Co-benefits: Three Short Stories

Kirk R. Smith, PhD, MPH
Professor of Global Environmental Health
University of California, Berkeley

Workshop on Technologies and Policies to Mitigate Climate Change
CICERO and Tsinghua University
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Main theme
Need for Standard Methods to bring Co-benefits into National and Global Policy Making

Roadmap

Landscape of Co-benefits Opportunities

Methane: Carbon on Steroids

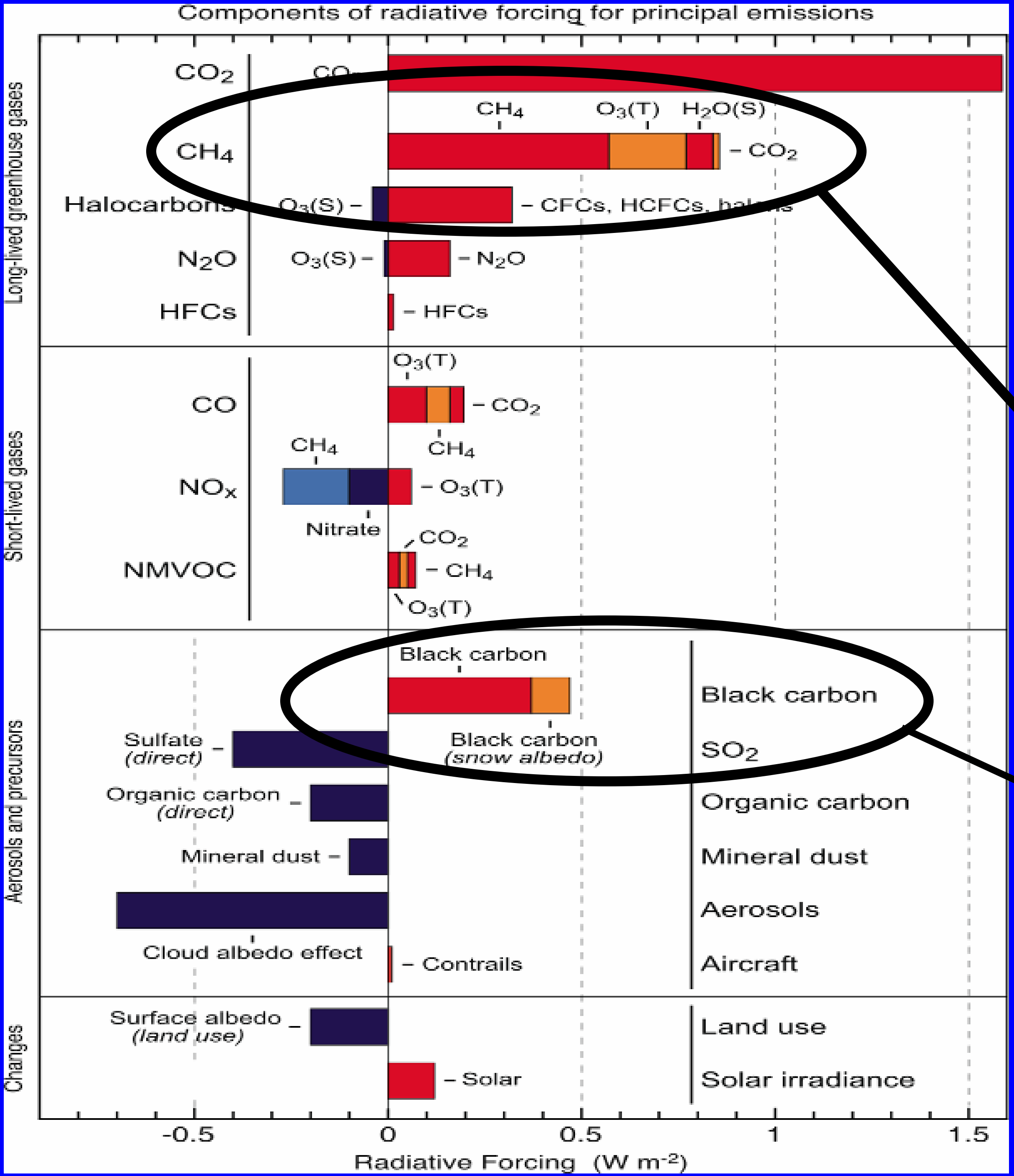
Household Fuels in China

Why Worry about Co-benefits?

- Helps reduce the cost of mitigation by sharing cost with other sectors.
- Recognizes that society still has major goals besides avoiding climate change, such as providing acceptable levels of health protection
- Potentially reduces political gap between developed and developing countries in international climate negotiations – early achievement of more certain benefits that directly relate to development needs ("no regrets investments")

Air Pollution from Energy Use

- Household solid fuels
  - Large source of ill-health worldwide in poorest populations – 1.6 million premature deaths
  - Non-renewable biomass and coal carbon emissions
  - Poor combustion leads to non-CO2 GH-related emissions
- Outdoor emissions from energy systems
  - 0.8 million premature deaths
  - Most well documented benefits, climate and health
- Special advantage to eliminating black carbon, but difficult to ascertain relative climate impacts of different aerosols.
- China has the largest global impacts for both these categories of air pollution



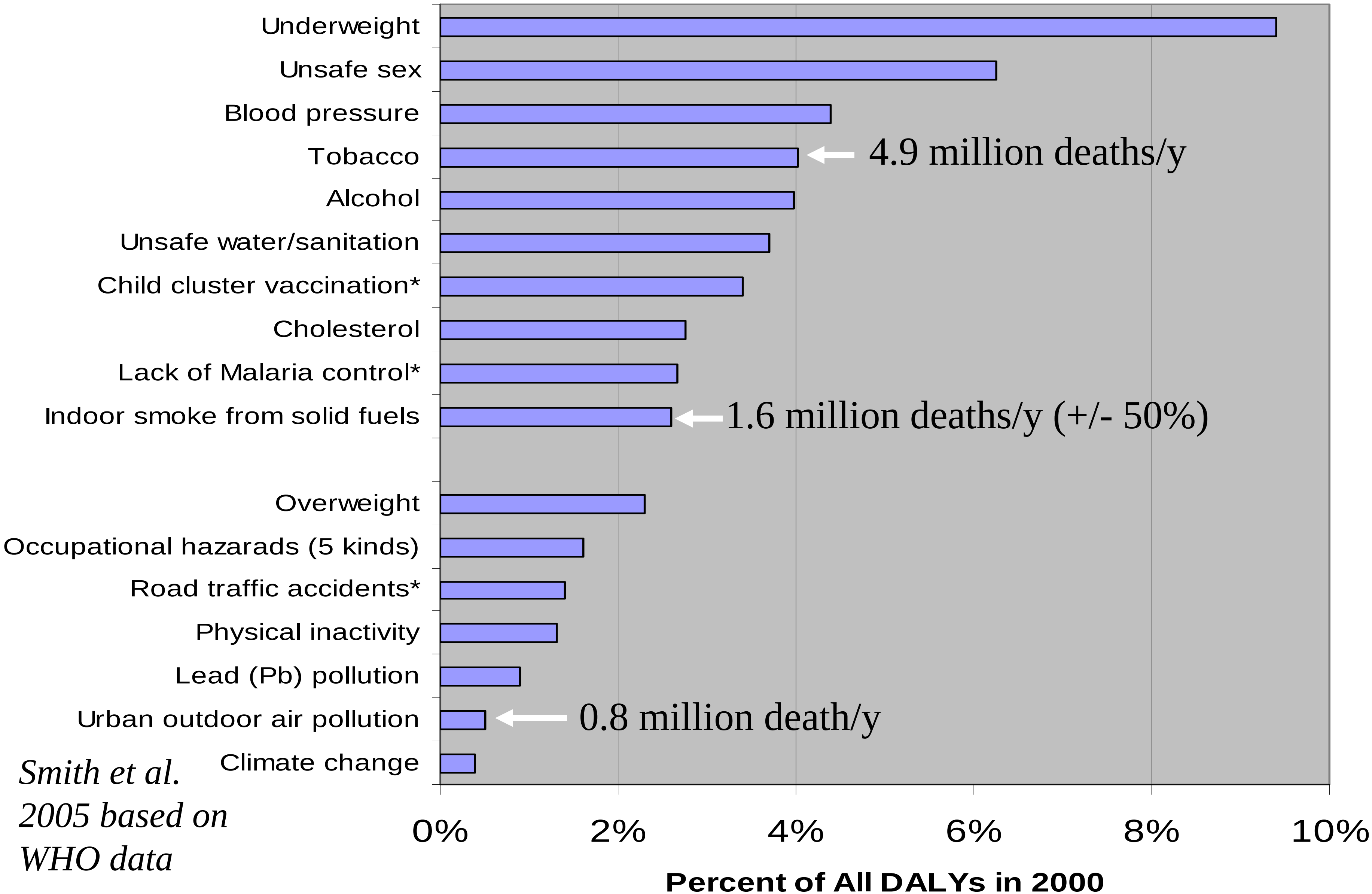
Warming in 2005 from emissions since 1750

Note importance of methane and black carbon

IPCC, 2007

Global Burden of Disease from Top 10 Risk Factors

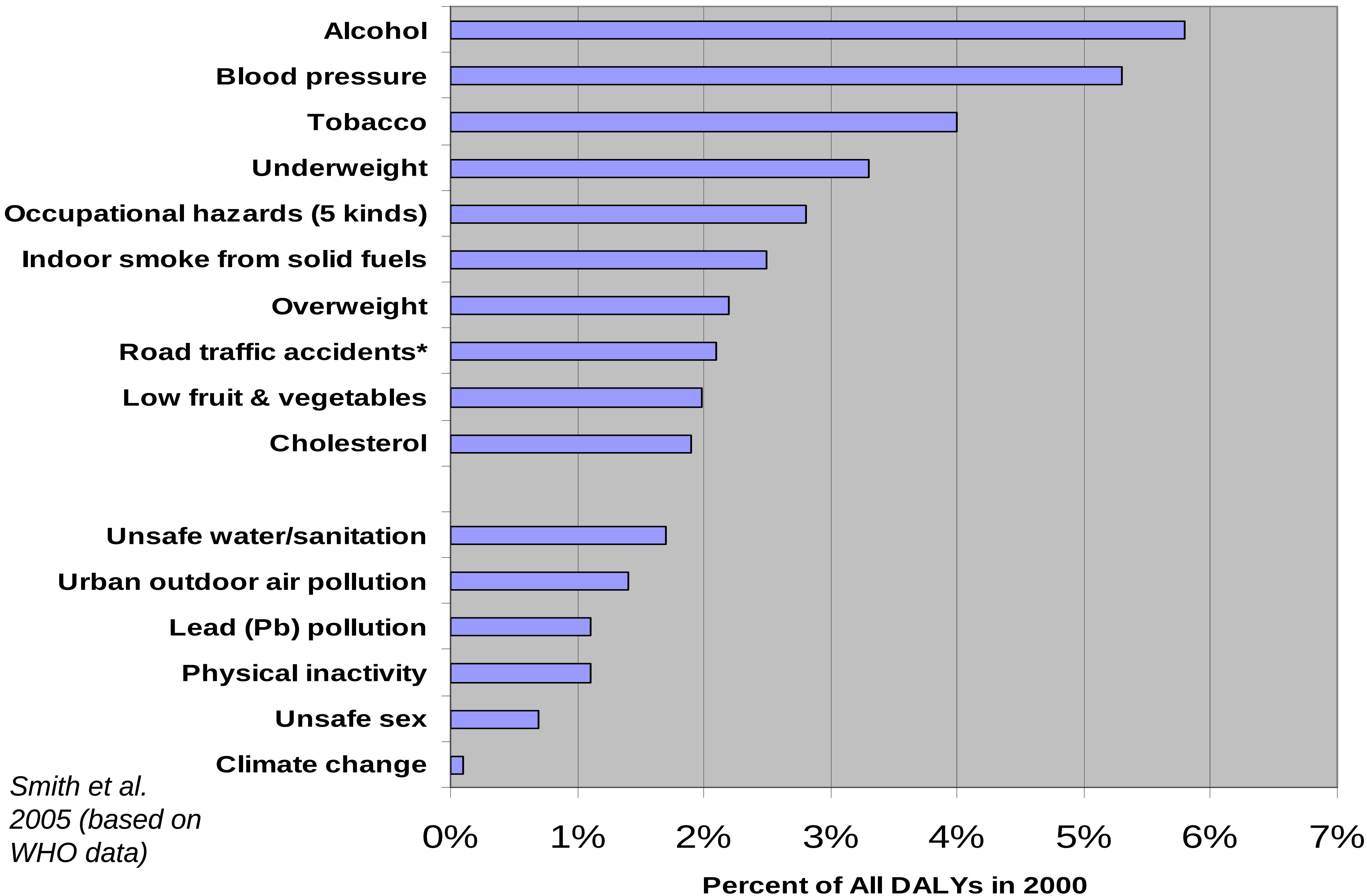
plus selected other risk factors



Smith et al. 2005 based on WHO data

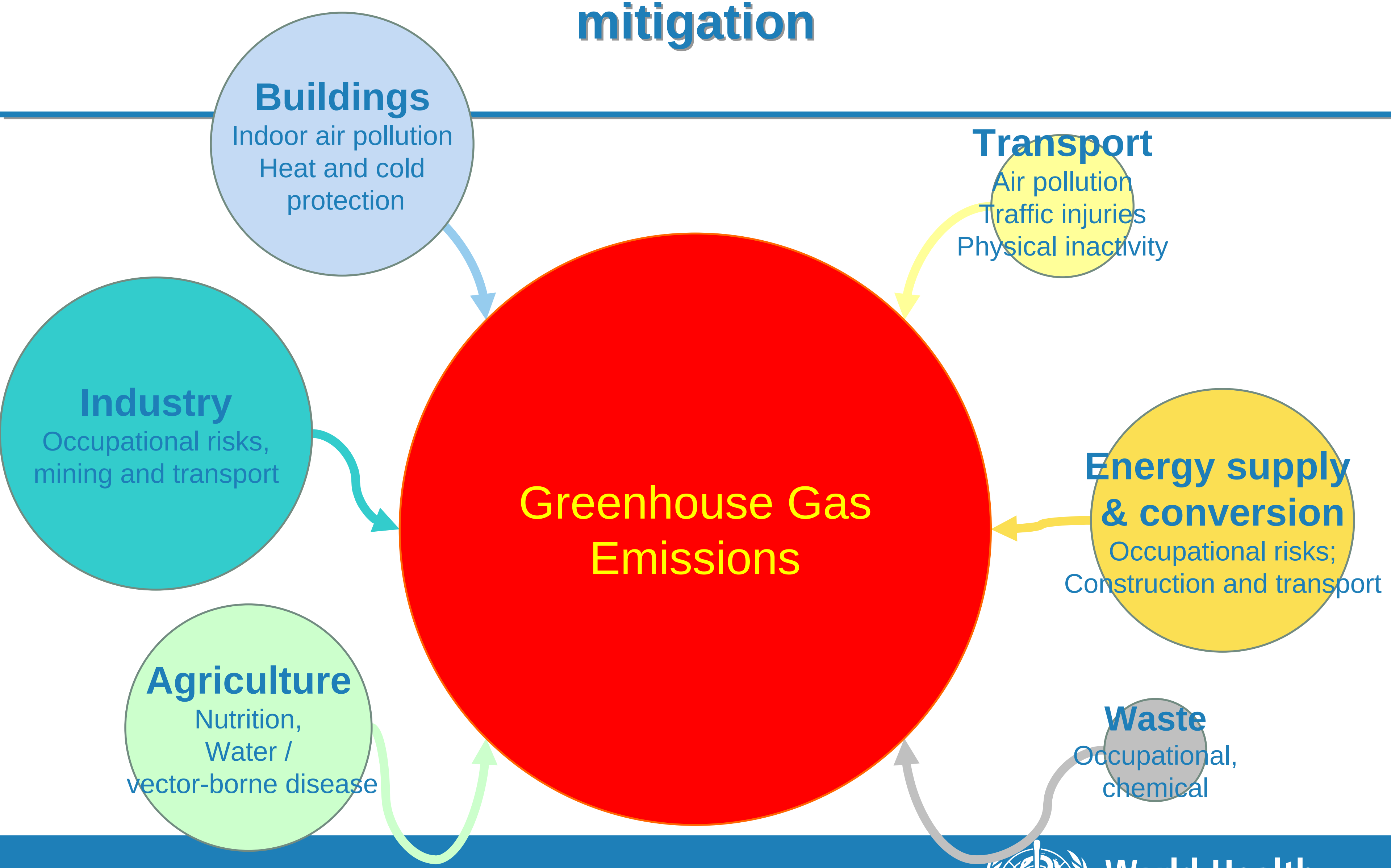
Chinese Burden of Disease from Top 10 Risk Factors

Plus Selected Other Risk Factors



Smith et al. 2005 (based on WHO data)

Maximizing the health benefits of climate change mitigation



World Health Organization

Modifying the Built Environment

- Obesity, traffic accidents, and lack of physical activity responsible for 3+ million additional premature deaths annually
- Reduce vehicle use (air pollution, obesity, safety, etc)
- Change urban design to increase physical activity (obesity, air pollution, safety)
- Improve energy efficiency of buildings (avoid health risks of energy poverty) - great opportunity in rural China

Enhancing Biomass Carbon Storage

- Reforestation in river basins to reduce flood risks – Yangtze River Basin Commission
- Increase green space in cities and forests in rural areas – identifiable mental, livelihood, and other benefits to local populations

Redirecting Diet Preferences

- Livestock responsible for 20+% of global greenhouse emissions – methane from animal digestion plus operation of meat/dairy feed/supply systems
- Converge on lower mean global red meat consumption
  - Suggested 90 g/wk – Lancet 2007
  - Major health benefits: heart disease, stroke, obesity, bowel and breast cancer
- Similar benefits to convergence in global dairy consumption
- China has the major global growth potential

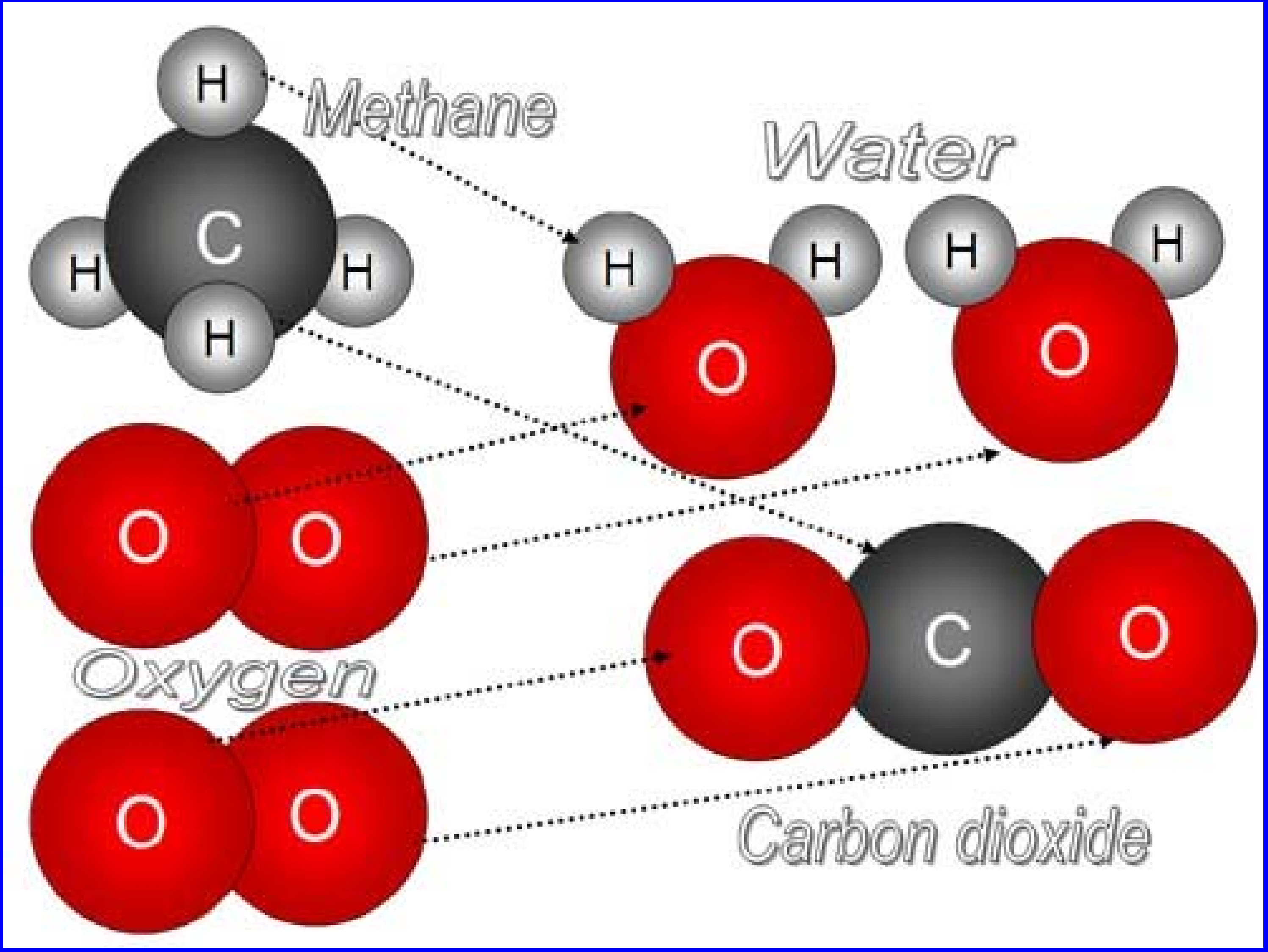
Most cost-effective GHG control device is probably a condom

- Many tens of millions of women wish to have fewer children, but do not have access to contraceptives
- Giving them access could mean 1-2 billion fewer people by 2100 – a major reduction of stress on the Earth
- Many health benefits to smaller, more planned families

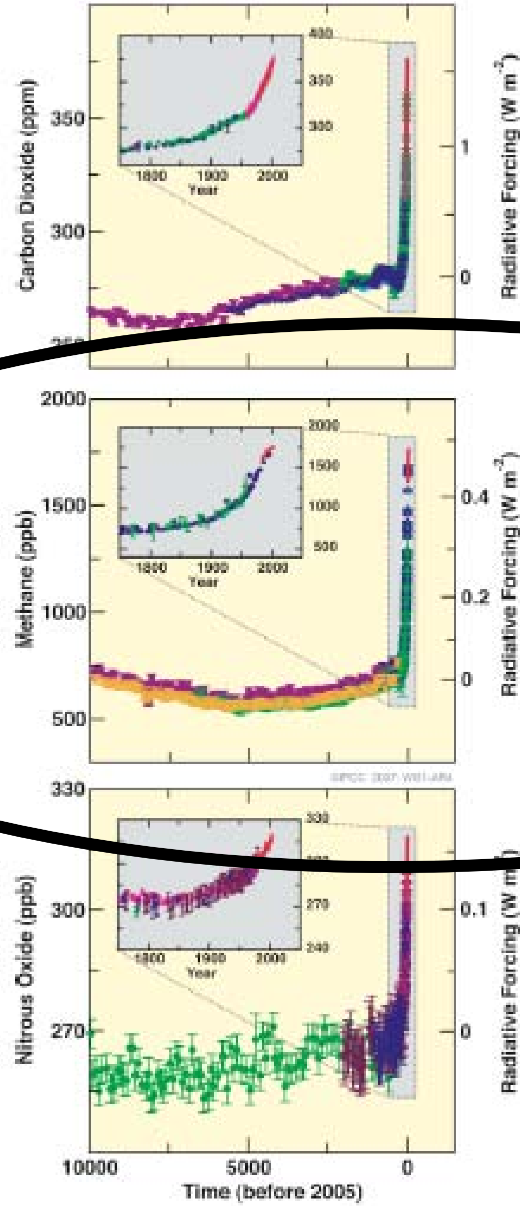
Methane Reduction

- Major and probably undervalued global GHG
- Major cause of rise in global tropospheric ozone concentrations – important health-damaging and crop-damaging pollutant
- Livestock major source, as noted above
- Leaks: Coal mines, gas pipelines, etc.
- Waste management: Landfills, wastewater
  - Other health benefits here also
- Incomplete combustion: biomass and coal in households – China a main source globally

The Methane Story: CH_4



Atmospheric
Greenhouse gas
concentrations



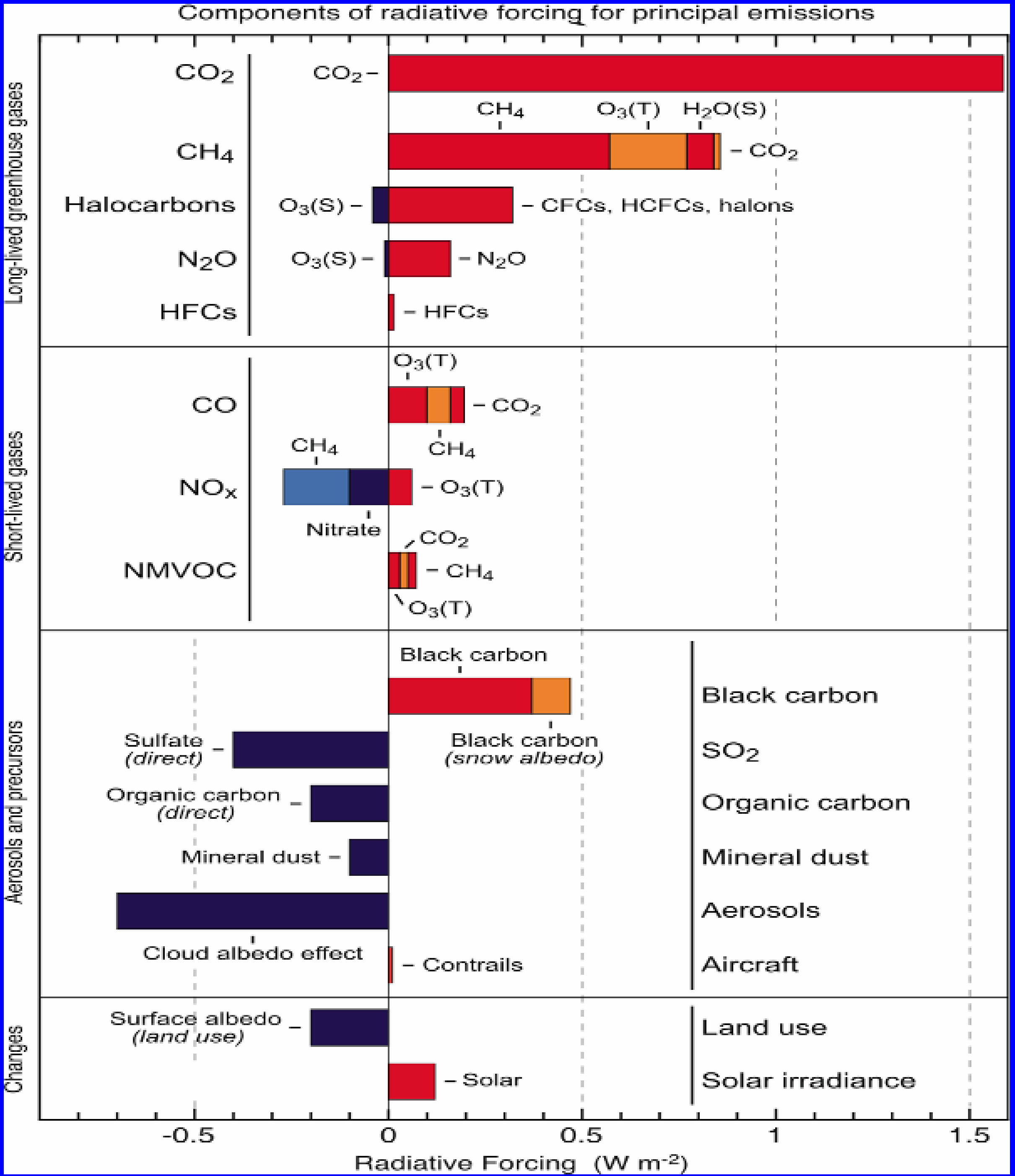
Anthropogenic Sources

CO_2
Fossil fuels
Land use change
Cement manufacturing

Methane
Landfills
Rice
Livestock
Waste management
Fossil recovery

N_2O
Fertilizer
Planted N-fixers
Combustion

Figure SPM.1
IPCC 2007



Warming in 2005 from emissions since 1750

Methane more than half of total from CO_2

IPCC, 2007

Methane and Global Warming

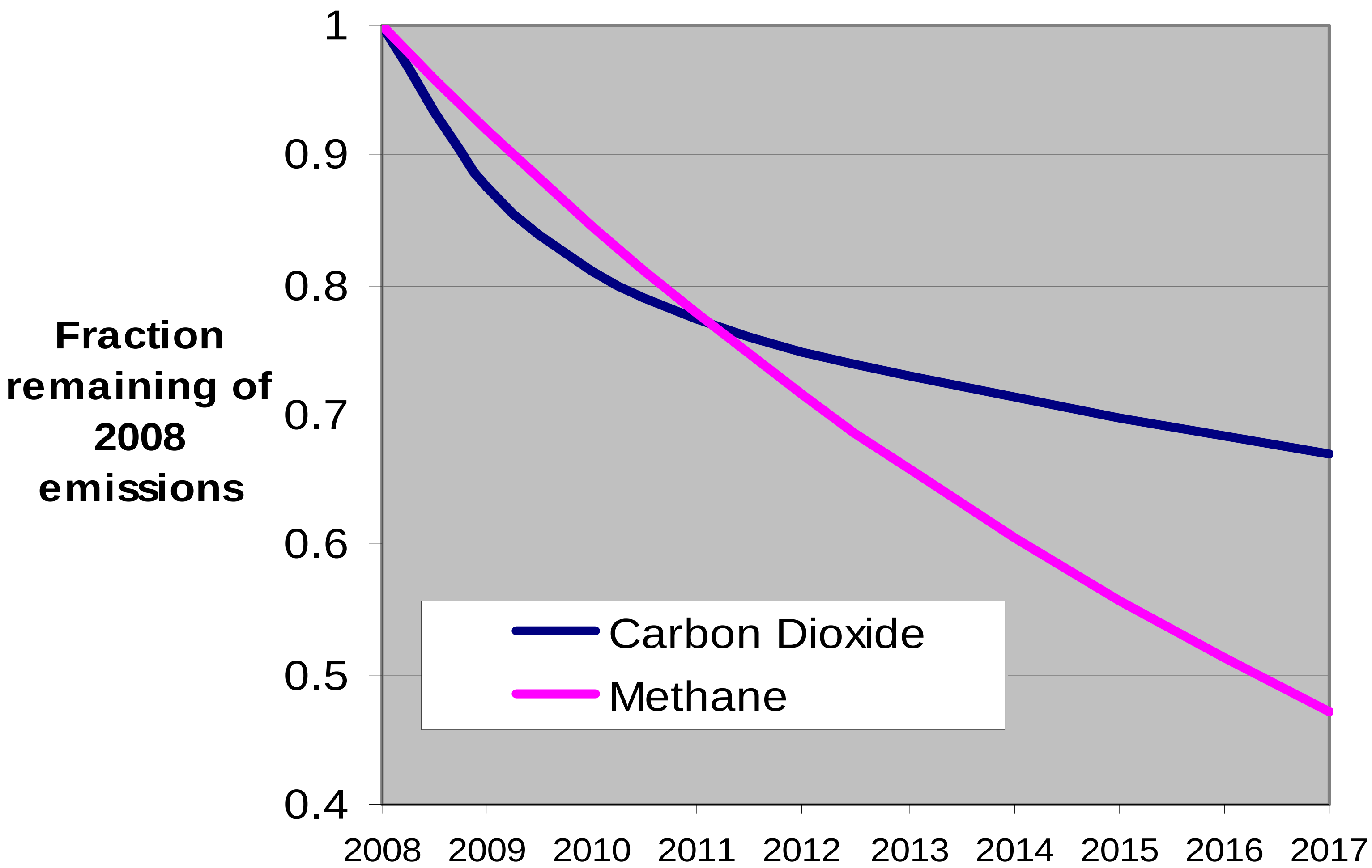
- A much more powerful greenhouse gas (GHG) than CO_2
- Partly due to its direct effect, but also because it creates ozone (O_3), another powerful GHG
- Nearly 100 times more per ton than CO_2 at any one time (73x from direct effects)
- Eventually turns to 2.75 times as much CO_2 by mass
- Methane has thus contributed a significant amount to global warming, more than half that of CO_2
- But has a much shorter atmospheric lifetime compared to CO_2

Math of GHG Decay (AR4)

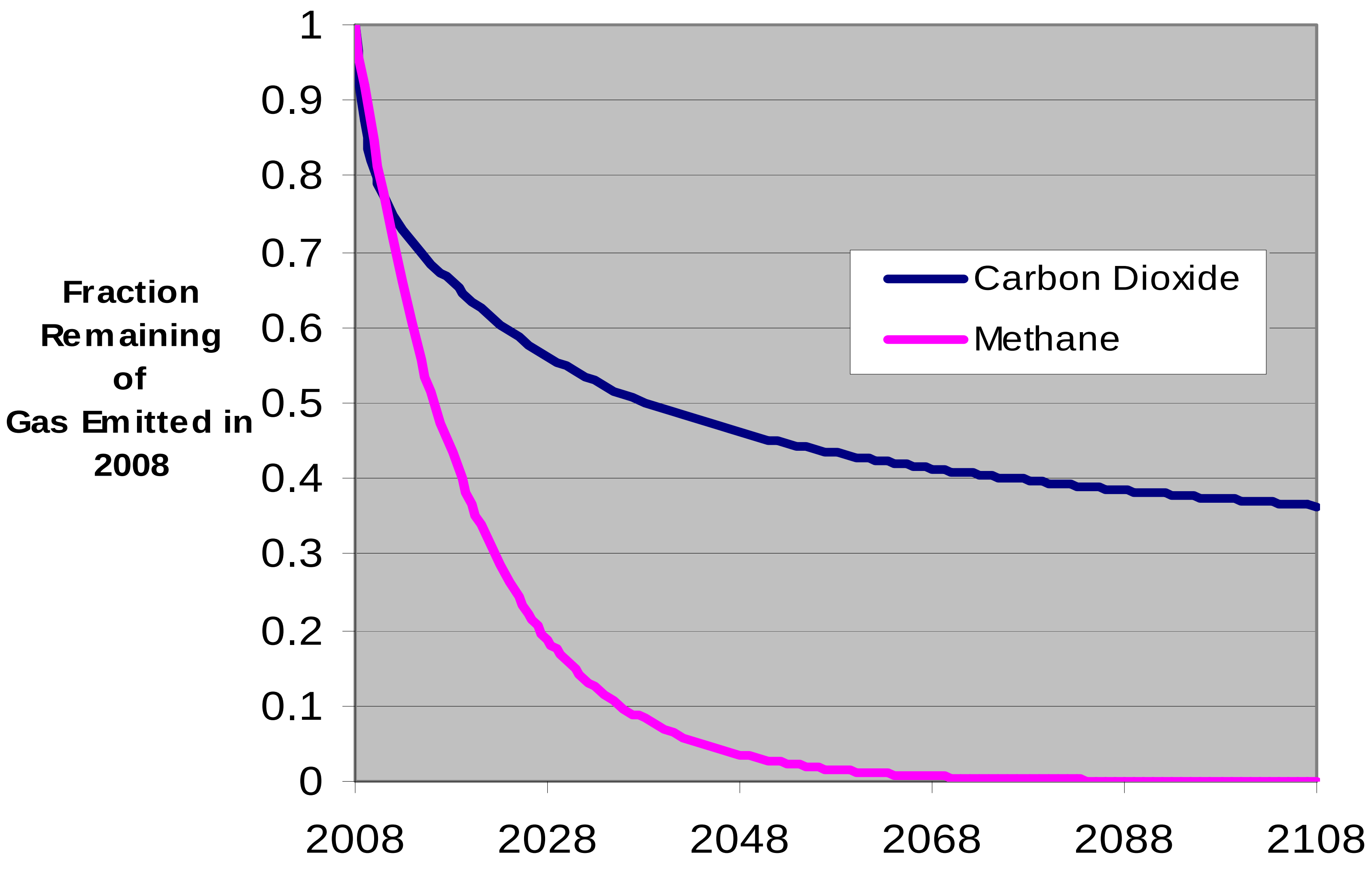
- CO_2 goes into four compartments:
  - 19% of total with a lifetime* of 1.2 years
  - 34% at 18.5 y
  - 26% at 173 y
  - 21% with a lifetime of “many thousand years”
- Methane has a 12 y lifetime,
  - but contributes to ozone, a GHG
  - and eventually oxidizes to CO_2

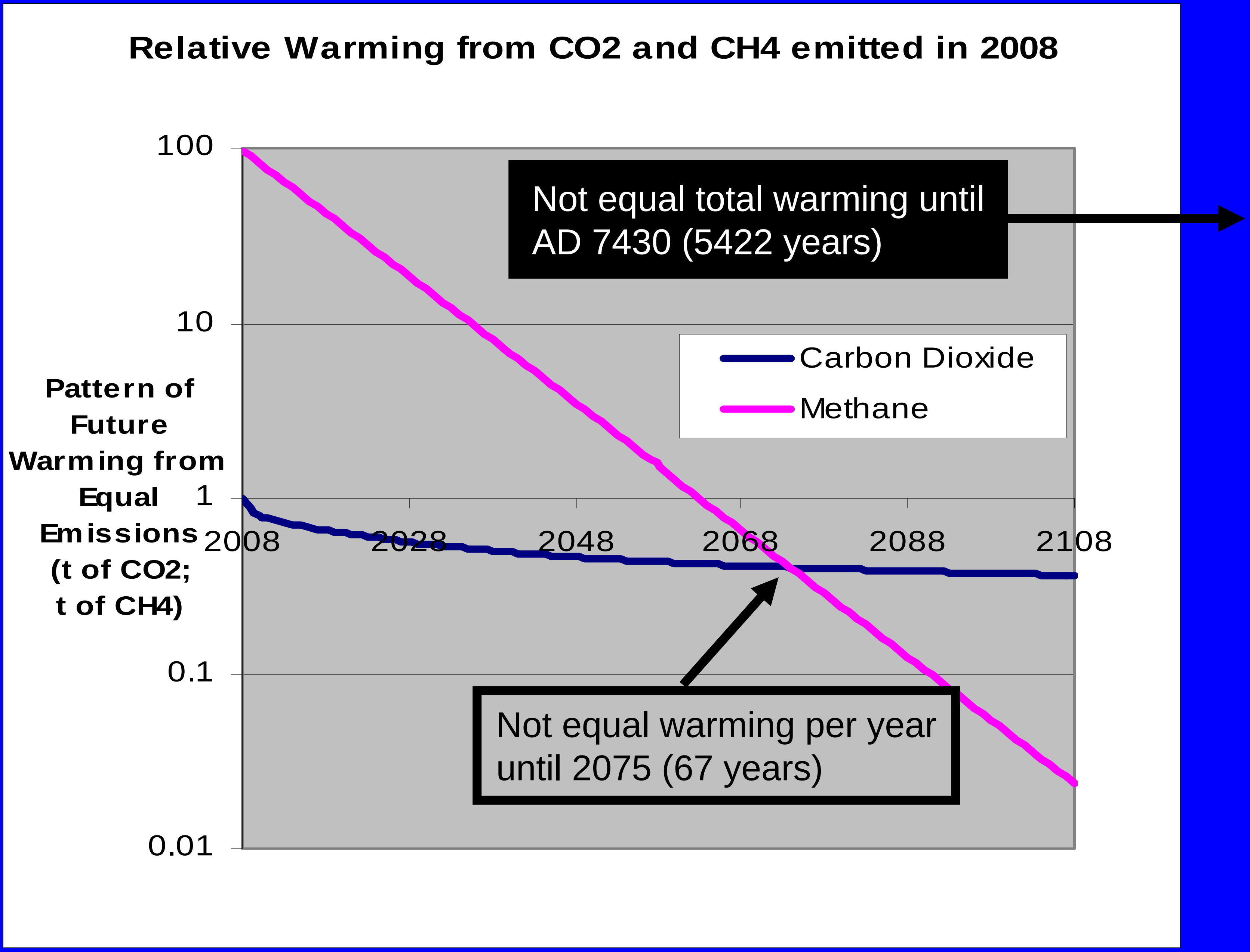
*Lifetime refers to the time to reach 1/e (37%) of the original amount

Natural CO2 and CH4 Depletion - first 10 years



Natural CO2 and CH4 Depeletion - 100 years



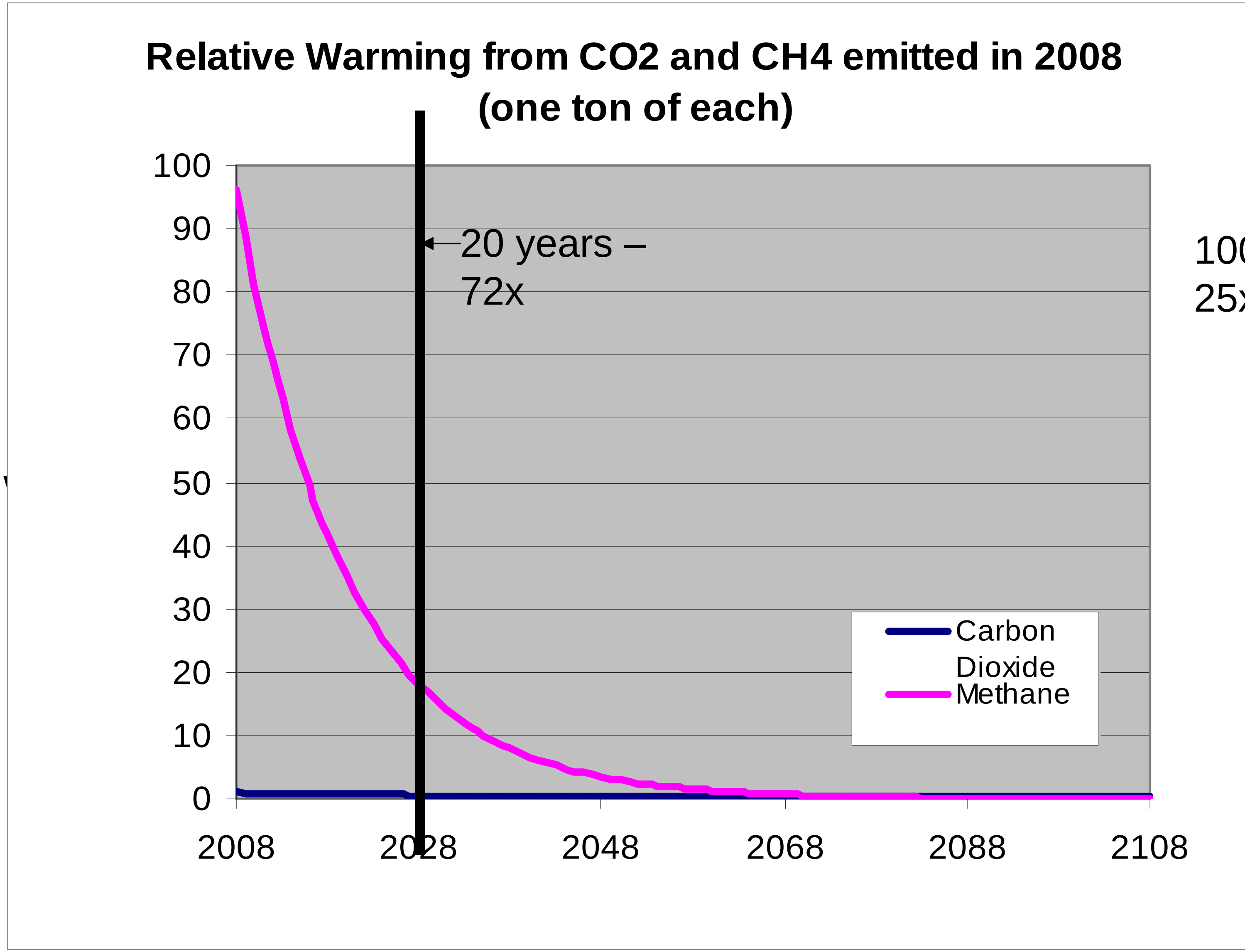

Relative Warming from CO2 and CH4 emitted in 2008
Not equal total warming until AD 7430 (5422 years)
Carbon Dioxide
Methane
Pattern of Future Warming from Equal Emissions (t of CO2; t of CH4)
100
10
1
0.1
0.01
2008
2028
2048
2068
2088
2108
Not equal warming per year until 2075 (67 years)

How can we compare projects to reduce different GHGs?

- Why not just take all future warming into account?
- This would mean that no effort would go into avoiding emissions of the shorter lived GHGs, such as methane, because CO_2 has such a long lifetime.
- It would result in spending most money to protect people thousands of years into the future and ignoring the needs of ourselves and our children.
- Thus, the IPCC established in 1996, official Global Warming Potentials (GWPs), which are weighting factors to compare the impact of different GHGs
- GWPs are built into the Kyoto Protocol, the Clean Development Mechanism, and nearly all national inventories and reduction plans.

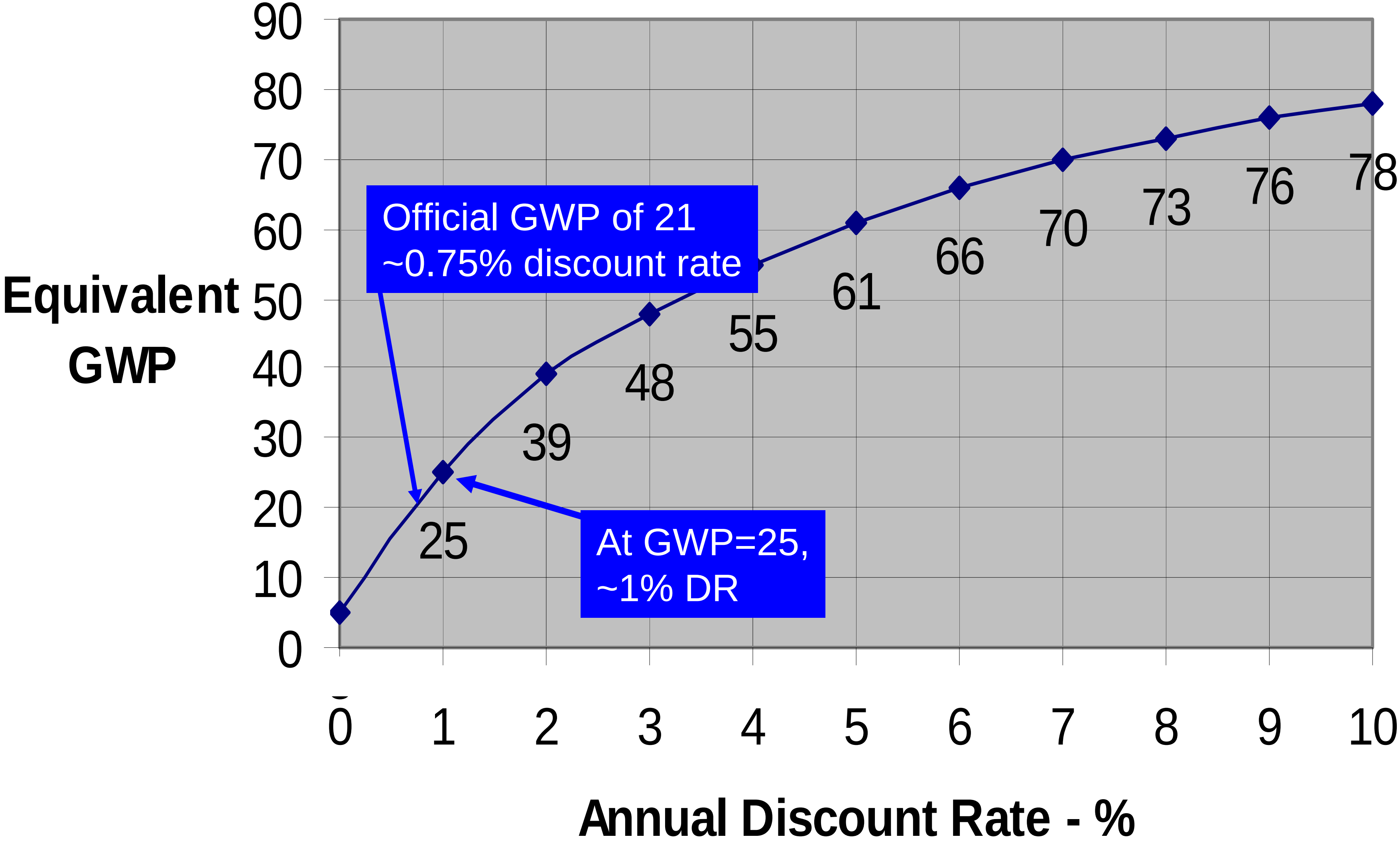
Methane and Time

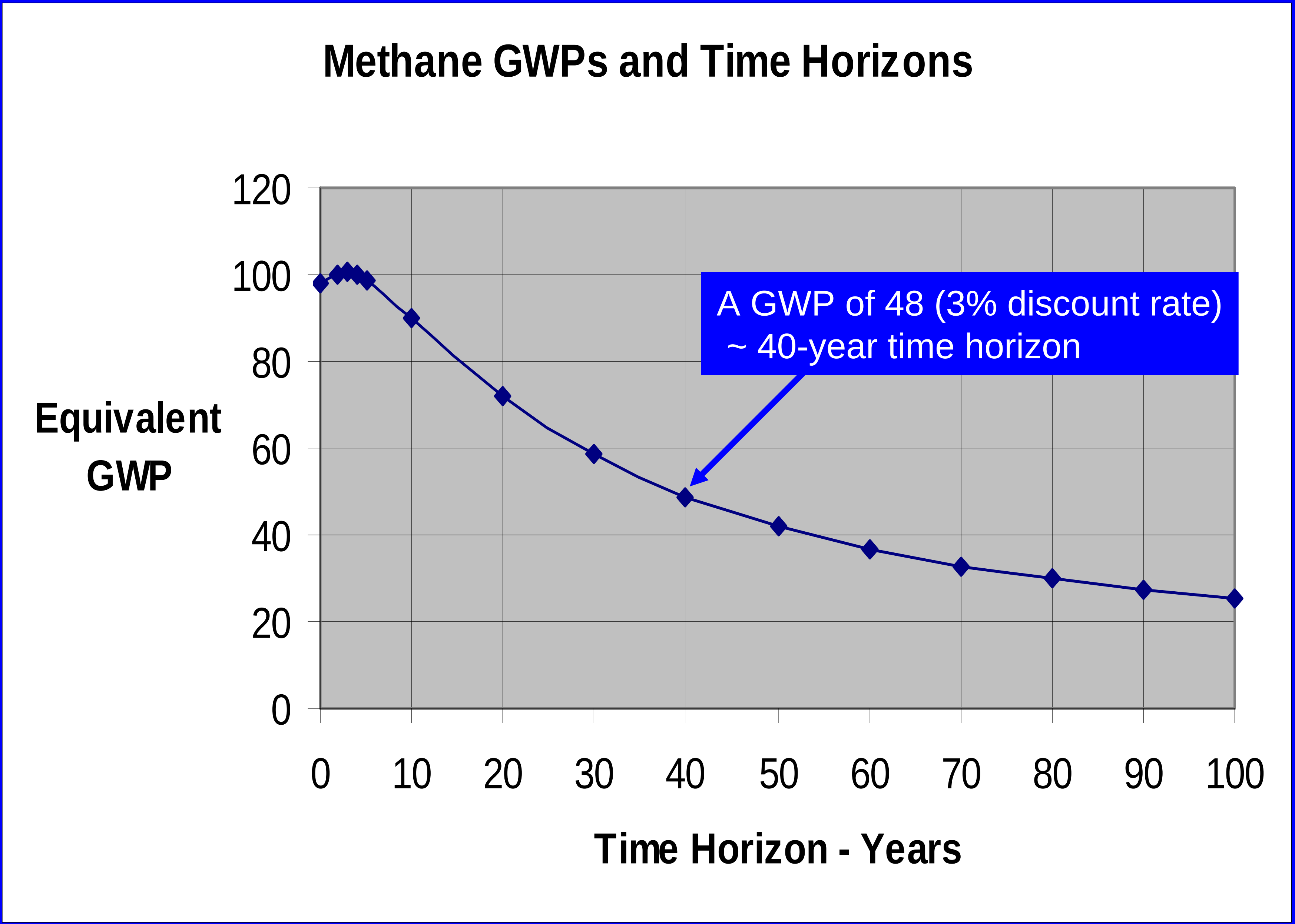
- The current official GWPs are based on 100-year time horizons
  - Methane is 21 x CO_2 by weight (25 in AR4)
  - Equivalent to ~0.75% discount rate
- For making decisions on how to spend resources when impacts are upon us, <1% is probably too low.
- The other GWP published by IPCC, has a 20-year time horizon
  - Methane is 72 x CO_2 by weight
  - Equivalent to ~ 8% discount rate
  - More compatible with financial investments
- International health investments use a 3% discount rate, which would be a GWP of ~48

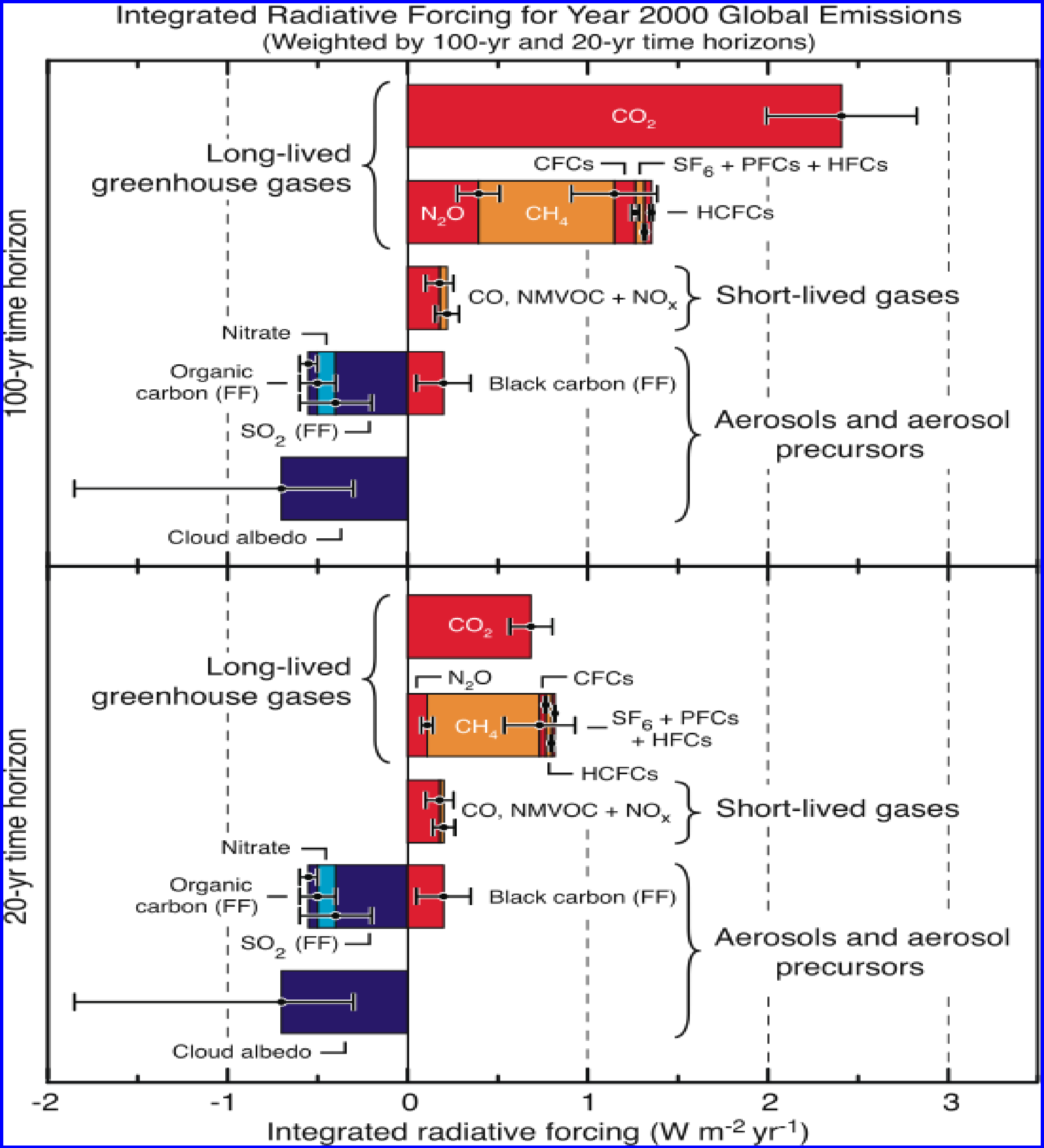


100 years –
25x

Methane GWPs and Discount Rates




Methane GWPs and Time Horizons
Equivalent GWP
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Time Horizon - Years
A GWP of 48 (3% discount rate)
~ 40-year time horizon



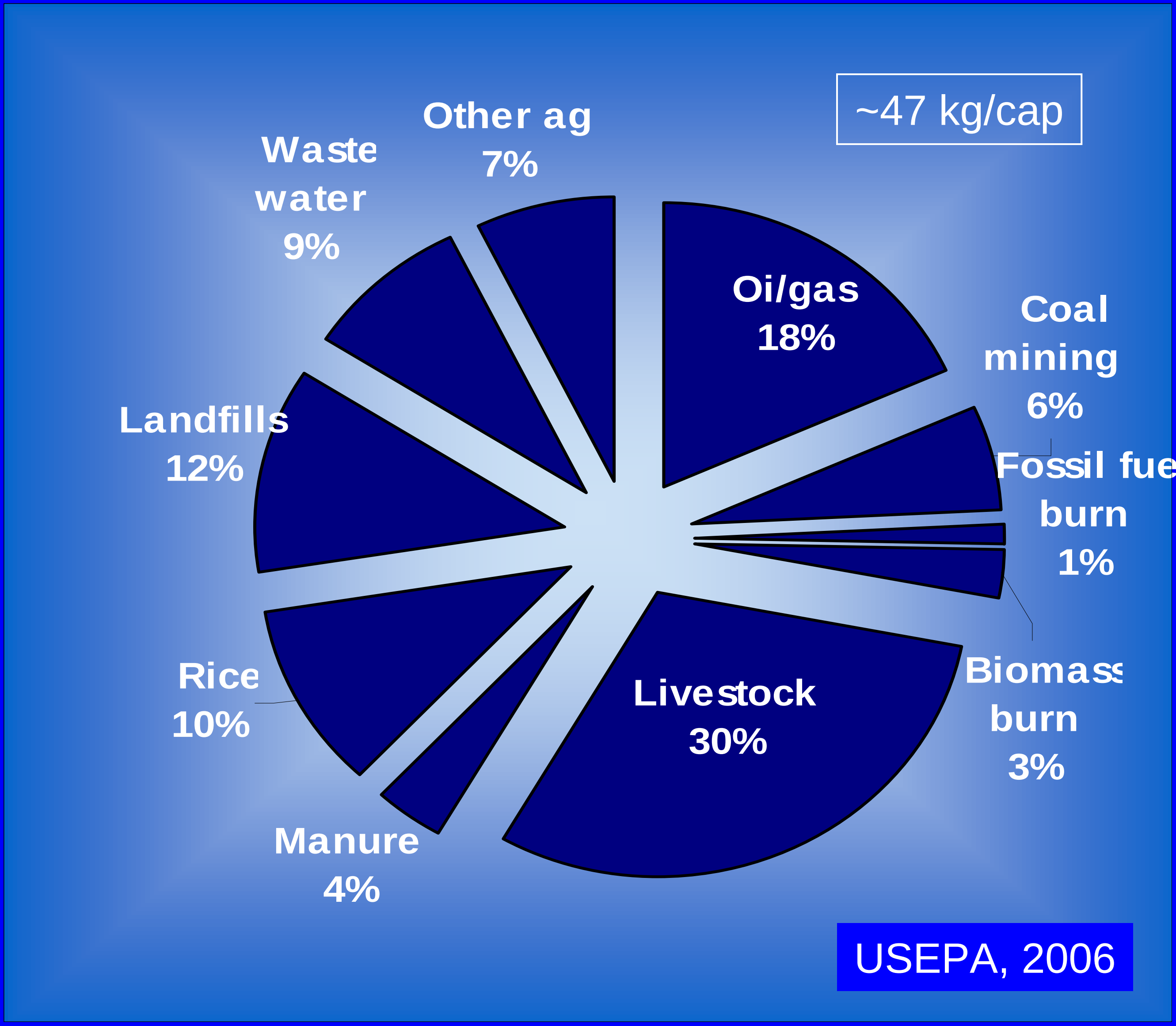
100-y horizon

Time perspective makes a difference

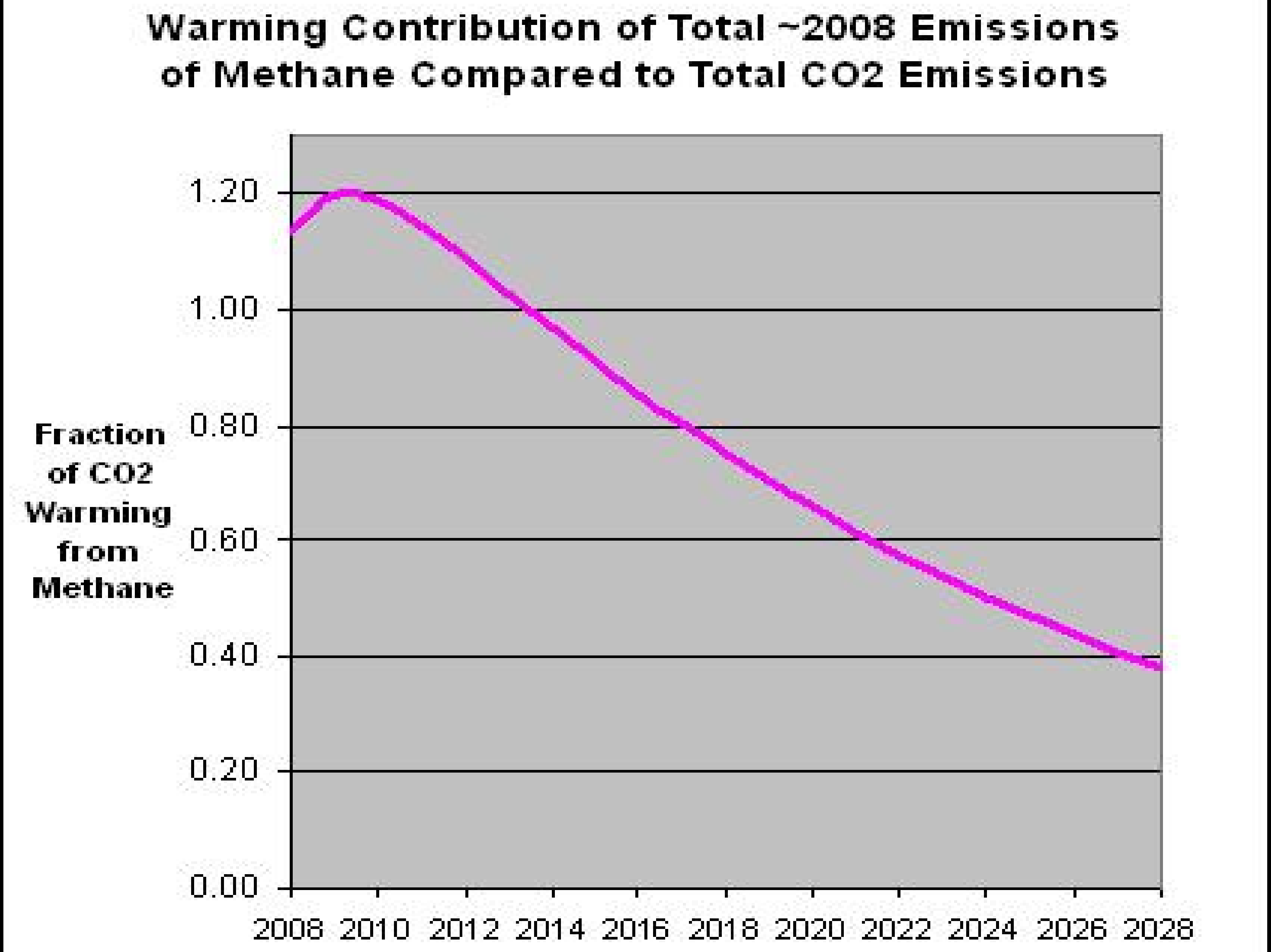
20-y horizon

IPCC, 2007

Global Anthropogenic Methane Emissions ~2005
Total ~ 305 million tons

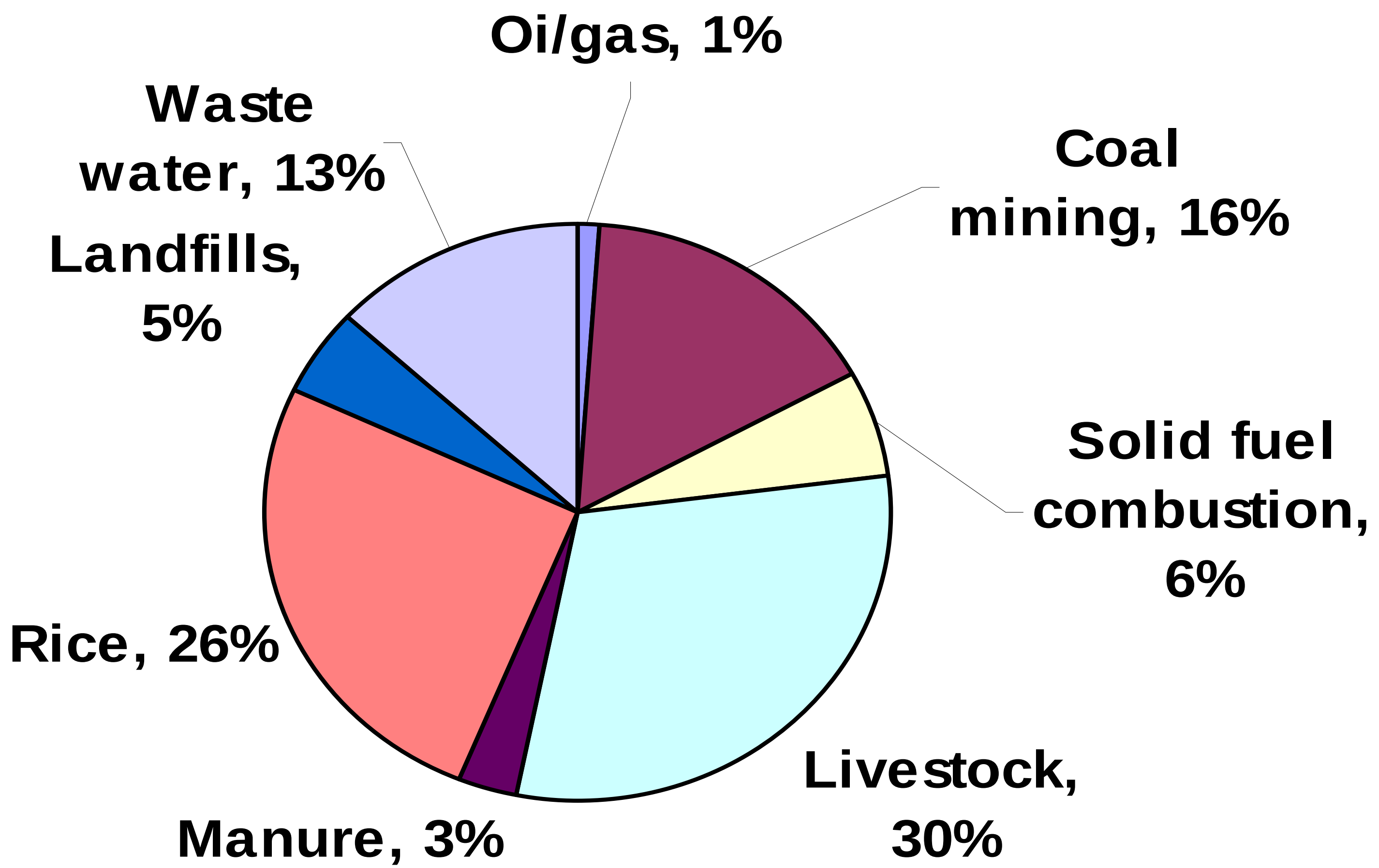


Expected to grow at ~1.5% per year


Warming Contribution of Total ~2008 Emissions
of Methane Compared to Total CO2 Emissions
Fraction of CO2 Warming from Methane
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028

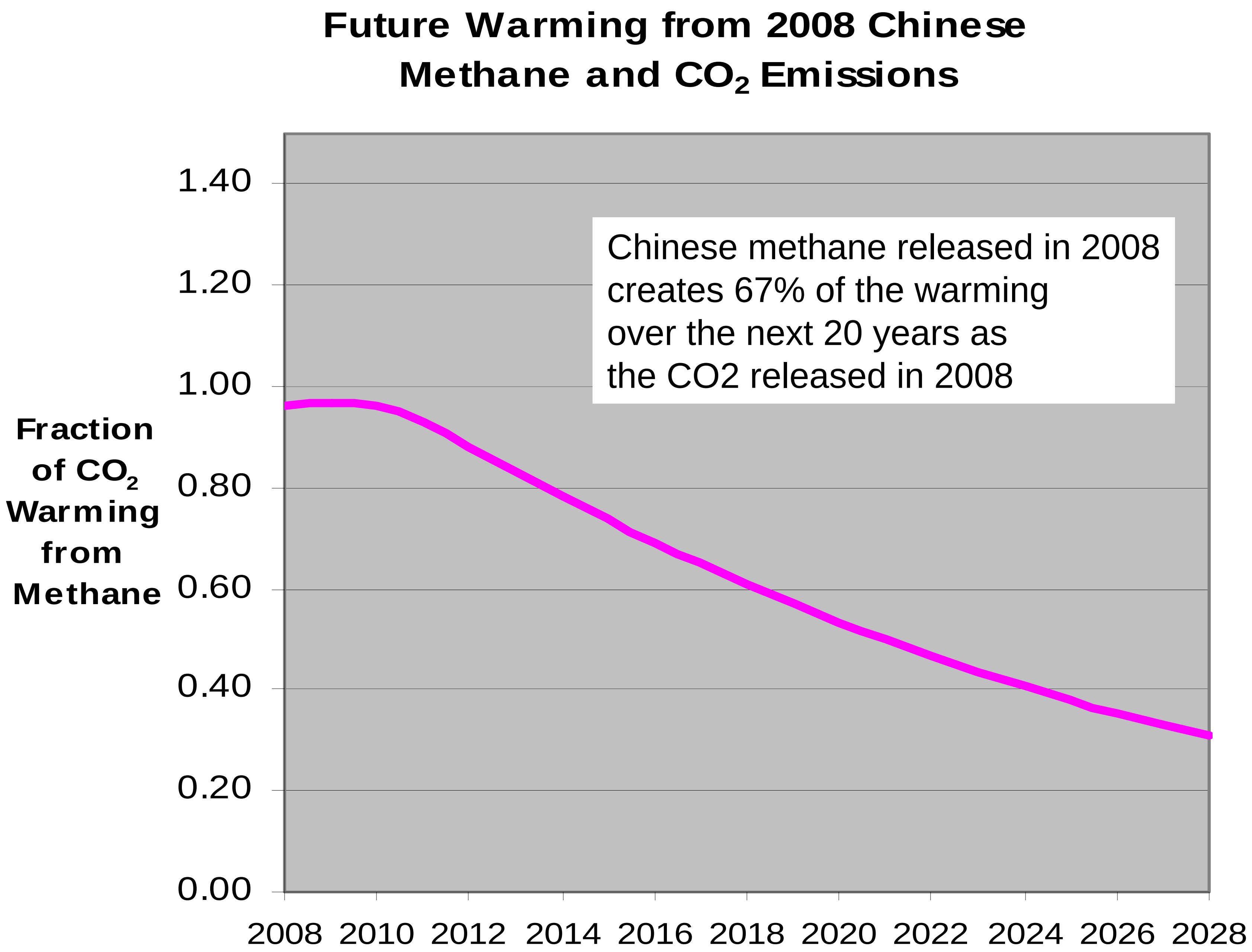
Chinese Methane Emissions in 2005

31 kg/capita



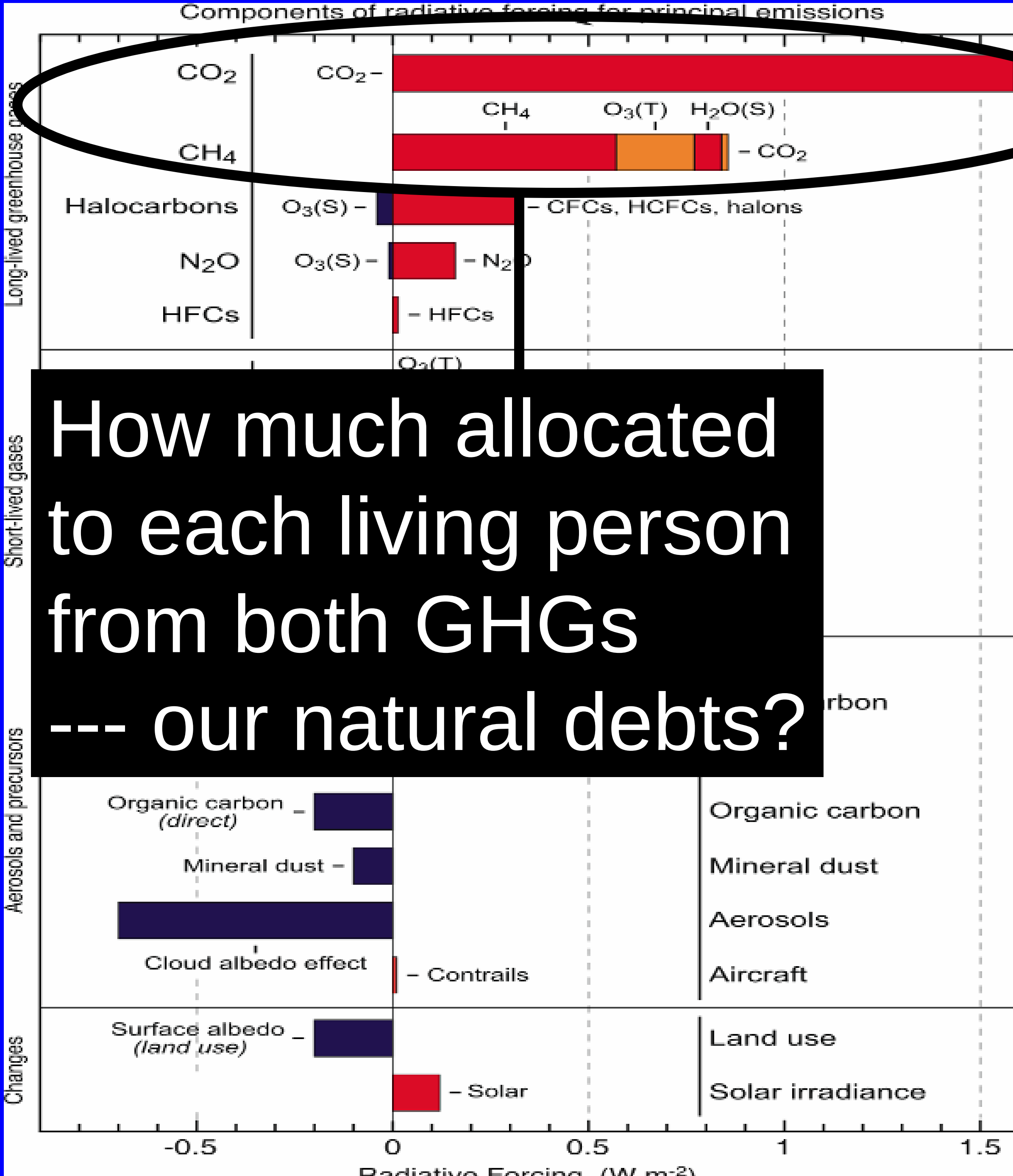
41 Mt = 13% of world

USEPA, 2006


Future Warming from 2008 Chinese Methane and CO_2 Emissions
Fraction of CO_2 Warming from Methane
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
Chinese methane released in 2008 creates 67% of the warming over the next 20 years as the CO2 released in 2008

Methane and Global Equity

- We have seen how methane's health impacts, direct, indirect, and associated, mostly affect the poor
- What about methane emissions: how are they distributed?



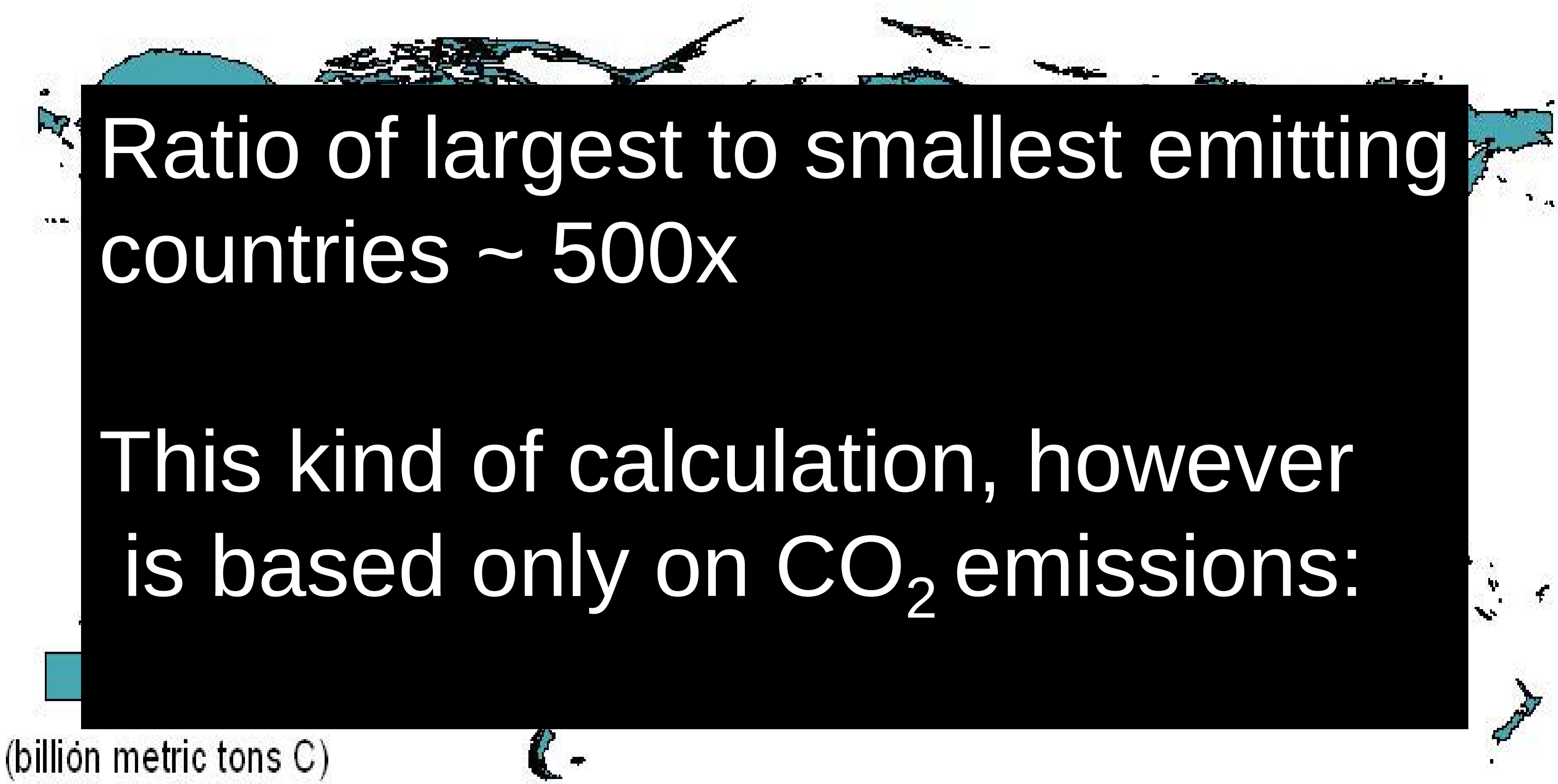
How much allocated to each living person from both GHGs --- our natural debts?

Warming in 2005 from emissions since 1750

More than half due to methane

IPCC, 2007

National Natural Debts:
Cumulative CO_2 emissions, depleted by natural processes

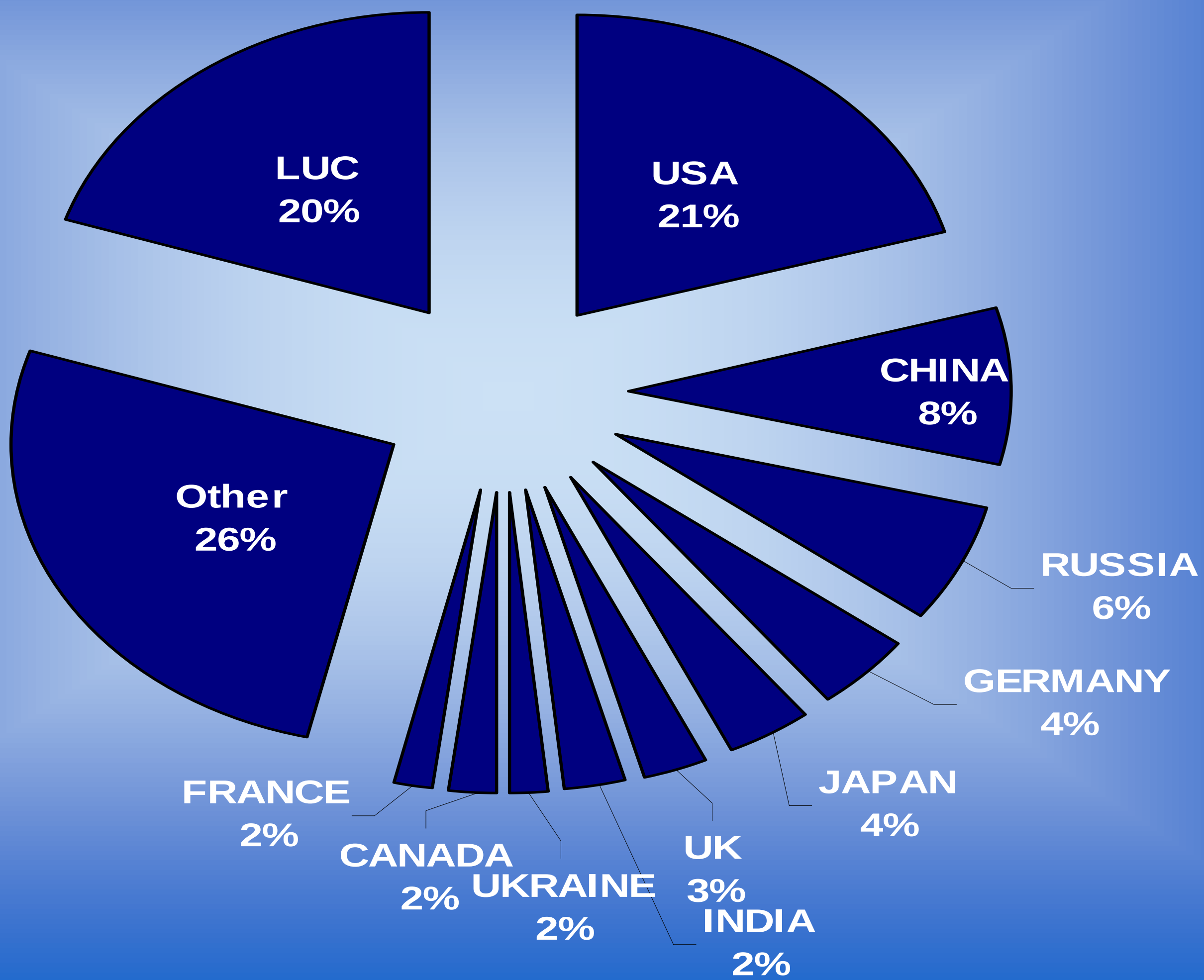


Ratio of largest to smallest emitting countries ~ 500x

This kind of calculation, however is based only on CO_2 emissions:

Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR, 2007, **Climate change and global health: Quantifying a growing ethical crisis**, EcoHealth 4(4): 397–405, 2007.

Distribution of Global Natural Debt Among Top 10 Nations CO2 only in 2005



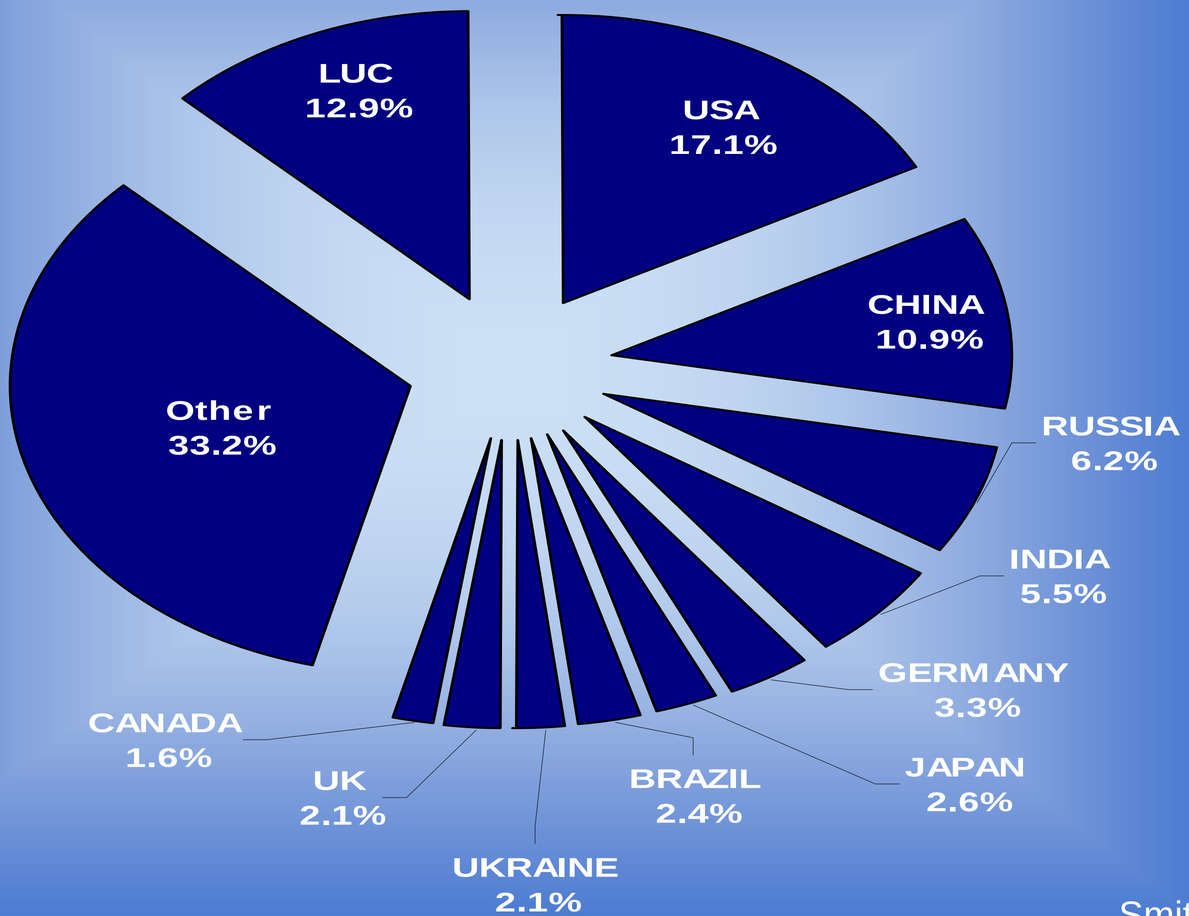
Brazil: 0.8%

Nb. Land-use change emissions not are parsed out by country

Smith and Rogers, in preparation

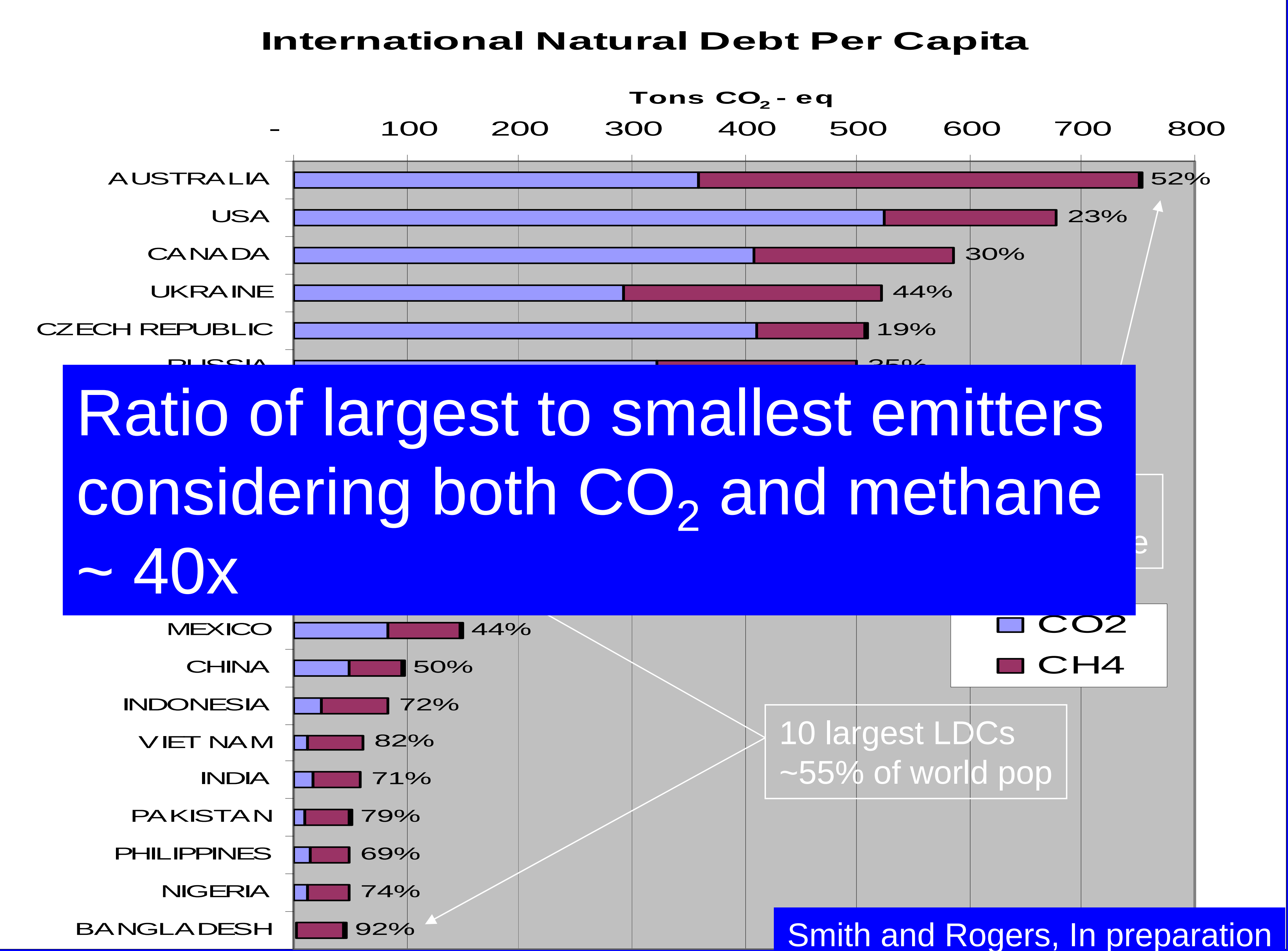
Distribution of Global Natural Debts in Top 10 Nations CH4 and CO2 in 2005

[compared to CO2 alone; note decrease for USA, increase for China, and large increases for India and Brazil]



Smith and Rogers, in preparation

Nb. National fossil fuel/cement emissions only for CO2, land-use change emissions are not parsed out by country



International Natural Debt Per Capita
Tons CO_2 - eq
- 100 200 300 400 500 600 700 800
AUSTRALIA 52%
USA 23%
CANADA 30%
UKRAINE 44%
CZECH REPUBLIC 19%
MEXICO 44%
CHINA 50%
INDONESIA 72%
VIET NAM 82%
INDIA 71%
PAKISTAN 79%
PHILIPPINES 69%
NIGERIA 74%
BANGLADESH 92%
CO2
CH4
Ratio of largest to smallest emitters considering both CO_2 and methane ~ 40x
10 largest LDCs
~55% of world pop
Smith and Rogers, In preparation

Ranking of Carbon Emissions:
The Pharmaceutical Index

- Carbon dioxide is noxious if fossil or forest derived, but benign if from renewable sources
- Products of incomplete combustion (PIC) such as carbon monoxide and hydrocarbons are like CO_2 on caffeine – several times worse
- Methane from any source (fossil, biologic, or incomplete combustion) is like CO_2 on steroids – dozens of times worse.
- Black carbon in particles from incomplete combustion is like CO_2 on cocaine– hundreds of times worse.

Conclusion on Methane

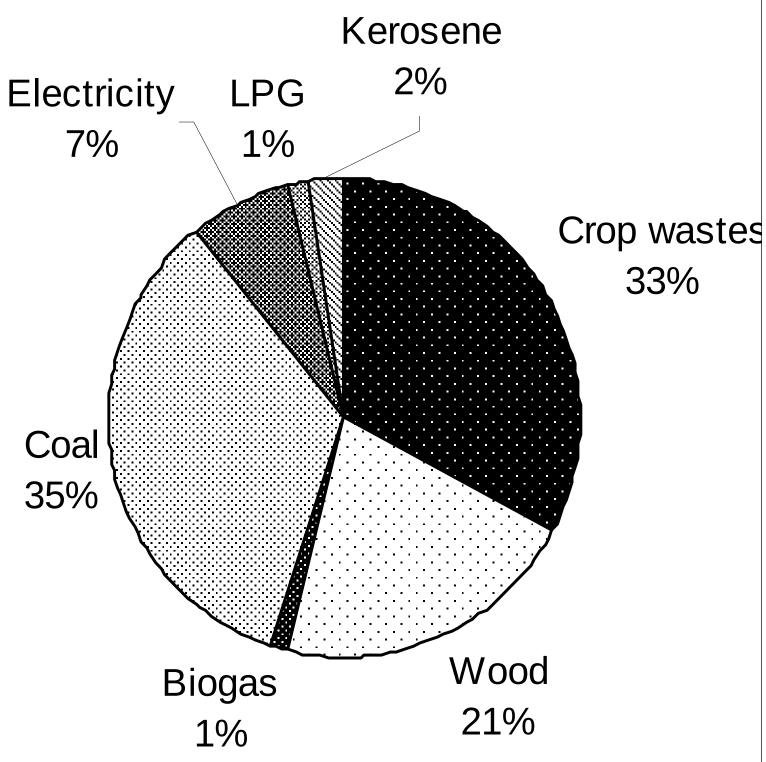
- Methane emissions are more important than current official weighting factors indicate because of its large effect over the next generation
- May well increase in "value", perhaps during the post-Kyoto deliberations now starting
- Developing countries have a bigger role
- Methane is emitted as part of the poor combustion process of solid fuels, which also produce much health-damaging pollution
- Contributes directly to global tropospheric ozone levels
- Improving this combustion offers substantial GHG as well as health benefits in a cost-effective manner
- Ways to control are quite different from CO_2
- And may be easier in the short term

Methane – bottom lines?

- Way to reduce warming in the next generation is to put more attention on methane (and other shorter lived GHGs)
- Once the heat enters Earth's systems, it does not matter where it came from
- For some impacts, the **rate** of warming is as important as the total amount
- Only way to slow the rate is to immediately reduce methane emissions (and other short-lived GH pollutants)
- While working to stop CO_2 in the long run

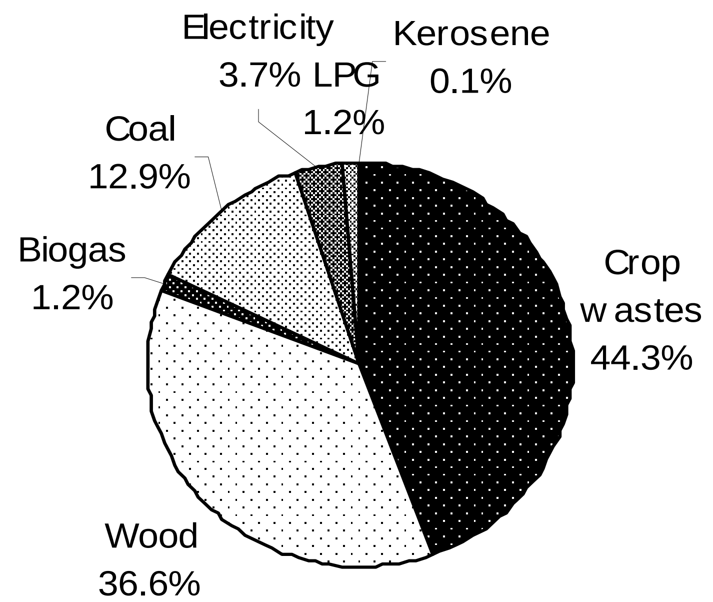
Rural Energy in China: 2004

Total



Ministry of Agriculture

Households

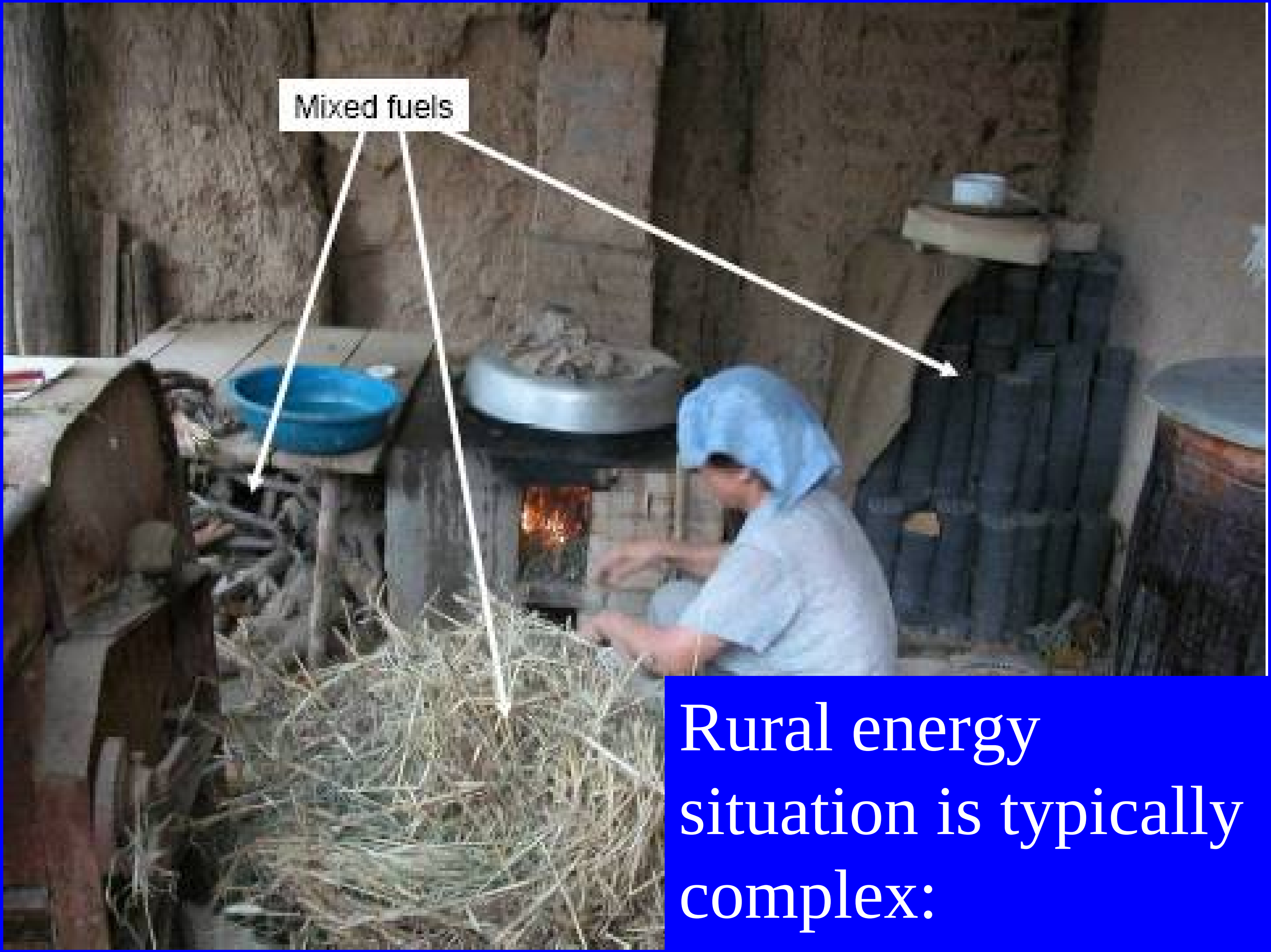


70% of total

National Bureau of Statistics

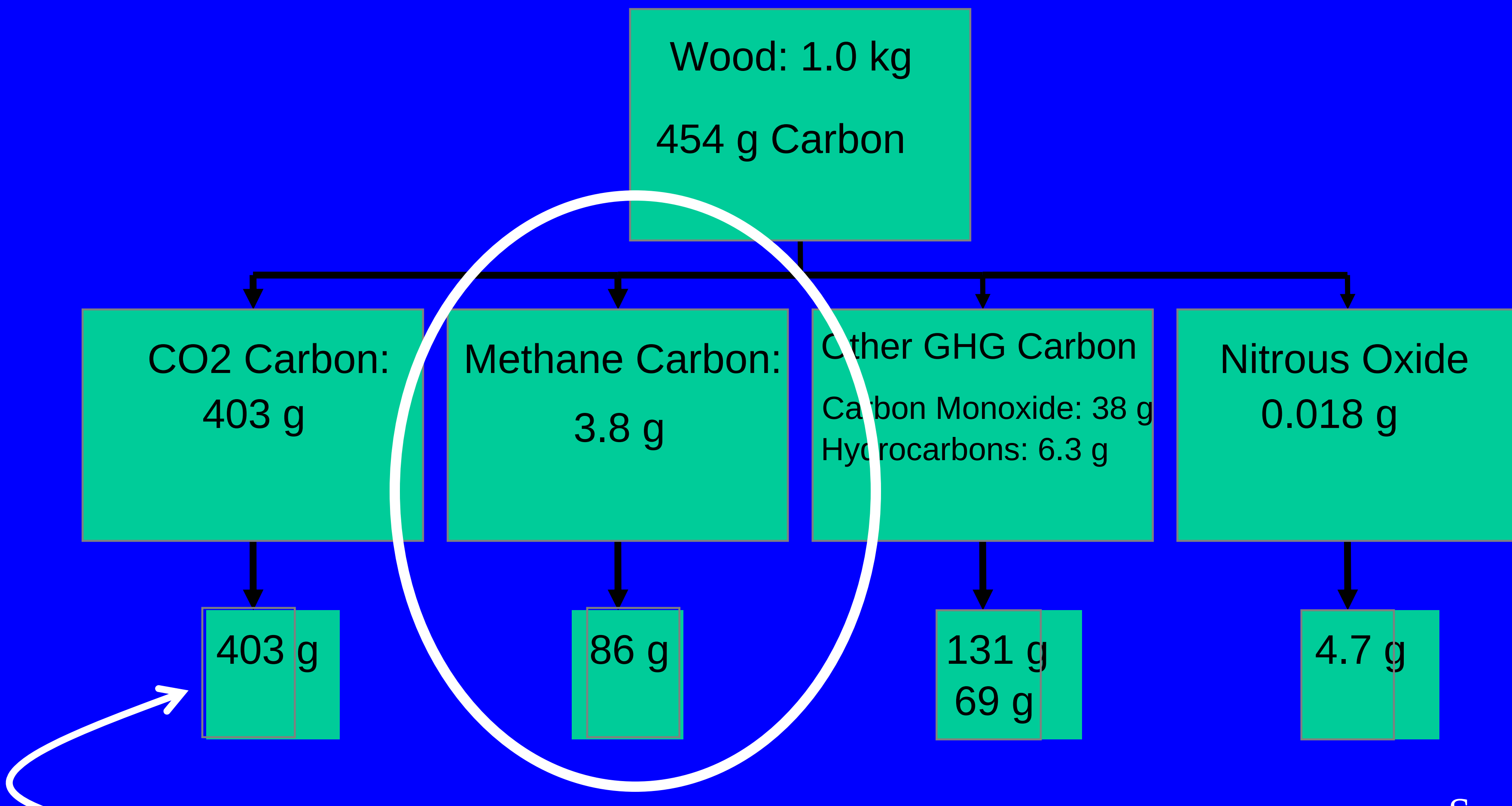
Household Energy in China

- >65% of China's population is rural.
- ~ 80% of energy use is simple solid biomass (wood, agricultural wastes)
- ~13% as coal
- Thus, it is still true to say that in China most people rely on biomass fuels for most of their energy
- A situation that has not changed since the mastery of fire by the human race



Rural energy situation is typically complex:

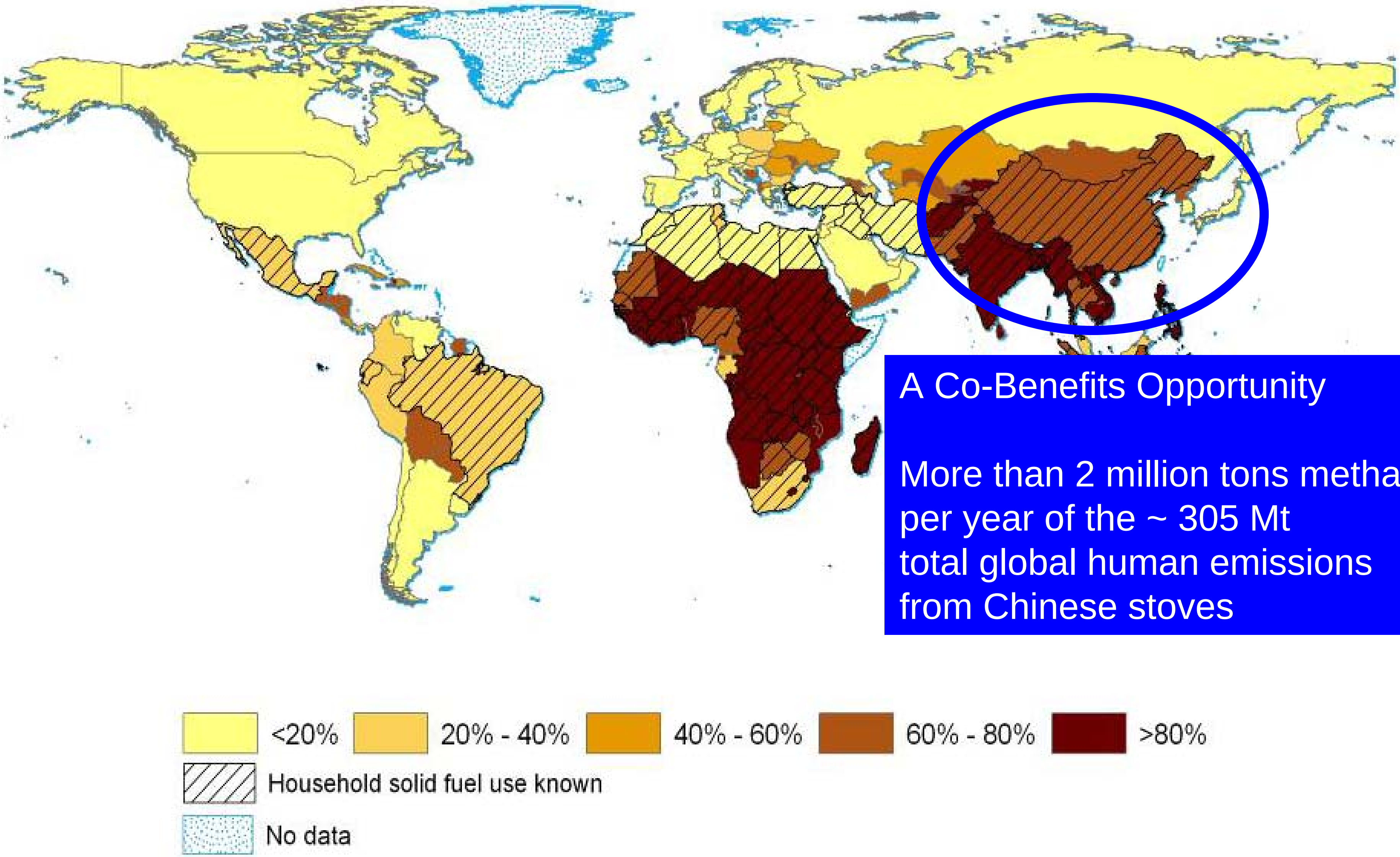
Greenhouse warming commitment per meal for typical wood-fired cookstove in India



Global warming commitments of each of the gases as CO_2 equivalents

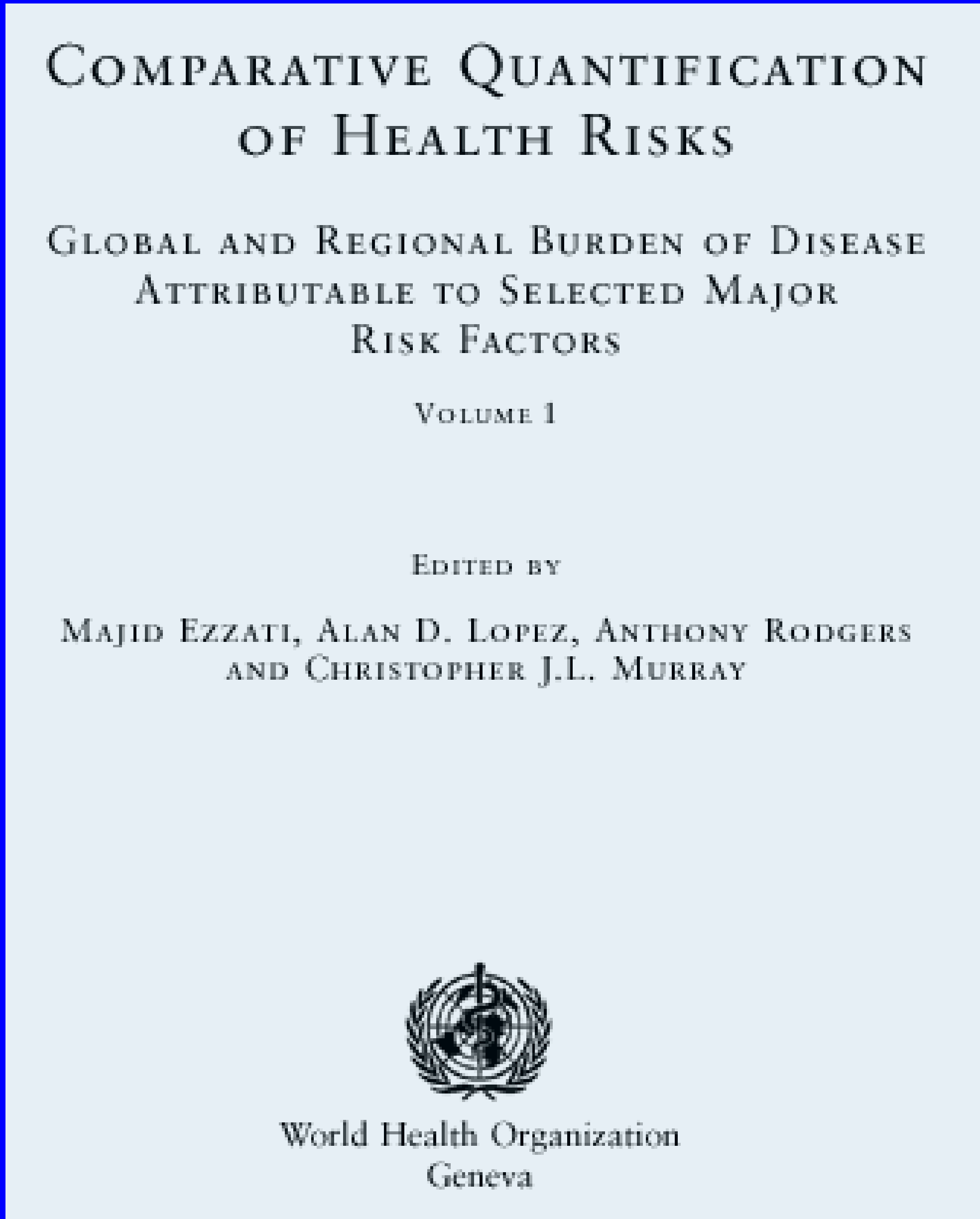
Source: Smith, et al., 2000

National Household Solid Fuel Use, 2000



A Co-Benefits Opportunity

More than 2 million tons methane per year of the ~ 305 Mt total global human emissions from Chinese stoves



COMPARATIVE QUANTIFICATION OF HEALTH RISKS

GLOBAL AND REGIONAL BURDEN OF DISEASE ATTRIBUTABLE TO SELECTED MAJOR RISK FACTORS

VOLUME 1

EDITED BY

MAJID EZZATI, ALAN D. LOPEZ, ANTHONY RODGERS AND CHRISTOPHER J.L. MURRAY

World Health Organization
Geneva

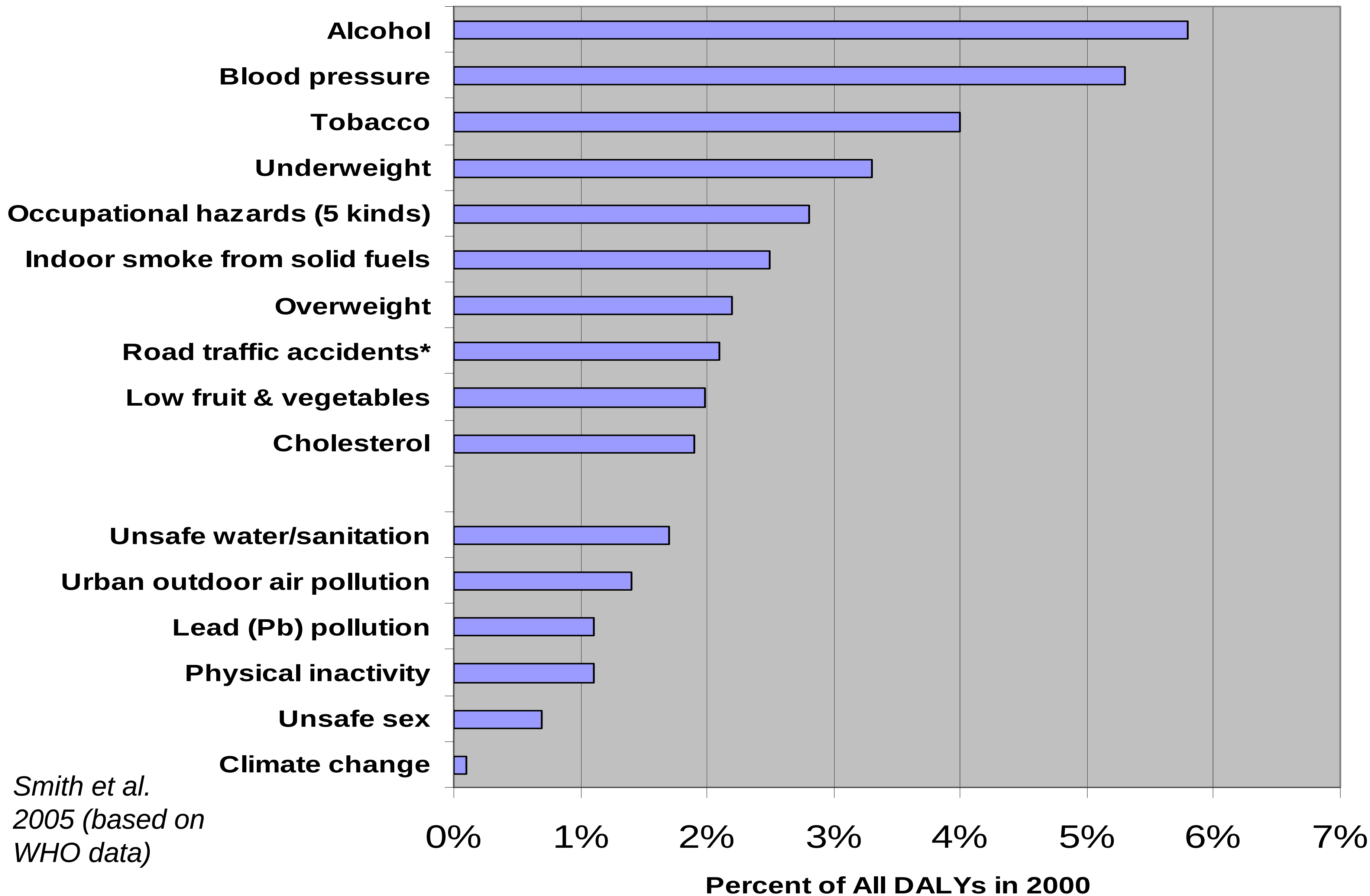
Published in late 2004,
2 vols, ~2500 pp

Available on the World Health Organization website

http://www.who.int/publications/cra/en/

Chinese Burden of Disease from Top 10 Risk Factors

Plus Selected Other Risk Factors



Smith et al. 2005 (based on WHO data)

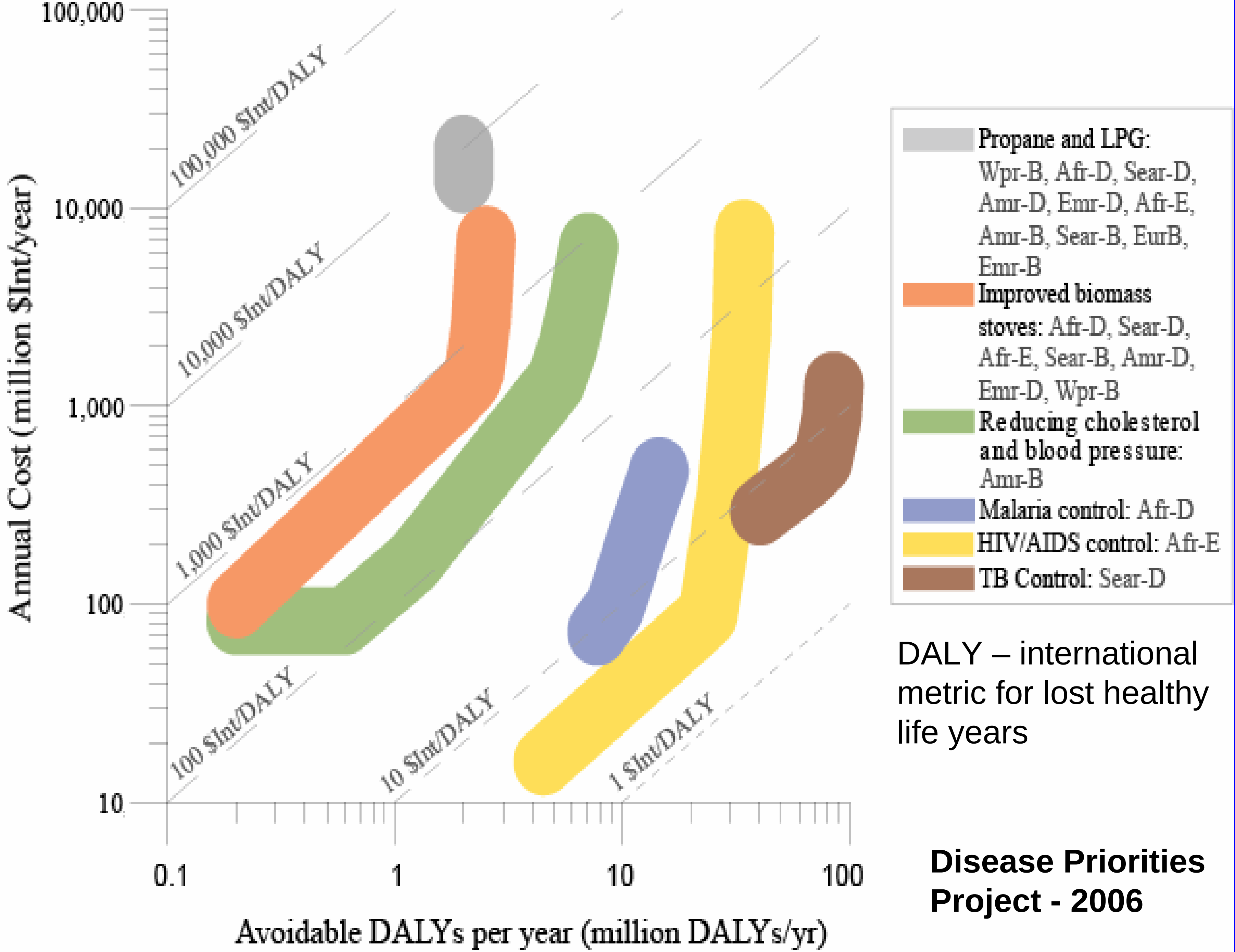
Chinese household rural energy:

A Chinese Biomass Gasifier Stove

Tests show emissions nearly at LPG levels:
Low health risk and essentially no greenhouse emissions

Recent International Collaborative Assessments Provide Much Needed for Co-benefits

- IPCC/UNFCCC: Metrics and procedures for calculating carbon credits
- Millennium Development Goals: 8 MDGs with ~30 explicit indicators and metrics
- Commission on Macro-economics and Health: established health burden metrics and standard methods for cost-effectiveness analysis
- WHO Comparative Risk Assessment: Metrics of exposure and health burden with estimated exposure –response relationships and uncertainties



DALY – international metric for lost healthy life years

Disease Priorities Project - 2006

Summary metrics for use in co-benefits scoping.

	Health	**Climate Change**	**Money**	
Metric	DALYs (Disability-Adjusted Life Years)	GWC (Global Warming Commitment)	International Dollars	
Unit	Years	Tons CO_2 equivalent	US Dollars	
Formulation	Years lost from premature death plus weighted years lost to disability	Tons CO_2 plus tons other GHGs multiplied by their global warming potentials (GWPs)	Local currency adjusted by its capability to buy standard market basket of purchases	
Discount Rates	DALYs	GWPs	Benefits	Costs
Kyoto Case	0%	100-year ~ 0.7%	1%	3%
Base Case	3%	20-year ~ 4.3%	3%	3%
Financial Case	3%	20-year ~ 4.3%	3%	6%

Exposure Response Relationships from Global Comparative Risk Assessment

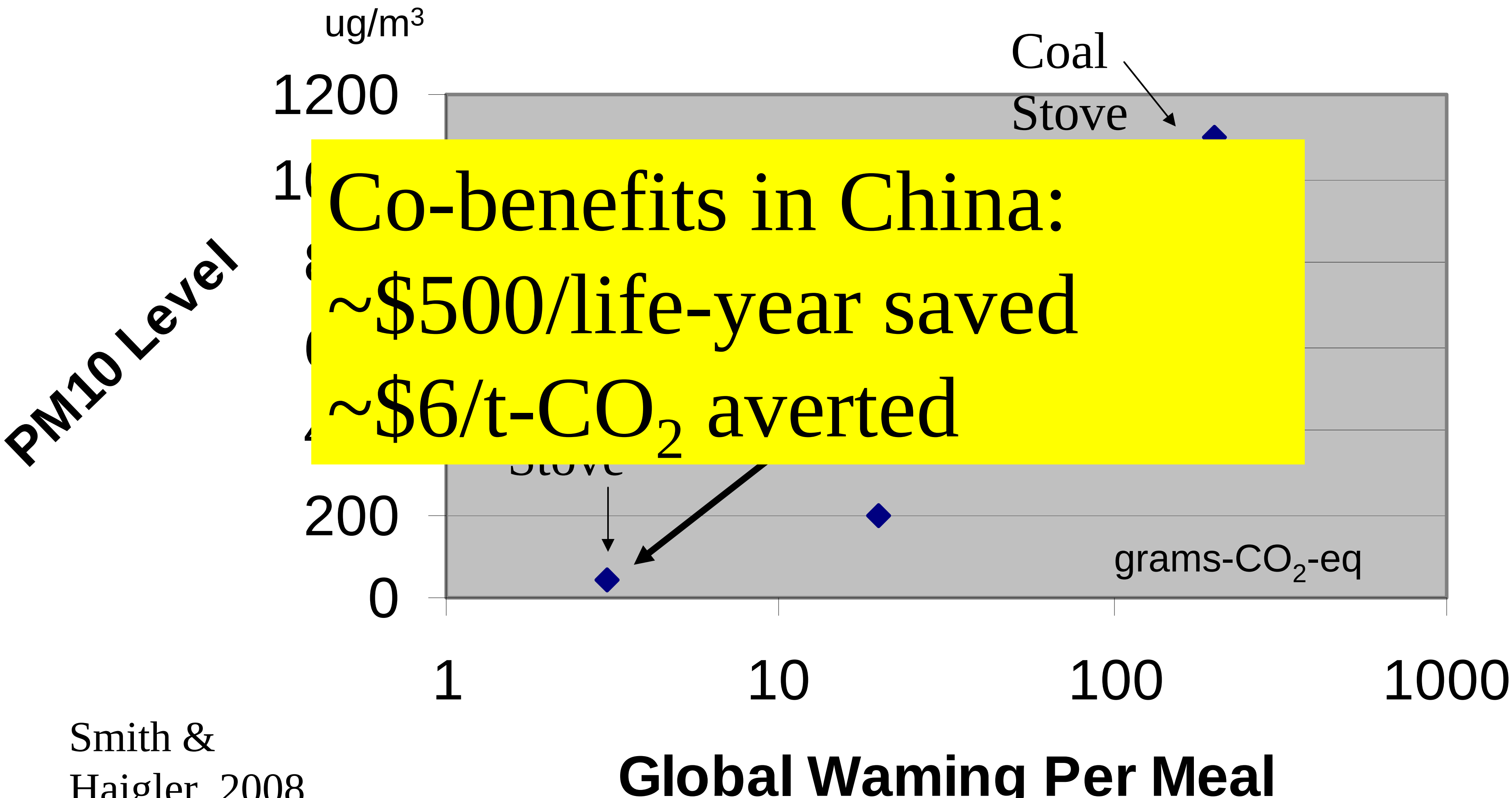
Table 2 Risks from outdoor and indoor air pollution with example from China. Disability-adjusted life years (DALYs)/exposure will be different in other countries because of different background disease risks. Sources: References 12 and 64

	Population	Exposure metric	Relative risk per unit	DALYs/exposure[a]	
Outdoor		1000 people		3% DALY	0% DALY
Cardiovascular	Adults >30	10 μg/m^3 PM2.5	1.059	1.56E-01	3.1E-01
Lung cancer	Adults >30	10 μg/m^3 PM2.5	1.082	2.26E-02	4.4E-02
Acute lower respiratory infections (ALRI)	Children <5	10 μg/m^3 PM10	1.01	1.64E-02	3.8E-02
Indoor		Household (HH)			
Chronic obstructive pulmonary disease (COPD)	Adults >30	Solid fuel use	3.2	2.72E-02	5.4E-02
Lung cancer	Adults >30	Solid fuel use	1.9	1.00E-03	2.0E-03
ALRI	Children <5	Solid fuel use	2.3	1.48E-02	3.4E-02

[a]These values would be different in other parts of the world. See References 17 and 55.

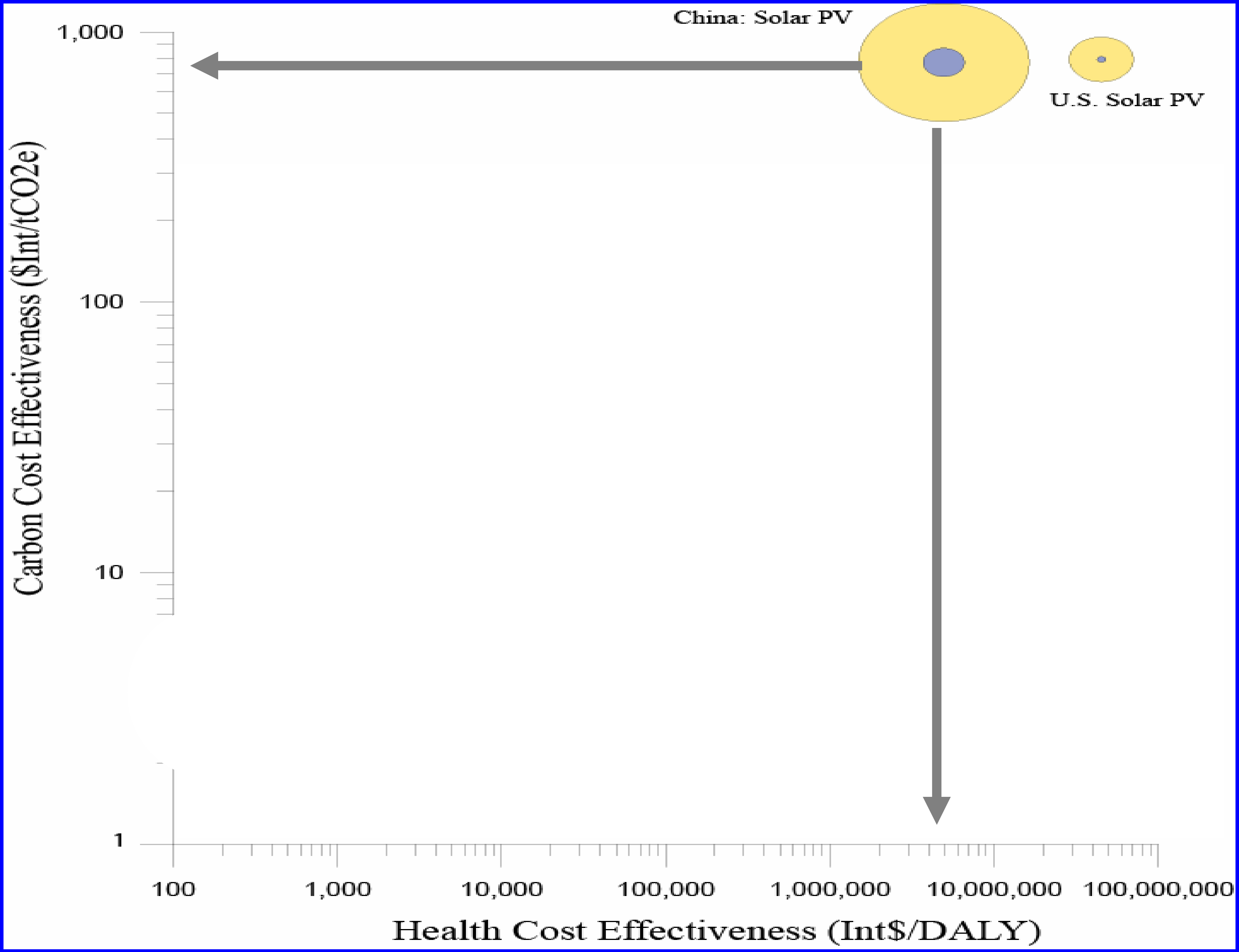
Smith and Haigler, 2008

Health and Greenhouse Gas Benefits of Biomass Stove Options

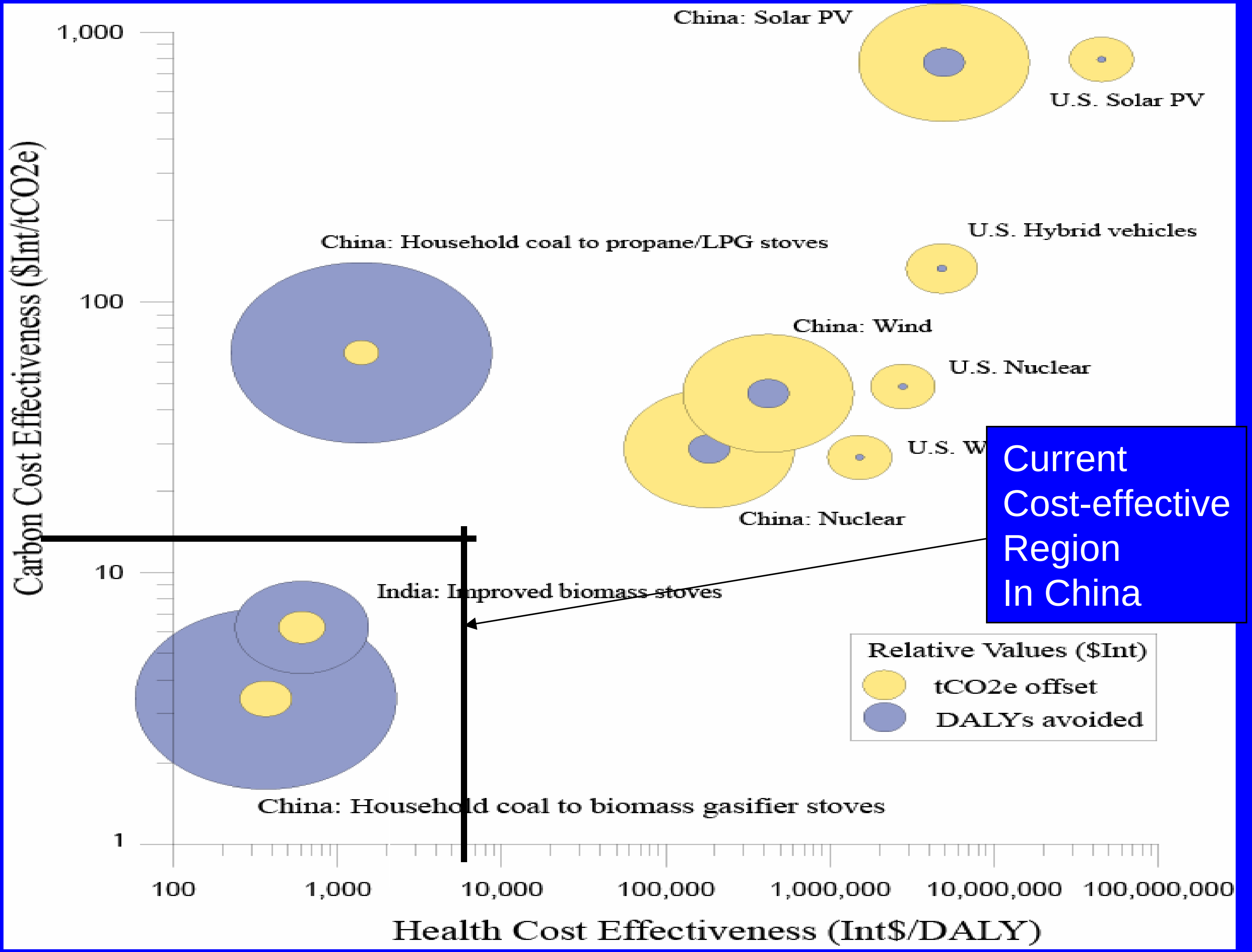


Co-benefits in China:
~$500/life-year saved
~$6/t-$CO_2$ averted

Smith & Haigler, 2008



Smith & Haigler, 2008



Smith & Haigler, 2008

Paying for Rural Energy Development

Global Climate Market

$ per ton-carbon (world carbon market) –
DR <1%

National MDG Health "Market"

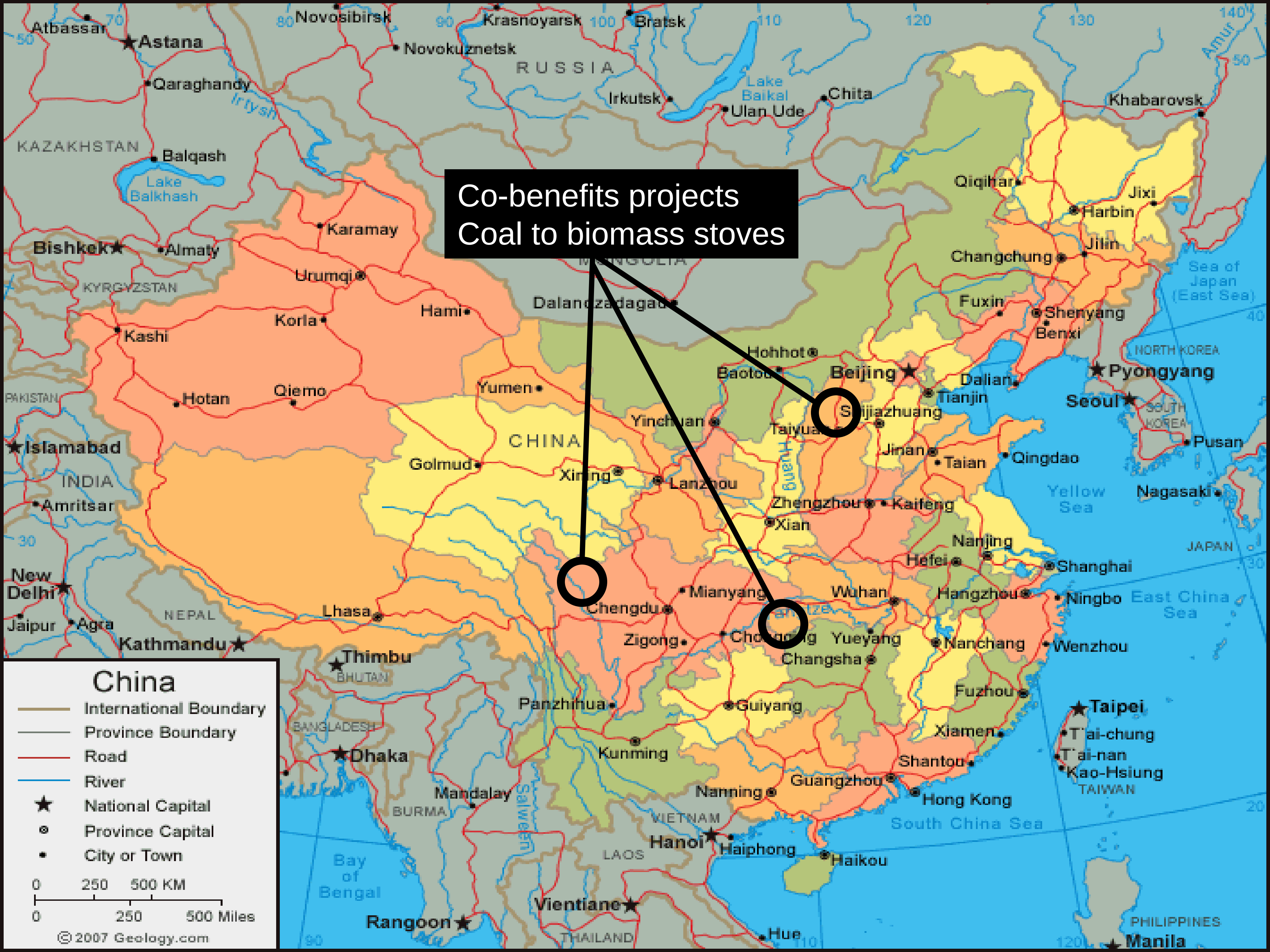
1-3x $GDP/capita per DALY saved (WHO/IBRD, etc. recommendation)
DR ~3%

Technology

High-efficiency low-emissions rural energy technology is too expensive for local markets

Once global and national markets pick up their portions, local market can pay remainder
DR ~40%

Economic Development



Co-benefits projects
Coal to biomass stoves
China
International Boundary
Province Boundary
Road
River
National Capital
Province Capital
City or Town
0 250 500 KM
0 250 500 Miles
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KAZAKHSTAN
KYRGYZSTAN
PAKISTAN
INDIA
NEPAL
BHUTAN
BANGLADESH
BURMA
LAOS
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