Methane Emission Reductions: Opportunities to Promote Health, Development, and Climate

Kirk R. Smith, PhD
Professor of Global Environmental Health
Nobel Laureate – 2007
(at the 0.03% level)
University of California, Berkeley

美国国家科学院 院士 **(1997 -)**
全球环境健康 教授

Methane to Markets, Beijing
October 30 – November 1, 2007

Road Map

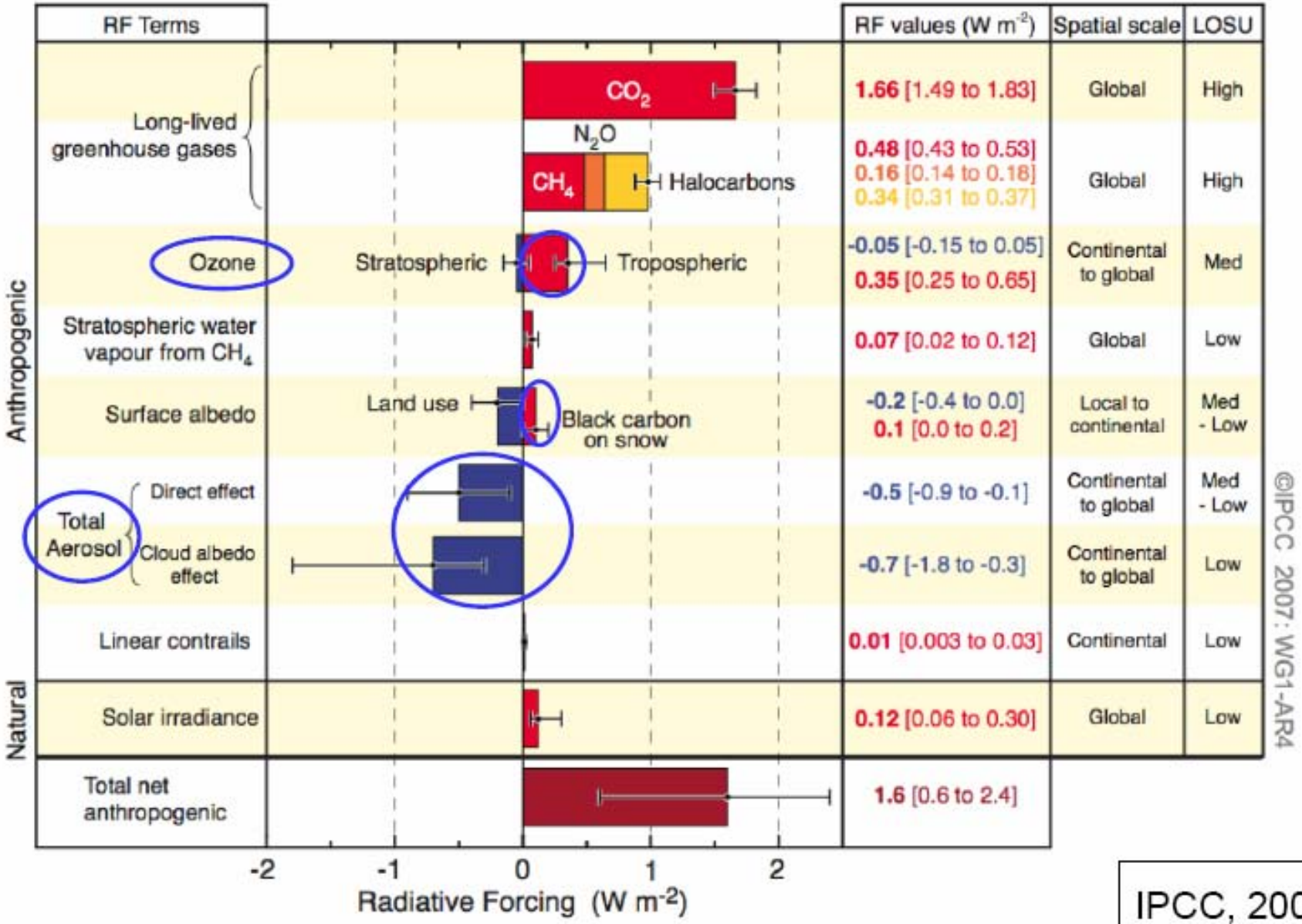
- Why methane emission reductions are undervalued
  - Way to reduce global warming fastest
  - More appropriate for comparison of costs of alternatives
  - Connection with ground-level ozone
- Co-benefits of household energy improvements
  - GHG reductions including methane
  - Health benefits

Methane Issue #1

- Methane contributes a significant amount to global warming
- But has a much shorter atmospheric lifetime compared to the other GHGs
- Thus, changes in emission rates will have a much faster impact to lower warming

Radiative Forcing of Climate, 1750-Present

Important Contributions of Air Pollutants

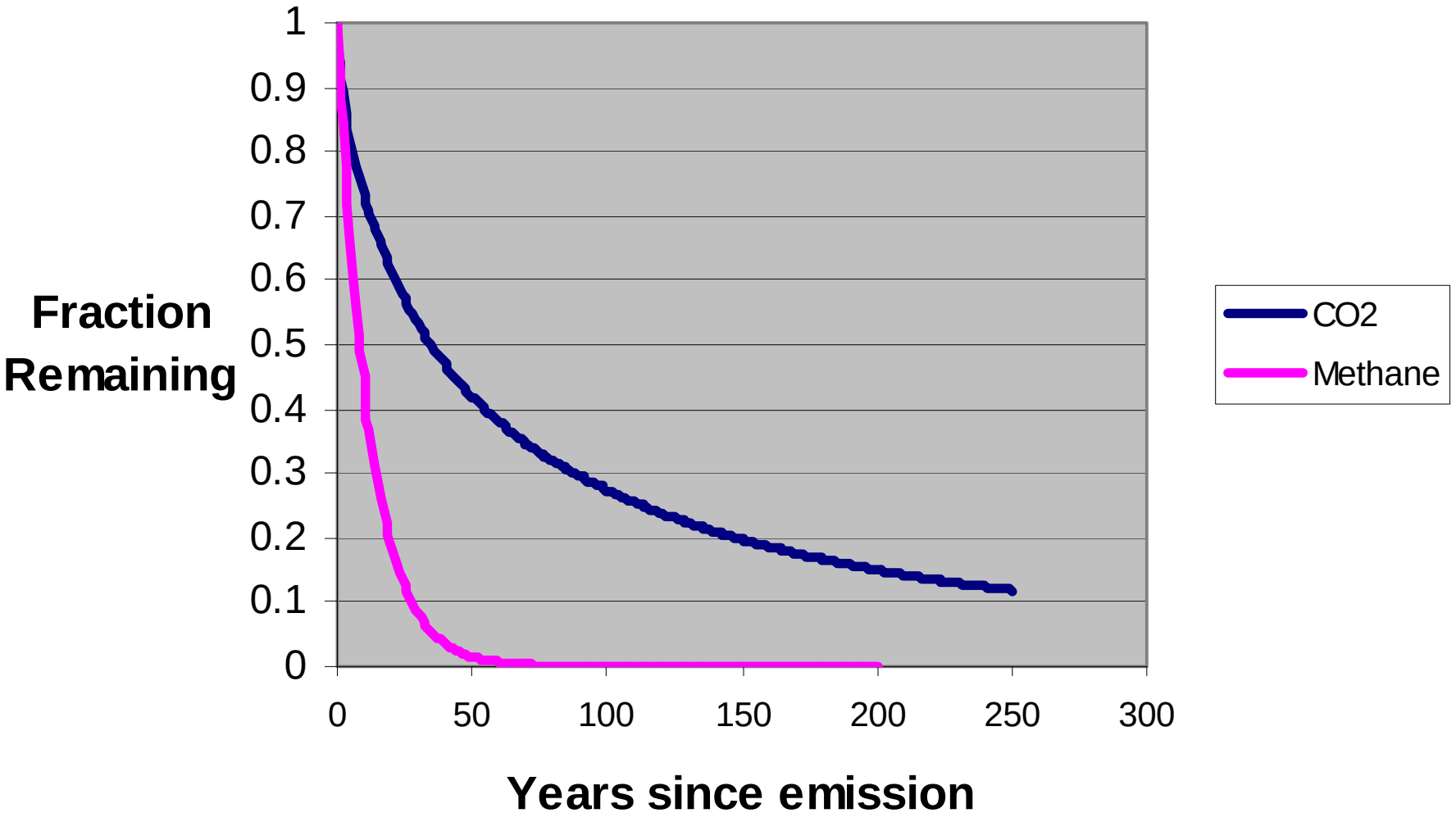


IPCC, 2007

Methane Issue #2

- The current official GWPs are based on 100-year time horizons
  - Methane is 23x CO2 by weight
  - Equivalent to a 0.7% discount rate
- For making decisions on how to spend money, however, 0.7% is too low.
- The other GWP published by IPCC, has a 20-year time horizon
  - Methane is 62x CO2 by weight
  - Equivalent to a 4.3% discount rate
- 20-year time horizon is more realistic, but even better would be something roughly equivalent to a 3% discount rate, i.e, a GWP of 40-50

CO2 and CH4 Depletion



Methane Issue #3

- Increases of wide-scale ground-level ozone is becoming a major world problem
- A significant health-damaging pollutant
- Methane emissions are one of its causes
- Reduction of methane emissions, therefore, will help protect health worldwide

Methane Emissions Affect Ozone Air Quality as well as Climate

- **Methane** contributes to the formation of **ozone**, a primary component of photochemical **smog**.

$$\text{VOCs} + NO_x + \text{sunlight} \rightarrow O_3$$

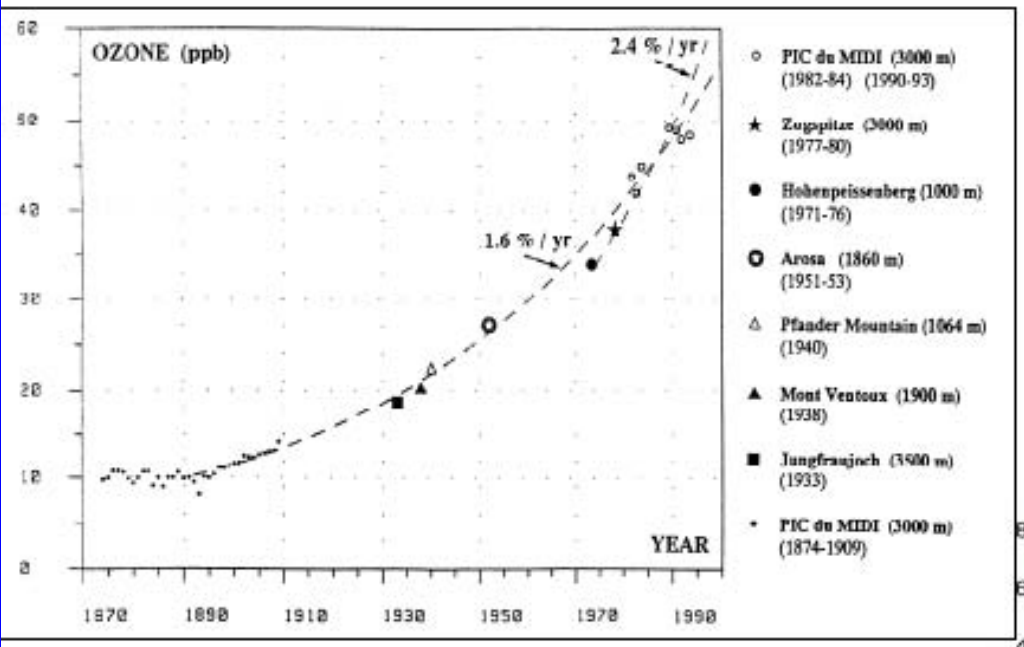
- **Ozone** is associated with **premature mortalities** (*Bell et al.*, 2004, 2005; *Levy et al.*, 2005; *Ito et al.*, 2005).

- **Background concentrations of ozone are increasing globally** due in part to increasing methane.

West and Mauzerall, 2006

Background Ozone is Growing …

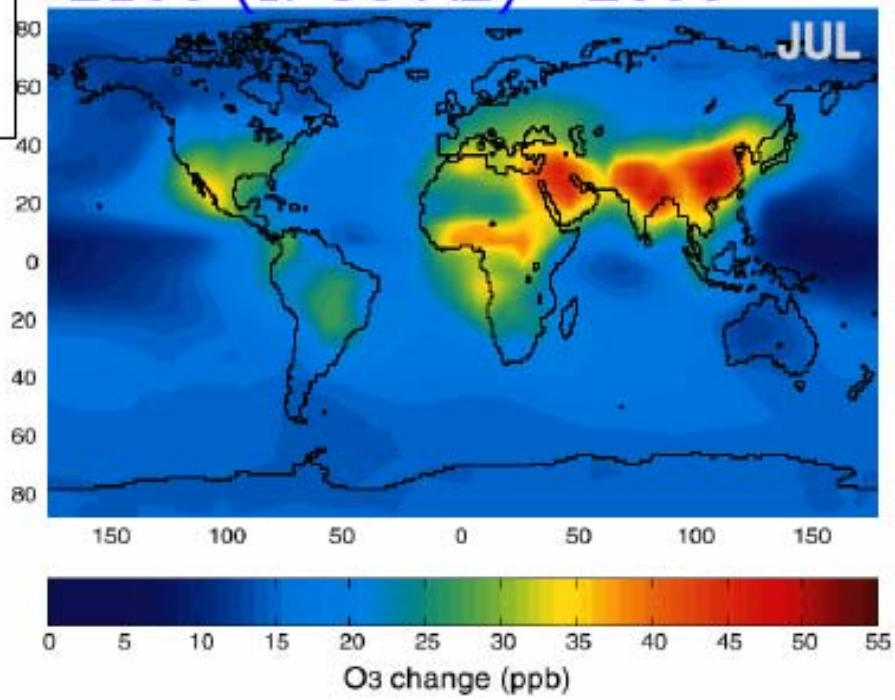
… and Will Continue to Grow!



Ozone trend at European mountain sites, 1870-1990 (Marenco et al., 1994).

Historic and future increases in background ozone are due mainly to increased methane and NO_X emissions (Wang *et al.*, 1998; Prather et al., 2003).

2100 (IPCC A2) - 2000



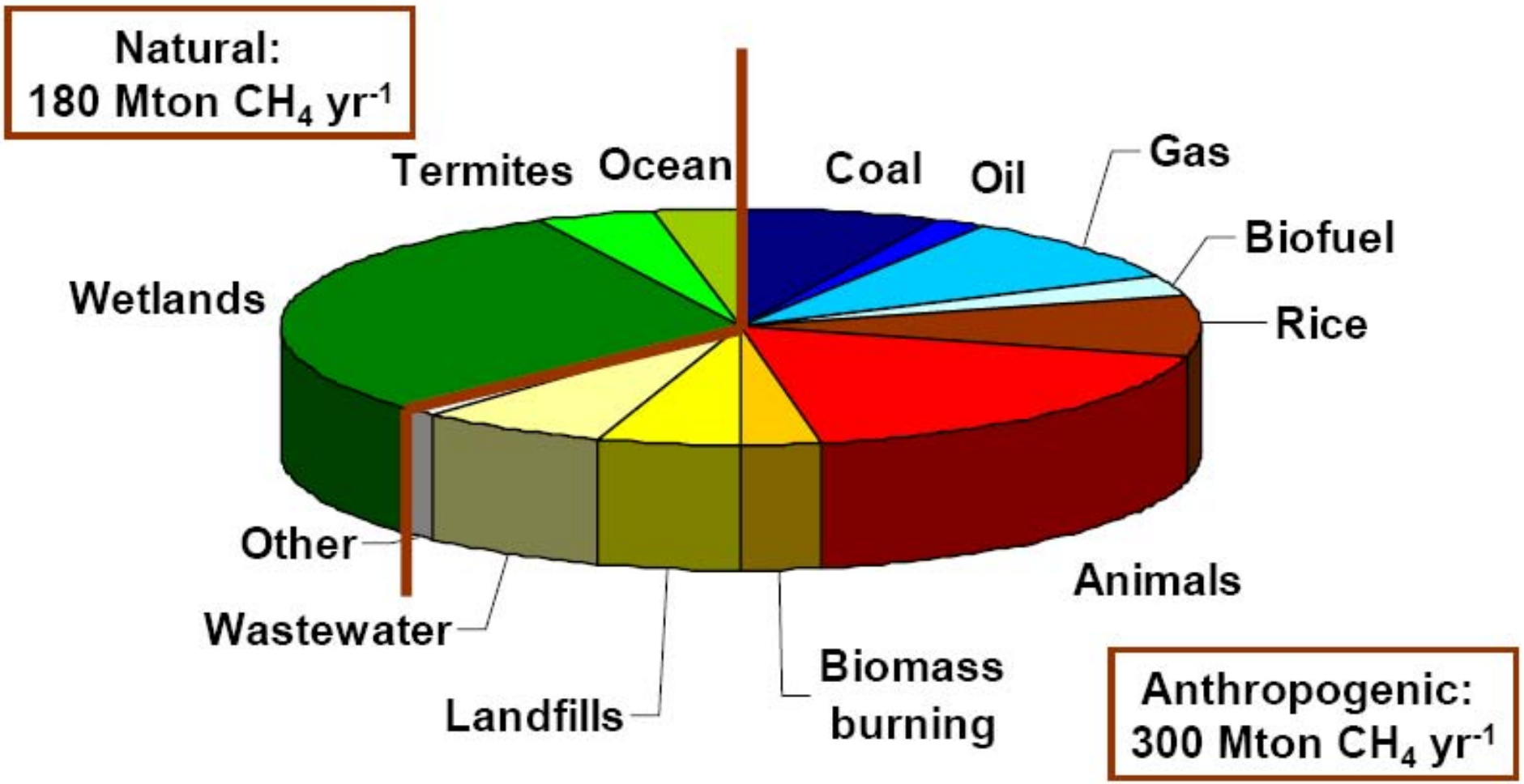
Multiple Benefits of Reducing Methane

Reducing ~20% of anthropogenic methane emissions will:

- Be possible at a net cost-savings.
- Reduce 8-hr. average ozone globally by ~1 ppb.
- Reduce global radiative forcing by ~0.14 W m^{-2}.
- Provide ~2% of global natural gas production.
- Prevent ~30,000 premature deaths globally in 2030, ~370,000 from 2010-2030.

Mauzerall, 2007

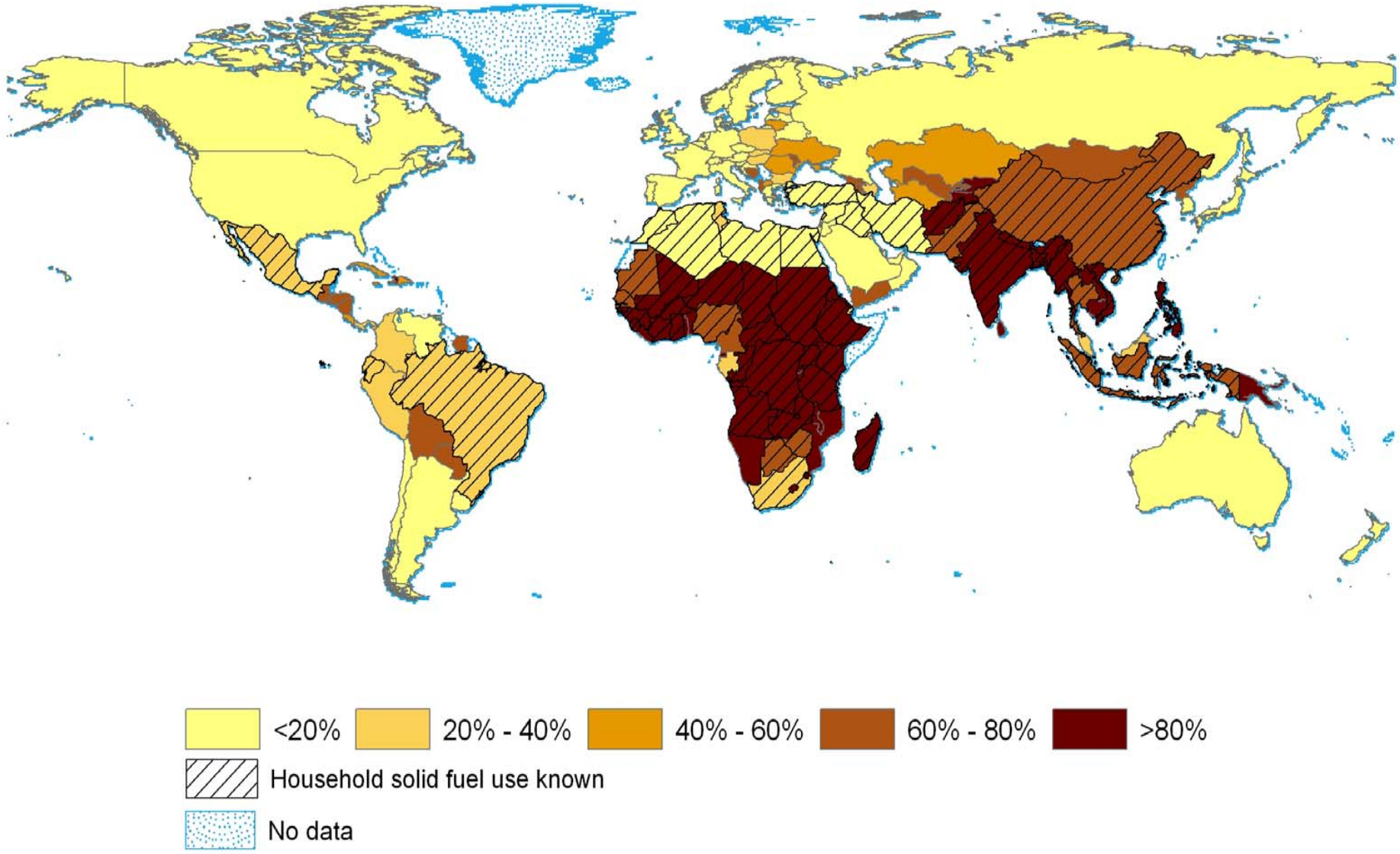
Global Methane Emissions



* USA is ~9% of global anthropogenic emissions.

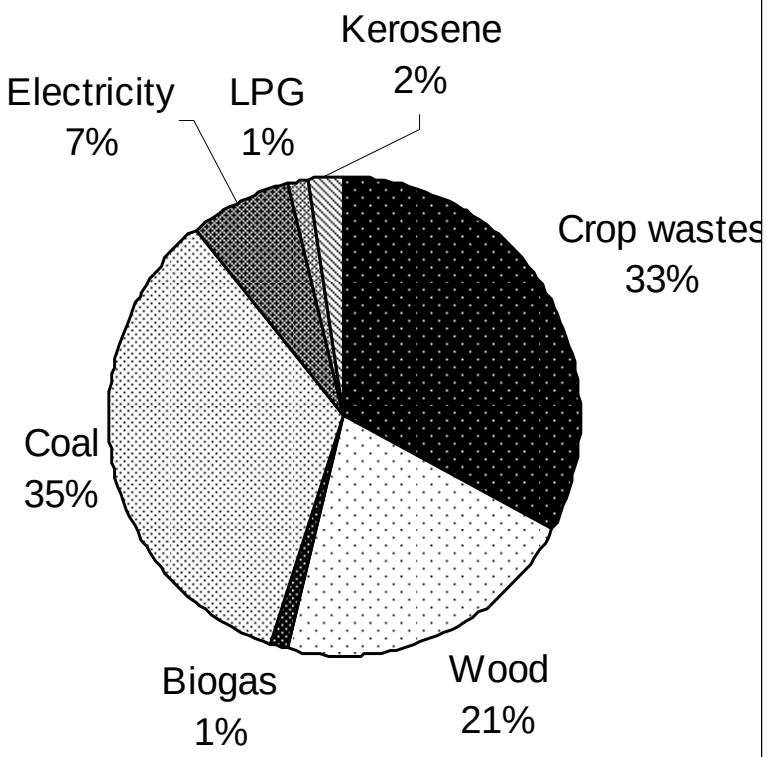
EDGAR3.2 & Houweling *et al.*, 1999

National Household Solid Fuel Use, 2000



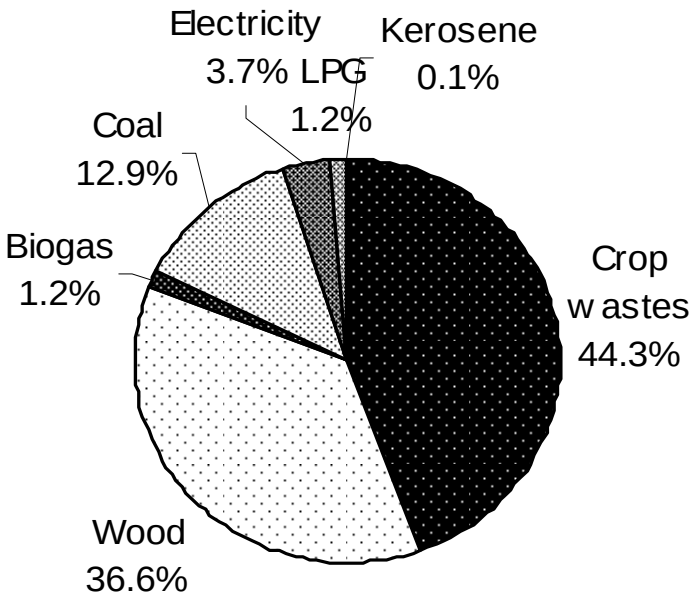
Rural Energy in China: 2004

Total



Ministry of Agriculture

Households



70% of total

National Bureau of Statistics

China rural energy situation complex:

Woodsmoke is natural – how can it hurt you?

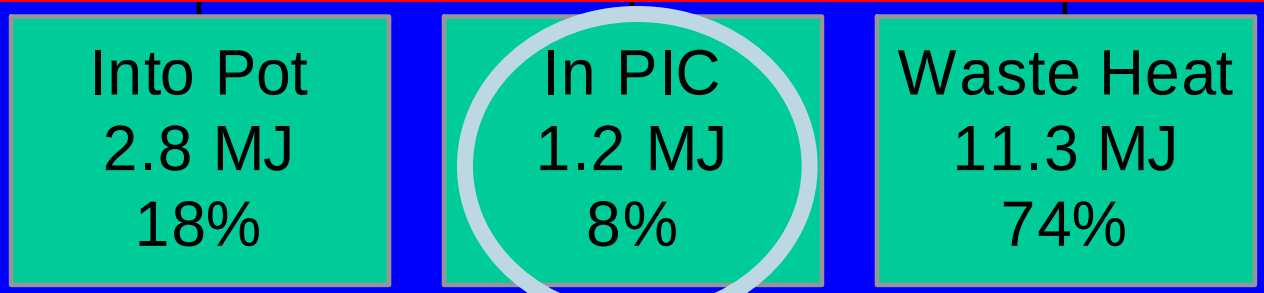
Or, since wood is mainly just carbon, hydrogen, and oxygen, doesn't it just change to CO_2 and H_2O when it is combined with oxygen (burned)?

Reason: the combustion efficiency is far less than 100%

Energy flows in a well-operating traditional wood-fired Chinese cooking stove

A Toxic Waste Factory!!

Typical biomass cookstoves convert 6-30% of the
fuel carbon to toxic substances + methane



PIC = products of incomplete combustion = CO, HC, C, etc.

Source: Zhang, et al., 2000

Toxic Pollutants in Biomass Fuel Smoke from Simple (poor) Combustion

- Small particles, CO, NO_2
- Hydrocarbons
  - 25+ saturated hydrocarbons such as *n-hexane*
  - 40+ unsaturated hydrocarbons such as *1,3 butadiene*
  - 28+ mono-aromatics such as *benzene & styrene*
  - 20+ polycyclic aromatics such as *benzo(α)pyrene*
- Oxygenated organics
  - 20+ aldehydes including *formaldehyde* & *acrolein*
  - 25+ alcohols and acids such as *methanol*
  - 33+ phenols such as *catechol* & *cresol*
  - Many quinones such as *hydroquinone*
  - Semi-quinone-type and other radicals
- Chlorinated organics such as *methylene chloride* and *dioxin*

Plus methane

Source: Naeher et al, *J Inhal Tox*, 2007

Diseases for which we have epidemiological studies

ALRI/ Pneumonia (meningitis)

Asthma

Low birth weight & stillbirth

Early infant death

Cognitive Effects?

Chronic obstructive lung disease

Interstitial LD

Cancer (lung, NP, cervical, aero-digestive)

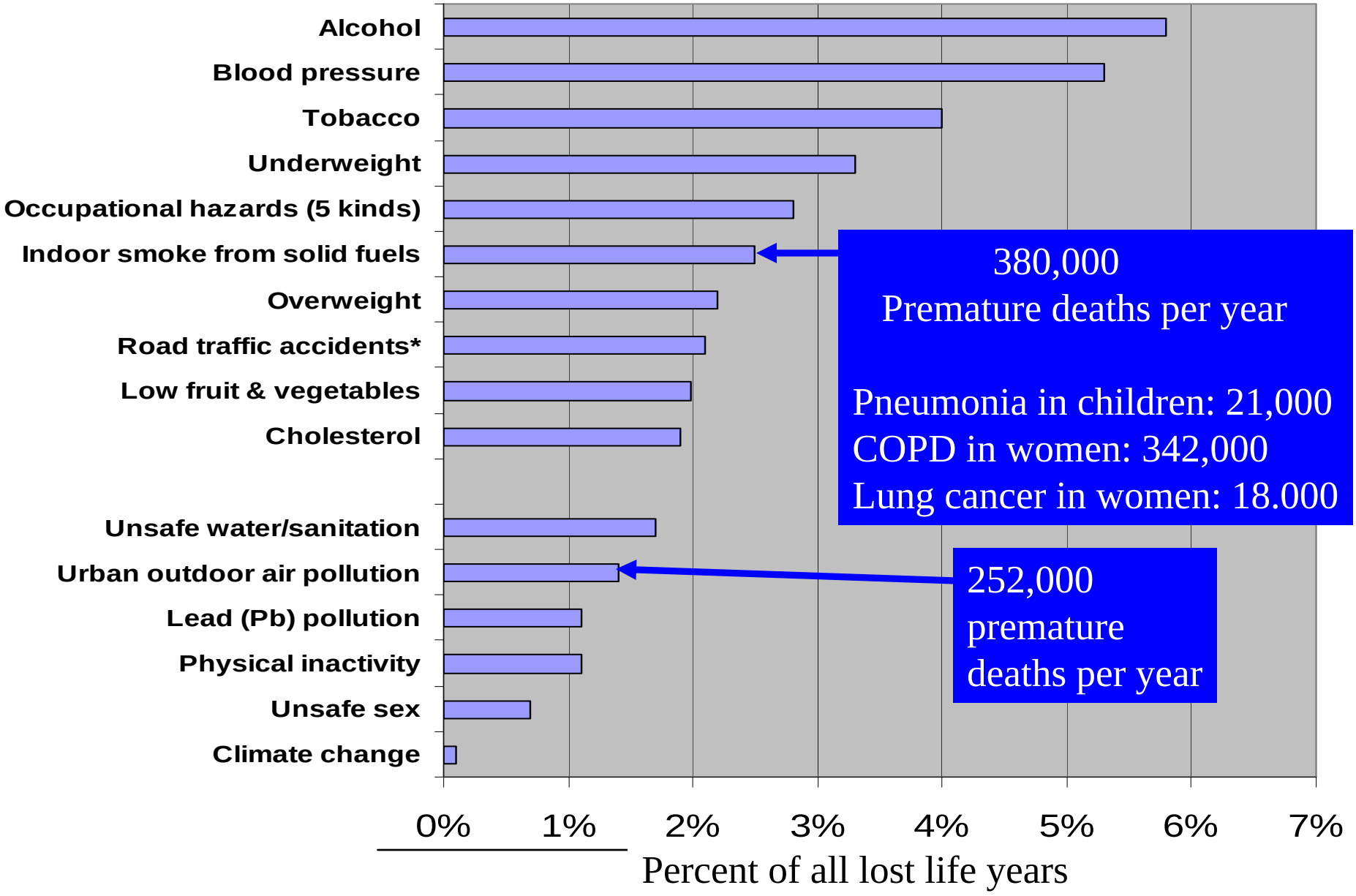
Blindness (cataracts, trachoma)

Tuberculosis

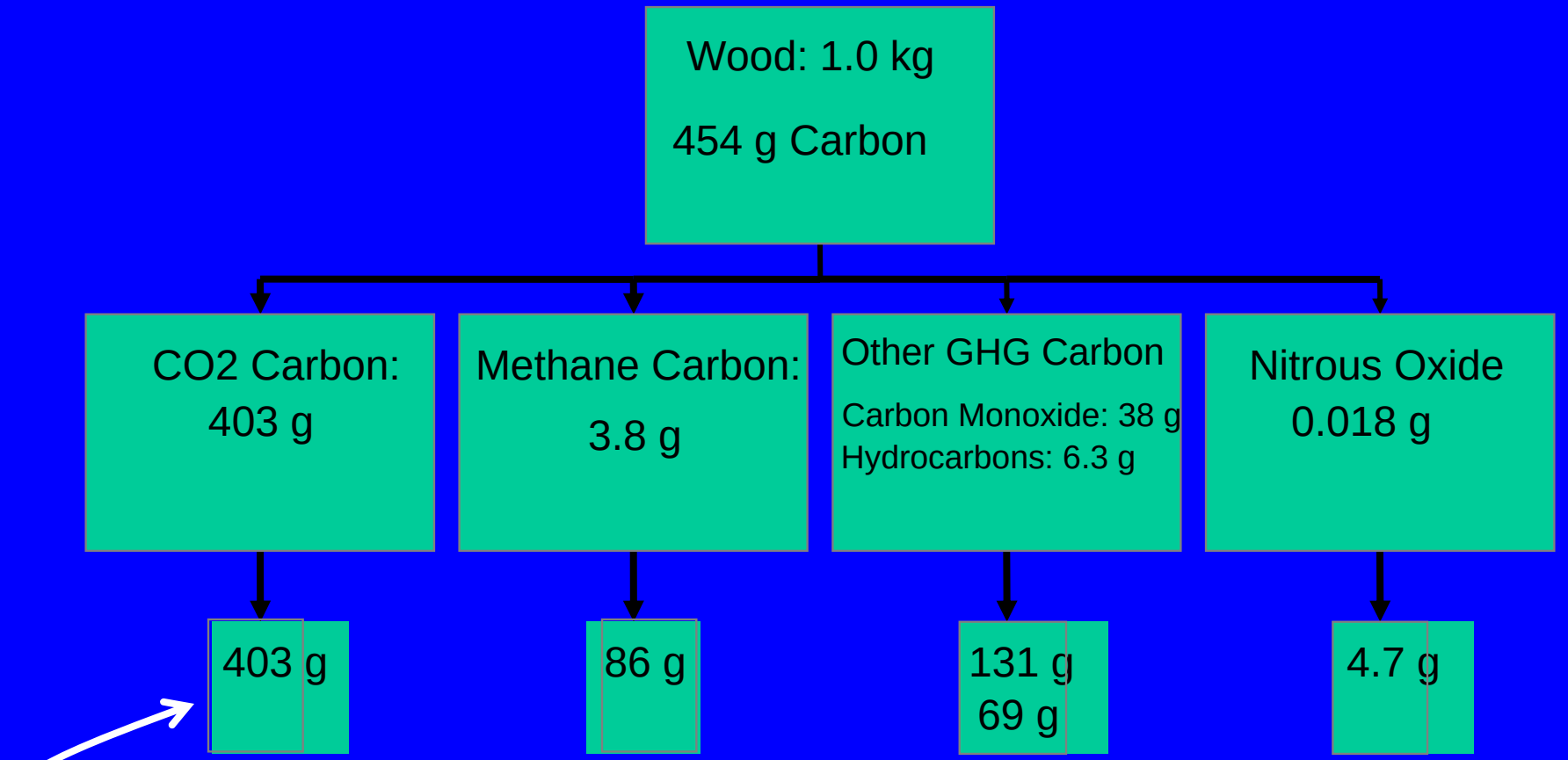
Heart disease

Chinese Burden of Disease from Top 10 Risk Factors

Plus Selected Other Risk Factors



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

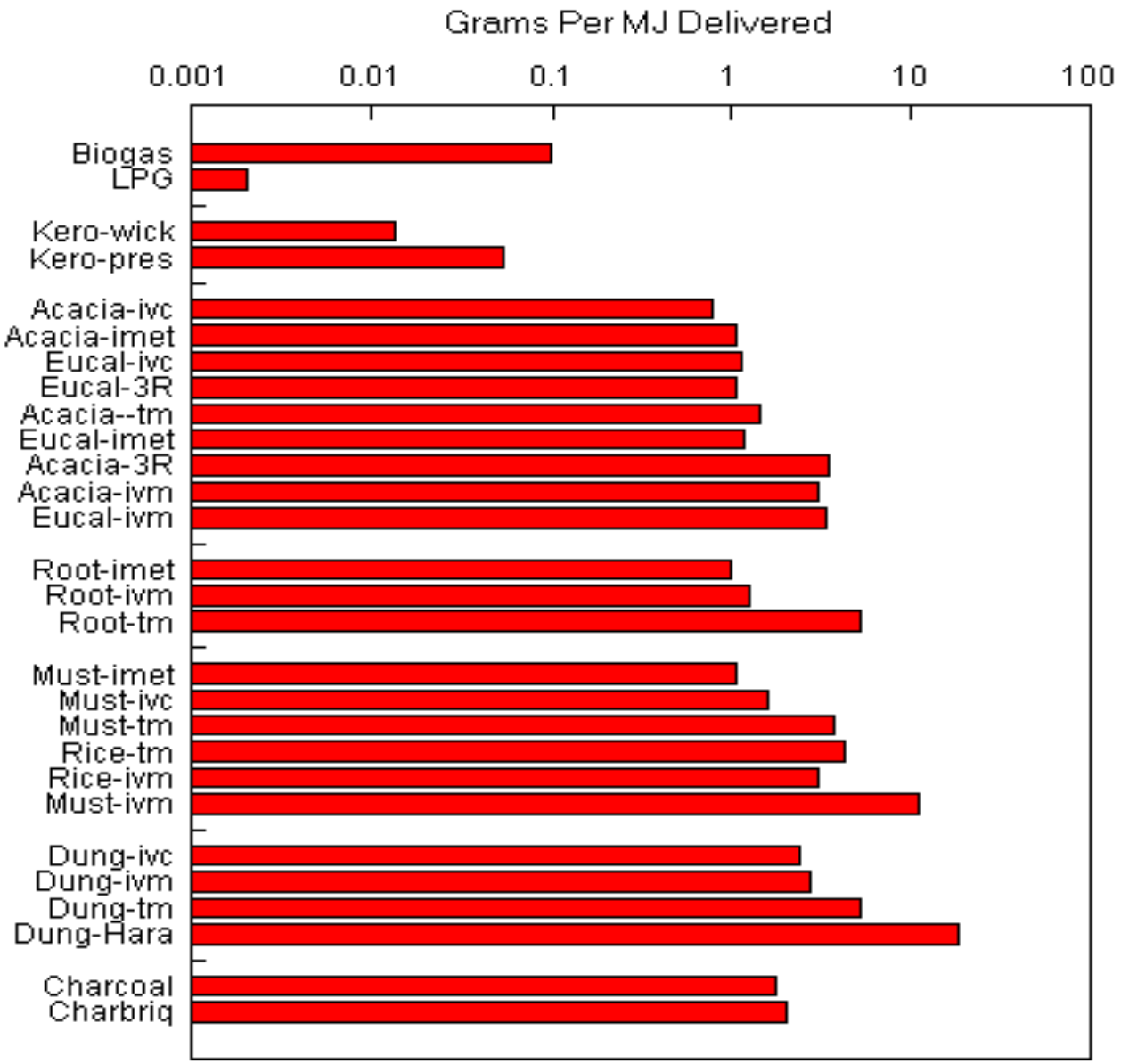


Global warming commitments of each of the gases as CO_2 equivalents

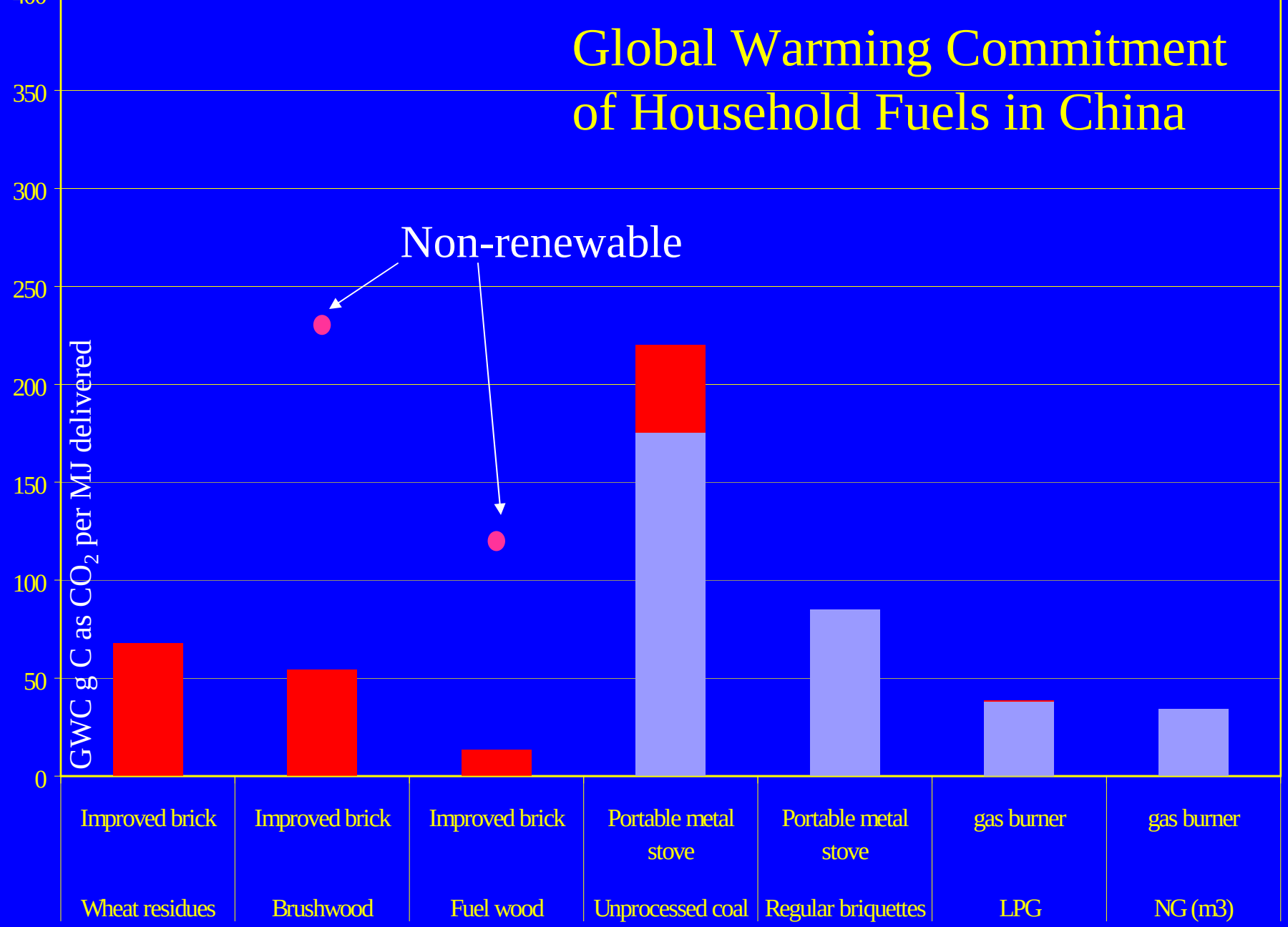
Source: Smith, et al., 2000

Figure 10. Methane Emission Factors

Per MJ Delivered to the Pot



Global Warming Commitment of Household Fuels in China



A Chinese Biomass Gasifier Stove

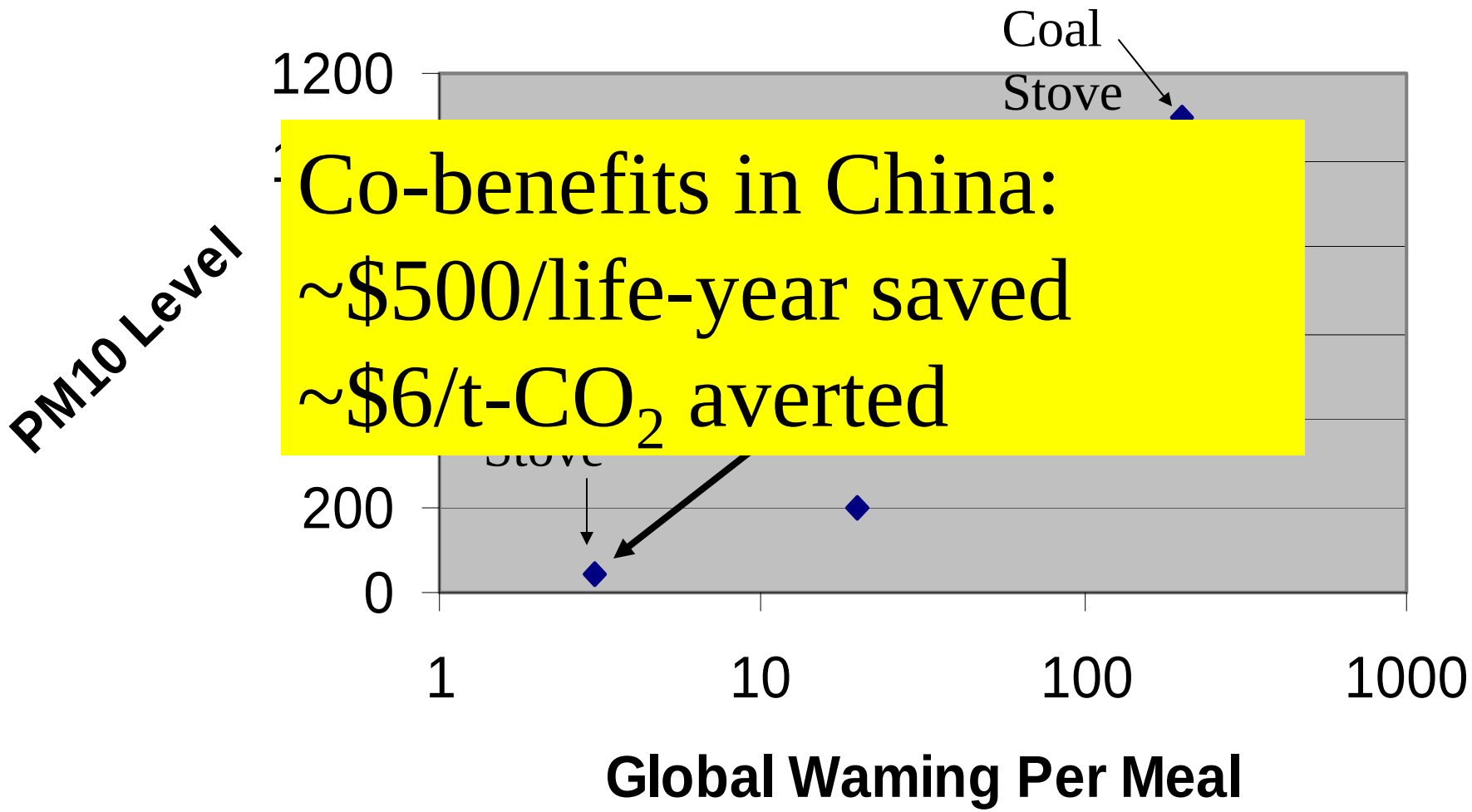
Tests show PIC emissions nearly at LPG levels.

Winner of Chinese national contest announced March 2007 for best stove meeting emissions and reliability criteria:
cost 300Y

Consider the substitution of coal stoves in rural China with advanced biomass gasifier stoves, now commercially available in several provinces

- 300Y retail cost/stove + 50% program cost
- 50% of performance in lab
- Typical household fuel use
- Kyoto greenhouse gases only, including methane
- Financial calculations as in CDM requirements
- Health calculations based on Chinese data using WHO methods

Health and Greenhouse Gas Benefits of Biomass Stove Options



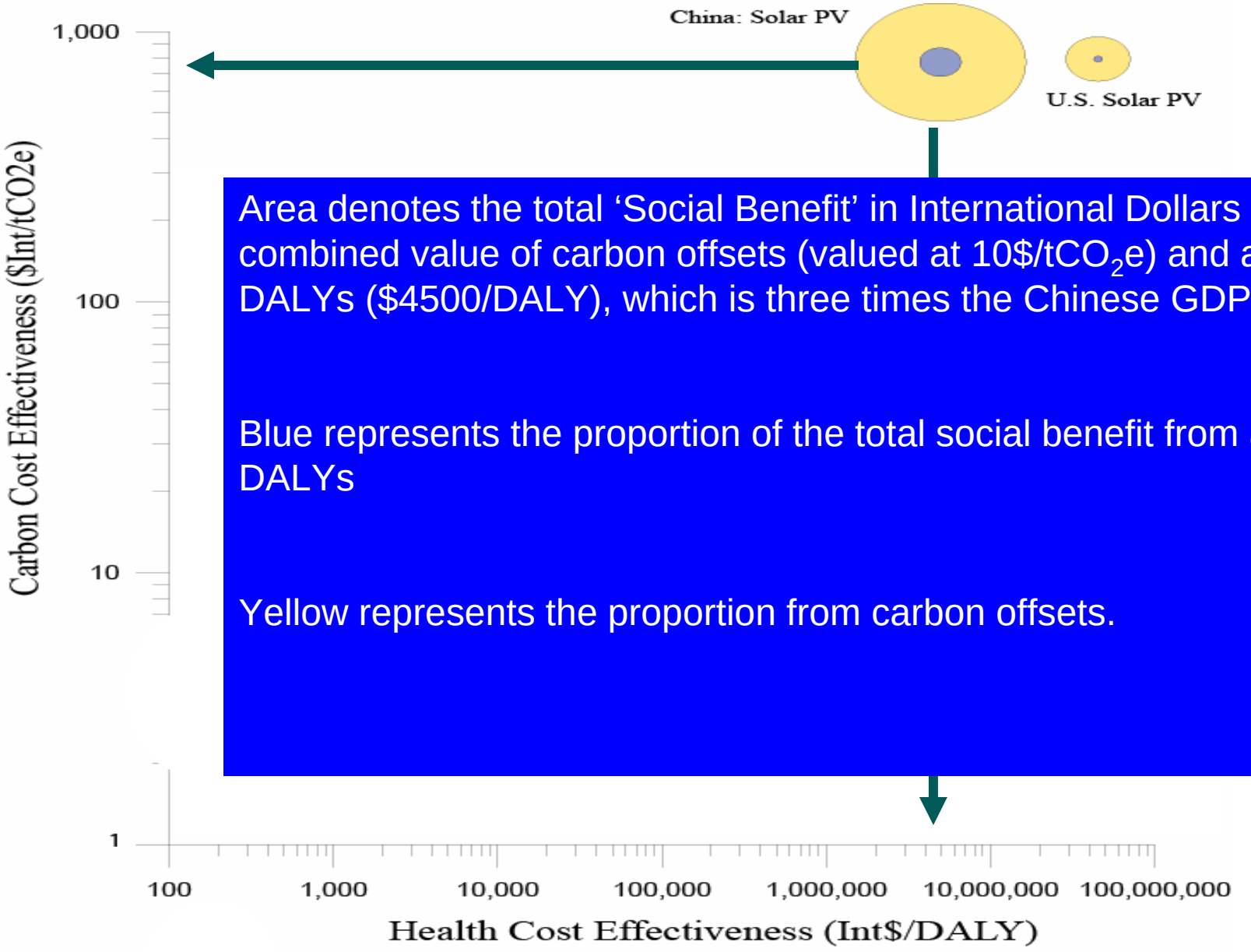
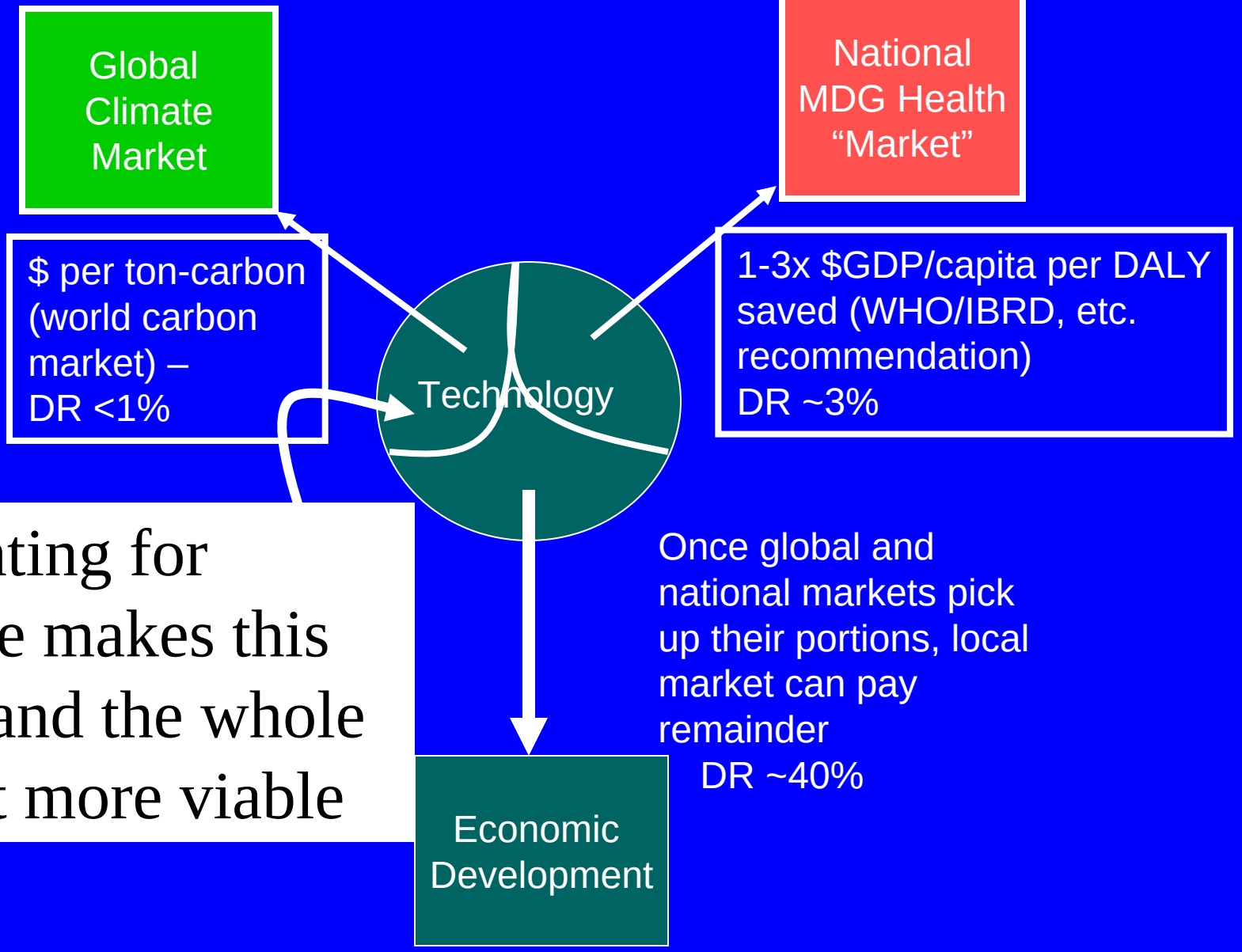


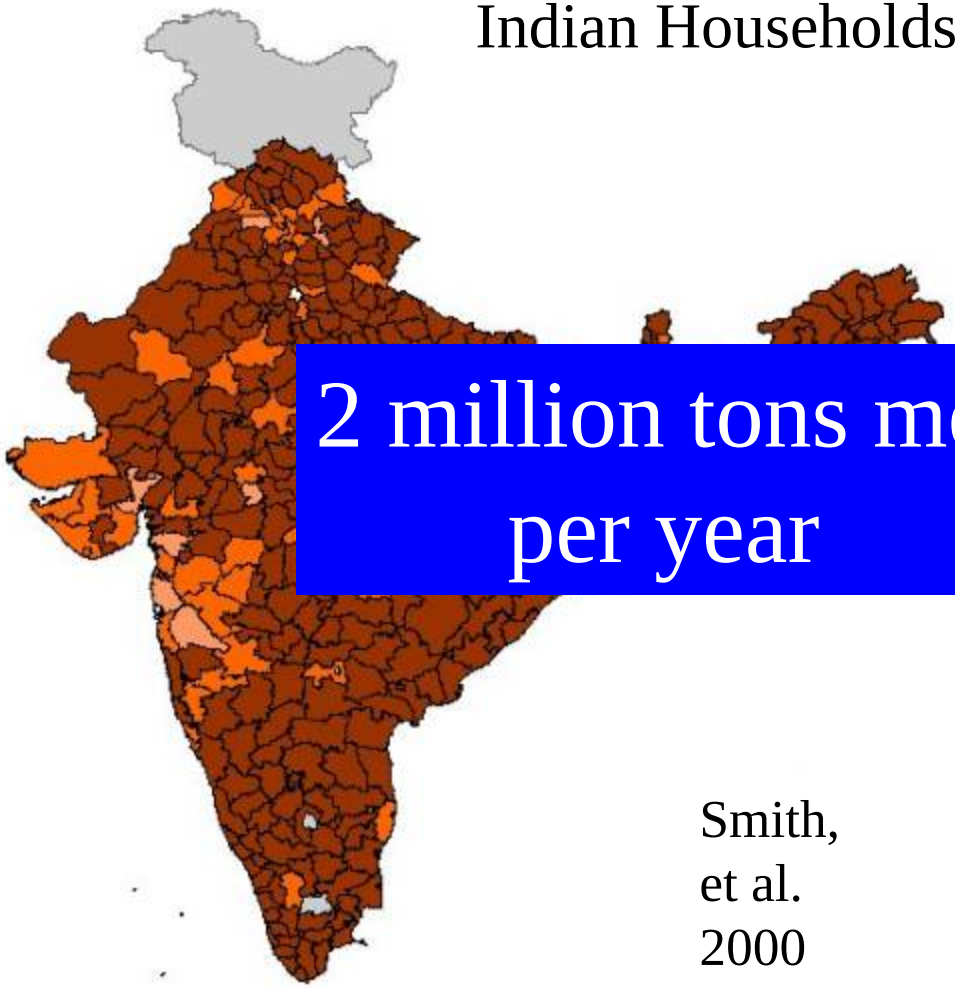
Figure: Smith & Haigler, in press

Paying for Rural Energy Development



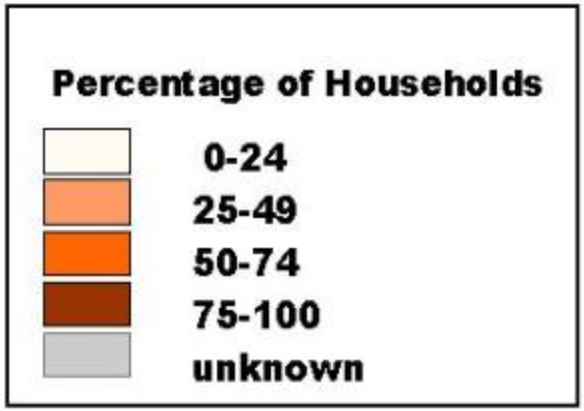
Accounting for methane makes this bigger and the whole concept more viable

Indian Households Using Biomass Fuels



2 million tons methane per year

Smith,
et al.
2000



*Source: Census of India 1991

Conclusions

- Methane emissions are more important than current official weighting factors indicate
- Likely to increase in “value”, perhaps during the post-Kyoto deliberations now starting
- Methane is emitted as part of the poor combustion process of solid fuels, which also produce much health-damaging pollution
- Improving this combustion offers substantial GHG as well as health benefits in a cost-effective manner

Origins of the Chinese Rural Energy Program

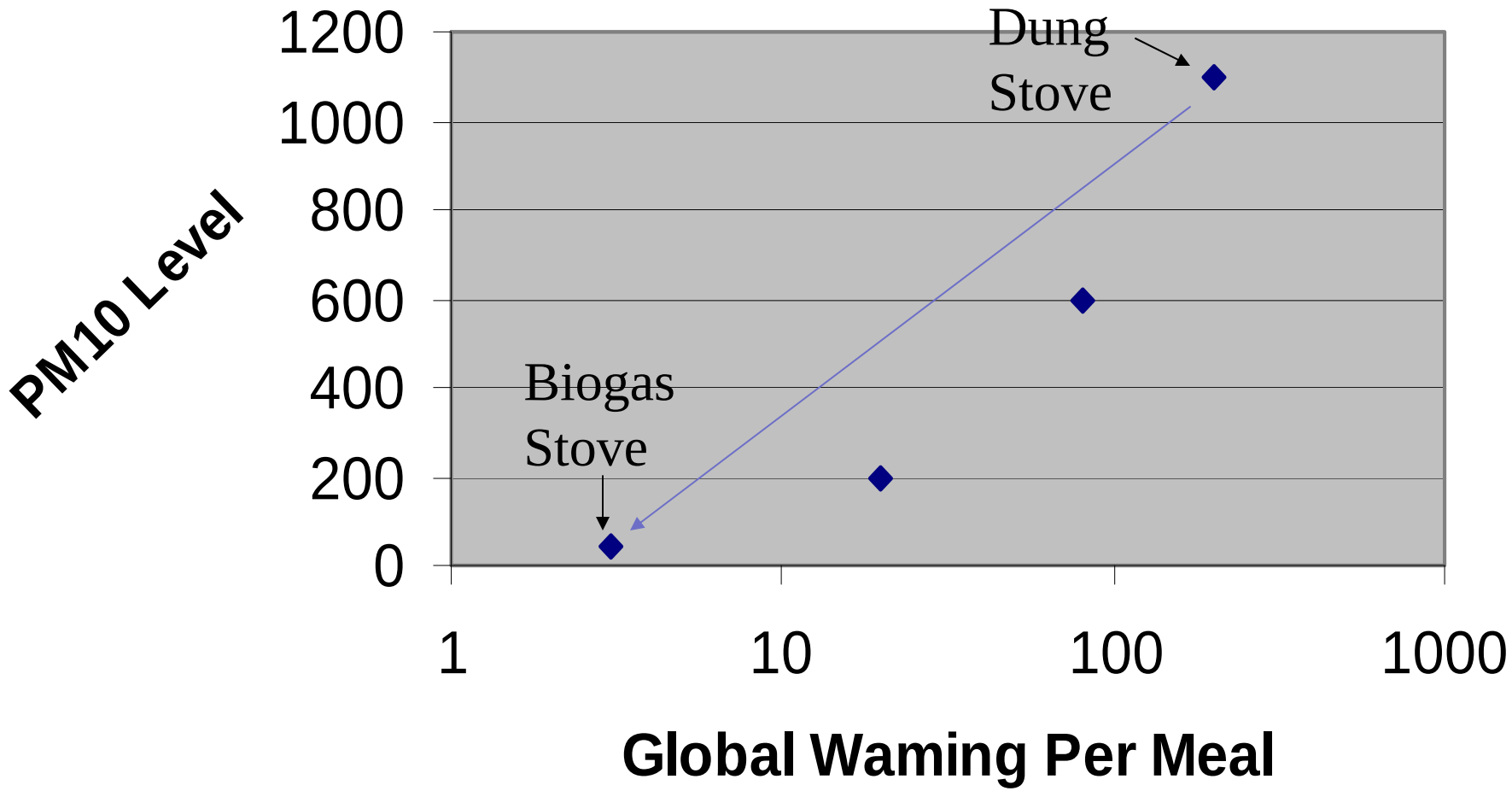
At a biogas stove exhibit in Wuhan on April 11, 1958, Mao Zhedong instructed,

“This should be well promoted.”

1958年4月11日毛主席视察武汉地方工业展览馆观看沼气灶演示，指示“这要好好地推广”

Being demonstrated of biogas stove on Wuhan local industry exhibition on April 11, 1958, Chairman Mao Zhedong instructed “ This should be well promoted”

Health and Greenhouse Gas Benefits of Household Biogas



This review is partly based on the articles:

Household Air Pollution from Coal and Biomass Fuels in China: Measurements, Health Impacts, and Interventions.

Environmental Health Perspectives 115 (6): 848-855, June 2007
Zhang J & Smith KR

Greenhouse Gases and Other Airborne Pollutants from Household Stoves in China: A Database for Emission Factors.

Atmospheric Environment, 34(26): 4537-4549, 2000
Zhang J, KR Smith, Y Ma, F Jiang, W Qi, P Liu, MAK Khalil, RA Rasmussen, & SA Thornelow,

All publications can be found at
http://ehs.sph.berkeley.edu/krsmith/

Thank You

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
- Nearly all burned under poor combustion conditions producing much pollution and methane

Remaining Warming: CO2 vrs CH4
Same amounts released at year 0