# 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

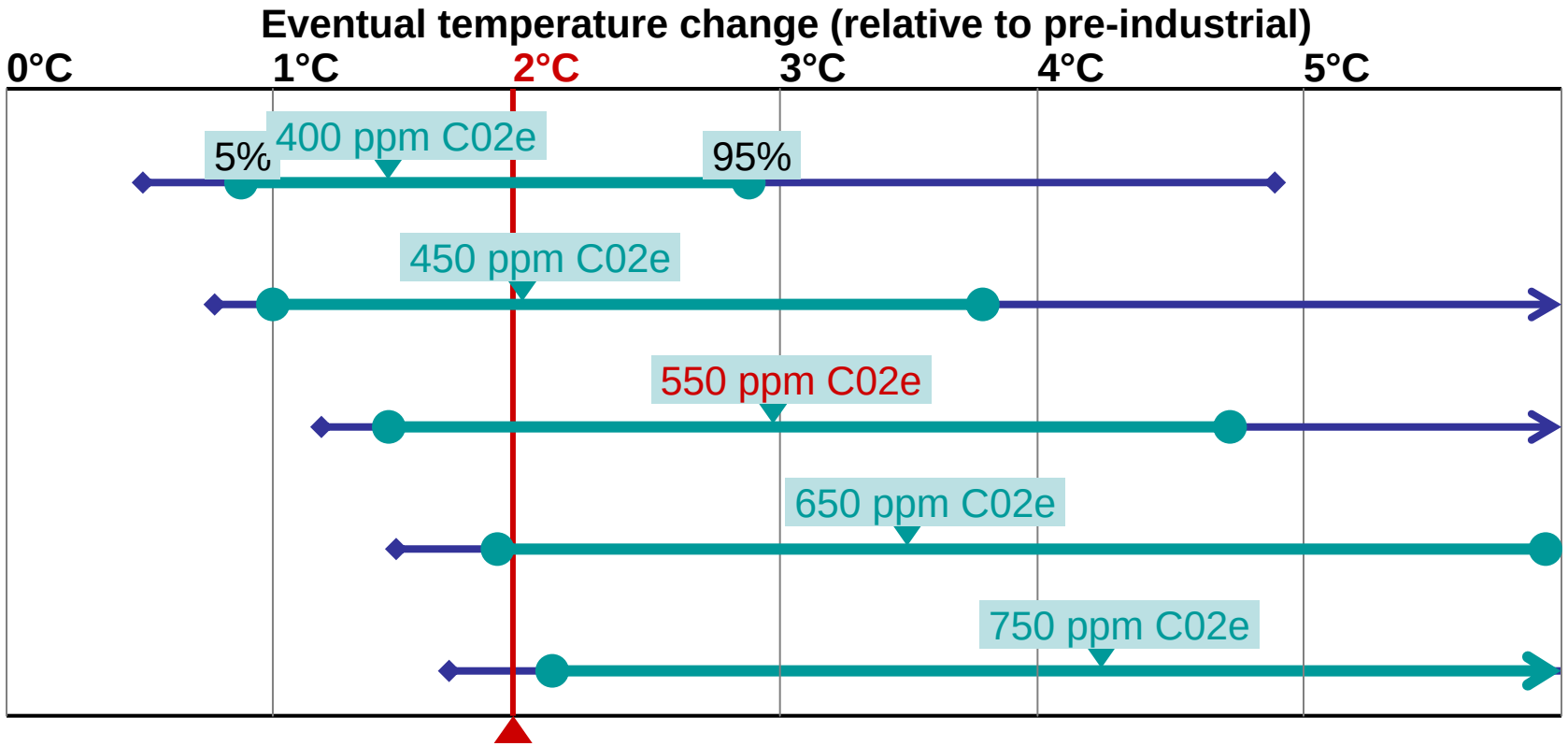
- Annex I countries: binding emission targets
- Non-Annex I countries (including China): voluntary participation
- Kyoto commitment period ends in 2012
- Commitments established through negotiation

Guiding principle: agreement between sovereign states

# Need for tough $CO_2$ targets

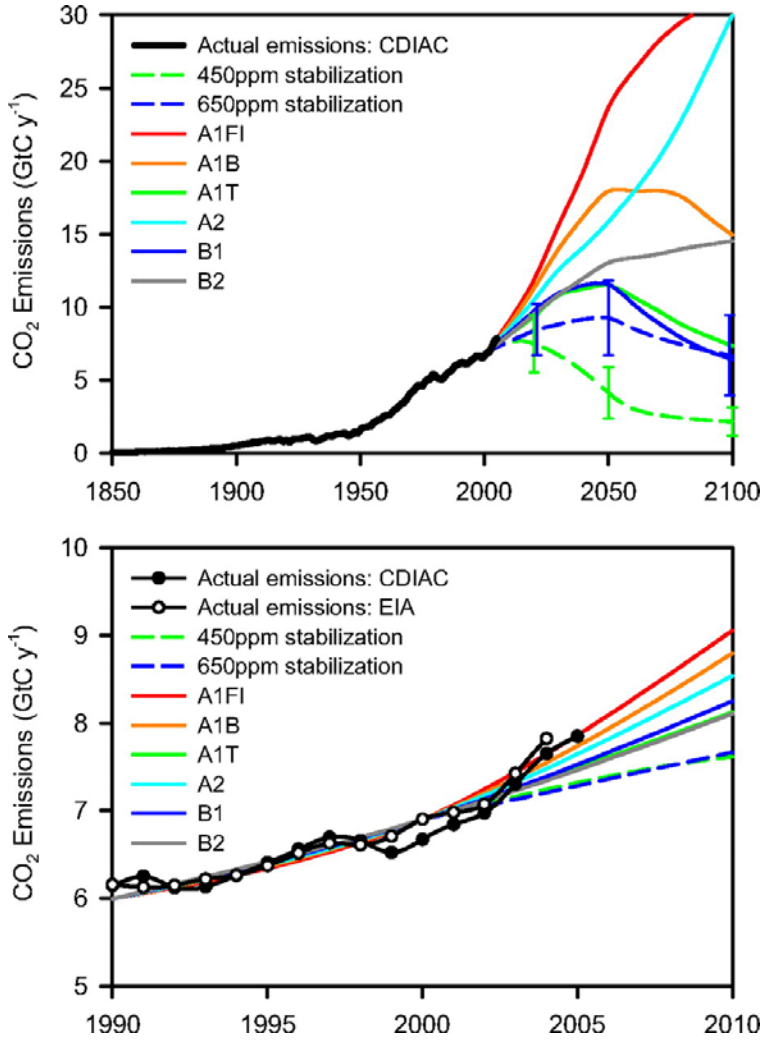
When we choose a target (with its headroom):
We are buying insurance, managing risk.

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.

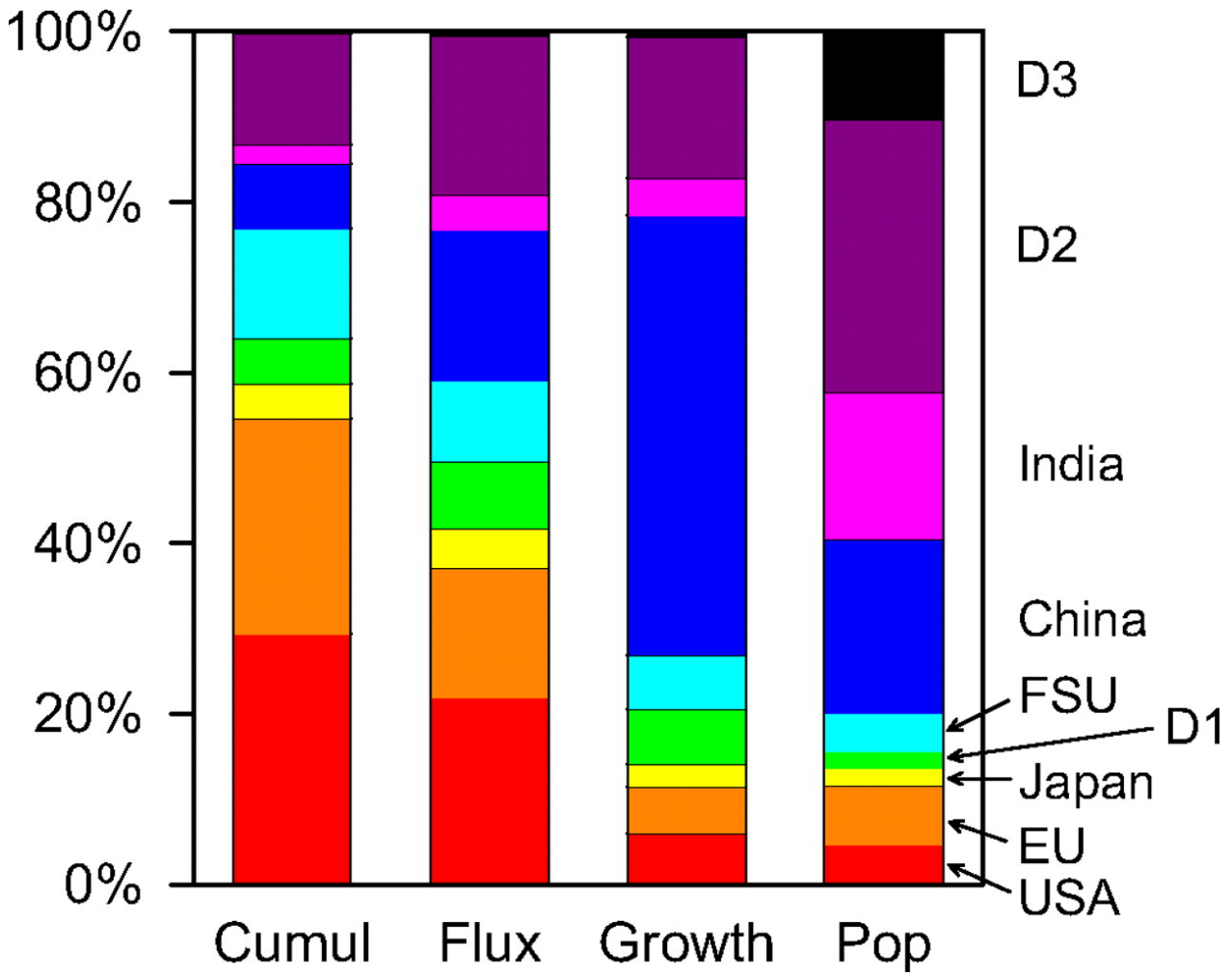



Source: Stern Review, 2006 citing Wigley et. al.; Murphy et. al.; Meinshausen. Based on a slide prepared by Hal Harvey.

**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)**



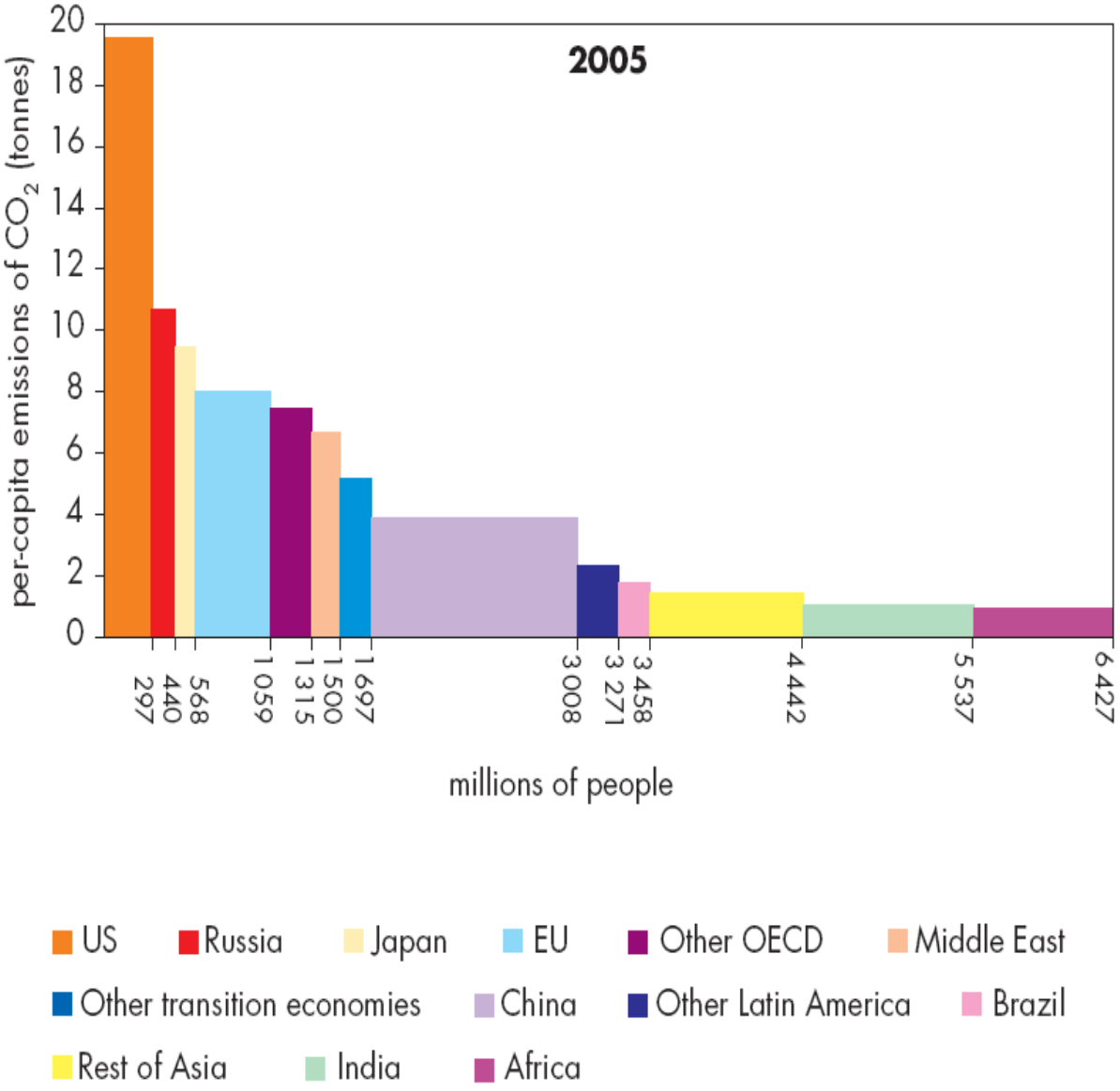

**Source: Raupach M. R. et.al. PNAS 2007;104:10288-10293**




**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)**

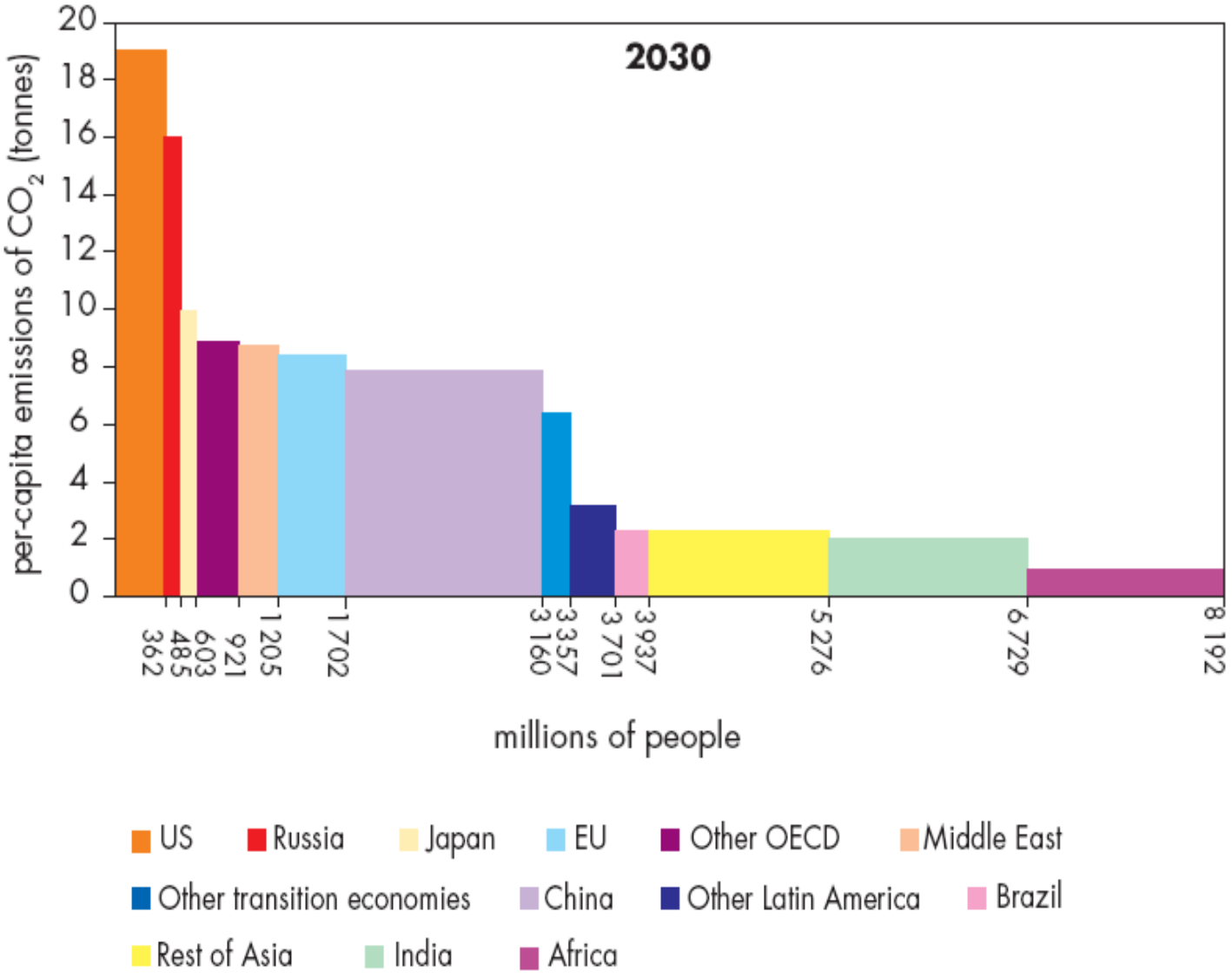
**Source: Raupach M. R. et.al. PNAS 2007;104:10288-10293**

# Per-capita energy related $CO_2$ emissions (current)




Source: IEA WEO 2007

# Per-capita energy related $CO_2$ 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 |
| *2030* | *1.75* | *0.44* |

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?

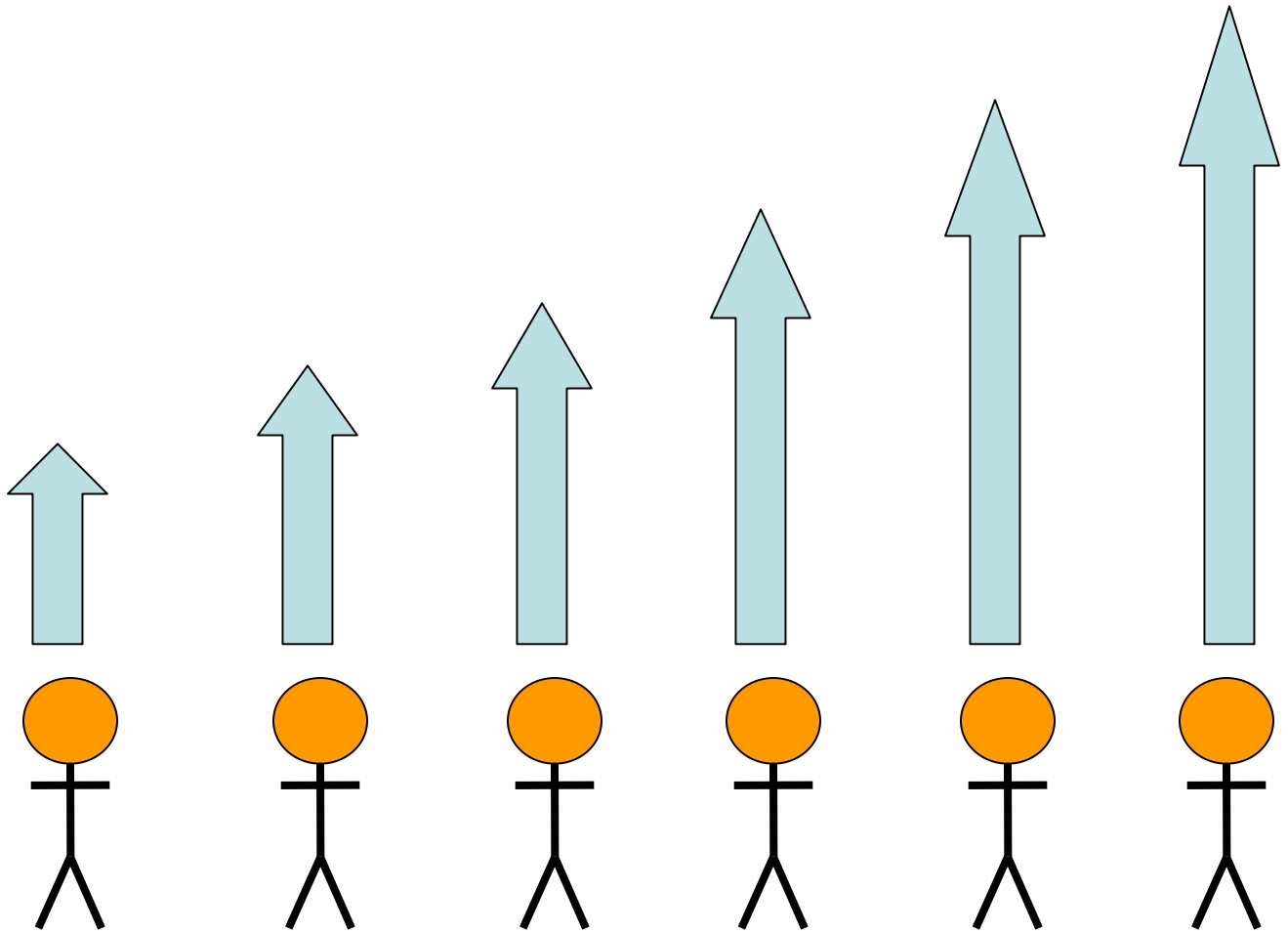
  Kyoto
- Based on the reduction potentials (geography, climate)?
- Based on national average per capita GHG emissions?
  - Contraction and convergence
- Based on emissions of individuals?
  - Global Development Rights paper & our paper.

# National responsibilities based on individual emissions

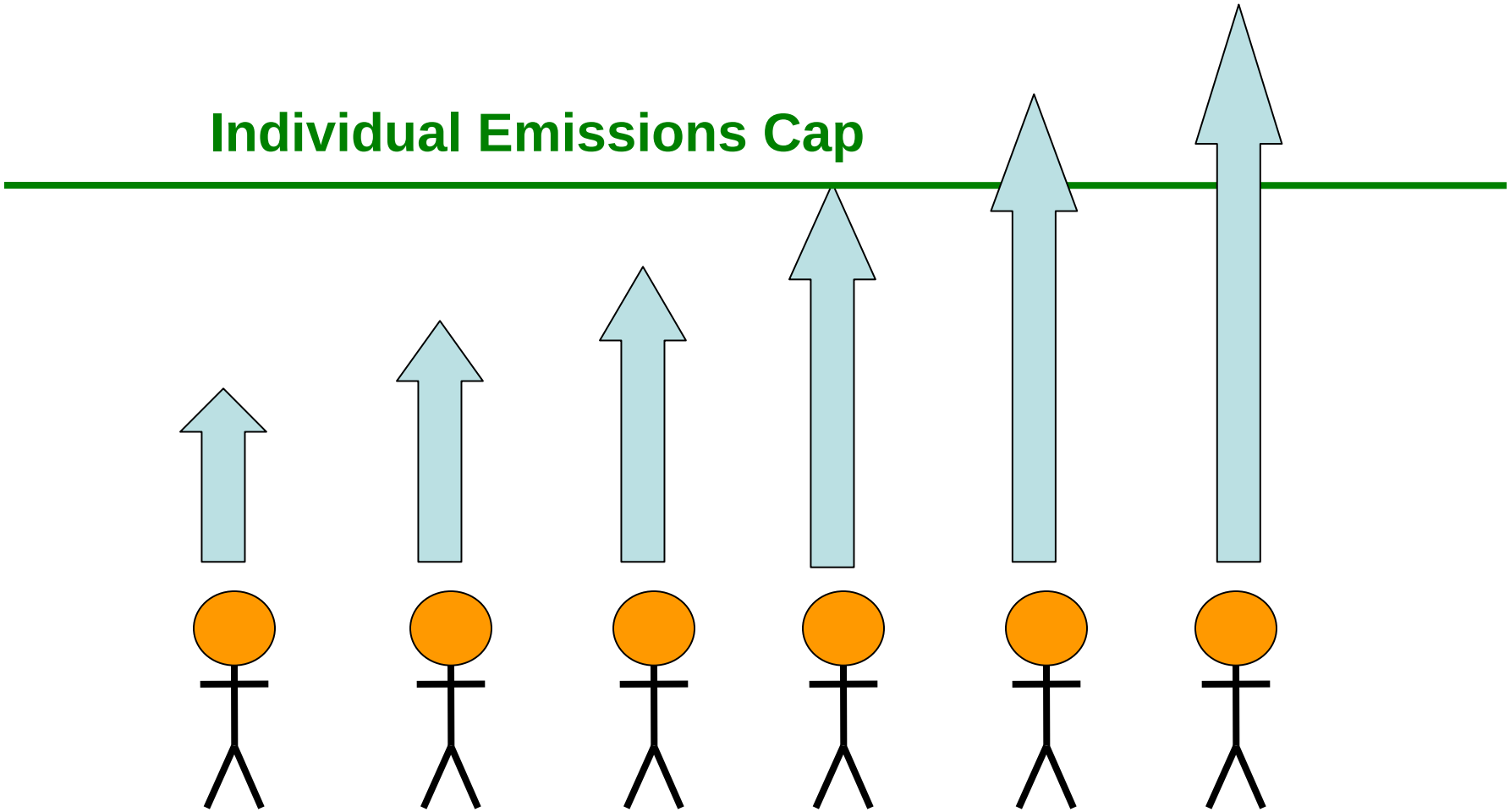
## Key Principles

- Focus on the individual
- Treat every individual in all countries in the same way
- Calculate the appropriate universal cap for the $CO_2$ 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 $CO_2$ target

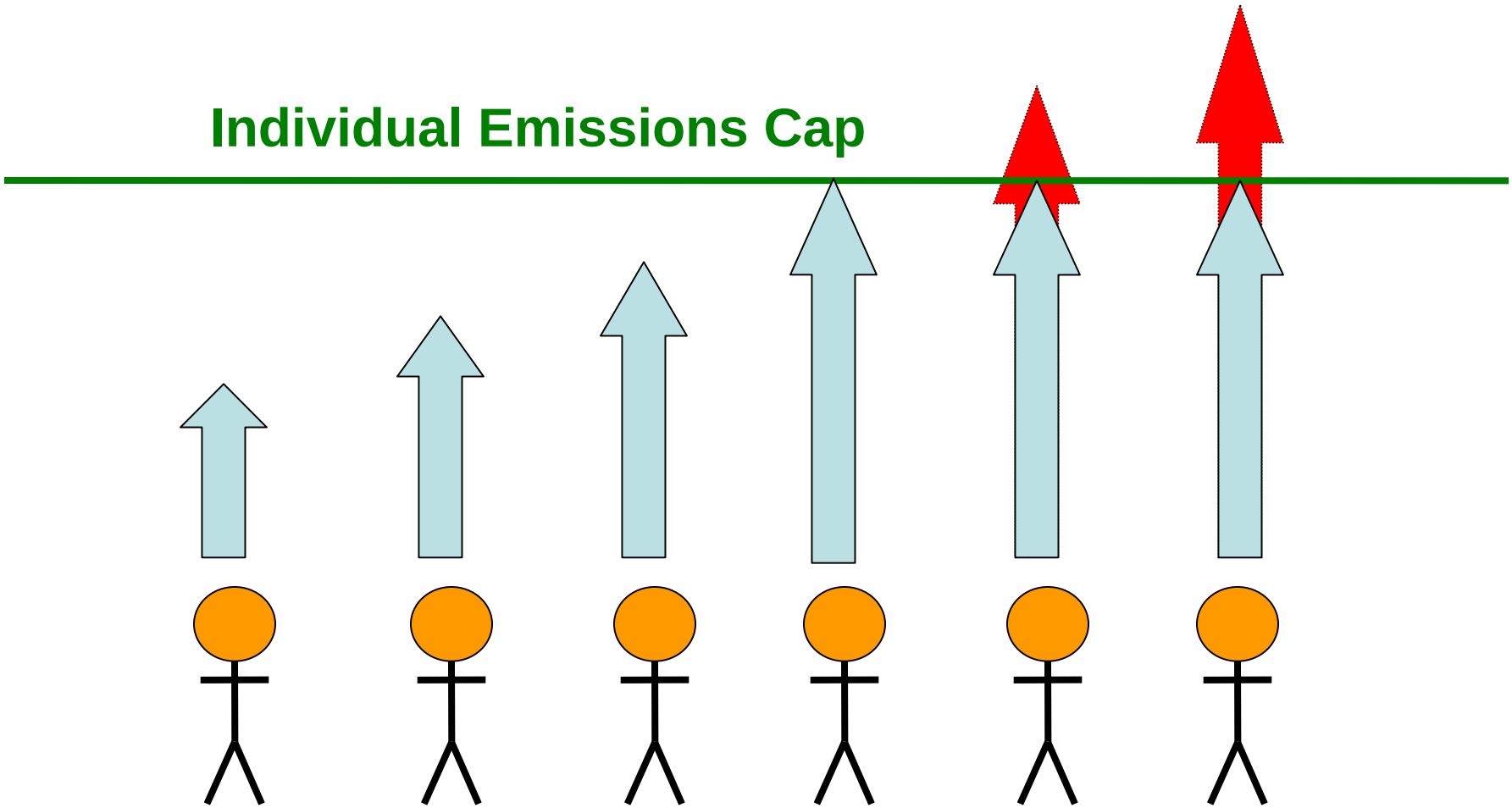
# People ranked by personal emissions



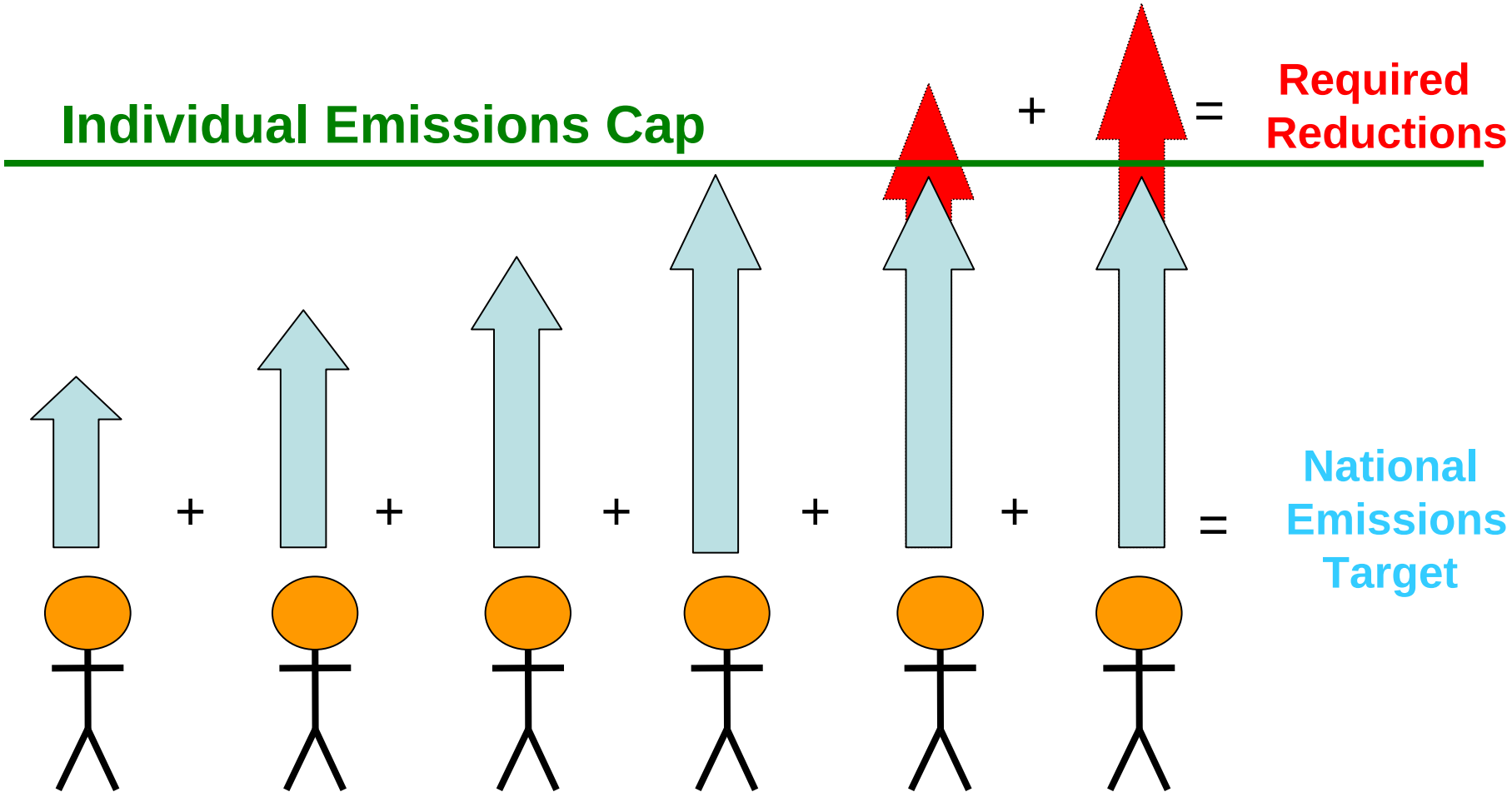
# Determine globally applicable individual emissions cap



# 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] |

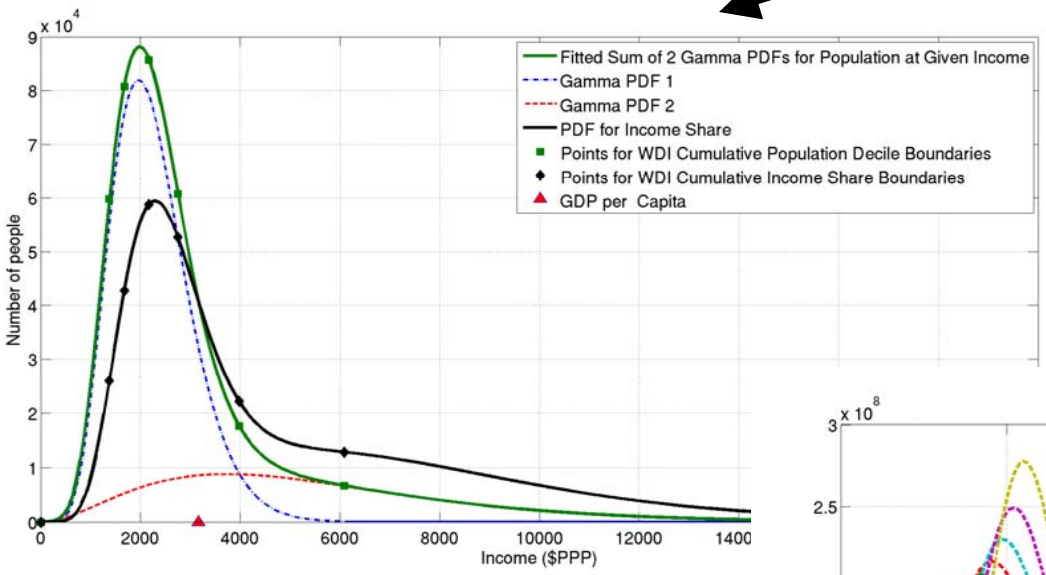
$$C_i = A_i * I^x$$

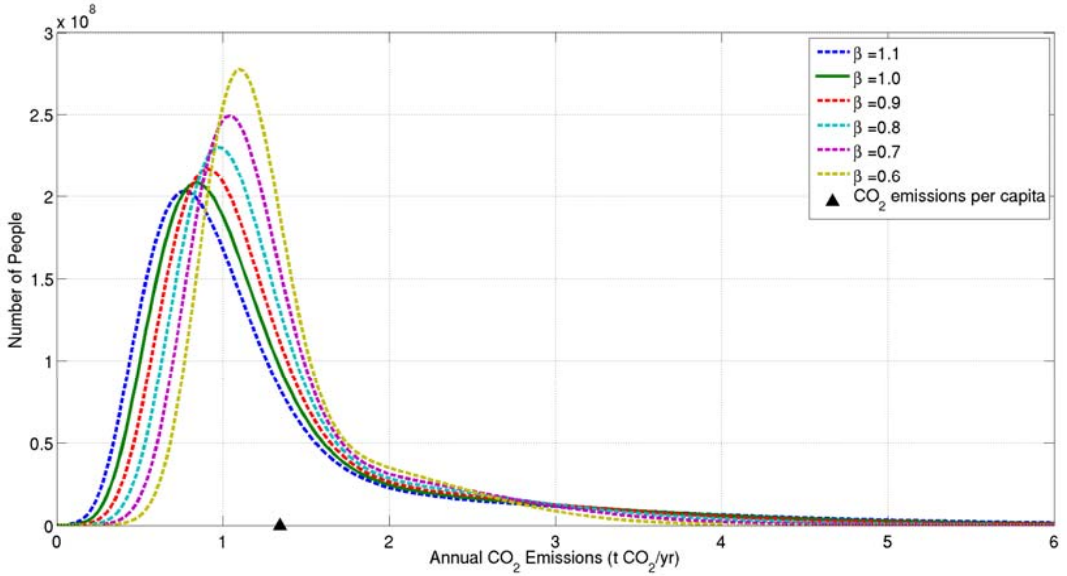
We will proceed with elasticity of x = 1.0 as the basic idea is independent of the elasticity.

# 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 |

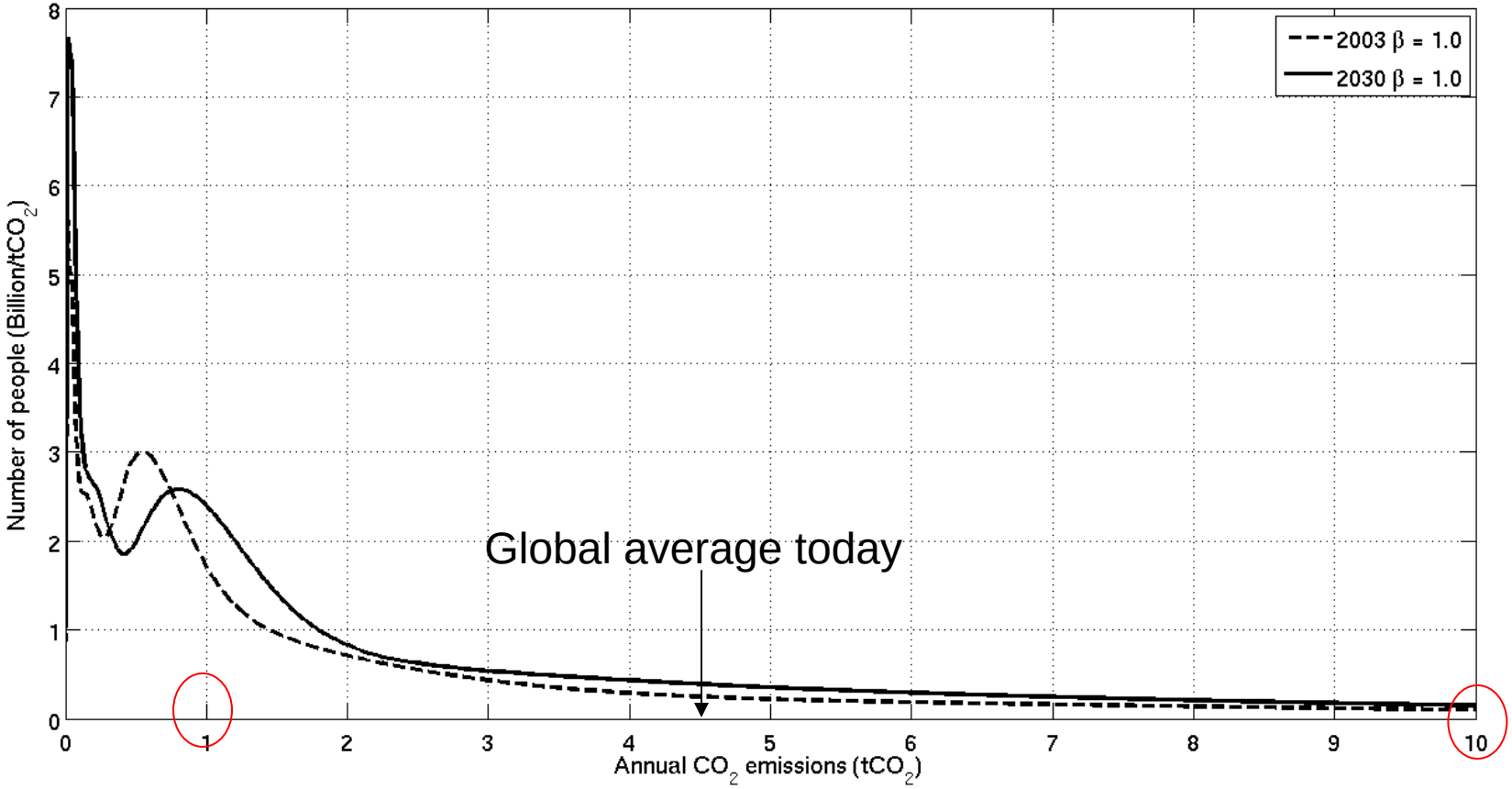


# Procedure for Projections

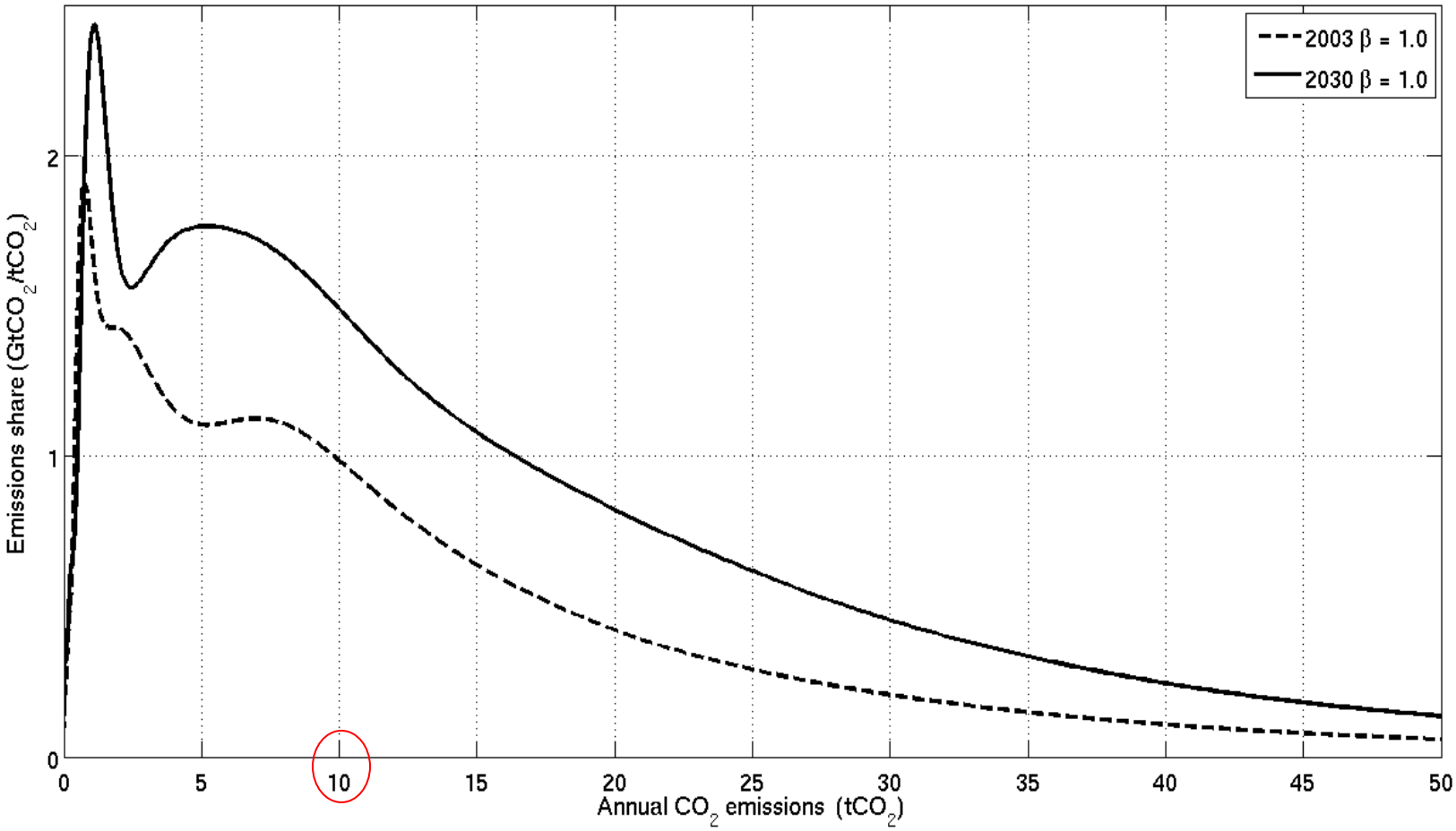
- Add country level distributions to obtain regional emissions distributions
- Project forward to 2030 using EIA IEO 2007.
- Derive a universal individual cap from global target and timetable.
- Apply individual caps to regions/countries to obtain regional/national targets.

# Global population distribution of individual emitters



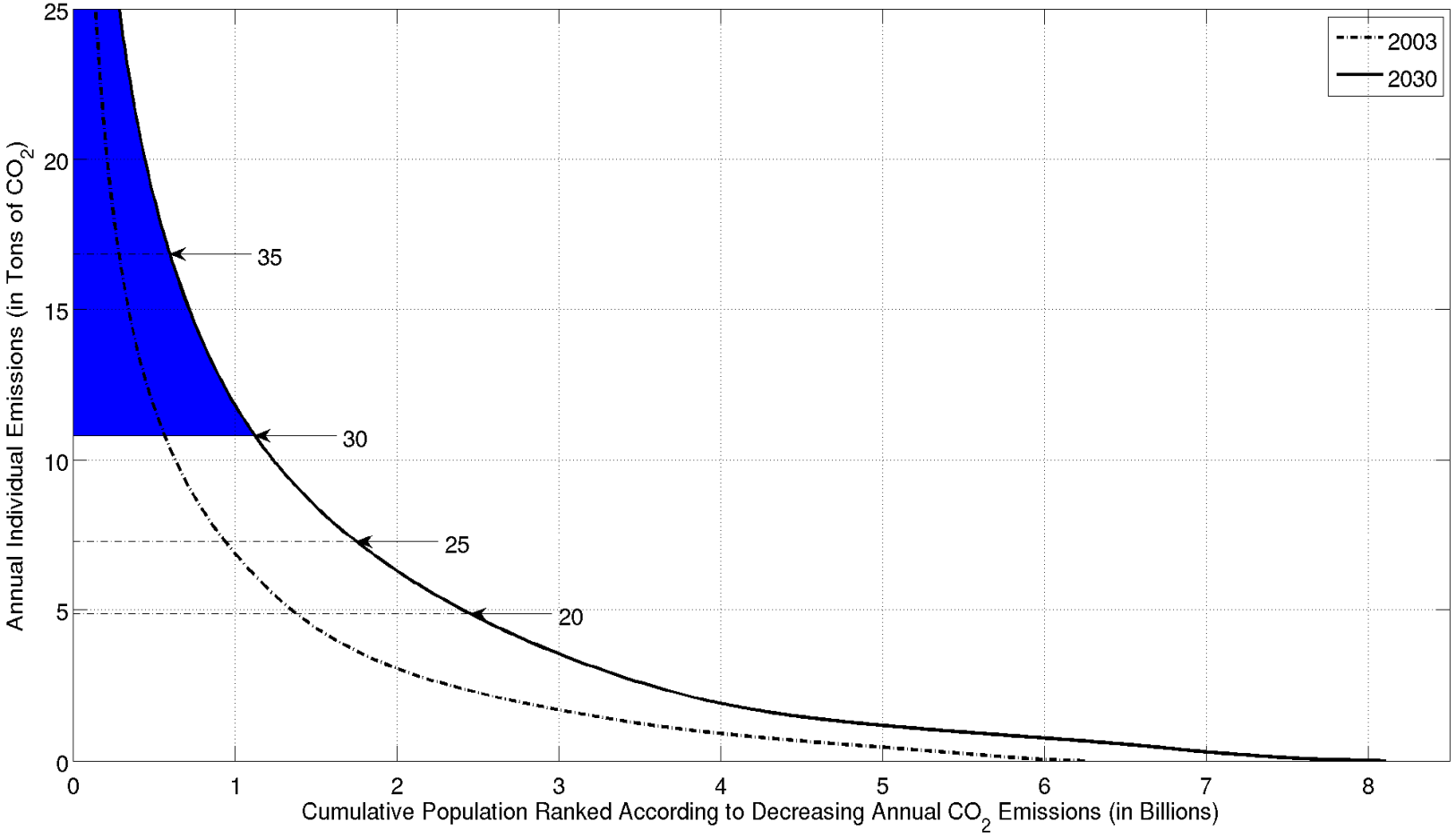

Note: linear scale. The high emitters are not in view.

# Global emissions distribution

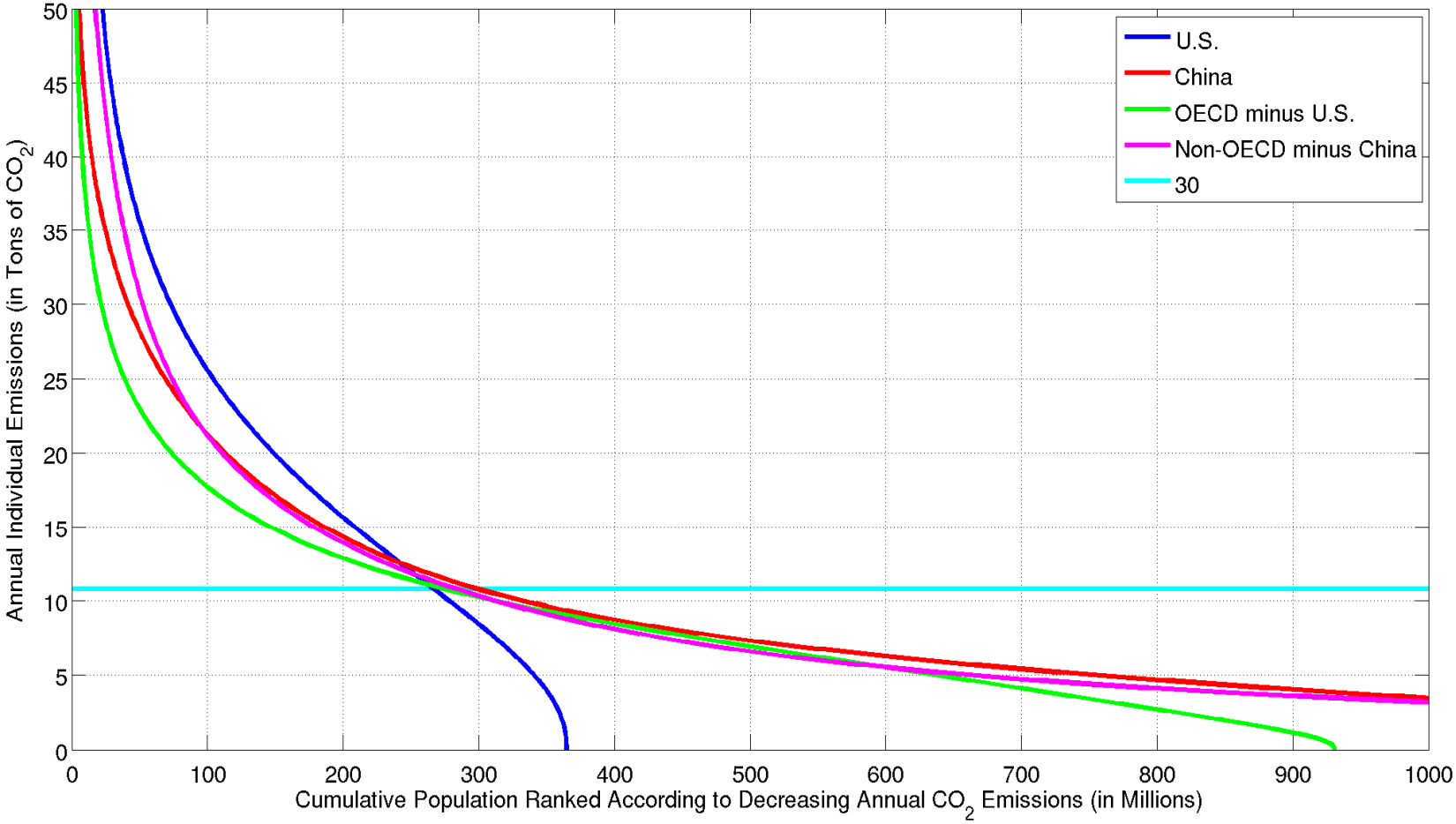



Note: Different scale from previous graph

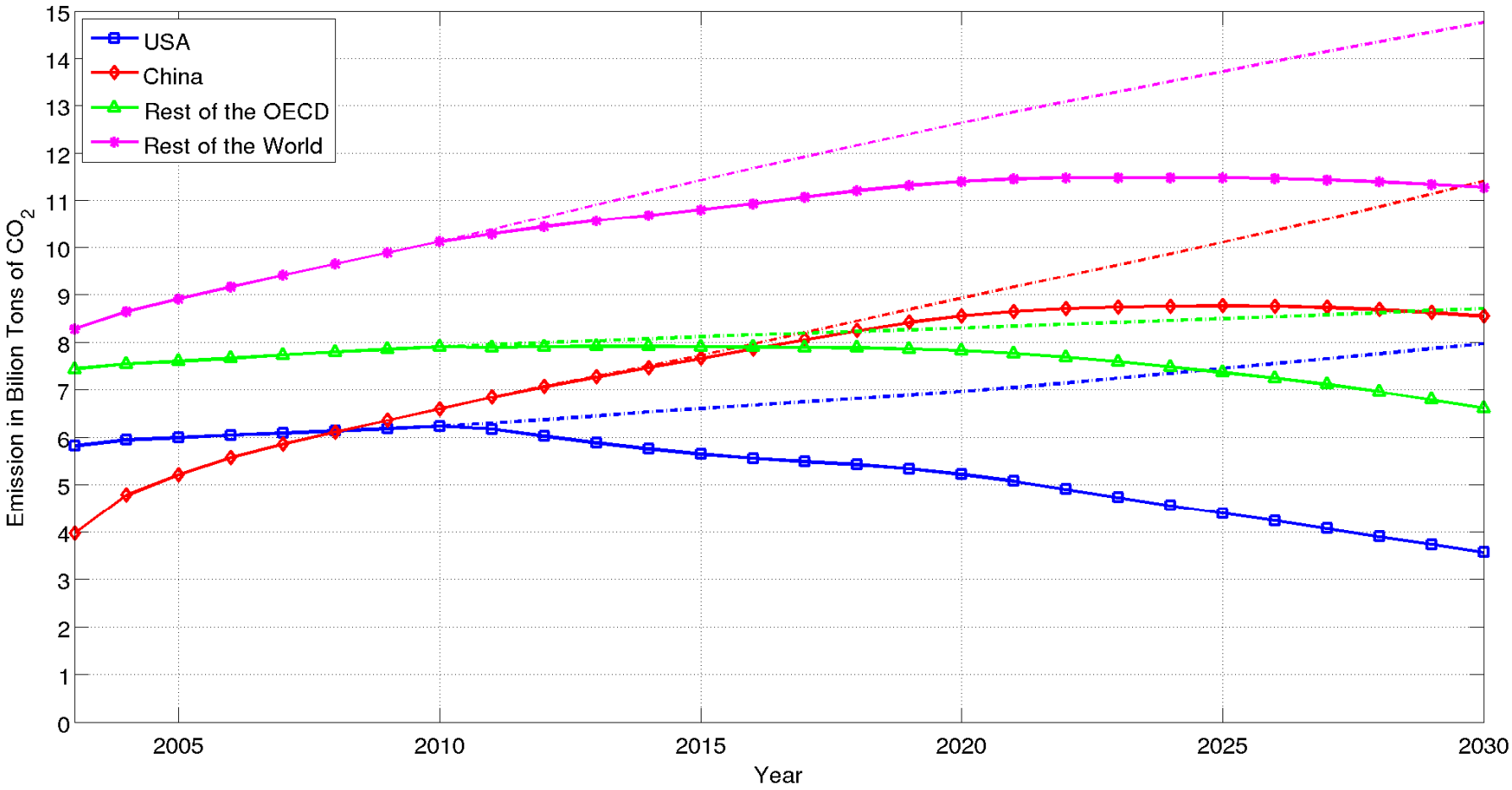
# Individual emissions caps from global emissions targets in 2030



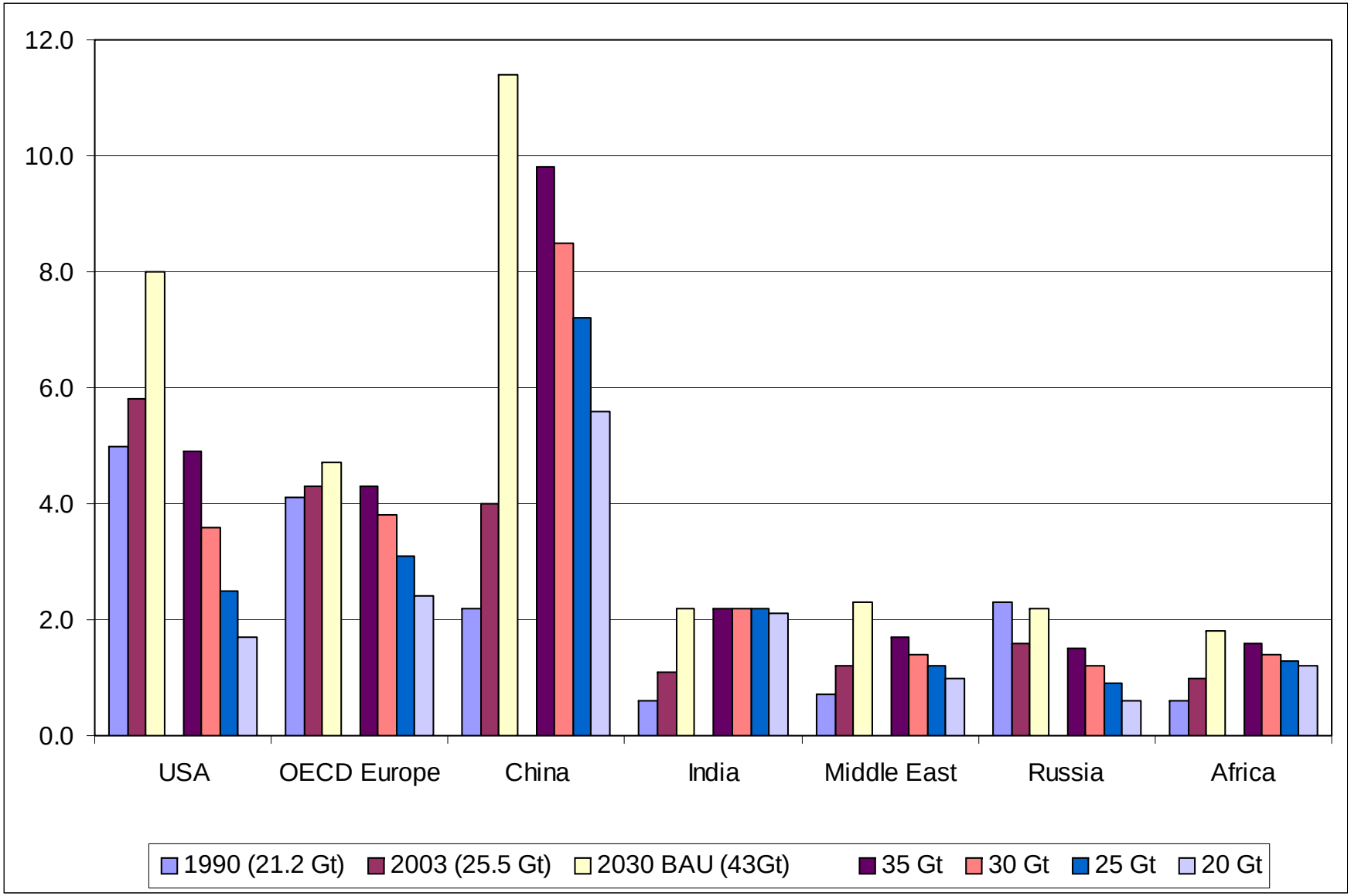
# Population within the cap by region



# 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.

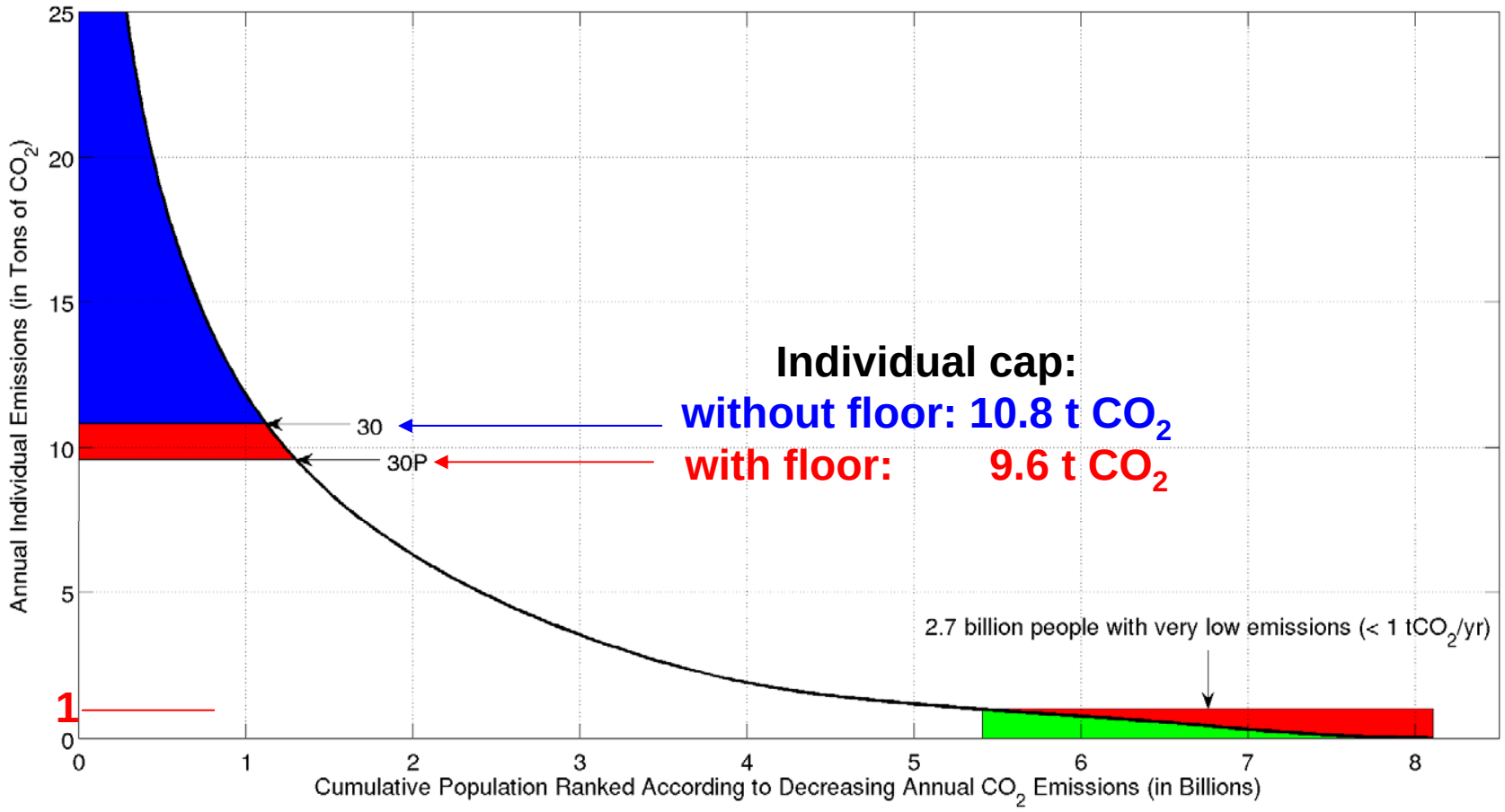
In our specific example, below, a floor is set at 1 $tCO_2$/year.

# What does 1 $tCO_2$/person-yr allow today?

| *Direct Energy Use* | *Household rate of use (4.5 people)* | *Individual emissions ($kgCO_2/yr$)* |
|---|---|---|
| Cooking | 1 LPG canister per month | 120 |
| Transport | 15 km per day | 220 |
| Electricity | 800 kWh per yr | 160 |
| *Total* | | *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 $GtCO_2$ global emissions cap plus 1 $tCO_2$ 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

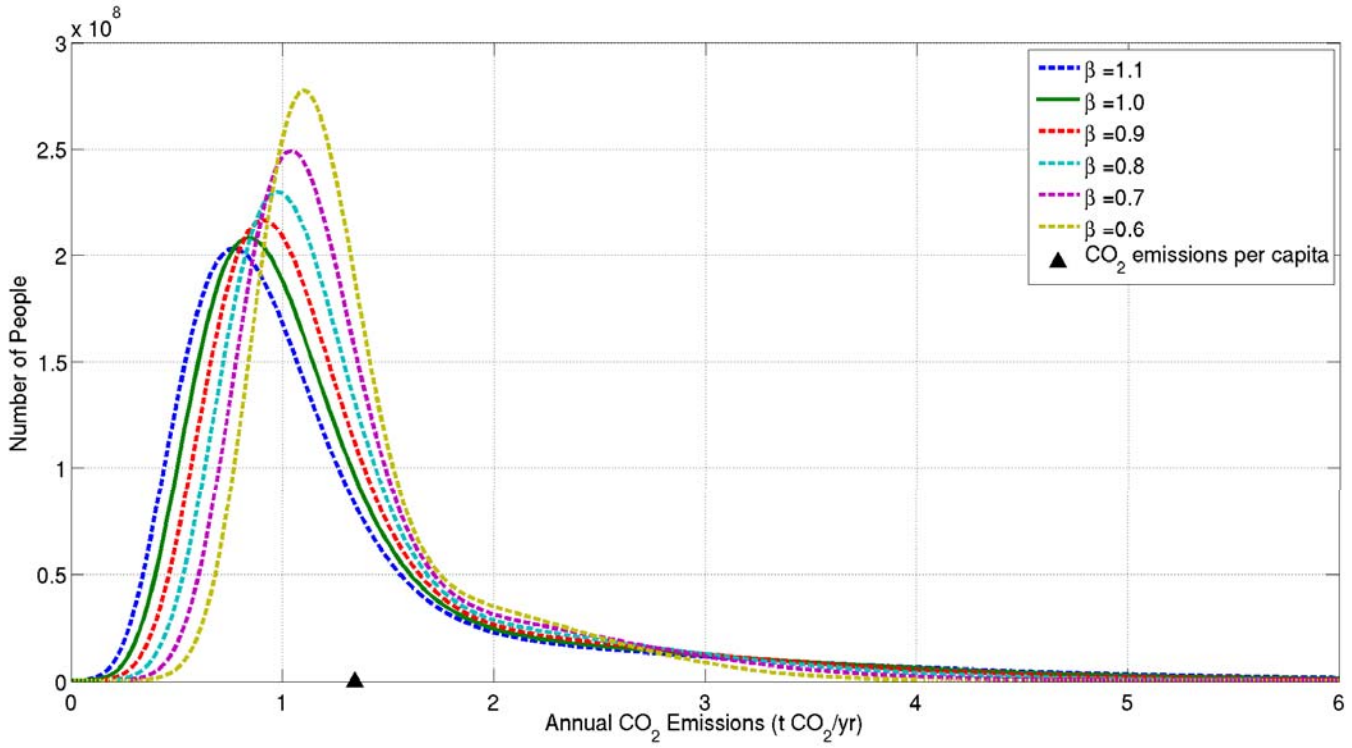
# Comparison with GDR

- Same basic approach to address country level inequality, some methodological differences. Also, unlike GDR, we do not address the issue of historical emissions.

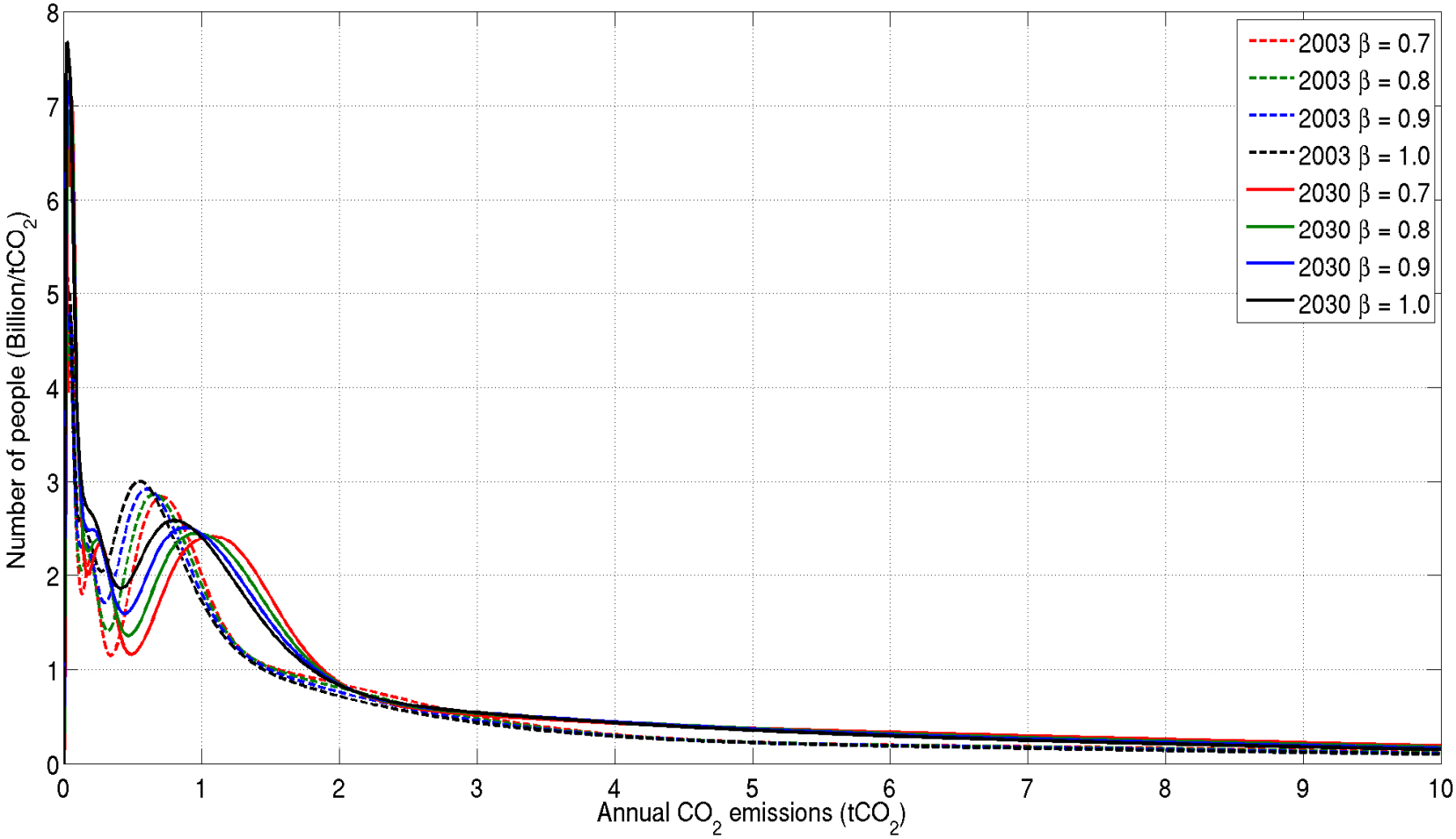
- Big difference in the procedure for setting national/regional emissions targets.
  - GDR: Divide the job of emissions reduction according to RCI
  - This work: Use individual emissions cap to obtain new emissions target. No negative emissions.

# Sensitivity Analysis

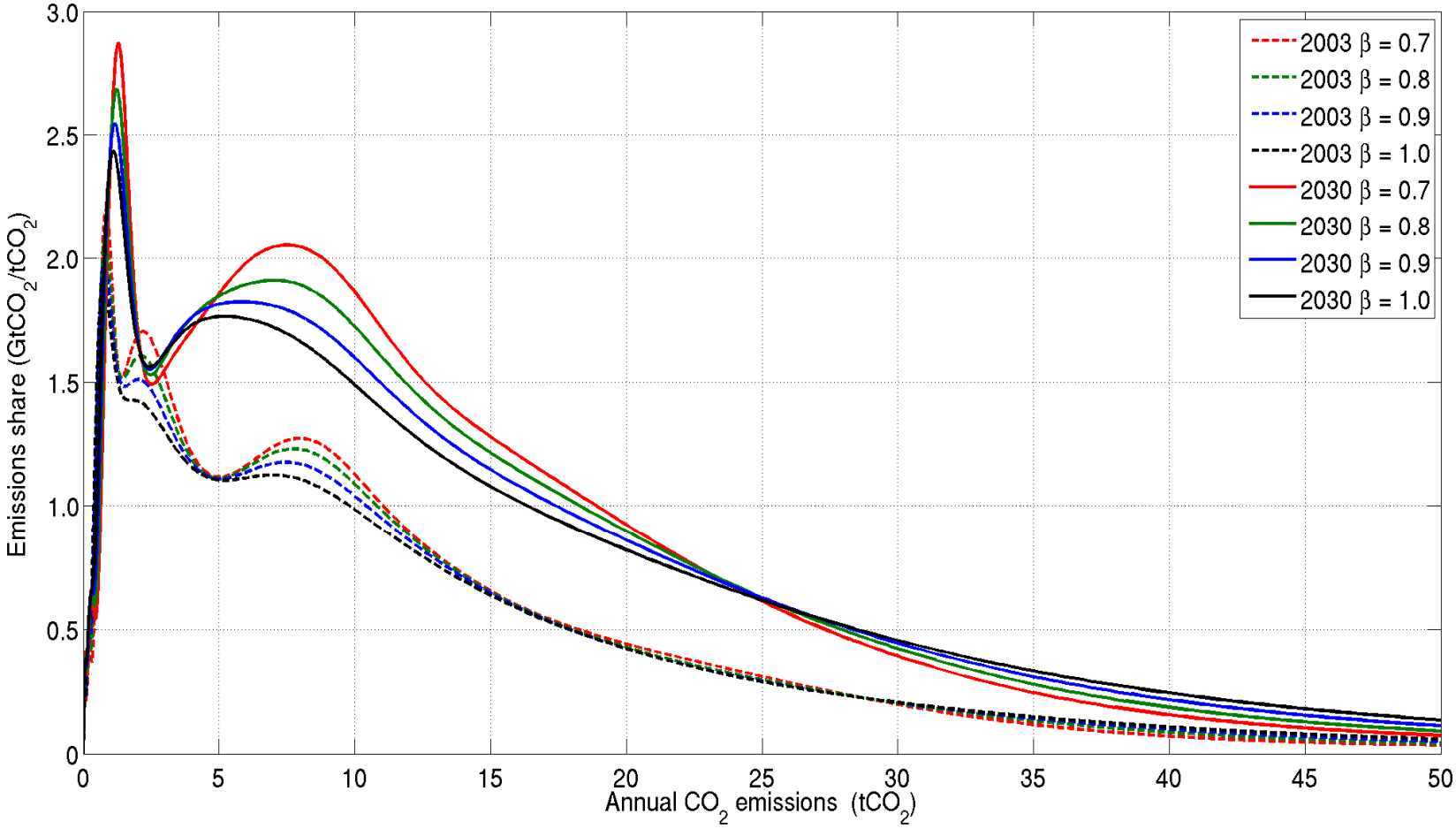
So far, we assumed that the emissions to income elasticity is 1. We now consider the effect of relaxing this assumption. Consider the effect on the distribution of a single country:



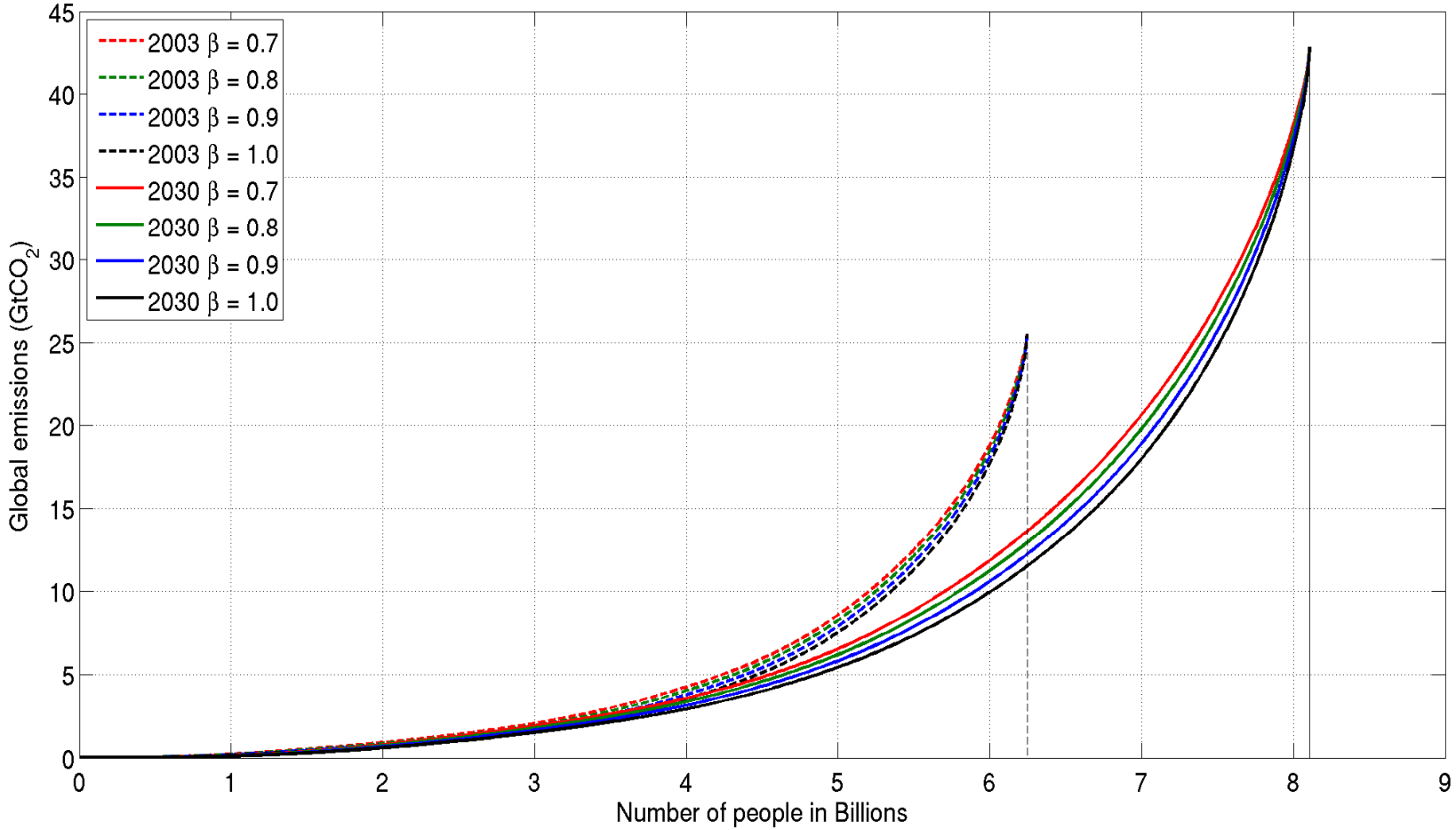
# Distribution of emitters for different elasticities (0.7-1.0)



# Distribution of emitters for different elasticities.



# Emissions “Lorenz curve” for different elasticities

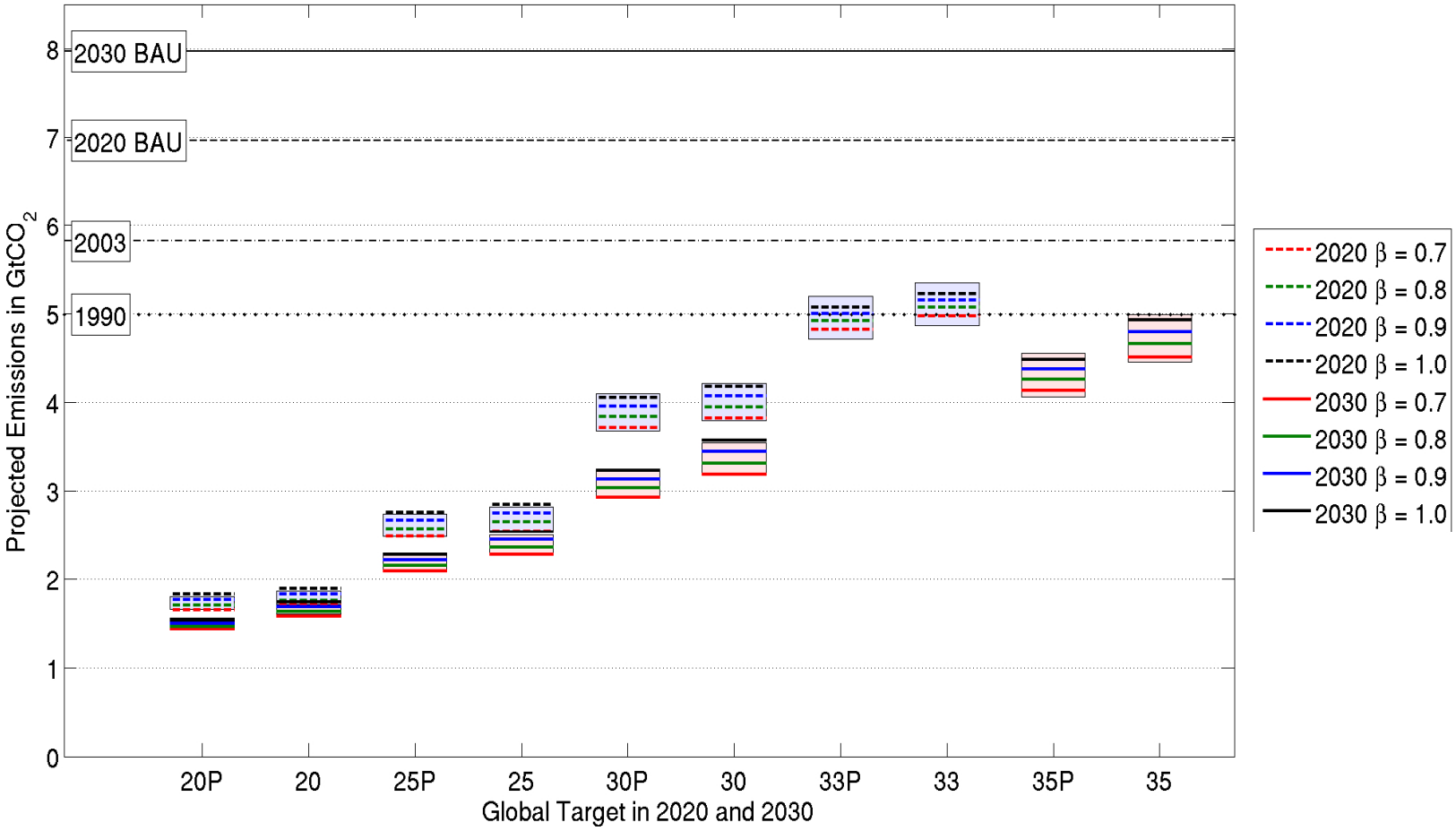


# Change in the personal emissions cap with elasticity.

| Year | Elasticity ($\beta$) | 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 $GtCO_2$. '20P' also includes a poverty floor of 0.5 $tCO_2$ in 2020 and 1.0 $tCO_2$ in 2030. The table shows how the cap changes for different constant elasticities of $CO_2$ emissions with consumption expenditure. BAU emissions in 2020 and 2030 are projected to be 36.8 $GtCO_2$ and 42.9 $GtCO_2$ respectively. The individual caps for the '30' and '30P' scenario (**10.8** $tCO_2$ and **9.6** $tCO_2$, respectively) in 2030 are extensively used in the main text.

# U.S.


2030 BAU
2020 BAU
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1990
Projected Emissions in GtCO2
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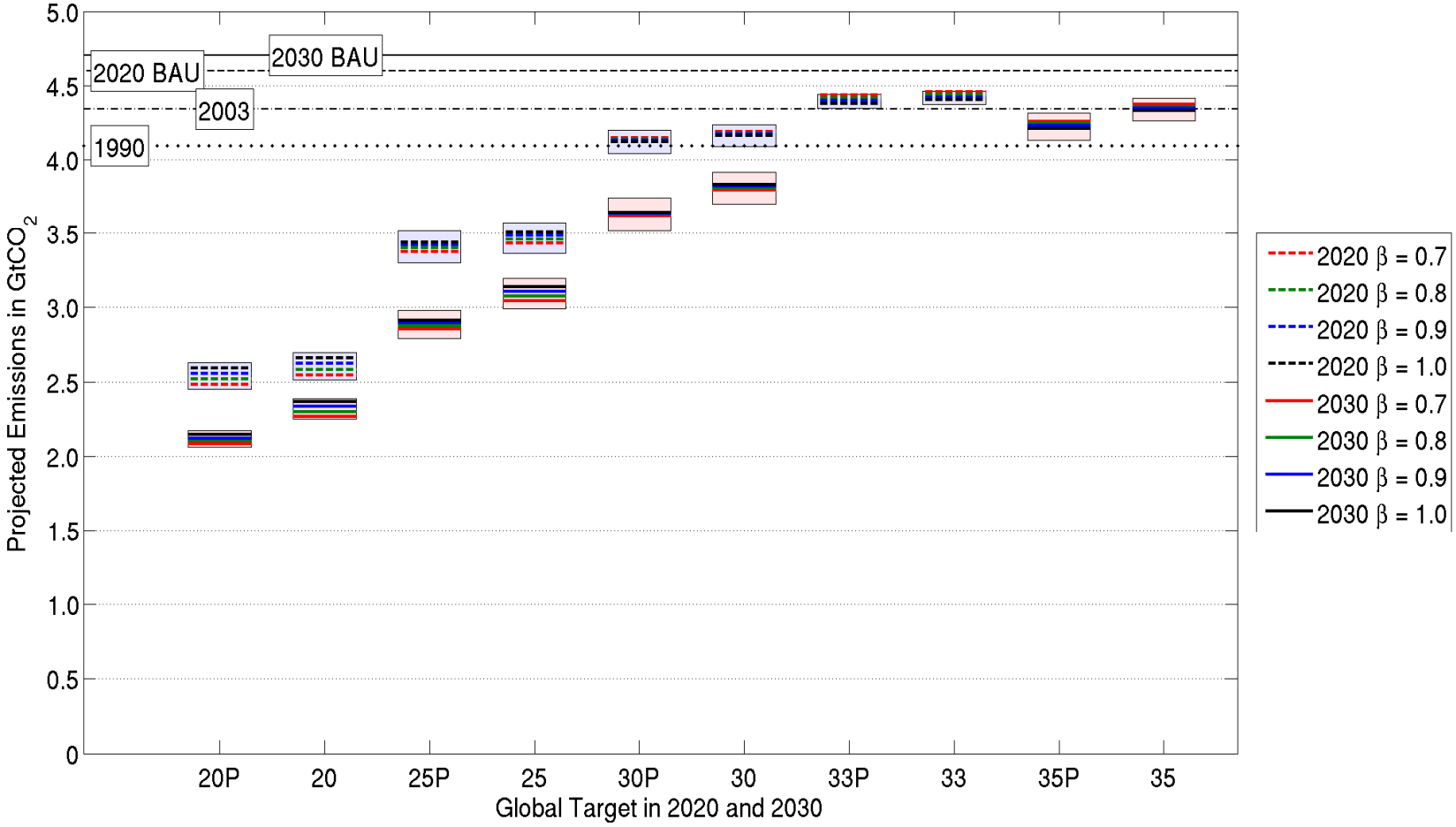
35
Global Target in 2020 and 2030
2020 β = 0.7
2020 β = 0.8
2020 β = 0.9
2020 β = 1.0
2030 β = 0.7
2030 β = 0.8
2030 β = 0.9
2030 β = 1.0

# OECD Europe


2020 BAU
2030 BAU
2003
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Projected Emissions in GtCO2
5.0
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Global Target in 2020 and 2030
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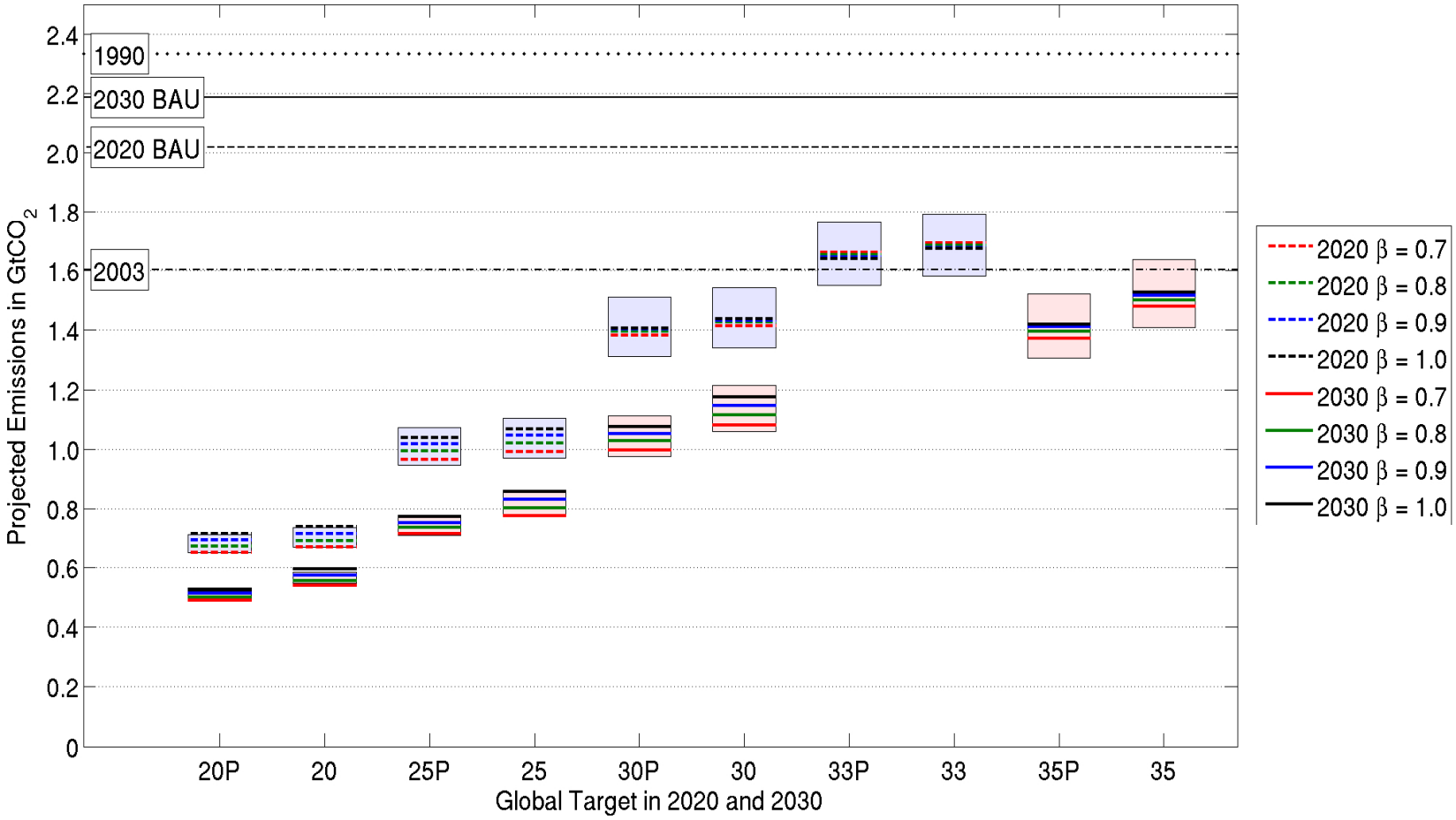
2020 β = 0.8
2020 β = 0.9
2020 β = 1.0
2030 β = 0.7
2030 β = 0.8
2030 β = 0.9
2030 β = 1.0

# Russia


1990
2030 BAU
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Projected Emissions in GtCO2
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33P
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35P
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Global Target in 2020 and 2030
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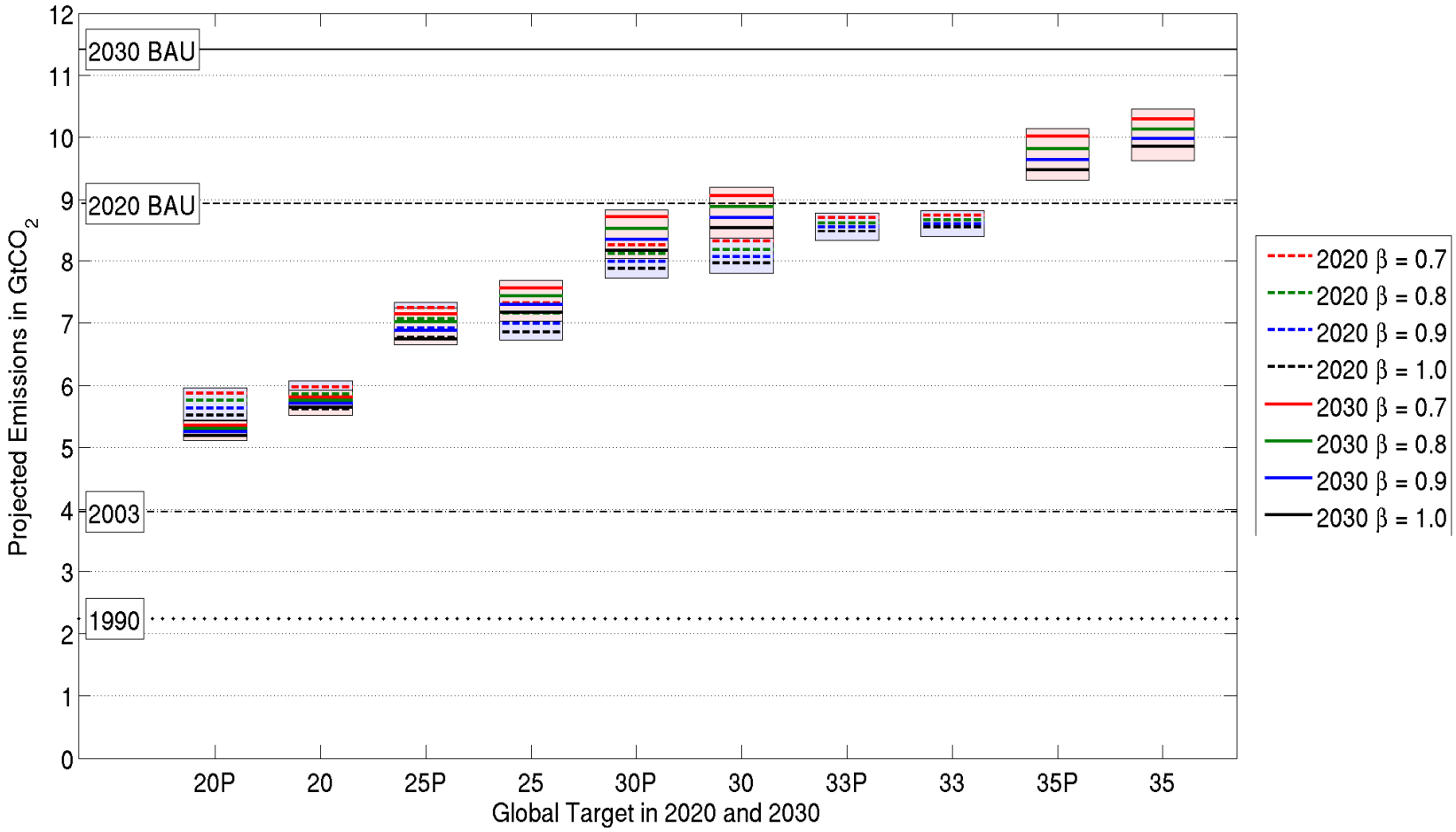
2020 β = 0.9
2020 β = 1.0
2030 β = 0.7
2030 β = 0.8
2030 β = 0.9
2030 β = 1.0

# China


2030 BAU
2020 BAU
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Projected Emissions in GtCO2
Global Target in 2020 and 2030
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2020 β = 0.7
2020 β = 0.8
2020 β = 0.9
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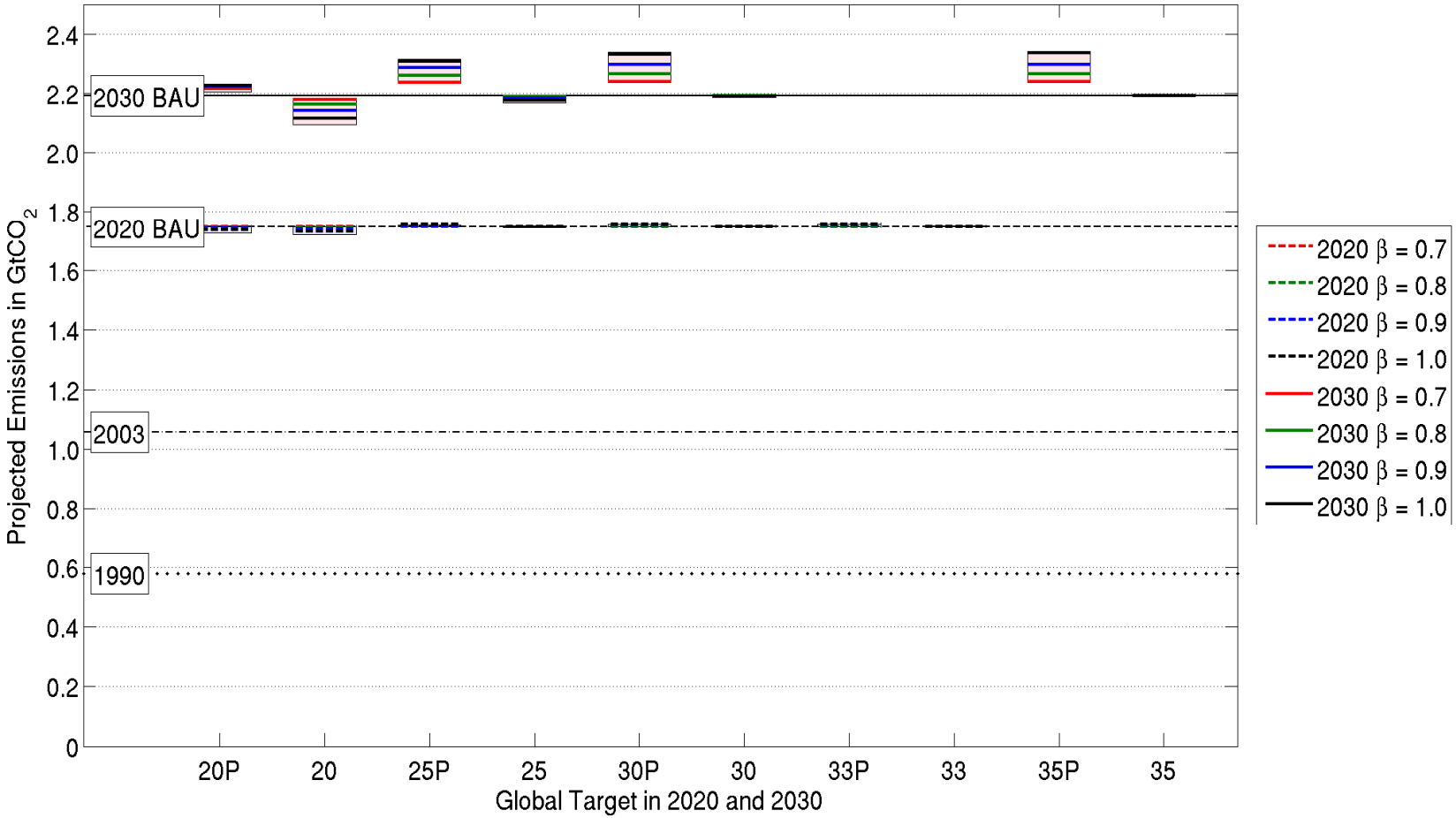
# India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2030 BAU
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Global Target in 2020 and 2030
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2020 β = 0.8
2020 β = 0.9
2020 β = 1.0
2030 β = 0.7
2030 β = 0.8
2030 β = 0.9
2030 β = 1.0

# 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.