

Climate Policy Based on Individual Emissions*

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Background

1992: UNFCCC

- Prevent “dangerous” climate change
- “Common but differentiated responsibilities”
- Two-tier world:
 - Annex I (industrialised countries) and non-Annex I (rest of the world)

1997: Kyoto Protocol

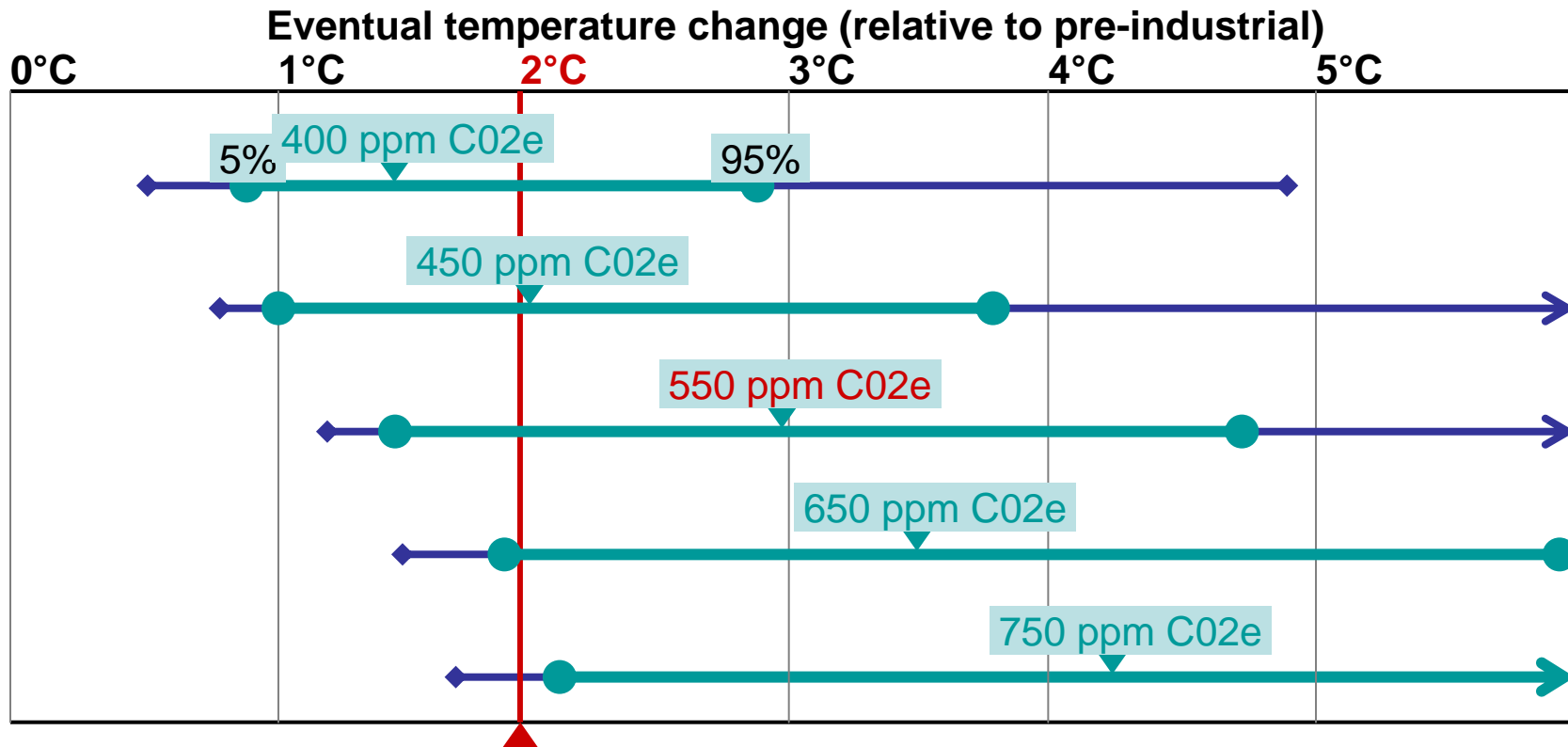
- Annex I countries: binding emission targets
- Non-Annex I countries (including China): voluntary participation
- Kyoto commitment period ends in 2012
- Commitments established through negotiation

Guiding principle: agreement between sovereign states

Need for tough CO₂ targets

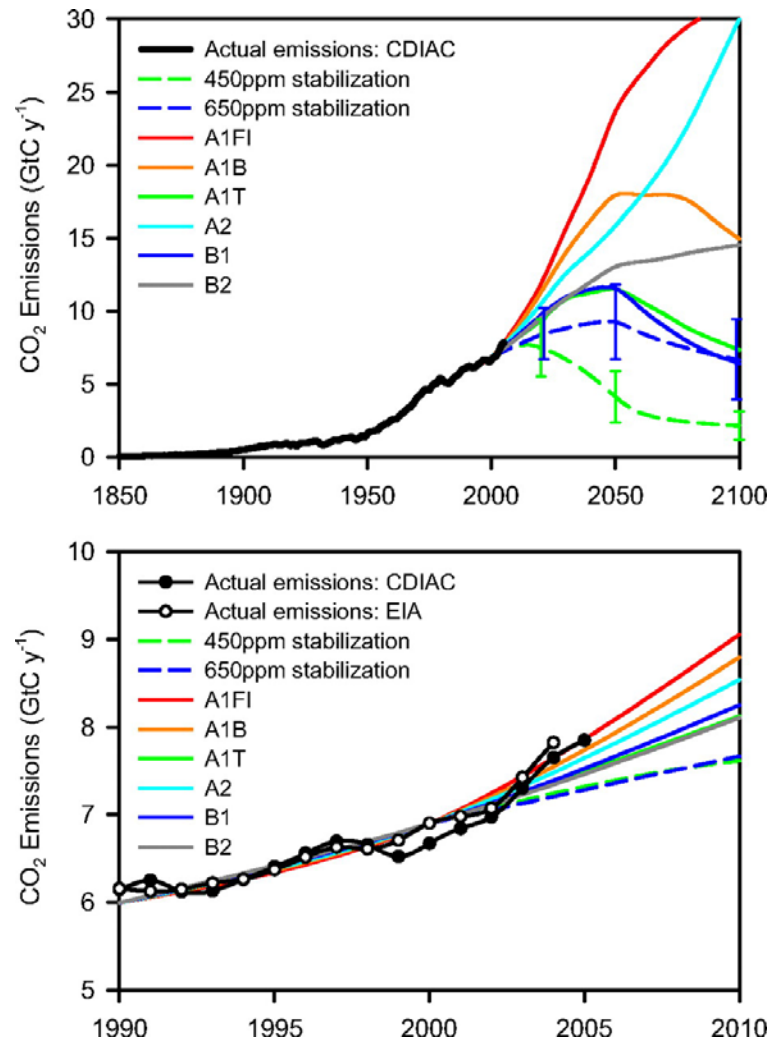
When we choose a target (with its headroom):
We are buying insurance, managing risk.

The worst and the best outcomes compatible with today's science are entirely different scenarios.
There is no line in the sand, with safety on one side and disaster on the other.



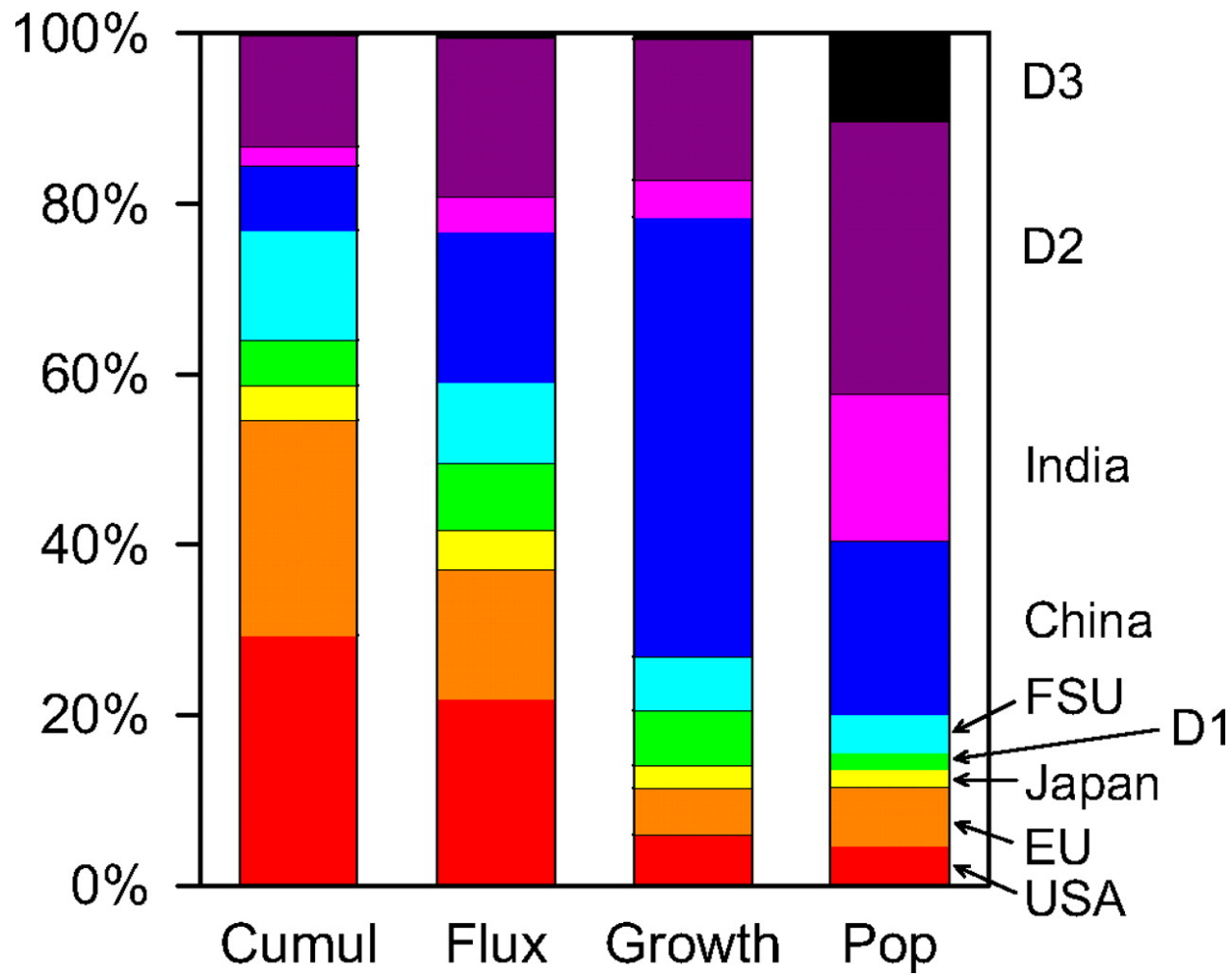
Source: Stern Review, 2006 citing Wigley et. al.; Murphy et. al.; Meinshausen. Based on a slide prepared by Hal Harvey.

Observed global CO₂ emissions including all terms in Eq. 1, from both the EIA (1980–2004) and global CDIAC (1751–2005) data, compared with emissions scenarios (8) and stabilization trajectories (10–12)



Source: Raupach M. R. et.al. PNAS 2007;104:10288-10293

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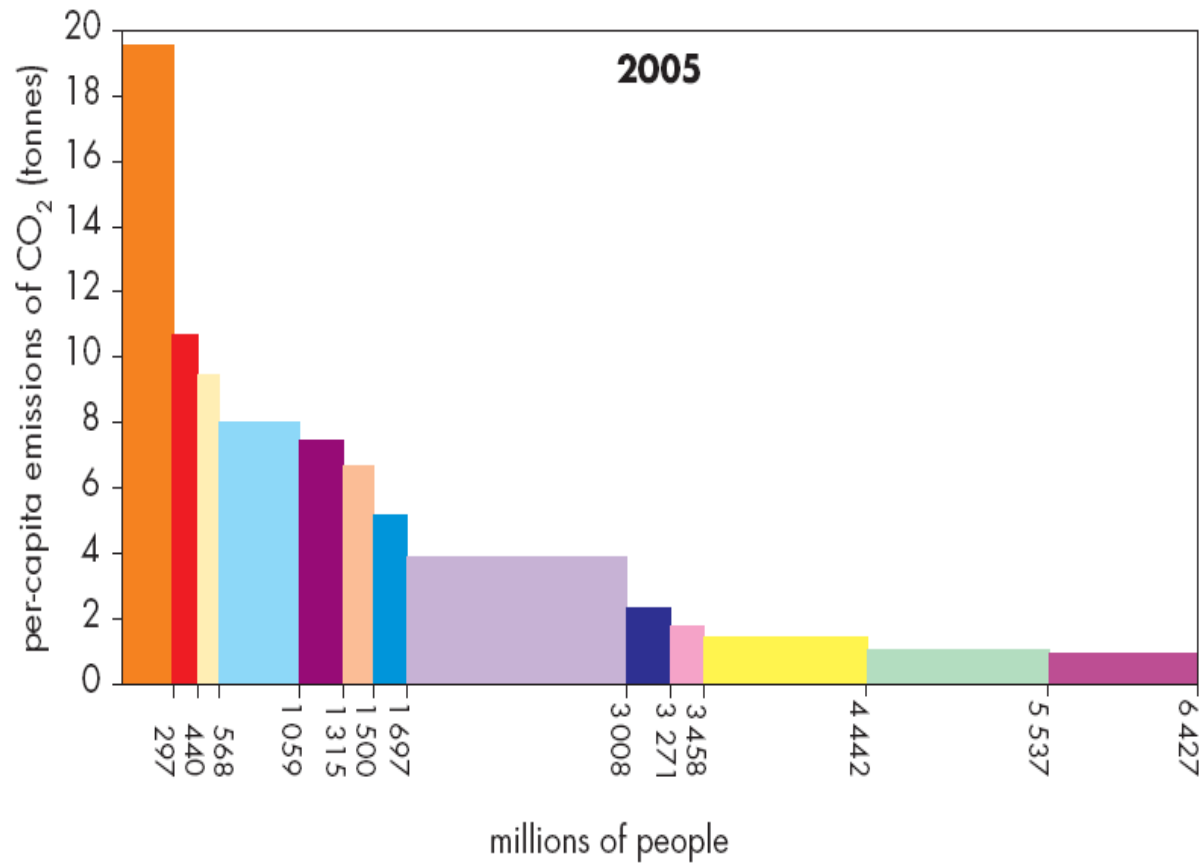


Relative contributions of nine regions to cumulative global emissions (1751–2004), current global emission flux (2004), global emissions growth rate (5 year smoothed for 2000–2004), and global population (2004)

Source: Raupach M. R. et.al. PNAS 2007;104:10288-10293

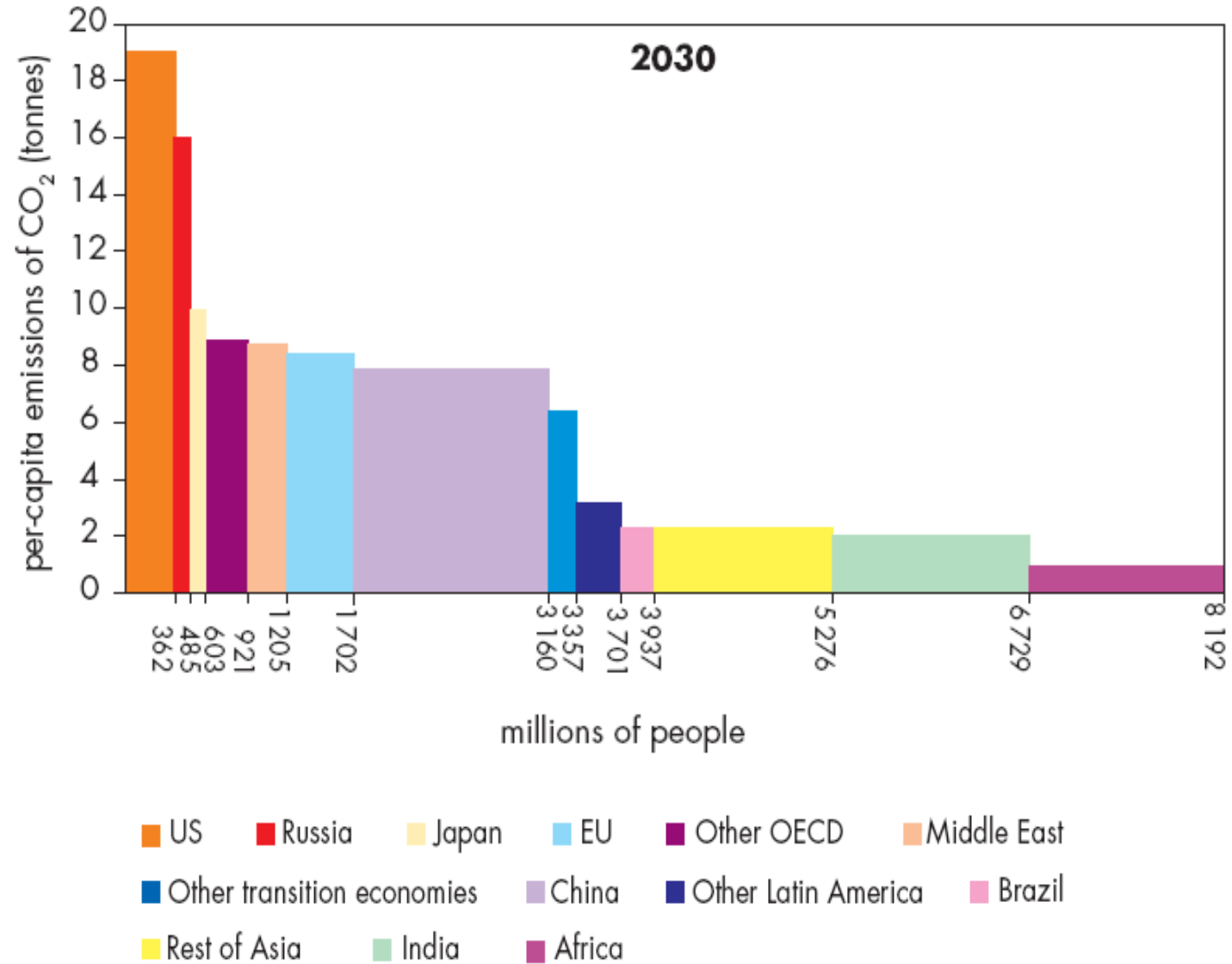
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Per-capita energy related CO₂ emissions (current)



- US
 Russia
 Japan
 EU
 Other OECD
 Middle East
- Other transition economies
 China
 Other Latin America
 Brazil
- Rest of Asia
 India
 Africa

Per-capita energy related CO₂ emissions (projected)



Source: IEA WEO 2007

A rapidly changing world...

	China/US ratio	
	Total Emissions	Per Capita Emissions
Rio:1992	0.48	0.10
Kyoto:1997	0.55	0.12
2007	1.13	0.26
<i>2030</i>	<i>1.75</i>	<i>0.44</i>

Source: EIA for the 1992, 1997 and 2030 projections. 2007 estimate is from MNP and BP

Equity and fairness matter,
but all countries/people have to be
involved to solve the climate crisis.

What is a fair distribution of emission allowances among countries?

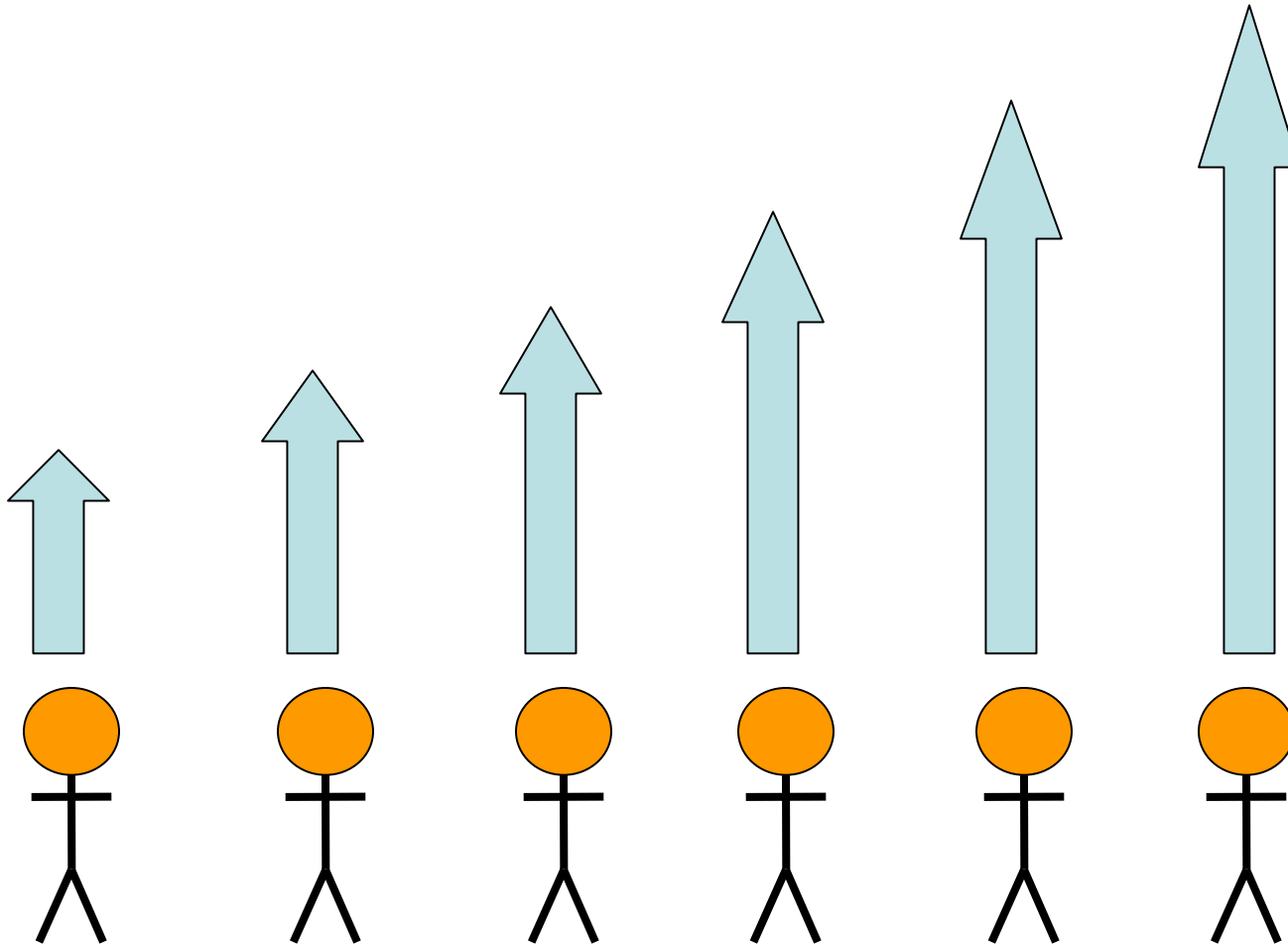
- Based on a negotiated outcome?
 - Kyoto
- Based on cumulative historical contribution to climate change?
 - Brazilian Proposal
- Based on future contribution to the climate problem?
- Based on carbon intensity?
- Based on total national emissions?
 - Kyoto
- Based on the reduction potentials (geography, climate)?
- Based on national average per capita GHG emissions?
 - Contraction and convergence
- Based on emissions of individuals?
 - Global Development Rights paper & our paper.

National responsibilities based on individual emissions

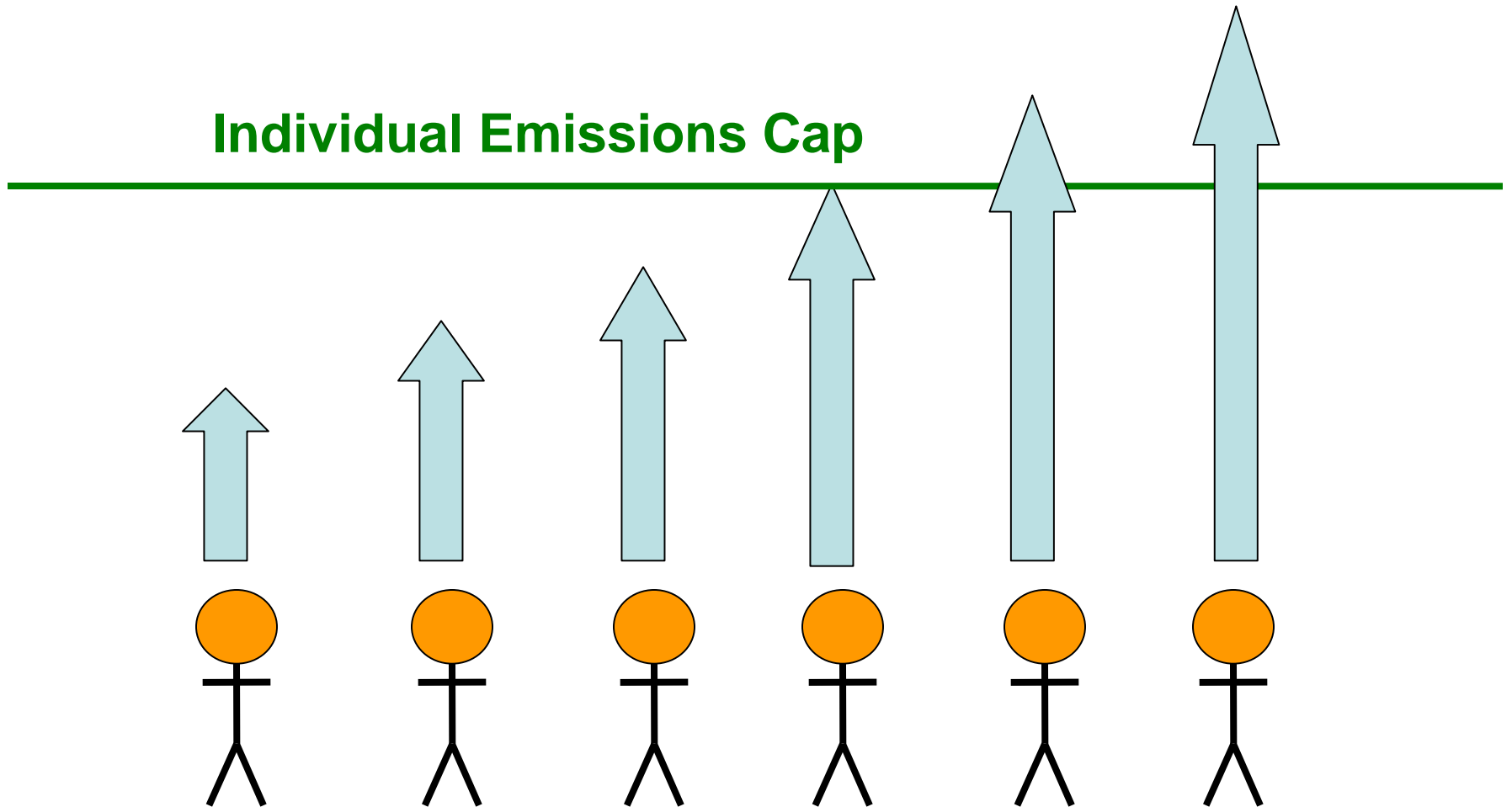
Key Principles

- Focus on the individual
- Treat every individual in all countries in the same way
- Calculate the appropriate universal cap for the CO₂ emission of an individual (for a given global emissions target)
- Add up the emissions, up to the cap, for each citizen to find a nation's CO₂ target

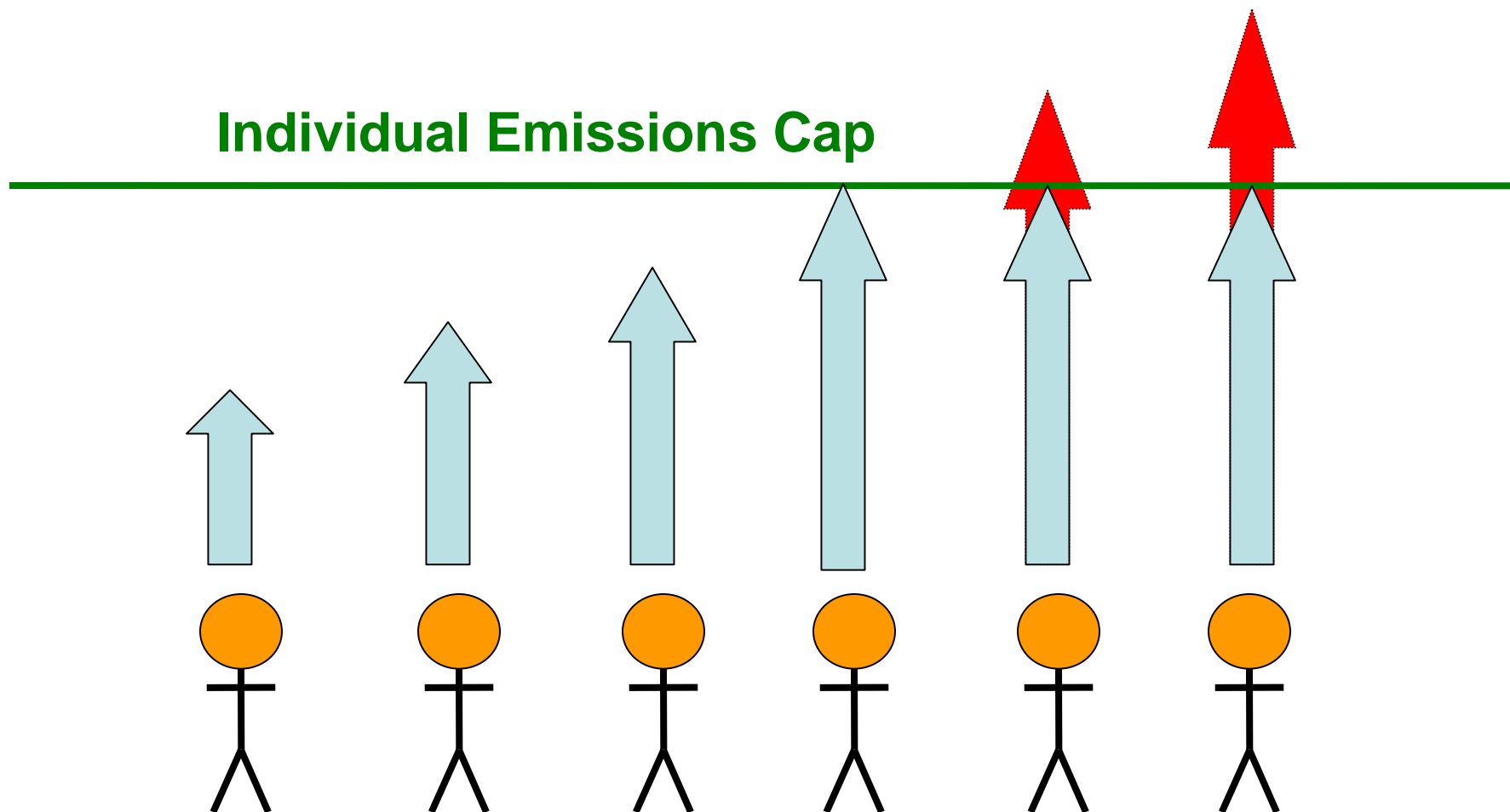
People ranked by personal emissions



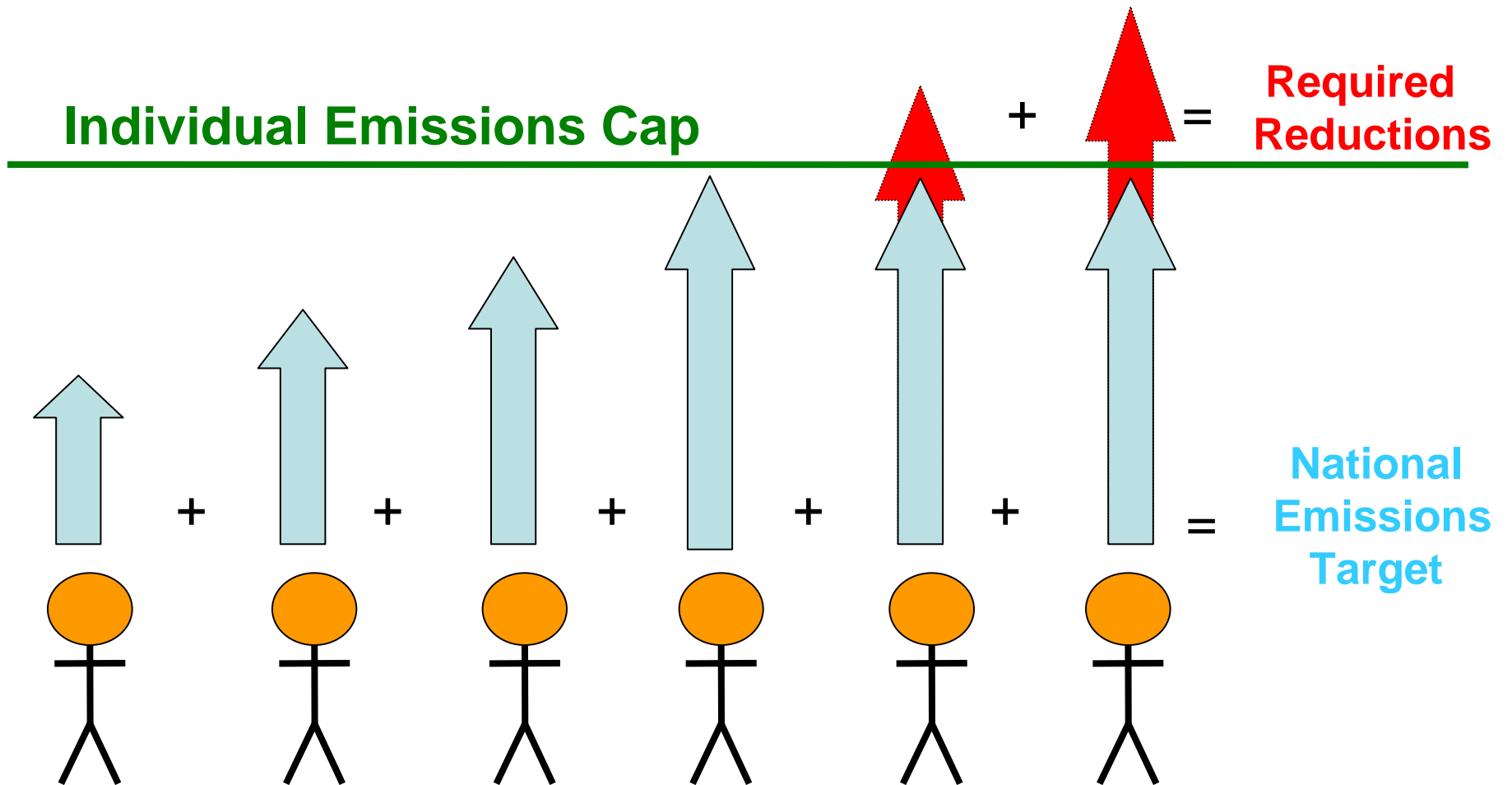
Determine globally applicable individual emissions cap



Some people exceed the individual emissions cap



Add the capped emissions of the citizens to determine the national target



Key Questions

- How to measure or estimate the distribution of individual emitters?
- How to determine the universal emissions cap for a given global emissions target?
- How to define national emissions targets?

Emissions-income elasticity from household surveys and input-output tables

Country	Reference	Year	Elasticity of energy ^a	Elasticity of CO ₂ emissions ^a
Australia	(1) Lenzen (1998)	1993-94	0.74	0.7
Australia	(2) Lenzen et al. (2006)	1998-99	0.78	
Brazil ^b	(2) Lenzen et al. (2006)	1995-96	1	
Denmark	(3) Wier et al. (2001)	1995	0.9	0.9
Denmark	(2) Lenzen et al. (2006)	1995	0.86	
India	(2) Lenzen et al. (2006)	1997-98	0.86	
Japan	(2) Lenzen et al. (2006)	1999	0.64	
Netherlands	(4) Vringer & Blok (1995)	1990	0.83	
New Zealand	(5) Peet et al. (1985)	1980	0.4 ^c	
Norway	(6) Herendeen (1978)	1973	0.72	
Norway	(7) Peters et al. (2006)	1999-2001		0.88
Spain	(8) Roca & Serrano (2007)	2000		0.91-0.99 ^d
U.S.	(9) Herendeen & Tanaka (1976)	1960-61	0.85	
U.S.	(10) Herendeen et al. (1981)	1972-73	0.78	
U.S.	(11) Weber & Matthews (2008)	2004		0.6-0.8 ^e

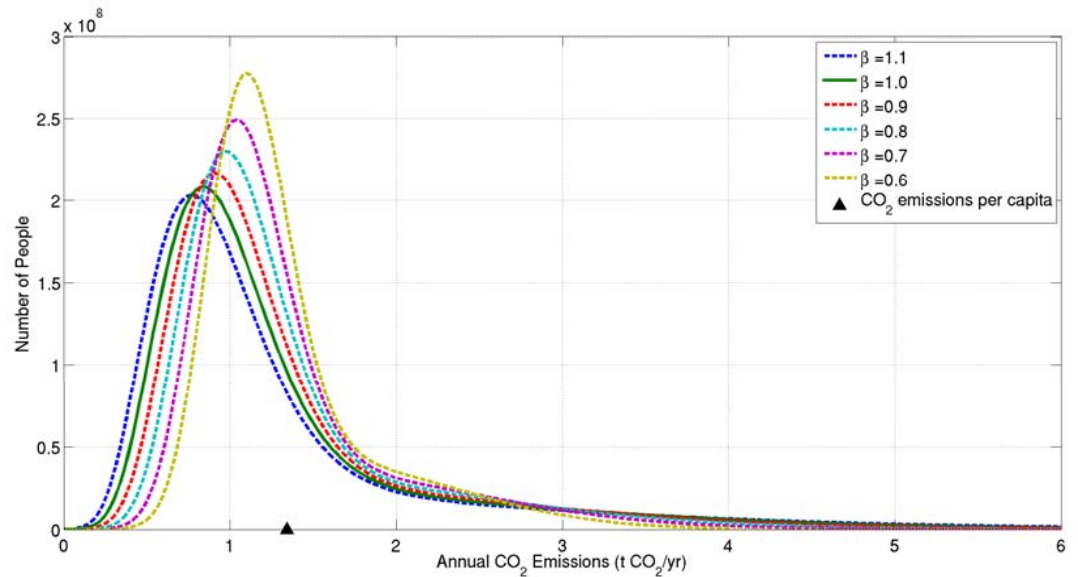
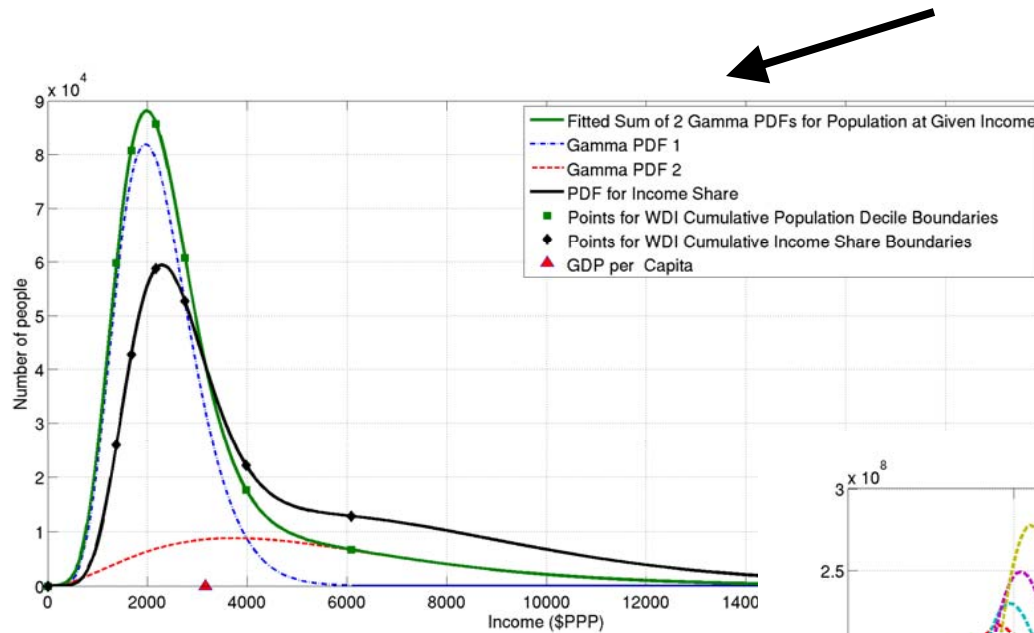
$$C_i = A_i \cdot I^x$$

We will proceed with elasticity of $x = 1.0$ as the basic idea is independent of the elasticity.

From income to carbon distributions

Data Source: World Bank's national surveys on income distribution

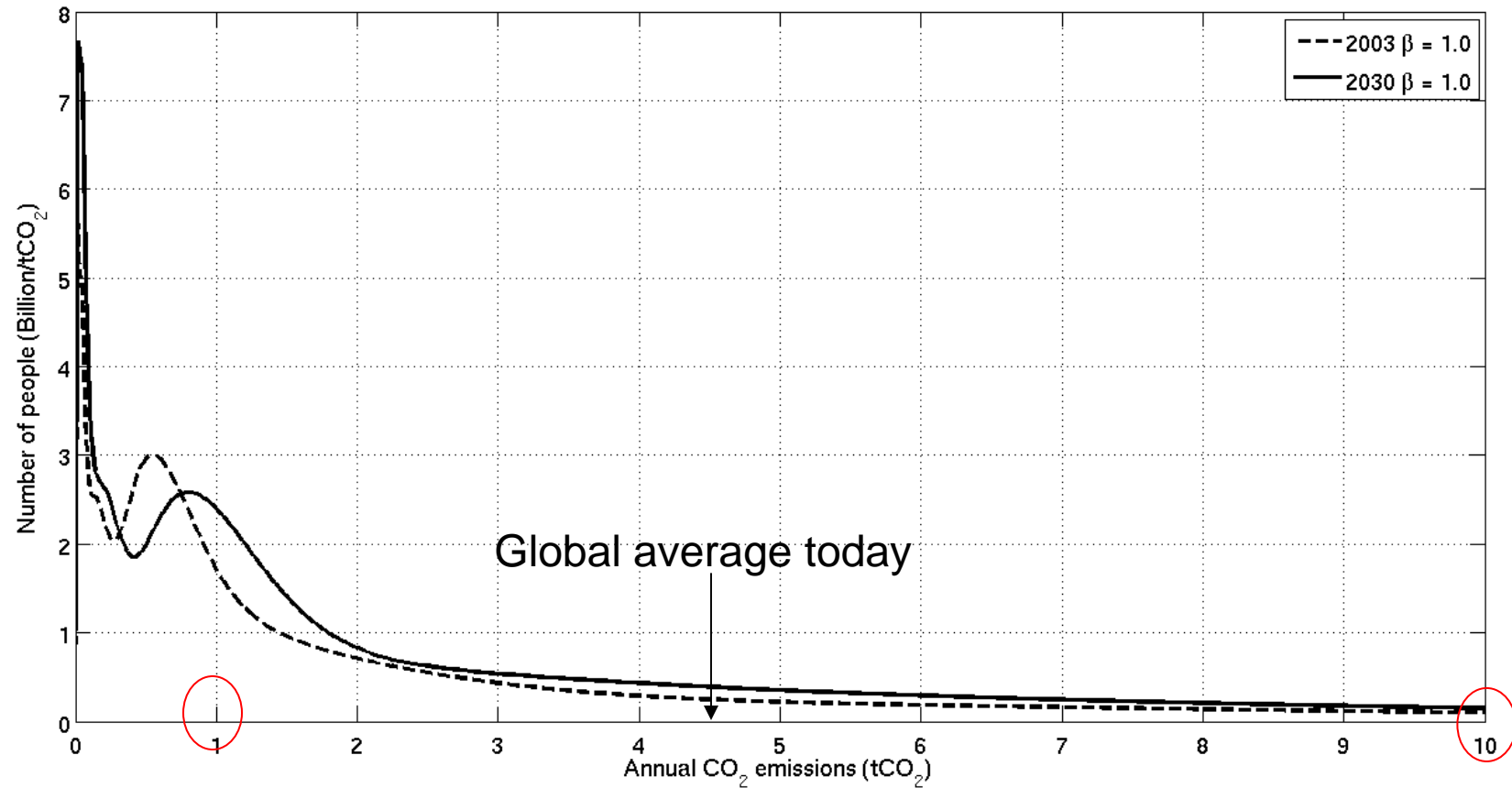
Population	0	0.1	0.2	0.4	0.6	0.8	0.9	1.0
Income share	0	0.036	0.084	0.20	0.36	0.57	0.71	1.0



Procedure for Projections

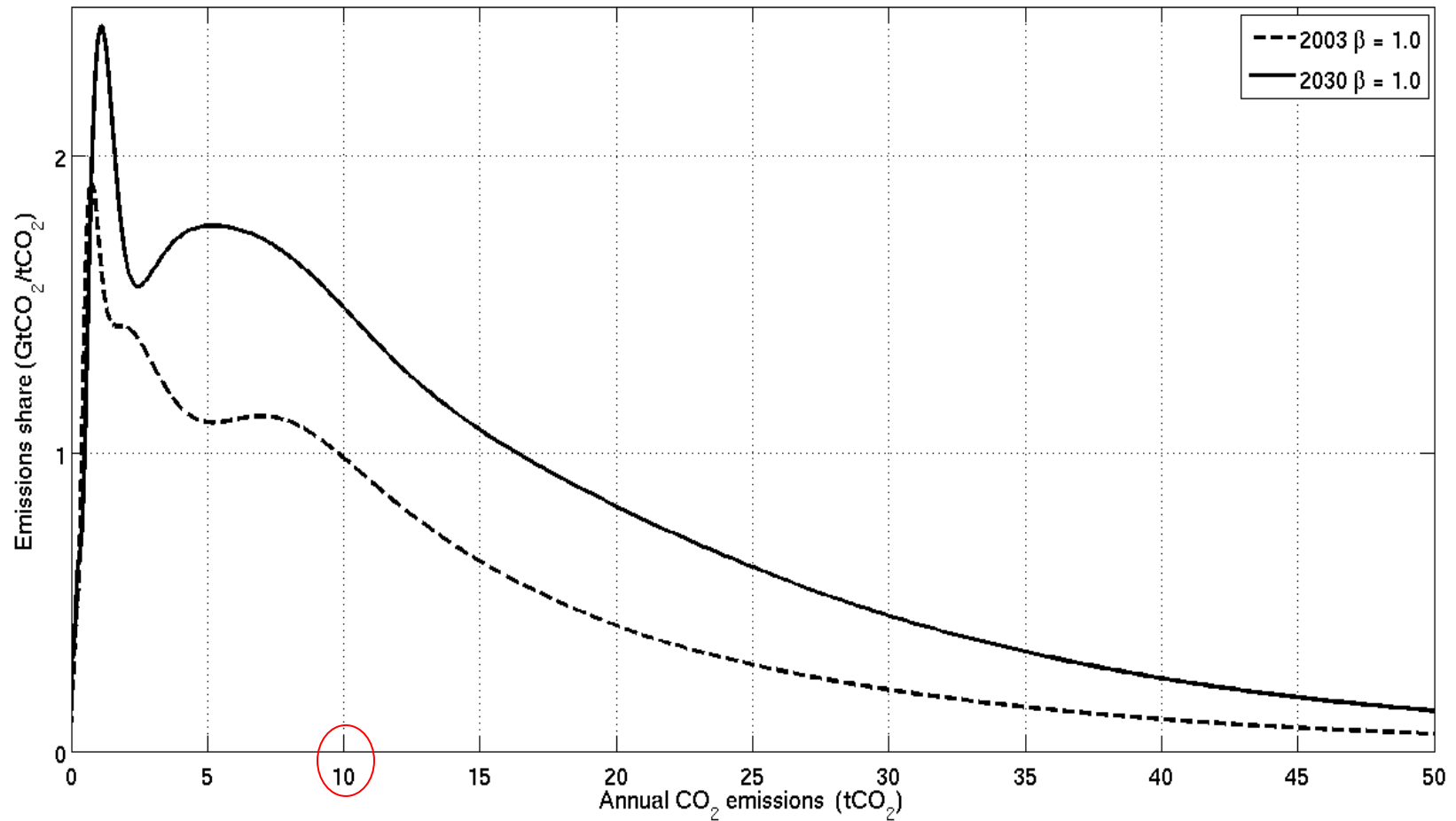
- Add country level distributions to obtain regional emissions distributions
- Project forward to 2030 using EIA IEO 2007.
- Derive a universal individual cap from global target and timetable.
- Apply individual caps to regions/countries to obtain regional/national targets.

Global population distribution of individual emitters



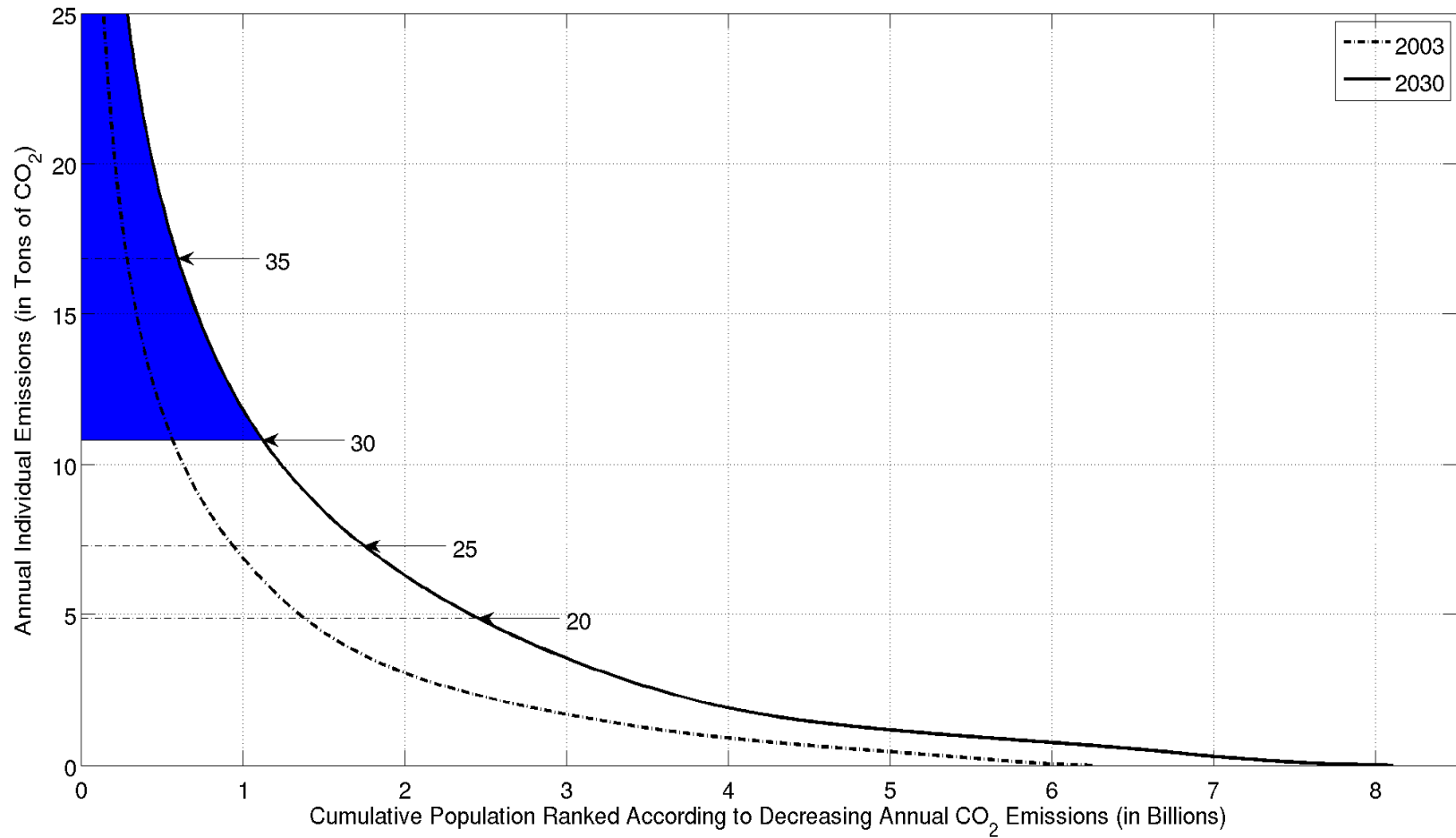
Note: linear scale. The high emitters are not in view.

Global emissions distribution

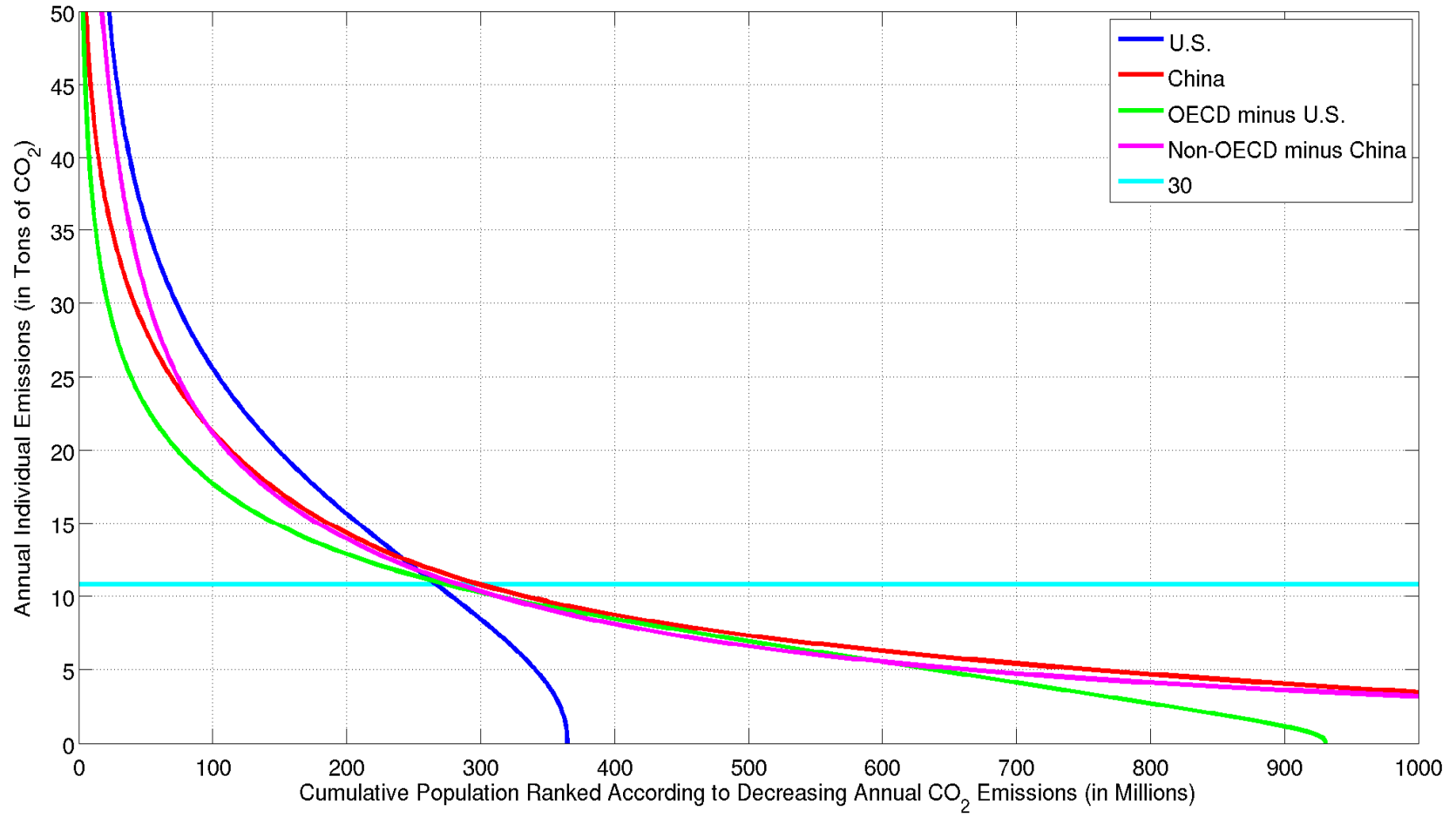


Note: Different scale from previous graph

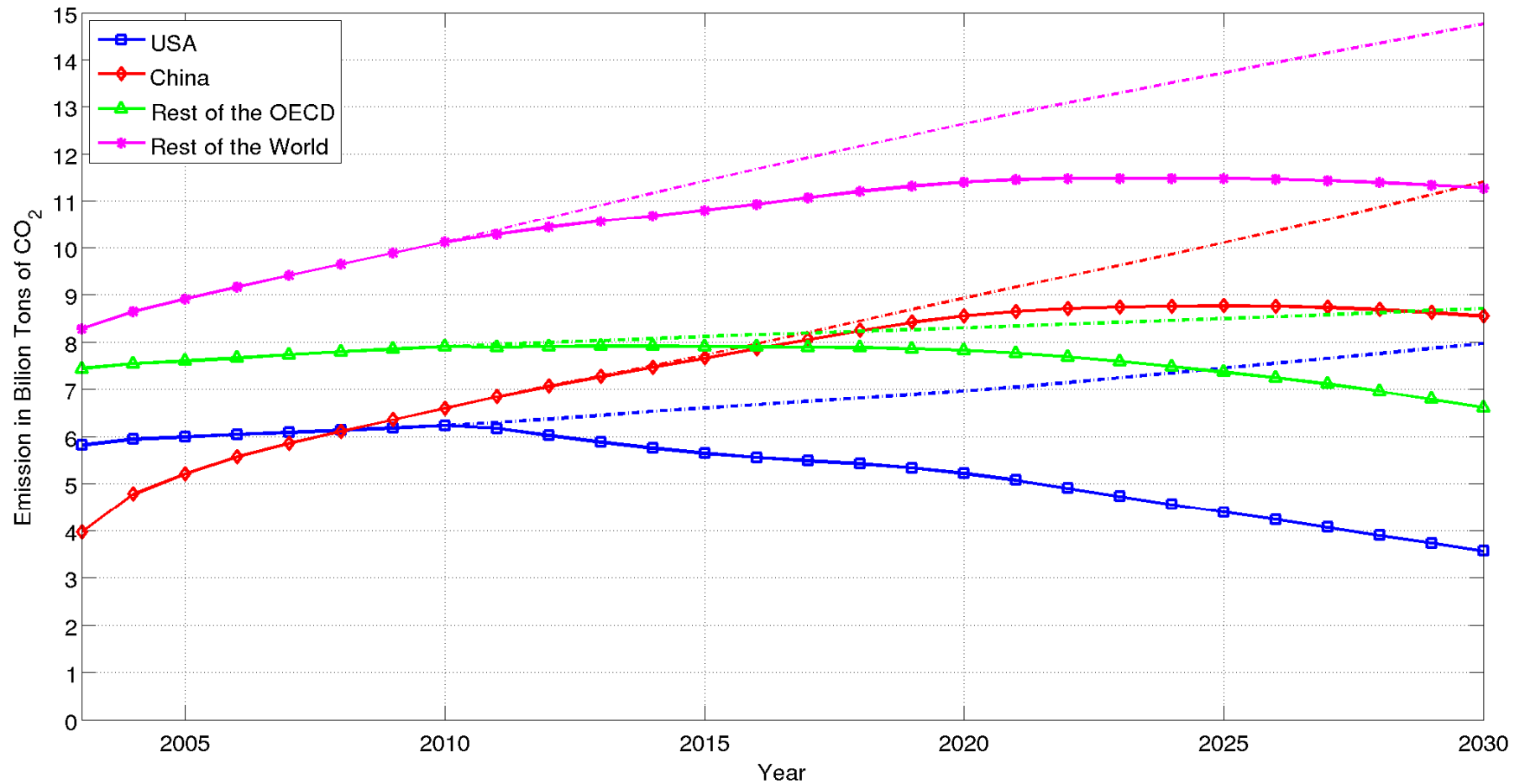
Individual emissions caps from global emissions targets in 2030



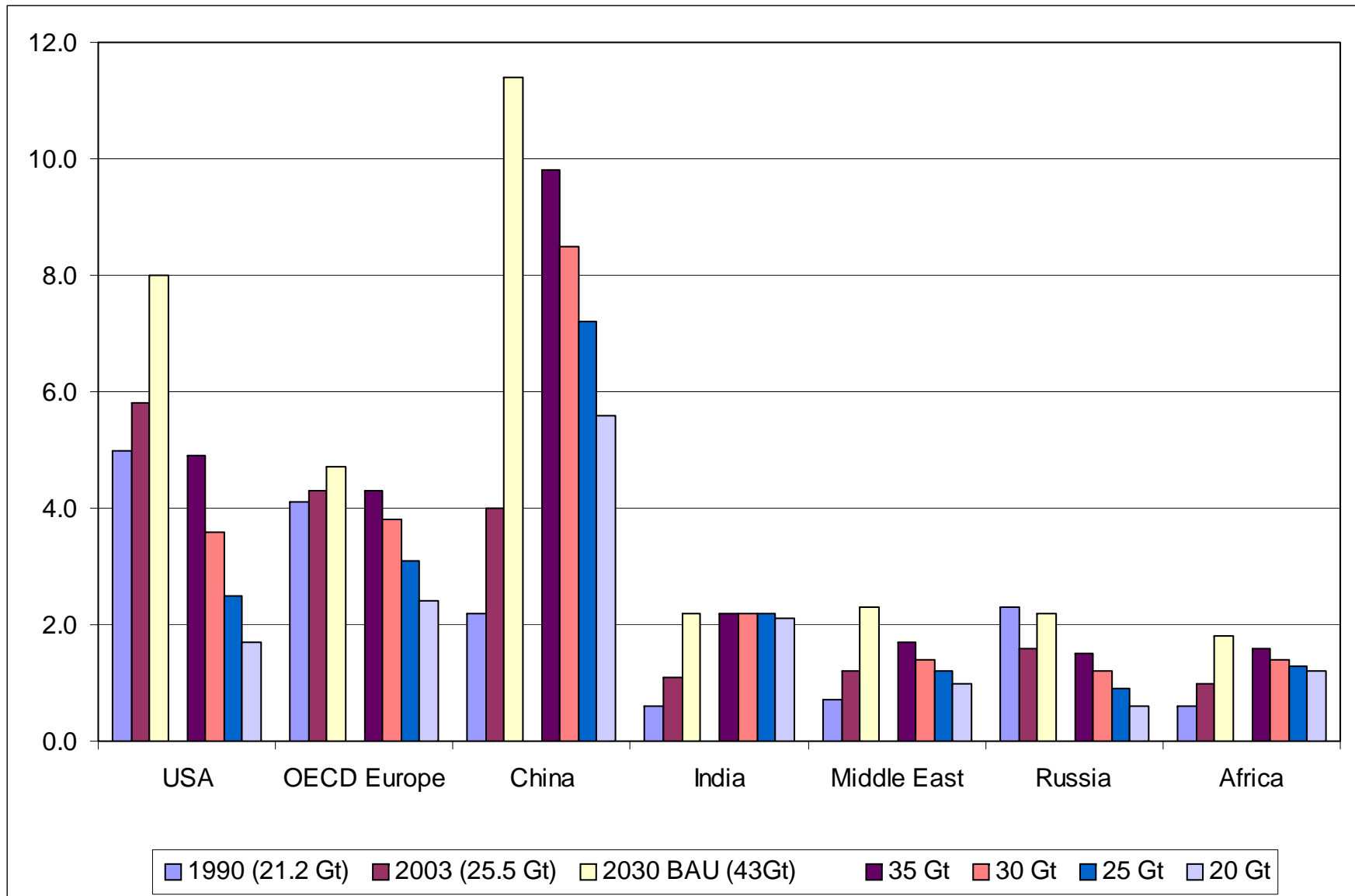
Population within the cap by region



Emission path over time for a trajectory that peaks at 33 Gt in 2020 and reduces to 30 Gt in 2030



Flexibility of the scheme: regional targets change with different global targets in 2030.



Significant inequality in emissions.

Year	Individual emissions (tCO ₂ /yr)	Number of people (billion)	Total emissions (GtCO ₂ /yr)
2003	< 0.5	1.3	0.31
	< 1.0	2.4	1.07
2020	< 0.5	1.4	0.30
	< 1.0	2.5	1.11
2030	< 0.5	1.5	0.31
	< 1.0	2.7	1.14

Headroom for the poor

We are recommending a floor on the emissions of low emitters to complement the ceiling on high emitters. “Fairness” then deals with the poor as well as the rich.

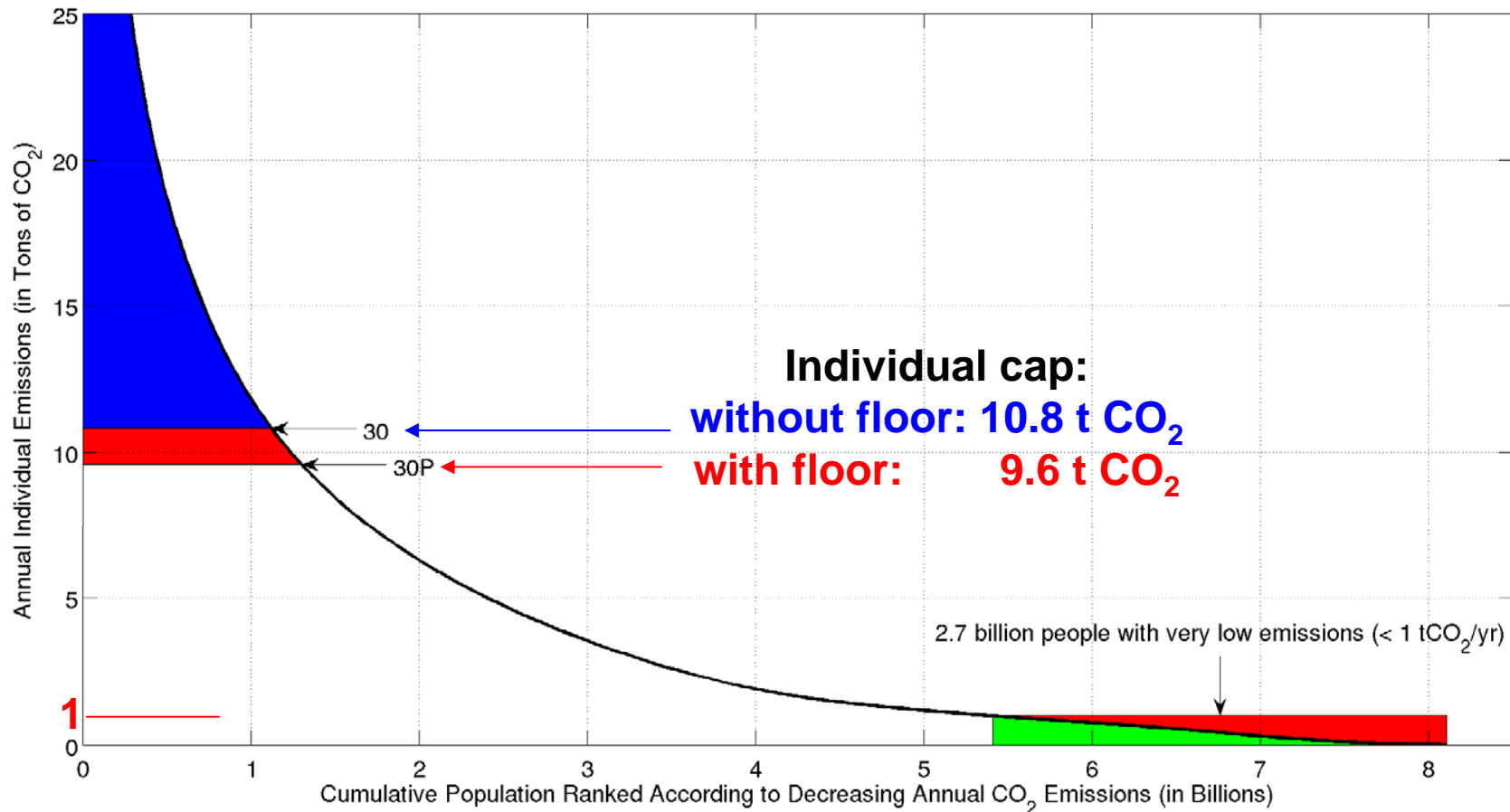
In our specific example, below, a floor is set at 1 tCO₂/year.

What does 1 tCO₂/person-yr allow today?

<i>Direct Energy Use</i>	<i>Household rate of use (4.5 people)</i>	<i>Individual emissions (kgCO₂/yr)</i>
Cooking	1 LPG canister per month	120
Transport	15 km per day	220
Electricity	800 kWh per yr	160
<i>Total</i>		500

1 tCO₂/yr: Double the “direct” emissions to account for “indirect” emissions.

Combine a global-emissions cap and an individual-emissions floor



“30P” in 2030: 30 GtCO₂ global emissions cap plus 1 tCO₂ floor

National allocation based on individual emission allowances

- Treats every individual equally irrespective of national borders
- High emitters in poor country does not free ride on the poor
- No immediate “convergence”: pragmatic and actionable approach
- Over time, the ceiling would descend and the floor would rise and our scheme is consistent with emissions convergence ultimately, while creating rules for a transition period.
- Simple and parsimonious scheme for deciding caps for both developed and developing countries: “one rule for every one”
- Flexible scheme that can be easily updated.
- Doesn't compromise economic efficiency. Linking of national mitigation goals through carbon trading schemes.

What's missing and how do we incorporate it ?

- Add CO2 from land use and non-CO2 gases
- Historical emissions
 - Possible modifications: lifetime emissions, link to demographic stats
- Emissions embedded in trade of goods and services
 - Who's responsible?
- Account for factors other than carbon intensity, eg climate, pop density

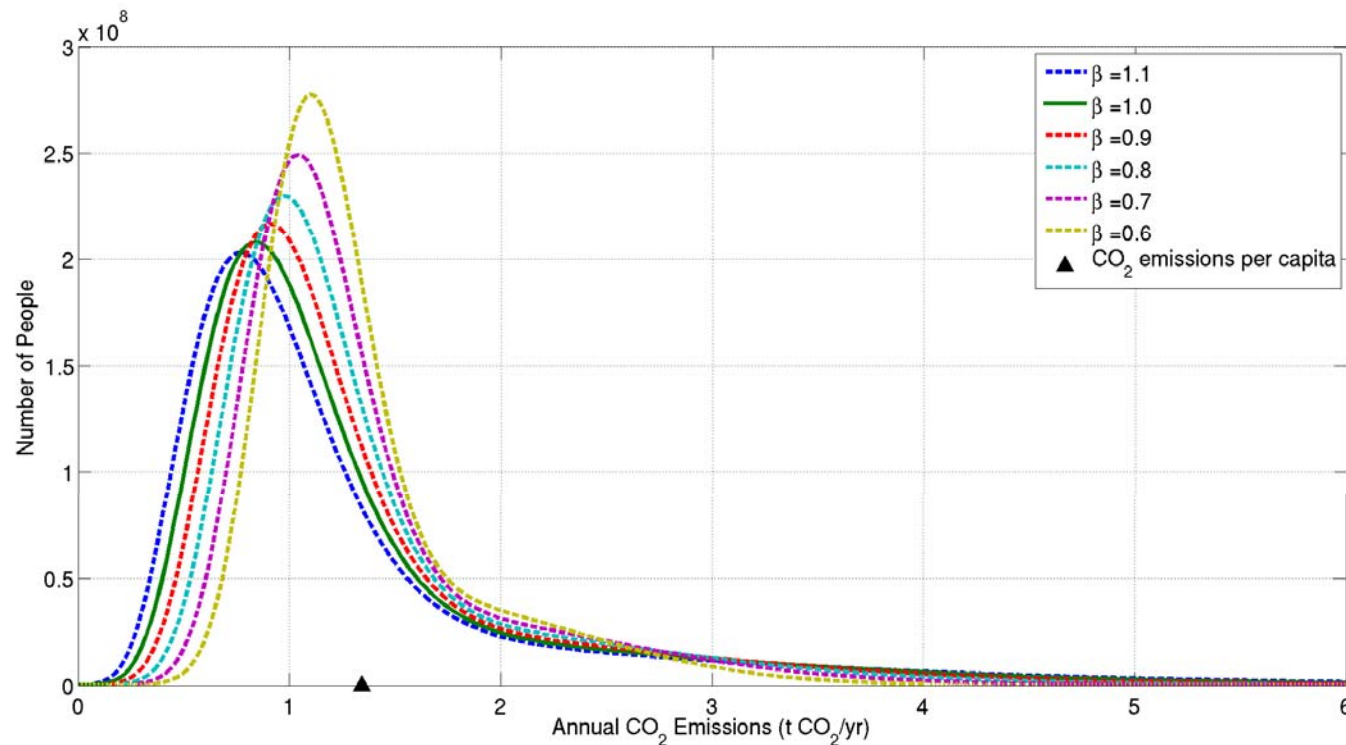
Extra slides for follow up
questions

Comparison with GDR

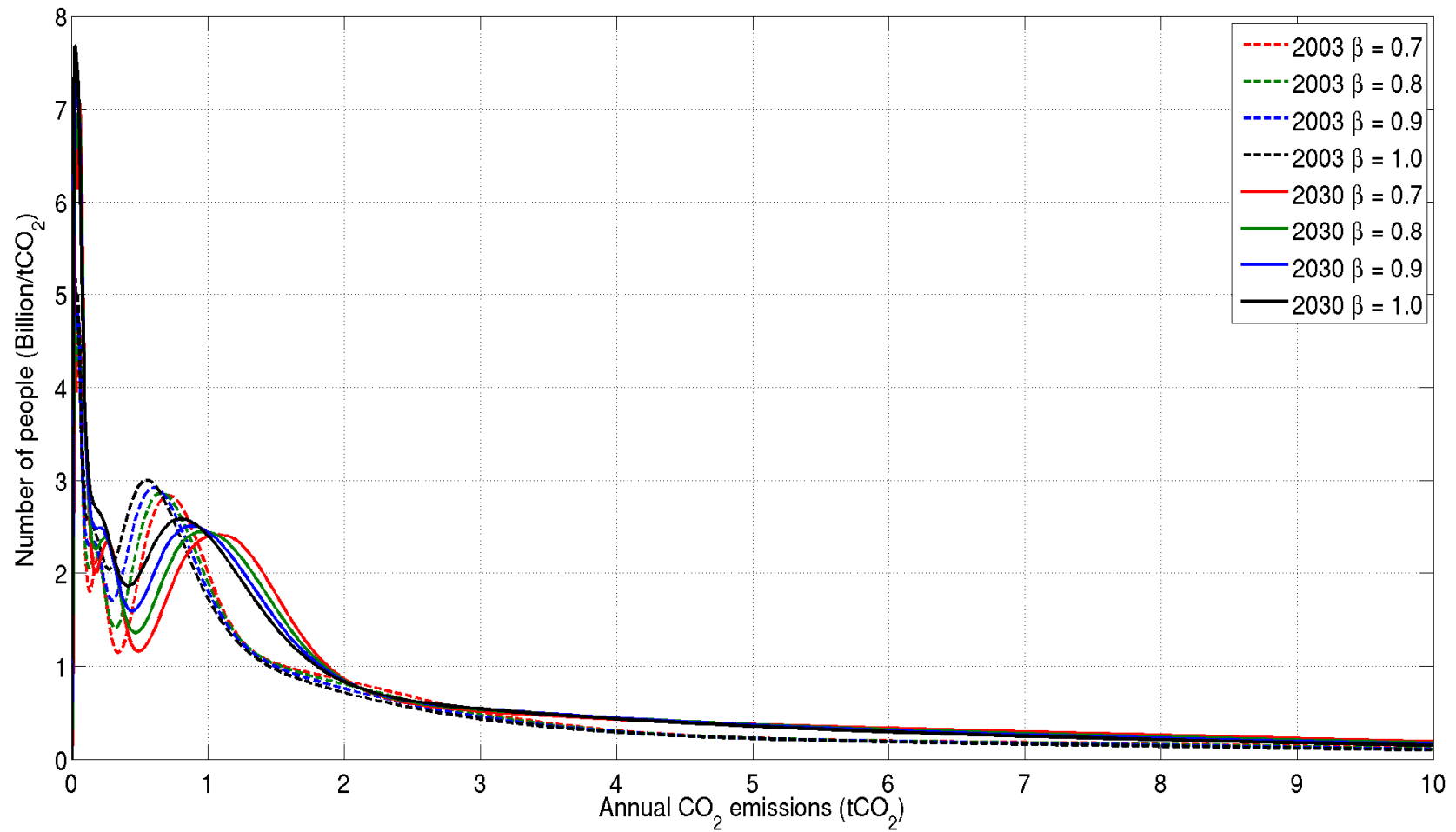
- Same basic approach to address country level inequality, some methodological differences. Also, unlike GDR, we do not address the issue of historical emissions.
- Big difference in the procedure for setting national/regional emissions targets.
 - GDR: Divide the job of emissions reduction according to RCI
 - This work: Use individual emissions cap to obtain new emissions target. No negative emissions.

Sensitivity Analysis

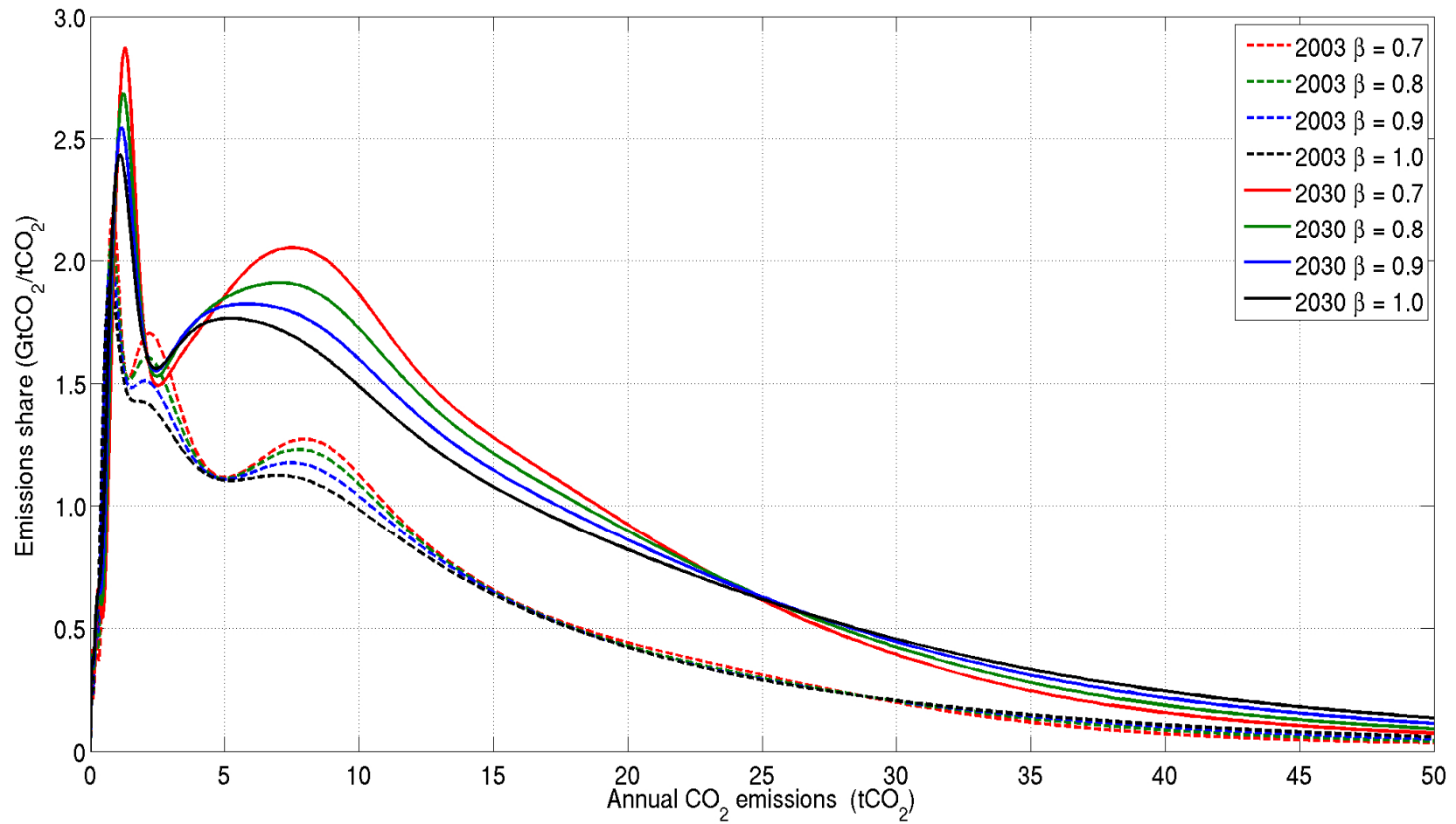
So far, we assumed that the emissions to income elasticity is 1. We now consider the effect of relaxing this assumption. Consider the effect on the distribution of a single country:



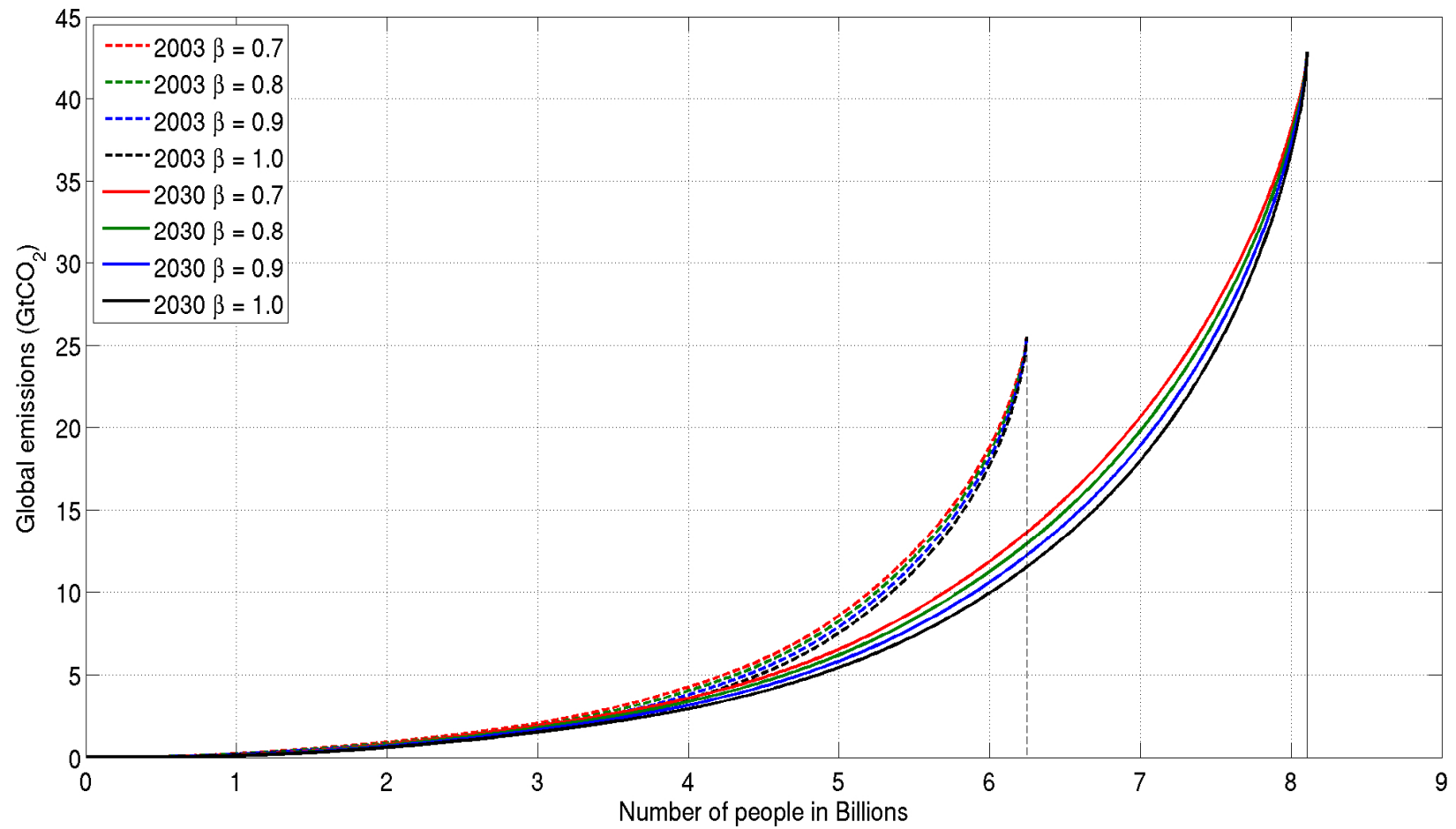
Distribution of emitters for different elasticities (0.7-1.0)



Distribution of emitters for different elasticities.



Emissions “Lorenz curve” for different elasticities

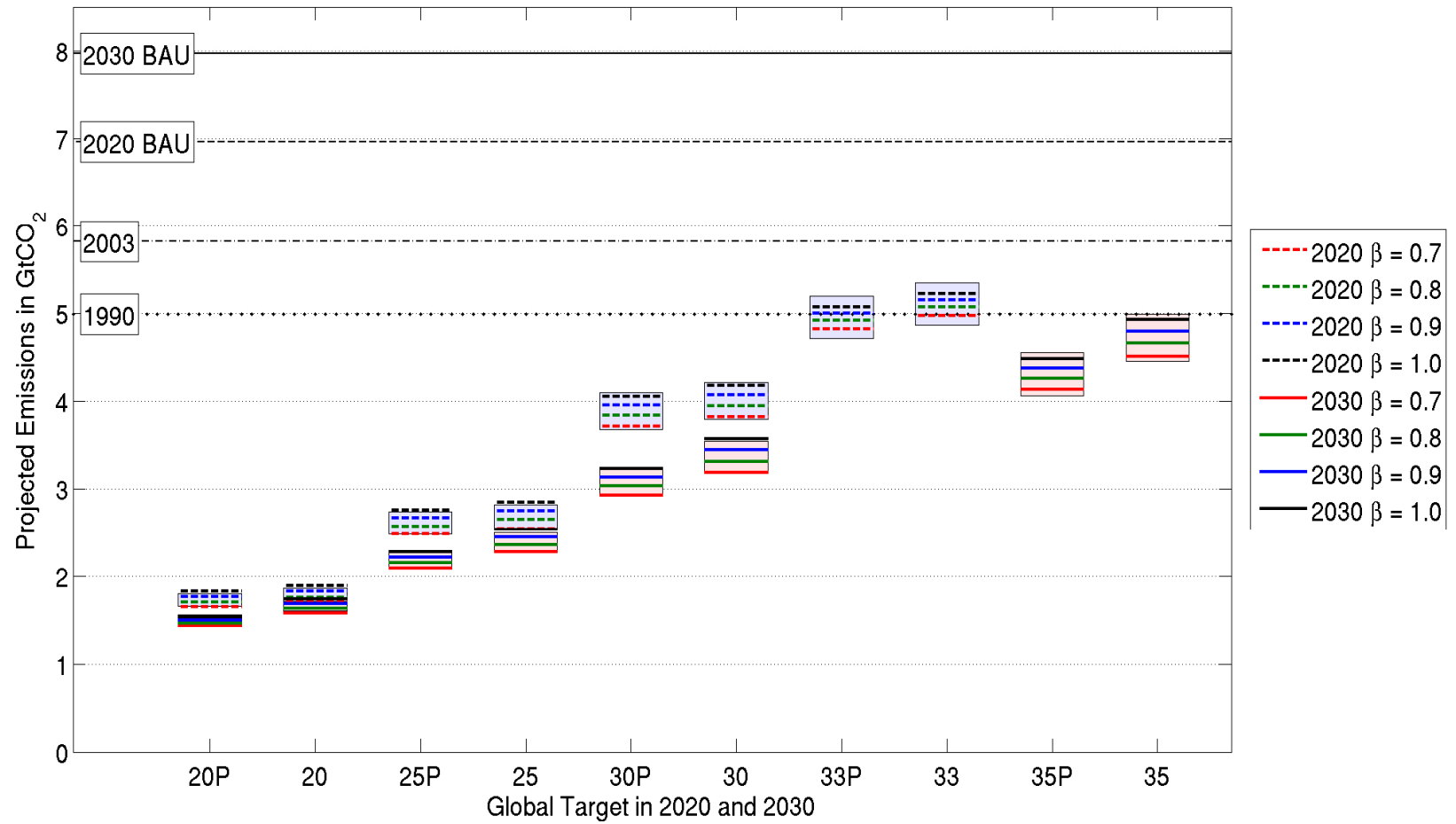


Change in the personal emissions cap with elasticity.

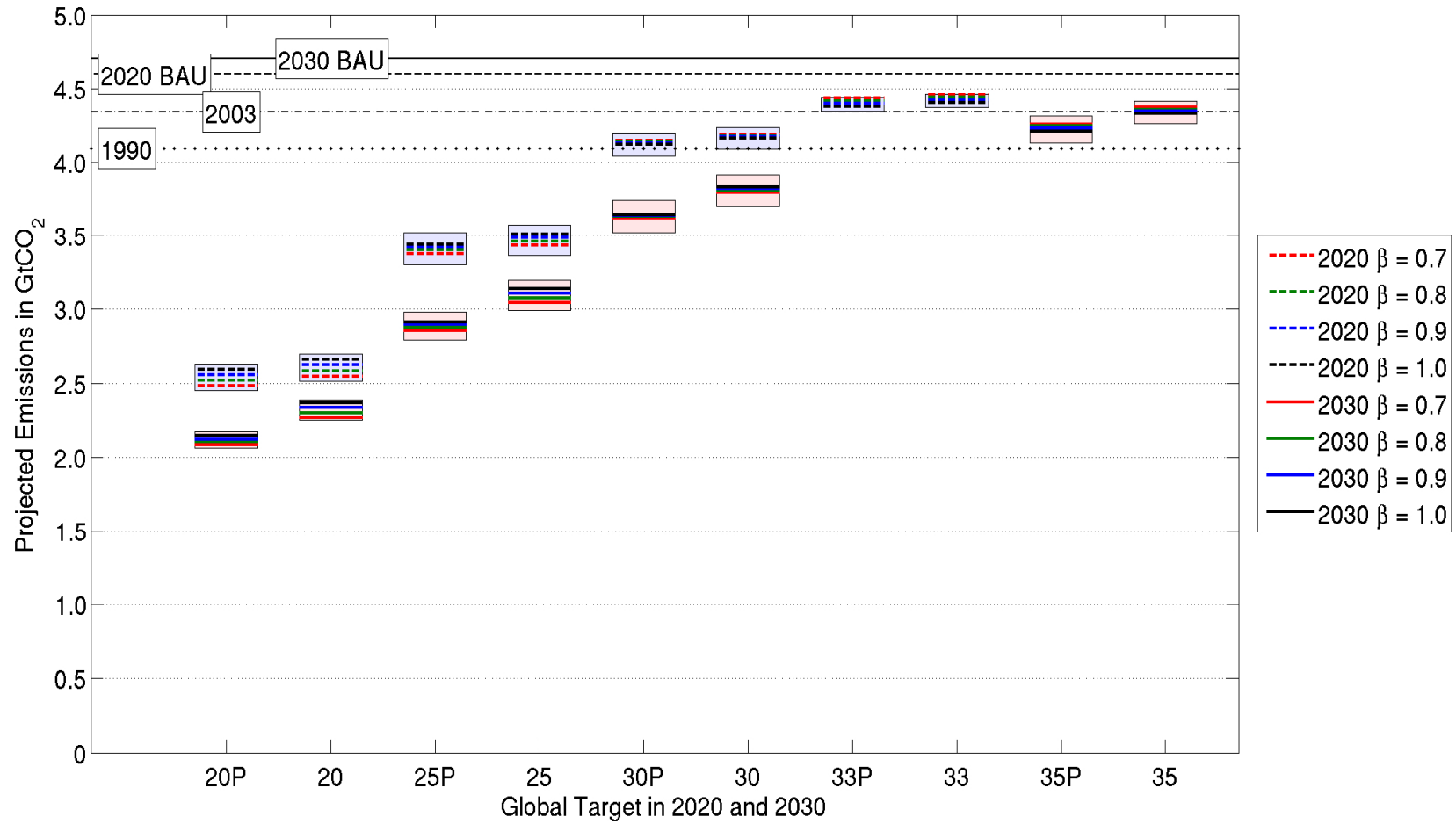
Year	Elasticity (β)	20	20P	25	25P	30	30P	33	33P	35	35P
		[Individual emissions cap in tCO ₂ /year]									
2020	1.0	5.8	5.6	9.2	8.8	15.2	14.6	22.8	21.4		
	0.9	5.5	5.3	8.6	8.3	14.0	13.4	20.5	19.3		
	0.8	5.3	5.1	8.1	7.8	12.9	12.4	18.6	17.6		
	0.7	5.1	4.9	7.7	7.4	12.0	11.6	17.0	16.3		
2030	1.0	4.9	4.3	7.3	6.5	10.8	9.6			16.8	14.6
	0.9	4.7	4.1	6.9	6.2	10.1	9.0			15.4	13.6
	0.8	4.5	4.0	6.5	5.9	9.4	8.6			14.2	12.6
	0.7	4.3	3.9	6.3	5.7	8.9	8.2			13.1	11.9

Table S10: The individual cap for different global targets. For example, ‘20’ and ‘20P’ refer to a global emissions target of 20 GtCO₂. ‘20P’ also includes a poverty floor of 0.5 tCO₂ in 2020 and 1.0 tCO₂ in 2030. The table shows how the cap changes for different constant elasticities of CO₂ emissions with consumption expenditure. BAU emissions in 2020 and 2030 are projected to be 36.8 GtCO₂ and 42.9 GtCO₂ respectively. The individual caps for the ‘30’ and ‘30P’ scenario (**10.8** tCO₂ and **9.6** tCO₂, respectively) in 2030 are extensively used in the main text.

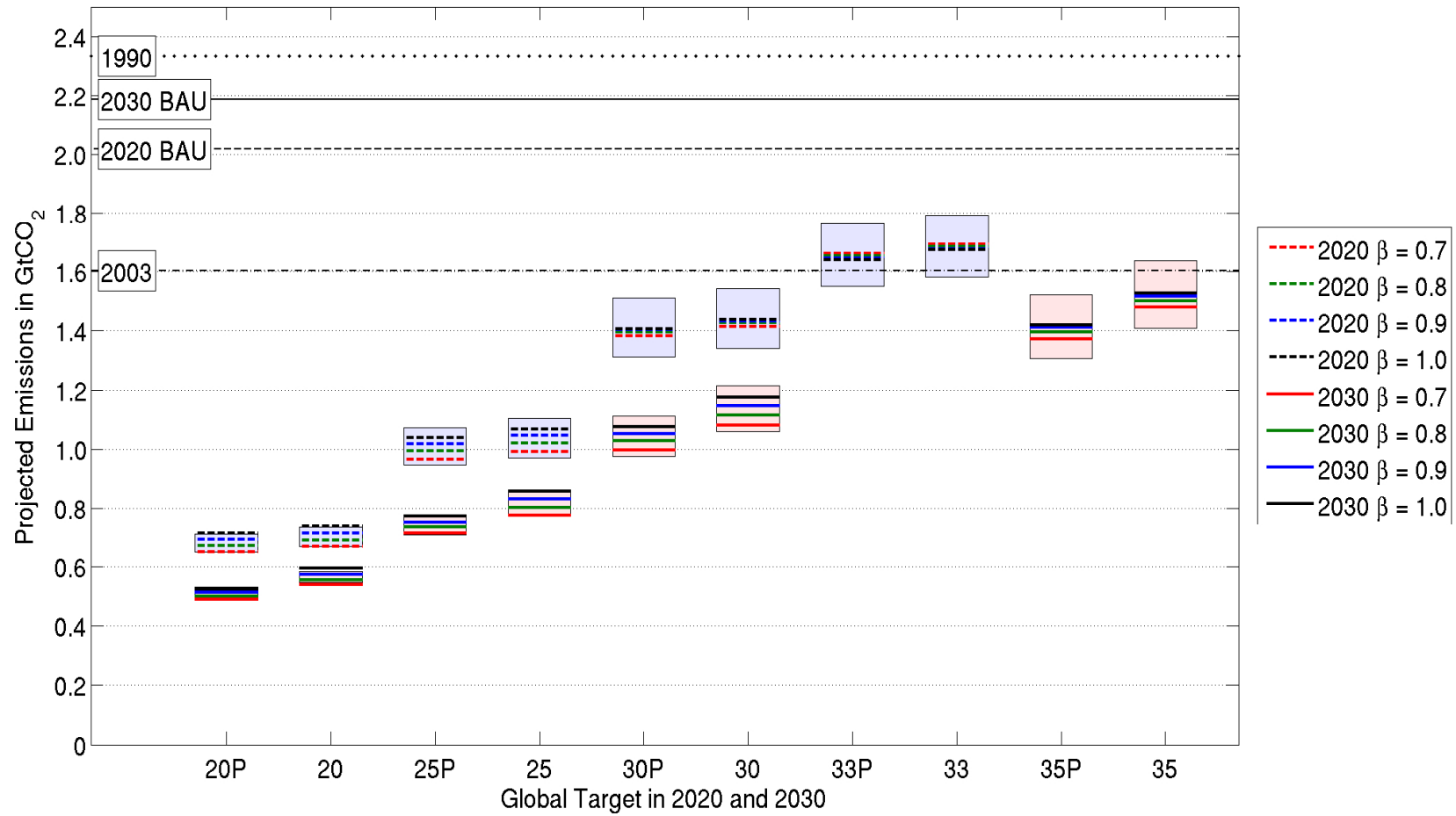
U.S.



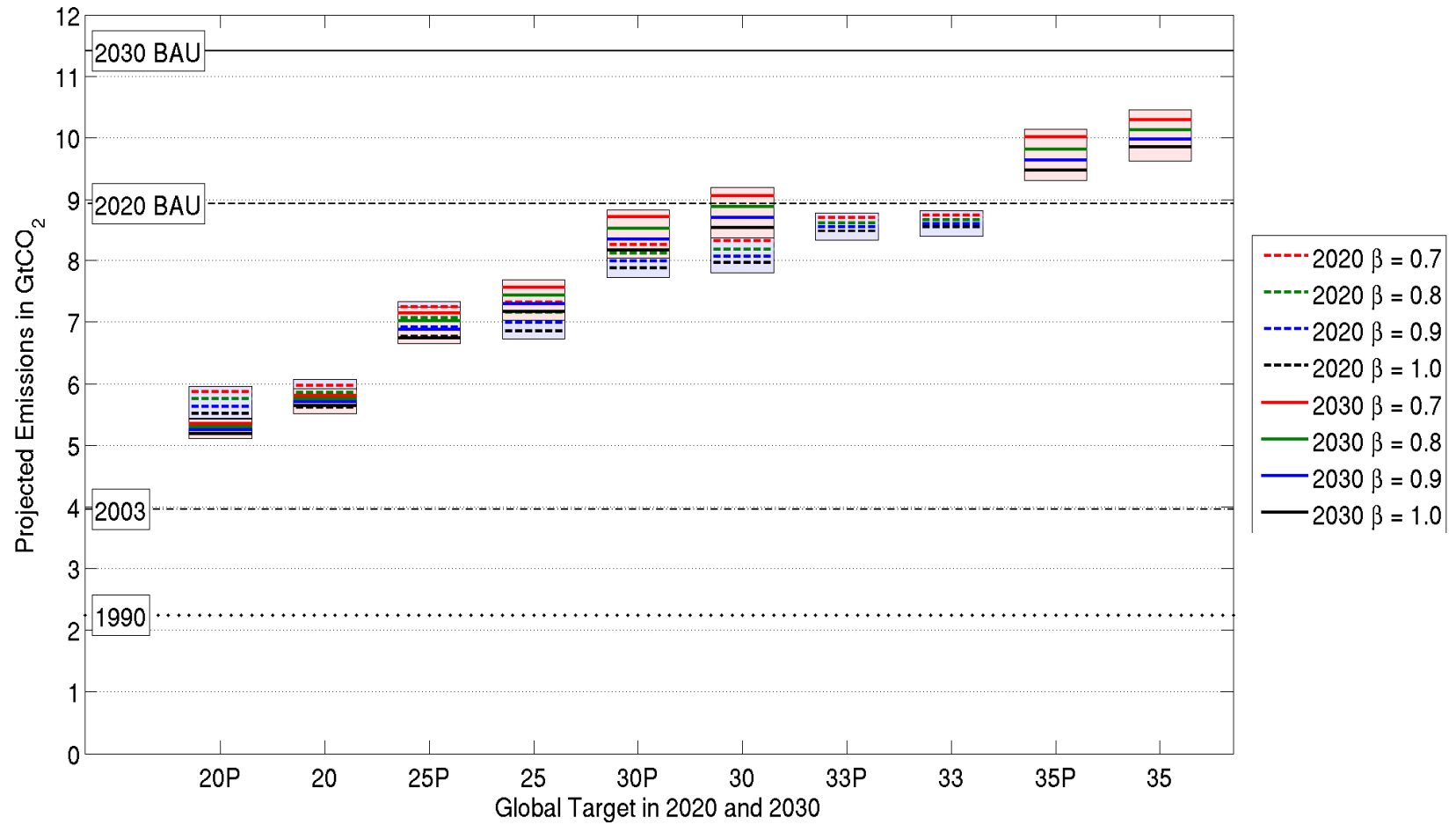
OECD Europe



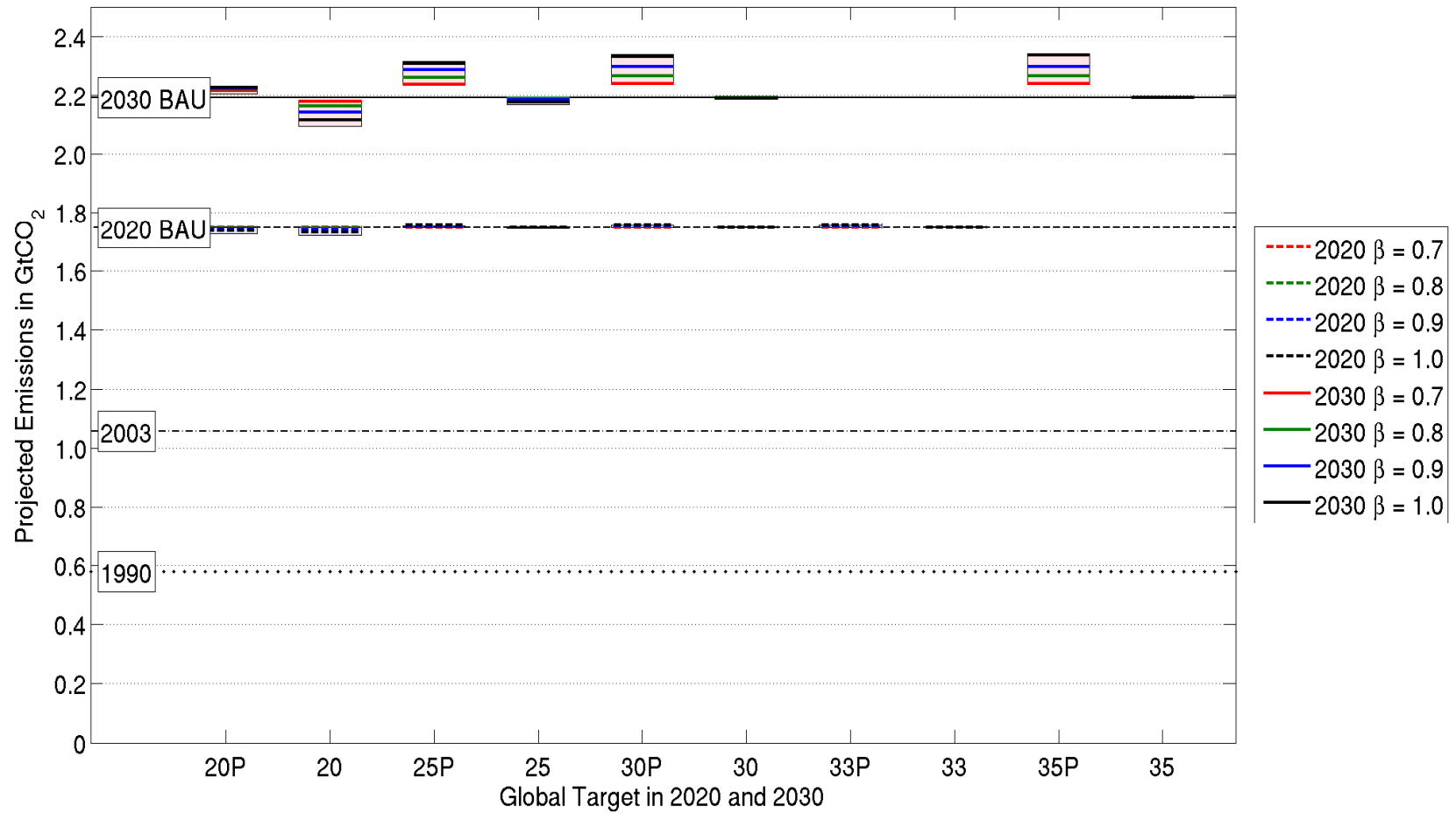
Russia



China



India



Emissions elasticity from analysis of historical data

Our estimate using datasets for 43 different countries in 1980-2004 is

$$C_i = A_i * I^{0.72}$$

But, we will proceed with elasticity of 1.0 instead of 0.72, as the basic idea is independent of the elasticity.