Eidgenössische Technische Hochschule Zürich
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Institut für Umweltentscheidungen
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The Economics of Climate Change

Lecture 5: Intragenerational equity in climate policy

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Previous lecture:

- How to derive the optimal abatement path
- How to optimize abatement under uncertainty with respect to damages from climate change
- Integrated Assessment Models – How they work
- How to account for equity across time (intergenerational equity)

In this lecture:

- How to account for equity across space (intragenerational equity) when deriving optimal emission levels

Intragenerational equity and optimal greenhouse gas abatement

- «Climate change is an external effect imposed to a significant degree by rich countries on poor countries.»

  (Heal, 2010)

- Climate change is a global problem, but…
  - historical responsibility for global warming lies foremost with wealthy industrialized nations.
  - impacts will be spread unevenly across the globe, with poorer countries being particularly affected.

Equity in the UN Framework Convention on Climate Change (Article 3, Principles)

"In their actions to achieve the objective of the Convention and to implement its provisions, the Parties shall be guided, inter alia, by the following:

1. *The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof."*

Equity in the UN Framework Convention on Climate Change (Article 3, Principles)

2. *"The specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, and of those Parties, especially developing country Parties, that would have to bear a disproportionate or abnormal burden under the Convention, should be given full consideration."*

Equity across time and space

- Intergenerational equity [see last week's lecture]
  - Deciding about the optimal abatement path over time
  - Distributing the burden of abatement between the present and future generations → Choice of discount rate
- Intragenerational equity
  - Deciding about the optimal abatement across world regions
  - Balancing the burden of abatement between nations
  - Accounting for regional differences in wealth when evaluating damage costs (How to value damages in rich vs. poor countries?)

Handling equity across space in economic climate models I

- Economic approach to global welfare maximization: Aggregation of individual utilities to get «social welfare function»

$$W = \int \sum u_i e^{-rt} \, dt$$

- Valuation of damages: lower monetary value of damages in poor developing countries due to resource constraint
- Impact of damages on utility: a specific amount of damage costs has a different impact on utility for rich/poor individuals due to decreasing marginal utility of consumption

Handling equity across space in economic climate models II

- Regionally disaggregated IAMs include separate utility and damage functions for each world region
- One option to account for interregional differences in income is equity weighting:

  Weights are put on the regional utility functions to account for interregional differences in per capita income

- In tendency, accounting for interregional equity increases damage costs and abatement levels in rich countries

A simple static model of equity weighting (Azar,1999)

- We assume two groups of individuals, rich (r) and poor (p)
- Global welfare function: $W = W(u_r, u_p)$
- Utility functions:

$$u_r = u\left(\frac{Y_r - C_r(x_r) + B_r(x_r + x_p)}{L_r}\right)$$

$$u_p = u\left(\frac{Y_p - C_p(x_p) + B_p(x_r + x_p)}{L_p}\right)$$

Y = income
x = level of abatement
C = abatement cost
B = benefit from abatement
L = population size

A simple static model of equity weighting (Azar,1999)

- Conditions for global welfare maximization:

$$\frac{\partial B_r}{\partial x_r} + \omega \frac{\partial B_p}{\partial x_r} = \frac{\partial C_r}{\partial x_r}$$

with ω = equity weight factor

$$\frac{\partial B_r}{\partial x_p} + \omega \frac{\partial B_p}{\partial x_p} = \omega \frac{\partial C_p}{\partial x_p}$$

→ choice of optimal regional abatement levels x_r and x_p

- The weight factor ω is given by: $\omega = \frac{u'(y_p)}{u'(y_r)} \frac{\partial W/\partial u_p(y_p)}{\partial W/\partial u_r(y_r)} \frac{L_r}{L_p}$

Some critical questions

- Is it realistic to assume that countries decide about their level of abatement on the basis of a global welfare function?
- What equity preferences are reflected by the currently observable levels of abatement in industrialized countries?
- Can the division between Annex I and non-Annex I countries in the Kyoto Protocol be justified?

The Stern Review on the Economics of Climate Change (2006)

- Report comissioned by the UK government and written under the auspices of the British economist Sir Nicholas Stern
- Assessment of evidence on the impacts and on the economic costs of climate change
- The review's conclusion: "The benefits of strong and early action far outweigh the economic costs of not acting"

The Stern Review – Main result

- Damage cost of climate change: equivalent to losing at least 5% of global GDP each year, now and forever (up to 20% of GDP, if a wider range of risks and impacts is taken into account)
- Cost of climate change mitigation: equivalent to losing around 1% of global GDP each year (with the goal of a stabilization between 500 and 550ppm CO_2e).

The Stern Review – Background

- Estimates are based on a simulation model (PAGE2000)
- Stern Review explicitly accounts for uncertainty as well as intertemporal and interregional equity, i.e. by addressing
  - Non-market impacts (environment/health) and catastrophic risks
  - Uncertainty in climate response to GHG emissions
  - Unequal regional distribution of damages
  - Intergenerational distribution of welfare
- The cost estimates of the Stern Review are at the high end of published cost estimates (SCC = $314/tC)
- The results are strongly in favor of early mitigation

The Stern Review – Background

Table 6.1 Losses in current per-capita consumption from six scenarios of climate change and economic impacts*.

Scenario		Balanced growth equivalents: % loss in current consumption due to climate change		
Climate	Economic	Mean	5th percentile	95th percentile
Baseline climate	Market impacts	2.1	0.3	5.9
	Market impacts + risk of catastrophe	5.0	0.6	12.3
	Market impacts + risk of catastrophe + non-market impacts	10.9	2.2	27.4
High climate	Market impacts	2.5	0.3	7.5
	Market impacts + risk of catastrophe	6.9	0.9	16.5
	Market impacts + risk of catastrophe + non-market impacts	14.4	2.7	32.6

*Utility discount rate = 0.1% per annum; elasticity of marginal utility of consumption = 1.0.

The Stern Review – Equity weighting

- Stern Review acknowledges strong ethical reasons for weighting the impacts on poorer countries more strongly
- To simplify the calculations, equity weighting (EW) is not explicitly applied in the Stern Review
- The review gives a rough estimate on how equity weighting would influence results:

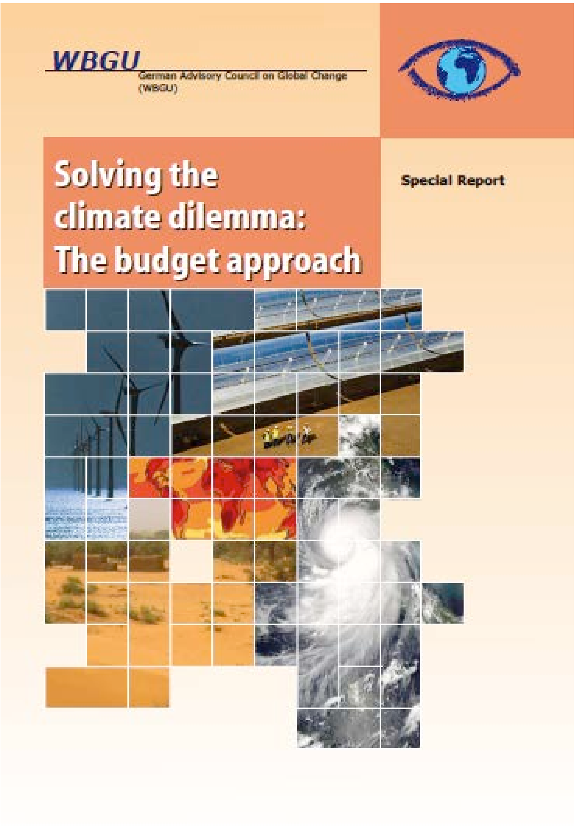
Damage costs with EW > 125% of damage costs without EW

→ increase in damage cost from 14.4% to 20%

The Stern Review – Criticism

- Economists discussed the review very critically – why?
  - Results of Stern Review are not based on optimization
  - Long time horizon (beyond 2100)
  - Inclusion of non-market impacts (high uncertainty in valuation of these impacts)
  - Extrapolation of damages into the future (neglecting the development of adaptive capacity over time)
  - Choice of very low discount rate

The WBGU Budget Approach and Equity in Climate Change



- Special report
- Issued in September 2009, before the Copenhagen Climate Change Conference
- Principal goals:
  - Operationalization of the 2 degrees guard rail
  - New approach to unwind the "Gordian knot of climate policy"

Scientific Foundations (1)

- **Longevity of CO_2 in the atmosphere:**

  Around half of the quantity of CO_2 remaining in the atmosphere in the first few years after emission will persist there for 1000 years.
  (Solomon et al., 2009)

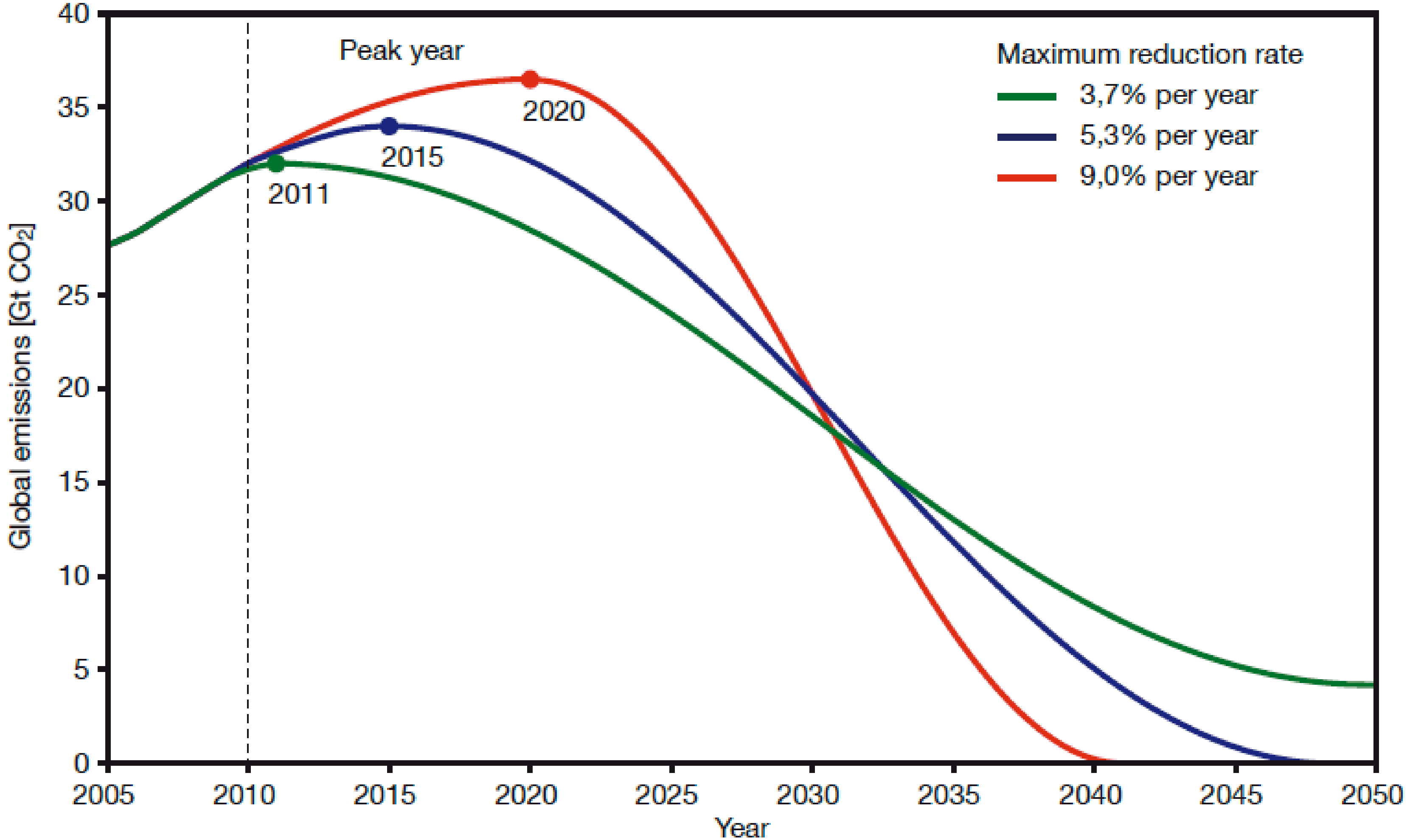
- **Role of cumulative CO_2 emission until 2050:**

  There is a two-thirds probability that temperature increase can be kept below 2 degrees Celsius if aggregate CO_2 emissions from fossil fuels do not exceed 750 Gt from 2010 until 2050.
  (Meinshausen et al., 2009)

Scientific Foundations (2)

- **Requirement of early peaking of emissions:**
  Emissions have to peak before 2020 to keep global warming below 2 degrees. The later the peak, the more severe the reductions in global emissions will have to be. (Allen et al., 2009; Meinshausen et al., 2009)

Global emissions pathways peaking before 2020



Exemplary emission pathways in order to remain within a budget of 750 Gt CO2 from fossil sources between 2010 and 2050. At this level, there is a 67% probability of staying below a warming of 2° C (WBGU, 2009).

Ethical Foundations

The WBGU budget approach is based on three principles:

- **Polluter pays principle:**

  Emphasis on particular responsibility of industrialized countries because of high cumulative emissions in the past.

- **Precautionary principle:**

  Call for timely action by <u>all</u> countries to prevent irreversible damage.

- **Principle of equality:**

  Allocation of global CO_2 budget on an equal per-capita basis; Idea of equal rights to the benefits of the global commons.

The Global Carbon Budget

- A global carbon budget should be defined, in order to:
  - Shift the focus from negotiations on country-specific reduction targets towards equitable distribution of shares in total emissions.
  - Put countries' reduction commitments and financial transfers on a transparent basis.
- 750 Gt CO_2 is proposed as global budget for CO_2 emissions for the period 2010-2050.

From Global to National Budgets

- The global budget of 750 Gt CO_2 should be subdivided into national budgets based on an equal per capita basis (equal cumulative capita emissions within a fixed period)
- Four parameters need to be internationally fixed:
  1) Start year of budget period (WBGU: 1990/2010)
  2) End year of budget period (WBGU: 2050)
  3) Probability of staying within 2 degrees guard rail (WBGU: 2/3)
  4) Demographic reference year (to allocate budget shares to countries based on population size)

Option «Historical Responsibility»

- 1990 as *demographic year of reference* and as *start year*
- Total global budget: 1100 Gt CO_2 (*75% probability of complying with 2 degrees guard rail*)
- Results in 3.5 tCO_2 per capita (yearly average) between 1990 and 2050 or 2.2 t CO_2 per capita (yearly average) from 2010 on

  → Some countries are already „carbon bankrupt“ (see table)

Option I: 'Historical responsibility', 1990–2050; 75% probability of compliance with the 2°C guard rail; 1990 as the reference year for population data. Only includes CO_2 emissions from fossil sources. CO_2 emissions for 2008 are estimations.
Source: WBGU, using data from: Meinshausen et al., 2009; WRI-CAIT, 2009; U.S. Census Bureau, 2009

	Share of world population in 1990 [%]	Total budget 1990–2050 [Gt CO_2]	Emissions to date 1990–2009 [Gt CO_2]	Budget 2010–2050 [Gt CO_2]		Estimated emissions in 2008 [Gt CO_2]	Reach of the budget lifetime, assuming annual emissions as in 2008 [years]
				Total period	Per year		
Germany	1.5	17	17	-0.90	-0.022	0.91	-1
USA	4.7	52	108	-56	-1.4	6.1	-9
China	22	239	75	164	4.0	6.2	26
Brazil	2.9	31	6.1	25	0.62	0.46	55
Burkina Faso	0.16	1.7	0.0090	1.7	0.042	0.00062	2810
Japan	2.3	26	23	2.4	0.058	1.3	2
Russia	2.8	31	31	-0.29	-0.0071	1.6	0
Mexico	1.6	18	6.9	11	0.26	0.46	23
Indonesia	3.4	38	4.8	33	0.81	0.38	88
India	16	175	19	156	3.8	1.5	103
Maldives	0.0041	0.045	0.0098	0.035	0.00086	0.00071	50
EU	8.9	98	81	18	0.43	4.5	4
World	100	1,100	500	600	15	30	20

WBGU (2009)

Option „Future Responsibility“

- 2010 as *demographic year of reference* and as *start year*
- Total global budget: 750 Gt CO_2 (*67% probability of complying with 2 degrees guard rail*)
- Results in 2.7 t CO_2 per capita (yearly average) from 2010 on

→According to WBGU a politically feasible parameter choice

Option II: 'Future responsibility', 2010–2050; 67% probability of compliance with the 2°C guard rail; 2010 as the reference year for population data. Only includes CO_2 emissions from fossil sources. CO_2 emissions for 2008 and population numbers for 2010 are estimations.
Source: WBGU, using data from: Meinshausen et al., 2009; WRI-CAIT, 2009; U.S. Census Bureau, 2009

	Share of world population in 2010 [%]	Budget 2010–2050 [Gt CO_2]		Estimated emissions in 2008 [Gt CO_2]	Reach of the budget lifetime, assuming annual emissions as in 2008 [years]	
		Total period	Per year			
Germany	1.2	9.0	0.22	0.91	10	→ in 2020
USA	4.6	35	0.85	6.1	6	→ in 2016
China	20	148	3.6	6.2	24	
Brazil	2.8	21	0.52	0.46	46	
Burkina Faso	0.24	1.8	0.043	0.00062	2892	
Japan	1.8	14	0.34	1.3	11	→ in 2021
Russia	2.0	15	0.37	1.6	9	→ in 2019
Mexico	1.6	12	0.29	0.46	26	
Indonesia	3.4	25	0.62	0.38	67	
India	18	133	3.2	1.5	88	
Maldives	0.0058	0.043	0.0011	0.00071	61	
EU	7.2	54	1.3	4.5	12	
World	100	750	18	30	25	

WBGU (2009)

Country groups following different decarbonisation pathways

- Group 1: budget would be exceeded in less than 20 years
  - 60 countries emitting more than 5.4t per capita per year;
  - mostly industrialised countries (almost all Annex I), some Arab states, Venezuela, South Africa, Iran
- Group 2: budget would be exceeded in 20-40 years
  - 30 countries emitting between 2.7 and 5.4t per capita per year
  - mostly newly-industrialising economies such as China, Mexiko, Argentina, Chile, Algeria or Thailand

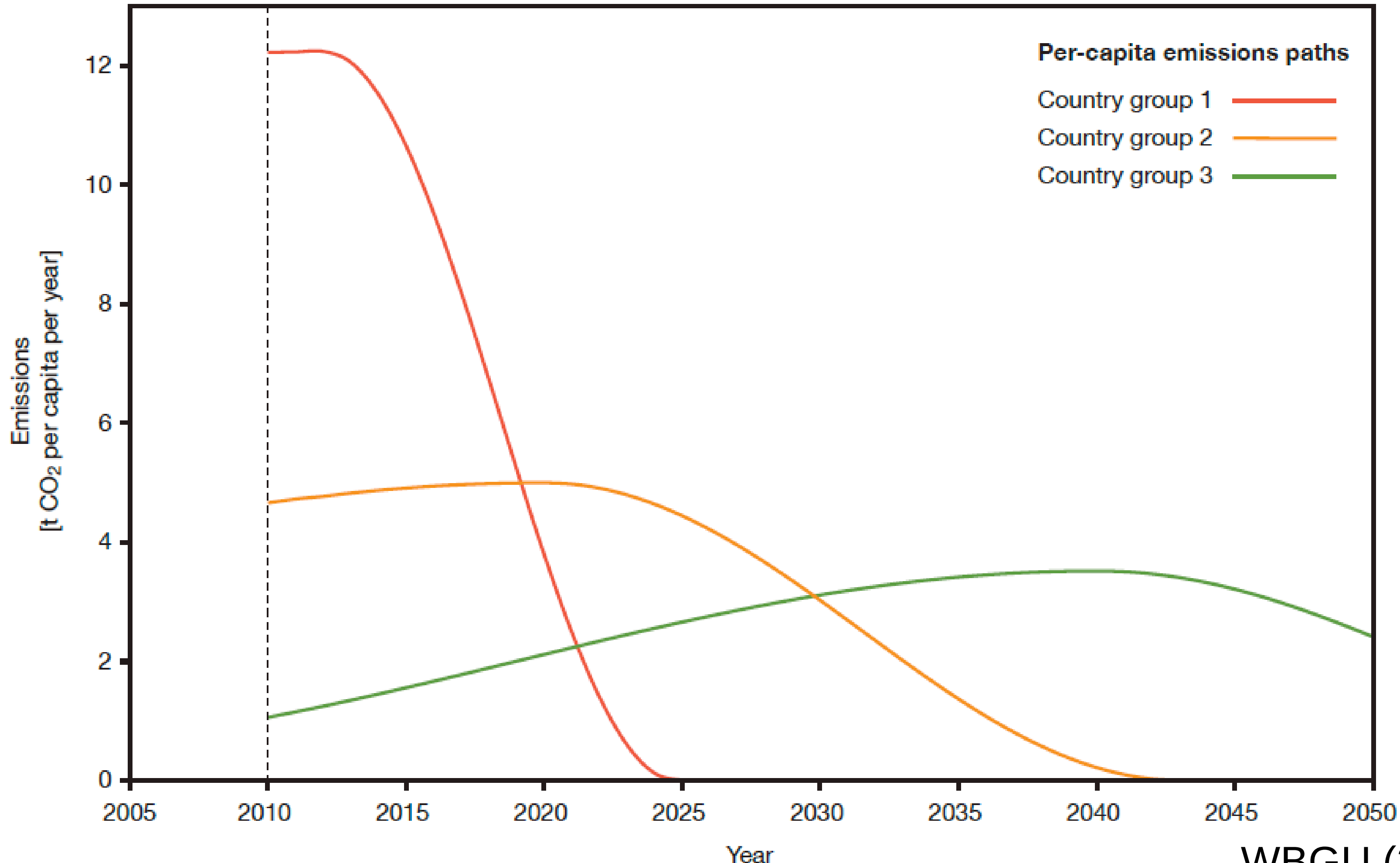
Country groups following different decarbonisation pathways

- Group 3: budget would last for more than 40 years
  - group of 95 remaining countries emitting less than 2.7t per capita per year
  - most developing countries (esp. sub-Saharan Africa) as well as India, Brazil, Egypt and Peru

  → This group will hold more than half the global emissions budget

  → Emissions of most of these countries may increase up to 2030 and will have to be reduced thereafter (except countries such as Brazil, Egypt or Peru)

Possible group pathways to 2050

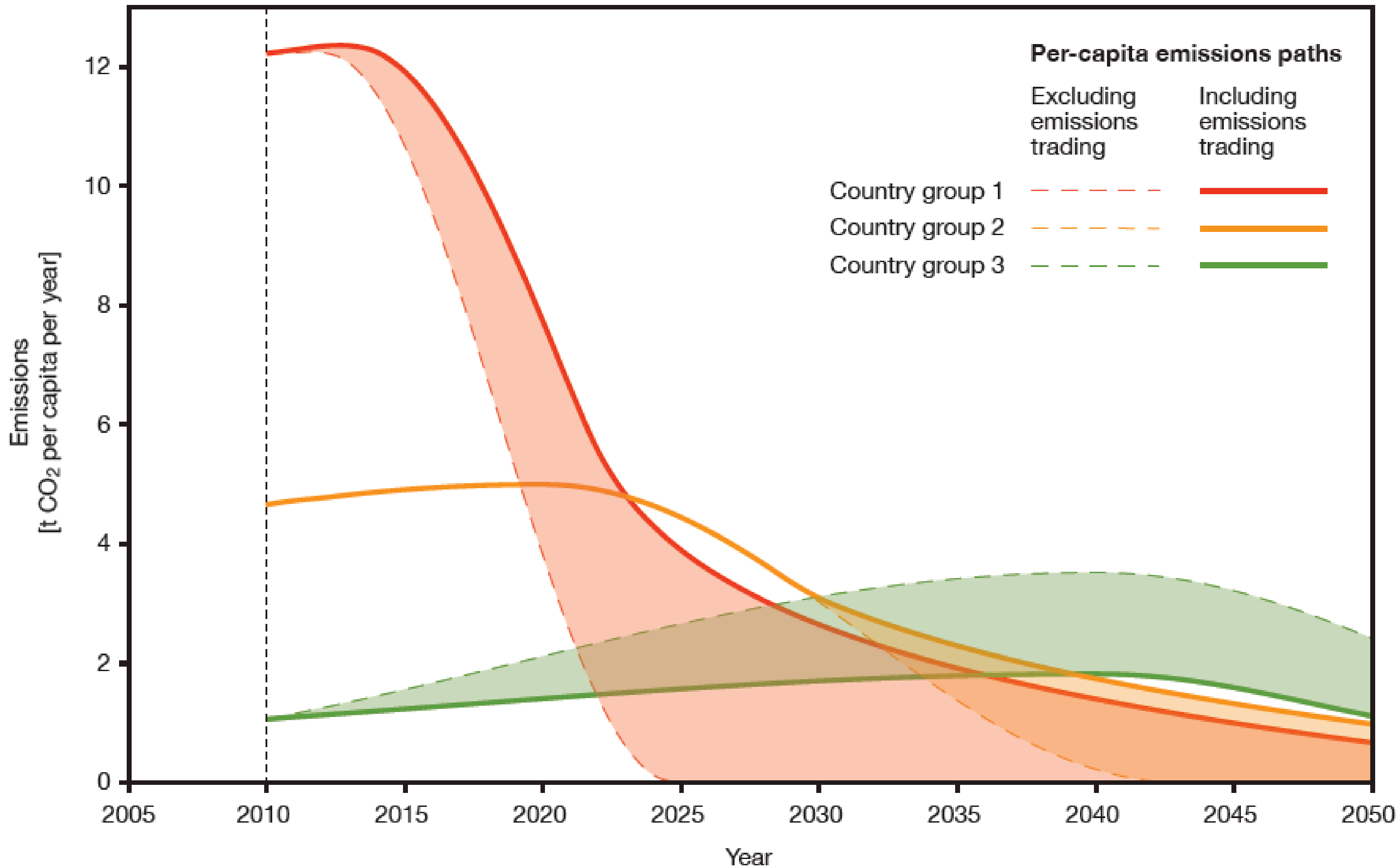


WBGU (2009)

Trading Within the Approach

- (Industrialized) countries without sufficient emission permits may buy additional allowances from (developing) countries with an oversupply of permits
- Win-Win-Situation: Countries with scarce emission rights can still emit and countries with an oversupply of permits can earn additional money which can be used for investments in low carbon development
- “Global Climate Bank” could serve as a facilitator

Possible group pathways to 2050 with emissions trading



WBGU (2009)

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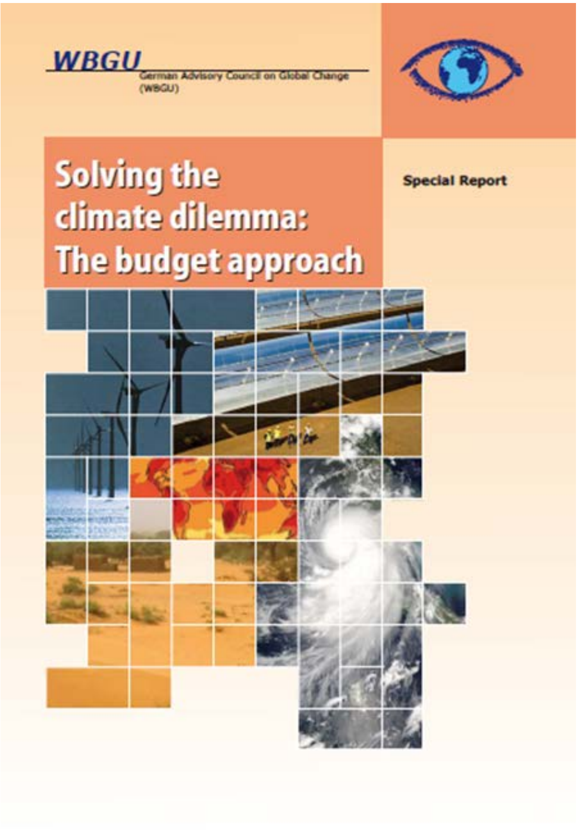

www.wbgu.de

⇒ Special reports

⇒ Budget approach