Case Studies in Integrated Assessment @ PBL*

Presented by Tom Kram, Netherlands Environmental Assessment Agency, Snowmass, 31 July 2008

* f.k.a. MNP; f.k.a. RIVM

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Two (very different) studies

1. **Climate benefits of changing diet.** Exploring the role of animal products in human diets wrt climate change with IMAGE/TIMER/FAIR

2. **Analysing the costs and benefits of climate policy: Value judgements and scientific uncertainties.** Looking at key factors and assumptions relevant for costs and benefits of climate strategies with a simple model.

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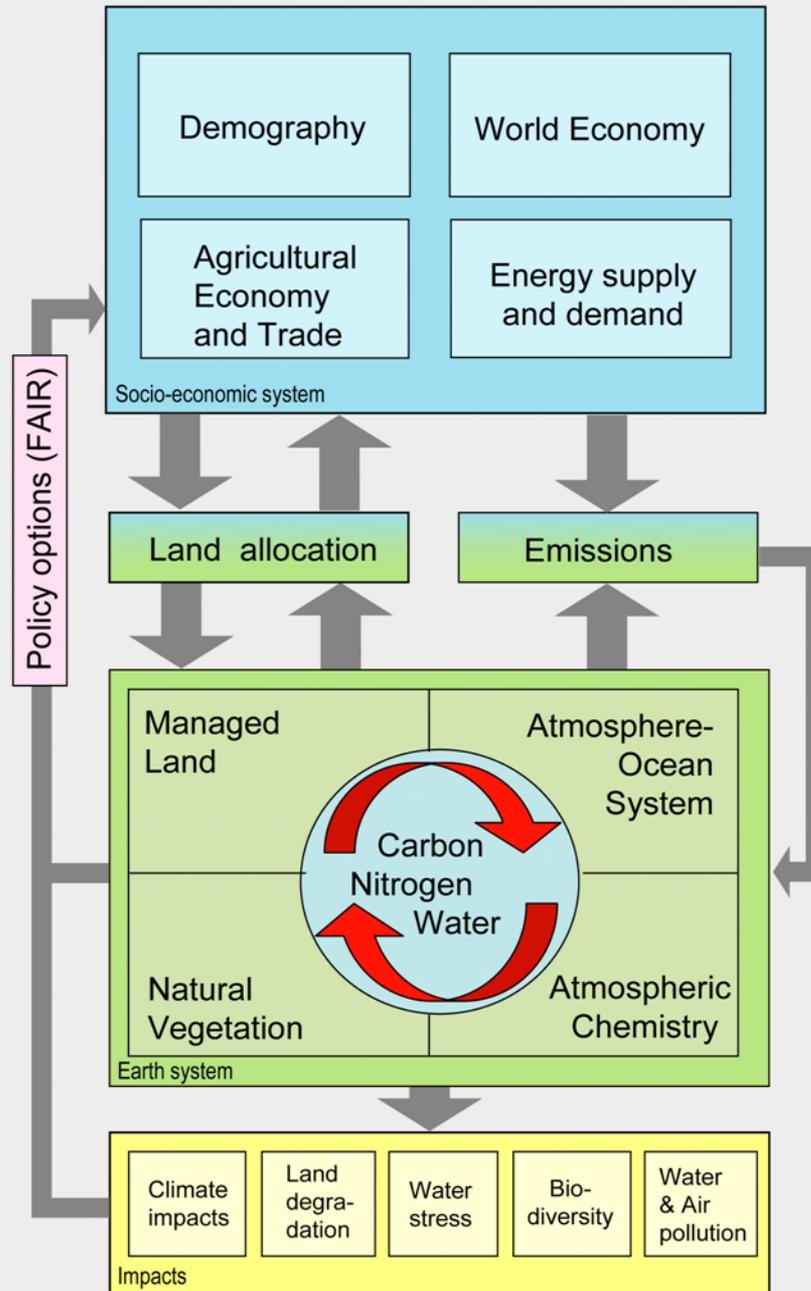
Climate benefits of changing diet

(article under review by :
Elke Stehfest, Lex Bouwman,
Detlef van Vuuren, Michel den
Elzen, Bas Eickout and Pavel
Kabat – WUR)

Tom Kram, PBL
Snowmass, 31 July 2008

IMAGE 2.4 Framework

Socio-economic system
- Demography
- World Economy
- Agricultural Economy and Trade
- Energy supply and demand

Policy options (FAIR)

Land allocation

Emissions

Earth system
- Managed Land
- Atmosphere-Ocean System
- Carbon Nitrogen Water
- Natural Vegetation
- Atmospheric Chemistry

Impacts
- Climate impacts
- Land degra-dation
- Water stress
- Bio-diversity
- Water & Air pollution

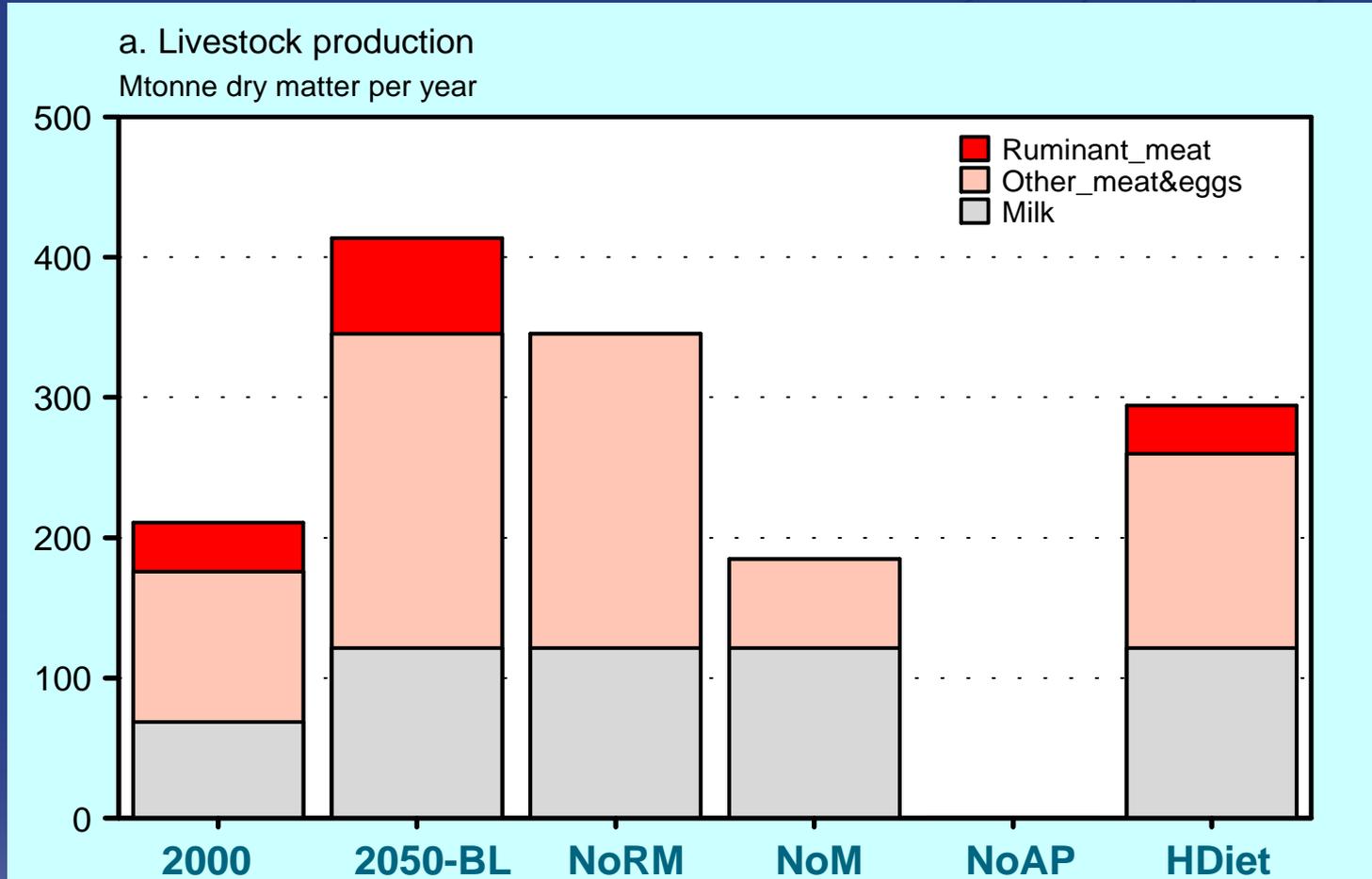**Netherlands Environmental Assessment Agency**

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Background

- FAO: livestock sector biggest contributor to CC (18%)
- Dominant trend in scenarios: strong growth in animal product consumption (here doubling to 2050)
- Research questions:
  – Closer look at livestock GHG emissions
  – Breakdown into different animal product groups and their relative importance
  – Potential for diet change to mitigate climate change

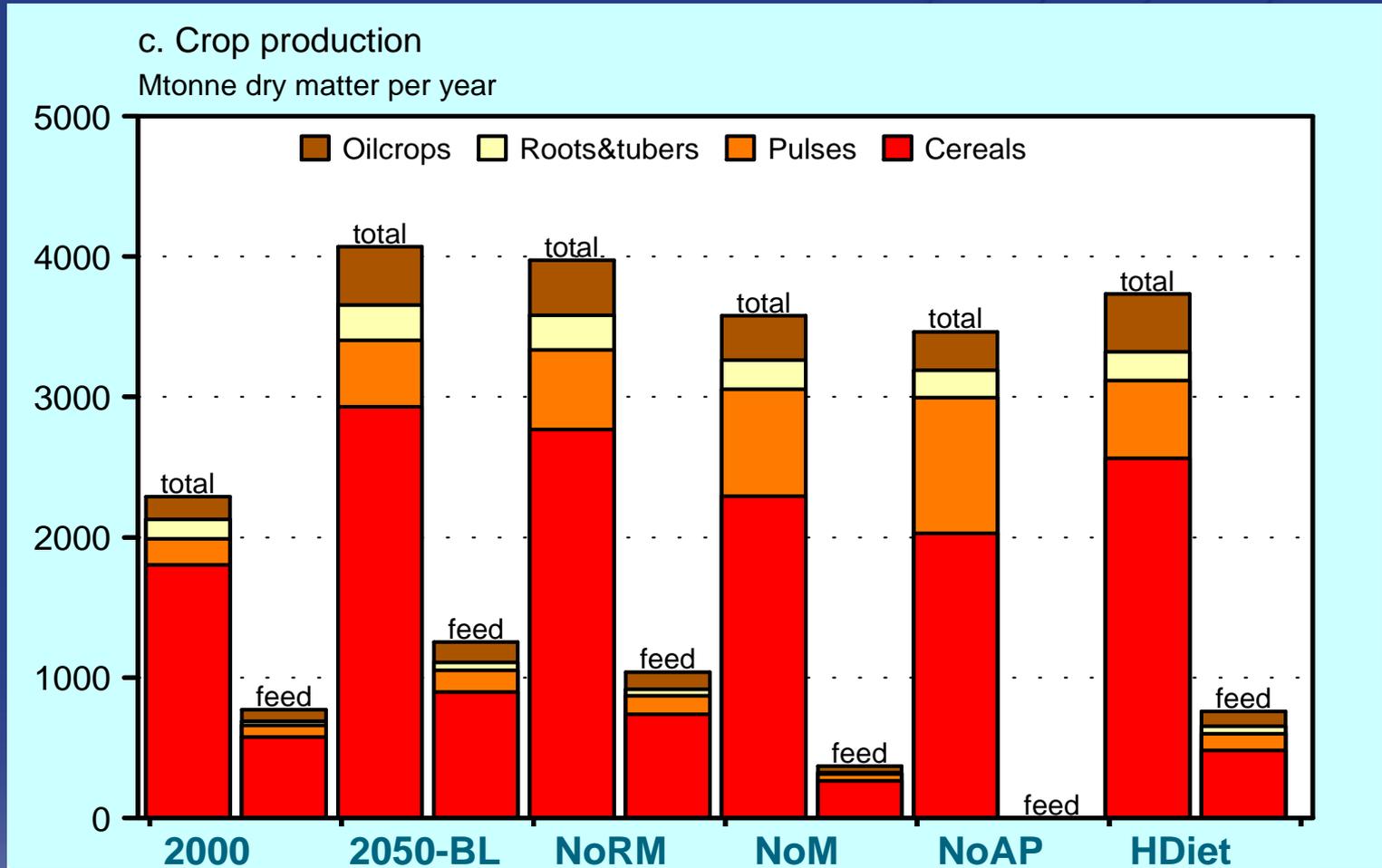**Netherlands Environmental Assessment Agency**

Approach

- Baseline: FAO scenario in IMAGE 2.4
- Four dietary change cases tested, replacing animal products with pulses and soybeans, while keeping protein supply at/above baseline level:
    - **NoRM**: no ruminant meat (beef, goat, sheep, etc)
    - **NoM**: no meat (also no poultry, pigs, etc)
    - **NoAP**: no animal products (also no dairy products)
    - **HDiet**: reduced, mixed meat consumption (derived from Willett, Harvard Medical School: 'Healthy Diet')
- Global diet shift from Baseline (2010-2030)
- Only consumption volume changes considered, other model settings as in baseline

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Livestock Production (Mtonne DM/year)

a. Livestock production

Mtonne dry matter per year

Legend:
- Ruminant_meat (red)
- Other_meat&eggs (pink)
- Milk (grey)

Categories: 2000, 2050-BL, NoRM, NoM, NoAP, HDiet

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Crop Production (Mtonne DM/year)

c. Crop production

Mtonne dry matter per year

Legend: Oilcrops | Roots&tubers | Pulses | Cereals

Categories: 2000, 2050-BL, NoRM, NoM, NoAP, HDiet

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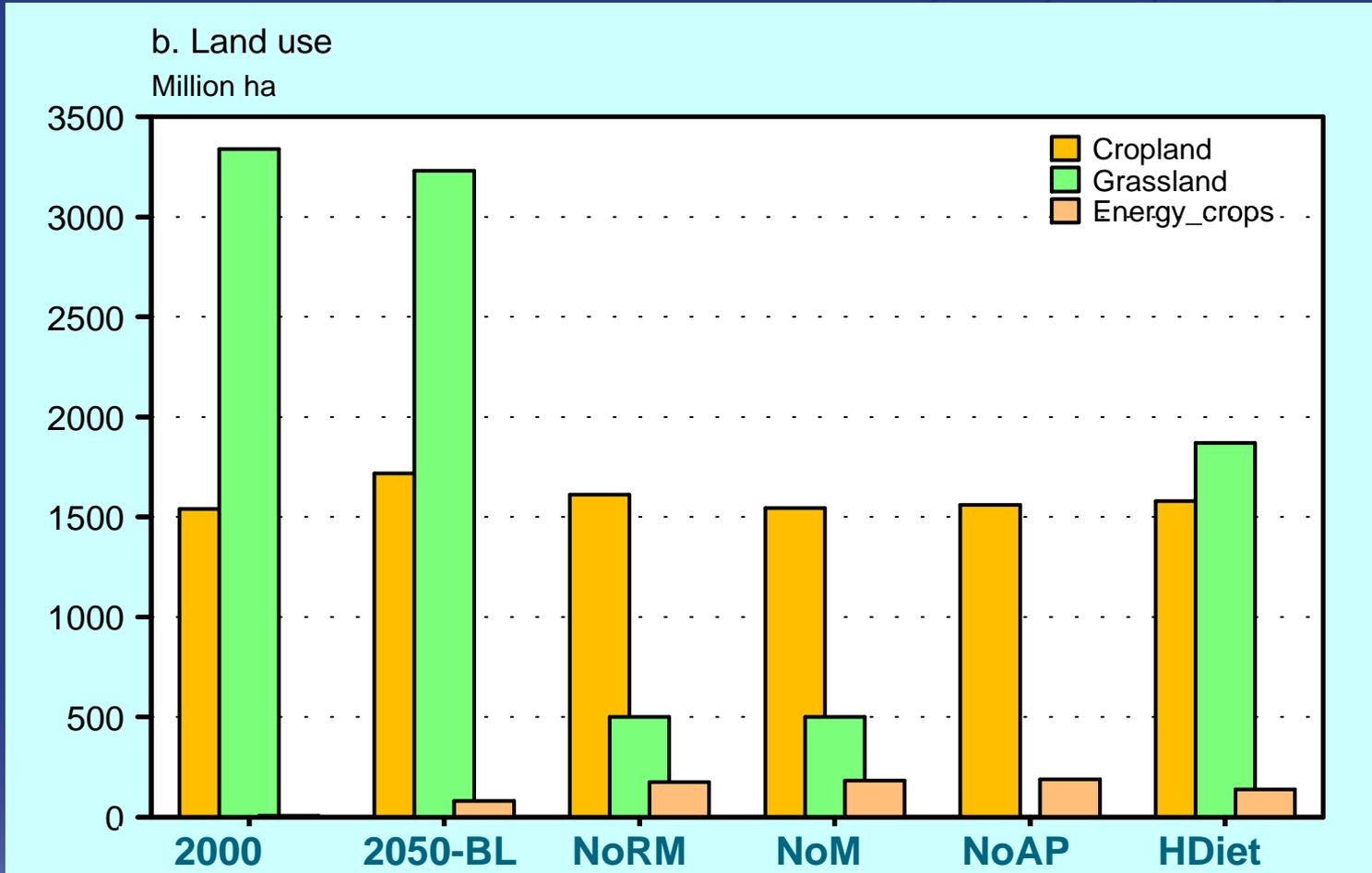
Land-use

- Baseline:
  - Small increase in total agricultural land: productivity gains
  - Decrease in grassland: shift to mixed/landless production
- NoRM/NoM:
  - 80% less grassland for ruminants
  - 6/10% decrease in cropland: direct consumption of crops more efficient than conversion by animals
- NoAP: zero grassland left, cropland similar to No(R)M
- HDiet: grassland reduced to 55% of baseline
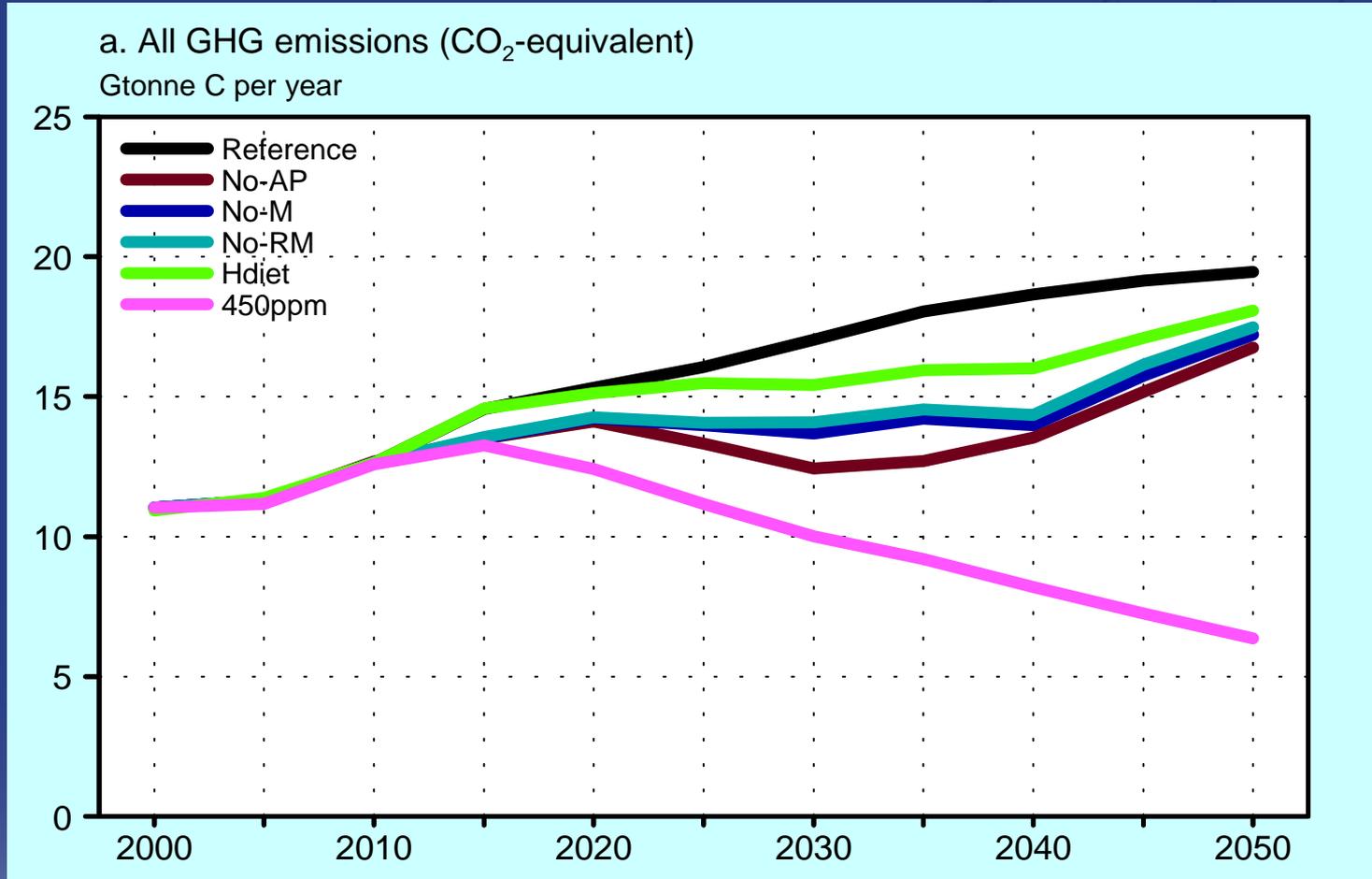- All cases: abandoned land used for bio-energy but mostly regrow to natural state

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Land Use (Million ha)

b. Land use

Million ha

Legend:
- Cropland
- Grassland
- Energy_crops

Categories: 2000, 2050-BL, NoRM, NoM, NoAP, HDiet
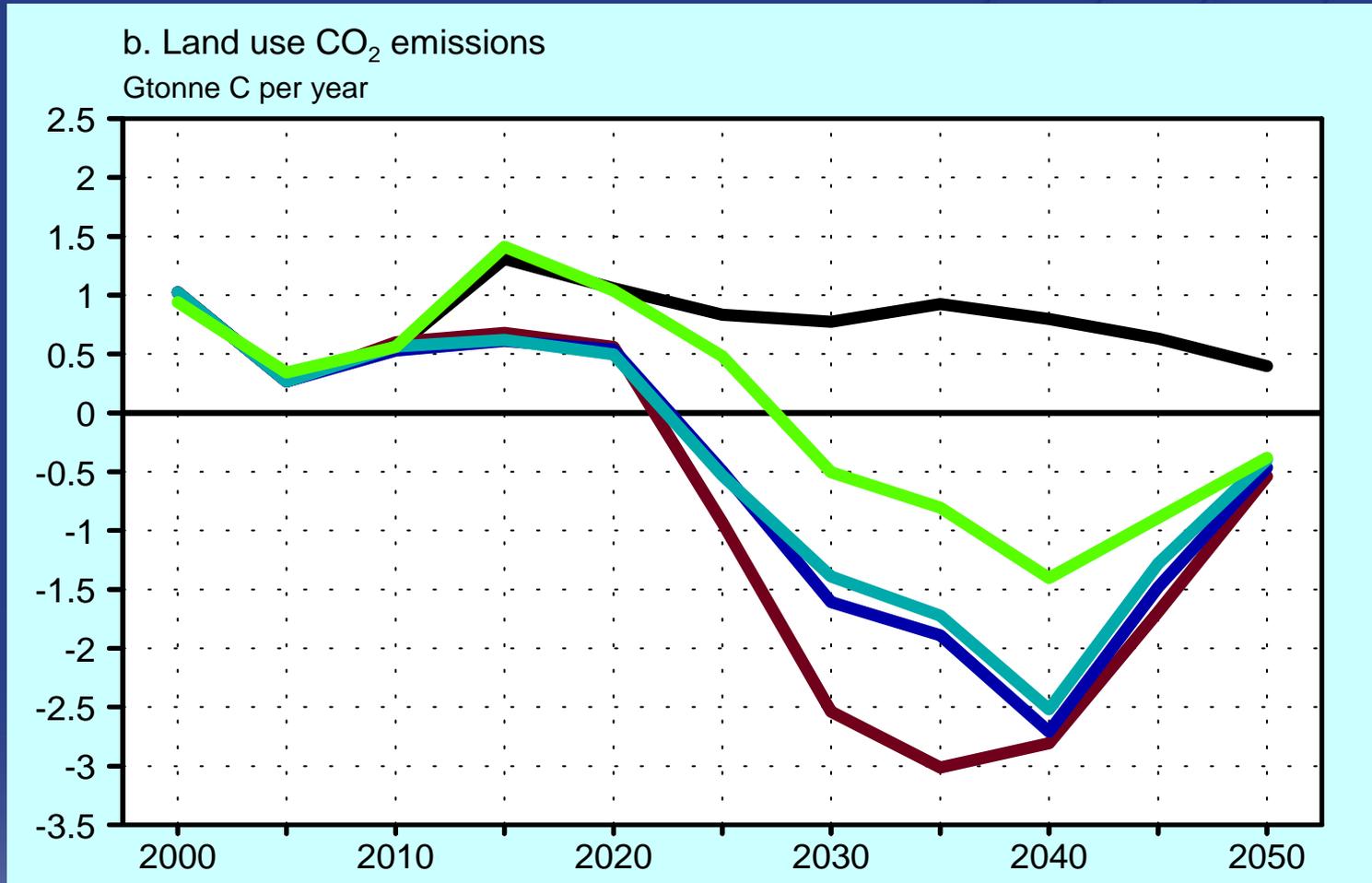
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GHG Emissions

- Cumulative emissions over 2010-50 period reduced up to 17% for CO2, 24% for CH4 and 21% for N2O

- Around -10% each for HDiet case

- Largest contribution (65-75%) from ruminant meat: 29 Gt C <u>sink</u> for NoRM vs. 39 Gt C <u>source</u> in the Baseline

- HDiet around 2Gt C source

- Note: CO2 effect arises from LU/LC _change_ and thus levels off; CH4 and N2O reduced permanently

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All GHG Emissions (Gtonne C-eq/year)

a. All GHG emissions (CO_2-equivalent)

Gtonne C per year

Legend:
- Reference
- No-AP
- No-M
- No-RM
- Hdiet
- 450ppm

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Land-use CO2 Emissions (Gtonne C/year)

b. Land use CO_2 emissions
Gtonne C per year

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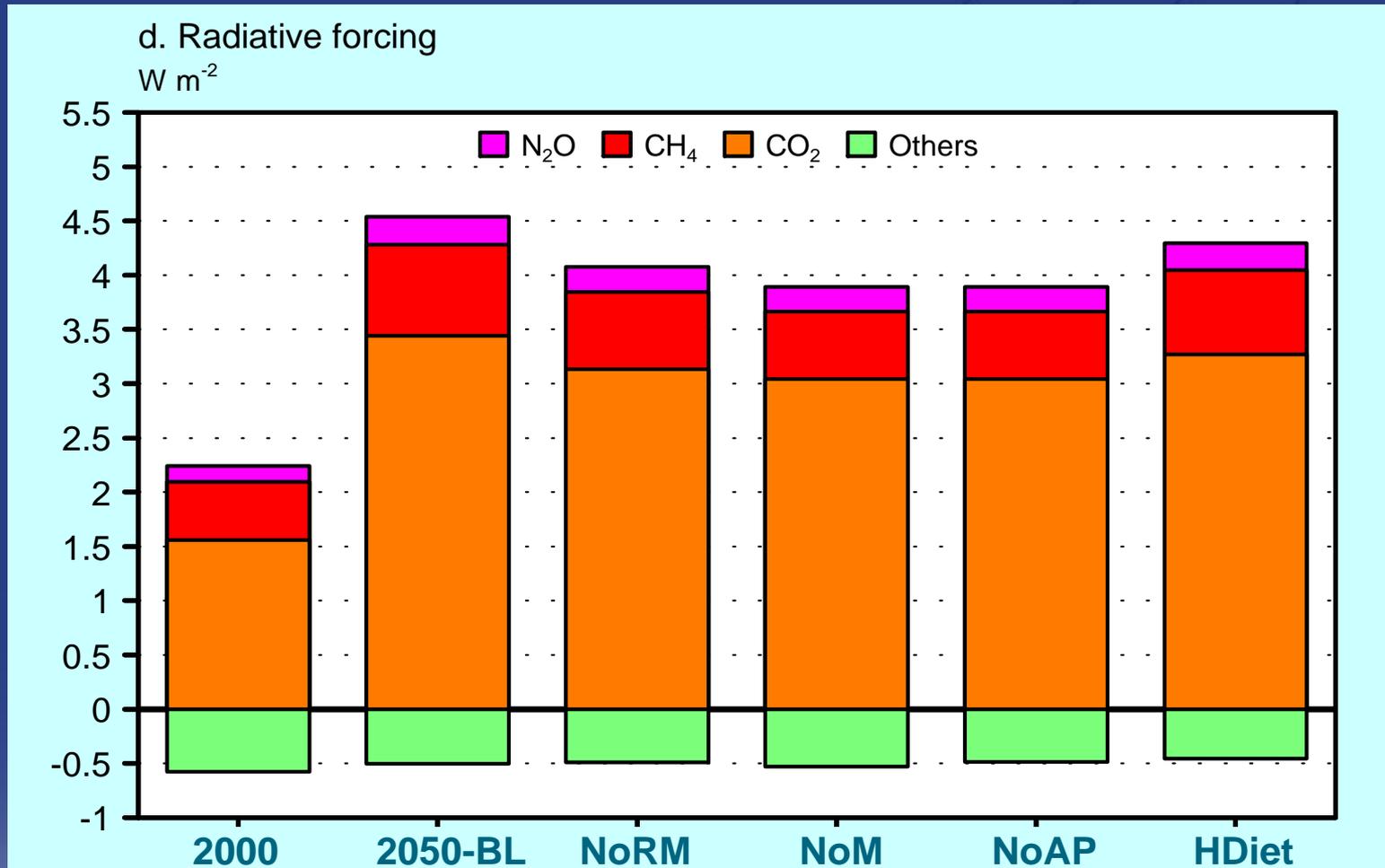Assessment Agency

GHG concentration and radiative forcing

- Dietary change cases (NoRM, NoM, NoAP) 57-76 ppm CO_2-eq below baseline in 2050

- HDiet still 30 ppm below Baseline

- Radiative forcing around 0.5-0.6 W/m2 lower than Baseline in 2050 (NoRM, NoM, NoAP); 0.3 for HDiet
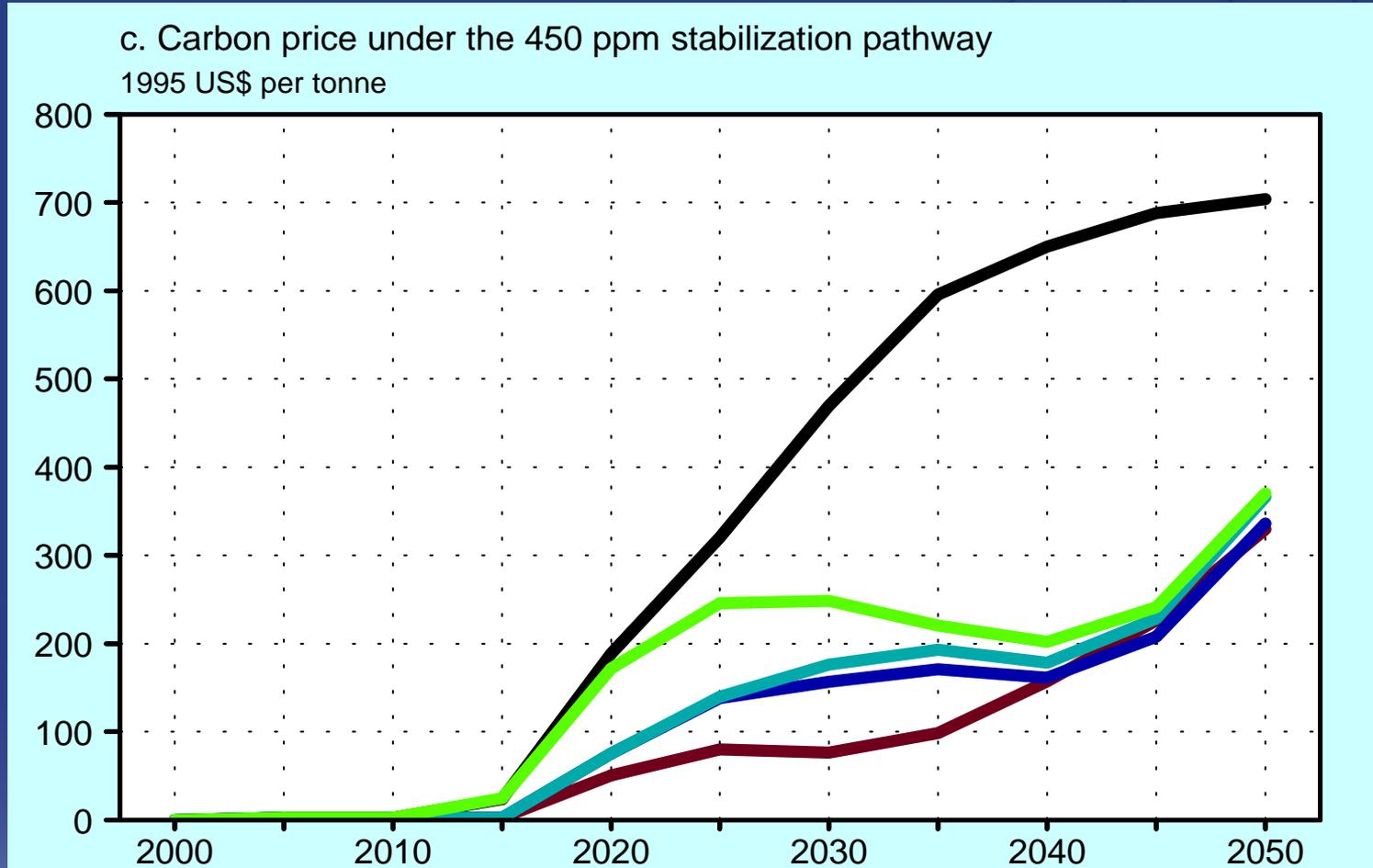
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Radiative Forcing (W/m²)

d. Radiative forcing
W m^{-2}

Legend: N$_2$O, CH$_4$, CO$_2$, Others

Categories: 2000, 2050-BL, NoRM, NoM, NoAP, HDiet

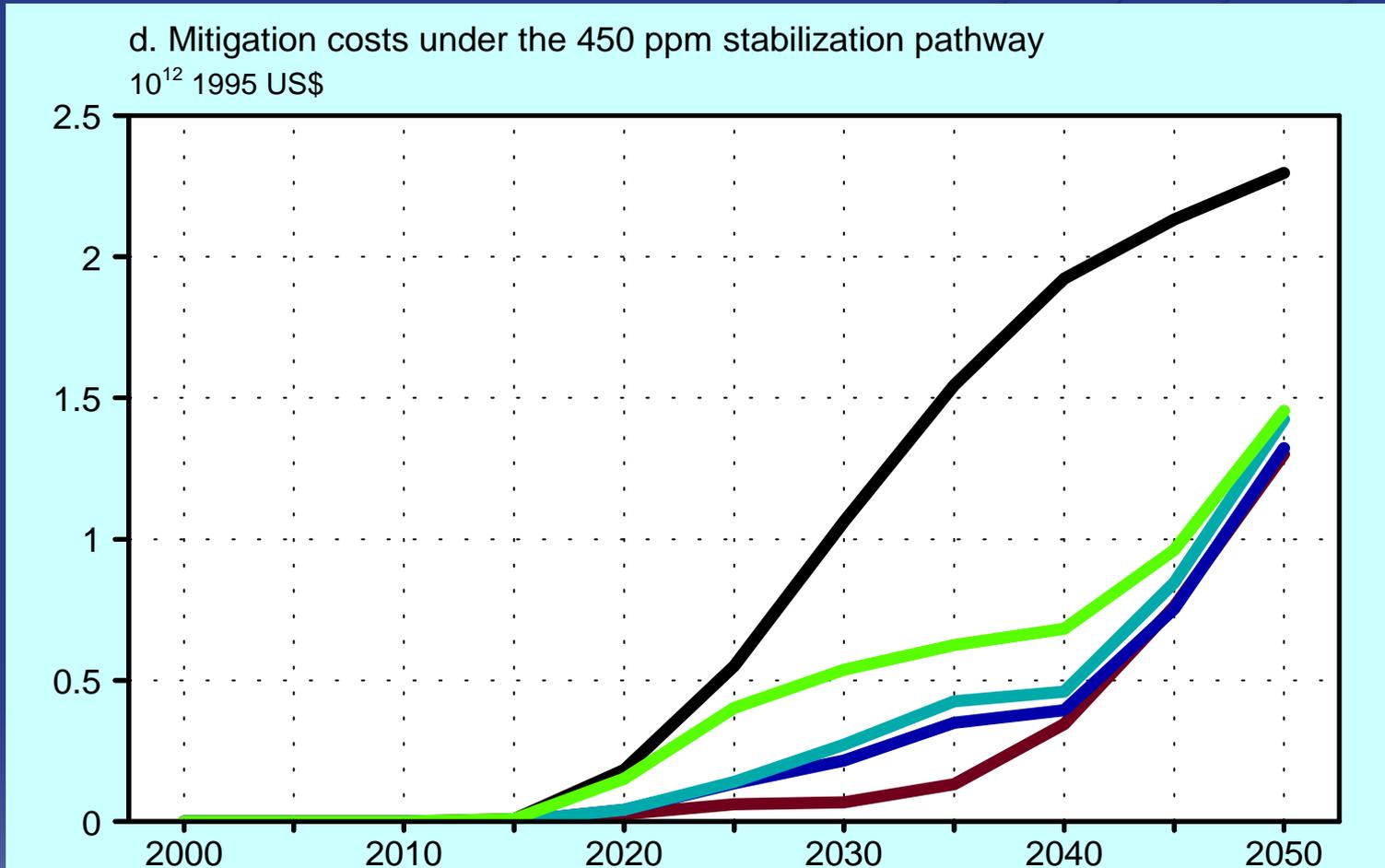Netherlands Environmental Assessment Agency

Reduced mitigation cost for 450ppm stabilization

- Compared with the Baseline diet assumptions, the dietary change cases offer lower marginal and total mitigation cost to reach the same target

- For HDiet, annual costs 2030/50 less than 50% compared with Baseline diet

- Note: no cost or welfare loss associated with stylized dietary change cases

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Carbon Price under 450 ppm Stabilization

c. Carbon price under the 450 ppm stabilization pathway
1995 US$ per tonne

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Mitigation Cost under 450 ppm Stabilization

d. Mitigation costs under the 450 ppm stabilization pathway
10^{12} 1995 US$

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Discussion

- Dietary patterns important determinant of GHG emissions and climate change

- Ruminant meat is the major factor

- The less drastic HDiet case still significant compared to commonly considered mitigation options

- Numerous uncertainties, notably the carbon cycle (recently evaluated and revised; well in line with literature)

- Key uncertainty is the return to climax natural vegetation on the abandoned grasslands, and the uptake and equilibrium in the carbon pool

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Not done yet

- Agro-economic consequence and feedbacks; e.g. lower land price -> more consumption and less productivity gains

- Welfare impacts and distributional effects

- Policy instruments??

    (For GBO-2 we tested a "meat-tax" -reflecting production cost increase to improve   e emissions from livestock. This   mer prices and around 5% lower m   nt literature is highly divided on th   odstuffs)

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And now, something completely different:

The Larch!

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Analysing the costs and benefits of climate policy: Value judgements and scientific uncertainties

(Andries Hof, Michel den Elzen and Detlef van Vuuren. GEC, 2008)

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Background

The benefits of strong, early action considerably outweigh the costs

Sir Nicholas Stern

The "ambitious" programs embedded in the Stern Review (...) are extremely expensive (...) due to the fact that they involve emissions reductions that are too sharp and too early in time
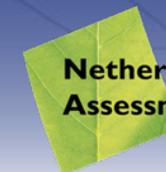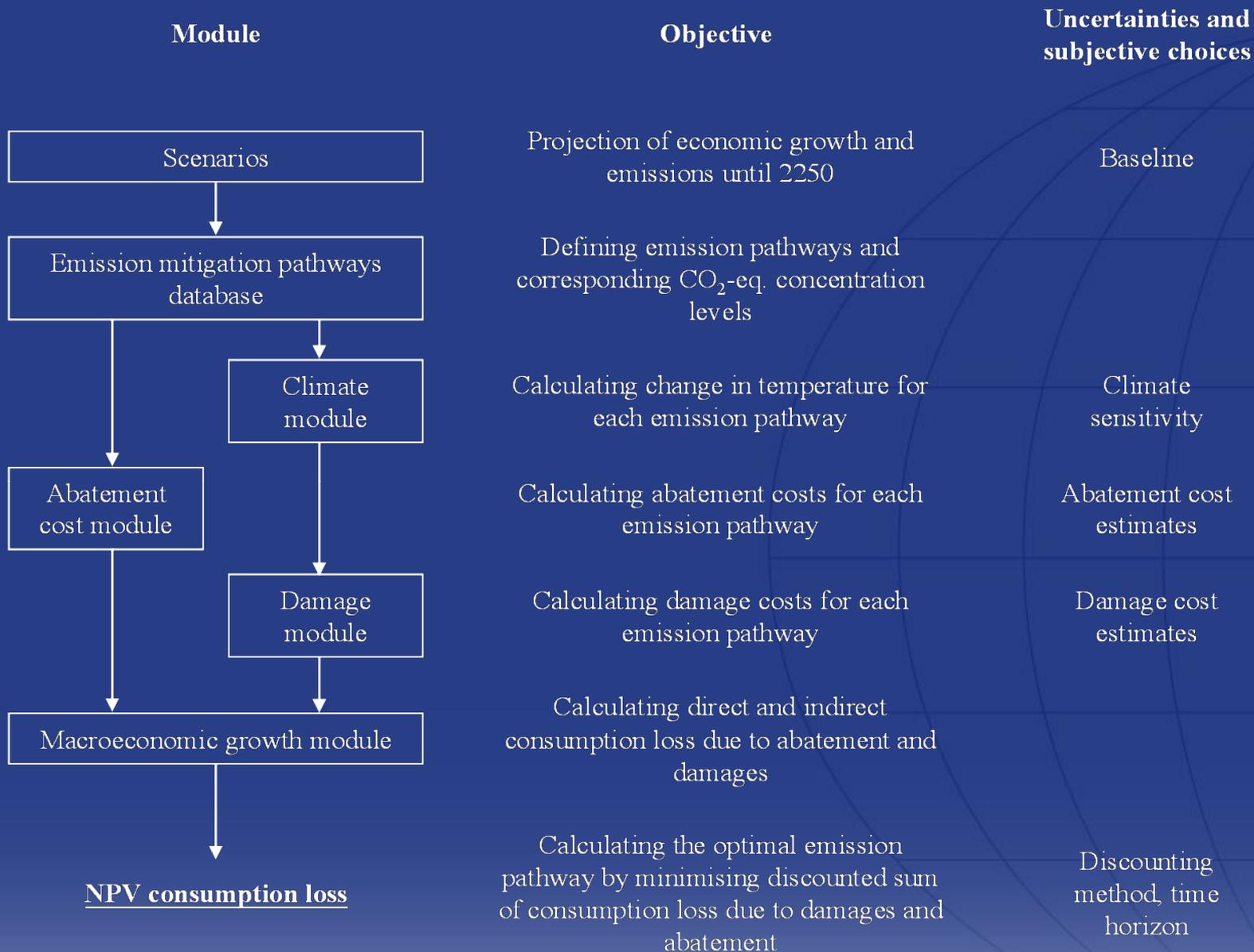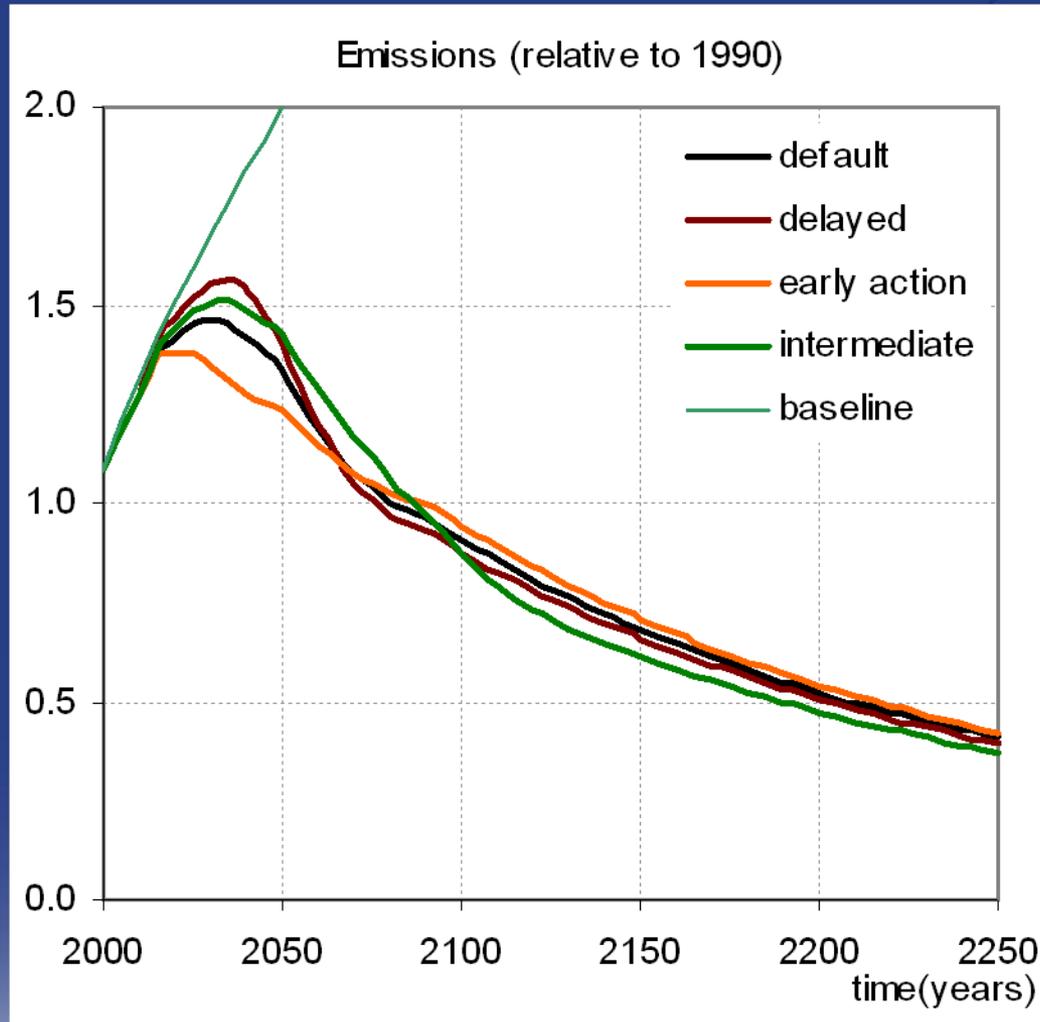
William D. Nordhaus

In FUND -with unequity aversion- optimal control even comes close to ensuring a stable atmospheric concentration of carbon dioxide at 550 ppm

Richard Tol

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Module	Objective	Uncertainties and subjective choices
Scenarios	Projection of economic growth and emissions until 2250	Baseline
Emission mitigation pathways database	Defining emission pathways and corresponding CO_2-eq. concentration levels	
Climate module	Calculating change in temperature for each emission pathway	Climate sensitivity
Abatement cost module	Calculating abatement costs for each emission pathway	Abatement cost estimates
Damage module	Calculating damage costs for each emission pathway	Damage cost estimates
Macroeconomic growth module	Calculating direct and indirect consumption loss due to abatement and damages	
NPV consumption loss	Calculating the optimal emission pathway by minimising discounted sum of consumption loss due to damages and abatement	Discounting method, time horizon

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Different mitigation pathways

Emissions (relative to 1990)

Legend:
- default
- delayed
- early action
- intermediate
- baseline

time(years)

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Model

$$Y = A \, K \, (t)^{\alpha} \, L^{1-\alpha}$$

$$K = K - \eta \, K \, (t) + I(t)$$

$$Y = C(t) + I(t) + EC(t) + D(t)$$
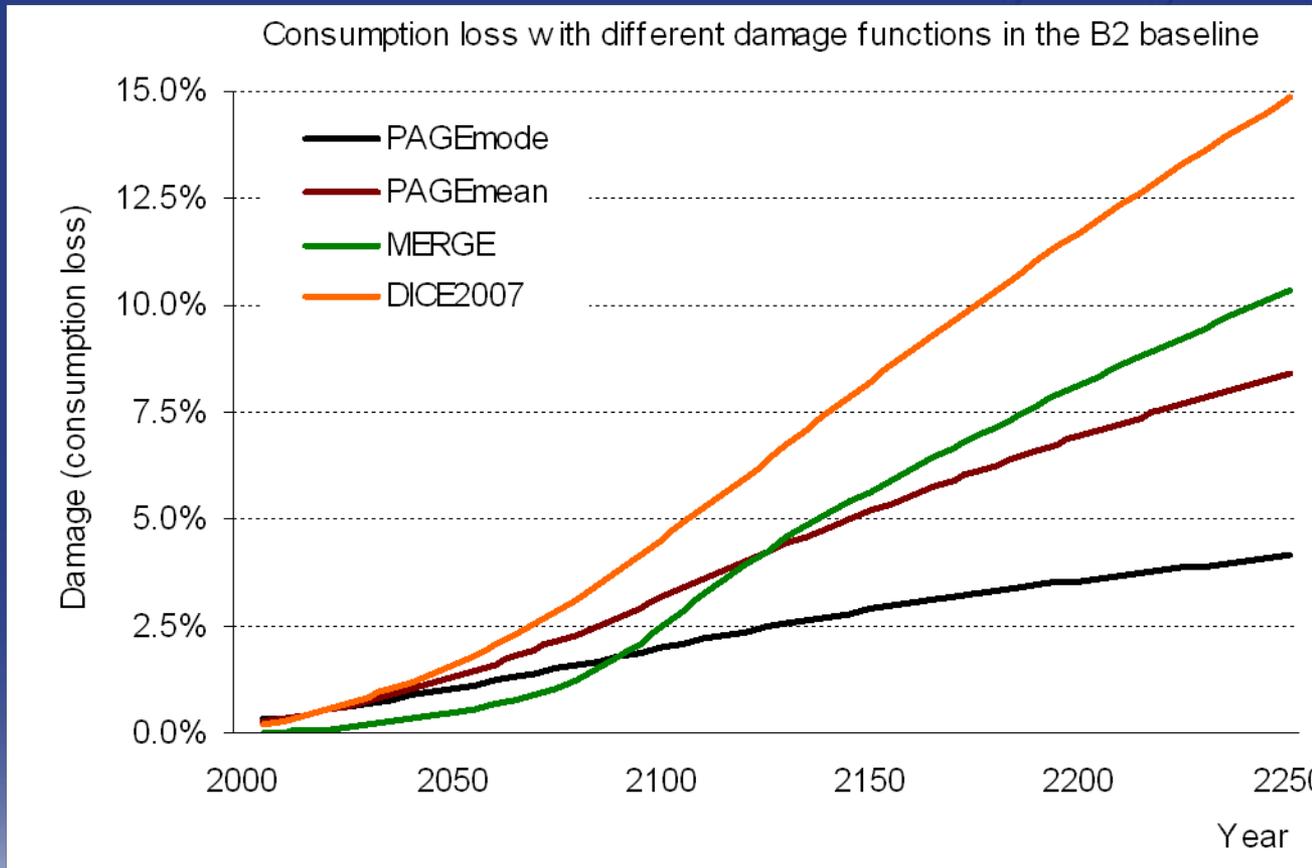
$$MAX(\int d * C dt)$$

Crucial uncertainties / choices:

    EC (mitigation costs)
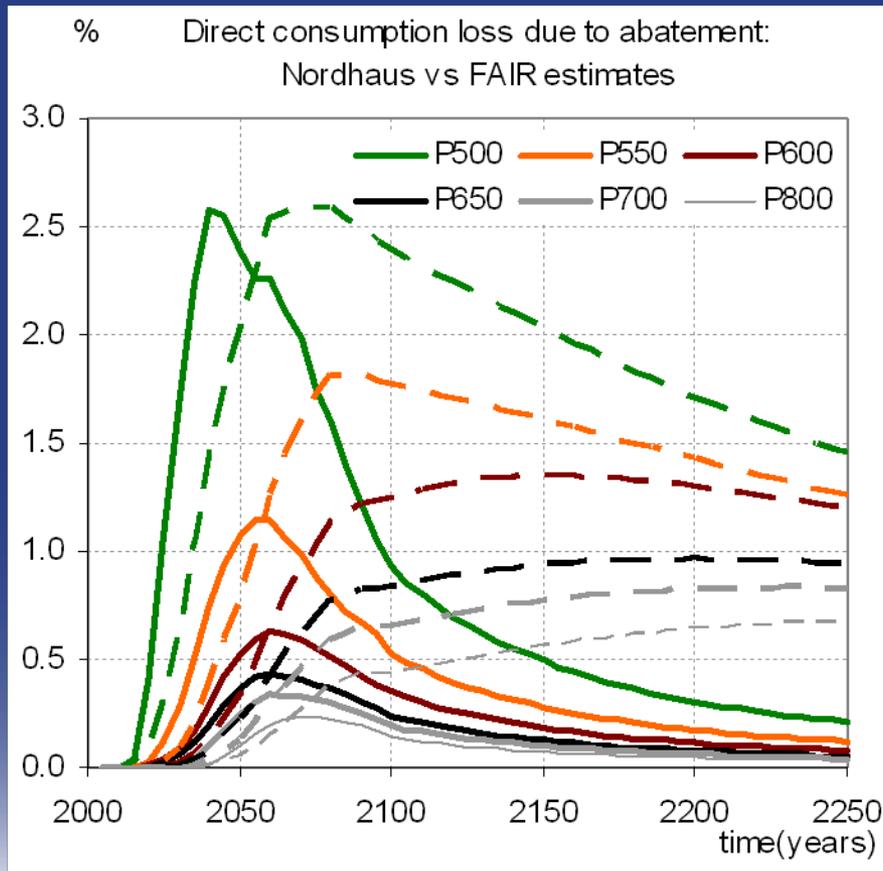
    D (damage costs)

    d (discount rate)

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Assumptions and default settings

- Scientific uncertainties:
  - Damage function (<u>DICE</u>, PAGE mean, PAGE mode, MERGE)

Consumption loss with different damage functions in the B2 baseline

Assumptions and default settings

- Scientific uncertainties:
  - Damage function (<u>DICE</u>, PAGE mean, PAGE mode, MERGE)
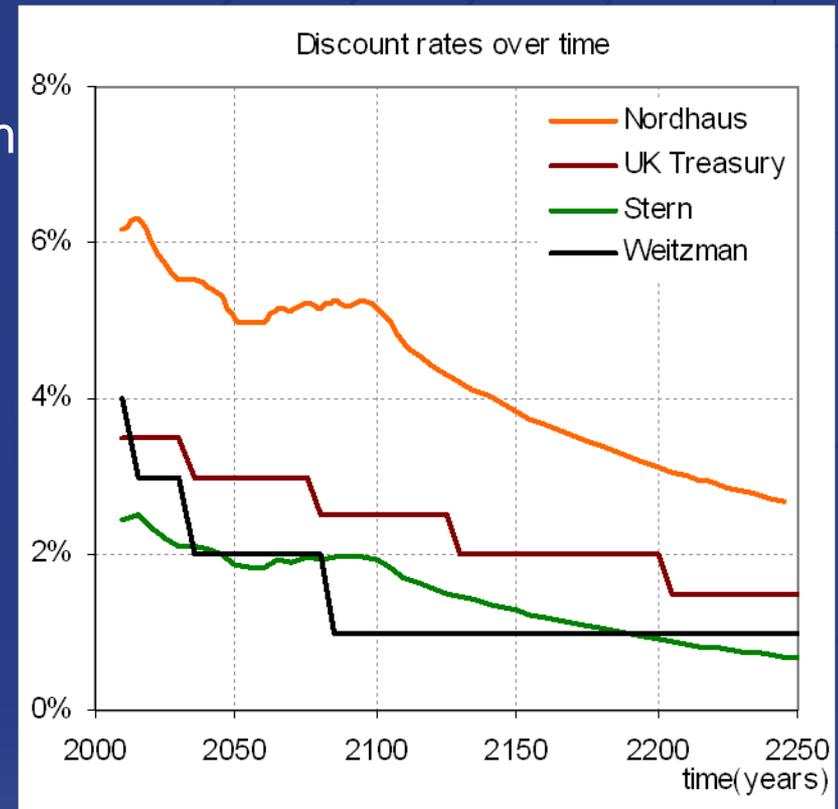 - Abatement costs (<u>FAIR</u>, DICE)

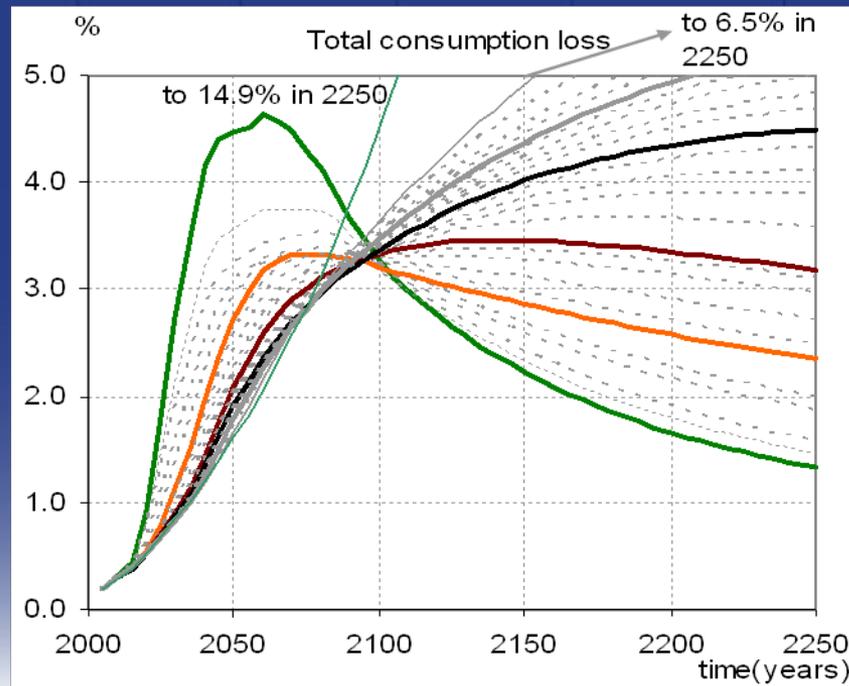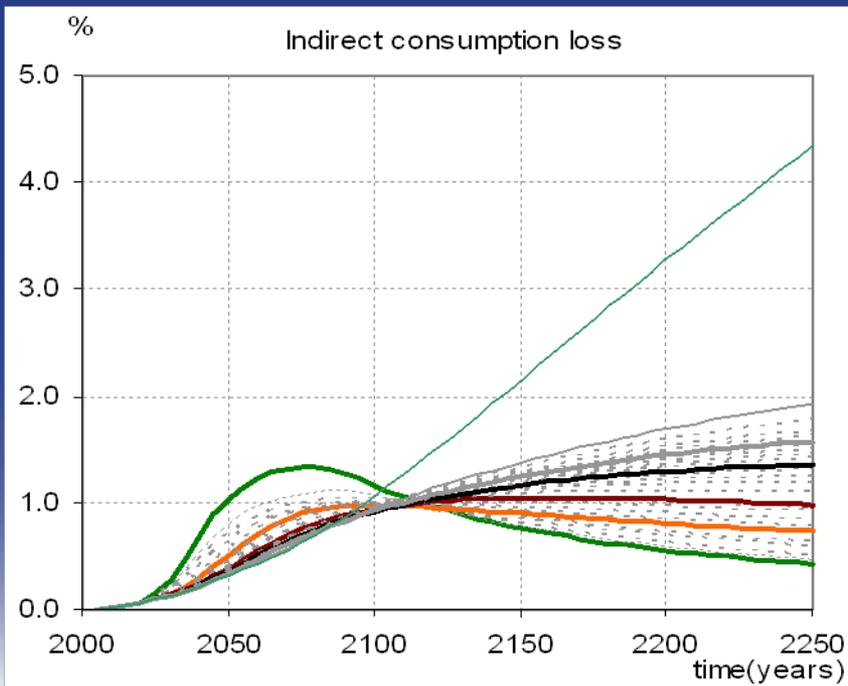% Direct consumption loss due to abatement: Nordhaus vs FAIR estimates

Assumptions and default settings

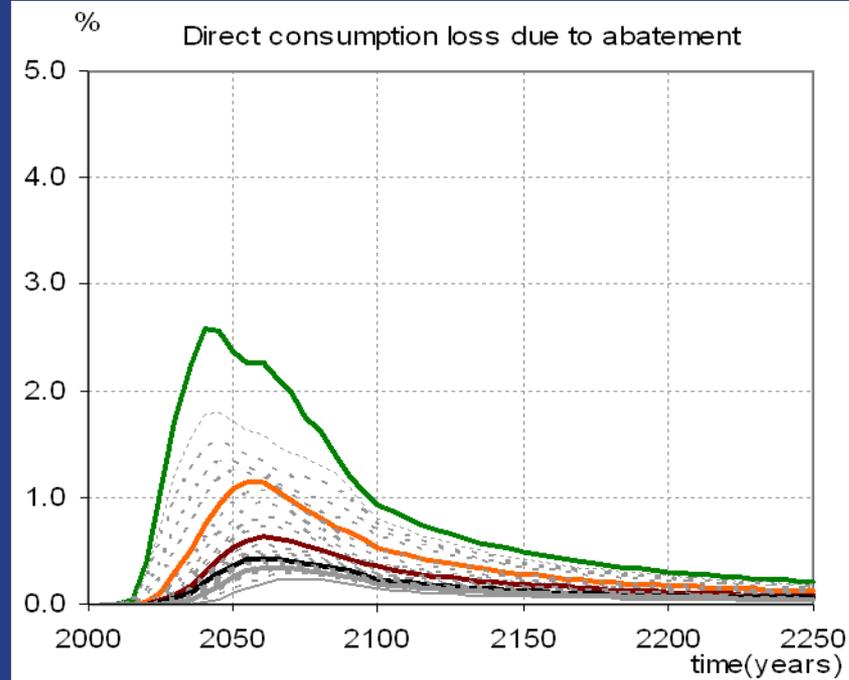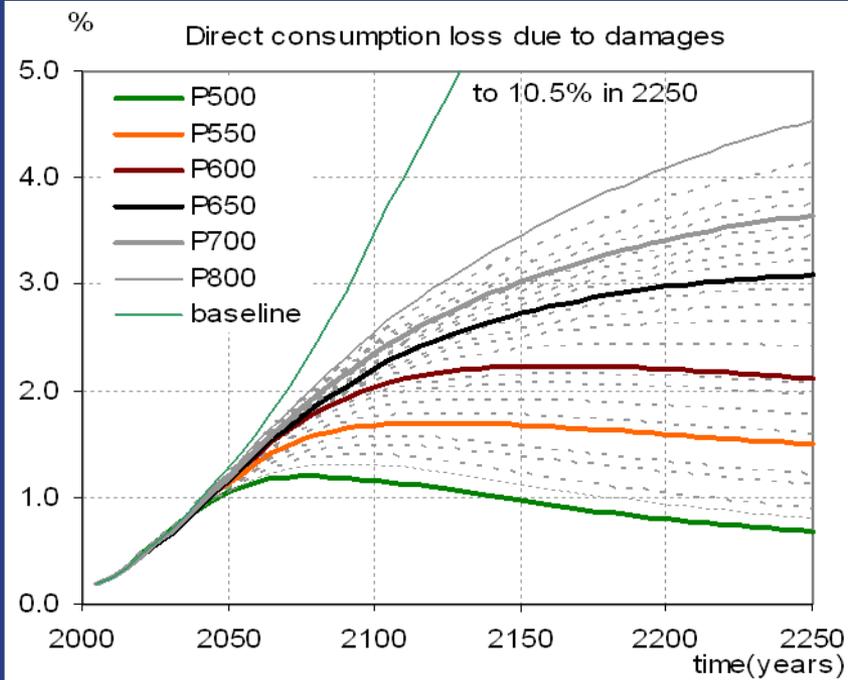- Scientific uncertainties:
  - Damage function (DICE, PAGE m
  - Abatement costs (FAIR, DICE)
  - Climate sensitivity (2.5, 3.0, 3.5)
  - Baseline (B2, A1)

- Value judgements:
  - Time horizon (2150, 2200, 2250)
  - Discount rate (UK Greenbook, Stern, Nordhaus, Weitzman)

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Direct consumption loss due to damages

% vs time(years)

Legend:
- P500 (green)
- P550 (orange)
- P600 (dark red)
- P650 (black)
- P700 (grey)
- P800 (light grey)
- baseline (thin green)

to 10.5% in 2250

Direct consumption loss due to abatement

% vs time(years)

Indirect consumption loss

% vs time(years)

Total consumption loss

% vs time(years)

to 14.9% in 2250

to 6.5% in 2250

Discounted results: default settings

NPV of consumption loss as % of NPV consumption: default settings

Minimum: 575/2.3

CO2eq. concentration peak level (ppm)

— Damage — Abatement — Indirect — Total

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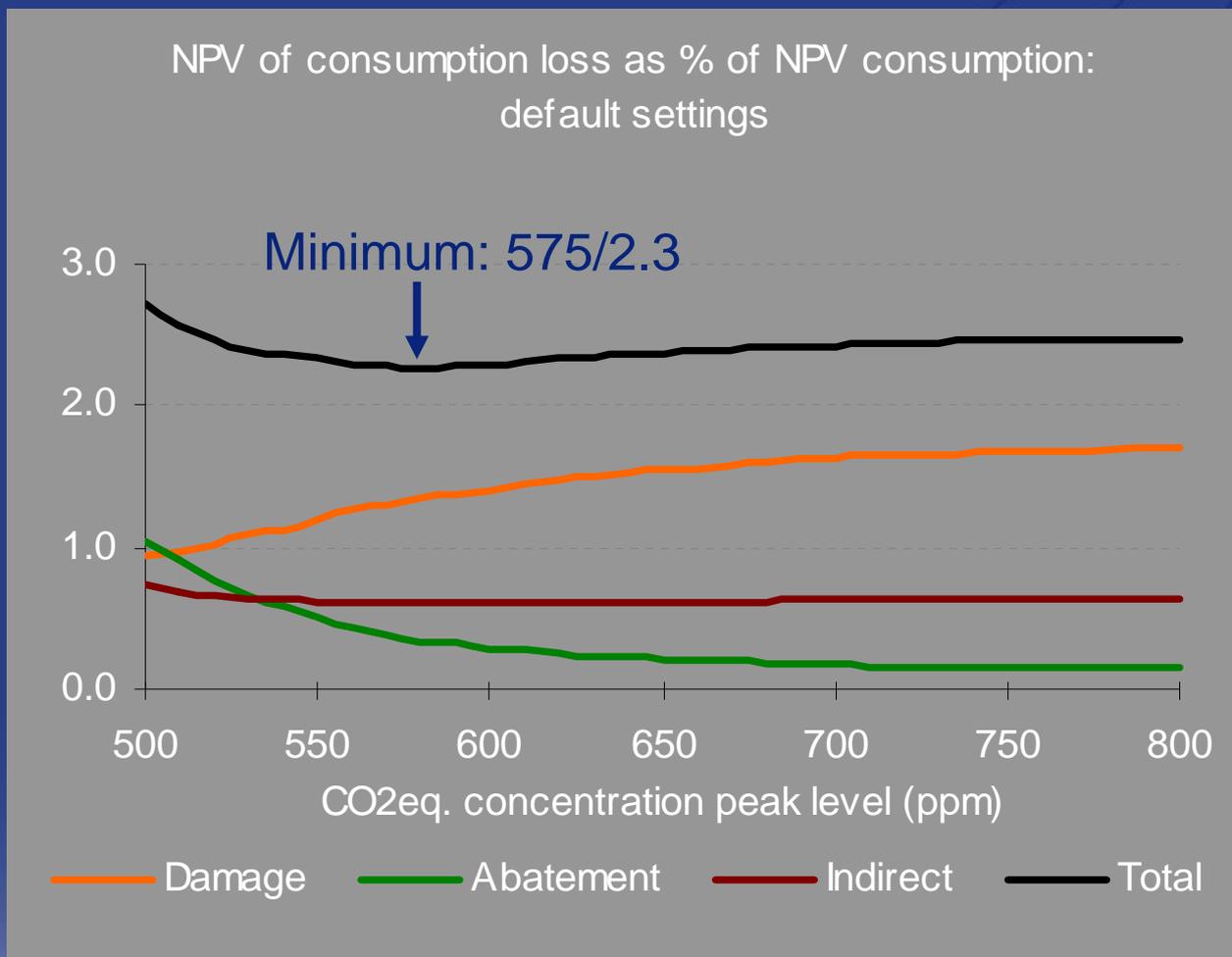
Discounted results: factor analysis

Optimal temperature increase (compared to pre-industrial level)

Factor	Range
baseline	A1
CS	2.5 — 3.5
abatement	FAIR — DICE
damages	— PAGEmode
discounting	Weitzman — DICE
time horizon	2250 — 2150
total	Stern — Nordhaus

PAGEmean & MERGE

default

2.0   2.5   3.0   3.5   4.0
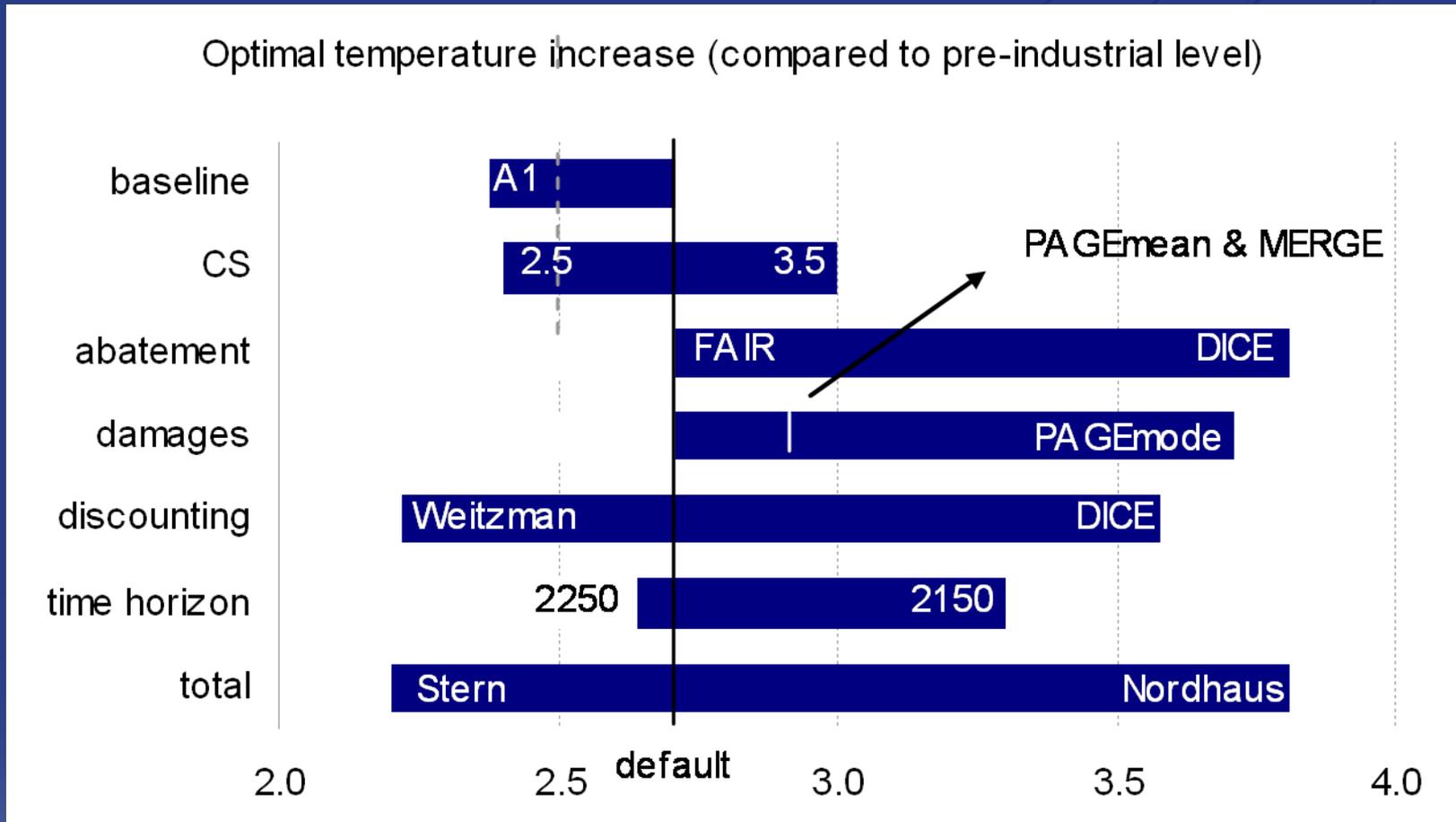
Robustness of results for the extreme cases

NPV of total consumption loss as % of NPV consumption: "Nordhaus" settings vs "Stern" settings

Nordhaus
Stern
Default

CO2eq. concentration peak level (ppm)
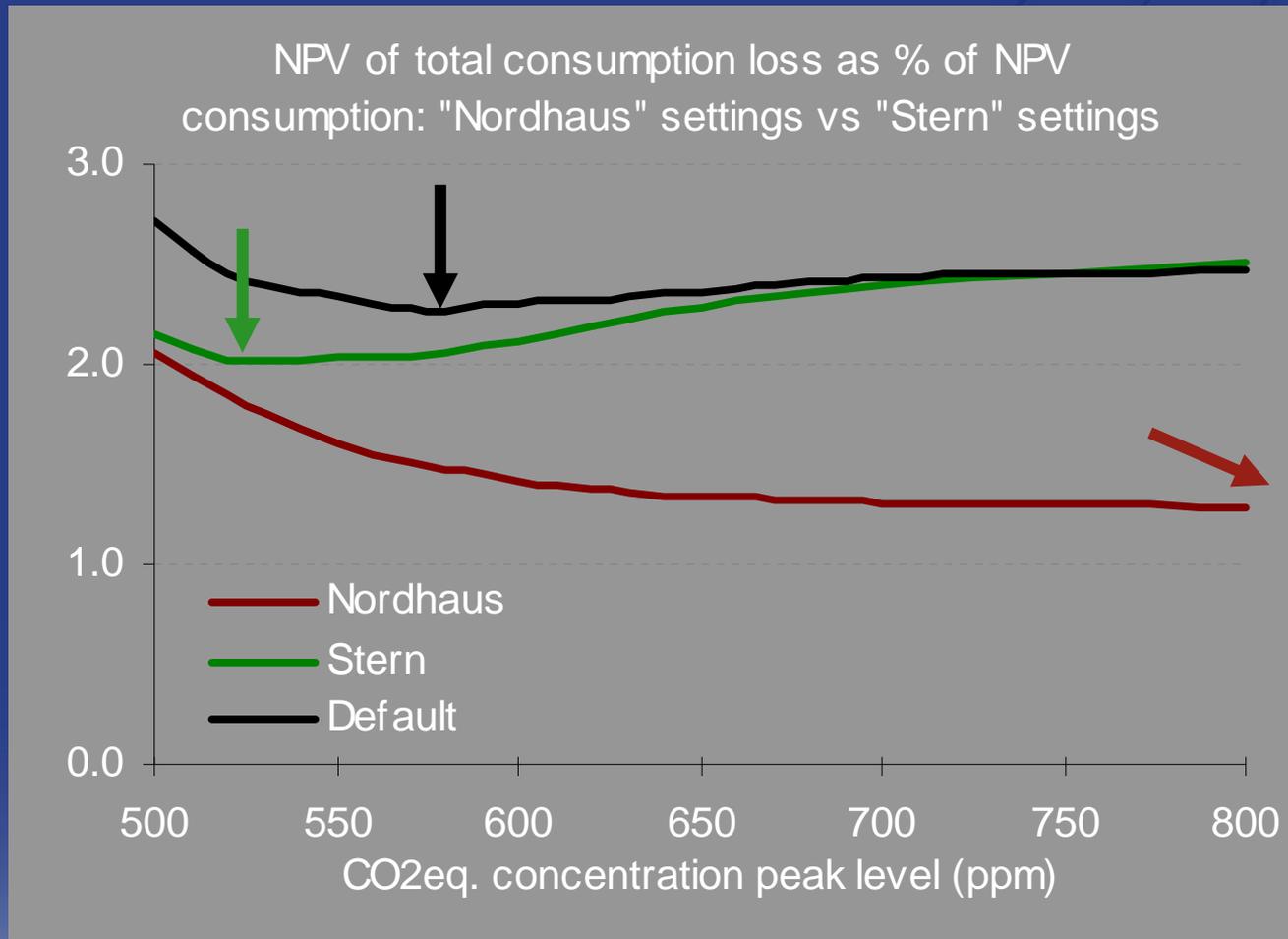
Conclusions

Cost-benefit analysis on climate change excellent tool to investigate impact of different assumptions

However, given

A) The importance of value judgements; and

B) Small differences in costs across a wide range of concentration targets:

an "optimal" climate policy target will largely remain a political choice.

Important: Co-benefits of climate policy can play a major role

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Future Work

NPV of consumption loss as % of NPV consumption: World

NPV of consumption loss as % of NPV consumption: USA

NPV of consumption loss as % of NPV consumption: Western Africa

NPV of consumption loss as % of NPV consumption: OECD Europe

NPV of consumption loss as % of NPV consumption: South Asia

RD   PC   Abt
Indirect   Total

CO2eq. concentration peak level (ppm)

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