# Ongoing work (IMAGE 2.2) on stabilisation scenarios.

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**RIVM: National Institute for Public Health and the Environment**

**The Netherlands**

# Outline of presentation

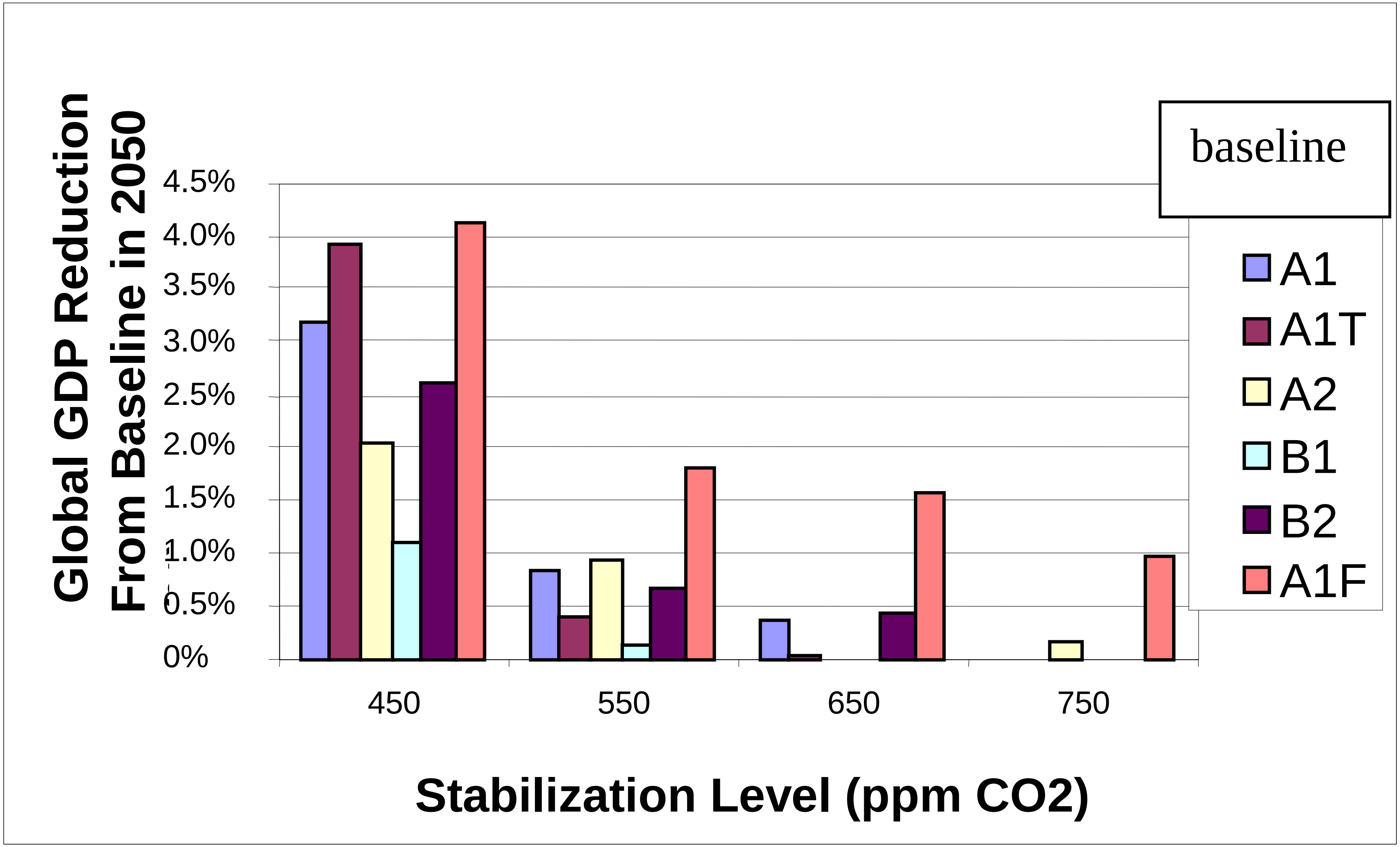
## 1. Multi-gas stabilisation scenarios

- EMF-21 (stabilisation at 4.5 W/m2)
- Other stabilisation targets

## 2. Issues in stabilisation scenarios

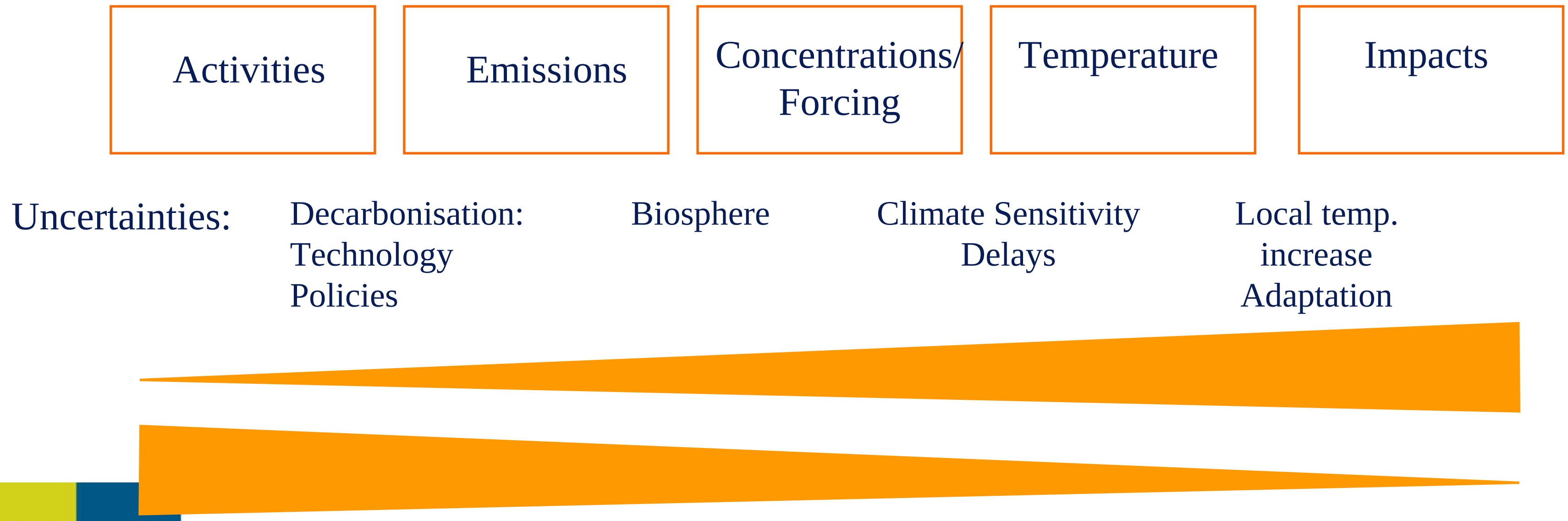
- Overshoot scenarios
- Implementation of scenarios --> Differentation of commitments
- Stabilisation scenarios and non-Kyoto-gas /non-GHG impacts

# Stabilisation in TAR



# Multigas stabilisation

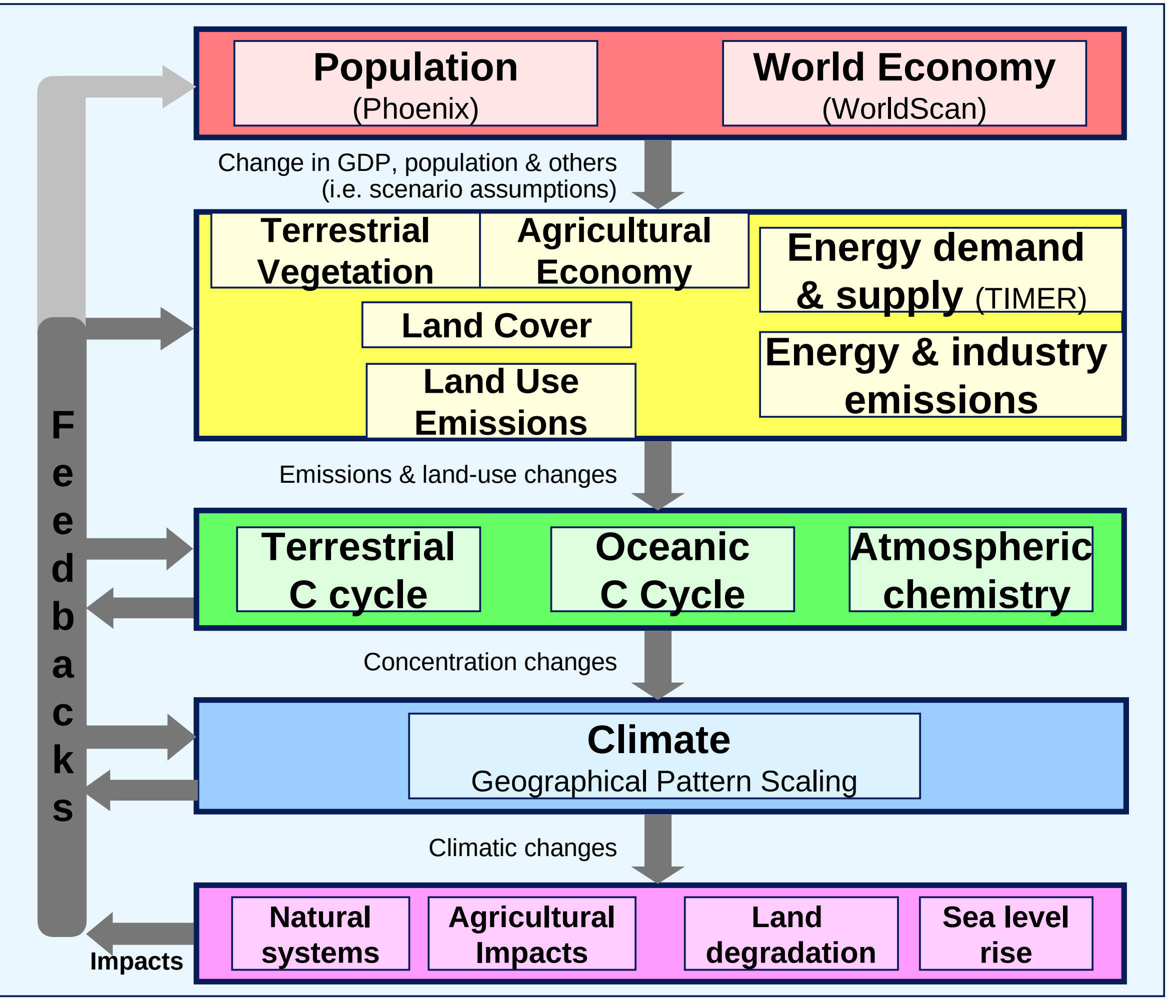
- But how to define multi-gas stabilisation scenarios (in order to improve comparison)
  - Stabilisation of radiative forcing?
  - Stabilisation of temperature?



# EMF-21: Analysis of MG stabilisation

- Question: How do scenarios that aim to stabilise radiative forcing using a multi-gas approach compare to $CO_2$-only cases.
- Two cases, both aiming for 4.5 W/m2 in 2150
  - Multigas (Kyoto-gasses)
  - $CO_2$-only: Using the same profile as for Multigas

# Structure of IMAGE 2.2




- Set of integrated and linked, system dynamic type of simulation models
- 17 world regions (socio-economic systems)
- 0.5 x 0.5 degree (environment/land use)
- 10 energy carriers
- detailed description of non-$CO_2$ sources (e.g. $CH_4$ : 10 agr. sources)

# Emissions and sources in IMAGE 2.2

EMISSIONS

- $CO_2$
- Methane
- Nitrous oxide
- Cl/F/Br gases
- CO
- $NO_x$
- $SO_2$
- VOC
- (BC/OC)

SOURCES

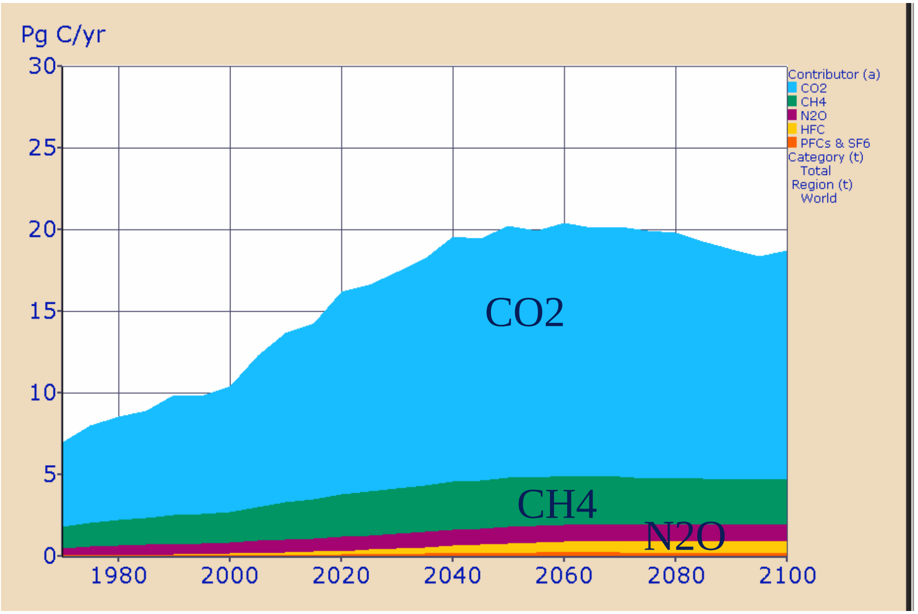
- Energy consumption & production (10 fuel types)
- Industrial processes
- Waste
- Animal husbandry
  - (5 types of livestock)
- Agriculture
  - (8 crop types)
- Land use / soils
  - (19 land cover types)
- Natural sources

# Methodology

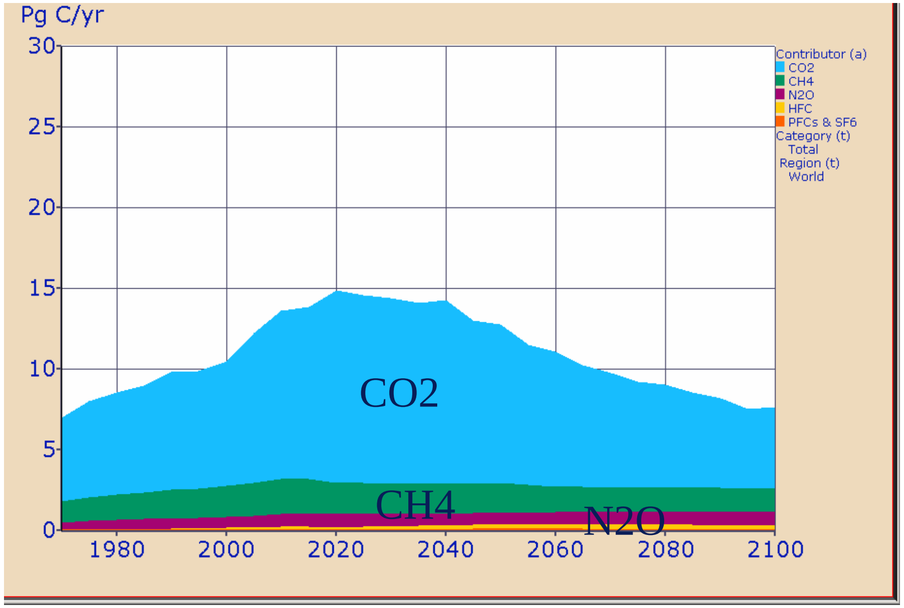
- Baseline: Common POLES IMAGE (CPI) (~ B2/A1b)
- Mitigation: Emission profiles for GHG-conc. stabilisation
  Until 2012: Kyoto + Bush Plan
  Full emission trading (no transaction costs)
- Competition among different gasses on the basis of 100 year GWP;
- MAC-based approach
  - $CO_2$: IMAGE/TIMER model
  - Non-$CO_2$: EMF & GECS MACs
  - Sinks: IMAGE MACs

# Results: Contribution of different gasses

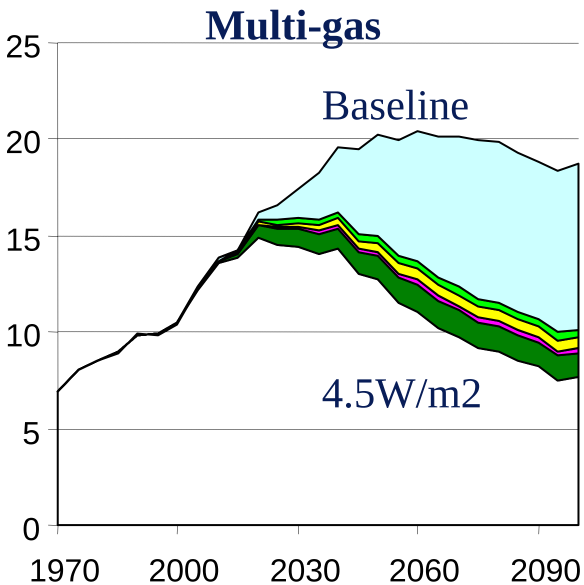
Baseline

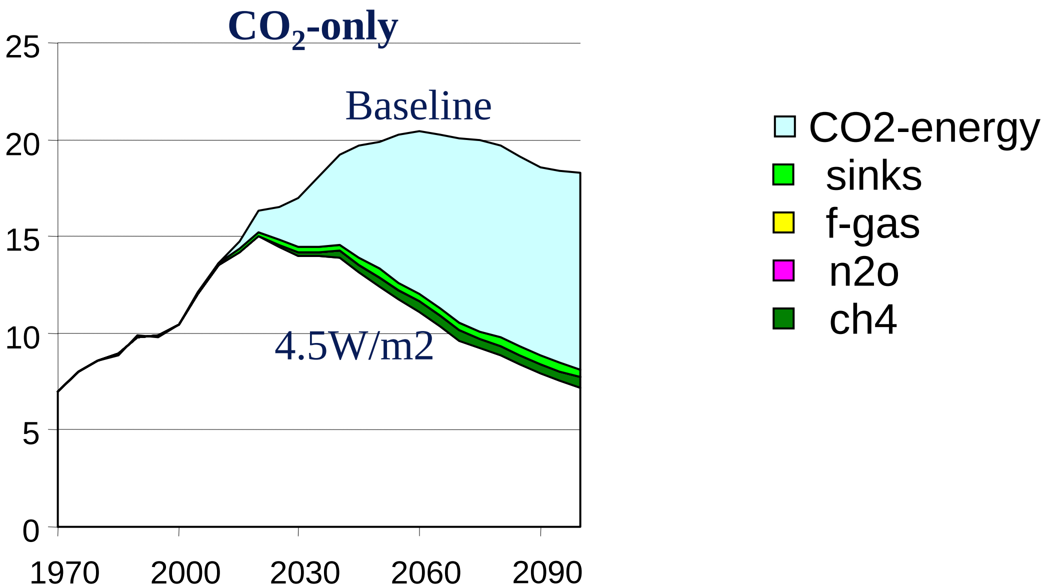



4.5 W/m2 stabilisation



# Results: Contribution of different gasses

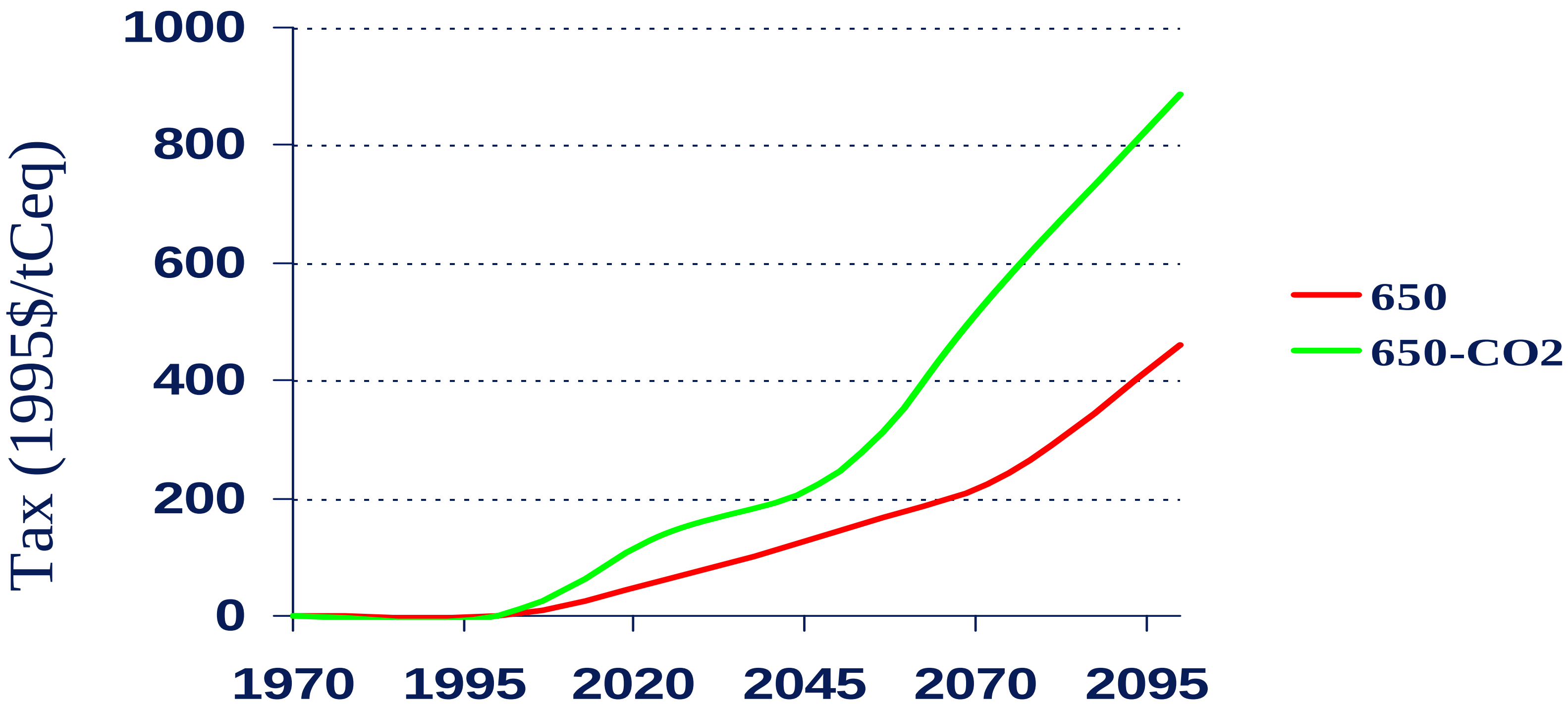



| | *2020* | | *2050* | | *2100* | |
|---|---|---|---|---|---|---|
| | *Multi* | *CO2-only* | *Multi* | *CO2-only* | *Multi* | *CO2-only* |
| *CO2* | 4% | 10% | 36% | 47% | 64% | 78% |
| *CH4* | 25% | 1% | 39% | 15% | 45% | 19% |
| *N2O* | 6% | 0% | 24% | 0% | 24% | 0% |
| *F-gas* | 44% | 0% | 57% | 0% | 65% | 0% |
| *Total* | 8% | 12% | 37% | 38% | 59% | 61% |

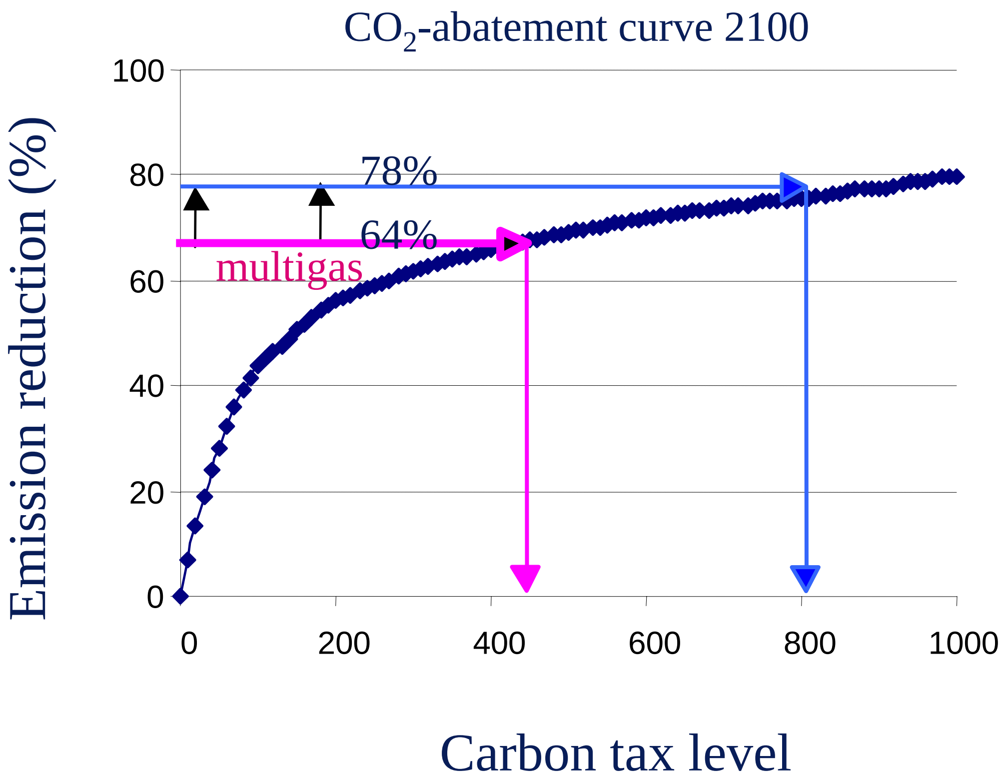
- Contribution of non-$CO_2$ gasses in this approach large early on (due to low costs), but small by 2100 (due to exhaustion of reduction options

# Carbon taxes required to meet the scenarios (1/2)



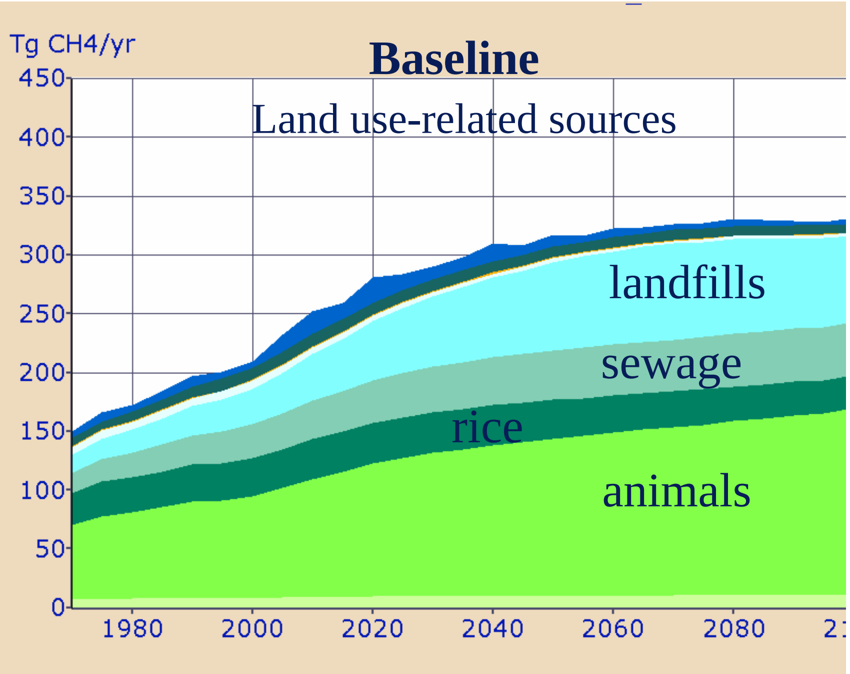

- CO2-only scenario much more expensive than multigas alternative.

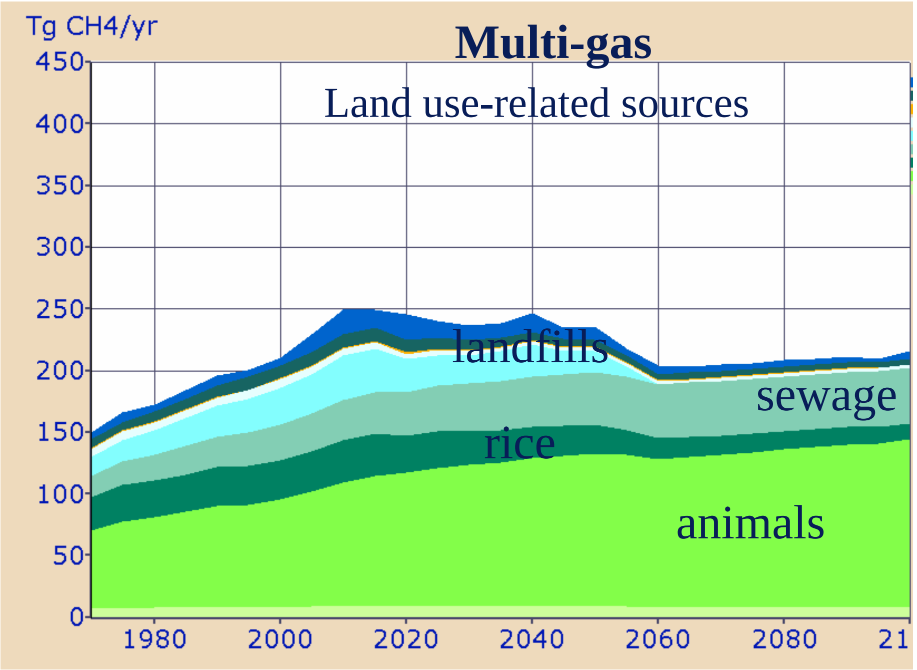
# Carbon taxes required to meet the scenarios (2/2)




- Impact of non-$CO_2$ gasses on permit price can be relatively large - in particular for small reductions (and thus hardly use of $CO_2$ measures) and very large reductions

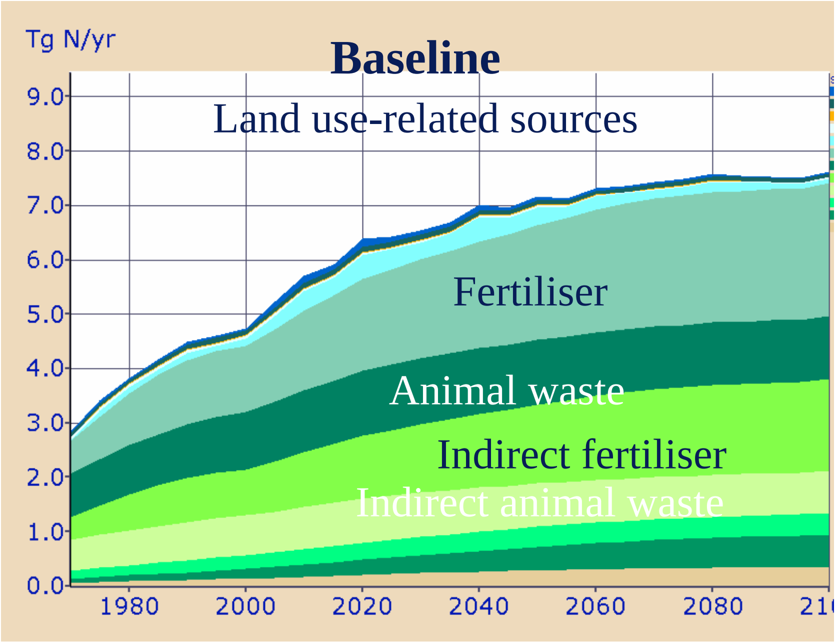
# Results: Reductions of $CH_4$ emissions

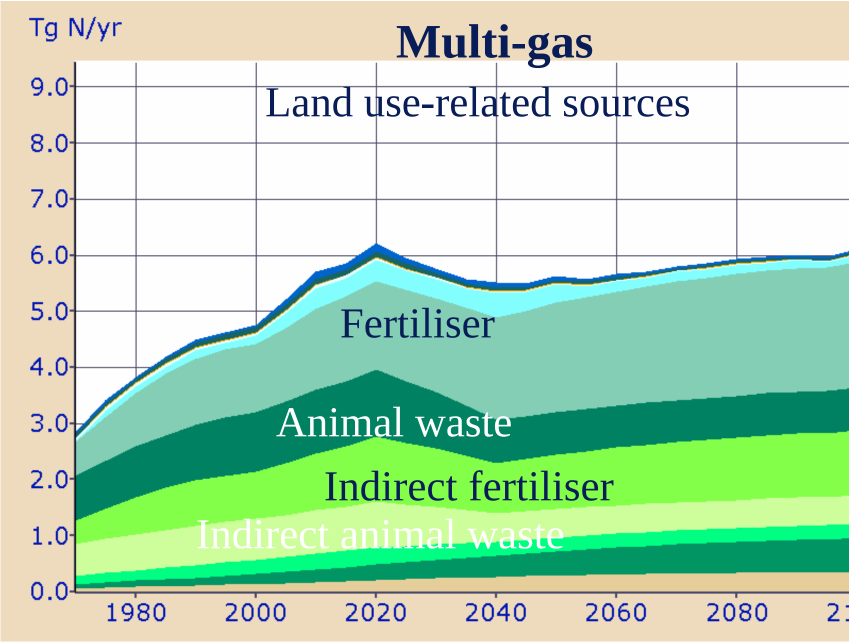



| | CPI | | 650 | | Reduction | | Contribution |
|---|---|---|---|---|---|---|---|
| | 2050 | 2100 | 2050 | 2100 | 2050 | 2100 | 2050 |
| landfills | 75 | 73 | 17 | 0 | 78% | 100% | 32% |
| sewage | 42 | 45 | 42 | 45 | 0% | 0% | 0% |
| wetland rice | 33 | 28 | 24 | 13 | 28% | 54% | 5% |
| animals (incl. Waste) | 144 | 169 | 133 | 144 | 8% | 15% | 6% |
| Coal prod | 48 | 36 | 13 | 3 | 73% | 92% | 19% |
| Oil prod | 8 | 1 | 6 | 1 | 25% | 0% | 1% |
| Gas prod | 96 | 68 | 30 | 22 | 69% | 68% | 36% |
| Other | 25 | 18 | 22 | 16 | 13% | 11% | 2% |

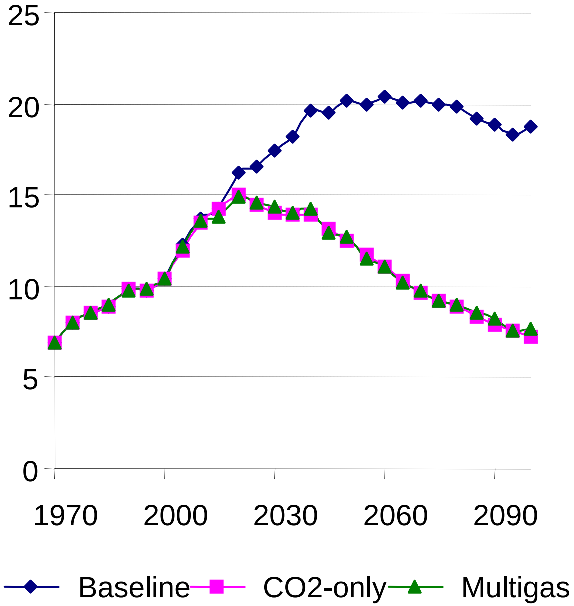
# Results: Reductions of $N_2O$ emissions



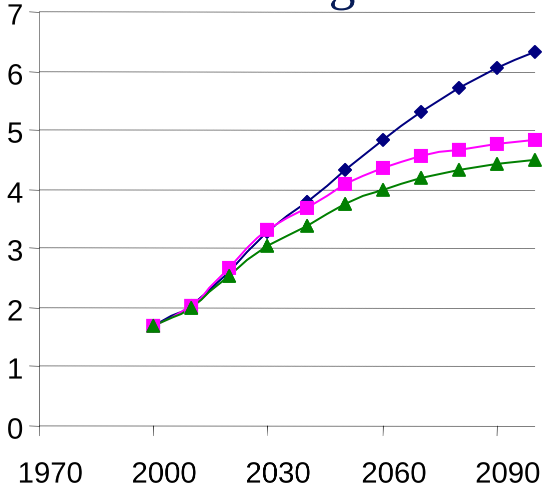




| | CPI | | 650 | | Reduction | | Contribution |
|---|---|---|---|---|---|---|---|
| | 2050 | 2100 | 2050 | 2100 | 2050 | 2100 | 2050 |
| fertilizer | 3.6 | 4.1 | 2.9 | 3.4 | 18% | 18% | 38% |
| animals | 2.0 | 1.9 | 1.3 | 1.3 | 35% | 35% | 40% |
| energy consumption | 0.4 | 0.4 | 0.2 | 0.2 | 50% | 58% | 13% |
| Other | 1.6 | 1.5 | 1.4 | 1.4 | 11% | 8% | 10% |

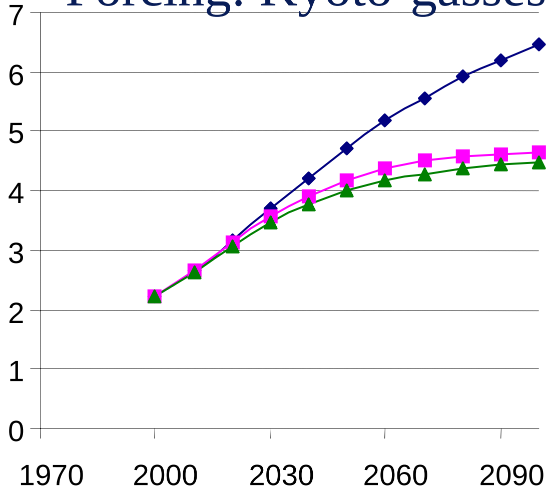
## Equivalent emissions



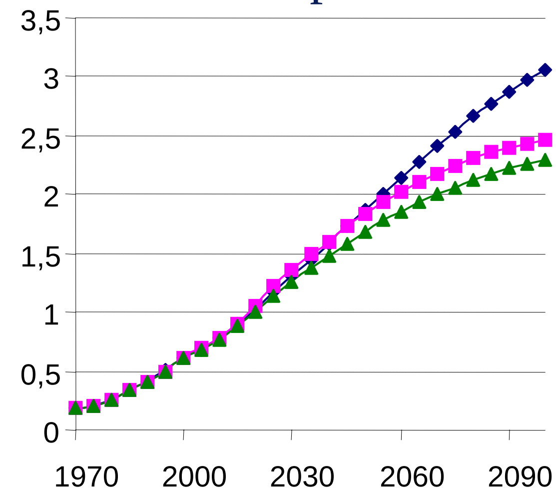

## Forcing: total




## Forcing: Kyoto-gasses



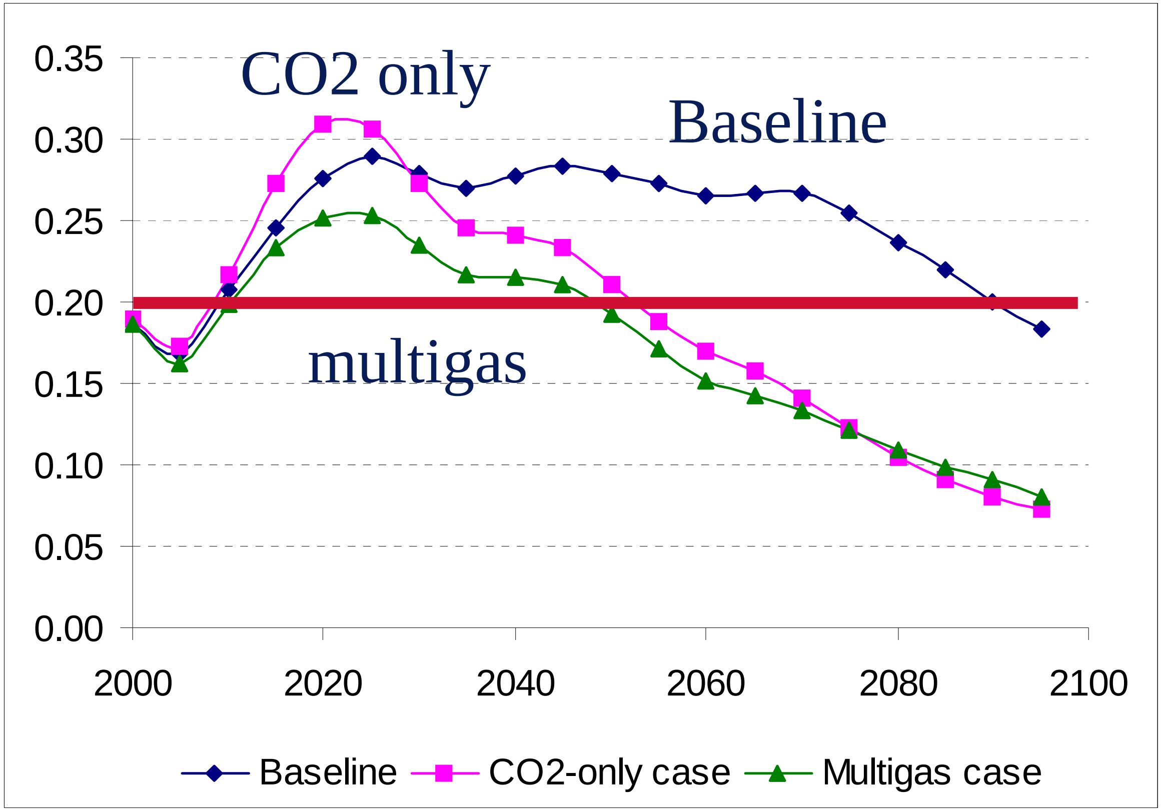

## Temperature




# Why lower temperature multi-gas case:

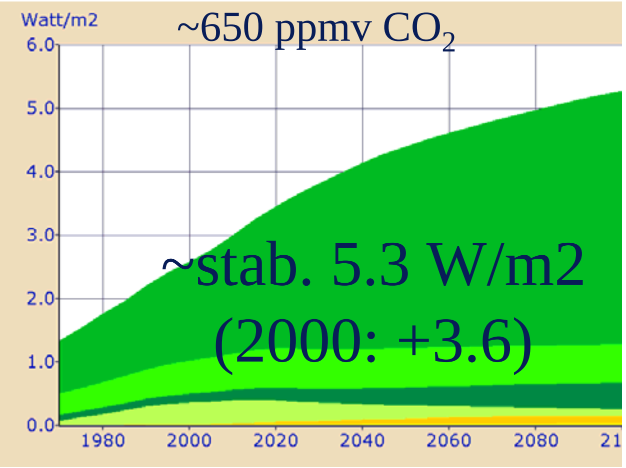
- Faster response non-$CO_2$ gasses
- Sulphur is reduced more in $CO_2$ case
- Use of GWPs

# Annual temperature change

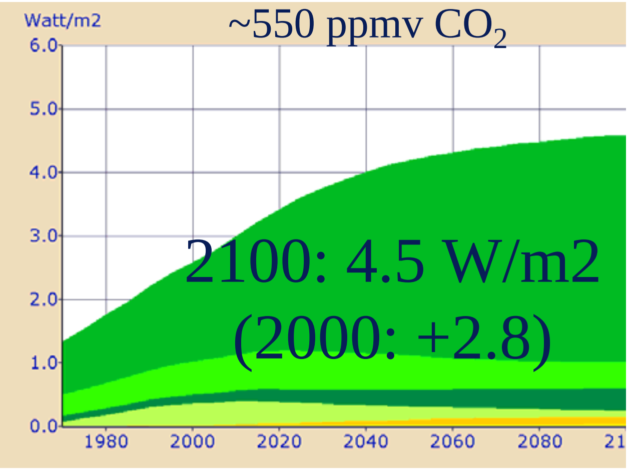


# Other stabilisation levels

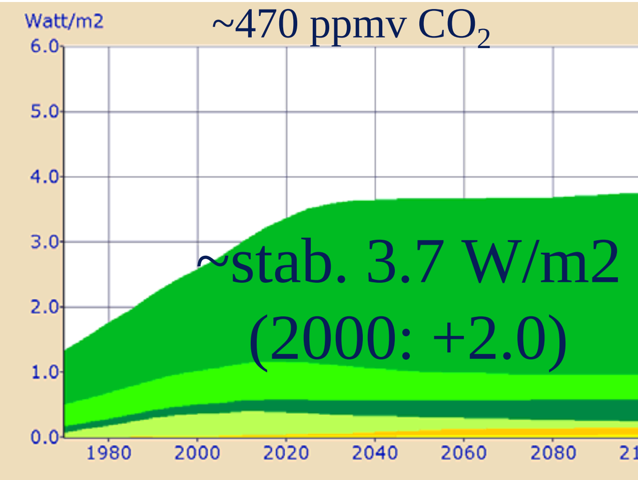
‘750-CO2eq’

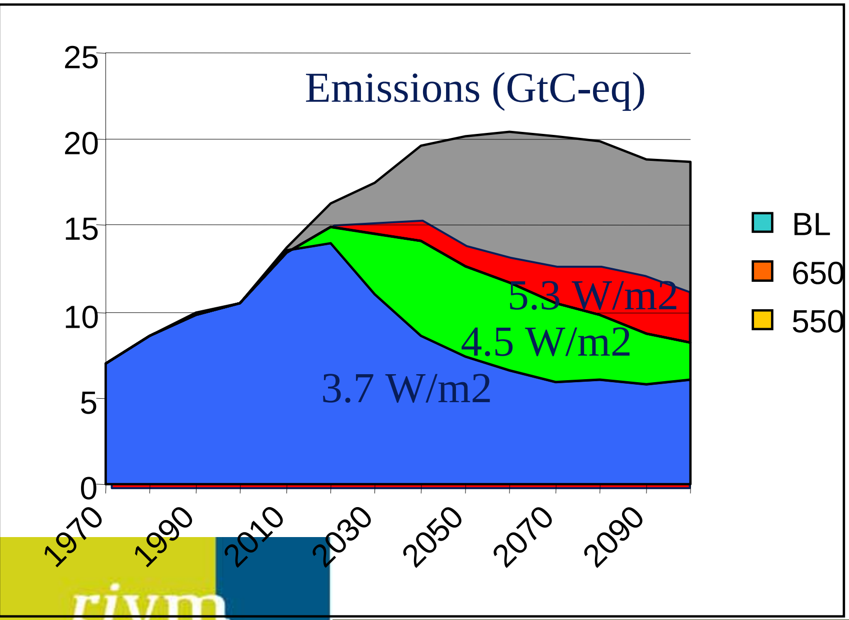



‘650-CO2eq’

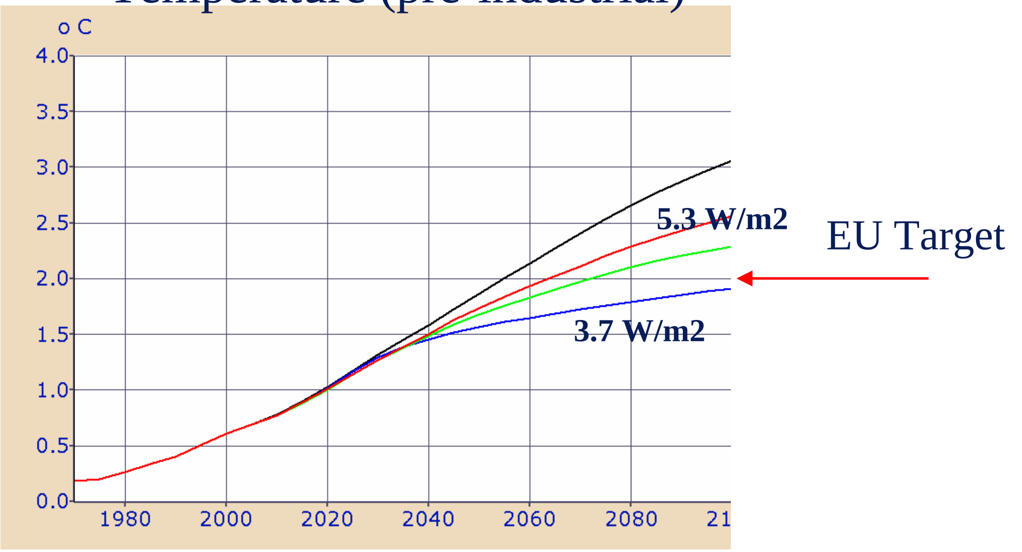



‘550-CO2eq’

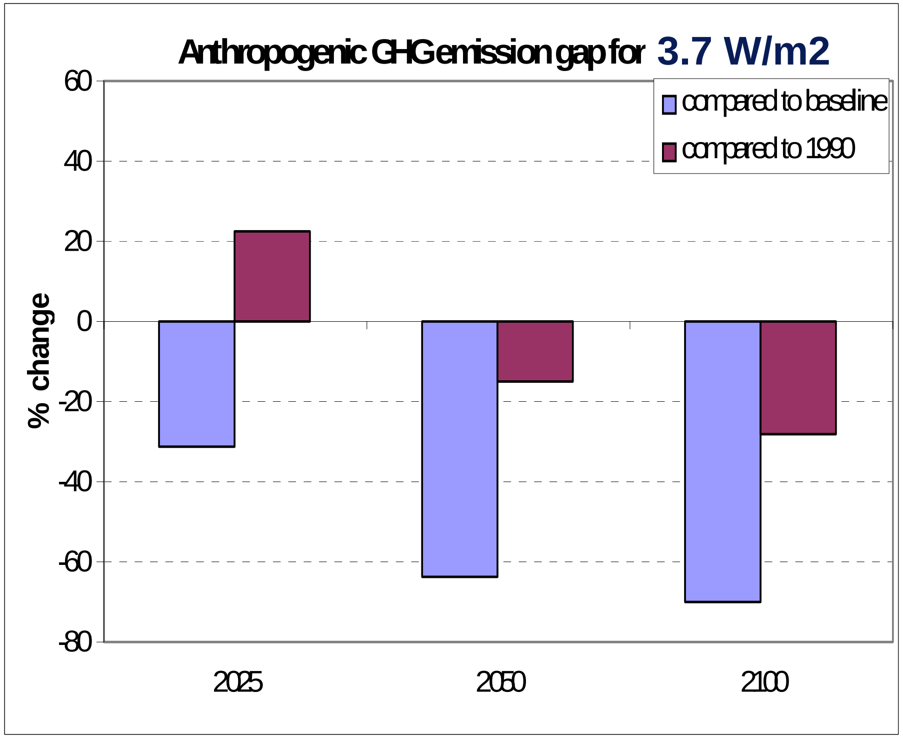


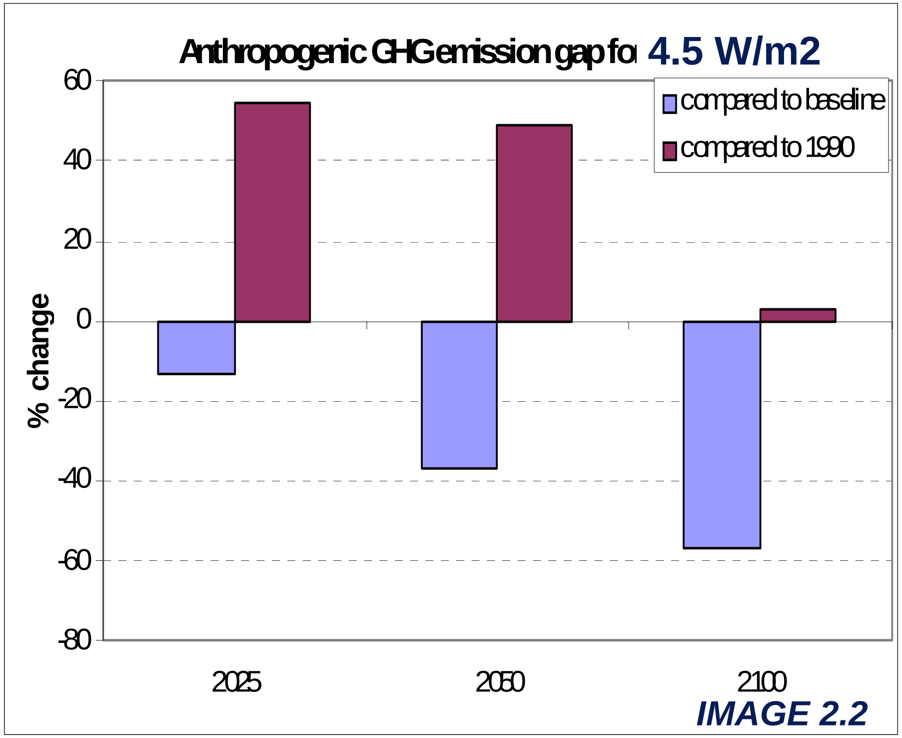




Temperature (pre-industrial)



# Large differences in reduction efforts:



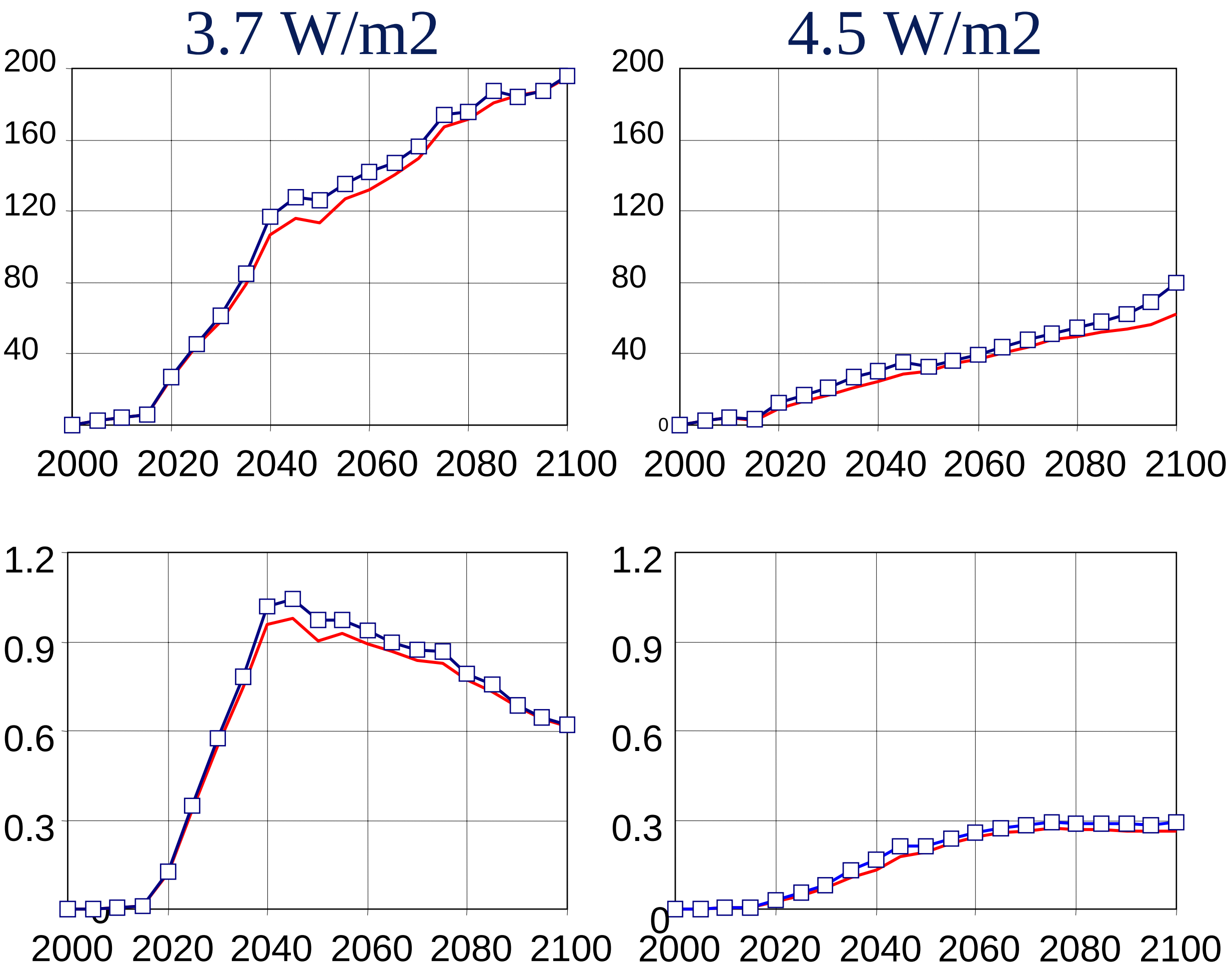




- 3.7 W/m2: in 2025 emissions can increase to 20% above 1990 levels (-30% compared to baseline). In 2050 20% reduction compared to 1990 levels.
- 4.5 W/m2: less stringent, but still a 35% reduction below baseline in 2050.

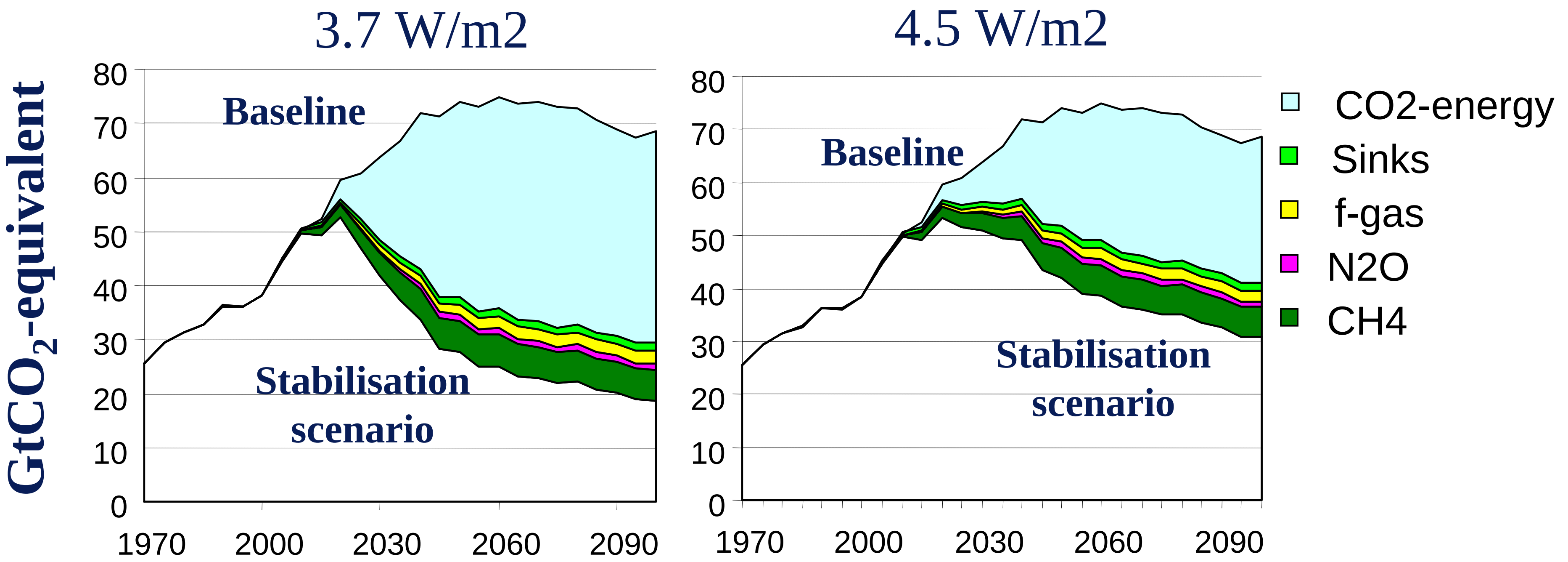
# Abatements costs

Carbon price (Euro/tCO2e)

Costs per unit of GDP (%)

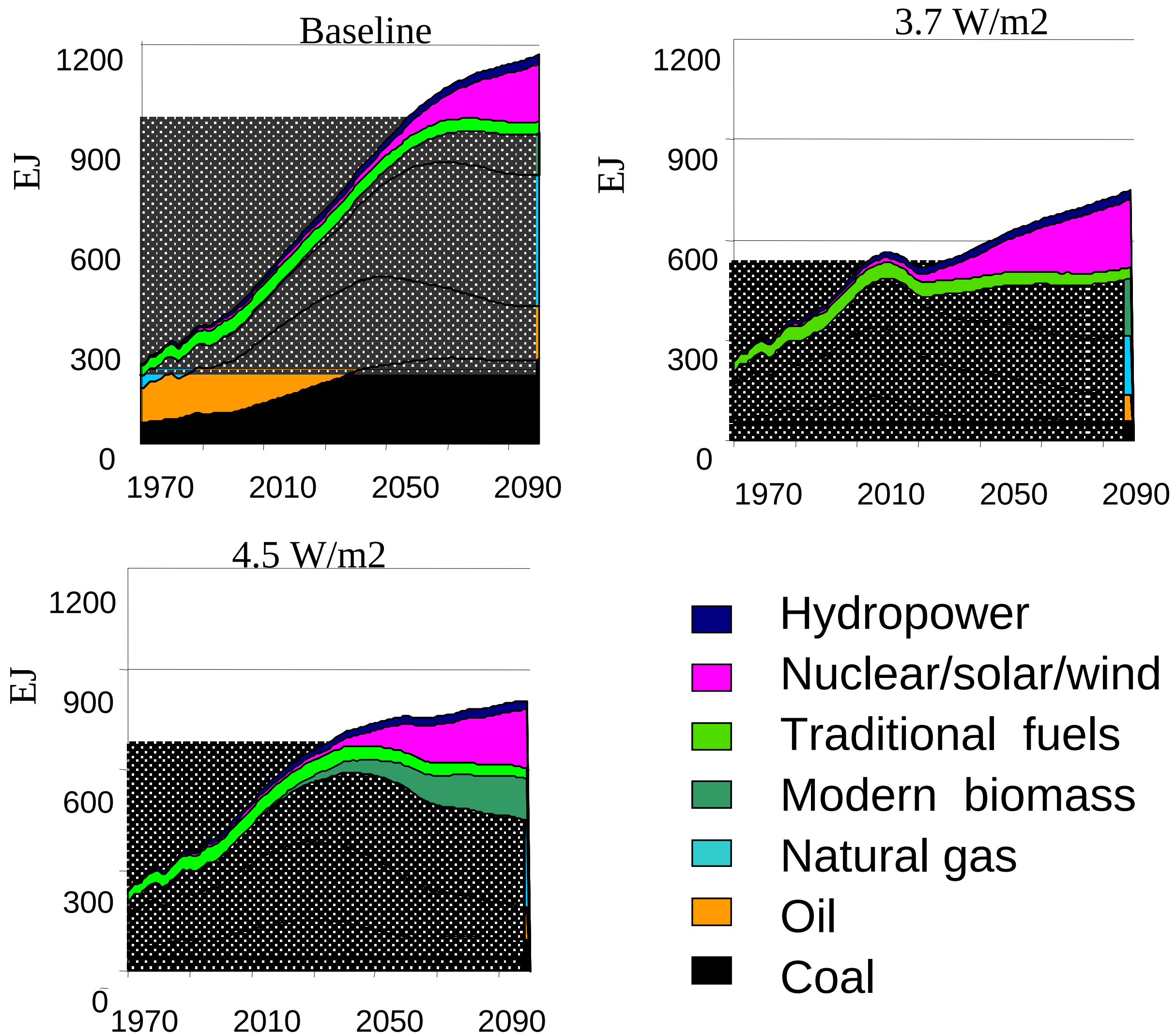


# Contribution in mitigation



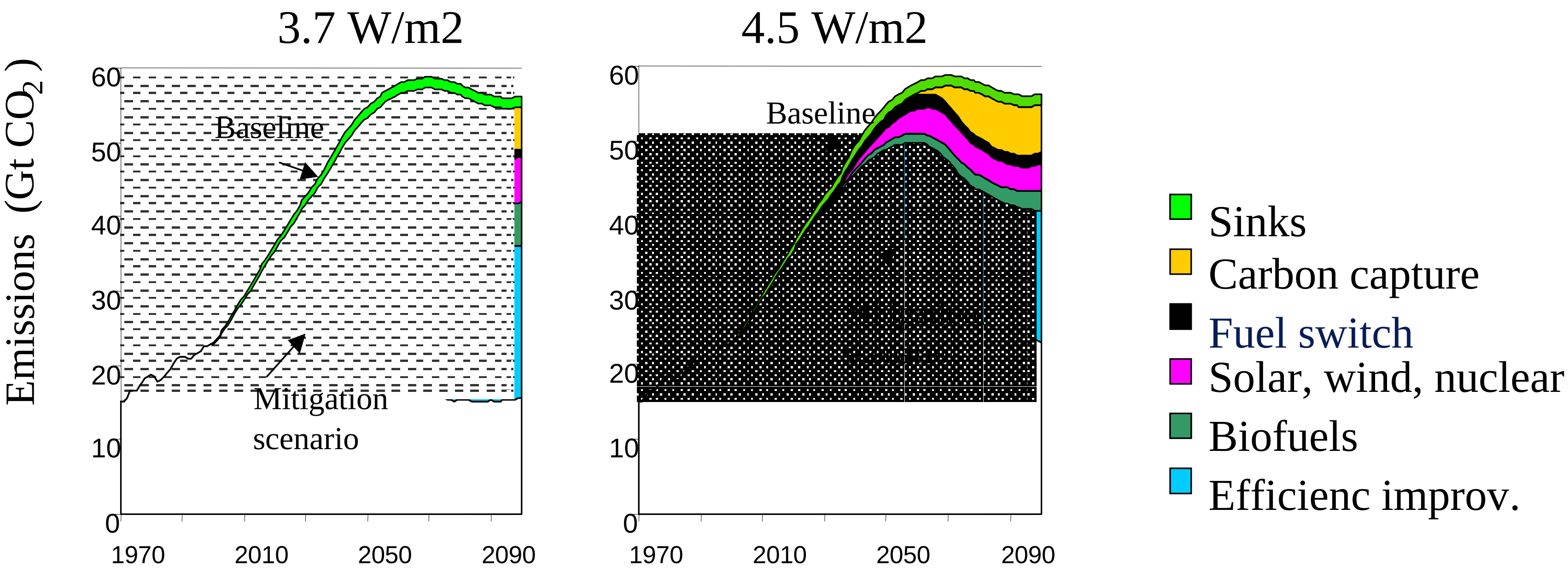

- In short terms, large contributions from sinks and non-$CO_2$ GHGs (upto 80%) due to low costs
- Longer term, contribution of different options more according to their share in emissions
- Contribution from sinks uncertain: here 0.35 $GtCO_2$ but estimates vary between 0.2-2 GtC depending on land availability - but also implementation barriers

# Contribution in mitigation




- GHG stabilisation level strongly affects energy demand.
- Stabilisation level strongly affects energy mix: strong reduction in coal;

# Contribution of Energy system $CO_2$ emission reductions




- major contribution from energy efficiency improvement – in particular from DCs
- In the longer run changes in energy production become more important
- Carbon capture and storage option could make an important contribution

# Issues for further analysis

- Overshoot profiles / hedging
- Dealing with uncertainties
  - Climate sensitivity
  - Technology development
- Implementation
  - Differentiation of future commitments
- Stabilisation scenarios and non-Kyoto gasses / non-GHG impacts (land use)

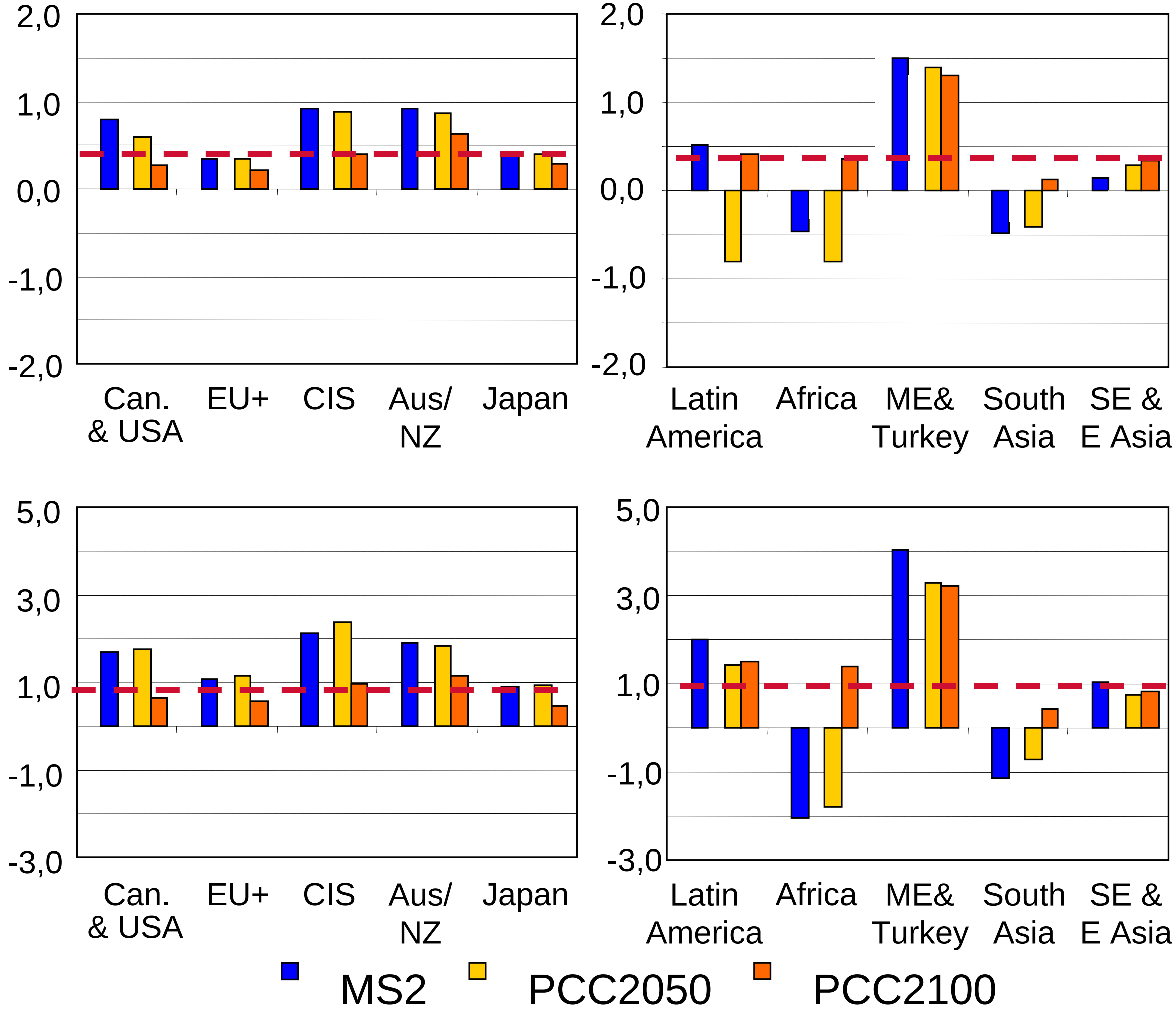
# Proposals for differentiation

- **Brazilian Proposal (Brazil / RIVM)**
- **Multi-stage (RIVM)**
- **Contraction & Convergence (Global Commons Institute)**
- **Global Compromise (Benito Müller)**
- **Jacoby rule (MIT)**
- Multi-criteria convergence (CICERO)
- Emission intensity targets approach
- Global Triptych approach (University of Utrecht)

# Proposals for differentiation

2025

2050

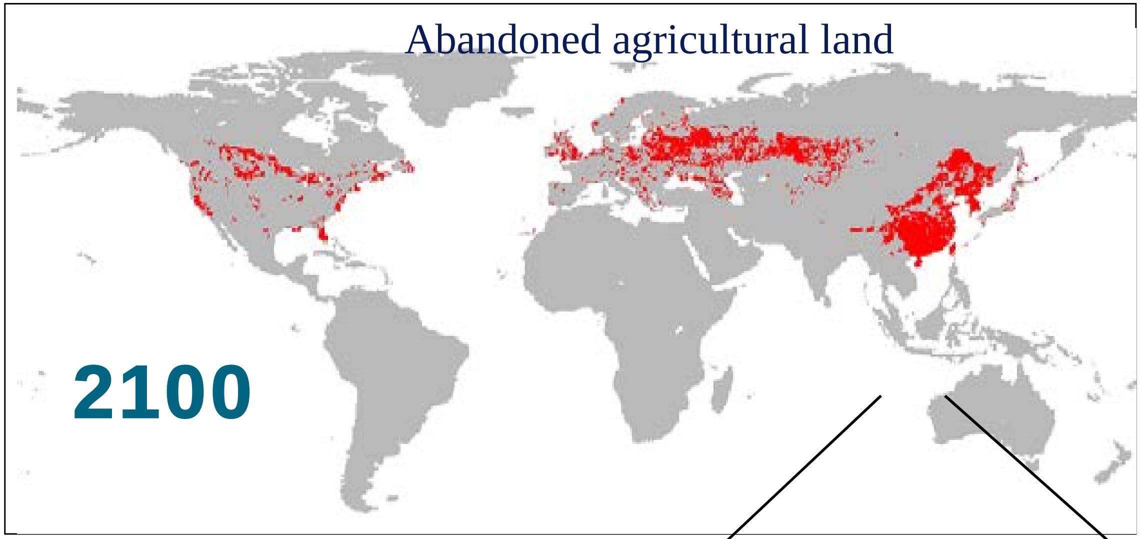



'Four groups' regarding costs levels:

- High emissions/high income: average costs (most OECD regions).
- High emissions/medium income: Relatively high costs (CIS, ME, Lat. America?)
- Medium emission/low-medium income: Average to low costs (SE& E Asia)
- Low emissions/low income: low costs or net gains (Africa, South Asia)

Van Vuuren et al. (2003). Den Elzen et al. (2003).

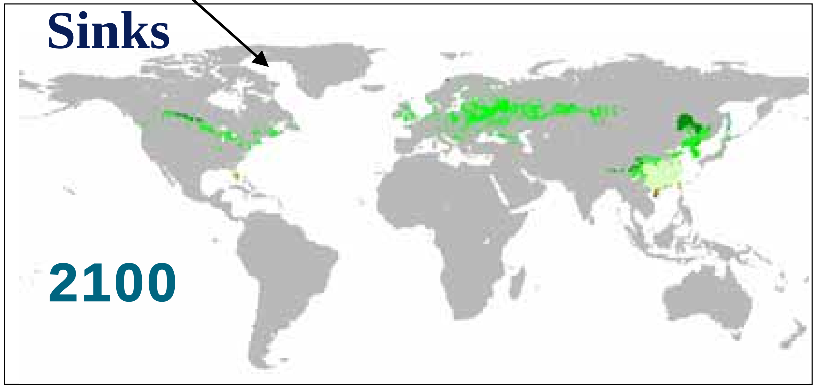
# Stabilisation scenarios and non-GHG impacts




- Analysis land use / energy system: IMAGE 2.2
- Climate: the coupled atmosphere/ocean model ECBilt-CLIO ('small scale GCM')

WORK in PROGRESS!


Biofuels offset mainly oil

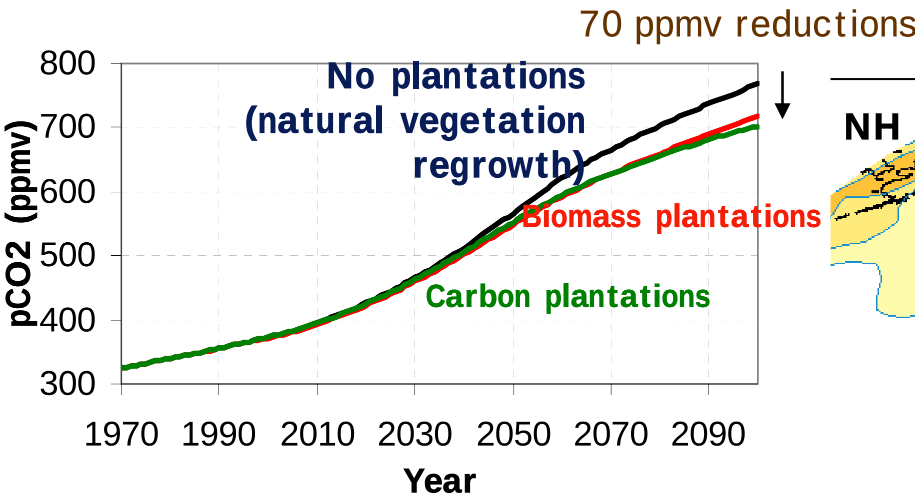


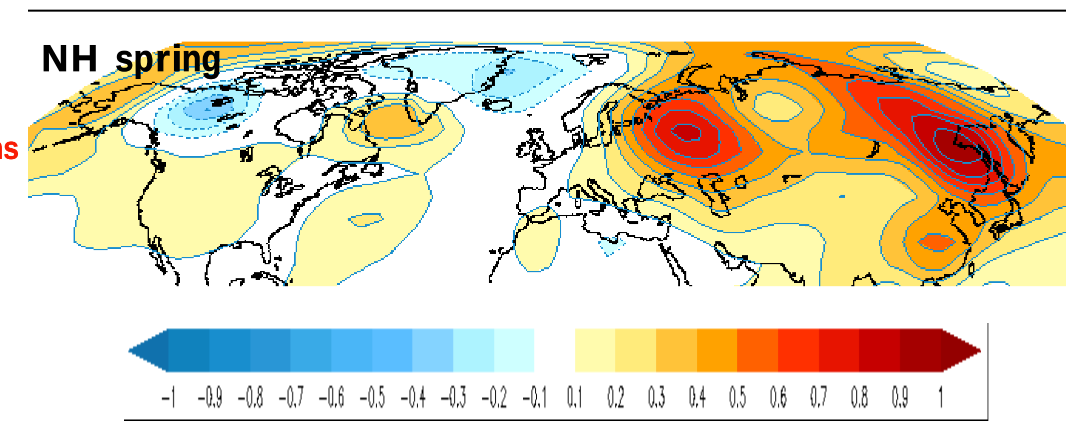

Carbon plantations are harvested every 25 years. Harvested C is stored forever.

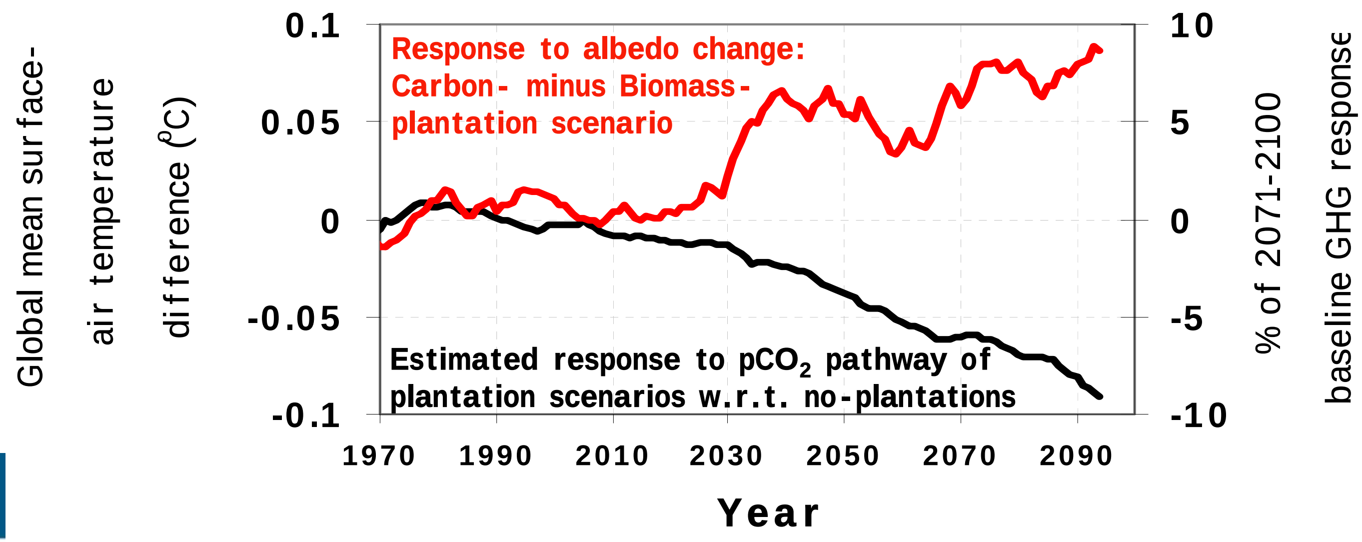
M. Schaeffer, B. Eickhout, M. Hoogwijk, R. Leemans,T. Opsteegh, D. van Vuuren (2004)

# Stabilisation scenarios and non-GHG impacts

WORK IN PROGRESS!



# Conclusions

- Thanks to EMF-21 a large group of models is able to perform multigas studies.
- EMF-21 analysis on 4.5 W/m2 stabilisation shows:
  - Using GWPs: a considerable share of early abatements is in methane/ N2O. Later most abatement needs to come from $CO_2$.
  - Still, very clear difference in carbon value $CO_2$-only vs. multigas
- Further analysis could focus on:
  - Role of uncertainties (e.g. technology progress, climate sensitivity)
  - Short / long-term targets
  - Other stabilisation targets: how does that change results
  - Implementation
  - Land-use / non-Kyoto gasses…