# Fall Term - 2013

# Woodrow Wilson School 585b

## Living in a Greenhouse: Technology and Policy


## Robert Socolow

## Phil Hannam, AI


## Week Five: October 9, 2013

## Individual demand, footprints, and poverty

# Next four classes

***L4 (October 7, two days ago)***
Fossil energy below ground (begun in L3)
Conversion of fossil fuel into  electricity, vehicle fuel, and heat

***L5 (October 9, today)***
AR5 WG1 SPM (drawing on your First Papers, submitted Tuesday at midnight)
Personal energy use
- One billion high emitters
- Poverty

***L6 (October 16, a week from today)***
Personal energy use
- Your own (drawing on your Second Problem Sets **(I encourage you to submit electronically by Tuesday, October 15, at midnight)**

National and regional energy strategies
*Guest at 3 pm: Jim Hansen*

***L7 (October 21, the following Monday)***
Phil Hannam: International governance and the climate regime

BREAK WEEK (L8 is November 6, 16 days later)

# Class 5 Preamble: AR5 WG1 SPM

What did you notice? We'll make a list on the blackboard

My own experience last week:

Some observations and questions

An exchange with a *Nature* reporter, leading to being quoted.

What did you notice? We’ll make a list on the blackboard

# IPCC SPM: Did the scientists "embrace" anything?

Justin Gillis, the New York Times correspondent, dateline Stockholm, Friday Sept 27, lead sentence: The scientists "embraced" an upper limit. *Did they?*

> "To stand the best chance" of remaining below "an internationally agreed target" [2$^{o}$C], only about 1 TgC "can be burned " and "spewed in the atmosphere"
>
> "Just over" 0.5 TtC has been emitted "since the Industrial Revolution."
>
> "More than" 3 TtC "still left in the ground as fossil fuels."
>
> "Forest destruction" is in some sentences but not others.

I concluded that Gillis was overreaching and the scientists had not "embraced" 2$^{o}$C.

# IPCC AR4 and AR5 SPM Forcings

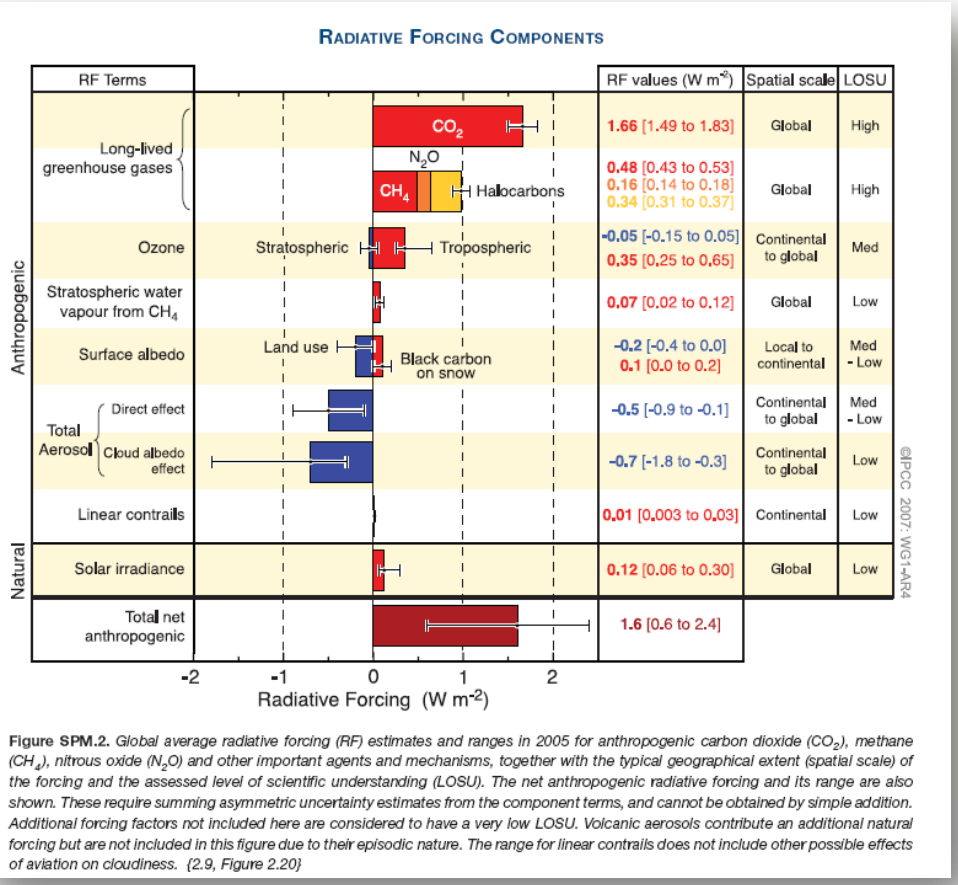
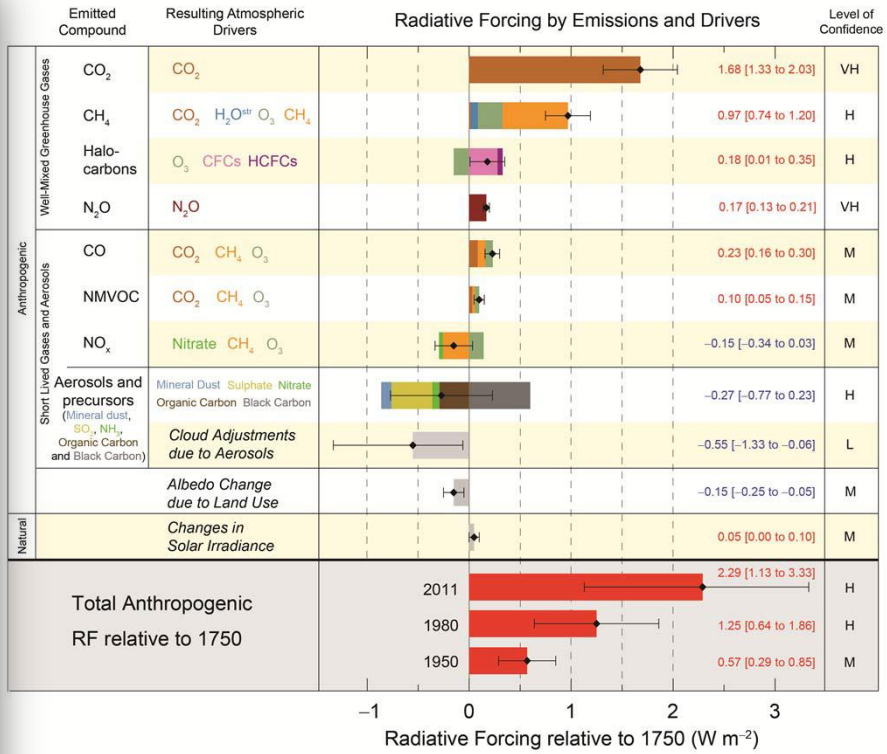



**Figure SPM.2.** *Global average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms, and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. The range for linear contrails does not include other possible effects of aviation on cloudiness. {2.9, Figure 2.20}*




*Observations*:

$CO_2$ error bar is larger in AR5.

Black carbon is separately reported, large, and positive in AR5.

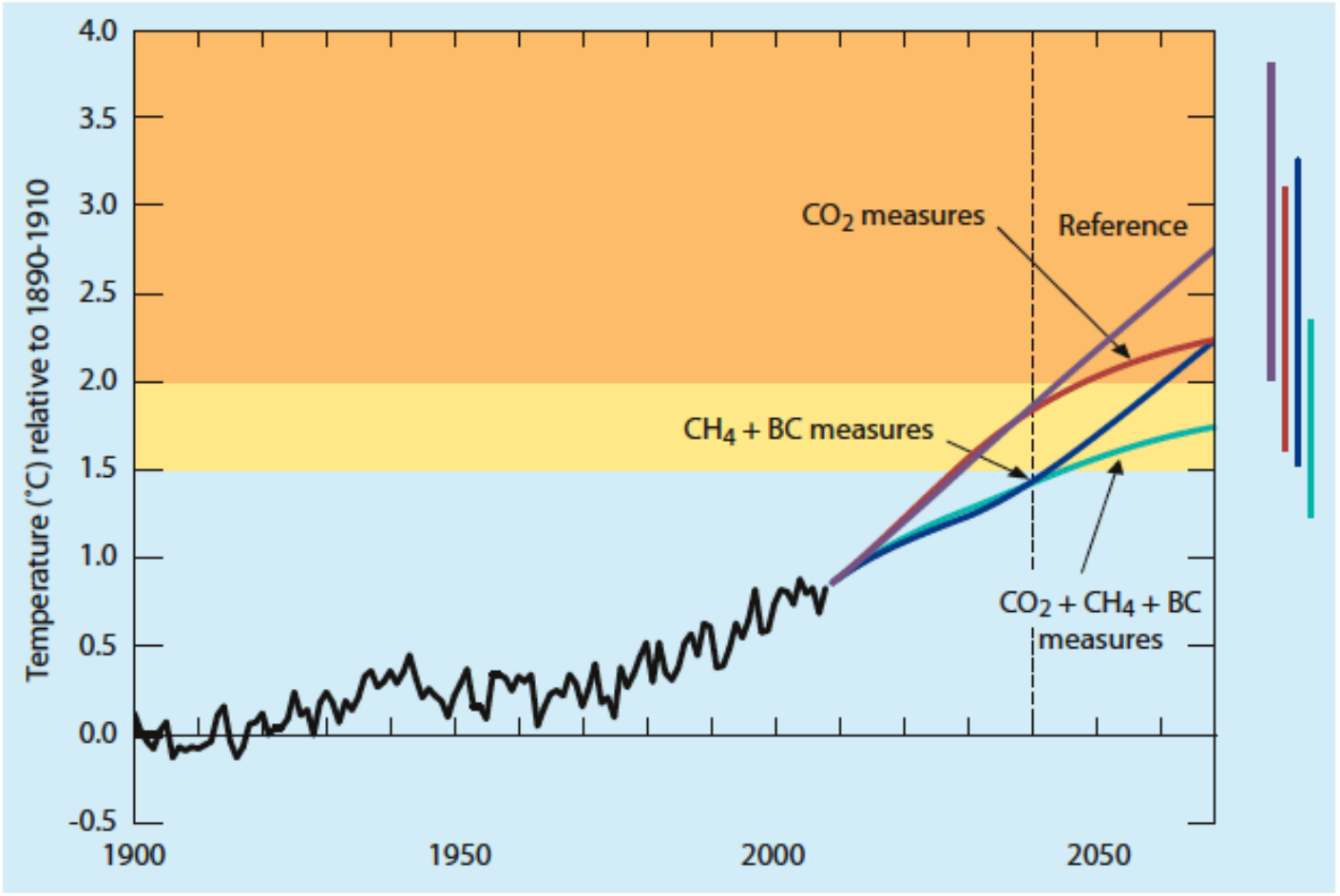
# Problematic 2ºC carbon-budget results on page SPM-20 re other GHGs

IPCC Text: "Limiting the warming caused by anthropogenic $CO_2$ emissions alone with a probability of >33%, >50%, and >66% to less than 2˚ C since the period 1861–1880 will require cumulative $CO_2$ emissions from all anthropogenic sources to stay between 0 and about 1560 GtC, 0 and about 1210 GtC, and 0 and about 1000 GtC since that period respectively. These upper amounts are reduced to about 880 GtC, 840 GtC, and 800 GtC respectively, when accounting for non-$CO_2$ forcings as in RCP2.6. An amount of 531 [446 to 616] GtC, was already emitted by 2011. {12.5}"

| | **66% avoidance (GtC)** | **33% avoidance (GtC)** |
|---|---|---|
| **CO2 only** | 1000 | 1560 |
| **CO2 + other GHGs** | 800 | 880 |

*SOMETHING IS FISHY. I have written various IPCC authors, so far without results, as follows:* "The budget for avoiding 2ºC with probabilities of 33% and 66% are far apart for $CO_2$ only, but nearly the same when non-$CO_2$ forcings are included: For $CO_2$ only, 1560 vs. 1000 GtC, but for all forcings, 860 vs. 800 GtC. Can you explain why adding $CH_4$ and what-not shrinks the range?"

# Problematic 2ºC carbon-budget results on page SPM-20 re other GHGs




Source: UNEP/WMO (2011) using an average of two global composition-climate models (GCMs) that estimate pollutant concentrations, radiative forcing and global climate

# Request from Daniel Creesey, reporter for *Nature*, re SPM, Sept 29, 2013 (1 of 2)

**From**: Cressey, Daniel [mailto:d.cressey@nature.com]
**Sent**: Friday, September 27, 2013 11:04 AM
**To**: Robert H. Socolow
**Subject**: Media query re geo-engineering in IPCC V

Dear Professor Socolow,

I'm one of the reporters at Nature and I'm looking into what the language about geo-engineering in the IPCC report means for the field, whether this indicates geo-engineering will now get more attention / funding from governments. I'm also interested in whether it has been acknowledged enough that some form of geo-engineering is unavoidable if we want to limit warming to 2 degrees, at least under some of the scenarios considered by IPCC.

As you've probably seen, the summary for policy makers has this phrase:
---
*A large fraction of anthropogenic climate change resulting from CO2 emissions is irreversible on a multi-century to millennial time scale, except in the case of a large net removal of CO2 from the atmosphere over a sustained period.*
---

# Request from Daniel Creesey, reporter for *Nature*, re SPM, Sept 29, 2013 (2 of 2)

And there's this longer specific paragraph on geo-engineering:

---

*Methods that aim to deliberately alter the climate system to counter climate change, termed geo-engineering, have been proposed. Limited evidence precludes a comprehensive quantitative assessment of both Solar Radiation Management (SRM) and Carbon Dioxide Removal (CDR) and their impact on the climate system. CDR methods have biogeochemical and technological limitations to their potential on a global scale. There is insufficient knowledge to quantify how much CO2 emissions could be partially offset by CDR on a century timescale. Modelling indicates that SRM methods, if realizable, have the potential to substantially offset a global temperature rise, but they would also modify the global water cycle, and would not reduce ocean acidification. If SRM were terminated for any reason, there is high confidence that global surface temperatures would rise very rapidly to values consistent with the greenhouse gas forcing. CDR and SRM methods carry side effects and long-term consequences on a global scale.*

---

I'm not entirely sure what to make of this and would welcome any comments from you on its significance. Regards, Daniel

**Daniel Cressey**
News Reporter
Nature
www.nature.com

# My note re SPM to Daniel Creesey, reporter for *Nature*, Sept 29, 2013 (1 of 2)

Introducing  is not embracing. The SPM introduces both the two-degree target and geoengineering. But it embraces neither one. For WG1 to have endorsed either a target or a particular responsive strategy would have been inappropriate, yet both endorsements are being read into the document.

Targets are discussed in a new way, relating them to cumulative carbon emissions thanks to papers of the past five years that identified a powerful linear relationship. People now can more productively consider the trade-off between improving the probability of meeting some target and the accelerating the move to a world less dominated by fossil fuels. Avoiding a two-degrees temperature rise with 66% probability by keeping cumulative emissions since 1750 below 1000 GtC is one example in the text. But nowhere does one find a recommendation for this constraint, which indeed is a formidable one.

# My note re SPM to Daniel Creesey, reporter for *Nature*, Sept 29, 2013 (2 of 2)

Similarly, the final paragraph of the document introduces geoengineering. The paragraph is a collection of warnings about deployment. Today's scrimmage line in the contest to push ahead toward achieving a capability to conduct geoengineering is at the point where the appropriateness of R&D is the issue. Neither opponents nor supporters of initiating R&D can find an embrace of their preference.

Personally, I recommend that all R&D be embedded in main-stream science, subject to the norms and discipline that main-stream science provides. Priority should be given to getting straight how the earth works, and learning how to manipulate it should be subordinated. There will be opportunities for dual-use research. While seeking to understanding clouds, one can expect to learn more about deliberate cloud brightening. Seeking to understand arctic ice dynamics, one can hope to learn how a human intervention might slow the arctic's contribution to sea-level rise. But first of all we will reduce our collective ignorance about clouds and ice. No message comes through from the SPM more forcefully than how urgent it is to improve earth system science.

# What was published

Many geoengineering experts complain about the lack of research in the field, and widespread deployment of the technologies seems a distant prospect.

The debate is "at the point where the appropriateness of [research and development] is the issue," says Robert Socolow, who works on carbon management and sequestration at Princeton University in New Jersey.

Socolow says that the focus now should be understanding how the Earth works, research that will serve two purposes. Studies of Arctic ice, for example, will help researchers to understand how intervention could slow sea-level rise, and work on clouds could contribute to solar-radiation management.

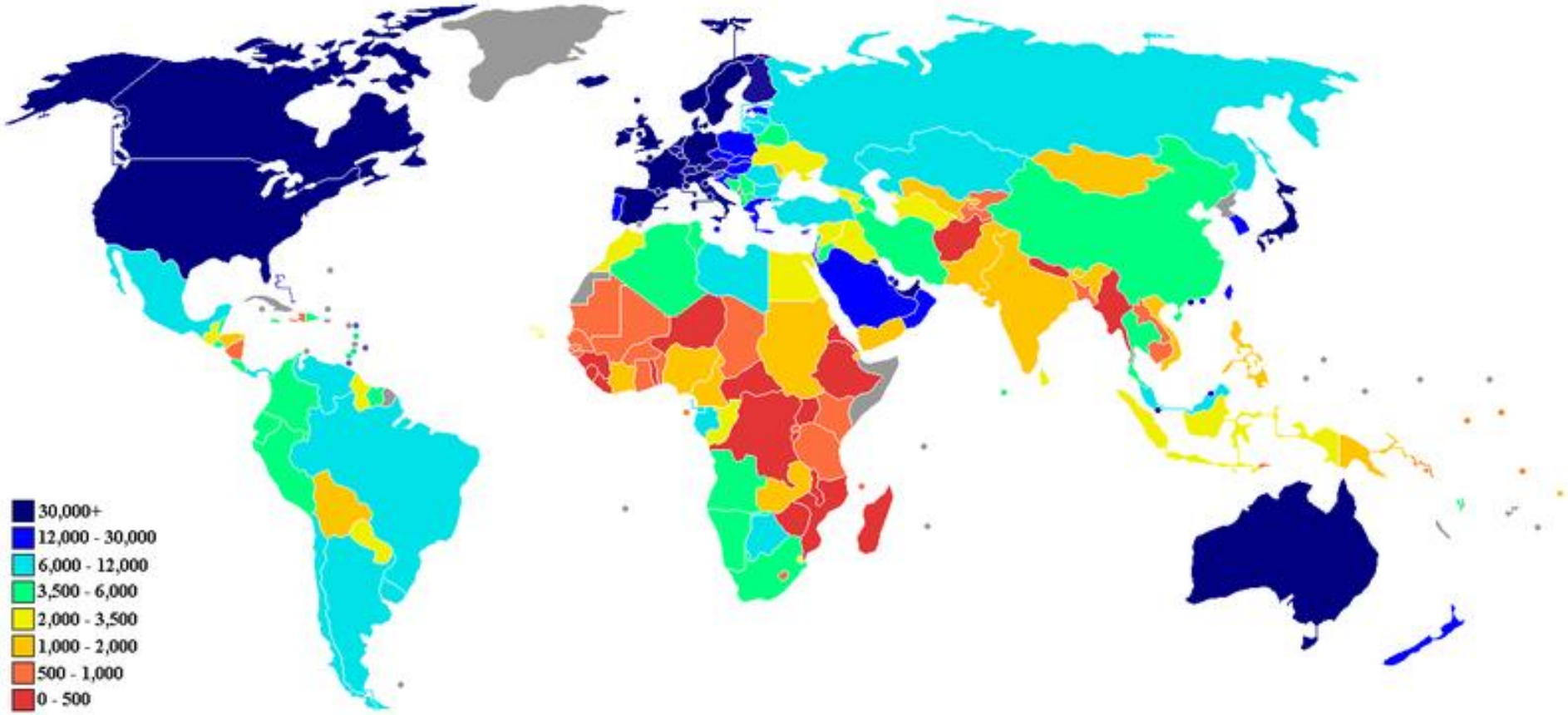
"But first of all we will reduce our collective ignorance about clouds and ice," he says. "No message comes through from the [summary for policy-makers] more forcefully than how urgent it is to improve Earth-system science."

http://www.nature.com/news/climate-report-puts-geoengineering-in-the-spotlight-1.13871, final four paragraphs.

# Class 5 Outline

One billion high emitters
Population
Poverty

# GDP per capita, 2009

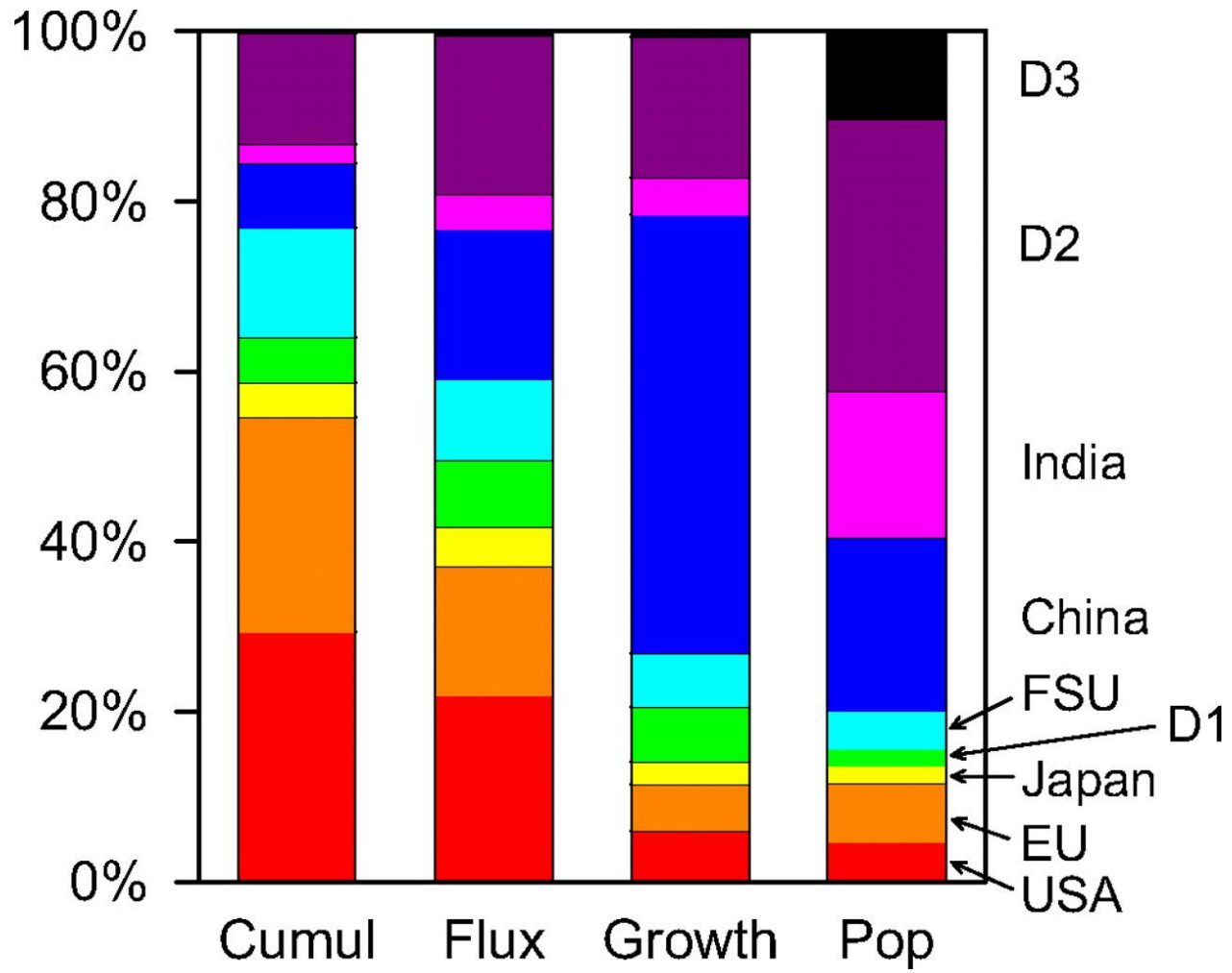



World Bank Statistics, Map from Wikipedia

# Gross domestic product 2010

| *Ranking* | *Economy* | *(millions of US dollars)* |
|---|---|---|
| 1 | United States | 14,582,400 |
| 2 | China | 5,878,629 |
| 3 | Japan | 5,497,813 |
| 4 | Germany | 3,309,669 |
| 5 | France | 2,560,002 |
| 6 | United Kingdom | 2,246,079 |
| 7 | Brazil | 2,087,890 |
| 8 | Italy | 2,051,412 |
| 9 | India | 1,729,010 |
| 10 | Canada | 1,574,052 |
| 11 | Russian Federation | 1,479,819 |
| 12 | Spain | 1,407,405 |
| 13 | Mexico | 1,039,662 |
| 14 | Korea, Rep. | 1,014,483 |
| 15 | Australia | *924,843* |
| 16 | Netherlands | 783,413 |
| 17 | Turkey | 735,264 |
| 18 | Indonesia | 706,558 |
| 19 | Switzerland | 523,772 |
| 20 | Poland | 468,585 |
| 21 | Belgium | 467,472 |
| 22 | Sweden | 458,004 |

Source: World Bank Statistics, 2011




**Relative contributions of nine regions to cumulative global emissions (1751–2004), current global emissions (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**

# The North-South Impasse

Five sixths of the world population are in the “South.”

*and*

half of the world’s emissions are in the South.

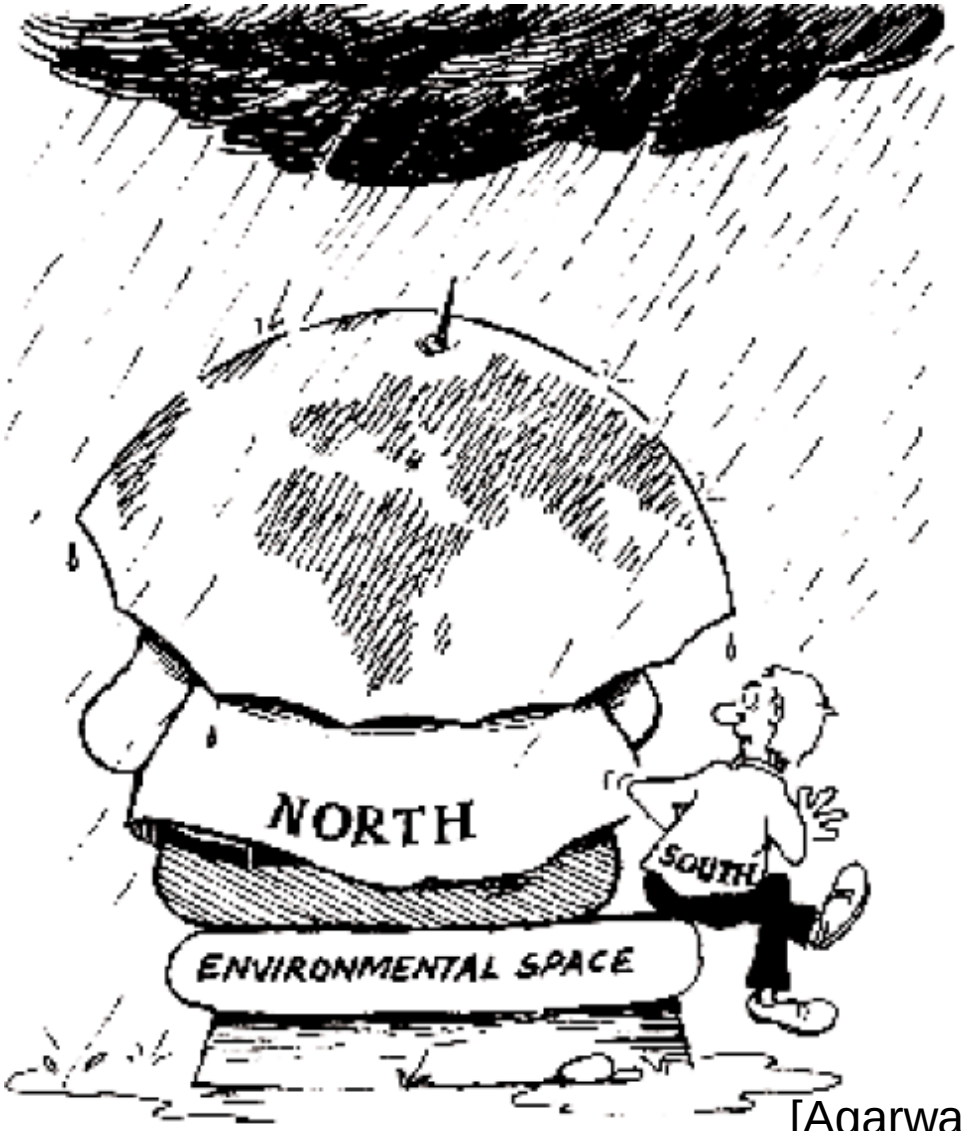
Says the South: “Our per capital emissions are negligible!”

Says the North: “If you ignore carbon, even if we go to zero you will wreck our common planet!”

# The North-South Impasse


[Agarwal and Narain 1991]

# The North-South Impasse




[Agarwal and Narain 1991]

# “Common but differentiated responsibilities”

In international agreements, “*common but differentiated responsibilities*” describes how much each nation is required to do to mitigate climate change. As initially stated, industrialized countries (“Annex One countries”) are required to reduce emissions, while developing countries get an indefinite pass.

What if the differentiation among nations were quantified not by per capita emissions but by the aggregate emissions of the high-emitting *individuals* (“high emitters”) in each country? This would be a new metric for “fairness.”

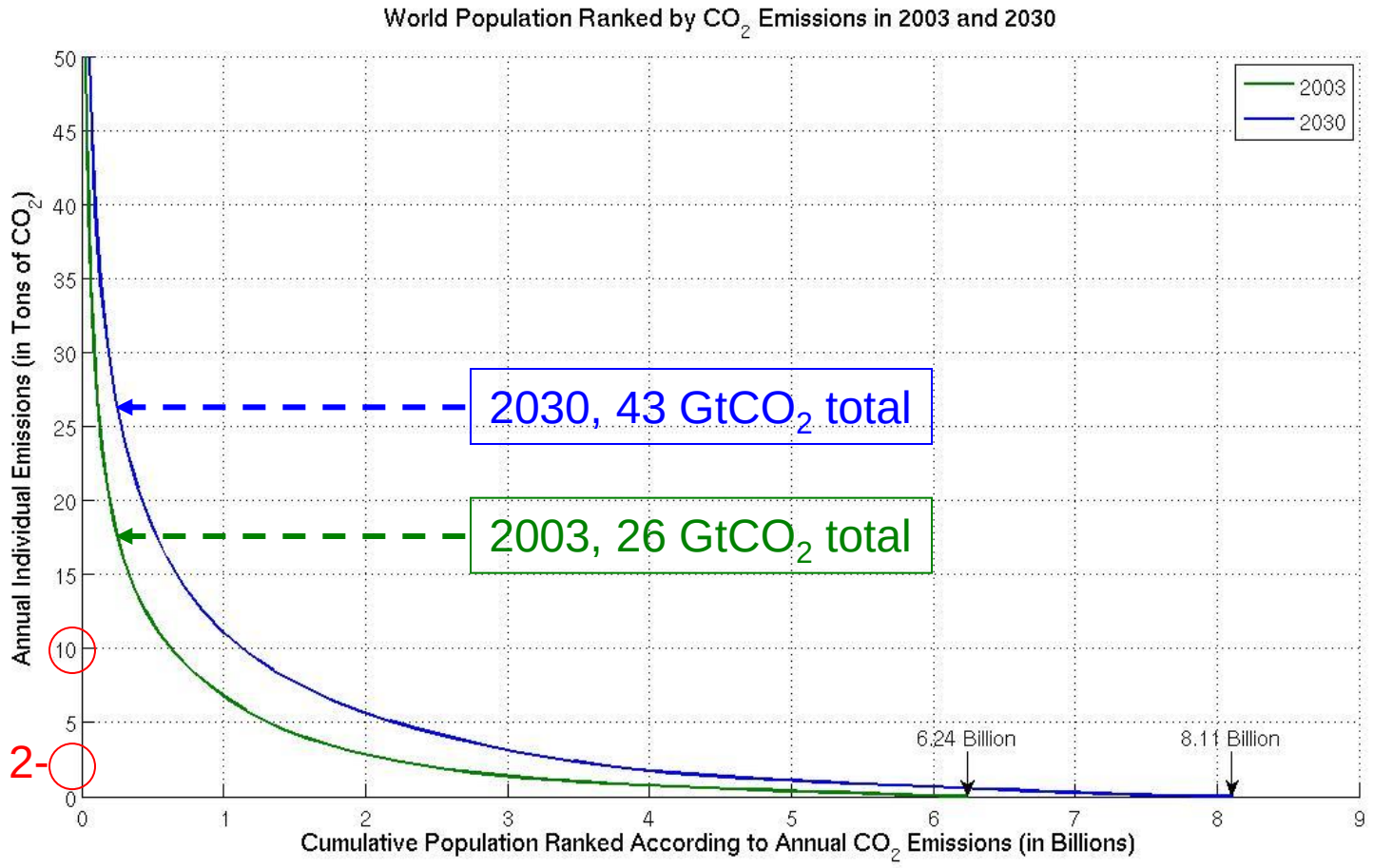
# Beyond per capita

We can't solve the climate problem without moving beyond "per capita" – looking *inside* countries.

What if "common but differentiated responsibilities" refers to individuals instead of nations?

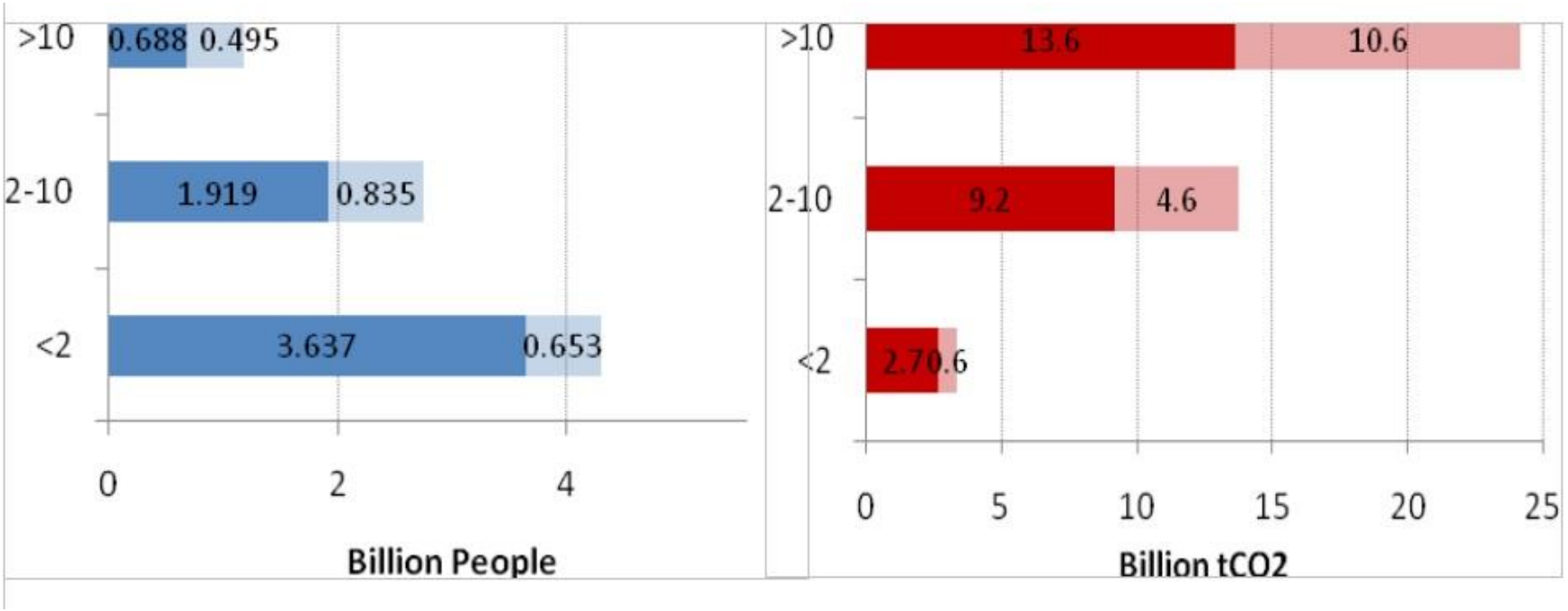
**"One-billion high emitters," *PNAS,* 2009. *Co-authors*: Shoibal Chakravarty, Ananth Chikkatur, Heleen de Coninck, Steve Pacala, Massimo Tavoni.**

# Ordered distribution of individual emissions, 2003 and 2030




For 2030, use EIA regional $CO_2$ projections, assume regional emissions distributions are unchanged.

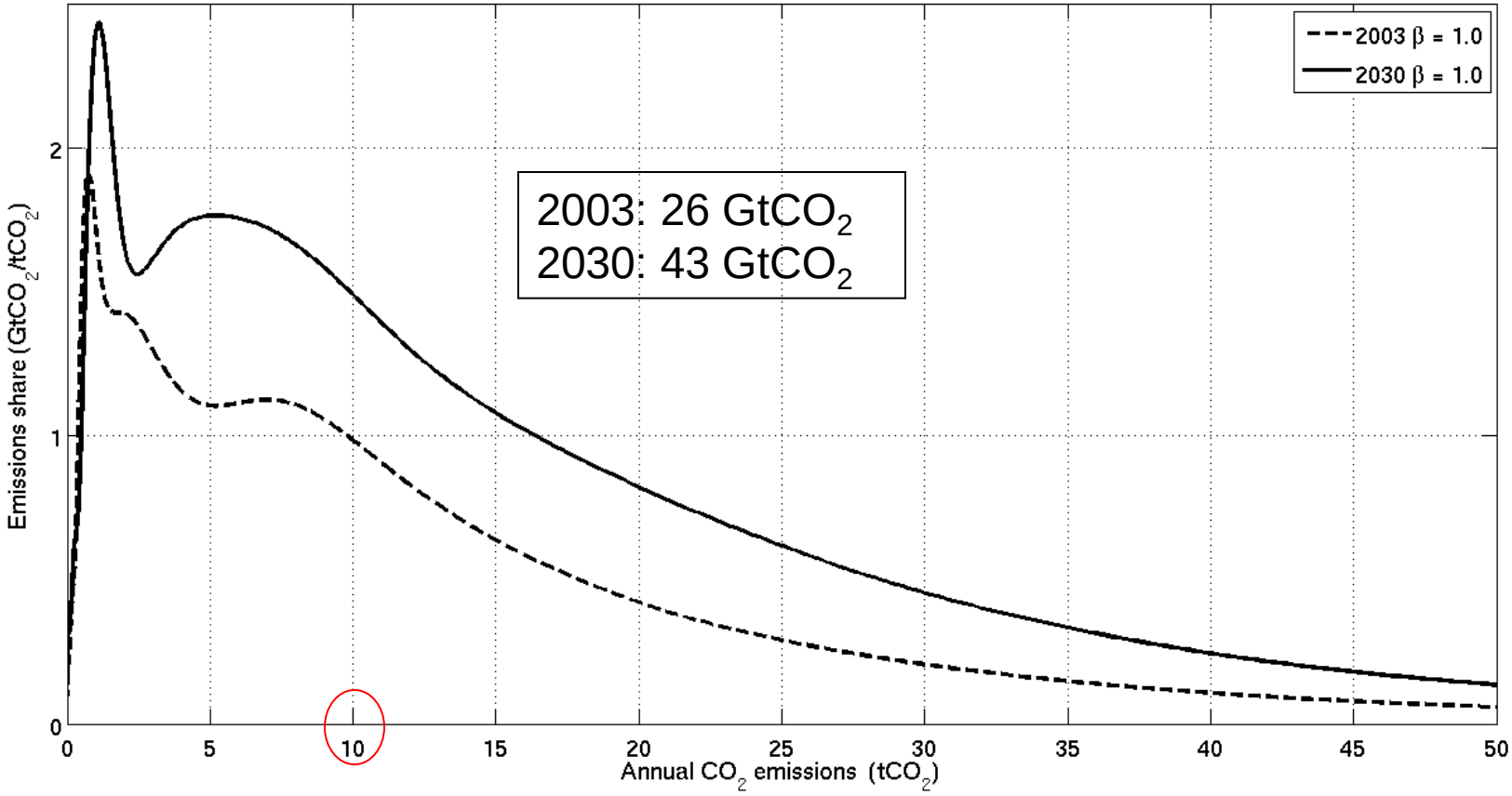
# Binning the world's individual emitters



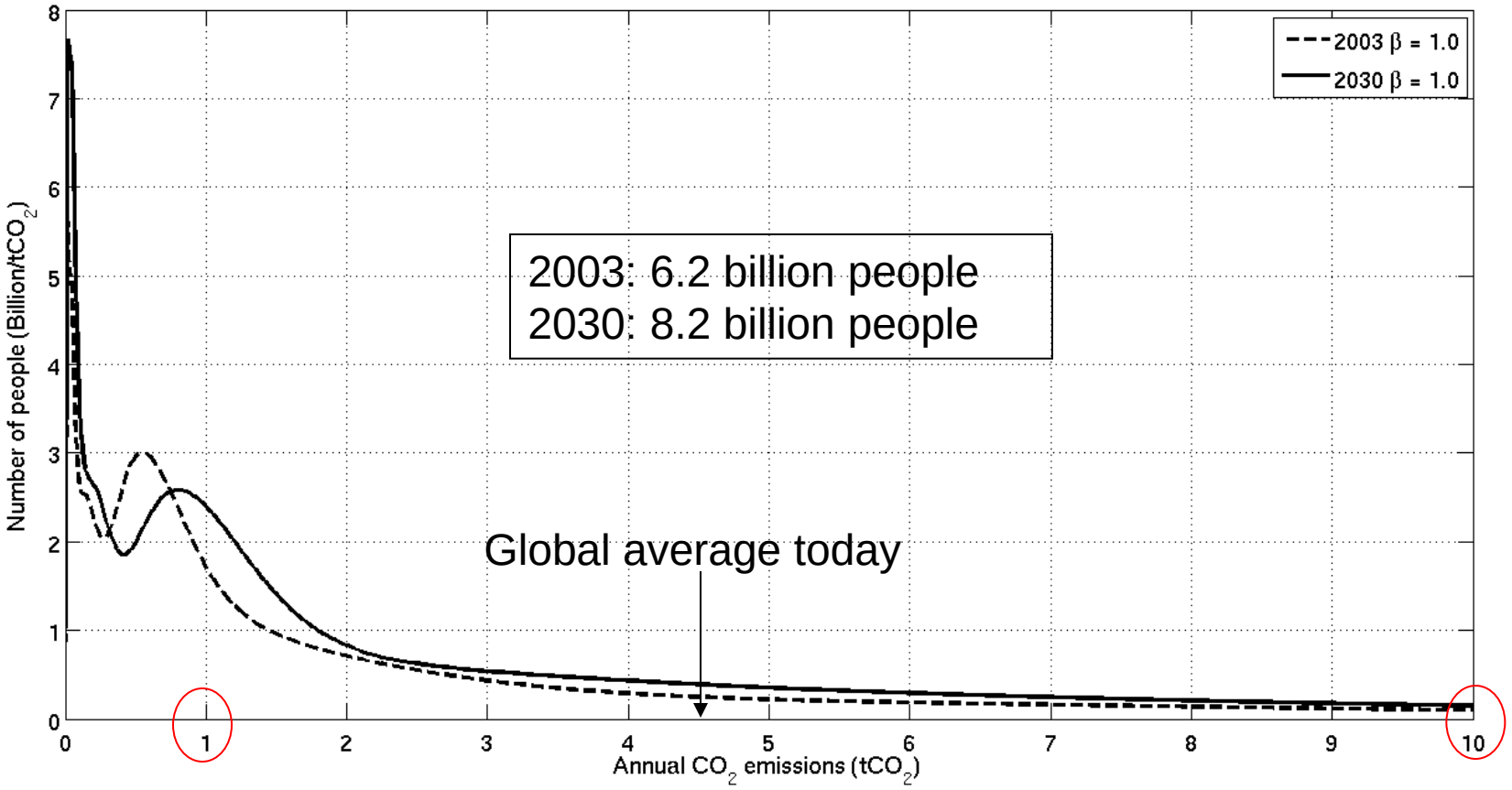

*Population (left panel) and emissions (right panel) for three individual emissions categories. The darker parts of the bars show 2003 data, and the lighter parts show additions from 2003 to 2030. Bin boundaries at 2 $tCO_2$/yr and 10 $tCO_2$/yr are approximately the 2003 per capita values for Brazil and the EU, respectively.*

*Source*: Chakravarty, Socolow, and Tavoni, 2009. Figure 1.
http://www.climatescienceandpolicy.eu/2009/11/afocus-on-individuals-can-guide-nations-towards-a-low-carbon-world/

# Distribution of global $CO_2$ emissions across individual emissions, 2003 and 2030

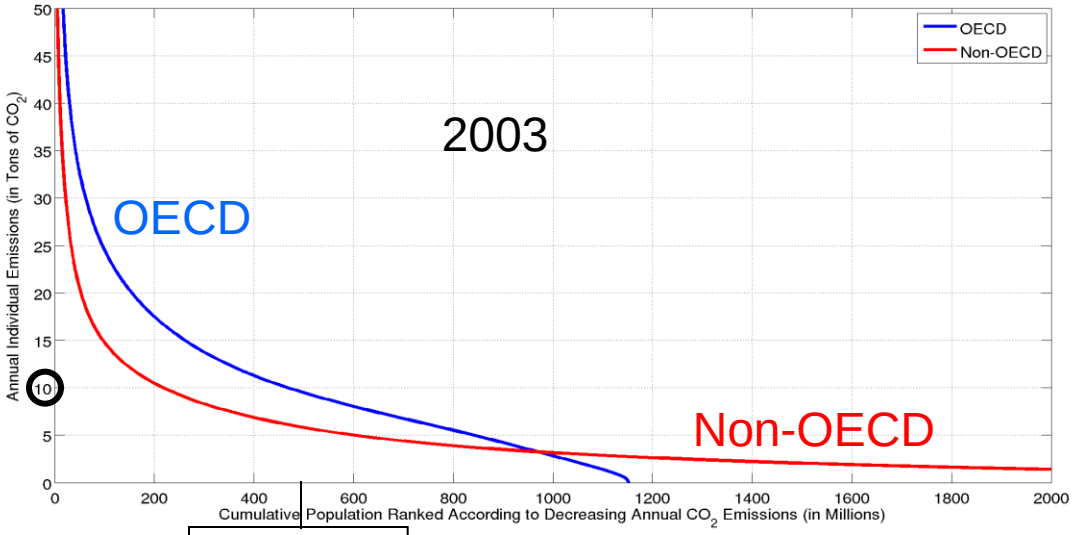


# Distribution of the world's population across individual emissions, 2003 and 2030

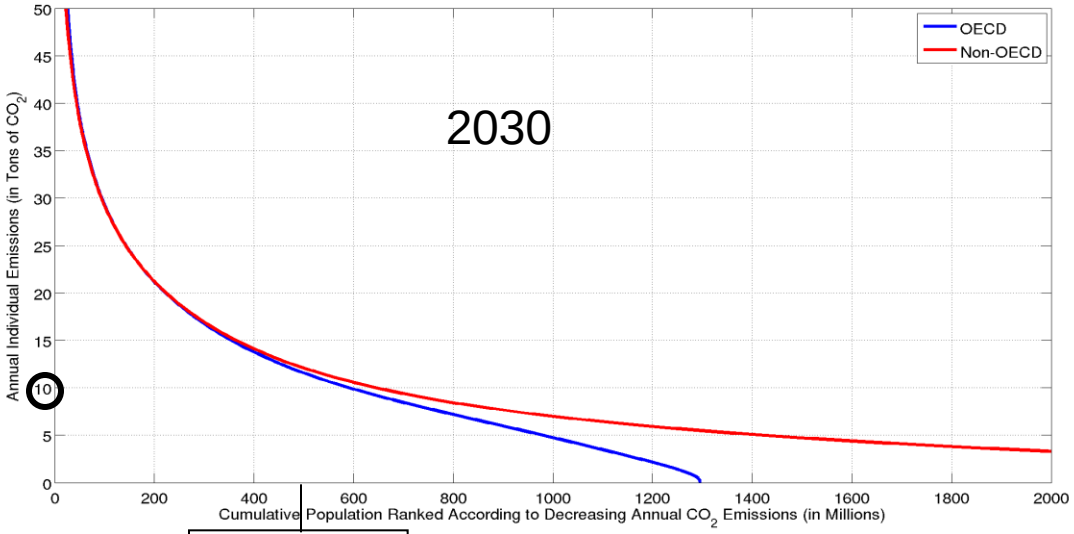



Note: linear scale. The high emitters are not in view.

# Ever more high emitters outside the OECD

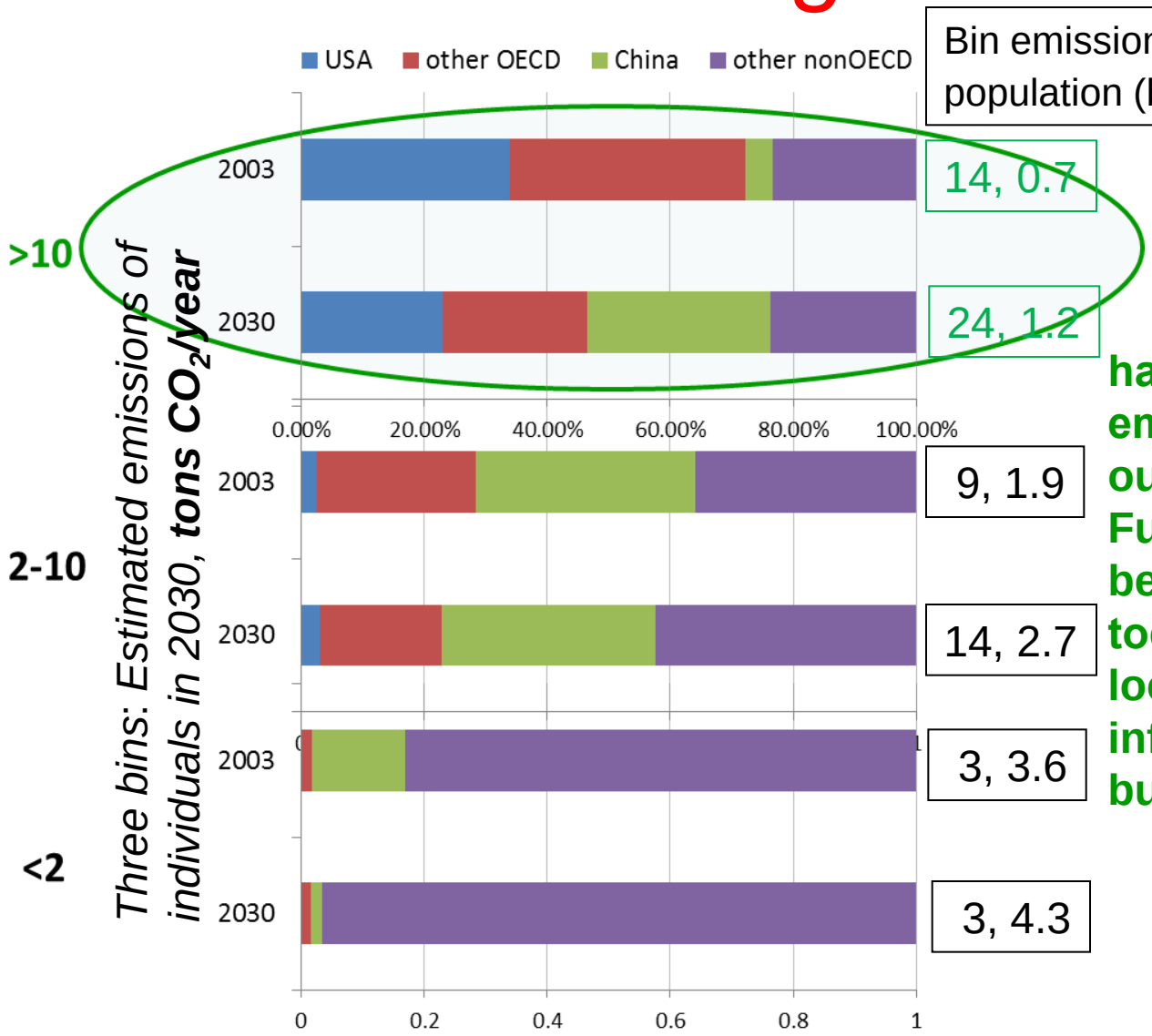



500 million




500 million

# One billion “high-emitters”

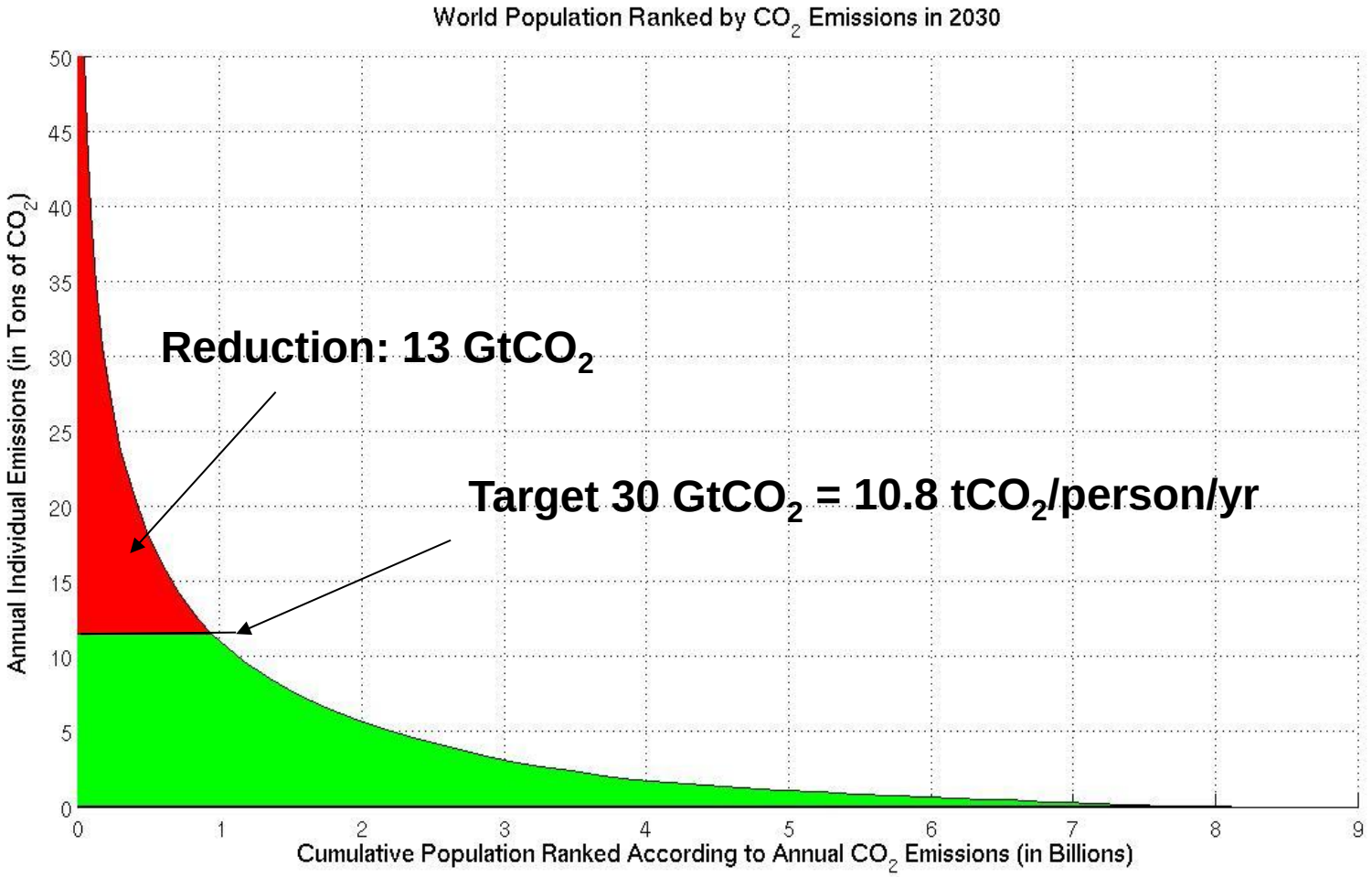



**In 2030, over half of the “high-emitters” will live outside the OECD. Future emissions are being determined by today’s national and local policies on infrastructure, buildings, land use.**

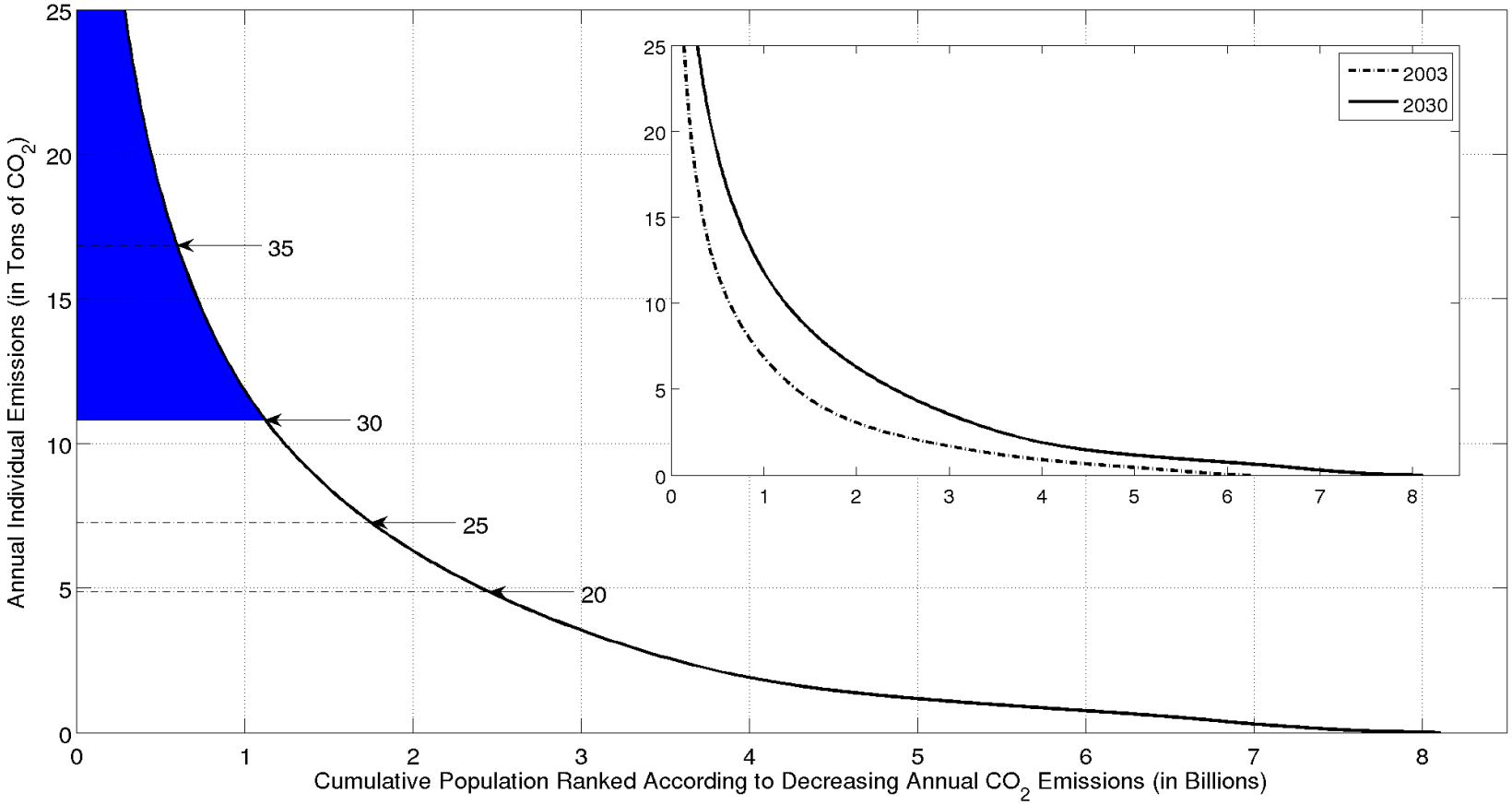
*Source*: http://www.climatescienceandpolicy.eu/2009/11/afocus-on-individuals-can-guide-nations-towards-a-low-carbon-world

# A policy proposal

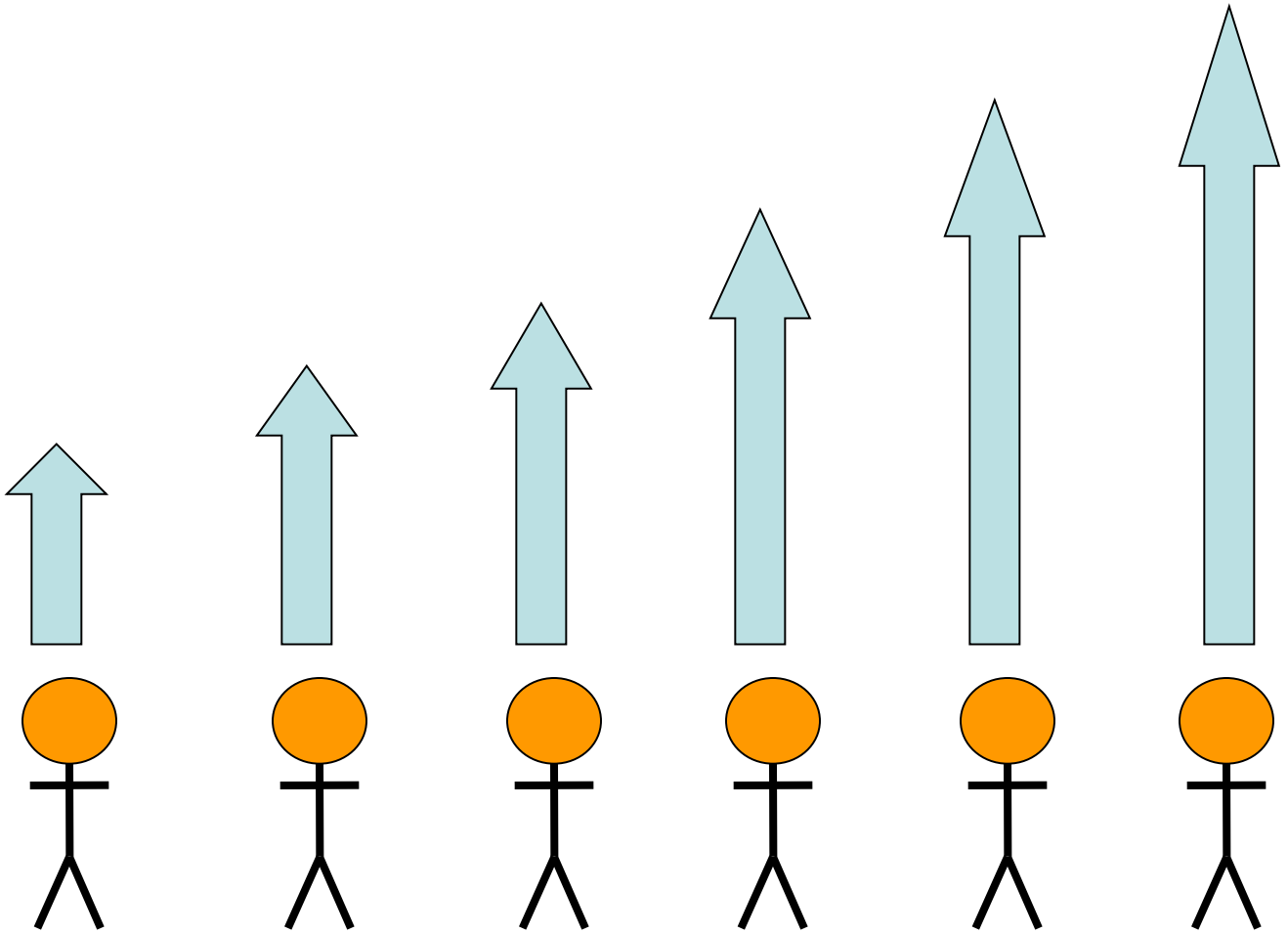
# Choose a global target: 30 $GtCO_2$ in 2030



# Alternative 2030 global emissions targets and corresponding individual emissions caps

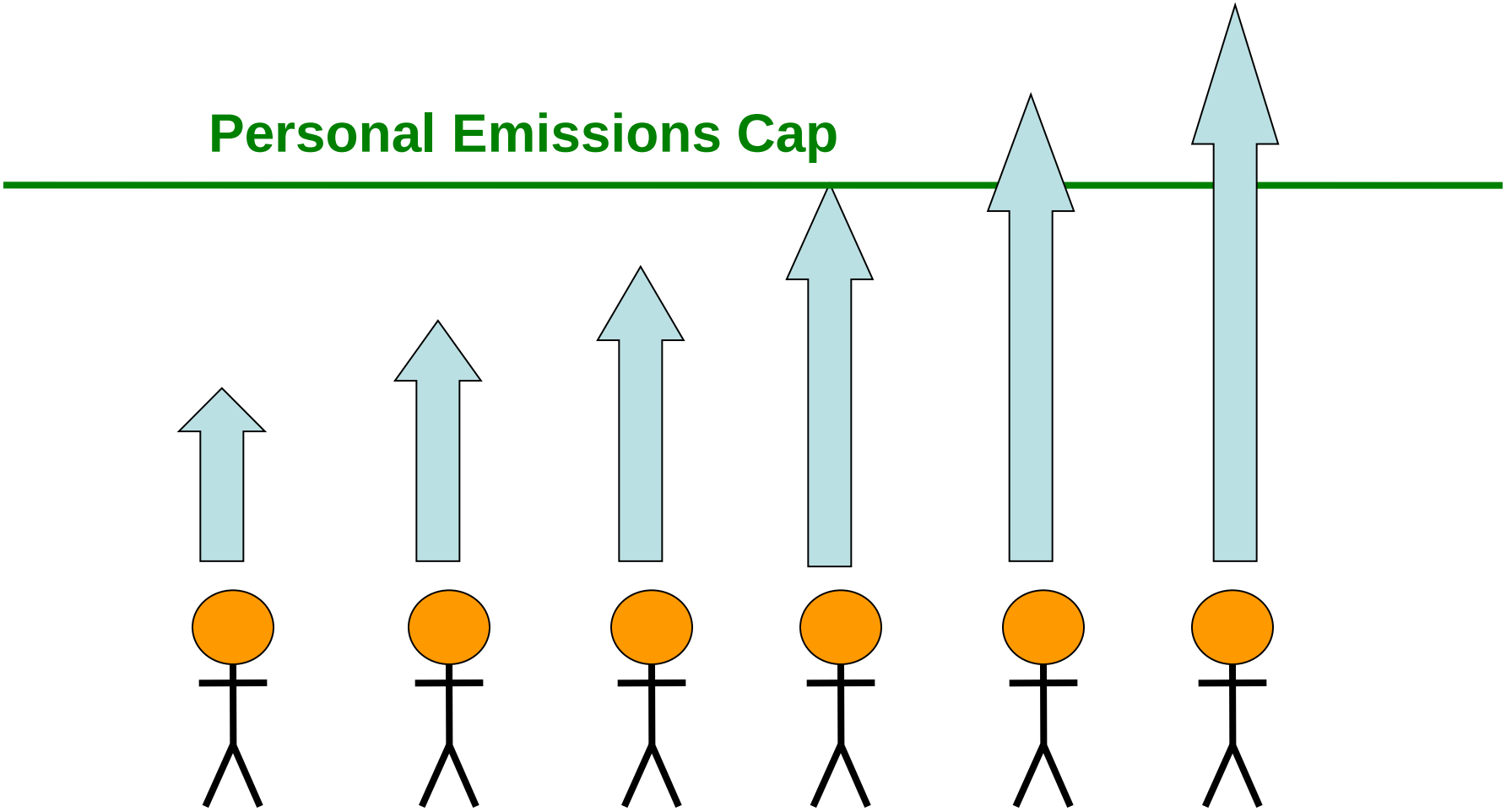


# People ranked by personal emissions



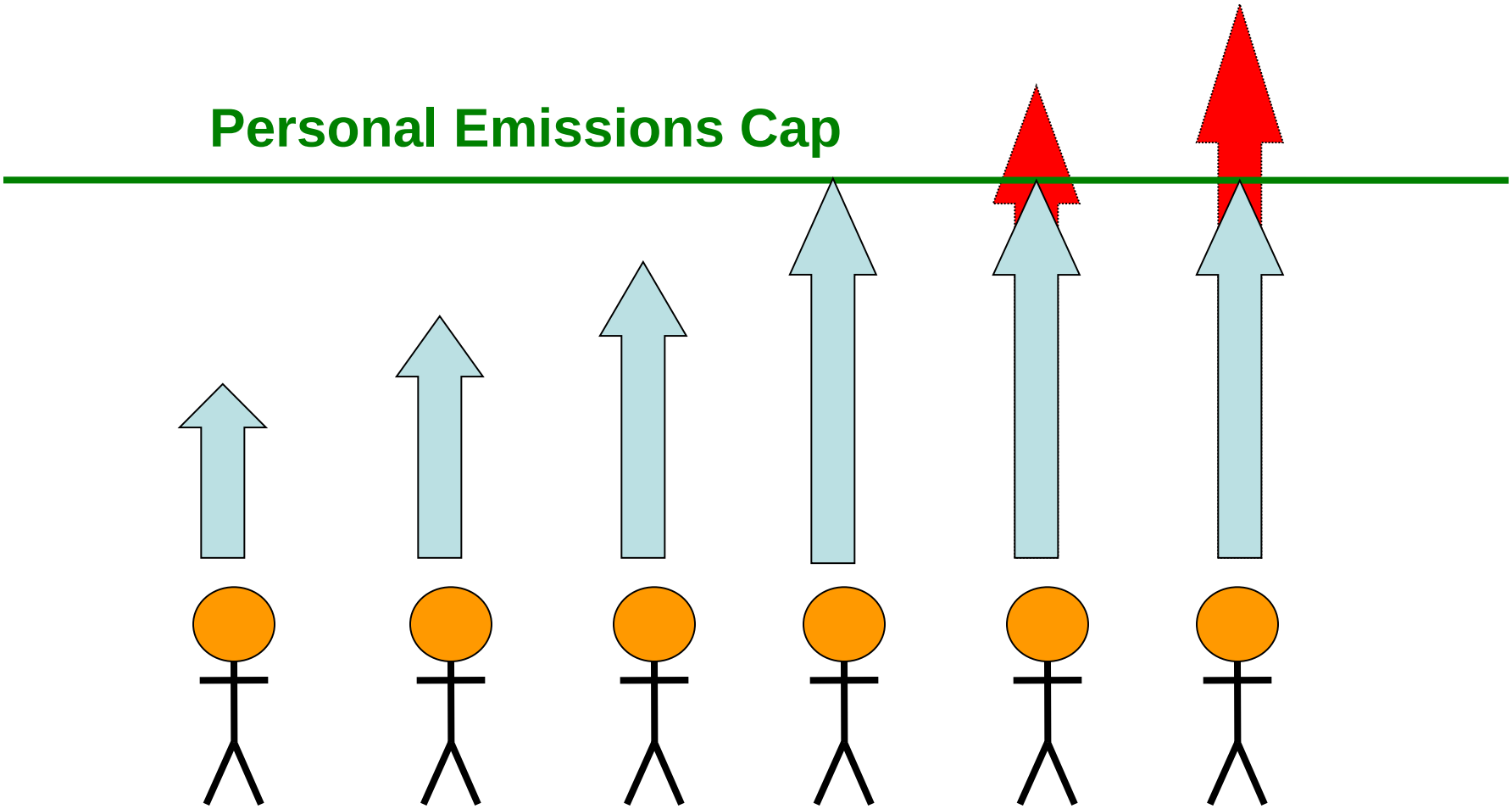
*Source*: Steve Pacala, private communication, 2008

# Determine globally applicable personal emissions cap



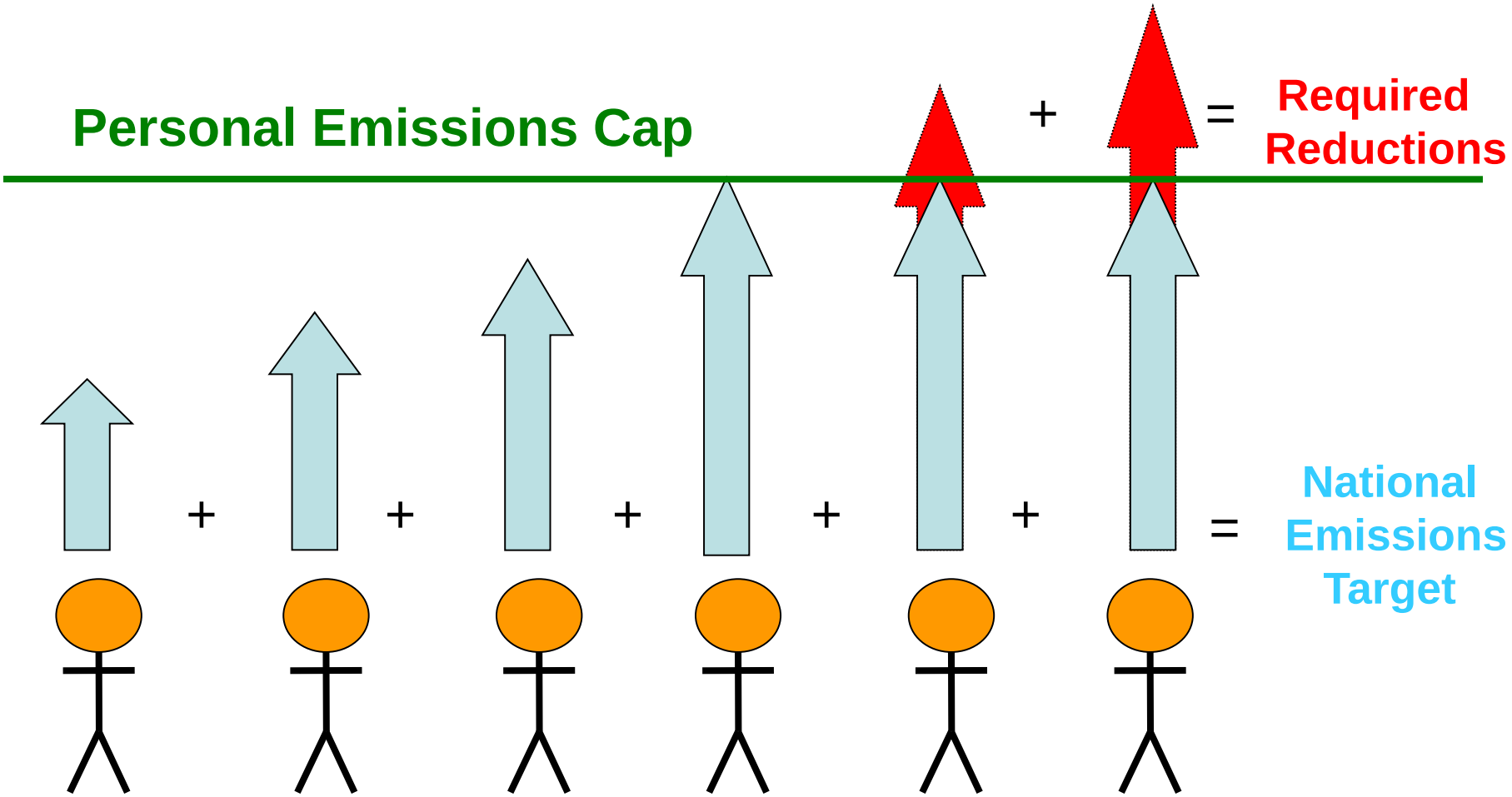

*Source*: Steve Pacala, private communication, 2008

# Some people exceed the personal cap



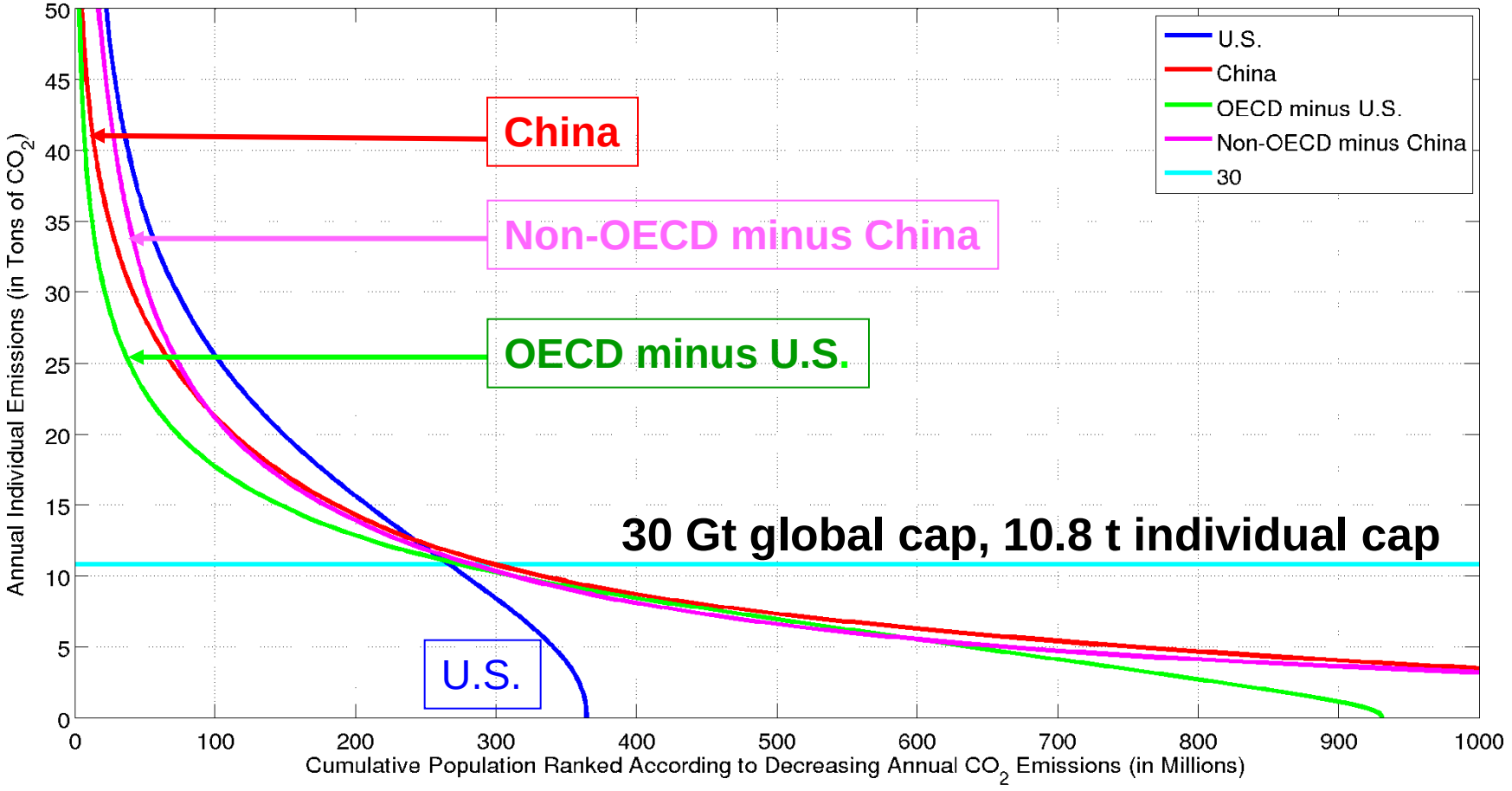

*Source*: Steve Pacala, private communication, 2008

# Add the individual capped emissions to determine the national target



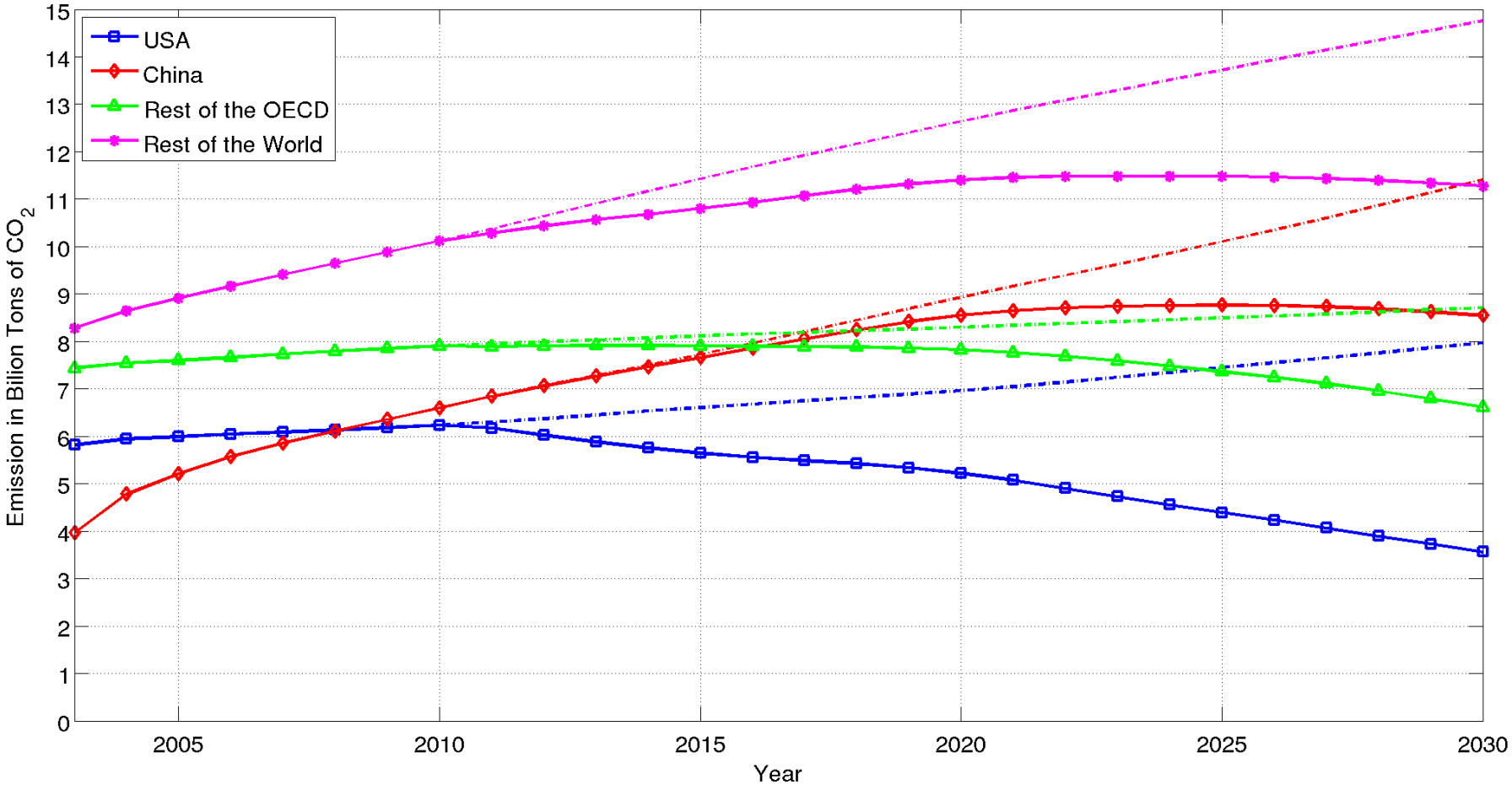

*Source*: Steve Pacala, private communication, 2008

# Regional emissions in 2030




For a 30 $GtCO_2$ global cap in 2030, four regions have comparable assignments

# Emissions paths over time




*Dashed lines*: EIA Business As Usual
*Solid lines*: Global cap is 30 $GtCO_2$ in 2010, 33 $GtCO_2$ in 2020, 30 $GtCO_2$ in 2030.

# Cosmopolitan ethics

Philosophers call this view of fairness *cosmopolitan ethics*. Think of individuals first, nations second.

# The $CO_2$ problem is a product of prosperity (1 OF 2)

The $CO_2$ problem is a problem of modernity, a problem of prosperity, a byproduct of choices about what to consume, how to spend time. Today, it is nearly universally believed, a good life is one lived with exuberance: with a wide variety of experiences. Of great value are privacy, safety, convenience, and excitement. The pursuit of these goals drives resource use upward.

# The $CO_2$ problem is a product of prosperity (2 OF 2)

Looming large are the carbon emissions of the world's new arrivals into the "middle class," driving first mopeds and then cars, living in apartment buildings and then detached or semi-detached houses.

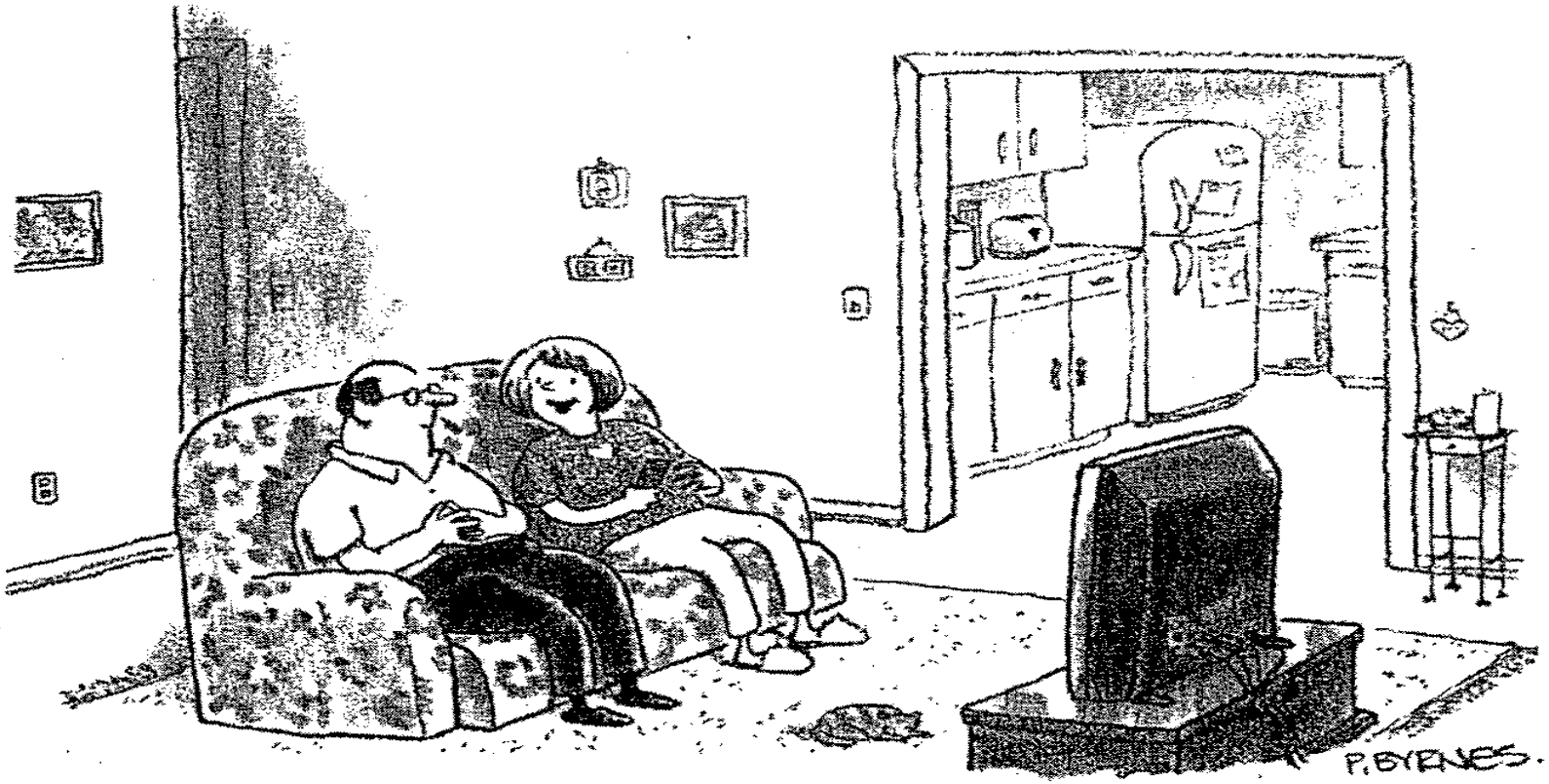
Major help comes from end-use efficiency. The end-use perspective highlights small systems, repeated billions of times -- for buildings, industry, and transport. Examples are the house window, the light bulb, the electric motor, and the car engine. Much effort has been expended understanding why so many end-use-efficiency opportunities are left on the table.

# Will “the good life” be redefined?

Many cultures in the history of the world have defined the good life differently than prosperous people do today. Are serious challenges to the values of the prosperous in view, anywhere in the world?

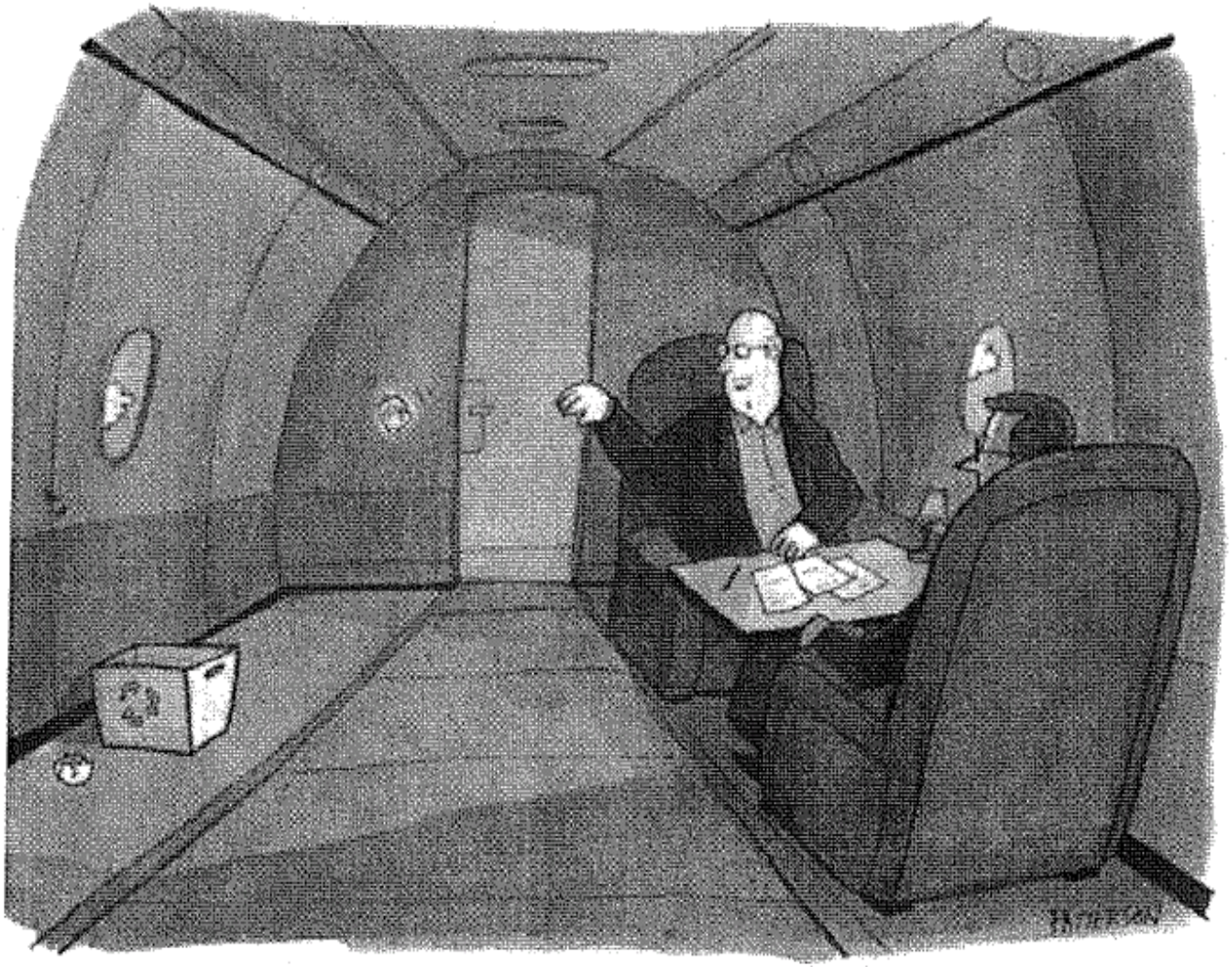
Let’s discuss this.

# Can virtual experiences substitute for travel?




*"When we retire, I want to watch travel videos."*

From *The New Yorker*, April 21, 2008



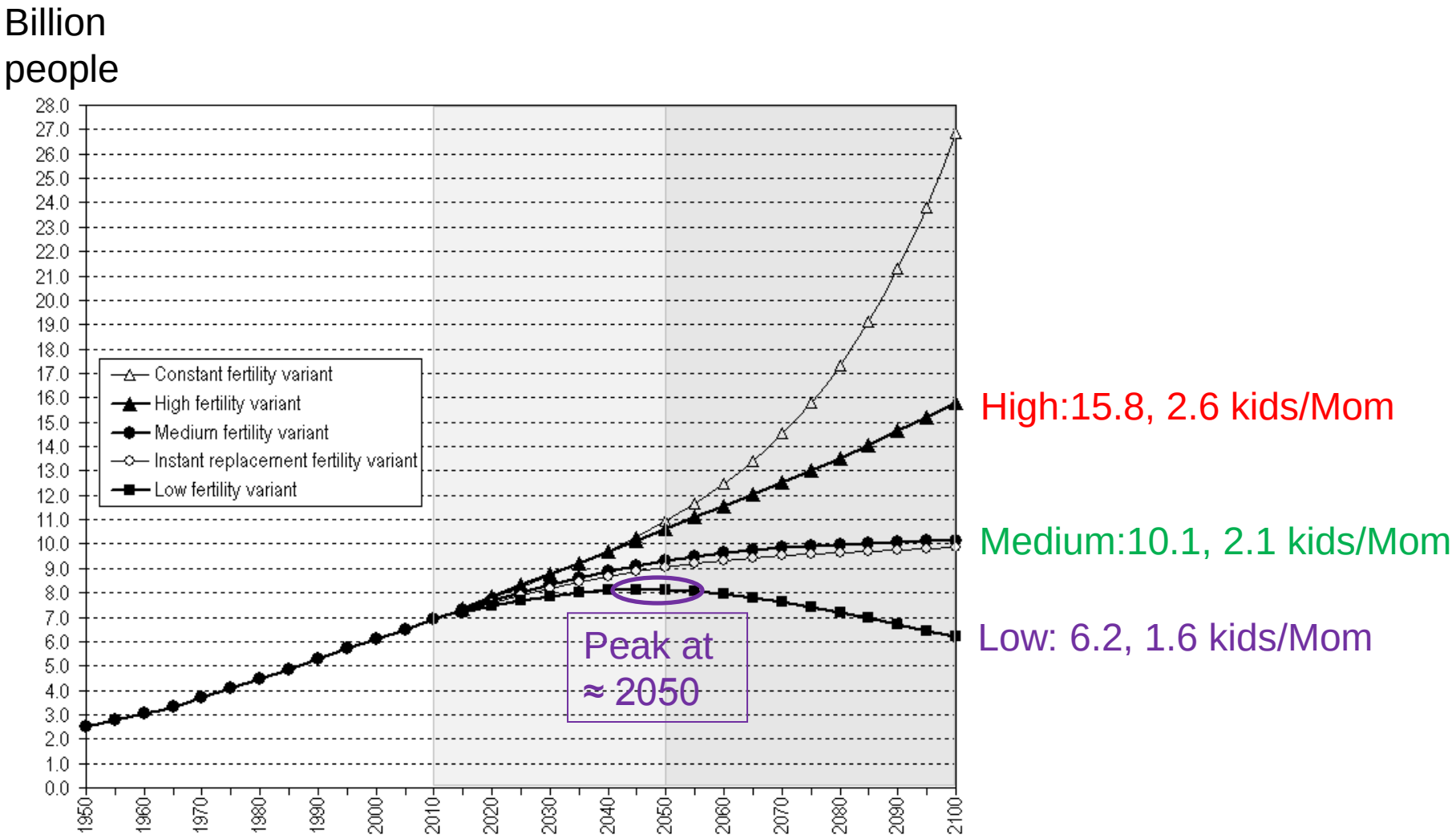
*"I try to do my part."*

*Source*: New Yorker, August 27, 2007

# Class 5 Outline

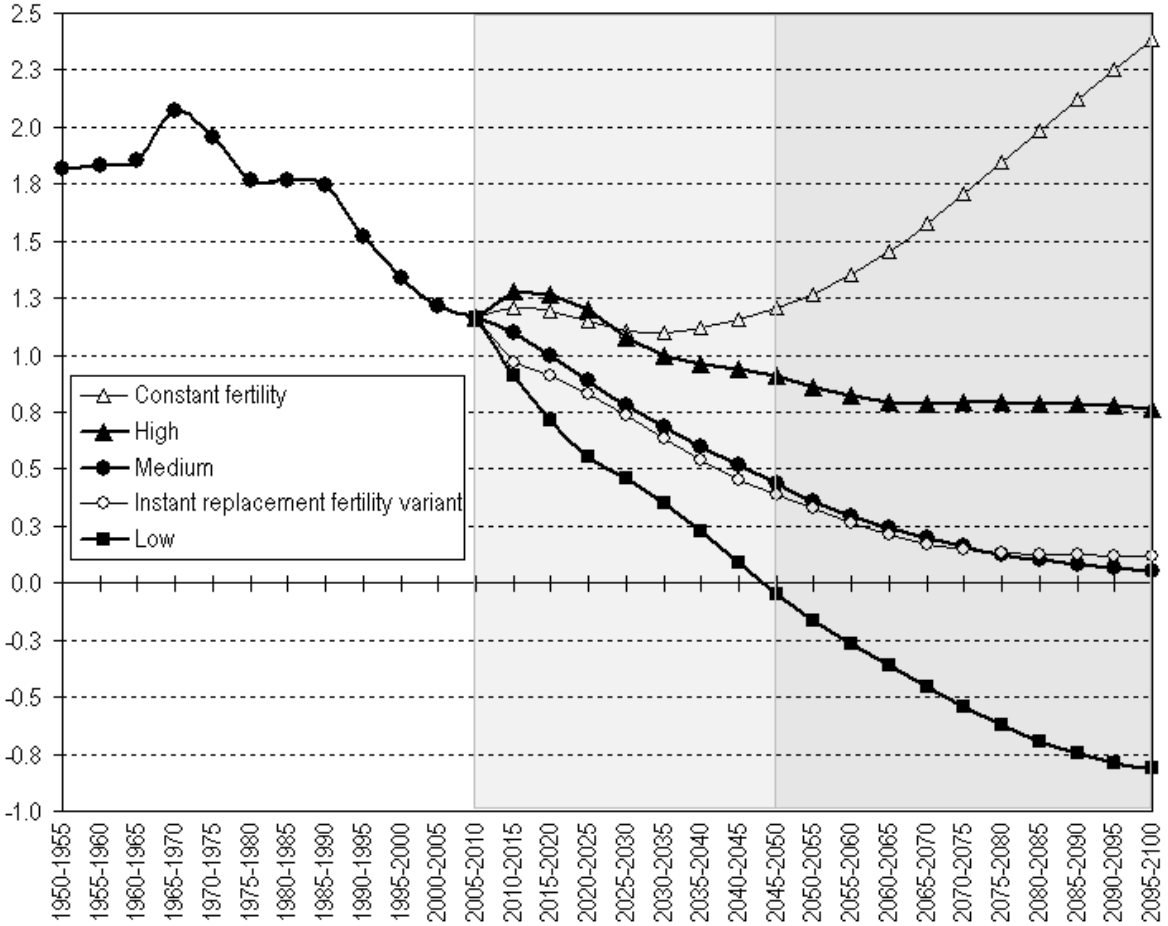
One billion high emitters
Population
Poverty

# UN Population Projections (1 of 2)




*Source*: United Nations. http://esa.un.org/unpd/wpp/unpp/panel_population.htm

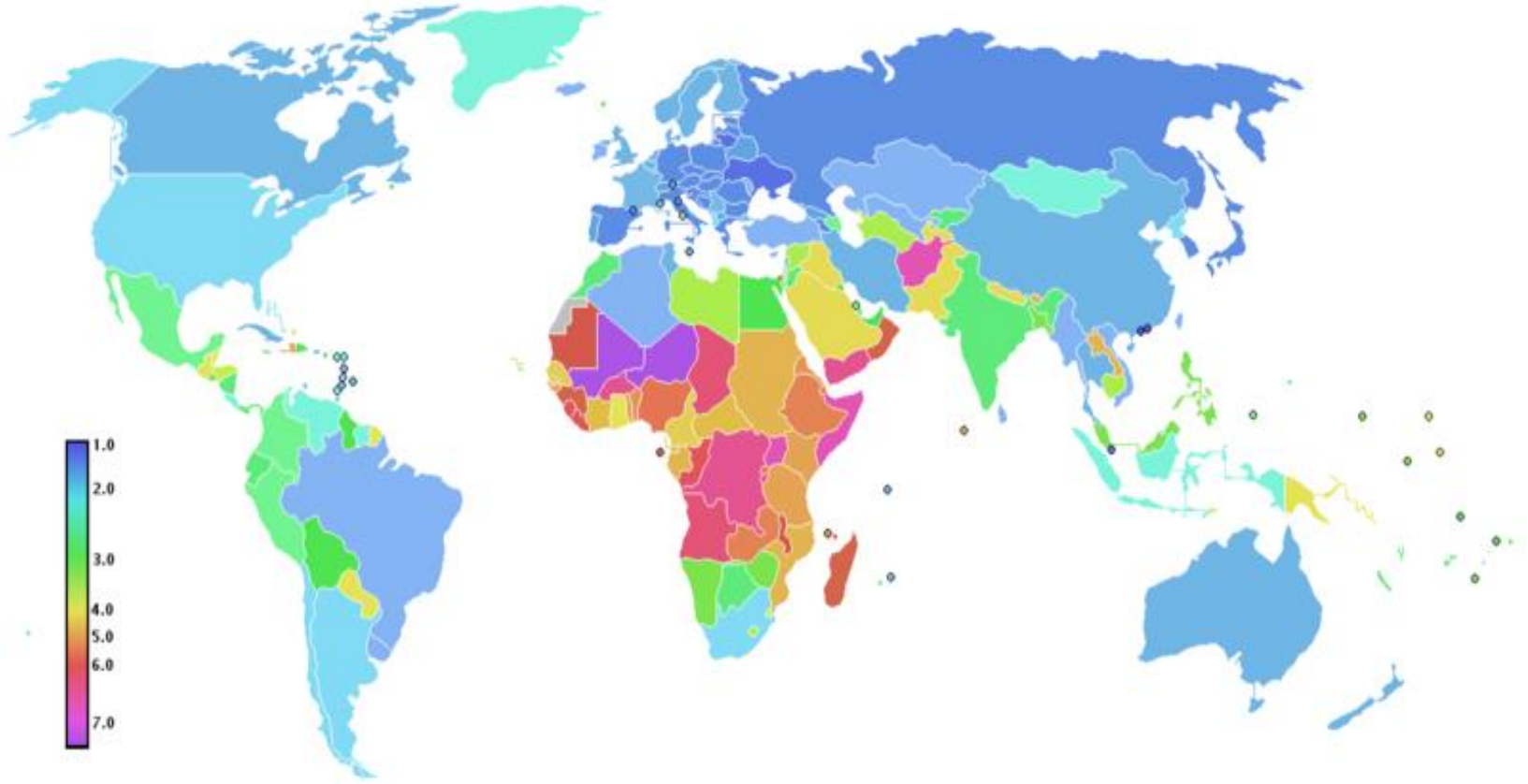
# UN Population Projections (2 of 2)




-0.8%/yr in 2100.
If sustained,
2.8 billion in 2200.

*Source*: United Nations. http://esa.un.org/unpd/wpp/unpp/panel_population.htm

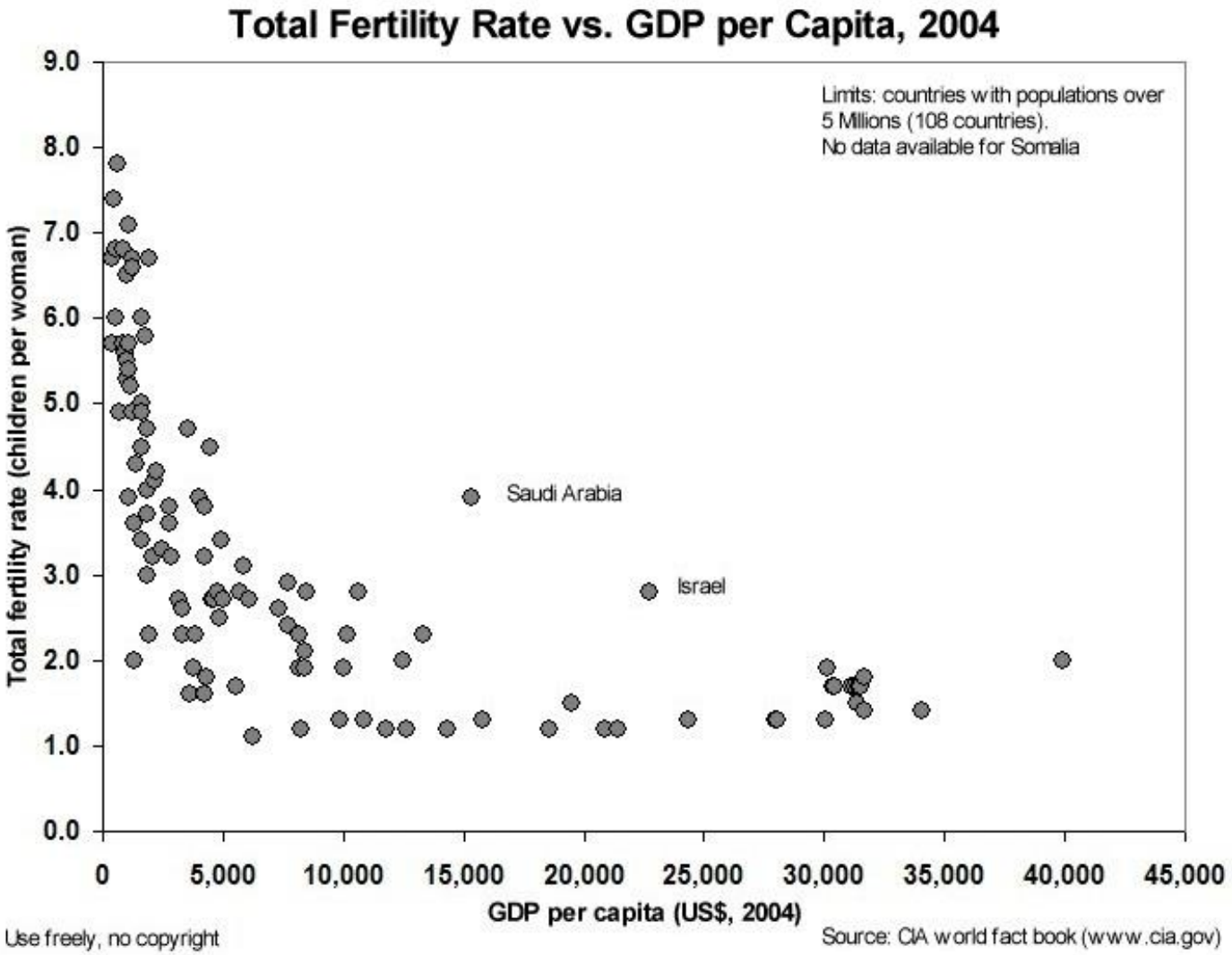
# International Fertility Rates




Rates reported in childbirths per average woman. A rate of 2.1 childbirths per woman is a stable population.

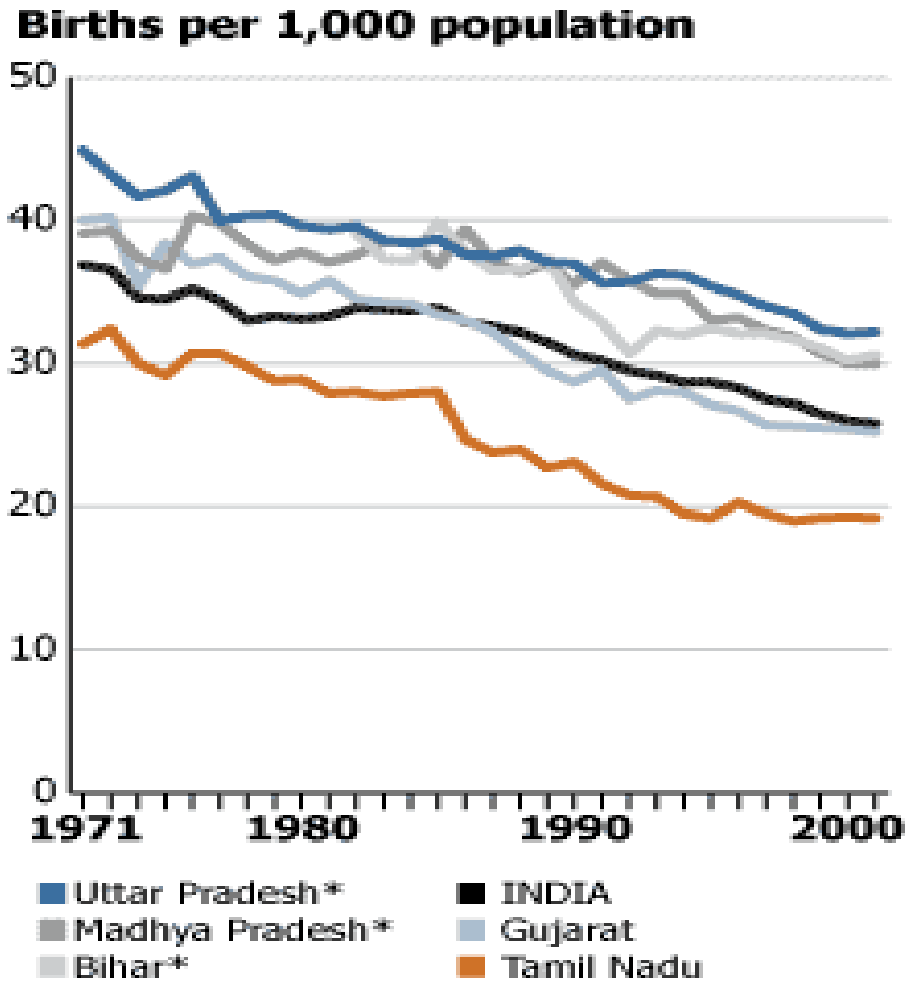
*Source:* Renee Raphael, Megan Leftwich, Onobu Akogwu, this course, 2008.

# Fertility Rates: Economic




*Source:* Renee Raphael, Megan Leftwich, Onobu Akogwu, this course, 2008.

# Family size in provinces of India




Higher rates in northern than in the southern regions. Southern regions have higher literacy levels and more women's rights.

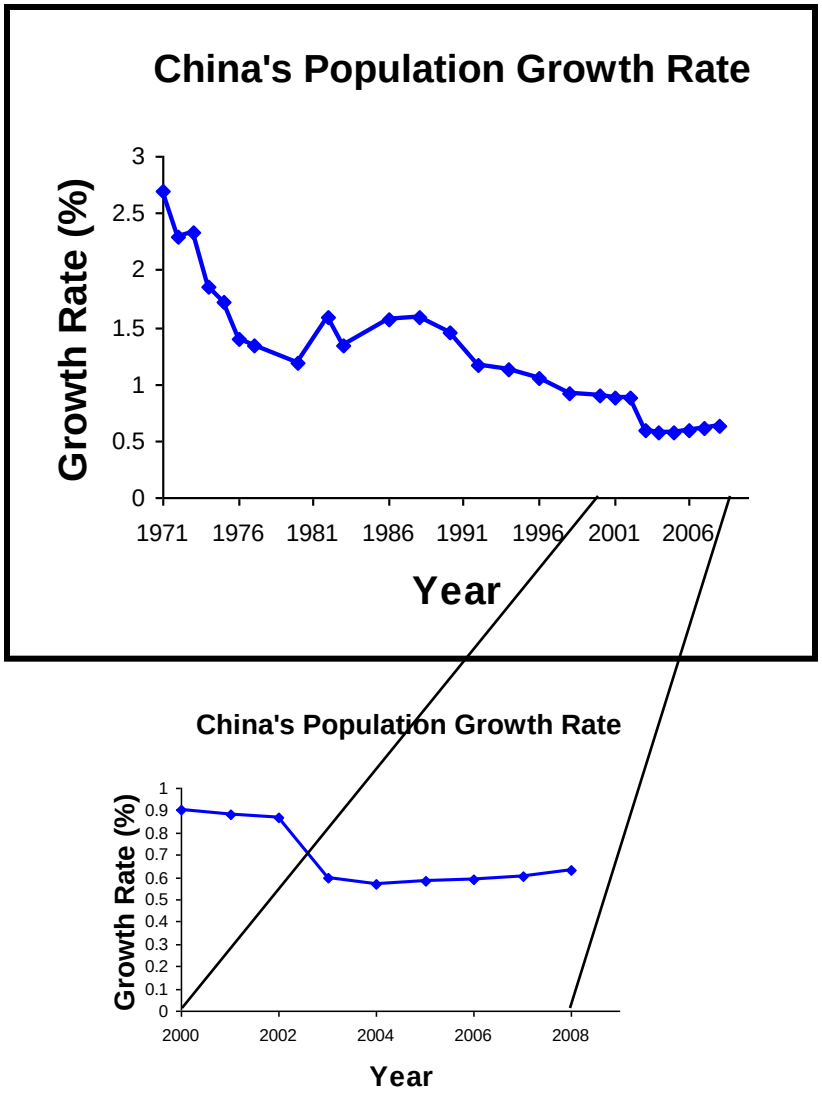
*Source:* Renee Raphael, Megan Leftwich, Onobu Akogwu, this course, 2008.

# Population growth in China

China has had a One Child Policy since 1979. It reduced population growth by 23% in first 20 years. Current fertility rate ~ 1.7.

Implementation: Fines, abortions (legal in china), and forced sterilization accompanying second or subsequent pregnancies. *Exception*: couples with no siblings may have two children.

Sex ratio at birth (SRB): 114 males to 100 females (105 males to100 females is the worldwide ratio)




*Source:* Renee Raphael, Megan Leftwich, Onobu Akogwu, this course, 2008.

# Population: Observations

Population and environment were joined at the hip in the first wave of environmentalism in the 1970s. No longer.

A young person's life-footprint (impact on natural resources) will be determined above all by one decision: how many children to have.

Achieving falling populations is not just a task for poor countries. "Three is the new two" in suburbia?

Shouldn't we welcome falling populations, not pay Moms to have more kids?

Might a worthy goal be to assure only wanted births everywhere?

# BREAK

# Required readings for Week 6 National and subnational policy (1 of 2)

Prep for James Hansen:

- CNN News on Hansen's career: http://www.youtube.com/watch?v=6XaqbFSRv6Q
- Hansen, J., Johnson, D., Lacis, A., Lebedeff, S., Lee, P., Rind, D., & Russell, G. (1981). Climate impact of increasing atmospheric carbon dioxide. Science,213(4511), 957-966.

S. Pacala and R. Socolow, 2004. "Stabilization wedges: solving the climate problem for the next 50 years with current technologies," *Science*, Vol. 305, pp. 968-972, August 13, 2004. (Inspect the 50 pages of supporting online material.)

R. Socolow and S. Pacala, 2006. "A plan to keep carbon in check," *Scientific American*, Vol. 295, No. 3, pp. 50-57.

Stavins, R. (2011). "Addressing Climate Change with a Comprehensive US cap-and-trade System." *in* Helm, D., & Hepburn, C. (Eds.). (2011 paperback version). *The economics and politics of climate change*. Oxford University Press. pp. 197-221.

# Required readings for Week 6 National and subnational policy (2 of 2)

State of California (2006). Overview of AB32 Global Warming Solutions Act. Available: http://www.arb.ca.gov/cc/ab32/ab32.htm

Executive Office of the President (June 2013) The President's Climate Action Plan.

IEA (2013) Executive Summary: Energy Policies of IEA Countries – Germany. Available at: http://www.iea.org/media/executivesummaries/GermanyExecSum.pdf

Schuman, S., & Lin, A. (2012). China's Renewable Energy Law and its impact on renewable power in China: Progress, challenges and recommendations for improving implementation. *Energy Policy*.

Government of India. 12th Five-Year Plan (2012-2017). Chapter 4: Sustainable Development, pp.112-143. See also Dubash, N. (2013). The Politics of climate change in India: Narratives of equity and cobenefits. WIREs Clim Change 2013, 4:191–201. doi: 10.1002/wcc.210.

# Recommended readings for Week 6 National and subnational policy

Institute for Public Policy Research (July 2013). “Pump up the Volume: bringing down the costs and increasing jobs in the offshore wind sector.”

Resources for the Future, 2010, Towards a New National Energy Policy: Assessing the Options.

P. Cafaro, 2011, Beyond business as usual: alternative wedges to avoid catastrophic climate change and create sustainable societies. Chapter 9 (pp. 192 - 215) in *The Ethics of Global Climate Change* (2011) ed., Denis G. Arnold.

# Will Happer lecture:

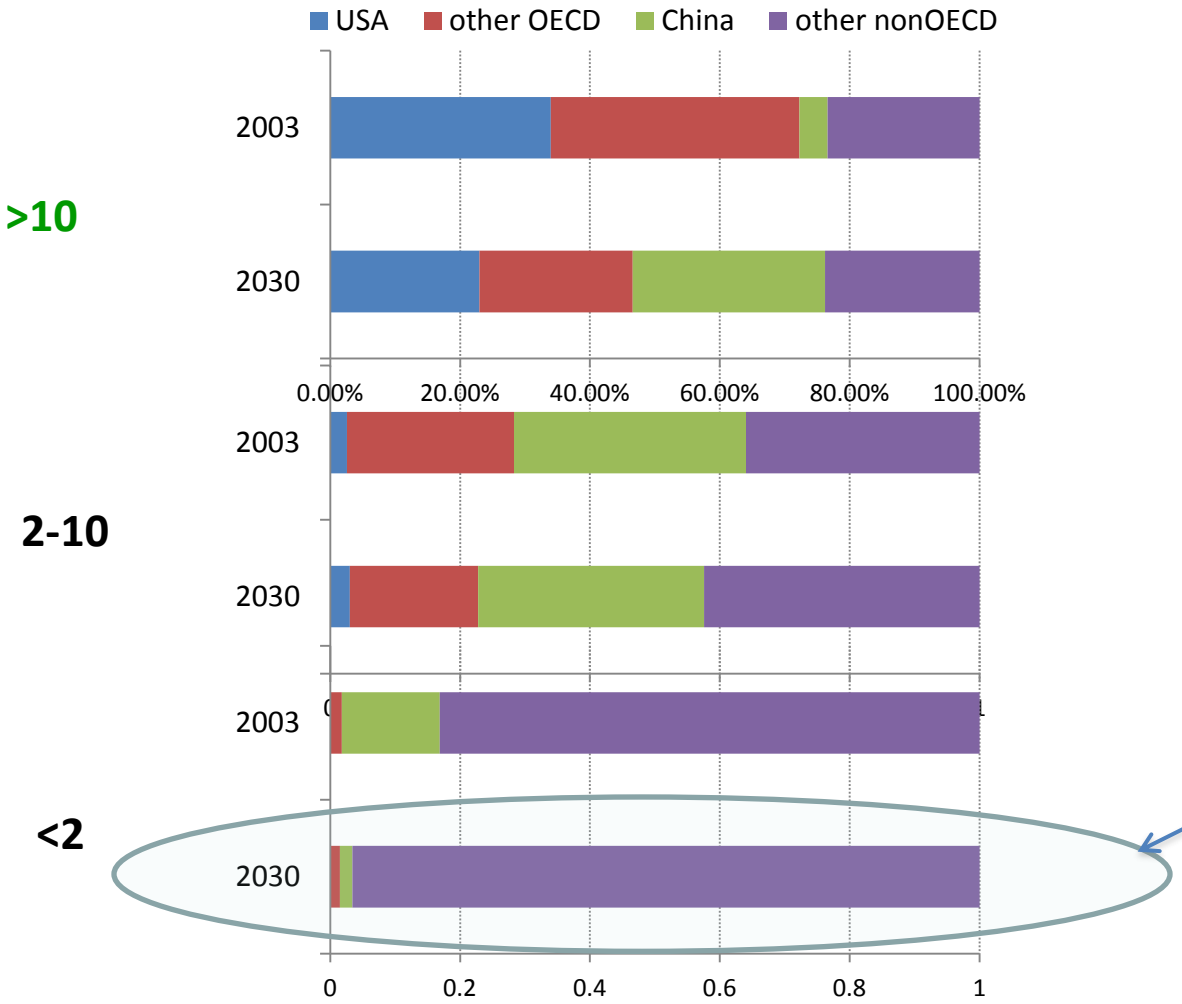
"Why has there been no global warming for the past decade?"

Thursday, 4:30 pm, Jadwin A-10

# Class 5 Outline

One billion high emitters
Population
Poverty

# Four billion low emitters in 2030: Acceptable?




**The lower half of the world's emitters in 2030, 8% of emissions.**

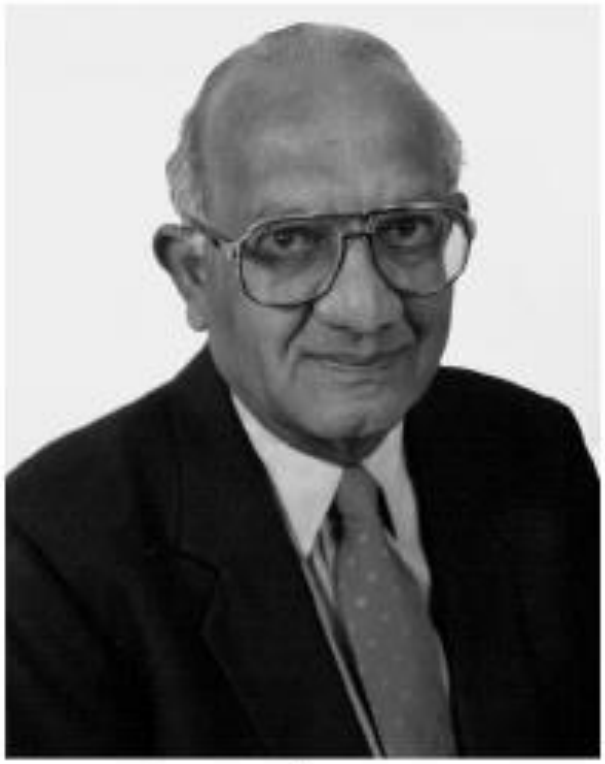
Estimated emissions of individuals in 2030, in tons $CO_2$/year

*Source*: Chakravarty, Socolow, and Tavoni, 2009. Figure 2.
http://www.climatescienceandpolicy.eu/2009/11/afocus-on-individuals-can-guide-nations-towards-a-low-carbon-world/

# Energy and Poverty

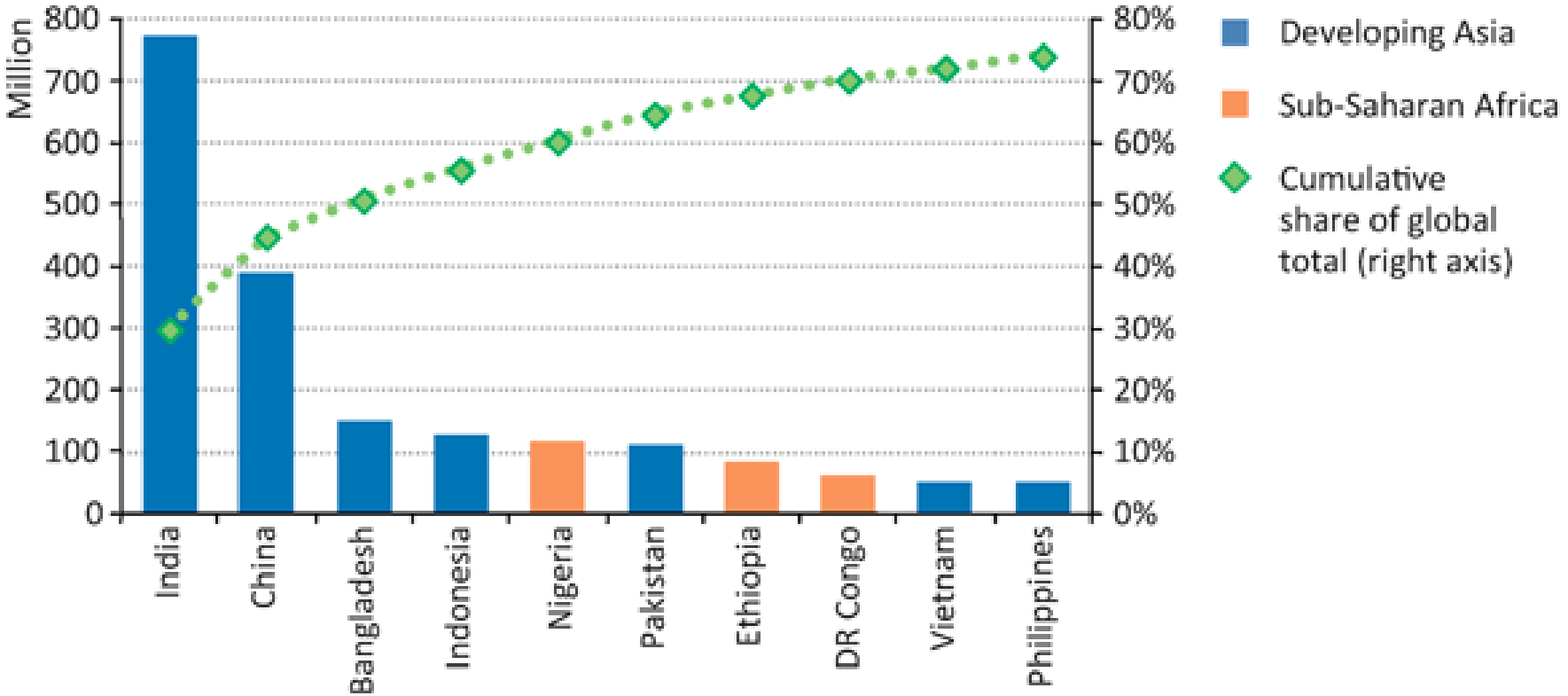
- Energy services are essential to overcome poverty: the poorest countries are 80%+ dependent on traditional biomass
- Poverty: income and opportunities
  - Domestic uses (heating and cooking)
  - Productive purposes (brick and ceramics firing, metal working, crop smoking)
  - Reducing drudgery (water pumping, grinding and milling)
  - Social services (health care, education)
- The two access issues that receive the greatest attention are cooking fuel and electricity

# *West of Bangalore*, the BBC film about the work of Amulya Reddy in Pura village



# Traditional cooking fuels

Countries with the largest population relying on traditional use of biomass for cooking, 2010



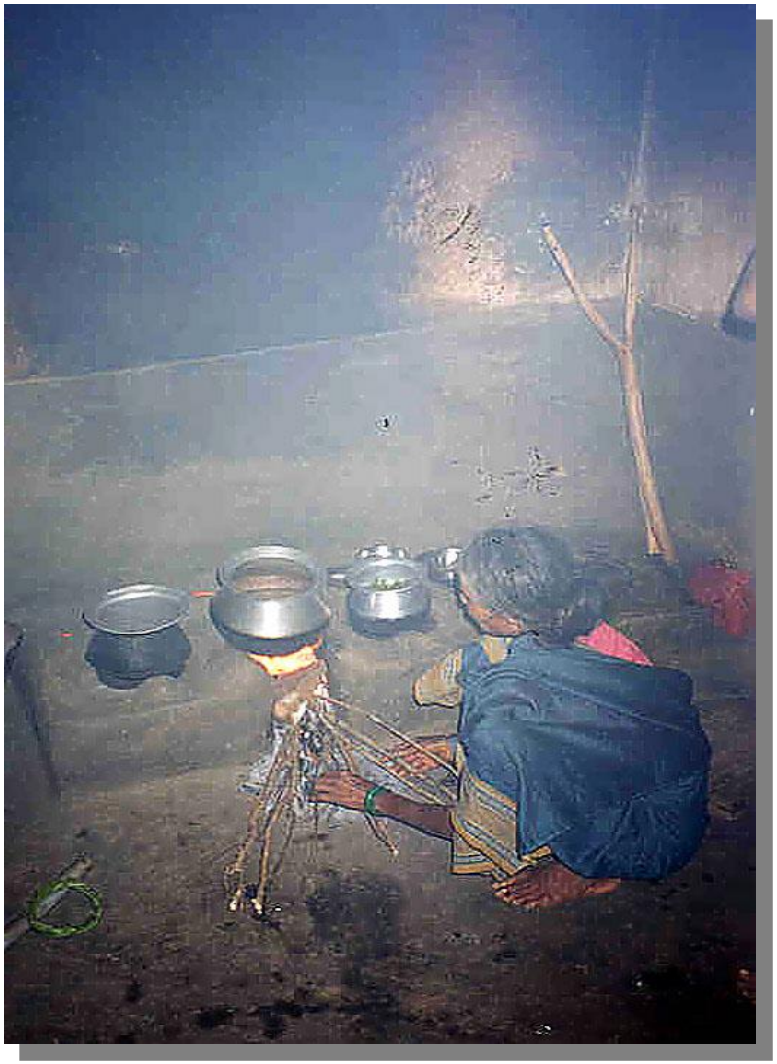

[IEA 2013]

*Source*: http://www.worldenergyoutlook.org/resources/energydevelopment/globalstatusofmodernenergyaccess/

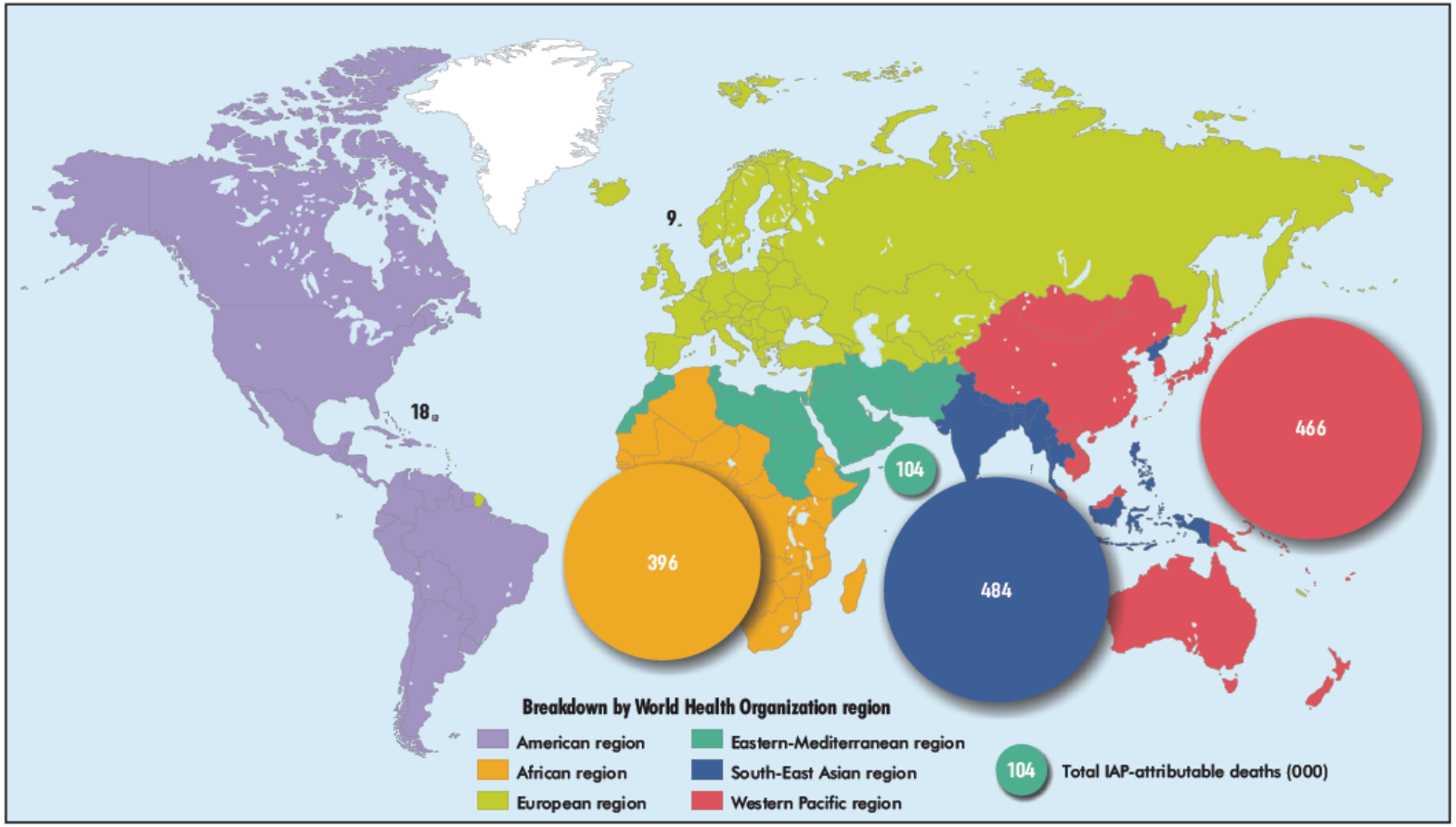
# Rural Energy: Traditional Fuels

# Indoor air pollution: the global energy system's largest negative health effect

Respiratory disease from cooking with traditional fuels kills more than a million people per year.



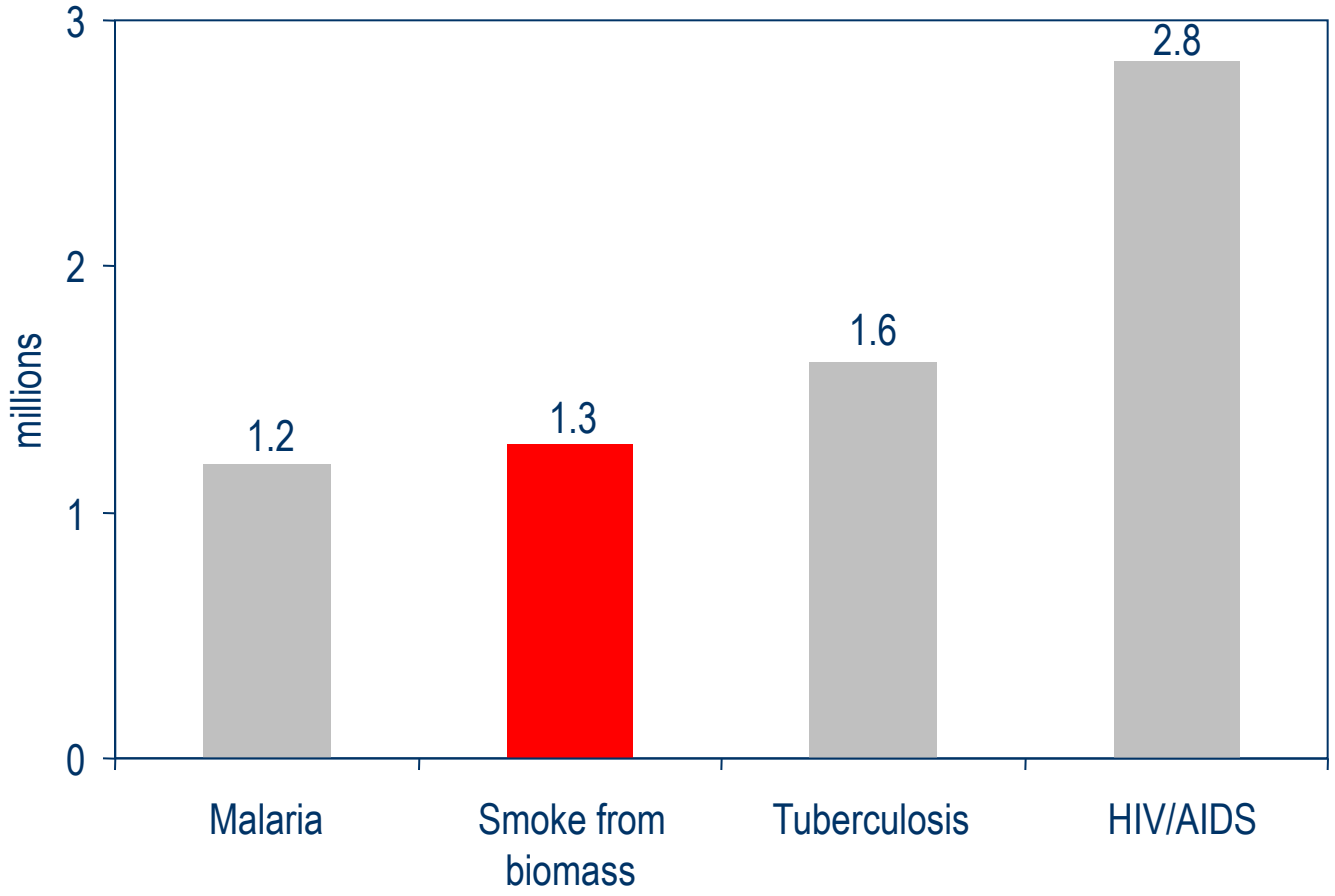
# Deaths per year caused by indoor air pollution




***Exposure to indoor air pollution from inefficient biomass use causes 1.3 million deaths per year, 70% in developing Asia***

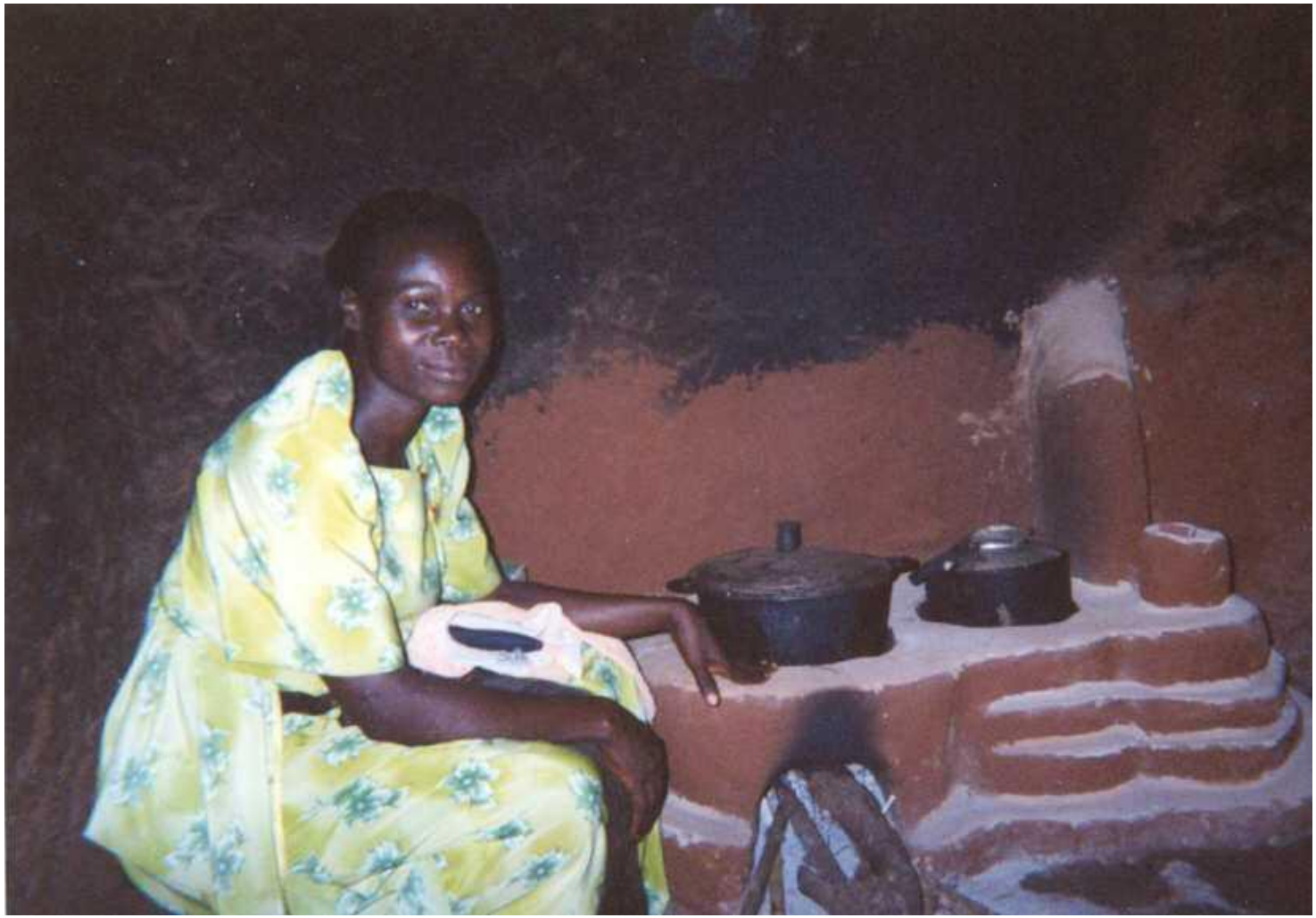
*Source*: International Energy Agency, *World Energy Outlook 2006*

# Energy Poverty: Annual Deaths from Indoor Air Pollution




*Source*: International Energy Agency, *World Energy Outlook 2006*

# Efficient vented stoves

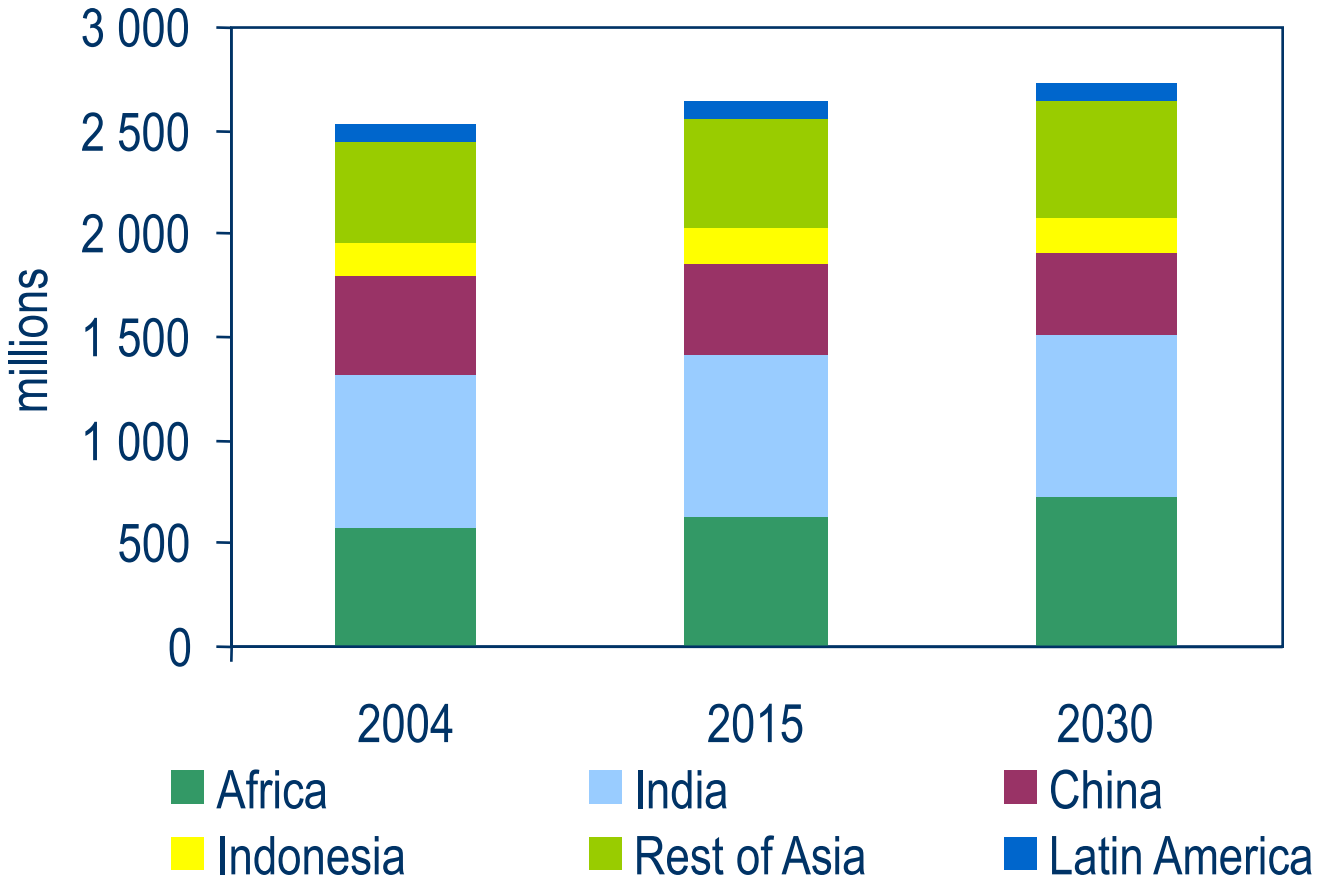


# Women and Energy

- Lack of access to energy affects women and girls disproportionately
  - Health: carrying tens of kilos of fuelwood over long distances; indoor air pollution
  - Literacy: girls are kept from school
  - Fertility: illiteracy increases family size
  - Safety: household fires, personal attack
  - Future economic participation of women

  (see *Generating Opportunities, UNDP 2001*)

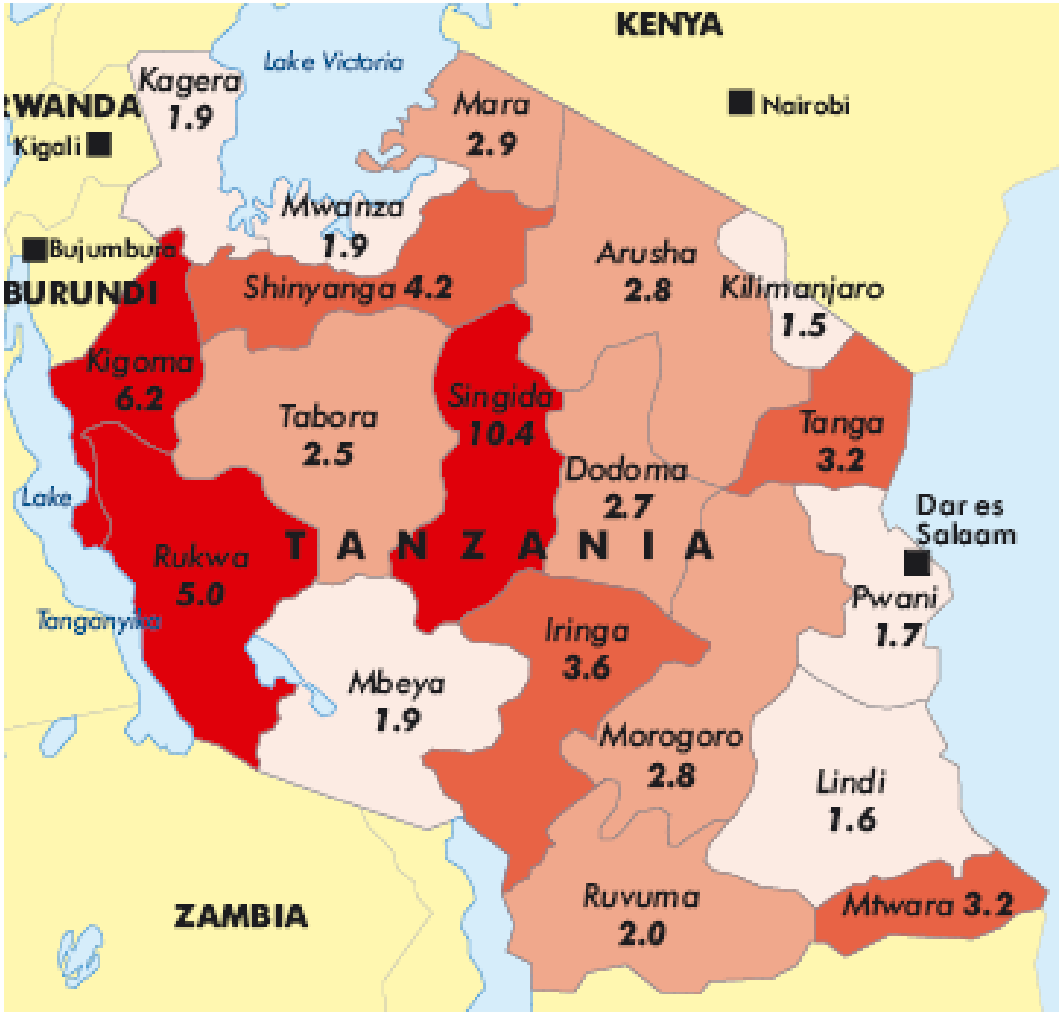
# Traditional Biomass for Cooking: No progress expected




***The population relying on traditional biomass is set to increase from 2.5 billion today to 2.7 billion in 2030.***

*Source*: International Energy Agency, *World Energy Outlook 2006*

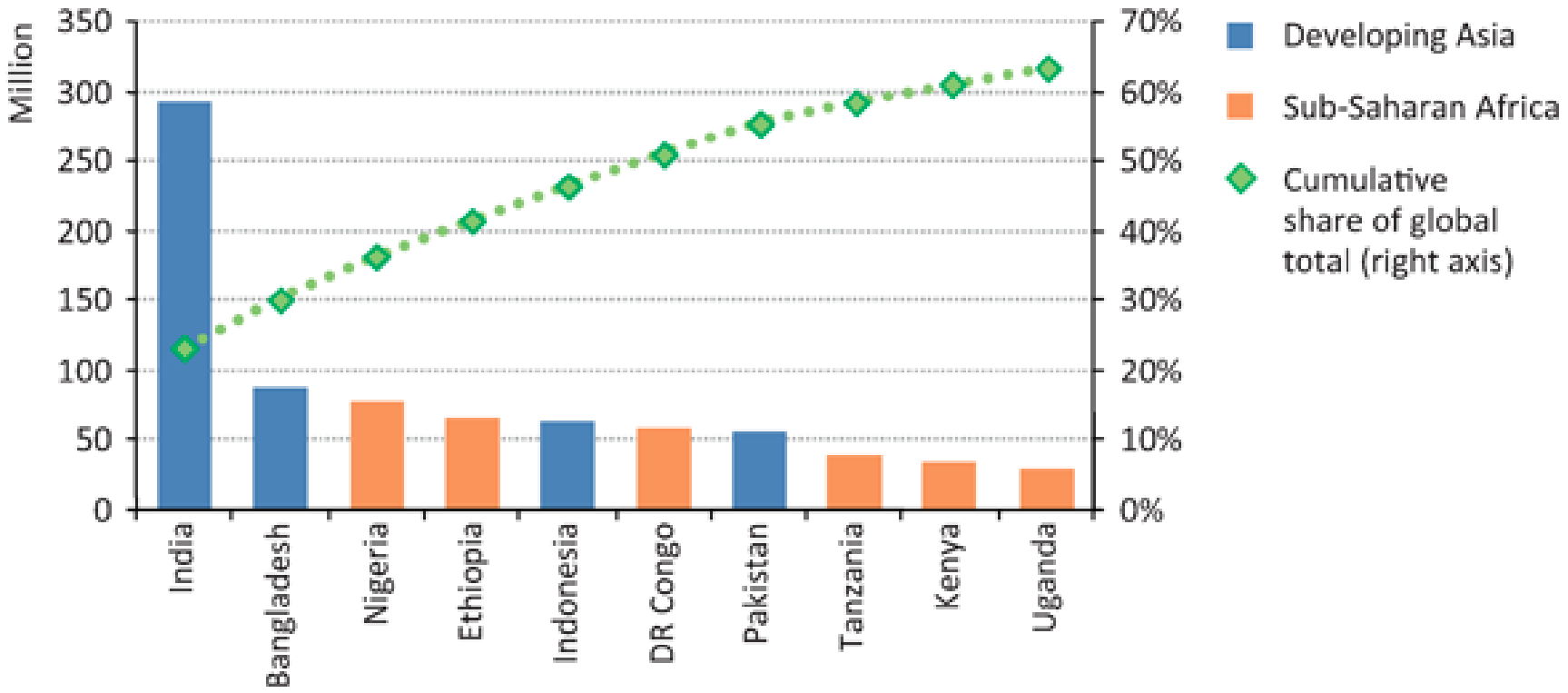
# Distance travelled (kilometers) to collect fuelwood in rural areas




*Source*: International Energy Agency, *World Energy Outlook 2006, p. 430*

# Electricity Access

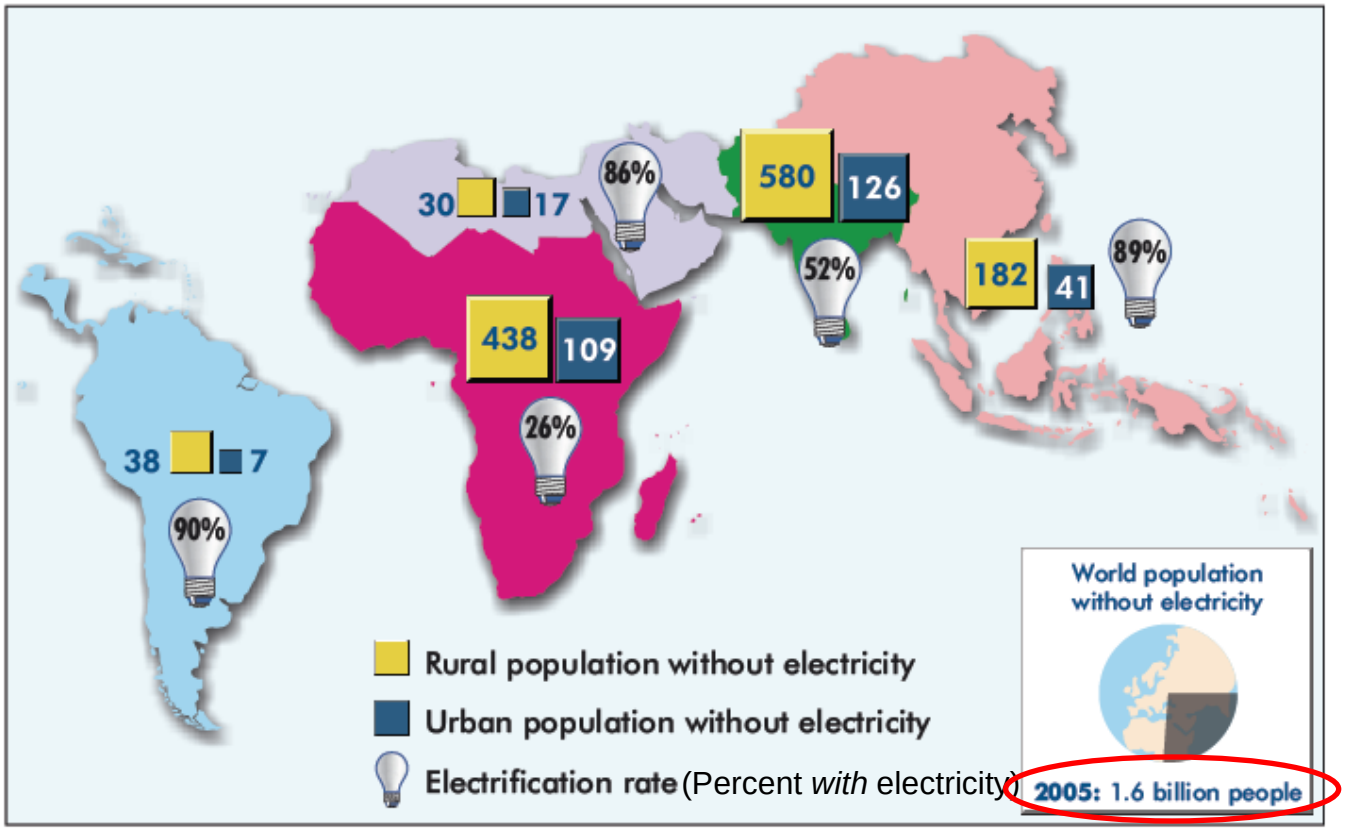
Figure 1: Countries with the largest population without access to electricity, 2010




[IEA 2013]

*Source*: http://www.worldenergyoutlook.org/resources/energydevelopment/globalstatusofmodernenergyaccess/

# Population without electricity, 2005

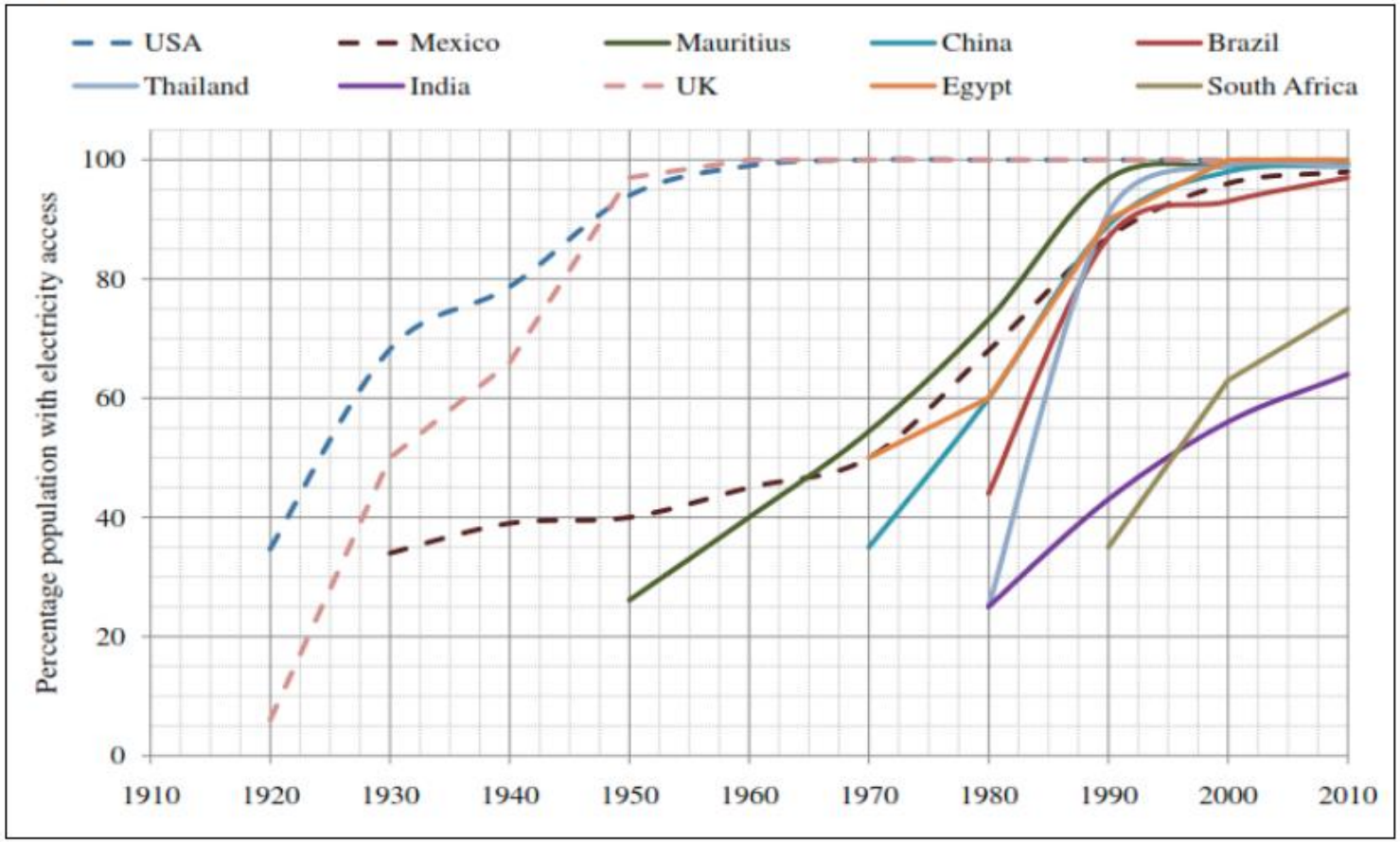



***To achieve the Millenium Development Goals, the number of people without access to electricity would need to fall to under a billion by 2015***

*Source*: International Energy Agency, *World Energy Outlook 2006, p. 156*

# Electrification around the world

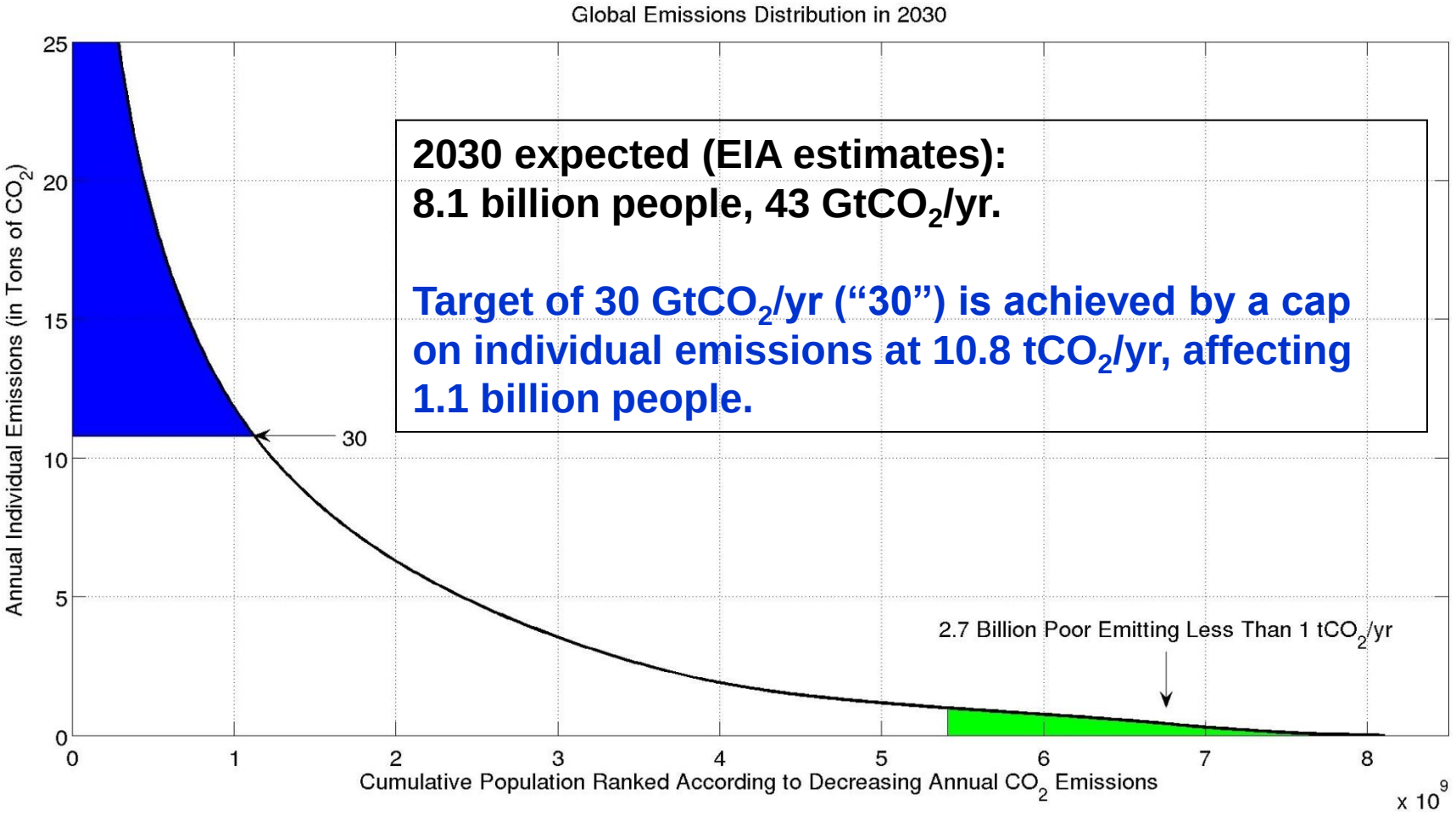
**Figure 1 ▷** **Evolution of household electrification over time in selected countries**



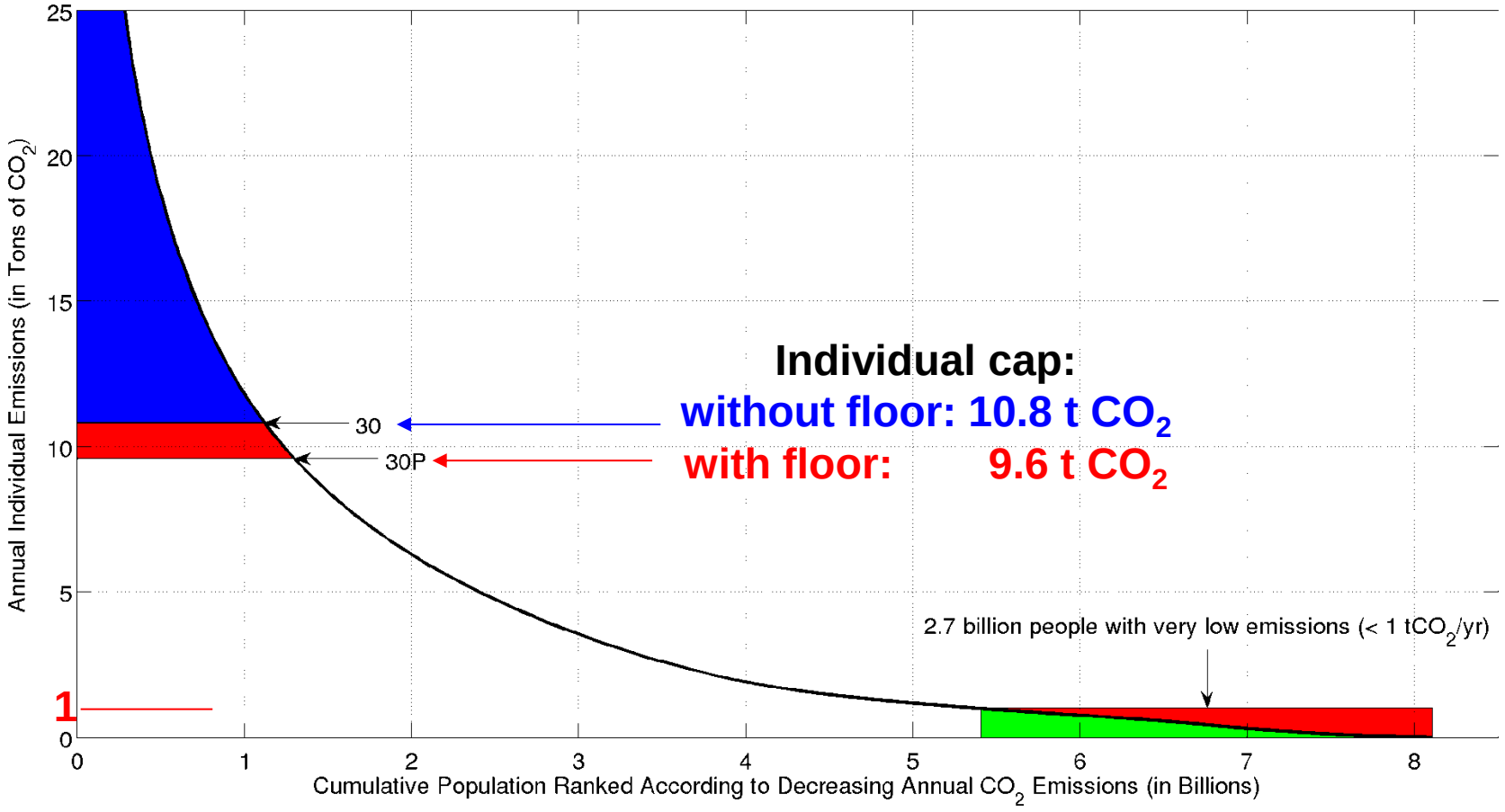

Source: Global Energy Assessment (forthcoming)

[UN, *Sustainable Energy for All,* 2012]

# $CO_2$ mitigation obligation, taking into account only the world's high emitters



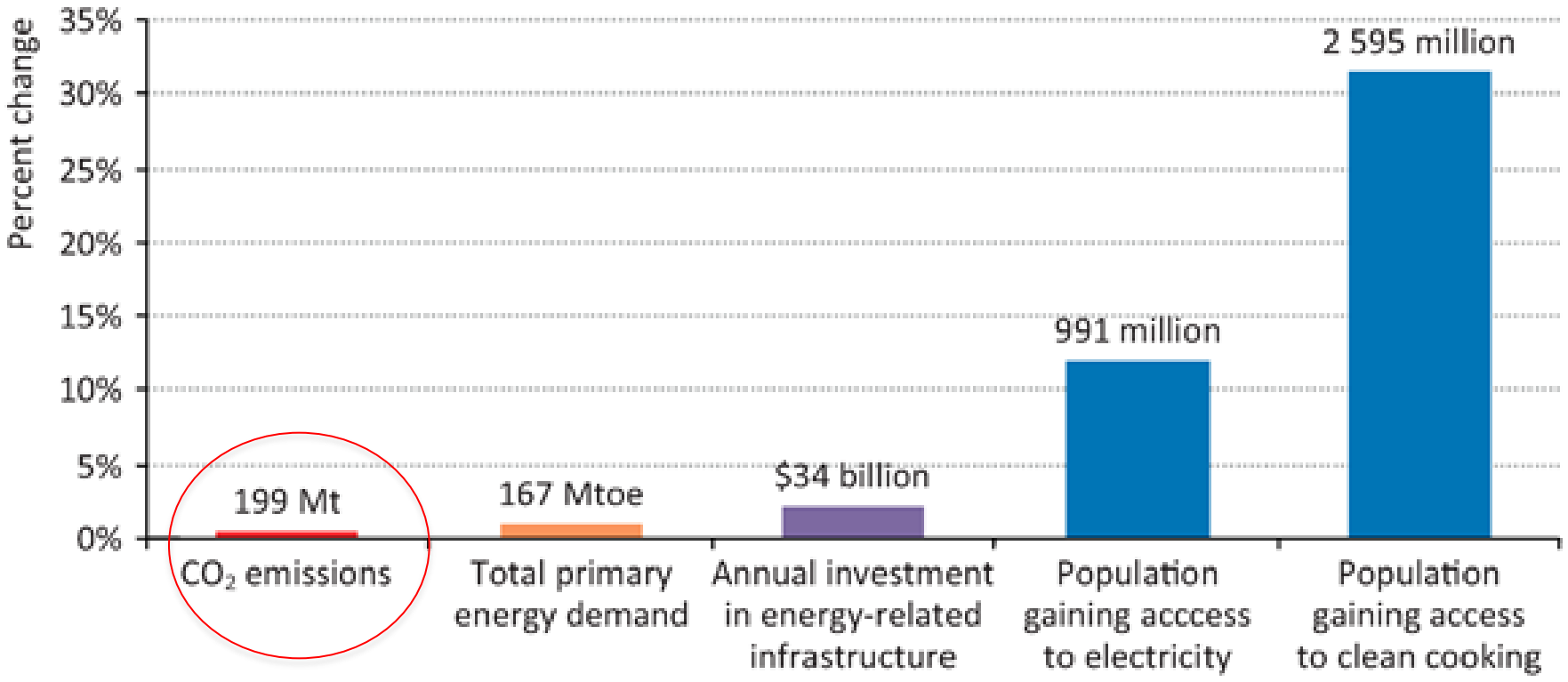
# Combine a global-emissions cap and an individual-emissions floor




The world's poor do not need to be denied fossil fuels.

# Energy Access for all: What effect on the climate?

Additional impact of the Energy for All Case compared to the New Policies Scenario




**Energy for all entails less than a 1% increase in global emissions** [IEA 2013]

*Source*: http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessprojectionsto2030/

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

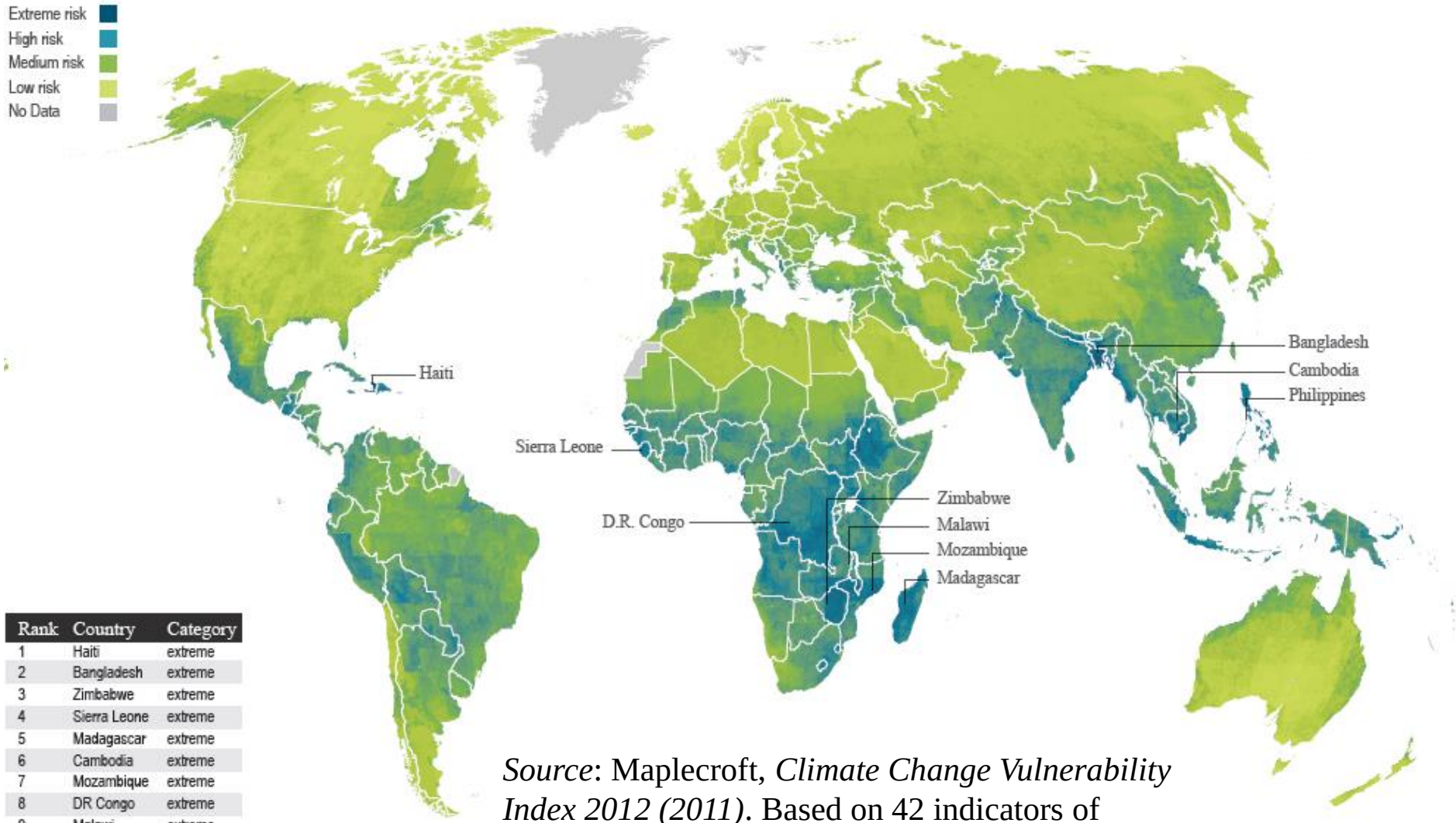
| *Direct Energy Use* | *Household rate of use (4.5 people)* | *Individual emissions ($kgCO_2$/yr)* |
|---|---|---|
| Cooking | 1 LPG canister per month | 120 |
| Transport | 70 km by bus, car, motorbike per day | 220 |
| Electricity | 800 kWh per year | 160 |
| *Total* | | *500* |

**1 tCO2/yr: Double the "direct" emissions to account for "indirect" emissions**.

# Four ways to emit 4 tons $CO_2$/yr (today's global per-capita average)

| **Activity** | **Amount producing 4 ton $CO_2$/yr emissions** |
|---|---|
| a) Drive | 15,000 miles/yr, 45 miles per gallon |
| b) Fly | 15,000 miles/yr |
| c) Heat home | Natural gas, average house, average climate |
| d) Lights | 300 kWh/month when all coal-power<br>(600 kWh/month, natural-gas-power) |

# Climate Change Vulnerability




| Rank | Country | Category |
|---|---|---|
| 1 | Haiti | extreme |
| 2 | Bangladesh | extreme |
| 3 | Zimbabwe | extreme |
| 4 | Sierra Leone | extreme |
| 5 | Madagascar | extreme |
| 6 | Cambodia | extreme |
| 7 | Mozambique | extreme |
| 8 | DR Congo | extreme |
| 9 | Malawi | extreme |
| 10 | Philippines | extreme |

*Source*: Maplecroft, *Climate Change Vulnerability Index 2012 (2011)*. Based on 42 indicators of exposure, human sensitivity, and adaptive capacity.

# Developing countries and adaptation

In a speech before the World Petroleum Congress in Beijing in October 1997, Exxon's CEO, Lee Raymond, was urging developing countries to resist climate policies: "I hope that the governments of this region will work with us to resist policies that could strangle economic growth."* As I recall, he argued (as did many others) that the greater a country's capacity to adapt to the consequences of climate change, the less severe the damage will be.

Indeed, in a developing country context, *adaptation* is embedded in overall economic development. Important sectors for adaptation include:

- Education
- Communications
- Public health
- Insurance
- Infrastructure

By contrast, *low-carbon development* requires deliberate policy.

**Source*: Sybille van den Hove, Marc Le Menestrel , Henri-Claude de Bettignies, 2002. "The oil industry and climate change: strategies and ethical dilemmas," *Climate Policy* 2 (2002) 3–18, reference 20: "Cited in Hamilton (1998). The speech is no longer available from ExxonMobil's web page. See also the comments on this speech in Business Week (Raeburn, 1997)."

# EXTRA SLIDES

# Mid-course correction: 2012

Reading your term papers: First of all, I was impressed. You worked hard and got beneath the surface.

But I have overemphasized the objective of doing calculations. It seems that I have conveyed to many of you that what I want you to get from this course is mostly the ability to invent problems that can be dealt with quantitatively.

I do want you to develop that skill. But it is secondary. Above all, I want you to wrestle with the complexities of a problem, its implicit conflicts over values. That can't be done quantitatively. If you do an interesting calculation, fine. But don't stop there.

Regarding length of all submissions: Any statements I make about number of pages or number of words is intended only for guidance. Never pad a paper to make it "long enough." Also, don't try to make it "short enough": a long paper can be made readable by subordinating (e.g., with appendices), thereby avoiding discarding something interesting that you want to show David and me.

# EXTRA SLIDES
# CARBON AND POVERTY

# An equity-based $CO_2$ strategy

1. ***Attain all savings from the largest emitters***

2. ***Mitigate uniformly for the same income level across all countries.***
    1. Coordinated development and deployment of efficient appliances, urban mass transit, videoconferencing, $CO_2$ capture and storage, renewables, and nuclear power.

3. ***Meet Basic Human Needs without considering carbon.***
    1. Don't discourage diesel engines for village-scale power or LPG for cooking.

    2. Expect a poor family to respond to a better insulated home by raising the indoor temperature ("takeback").

# Global equity

Two points:

1. Climate change cannot be managed without the participation of the developing countries.

2. The $CO_2$ emissions of the *global poor* (40% of the world's population) are negligible, from the perspective of global warming.

Collaborators: Shoibal Chakravarty (PEI), Ananth Chikkatur (Harvard), Heleen DeConinck (Free University, Amsterdam), Steve Pacala (PEI), Massimo Tavoni (FEEM, Milan)

# Amulya Reddy

Interpreter of development – ever in search of the deepest, simplest formalism.

Collaborator – sharing a love of science and a love of language

Friend – and two knitted families

Inspiration – a life fusing work and love..

> Only when love and need are one
> And the work is play for mortal stakes
> Is the deed ever really done
> For heaven and the future's sakes.
>
> Robert Frost, *Two Tramps in Mudtime*.

# THE EVOLUTION OF AN ENERGY ANALYST: SOME PERSONAL REFLECTIONS

**Amulya K. N. Reddy**

*International Energy Initiative, 25/5 Borebank Road, Benson Town, Bangalore 560046, India; e-mail: amulya1@vsnl.com*

*Annual Review of Energy and Environment 2002*. 27:23–56
doi: 10.1146/annurev.energy.27.122001.083506

# EVOLUTION OF AN ENERGY ANALYST, p. 29

Interestingly, these consumption patterns highlighted the importance of kerosene for lighting in unelectrified homes. It also showed that in order to make this lighting source accessible to the poor, kerosene had to be subsidized. But this subsidy had the associated effect of forcing diesel fuel to be subsidized and tilting the economics of goods transport against railways and in favor of trucks (12). Thus, a key to the country's oil import problem lay in the rural domestic sector—an interesting example of unforeseen inter-sectoral energy interactions.

shortened

# EVOLUTION OF AN ENERGY ANALYST, p. 31

When every household was illuminated with a fluorescent tubelight on Mahatma Gandhi's birthday, October 2, 1989, we felt that we were implementing his vision of the role of science and technology. This modified scheme was successfully operated by the villagers from 1987 up to 1996, and at its best, it demonstrated what we described as "The Blessing of the Commons" (19) in which there is a confluence of private and community interests.

shortened

# EVOLUTION OF AN ENERGY ANALYST, p. 36

At that time, energy thinking was dominated by growth-oriented, supply-sided, consumption-directed considerations. Deeply troubled by the environmental, security, and equity implications of that paradigm, we wanted to evolve a different perspective. To us, the human dimensions of energy were as important as the technological. We were acutely sensitive to the environmental impacts of energy production and use. We were deeply concerned about equity between industrialized and developing countries and within developing countries with their small islands of glaring affluence amid their vast oceans of abject poverty. Above all, we shared a vision of energy as an instrument of development and of technology as a crucial mechanism for energy to play this role.

This unity of perspective and values was enriched by the diversity arising from the differences in our backgrounds, culture, experience, and expertise. We forged bonds and functioned as a well-knit team. As a result, we produced together what none of us could have produced alone—the whole was greater than the sum of the parts.

shortened

# EVOLUTION OF AN ENERGY ANALYST, p. 40

The main information activity of IEI was envisaged to be its journal *Energy for Sustainable Development*. No international journal then existed either with the efficient production and use of energy as its exclusive focus or directed toward energy actors concerned with energy in developing countries. Neither was there a journal devoted to exchanging developing-country experiences in the field of energy. Above all, there was no international journal focusing on strengthening the capability of energy actors in developing countries to choose, plan, establish, manage, operate, and efficiently use energy systems.

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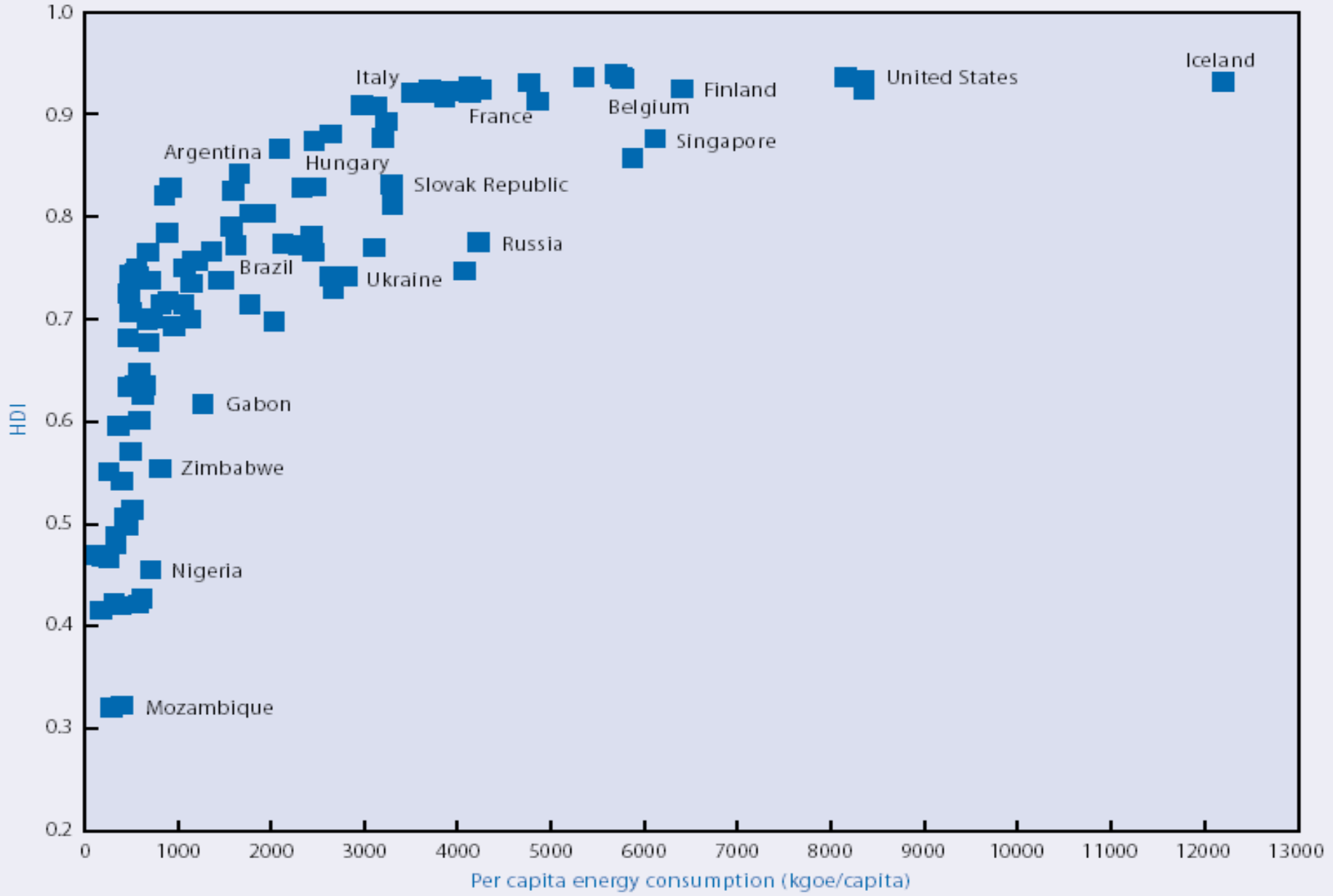
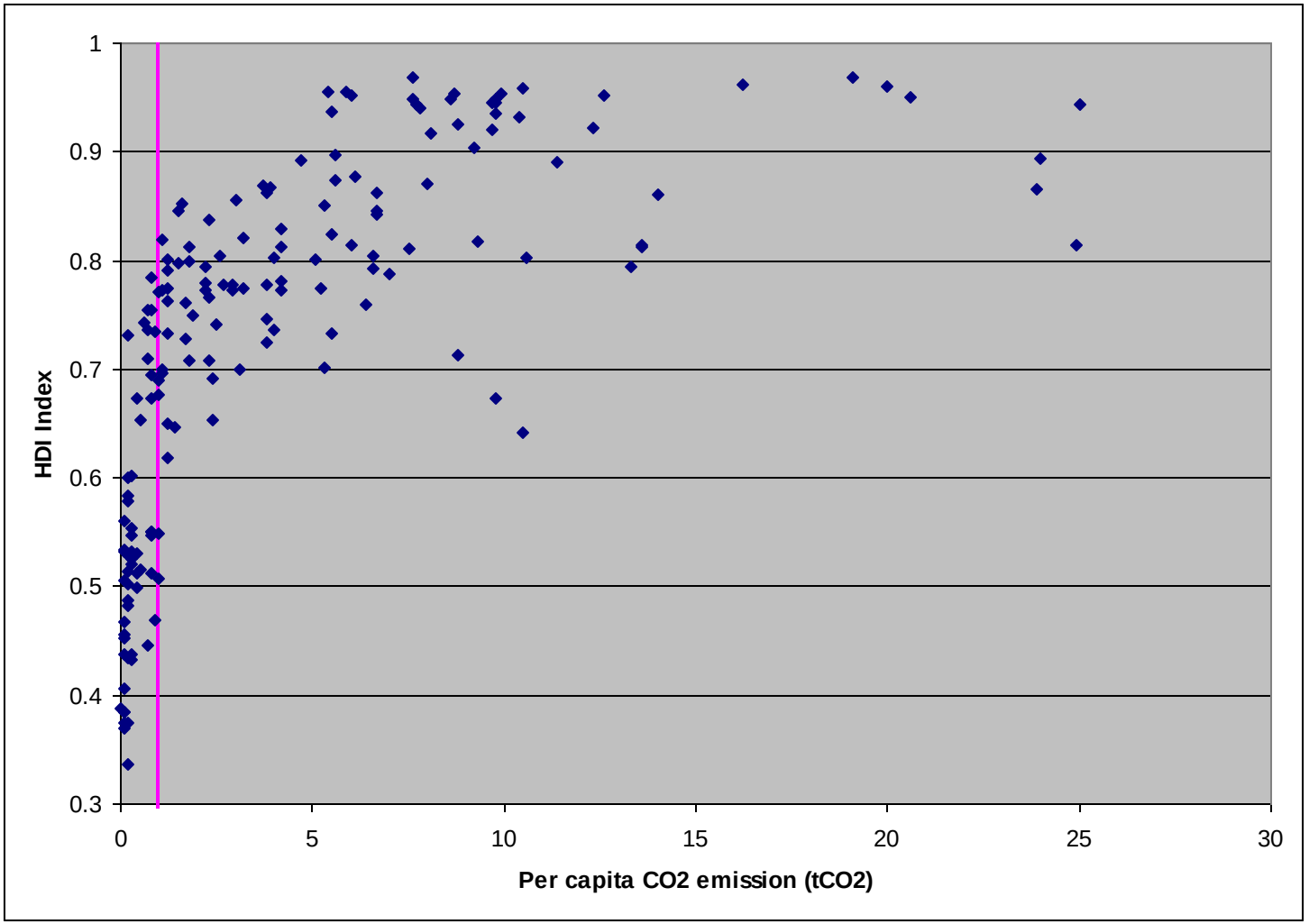
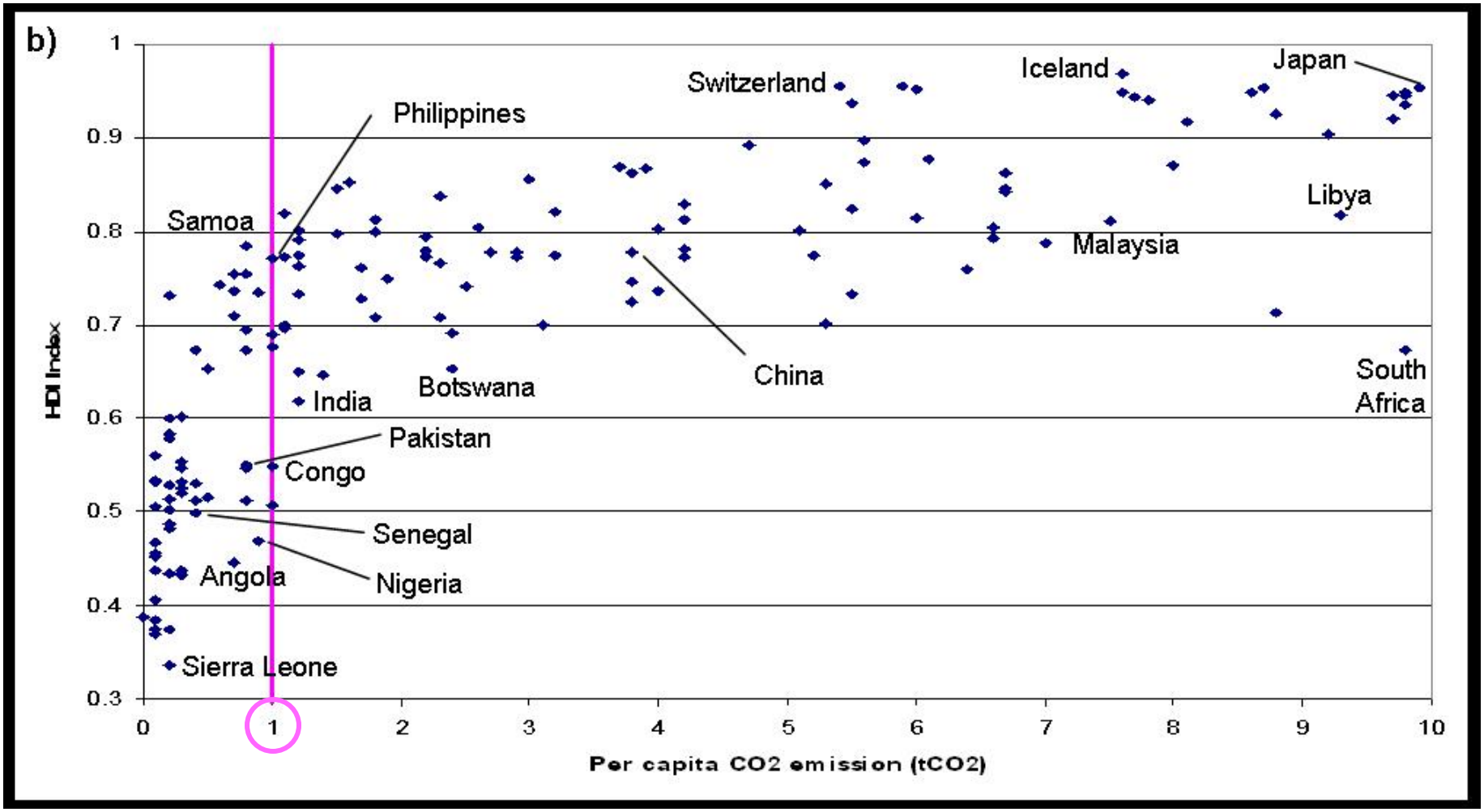
**FIGURE 3. RELATIONSHIP BETWEEN HDI AND PER CAPITA ENERGY USE, 1999/2000**




HDI Index
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
5
10
15
20
25
30
Per capita CO2 emission (tCO2)

# Per capita $CO_2$ vs the U.N.'s Human Development Index



# Basic Human Needs and Fossil Energy

The challenge of meeting Basic Human Needs for electricity and clean cooking fuels is widely understood to be political, not technical:

> Power *can* be brought to all villages.
>
> The indoor air quality catastrophe related to cooking fuels in rural and urban areas *can* be solved with modern fuels.

The **diesel fuel** for village-scale engines and the **LPG** (propane) or **DME** (dimethyl ether) fuel for clean cooking can be produced from biomass, natural gas, crude oil, or coal.

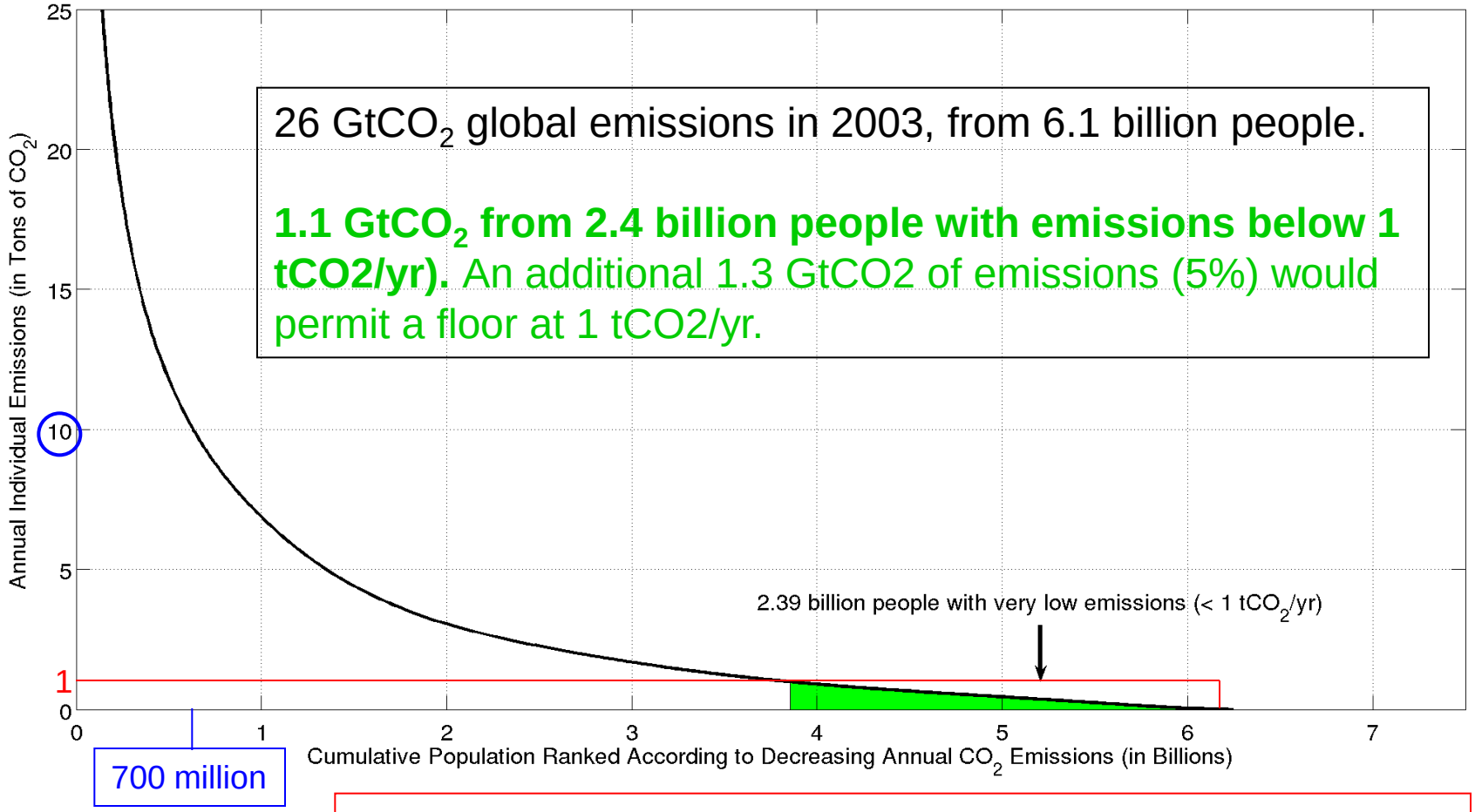
# Three questions and some possible answers

1. **Development – what is it?**
   - Economic development
   - Poverty reduction / health improvement (Sachs)
   - Freedom (Sen)

2. **How does development relate to environmental problems?**
   - Destruction of environment (WCED, IPCC Ch.19)
   - Protection from environment (Castro, IPCC Ch.19)

3. **What role do developing countries play in climate change?**
   - Victims or bystanders (Schelling, Gibbs)
   - An obligation for developed countries (Stern)
   - Independent actors (example of China)

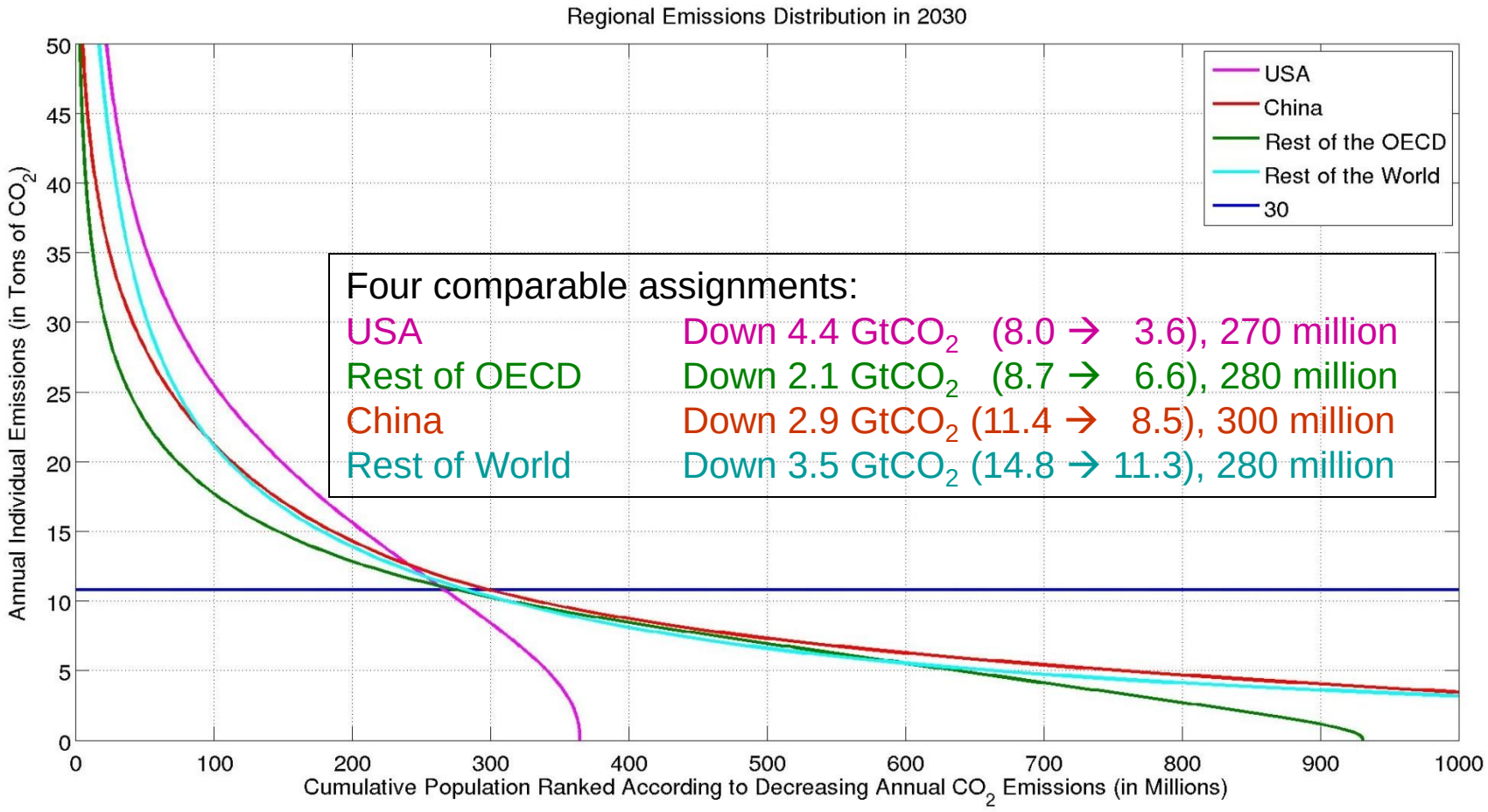
# The aggregate emissions of the world's poorest people are negligible




The world's poor do not need to be denied fossil fuels

# EXTRA SLIDES
# BEYOND PER CAPITA

# Four regions of the world have comparable assignments



# Safe is not fair, and fair is not safe

Define “fairness” as equal access to the atmosphere for all nations measured by *cumulative per capita emissions* over some time interval.

For a stringent target, fairness in this sense is not achievable.

Thus, fairness must be redefined: equal opportunity to develop, while benefiting from options not available in the past.

# Historical Responsibility

“Safe vs. fair: a formidable trade-off in tackling climate change.”

M. Tavoni, S. Chakravarty, and R. Socolow.

Slides that follow here are not the final versions in the publication.

# Historical emissions

| | World | Annex I | Non-Annex I |
|---|---|---|---|
| 1850-2005 | 1780 | 990 | 690 |
| 1950-2005 | 1190 | 660 | 530 |
| 1990-2005 | 450 | 220 | 230 |

*Table 1: Historical cumulative emissions of $CO_2$ from the world, Annex I and Non-Annex I (GtCO2).*

"Safe vs. fair: a formidable trade-off in tackling climate change." M. Tavoni, S. Chakravarty, and R. Socolow. Manuscript in preparation

# Equal cumulative per capita emissions

"Our fairness principle equates cumulative per capita emissions over some partly past and partly future time interval for some set of regions, using some well-defined value for the population of each region. We call this the *Equal Cumulative Per Capita (ECPC)* principle. It results from imagining that every region contains immortal individuals whose average emissions are identical over some time interval."

"Safe vs. fair: a formidable trade-off in tackling climate change." M. Tavoni, S. Chakravarty, and R. Socolow. Manuscript in preparation, *September 2010*

# Fairness via ECPC: consequences

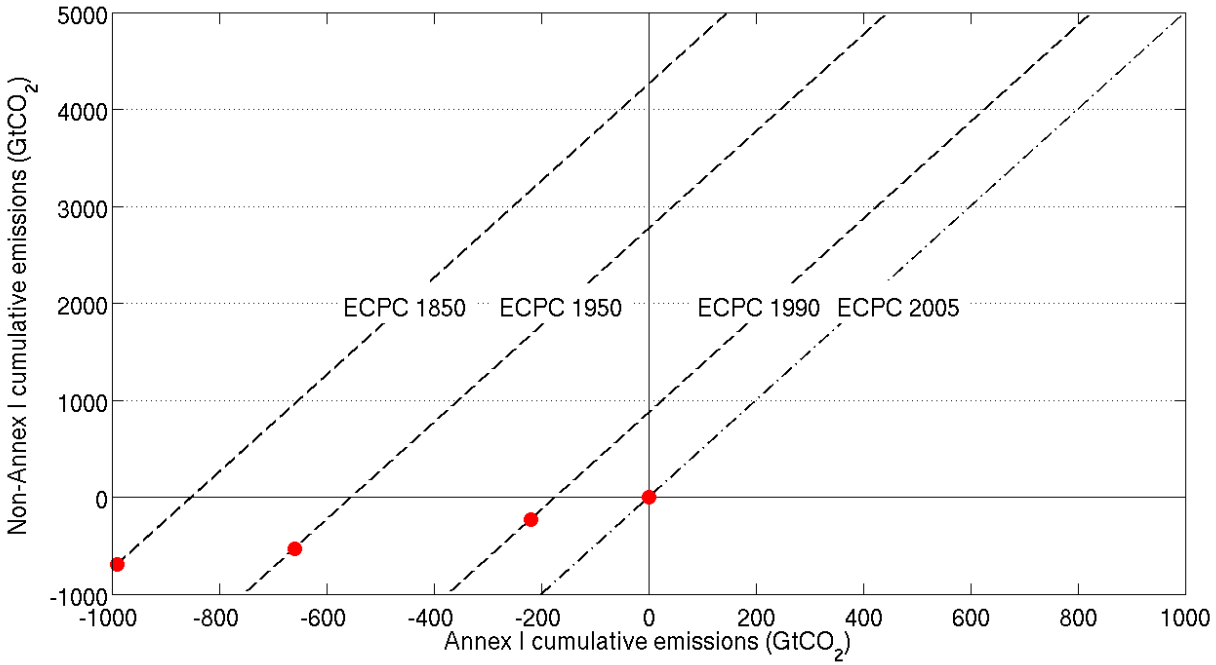



*Figure 1: Fairness lines for cumulative CO2 emissions after 2005 (GtCO2), for Annex I versus Non-Annex I, under four ECPC schemes. Circles identify the points corresponding to a clean slate with respect to historical emissions. Note that the scales are distorted such that a line at 45 degrees corresponds to a slope of 5.*

"Safe vs. fair: a formidable trade-off in tackling climate change." M. Tavoni, S. Chakravarty, and R. Socolow. Manuscript in preparation.

# Safety: 2000 $GtCO_2$ emissions = 1°C

| *Future cumulative emissions* | *Temperature Increase (bottom 5%)* | ***Temperature Increase (central value)*** | *Temperature Increase (top 5%)* | *Probability of not exceeding 2 ° C* |
|---|---|---|---|---|
| $GtCO_2$ | ° C | **° C** | ° C | % |
| 1000 | 0.8 | **1.3** | 1.9 | more than 95% |
| 2000 | 1.0 | **1.8** | 2.5 | just above 50% |
| 3000 | 1.3 | **2.3** | 3.3 | just below 50% |
| 4000 | 1.6 | **2.8** | 4.0 | somewhat above 5% |

*Table 2: Cumulative $CO_2$ emissions after 2005 and corresponding maximum-temperature target. The central value and top and bottom of the "very likely" range are shown, where "very likely" is the centered 90% interval of the distribution.*

"Safe vs. fair: a formidable trade-off in tackling climate change." M. Tavoni, S. Chakravarty, and R. Socolow. Manuscript in preparation.

# (Fairness, Safety) combinations

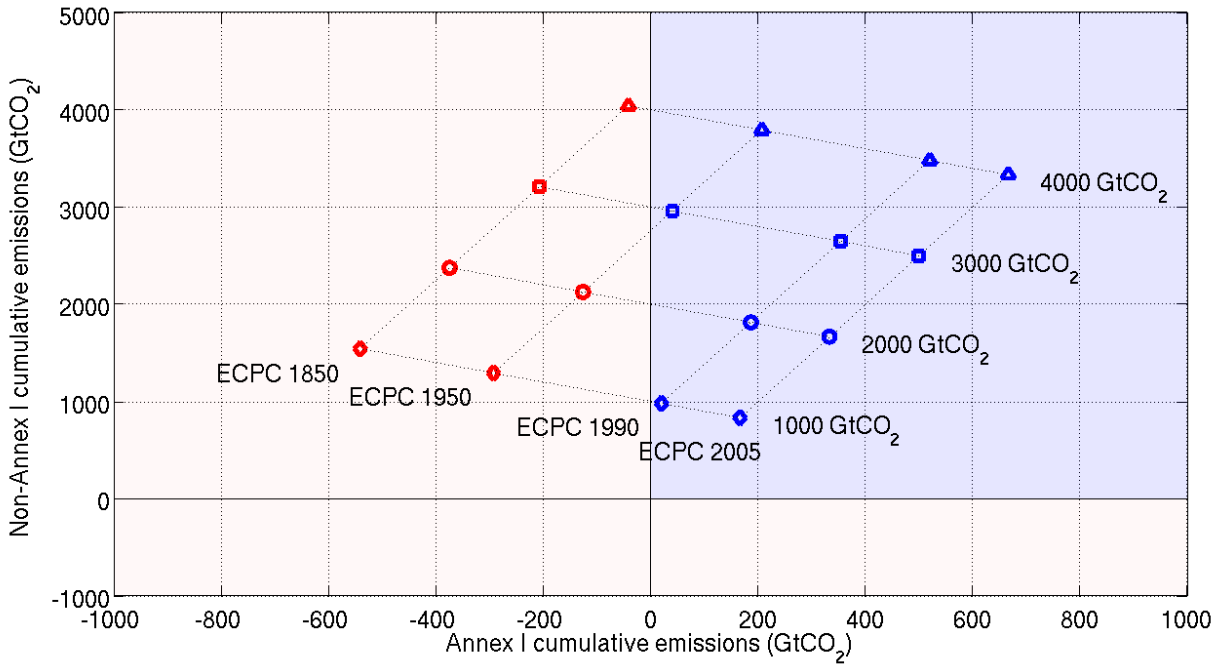



*Figure 2: The addition of safety targets to Figure 1. The 16 points correspond to intersections of four values of future CO2 emission budgets with the four fairness lines shown in Figure 1. The shaded region corresponds to positive values for both Annex I and non-Annex I.*

"Safe vs. fair: a formidable trade-off in tackling climate change." M. Tavoni, S. Chakravarty, and R. Socolow. Manuscript in preparation.

# Add “minimum cumulative emissions”

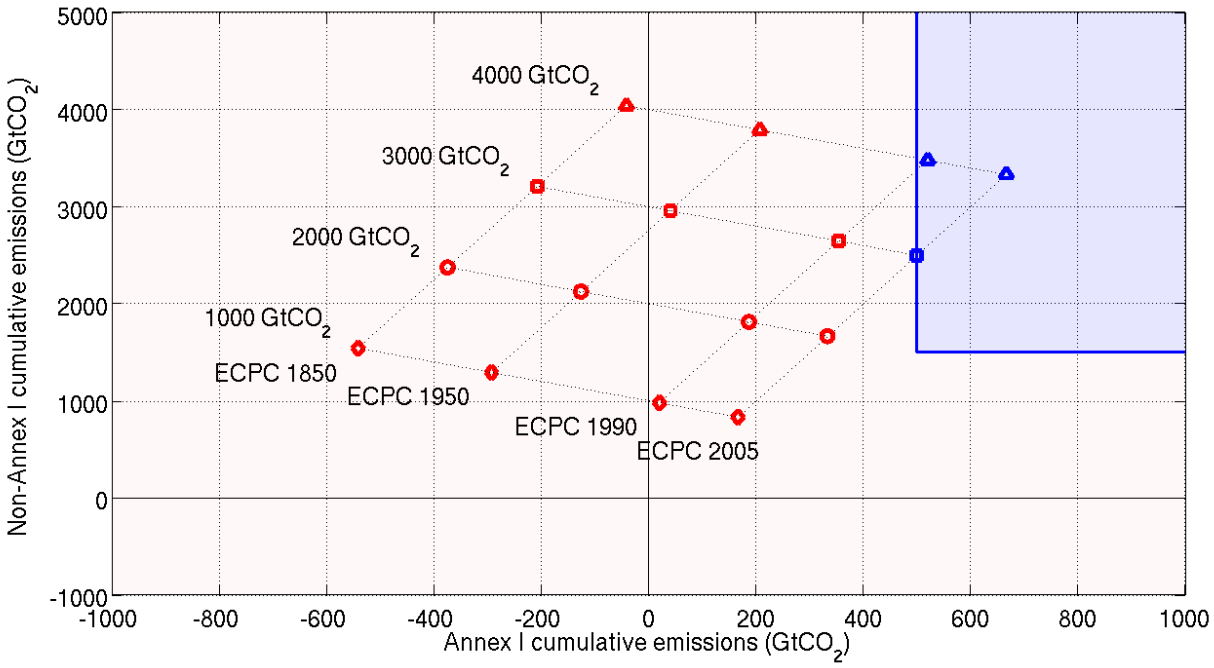
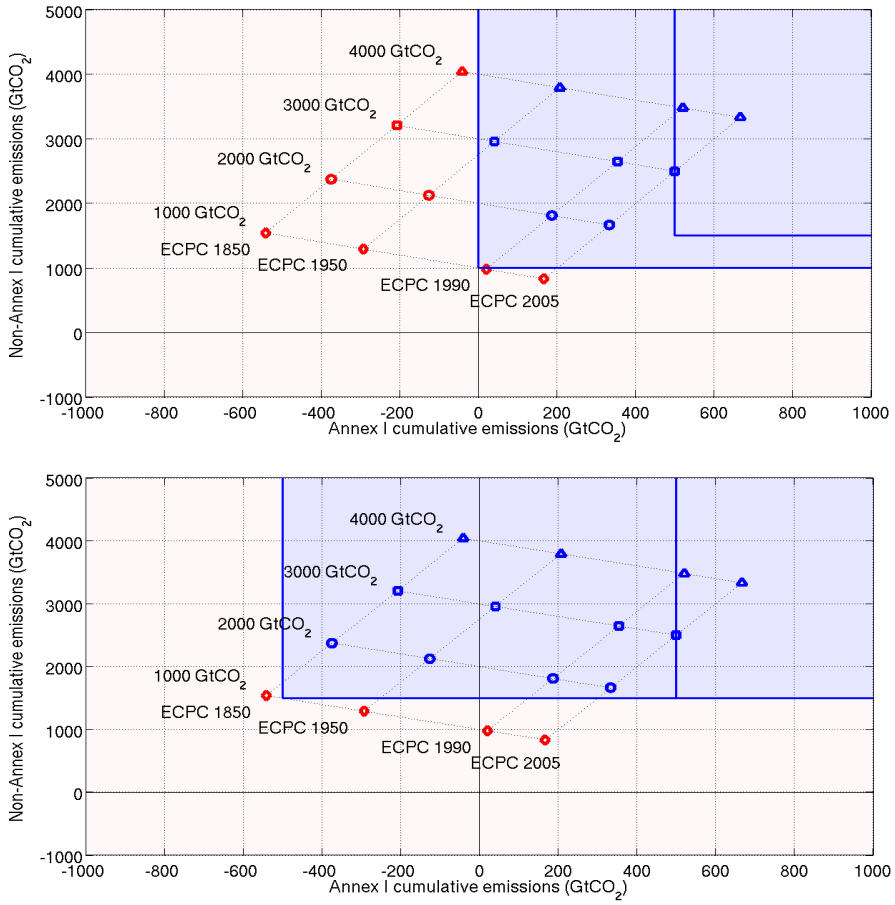



*Figure 3: The addition of minimum cumulative emissions (MCE) to Figure 2. The three points marked in blue lies in the feasibility space of 'allowed' targets shown as a shaded region (see text).*

“Safe vs. fair: a formidable trade-off in tackling climate change.” M. Tavoni, S. Chakravarty, and R. Socolow. Manuscript in preparation.

# Add 1000 $GtCO_2$ "negative emissions"




*Source*: "Safe vs. fair: a formidable trade-off in tackling climate change." M. Tavoni, S. Chakravarty, and R. Socolow. Manuscript in preparation.

*Figure 4: The addition of 1000 GtCO2 of negative CO2 emissions to Figure 3, resulting in additional area for the "allowed" region. Two allocations of these negative emissions are displayed: 500 GtCO2 to each region in the upper panel and all emissions to Annex 1 in the lower panel.*

# EXTRA SLIDES FROM ALEX WHITWORTH'S LECTURE ON DEVELOPMENT

- Economic development (World Bank)
- Poverty reduction (Sachs)
- Freedom (Sen)

# PART 1: DEVELOPMENT – WHAT IS IT?

# Development as Poverty Reduction

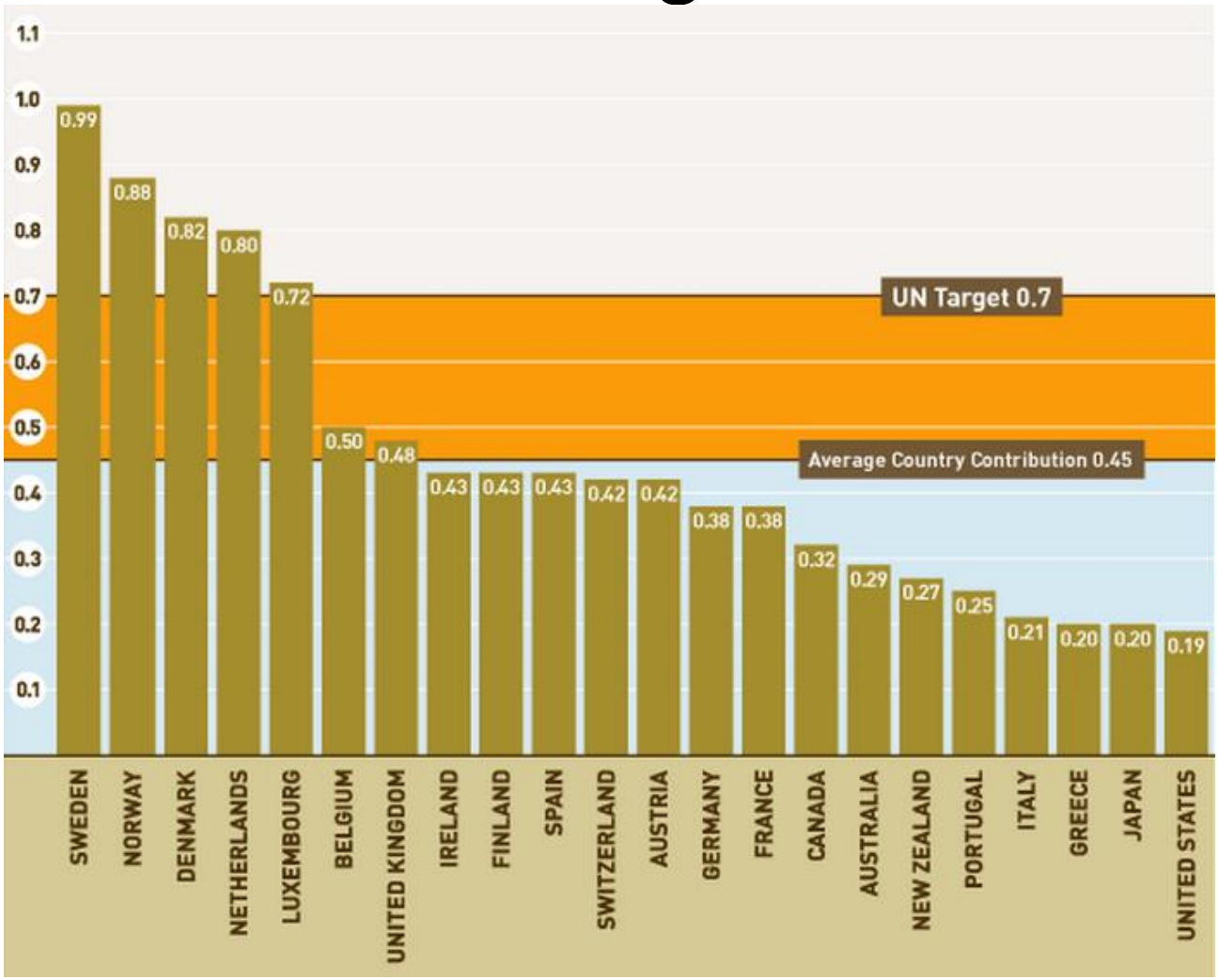
- A western philanthropic/charity movement based on ethical values

- UN Millennium Development Goals
  - end hunger
  - universal education
  - gender equality
  - child health
  - maternal health
  - environmental sustainability
  - etc.

# Poverty Reduction (contd.)

- **Sachs (2005):**
  - "*For the first time in history … the world [is] within reach of eliminating extreme poverty altogether*"
  - A "*concerted global effort*" is needed (led and funded by developed countries)
  - Doubling the $160b per year in aid to developing countries (about 0.5% of global GDP) would "go a long way" towards ending poverty. Long term target of 0.7% of global GDP.
  - Developing countries have "*roadblocks*" "*poor governance*" "*corruption*" negative "*geographic factors*" and live in a "*poverty trap*" (they are victims)
  - The rich countries should "*invest in reducing poverty*" and this will "*one day yield huge returns*"

# Aid as a Percentage of GDP, 2008




Source: OECD data, Bill and Melinda Gates Foundation (2010)

# Development as Freedom

- Amartya Sen defines development as improving the following 5 freedoms:

| | | |
|---|---|---|
| 1. | Political freedom | civil rights |
| 2. | Economic facilities | opportunity/re-distribution |
| 3. | Social opportunities | education/health care |
| 4. | Transparency guarantees | openness and trust / free press |
| 5. | Protective security | reduce vulnerability/ improve safety net |

- He also argues that these freedoms are causal factors in leading to economic development NOT the other way around. (compare Sachs)

Sen, 1999, pg.40-41

# PART 2:
# HOW DOES DEVELOPMENT RELATE TO ENVIRONMENTAL PROBLEMS?

- Destruction of environment (WCED, IPCC Ch.19)
- Protection from environment (Castro, IPCC Ch.19)

# Development as leading to environmental destruction

- **World Commission on Environment and Development (1987):**
  - Tragedy of the commons: as each country strives for prosperity, little will be left for future generations
  - Development, growth, consumption (and poverty) lead to environmental degradation
  - Environmental degradation can "*dampen or reverse*" economic development
  - Solution: "***Sustainable development*** *seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future*"; aim for a "*harmony among human beings and between humans and nature*"
  - Need to curb and limit development and population growth, focus on "*essential needs*"

# What does science say about development and environment?

- Look at the 2007 report by the Intergovernmental Panel on Climate Change (IPCC)

# IPCC Report (Development->destruction)

| Systems, processes or groups at risk [cross-references] | Prime criteria for 'key vulnerability' (based on the seven criteria listed in Section 19.2) | Relationship between temperature and risk. Temperature change by 2100 (relative to 1990-2000) 0°C | 1°C | 2°C | 3°C | 4°C | 5°C |
|---|---|---|---|---|---|---|---|
| **Global social systems** | | | | | | | |
| Food supply [19.3.2.2] | Distribution, Magnitude | | Productivity decreases for some cereals in low latitudes */• [5.4] | Productivity increases for some cereals in mid/high latitudes */• [5.4] Global production potential increases to around 3°C * [5.4, 5.6] | | Cereal productivity decreases in some mid/high-latitude regions */• [5.4] Global production potential very likely to decrease above about 3°C * [5.4, 5.6] | |
| Infrastructure [19.3.2] | Distribution, Magnitude, Timing | Damages likely to increase exponentially, sensitive to rate of climate change, change in extreme events and adaptive capacity ** [3.5, 6.5.3, 7.5]. | | | | | |
| Health [19.3.2] | Distribution, Magnitude, Timing, Irreversibility | Current effects are small but discernible * [1.3.7, 8.2]. | Although some risks would be reduced, aggregate health impacts would increase, particularly from malnutrition, diarrhoeal diseases, infectious diseases, floods and droughts, extreme heat, and other sources of risk */**. Sensitive to status of public health system *** [8.ES, 8.3, 8.4, 8.6]. | | | | |
| Water resources [19.3.2] | Distribution, Magnitude, Timing | Decreased water availability and increased drought in some mid latitudes and semi-arid low latitudes ** [3.2, 3.4, 3.7]. | Severity of floods, droughts, erosion, water-quality deterioration will increase with increasing climate change ***. Sea-level rise will extend areas of salinisation of groundwater, decreasing freshwater availability in coastal areas *** [3.ES]. Hundreds of millions people would face reduced water supplies ** [3.5]. | | | | |
| Migration and conflict | Distribution, Magnitude | Stresses such as increased drought, water shortages, and riverine and coastal flooding will affect many local and regional populations **. This will lead in some cases to relocation within or between countries, exacerbating conflicts and imposing migration pressures * [19.2]. | | | | | |

# IPCC Report (Development -> Protection)

- “The **distribution of impacts and vulnerabilities** is still considered to be uneven, and low-latitude, less-developed areas are generally at greatest risk due to both higher sensitivity and lower adaptive capacity”
- “Vulnerability to climate change differs considerably across socio-economic groups, thus raising important questions about equity.”
- **Adaptation** can significantly reduce many potentially dangerous impacts of climate change and reduce the risk of many key vulnerabilities. However, the technical, financial and institutional capacity, and the actual planning and implementation of effective adaptation, is currently quite limited in many regions…”
- **Does adaption or adaptive “capacity” mean development?**

# IPCC Ch.19 Environment impacts vs. Human impacts

- “There is high confidence that climate change will result in extinction of many species and reduction in the diversity of ecosystems..” in addition to geophysical changes.

- “But in terms of impacts on society, it is clear that adaptation potential is greater the more the system is under human management and control…”

- “A general conclusion on the basis of the present understanding is that for market and social systems there is considerable adaptation potential, but the economic costs are potentially large, largely unknown and unequally distributed, as is the adaptation potential itself.”

# Development as Protection from the Environment

- 9.0 magnitude quake and tsunami in Japan 2011 killed over 15,000
- US Drought of 2002 caused billions in damage, but no direct deaths
- Hurricane Katrina in U.S. 2005, $81b in damage and 1800 dead
- 7.0 magnitude quake in Haiti 2010 killed over 300,000
- East Africa drought 2011, over 29,000 children dead and 10m need food aid
- Cyclone Bhola in Bangladesh 1970, over 300,000 dead

# Most deadly natural disasters of the 20th century

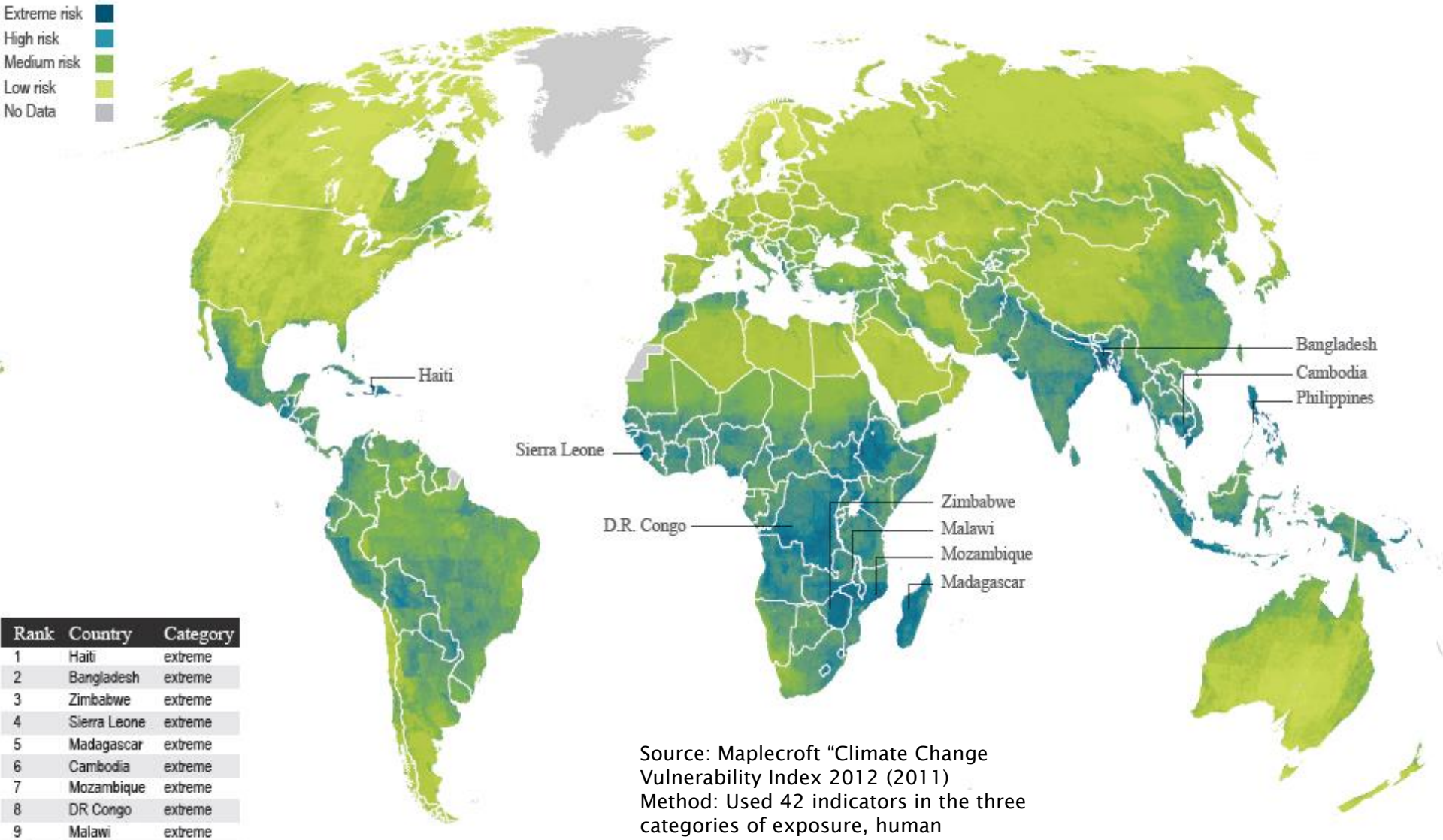
| | Country | Year | Day | Month | Disaster | Region | Continent | Killed |
|---|---|---|---|---|---|---|---|---|
| 1 | NA | 1917 | | | Epidemic | NA | ALL | 20,000,000 |
| 2 | Soviet Union | 1932 | | | Famine | Russia.Fed | Europe | 5,000,000 |
| 3 | China, P Rep | 1931 | | July | Flood | E.Asia | Asia | 3,700,000 |
| 4 | China, P Rep | 1928 | | | Drought | E.Asia | Asia | 3,000,000 |
| 5 | NA | 1914 | | July | Epidemic | Rest.Europ | Europe | 3,000,000 |
| 6 | Soviet Union | 1917 | | | Epidemic | Russia.Fed | Europe | 2,500,000 |
| 7 | China, P Rep | 1959 | | July | Flood | E.Asia | Asia | 2,000,000 |
| 8 | India | 1920 | | | Epidemic | S.Asia | Asia | 2,000,000 |
| 9 | Bangladesh | 1943 | | | Famine | S.Asia | Asia | 1,900,000 |
| 10 | China, P Rep | 1909 | | | Epidemic | E.Asia | Asia | 1,500,000 |
| 11 | India | 1942 | | | Drought | S.Asia | Asia | 1,500,000 |
| 12 | India | 1907 | | | Epidemic | S.Asia | Asia | 1,300,000 |
| 13 | India | 1900 | | | Drought | S.Asia | Asia | 1,250,000 |
| 14 | NA | 1957 | | May | Epidemic | NA | ALL | 1,250,000 |
| 15 | Soviet Union | 1921 | | | Drought | Russia.Fed | Europe | 1,200,000 |
| 16 | NA | 1968 | | | Epidemic | NA | ALL | 700,000 |
| 17 | Ethiopia | 1972 | | | Famine | E.Africa | Africa | 600,000 |

Source: www.disastercenter.com

# Castro (1972) article

- Developed countries frame the “environmental crisis” in terms of protecting the status quo i.e. a “freezing of the present international order” “conservatism rather than conservation”
- LDCs seek to alter the global status quo through development
- Development affects both the “pollution of affluence” (+’ve) and the “pollution of poverty” (-’ve). The author argues that the latter is more relevant to developing countries.

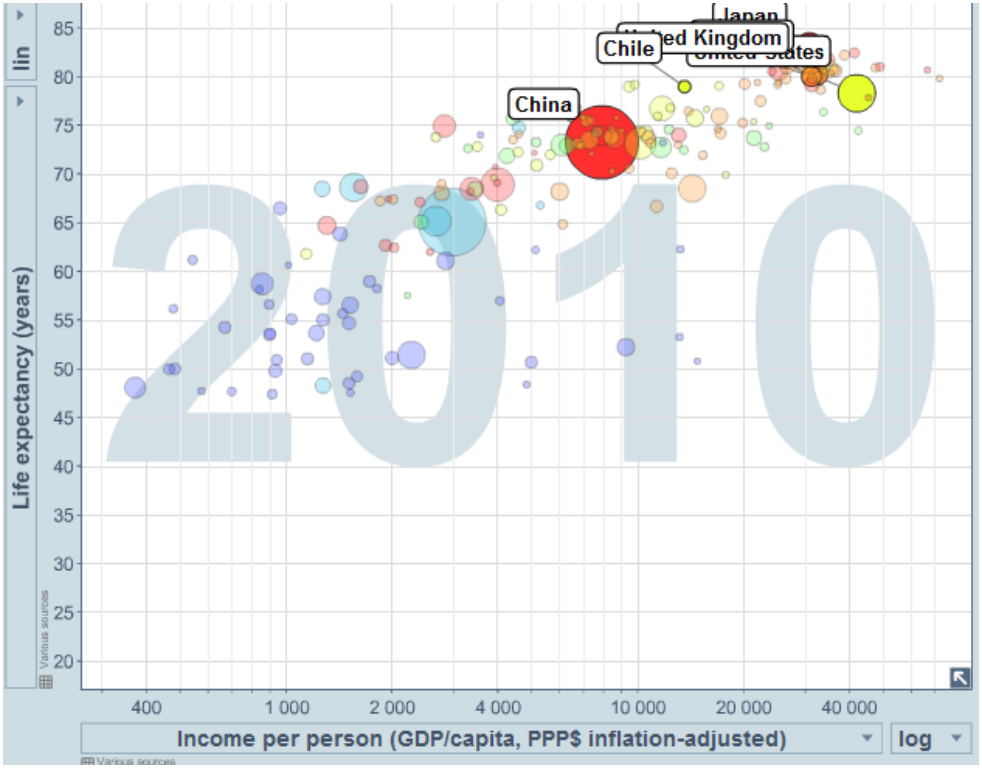
# Climate Change Vulnerability




| Rank | Country | Category |
|---|---|---|
| 1 | Haiti | extreme |
| 2 | Bangladesh | extreme |
| 3 | Zimbabwe | extreme |
| 4 | Sierra Leone | extreme |
| 5 | Madagascar | extreme |
| 6 | Cambodia | extreme |
| 7 | Mozambique | extreme |
| 8 | DR Congo | extreme |
| 9 | Malawi | extreme |
| 10 | Philippines | extreme |

Source: Maplecroft "Climate Change Vulnerability Index 2012 (2011)
Method: Used 42 indicators in the three categories of exposure, human sensitivity, and adaptive capacity

# Development Trends on Gapminder World, 1800-2010




http://www.gapminder.org/world/#$majorMode=chart$is;shi=t;ly=2003;lb=f;il=t;fs=11;al=30;stl=t;st=f;nsl=t;se=t$wst;tts=C$ts;sp=5.59290322580644;ti=2010$zpv;v=0$inc_x;mmid=XCOORDS;iid=phAwcNAVuyj1jiMAkmq1iMg;by=ind$inc_y;mmid=YCOORDS;iid=phAwcNAVuyj2tPLxKvvnNPA;by=ind$inc_s;uniValue=8.21;iid=phAwcNAVuyj0XOoBL_n5tAQ;by=ind$inc_c;uniValue=255;gid=CATID0;by=grp$map_x;scale=log;dataMin=295;dataMax=79210$map_y;scale=lin;dataMin=19;dataMax=86$map_s;sma=41;smi=2.65$cd;bd=0$inds=i44_r,,,,,,;i239_r,,,,,,;i110_r,,,,,,;i43_r,,,,,,;i82_r,,,,,,;i238_r,,,,,,;modified=75

# PART 3:
# WHAT ROLE DO DEVELOPING COUNTRIES PLAY IN CLIMATE CHANGE?

- Victims or bystanders (Schelling, Gibbs)
- An obligation for developed countries (Stern)
- Independent actors (example of China)

# Emissions

**Figure 3. Change in $CO_2$ emissions by region (2008-2009)**

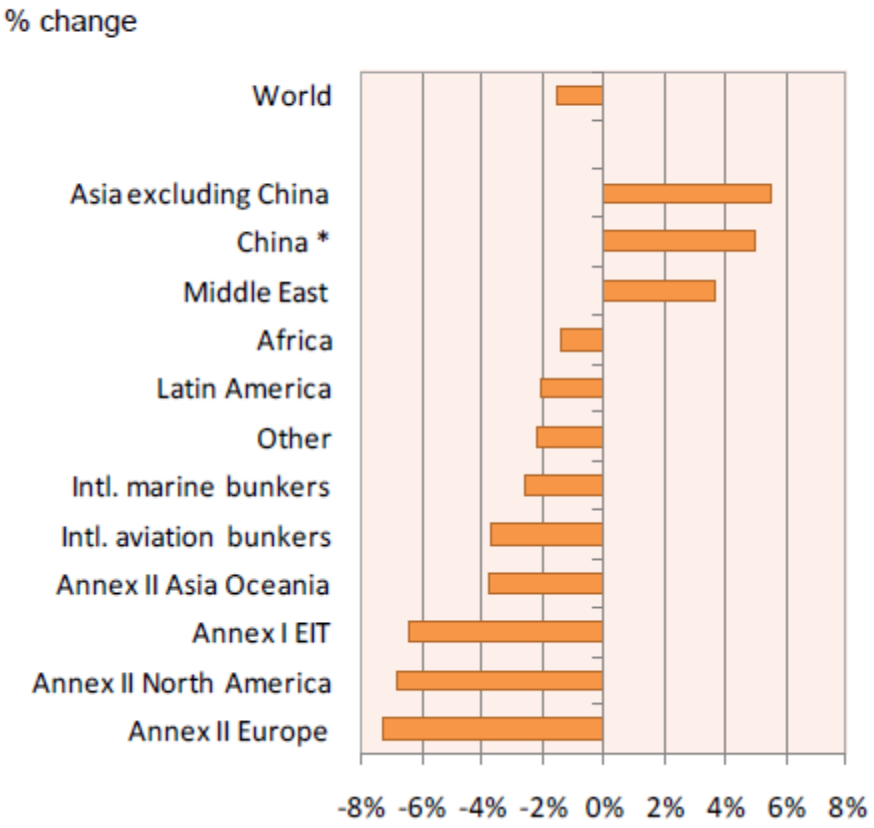
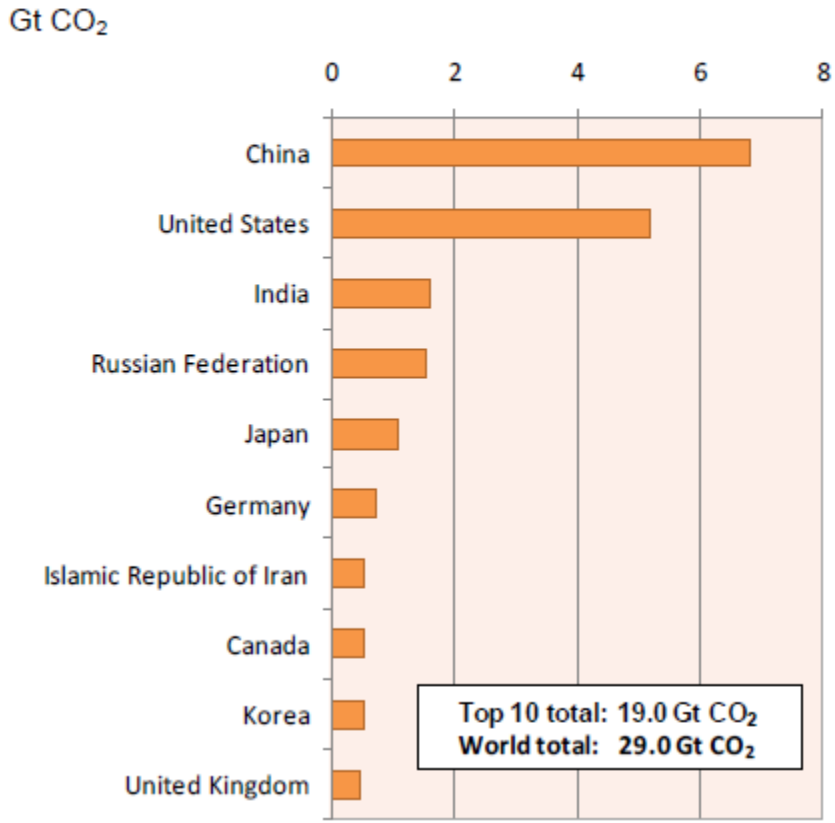
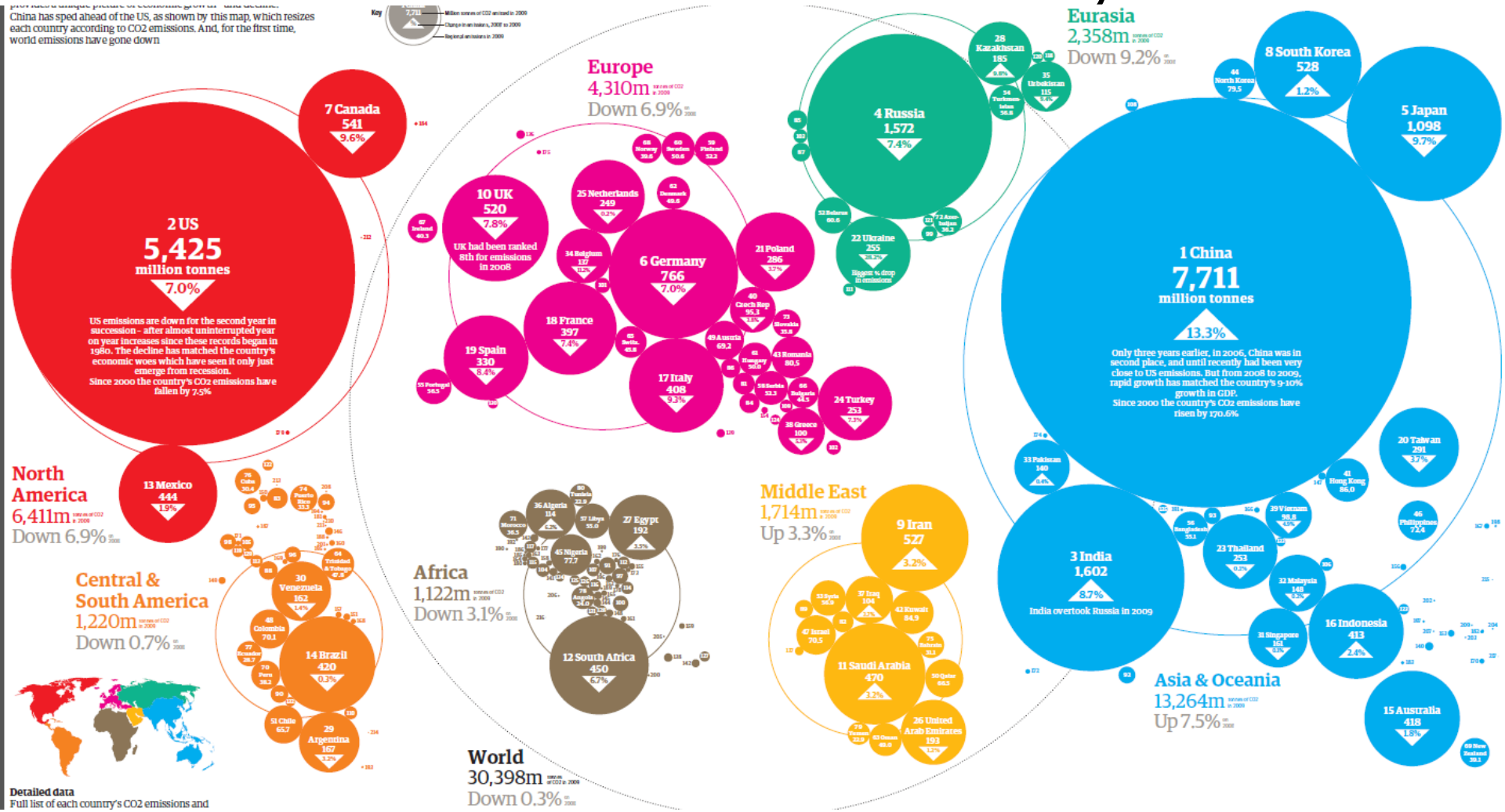



**Figure 4. Top 10 emitting countries in 2009**




Source: International Energy Agency 2011 Report on CO2 emissions

# Global CO2 Emissions, 2009




Source: EIA data; Guardian.co.uk "atlas of pollution"

# Schelling (1992) on Climate Change - summary

- Impact on human welfare in developed countries is likely quite modest compared to other changes (social, economic, technology) over time.

- "[developing countries'] best defense against climate change may be their own continued development."

- Arguments for helping less-developed countries include
  - caring about those less well-off (ethical)
  - Protecting the (global) environment and ecosystems (environmental)
  - Possible (unexpected) self-interest – i.e. catastrophic risk to developed countries.

- Disclaimer: Models cannot predict discontinuities.

# Adaption vs. Mitigation debate

- Question 1: Is it necessary to reduce emissions if technologies are available to adapt and protect our society and lifestyles? (are environmental outcomes important by themselves?)

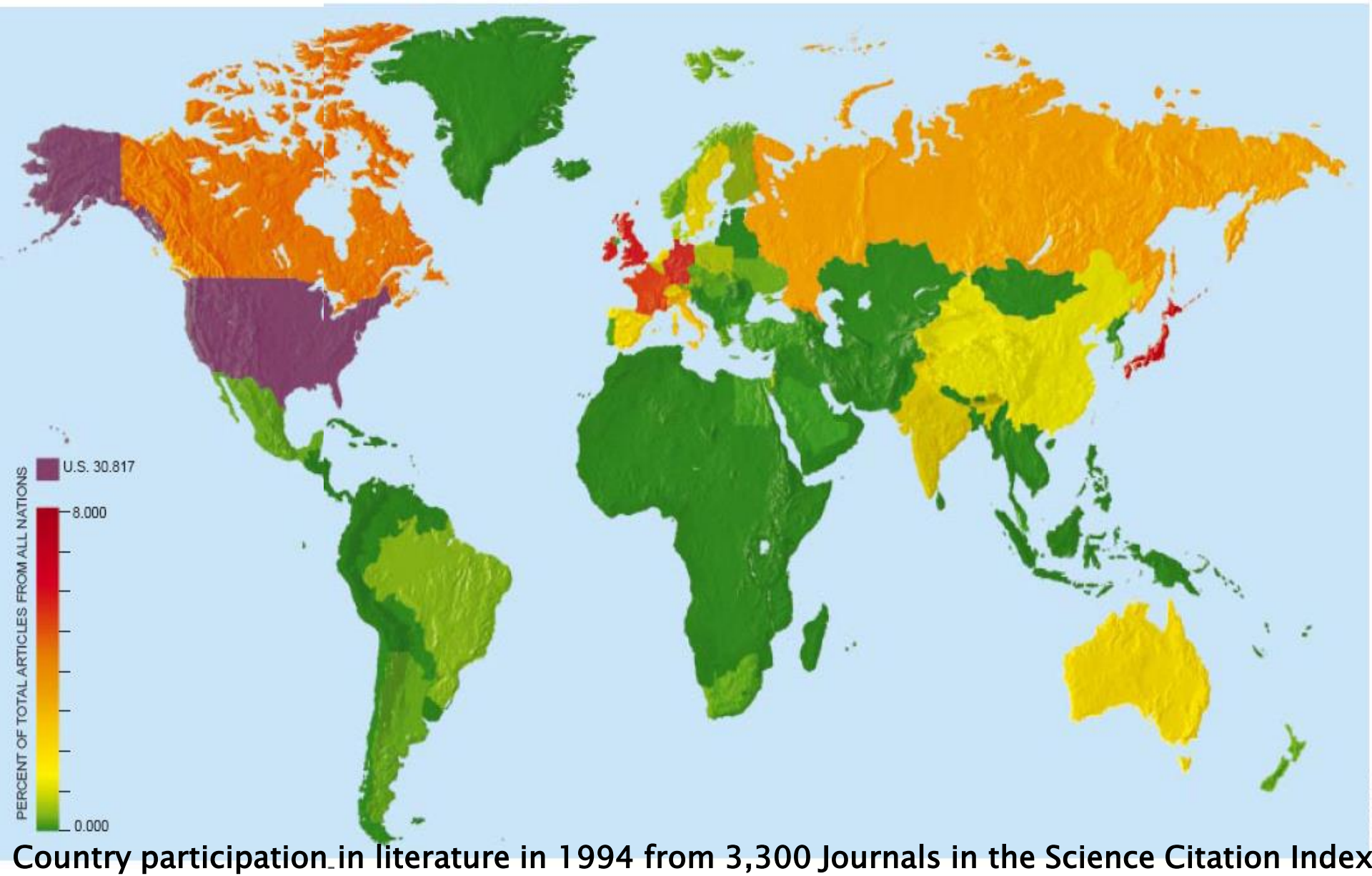
- Question 2: Who will have access to such technologies? Who will not? (are the outcomes of the poor important?)

- Mitigation is a public good shared by all. Adaption (and development) can be used exclusively.

# Agenda and information

- Developed countries have traditionally produced most scientific research and controlled the international political agenda (e.g. ozone depletion, animal conservation, climate change )

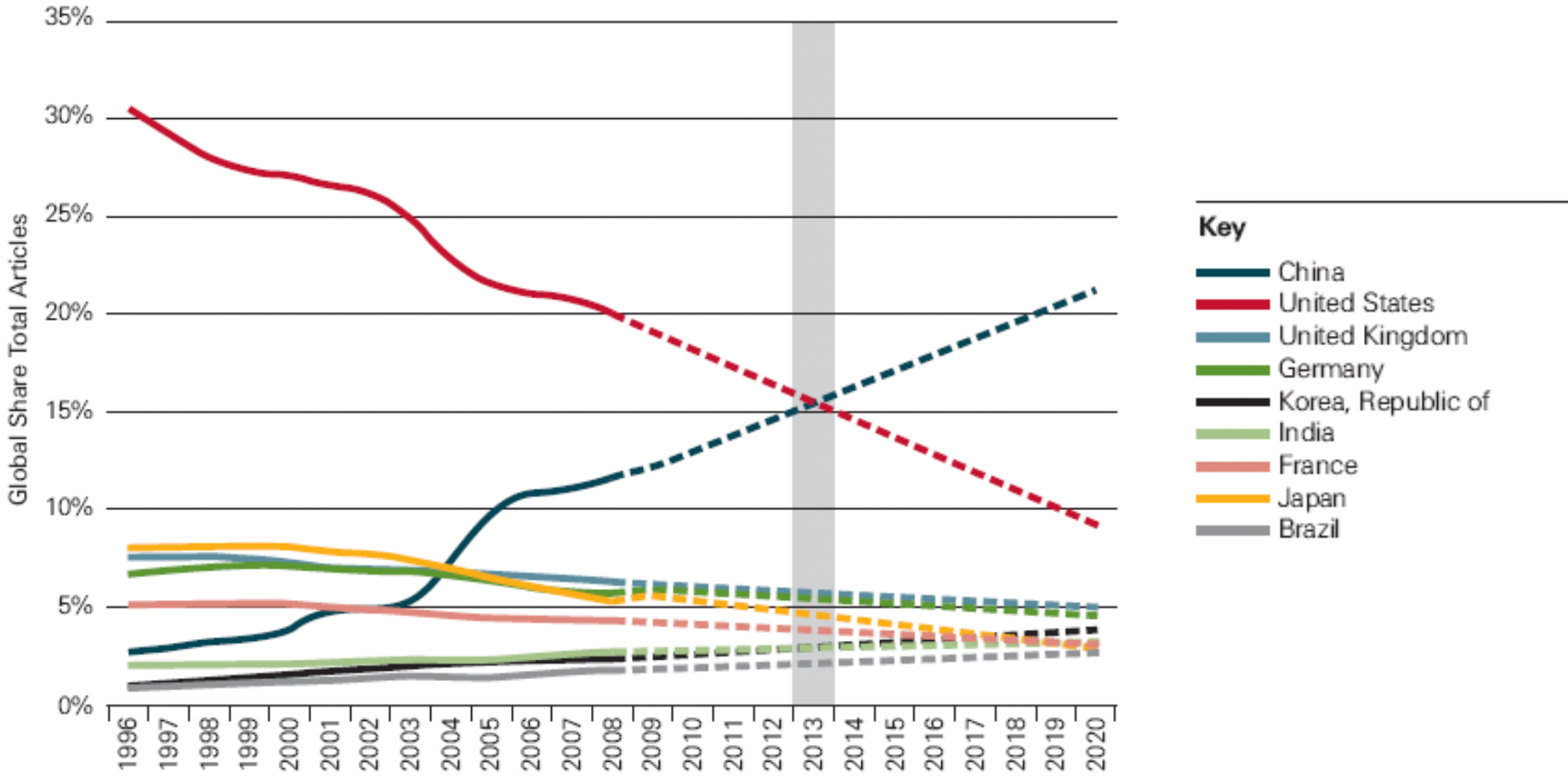
- This seems to be changing – what are the implications?




Country participation in literature in 1994 from 3,300 Journals in the Science Citation Index

(Gibbs, 1995, "Lost Science in the Third World", *Scientific American)*

# Recent Science Publication Trends




(Royal Society Report (2011) on "*Knowledge, Networks and Nations: Global scientific collaboration in the 21st century*")

# Is Climate Change an Obligation for the rich?

- **Stern Review, 2006**
  - Stern concluded (controversially) that the benefits of early action and mitigation of climate change more than justify the costs incurred (estimated at 1% of global GDP)
  - Therefore global management of the climate and policies such as a carbon price and international agreement are needed
  - "*Climate change mitigation raises the classic problem of the provision of a global public good. It shares key characteristics with other environmental challenges that require the international management of common resources to avoid free riding.*"
  - But who will be the managers? There has been pushback from interest groups in both developing and developed countries.

# China Case Stu

- The world's largest carbon dioxide emitter, but still low per capita emissions compared to USA
- Chose, and is choosing, a path of development which has successfully reduced poverty and increased adaptive capacity to disasters, while increasing carbon emissions
- Rapid developments in technologies and policies for improving energy efficiency and mitigating climate change

# Leading nations in Renewable Energy

**TOP FIVE COUNTRIES – Annual additions in 2010**

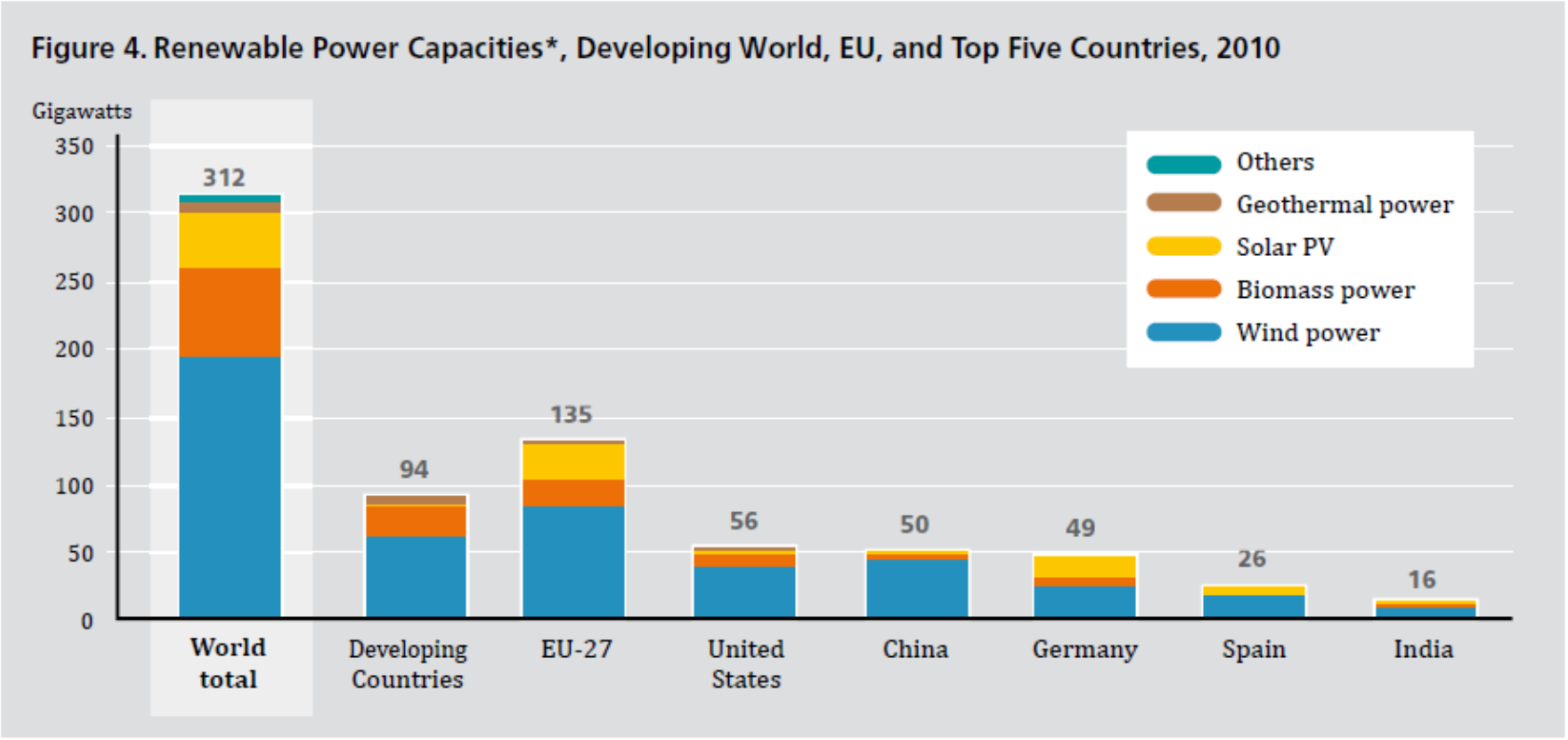
| | New capacity investment | Wind power | Solar PV | Solar hot water/heat[2] | Ethanol production | Biodiesel production |
|---|---|---|---|---|---|---|
| 1 | China | China | Germany | China | United States | Germany |
| 2 | Germany | United States | Italy | Germany | Brazil | Brazil |
| 3 | United States | India | Czech Republic | Turkey | China | Argentina |
| 4 | Italy | Spain | Japan | India | Canada | France |
| 5 | Brazil | Germany | United States | Australia | France | United States |

**TOP FIVE COUNTRIES – Existing capacity as of end-2010**

| | Renewables power capacity (not including hydro) | Renewables power capacity (including hydro) | Wind power | Biomass power | Geothermal power | Solar PV | Solar hot water/heat[2] |
|---|---|---|---|---|---|---|---|
| 1 | United States | China | China | United States | United States | Germany | China |
| 2 | China | United States | United States | Brazil | Philippines | Spain | Turkey |
| 3 | Germany | Canada | Germany | Germany | Indonesia | Japan | Germany |
| 4 | Spain | Brazil | Spain | China | Mexico | Italy | Japan |
| 5 | India | Germany/ India | India | Sweden | Italy | United States | Greece |

Source: REN21 Global Renewables Status Report 2011

# Breakdown of Renewable Energy by Country

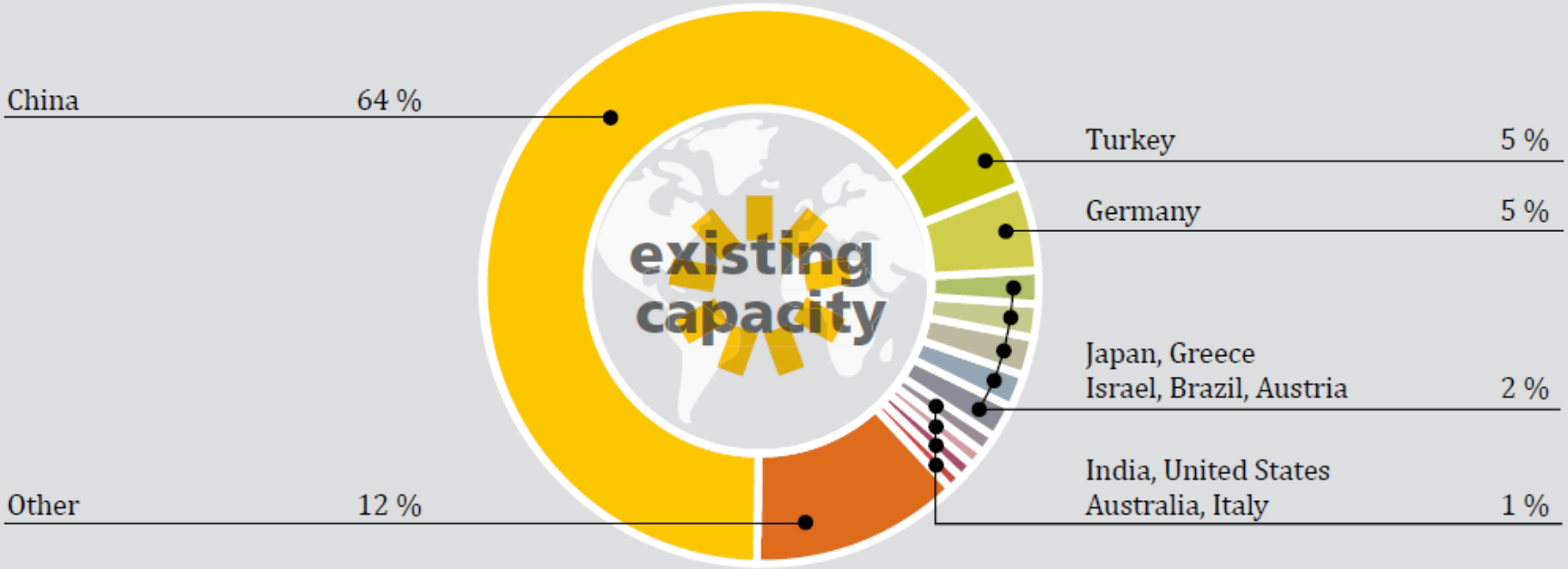



Note: China's hydro capacity is 197GW in 2009, the largest in the world and more than double the second placed nation (Canada)

Source: REN21 Global Renewables Status Report 2011

# Solar water heating capacity

**Figure 10. Solar Heating Existing Capacity, Top 12 Countries, 2009**




- Global Total = 185 GW thermal installed in 2010, growing about 16% (25GW) from 2009
- Over 10 percent of all households in China have solar hot water installed – technology is cheaper than competitors such as gas heating

Source: Weiss and Mauthner, 2011; REN21

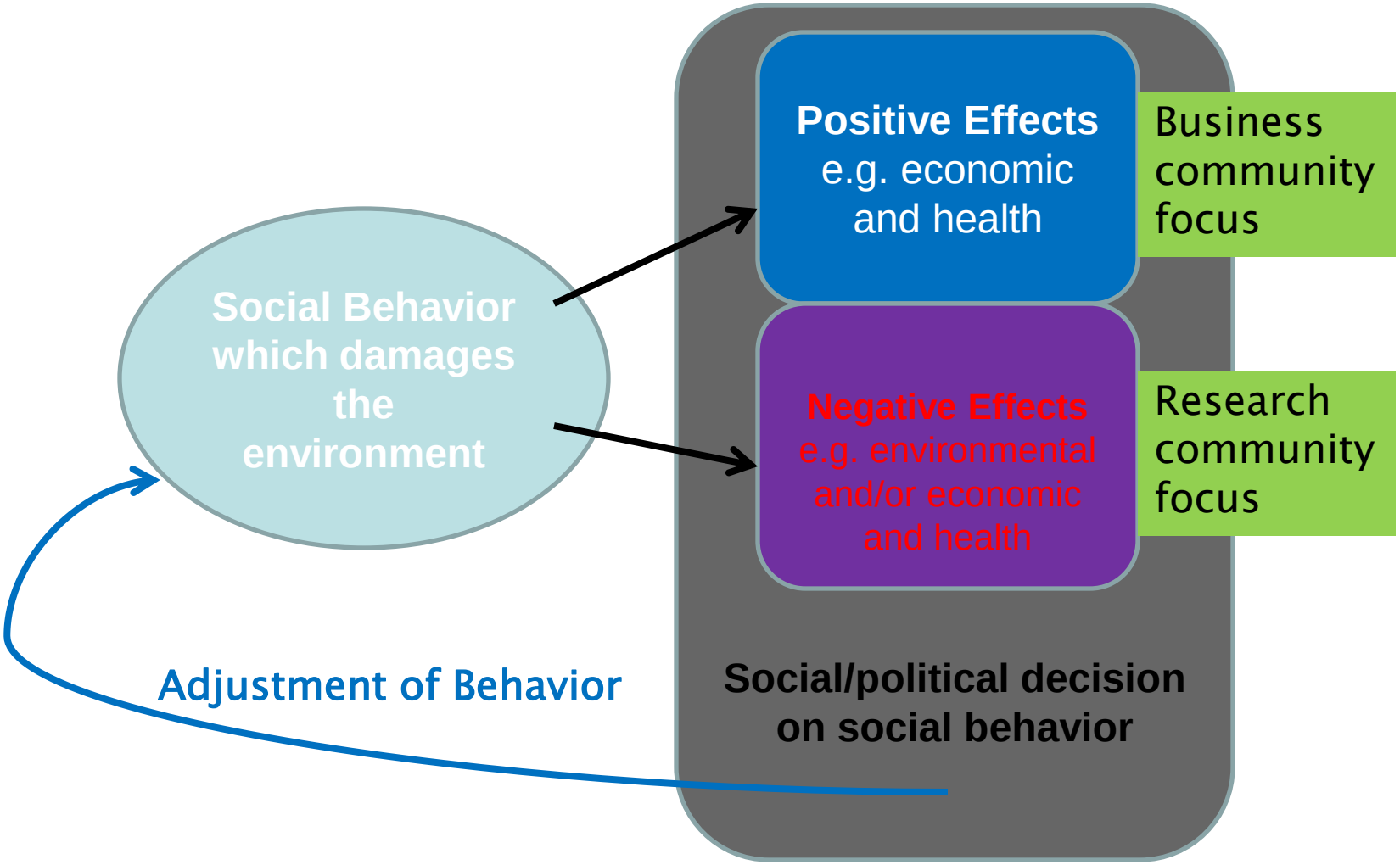
# OTHER OBSERVATIONS

# Range of values for making decisions on environmental issues

| Group | Heuristic for decision making |
|---|---|
| Green | Environmental impacts should be reduced and mitigated without regard for the social or economic cost |
| Green humanist | Environmental impacts should be reduced and mitigated as long as social and economic costs are reasonable/minimal and/or there is a social benefit |
| Humanist | Environmental impacts should be reduced only to the extent that they can be shown to benefit people and society |
| Skeptical humanist/ individualist | Environmental impacts should be reduced only to the extent that they can be clearly and directly be shown to benefit the individual actor |
| Skeptic | Environmental impacts are not important and should be ignored, or do not exist. Other values such as economic development or self-interest are more important |

Divergence in policy preferences on environmental issues

# Evaluating a social behavior



# Conclusion/Discussion

- How well can we answer these questions:

1. What is development?

2. How does development relate to environmental problems?

3. What role do developing countries play in climate change?

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