Marginal Abatement Curves and GHG Concentration in GMM Model

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Outline

- The energy-system GMM model
- Marginal abatement curves for CH_4 and N_2O
- GHG atmospheric concentrations
- An illustrative scenario
- Final remarks

The Energy-Systems GMM Model

- Global, five-region, energy-systems MARKAL model (Barreto, 2001; Rafaj *et al*., 2005)
- Calibrated to year-2000 statistics
- Clusters approach to technological learning
- Time horizon 2000-2100, 10-year steps
- Relative detail in energy supply technologies
- Stylized representation of end-use technologies
- Current version under ANSWER (Noble, 2005)

Marginal Abatement Curves (MAC)

- Implementation of MACs for methane (CH_4) and nitrous oxide (N_2O) following approach of MERGE (Manne and Richels, 2003)
- Three categories: exogenous baseline, endogenous baseline, non-abatable emissions
- Data from the U.S EPA (2003) study, potentials are relative to baseline emissions
- Technical-progress multipliers to extrapolate abatement potentials beyond 2020

GHG Atmospheric Concentrations

- Atmospheric concentration of CO_2, CH_4 and N_2O are computed using linear models of decay (so-called box models), following the MERGE Model (Manne and Richels, 2004)
- Five (5) boxes are used for CO_2 and one box each for CH_4 and N_2O
- This procedure allows computing scenarios with stabilisation of GHG concentrations

CO_2 Atmospheric Concentration

- Simplified model based on a linear impulse response function represented by the weighted summation of five exponential functions or "boxes" (Joos et al., 1996):

$$G(t) = \sum_{i=1}^{5} a_i * e^{-t/\tau_i} \qquad \sum_{i=1}^{5} a_i = 1$$

- Each exponential function represents the decay over time of a given fraction (a_i) of the injected CO_2, which has a given atmospheric lifetime, represented by the coefficient τ_i (in years).

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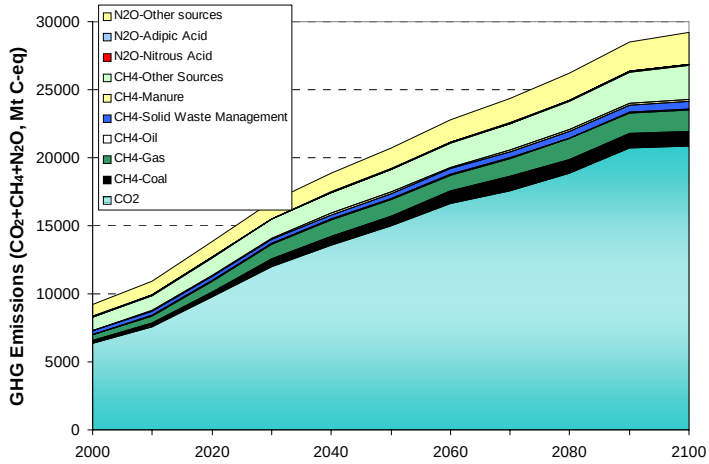
A Multi-GHG Baseline Scenario



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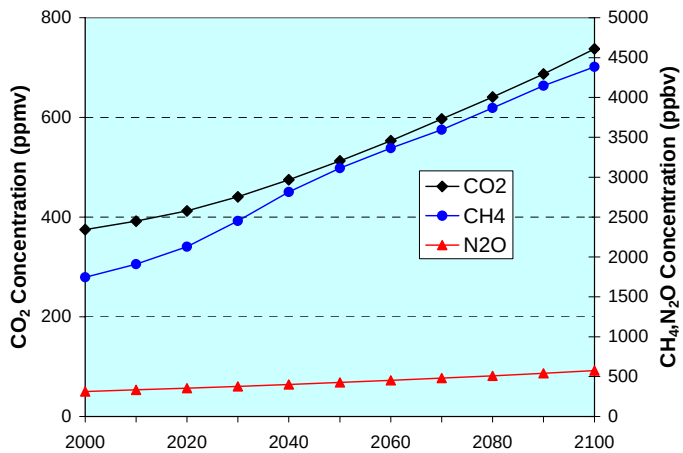
GHG Concentrations – Baseline Scenario



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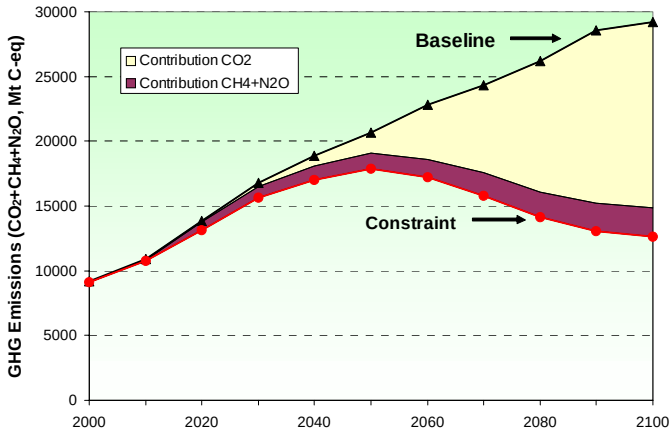
An Illustrative Mitigation Scenario



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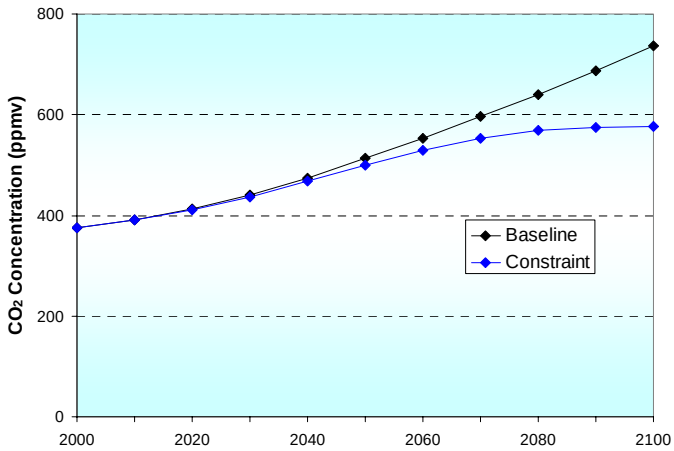
CO_2 Atmospheric Concentration



Final Remarks

- Marginal abatement curves allow incorporating the effects of non-CO_2 GHGs (CH_4,N_2O) into the energy-system GMM model
- Atmospheric concentrations are CO_2, CH_4 and N_2O are implemented in the GMM model using linear decay functions (“boxes”)

Acknowledgements

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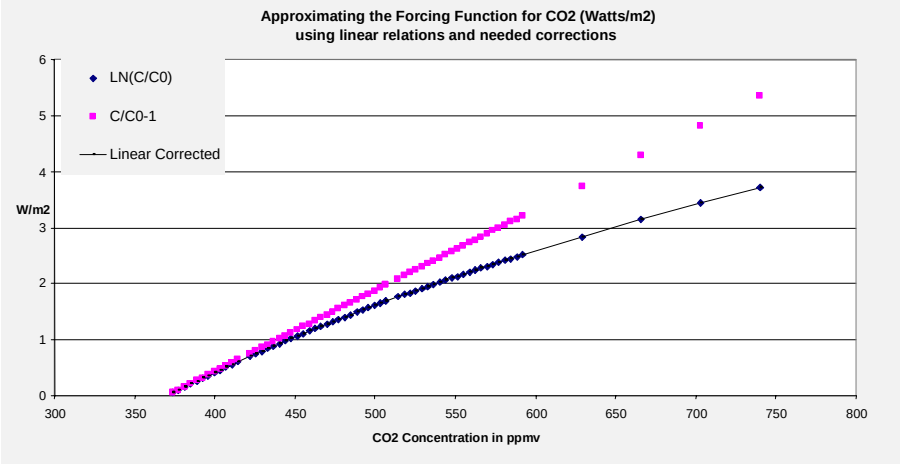
- These developments are based on the MERGE model (Manne and Richels, 2004)

Climate forcing as function of concentrations



Extension to Forcing

Therefore if we want to apply a constraint on forcing that implies a concentration limit of 450 ppmv we should define the constraint as

$\Delta F_{\Theta} = c_0 \cdot \ln((C_0 + \Delta\rho))/C_0) \le 1.047233\ W/m2$ which is equivalent to
$\Delta F_{\Theta} = c_0 \cdot (\Delta\rho_{\Theta}/C_0 - 1) \le 1.156757\ W/m2$ but the latter is linear!

Concentration C_t ppmv	Forcing $c_0 \cdot \ln((C_0+\Delta\rho)/C_0)$ (Ex) W/m2	Approximation $c_0 \cdot (\Delta\rho_{\Theta}/C_0 - 1)$ (Pr) W/m2	Error 1-E/P (-)	CFCF -	adjusted w/m2
400	0.417094	0.433784	0.038474	0.961526	0.417094
450	1.047233	1.156757	0.094681	0.905319	1.047233
500	1.610912	1.87973	0.143009	0.856991	1.610912
550	2.120822	2.602703	0.185146	0.814854	2.120822

Table 2: CO2 Forcing in W/m2 and Carbon Forcing Correction Factors (CFCF)