and adaptation policies?
- Do we need a mix of targets, timetables, technologies, and policies?