

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

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**Nobel Laureate – 2007**

**(at the 0.03% level)**

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**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

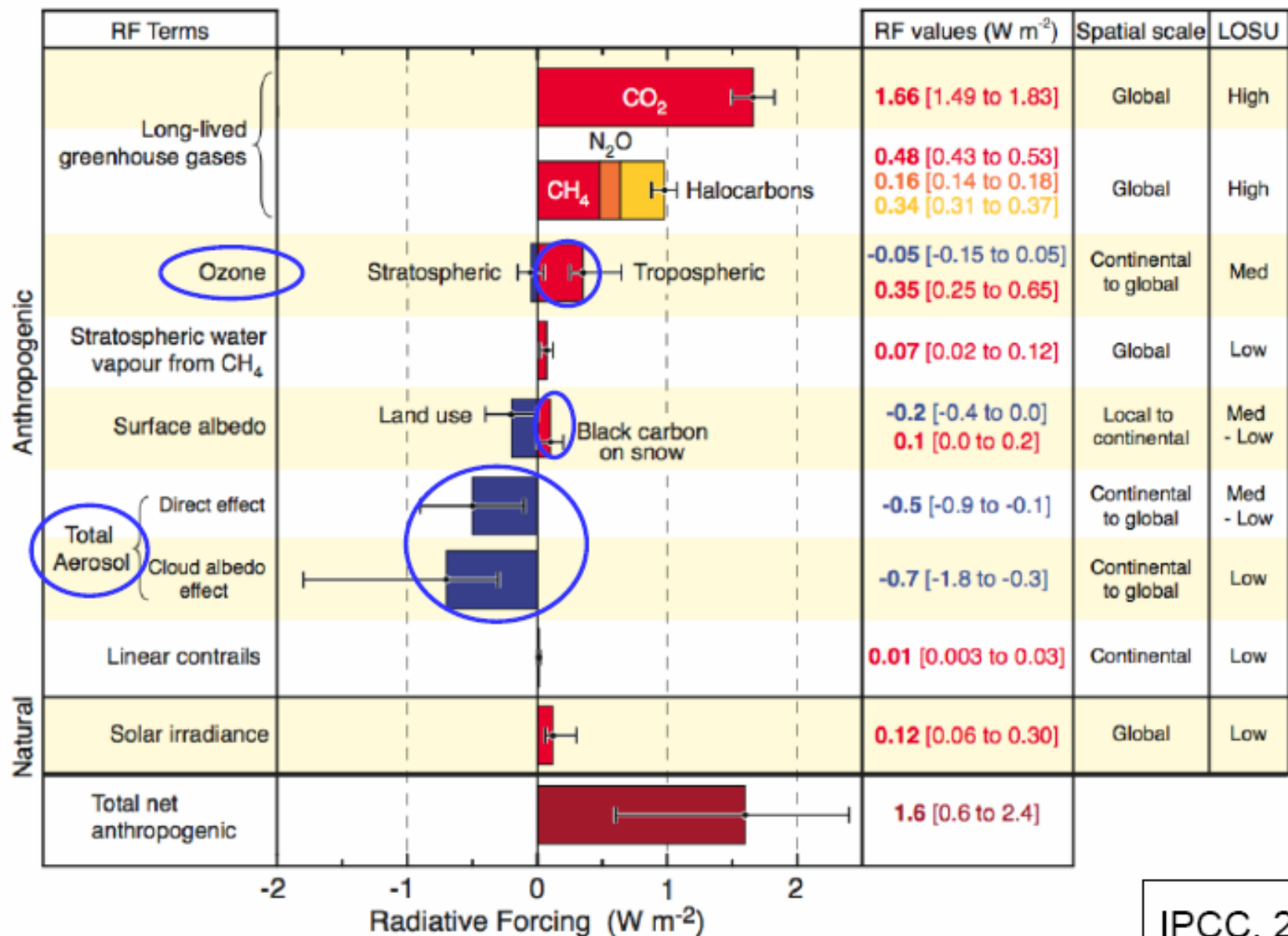
- Why methane emission reductions are undervalued
  - Way to reduce global warming fastest
  - More appropriate for comparison of costs of alternatives
  - Connection with ground-level ozone
- Co-benefits of household energy improvements
  - GHG reductions including methane
  - Health benefits

# 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

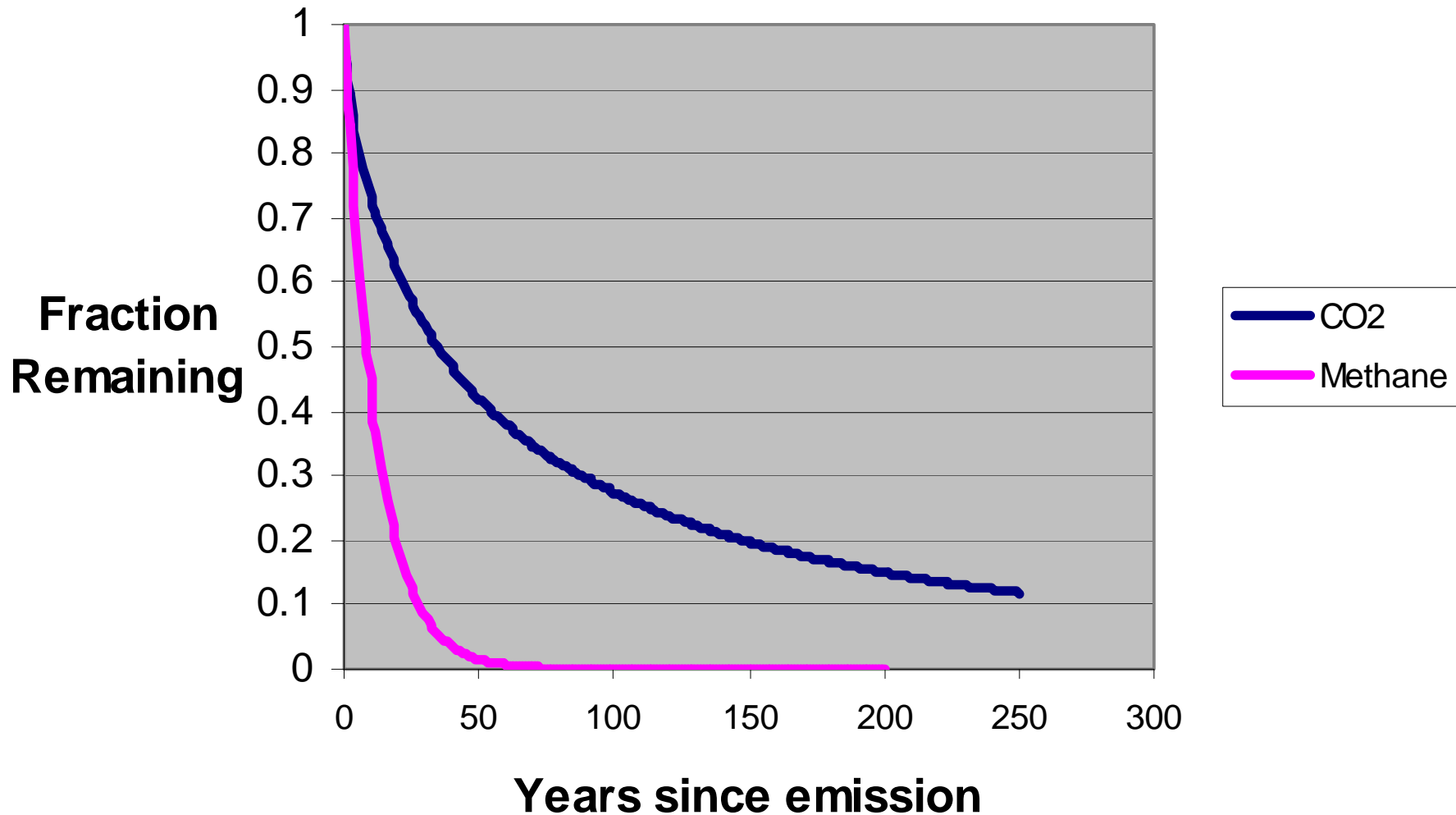
## Important Contributions of Air Pollutants



# Methane Issue #2

- The current official GWPs are based on 100-year time horizons
  - Methane is 23x CO<sub>2</sub> 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 CO<sub>2</sub> 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

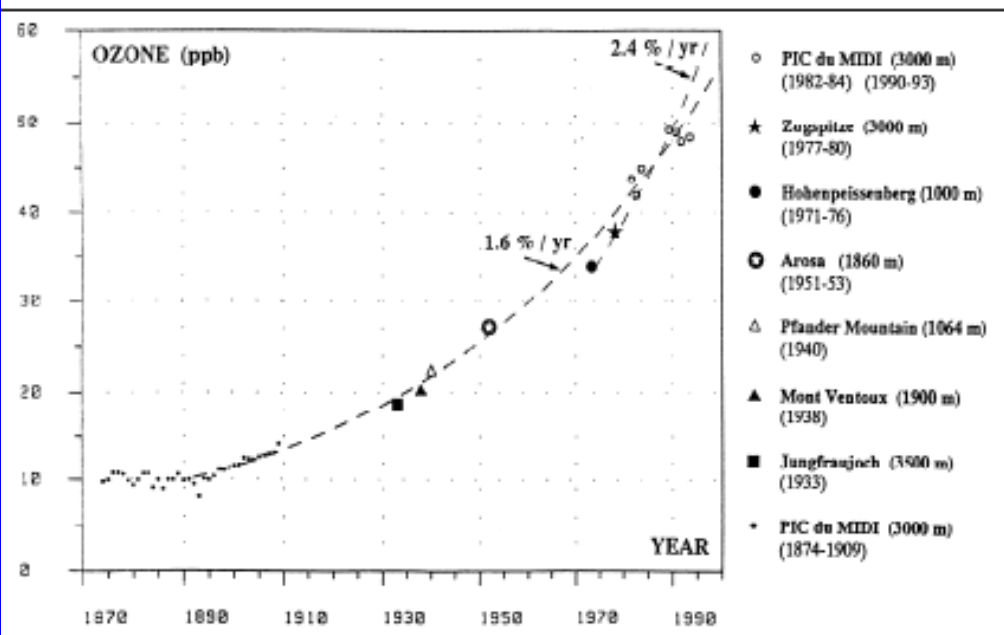


# Methane Issue #3

- 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
- Ozone levels are rising worldwide
- Reduction of methane emissions, therefore, will help protect health worldwide

## Background Ozone is Growing ...

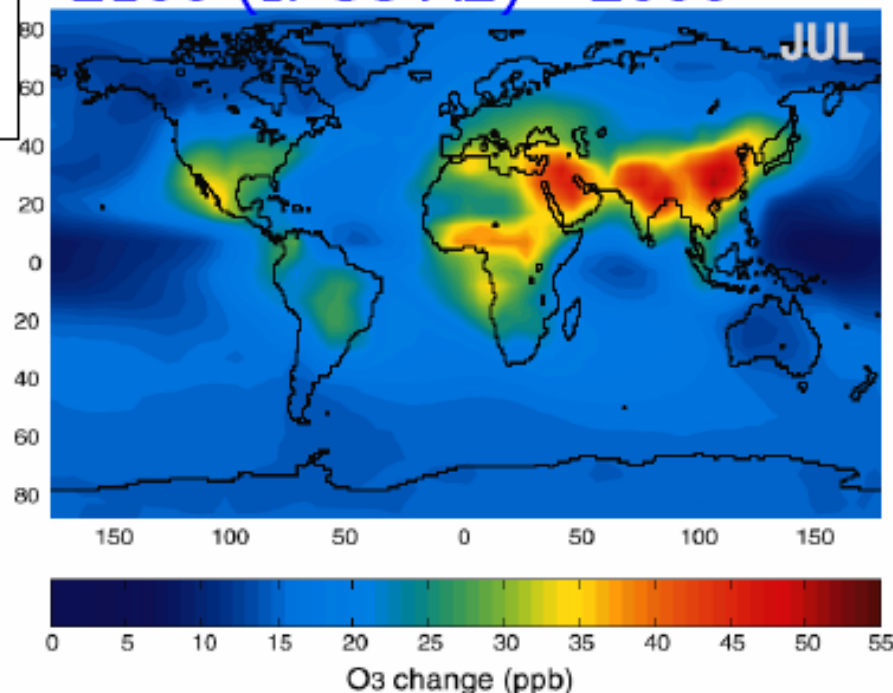
... and Will Continue to Grow!



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<sub>x</sub> emissions** (Wang *et al.*, 1998; Prather et al., 2003).

2100 (IPCC A2) - 2000





# Multiple Benefits of Reducing Methane

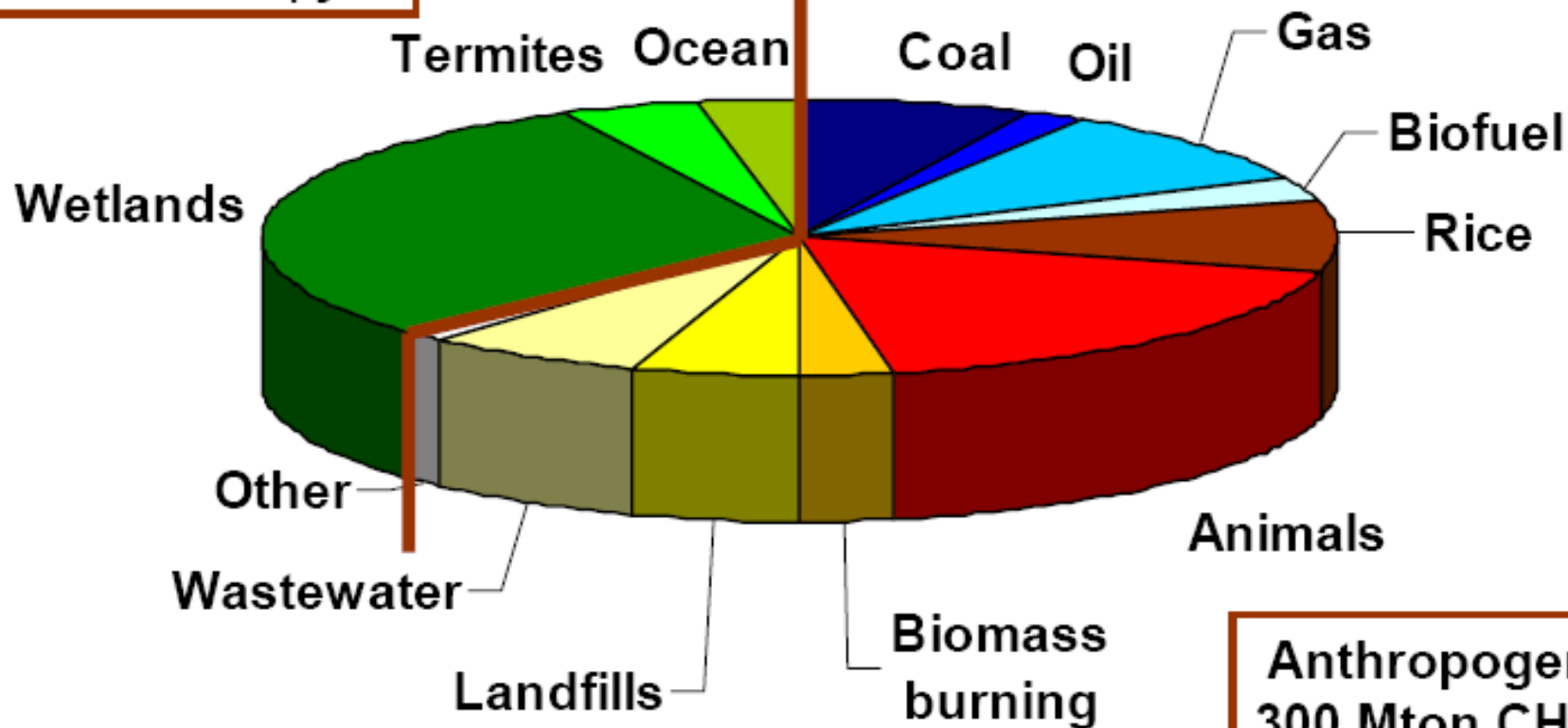
Reducing **~20% of anthropogenic methane emissions** will:

- 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<sup>-2</sup>**.
- 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

Natural:  
180 Mton CH<sub>4</sub> yr<sup>-1</sup>

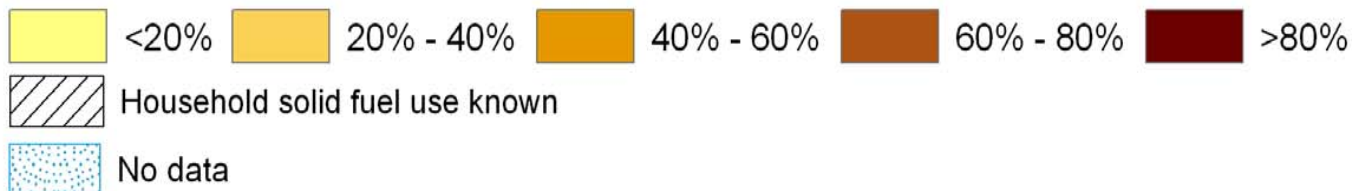
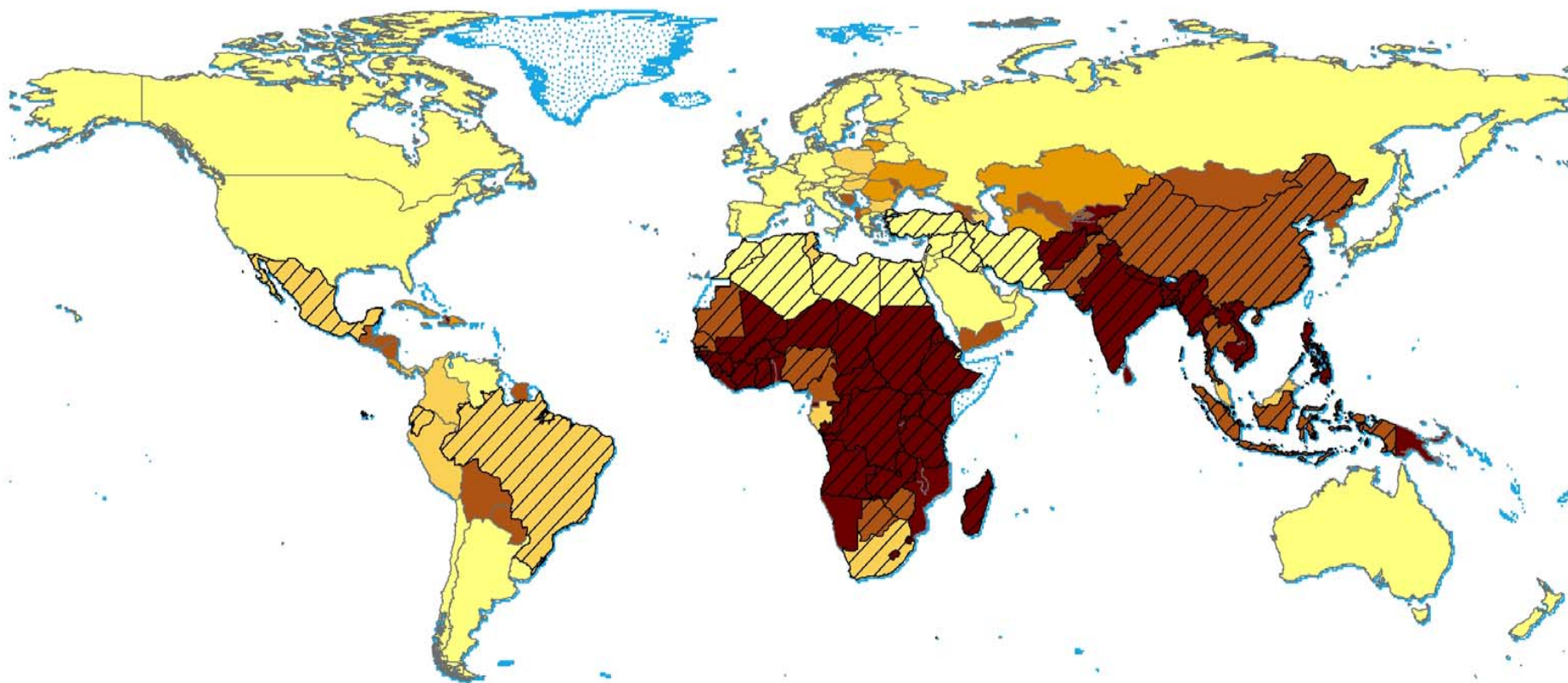


Anthropogenic:  
300 Mton CH<sub>4</sub> yr<sup>-1</sup>

\* USA is ~9% of global anthropogenic emissions.

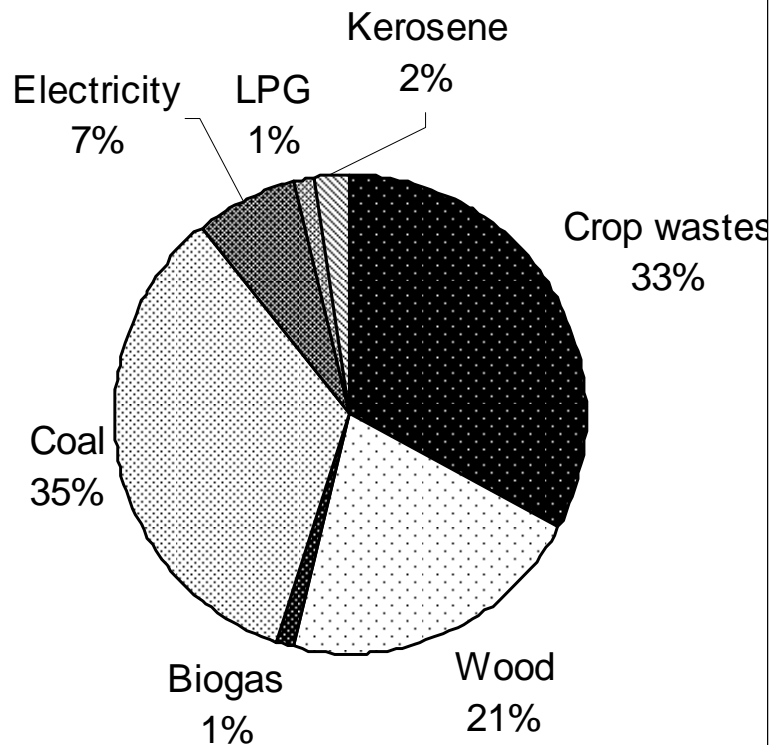
EDGAR3.2 &  
Houweling *et al.*, 1999

# National Household Solid Fuel Use, 2000



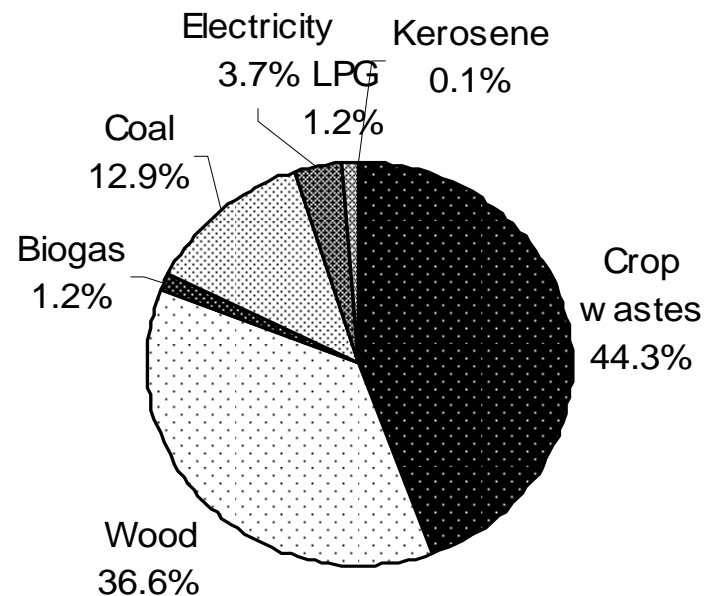
# Rural Energy in China: 2004

## 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  $\text{CO}_2$  and  $\text{H}_2\text{O}$  when it is combined with oxygen (burned)?

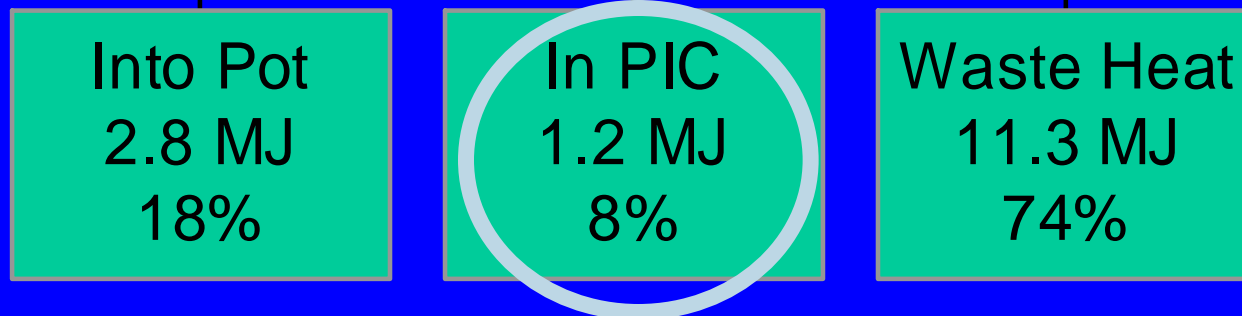


Reason: the combustion efficiency is far less than 100%

# 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<sub>2</sub>
- 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)

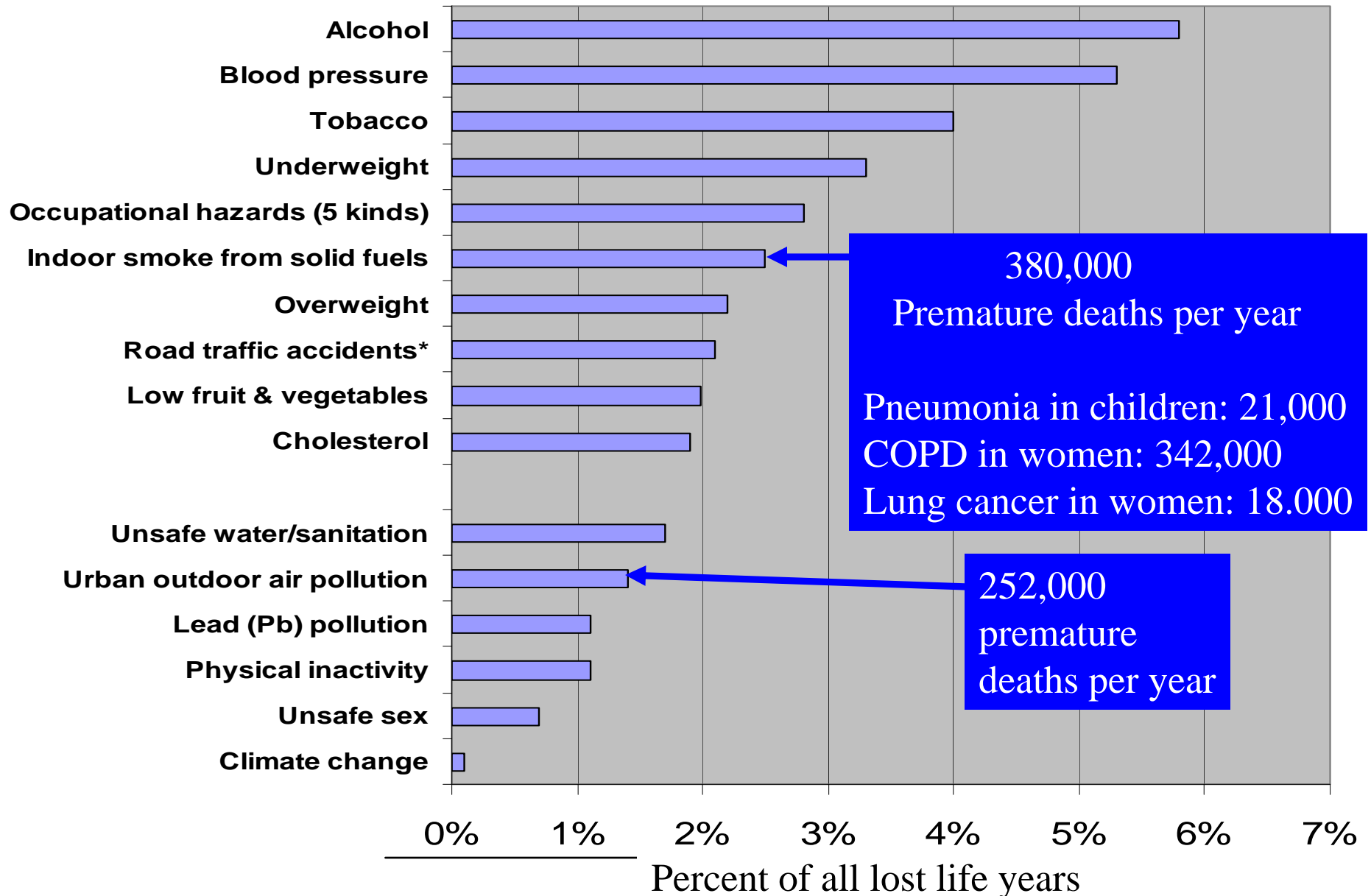
Tuberculosis

Heart disease

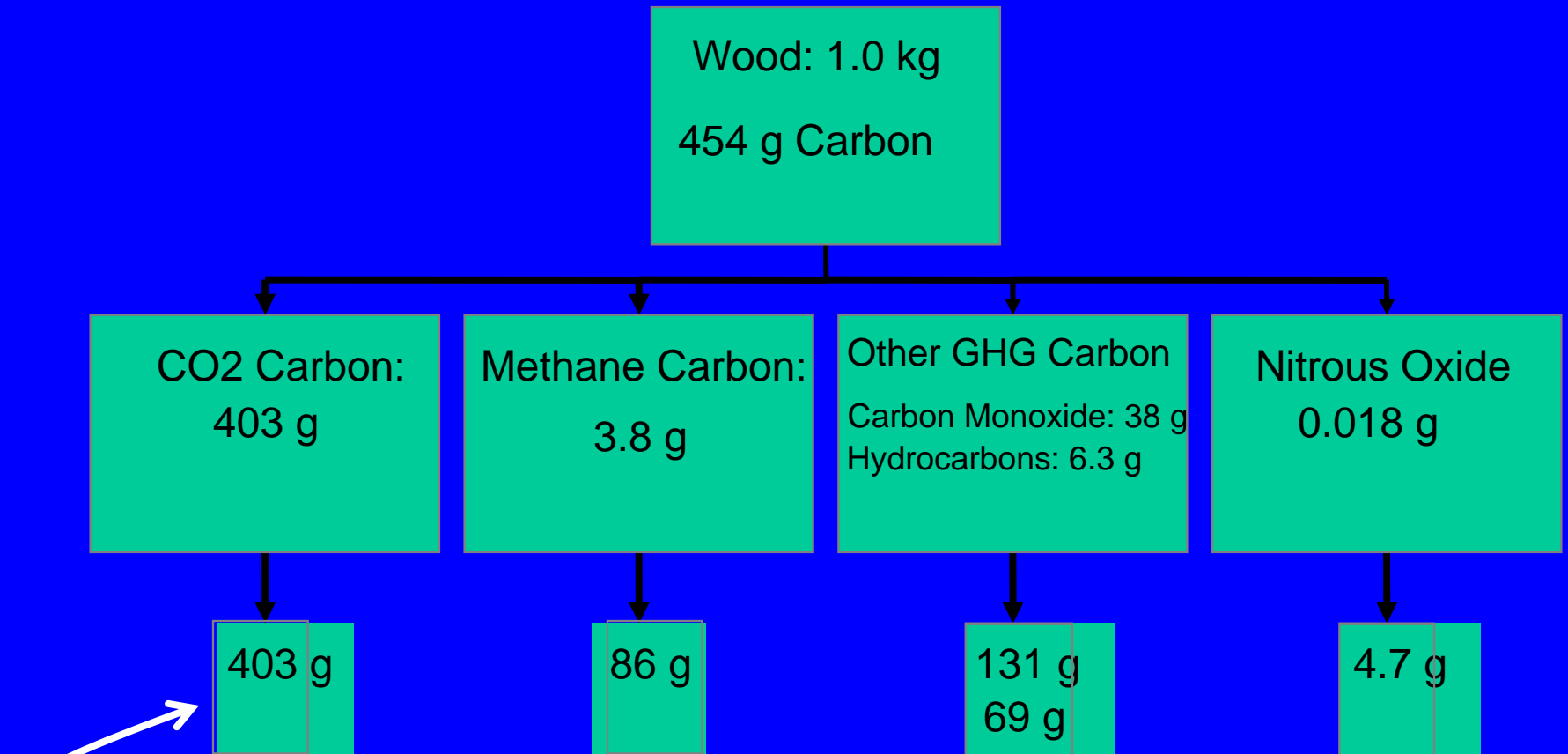


# Chinese Burden of Disease from Top 10 Risk Factors

Plus Selected Other Risk Factors



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

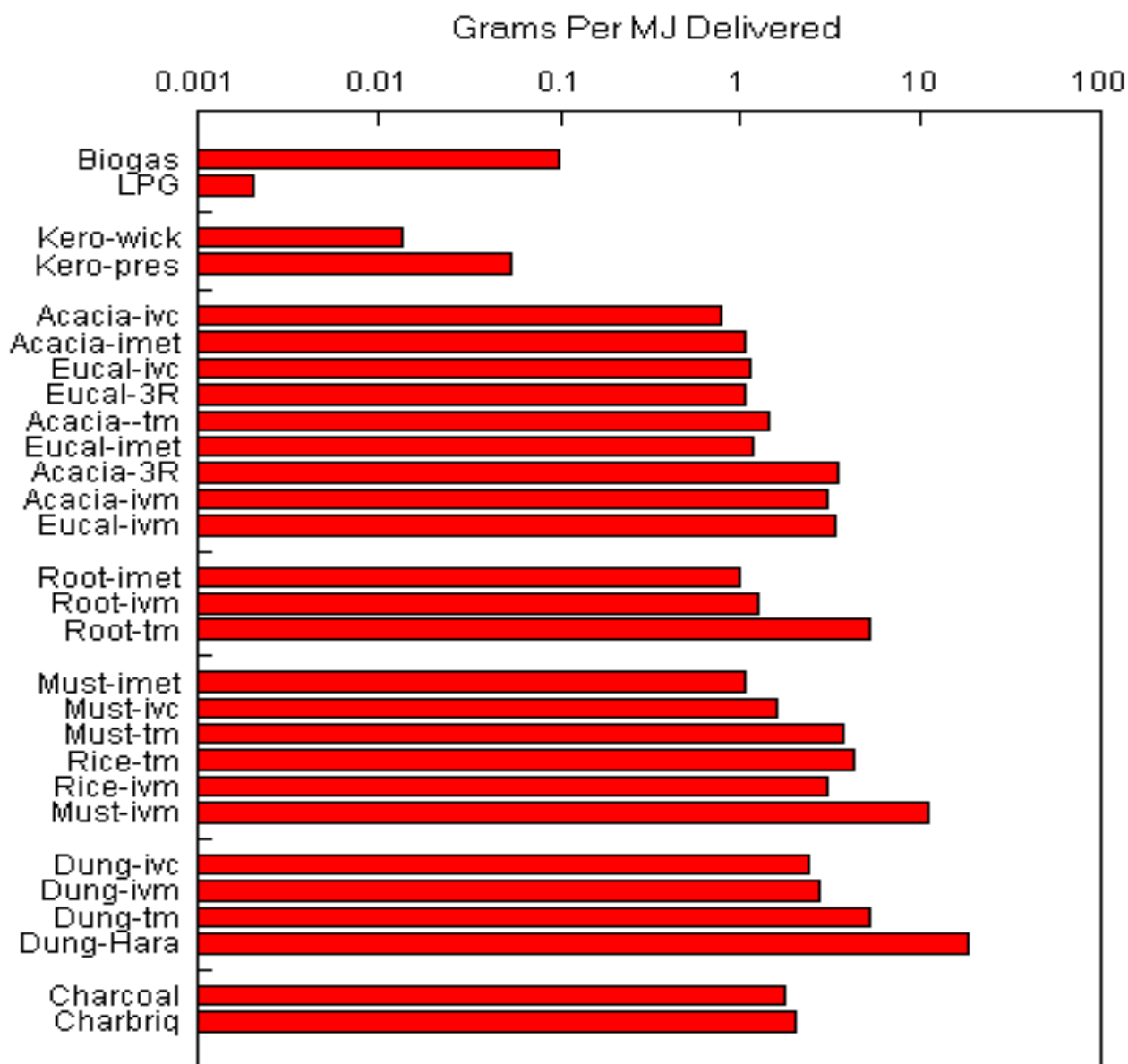


Global warming commitments of each of the gases as CO<sub>2</sub> equivalents

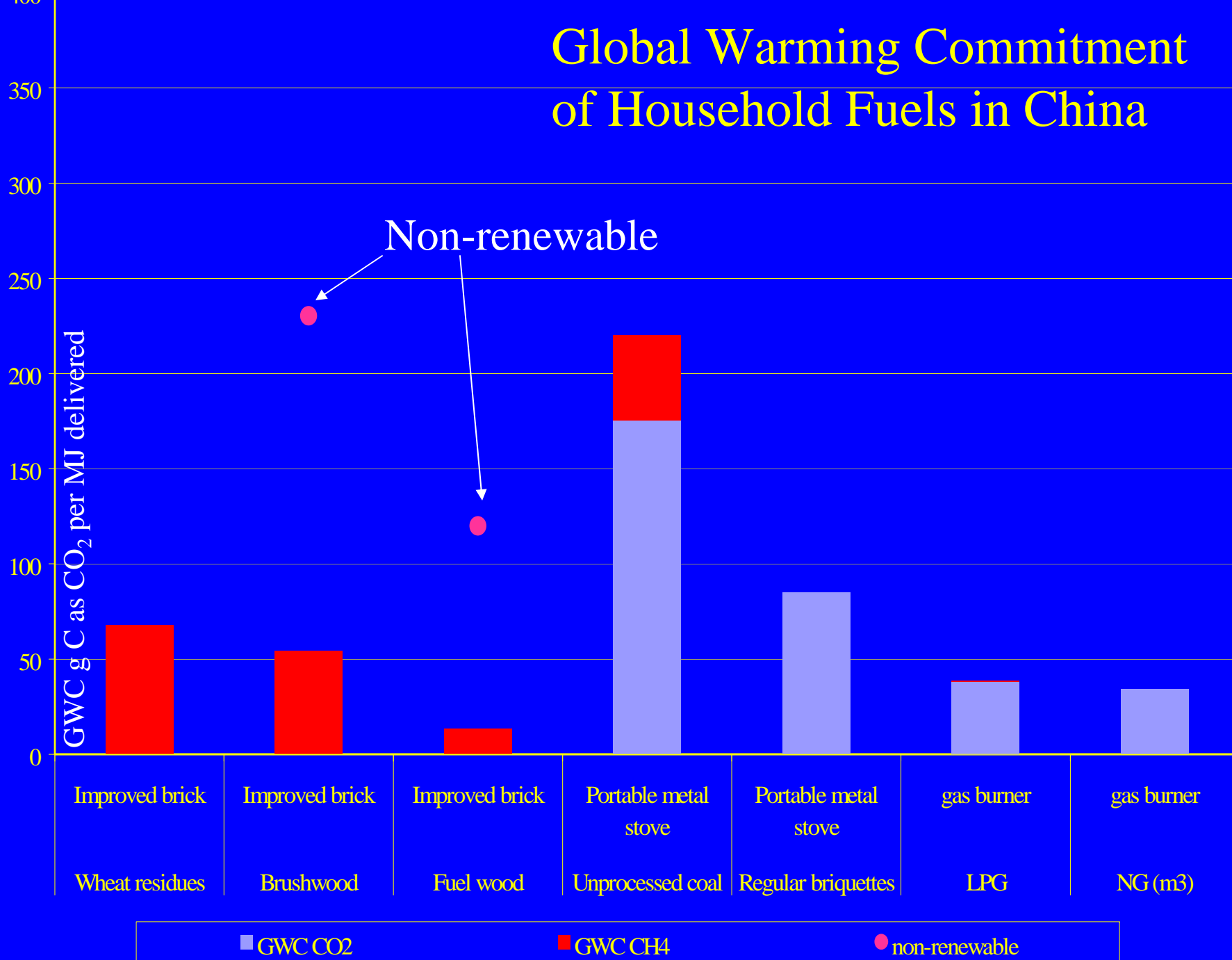
Source:  
Smith,  
et al.,  
2000

# 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.

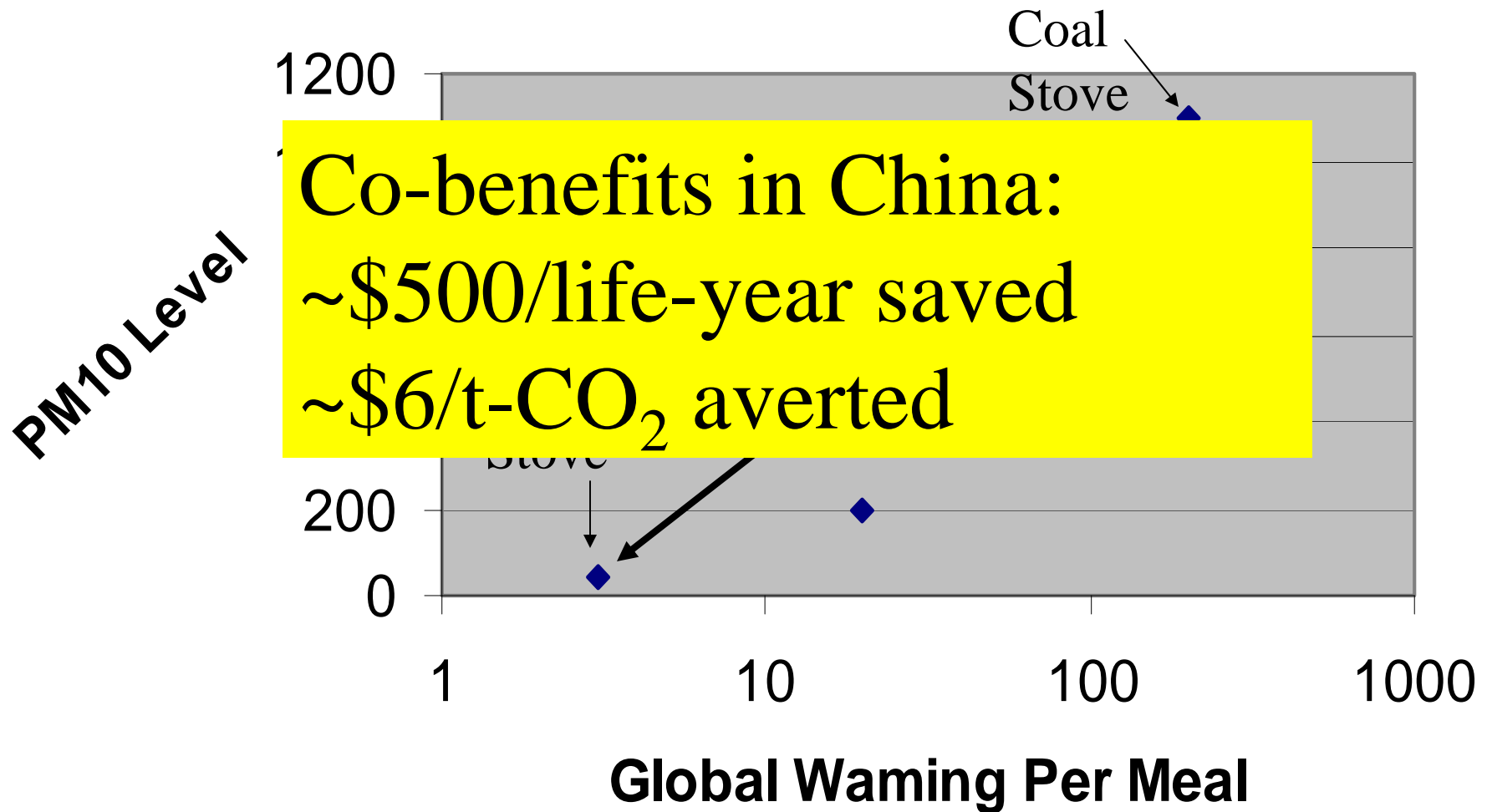
Winner of Chinese national contest  
announced March 2007 for best stove meeting  
emissions and reliability criteria:  
cost 300Y



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





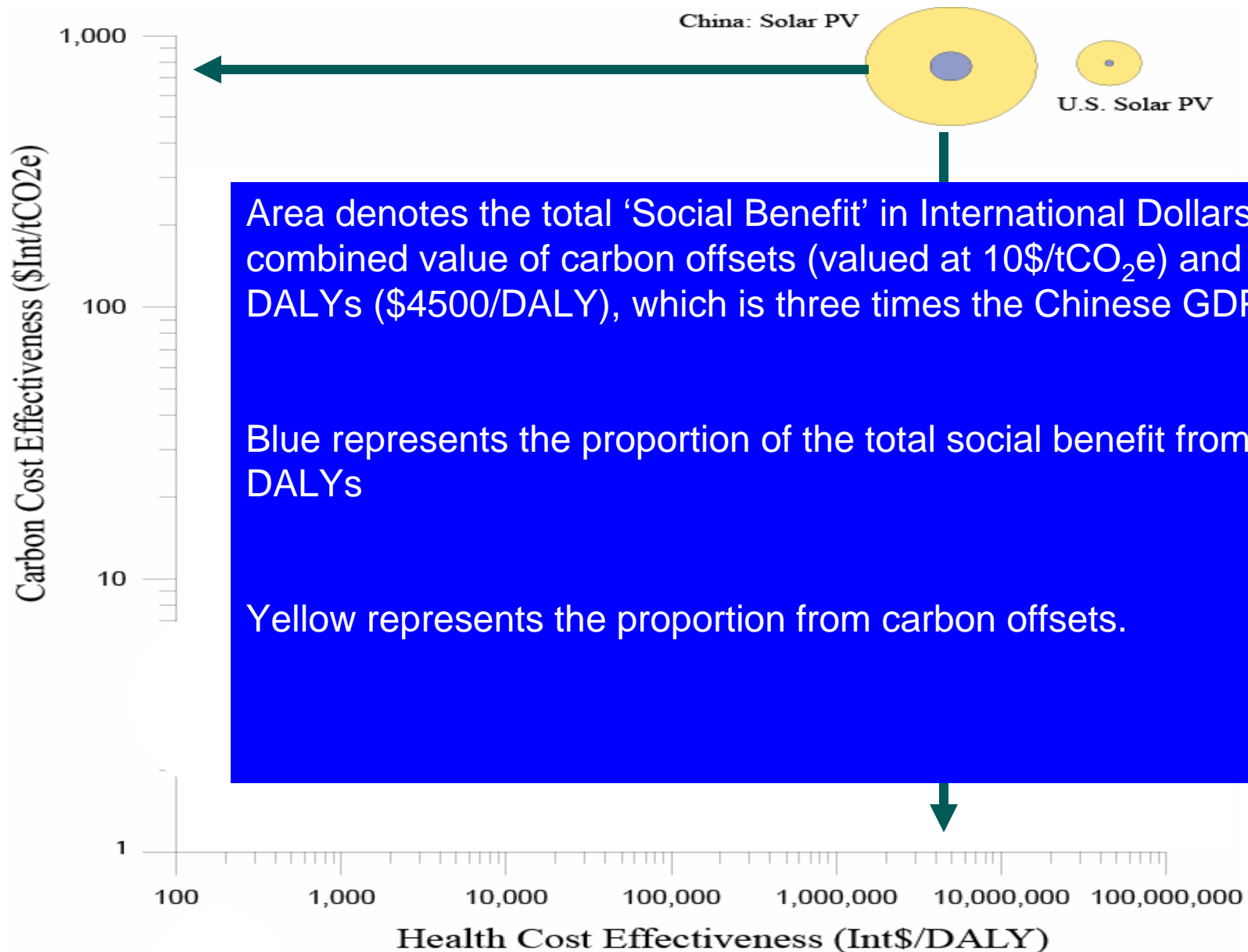


Figure: Smith & Haigler, in press

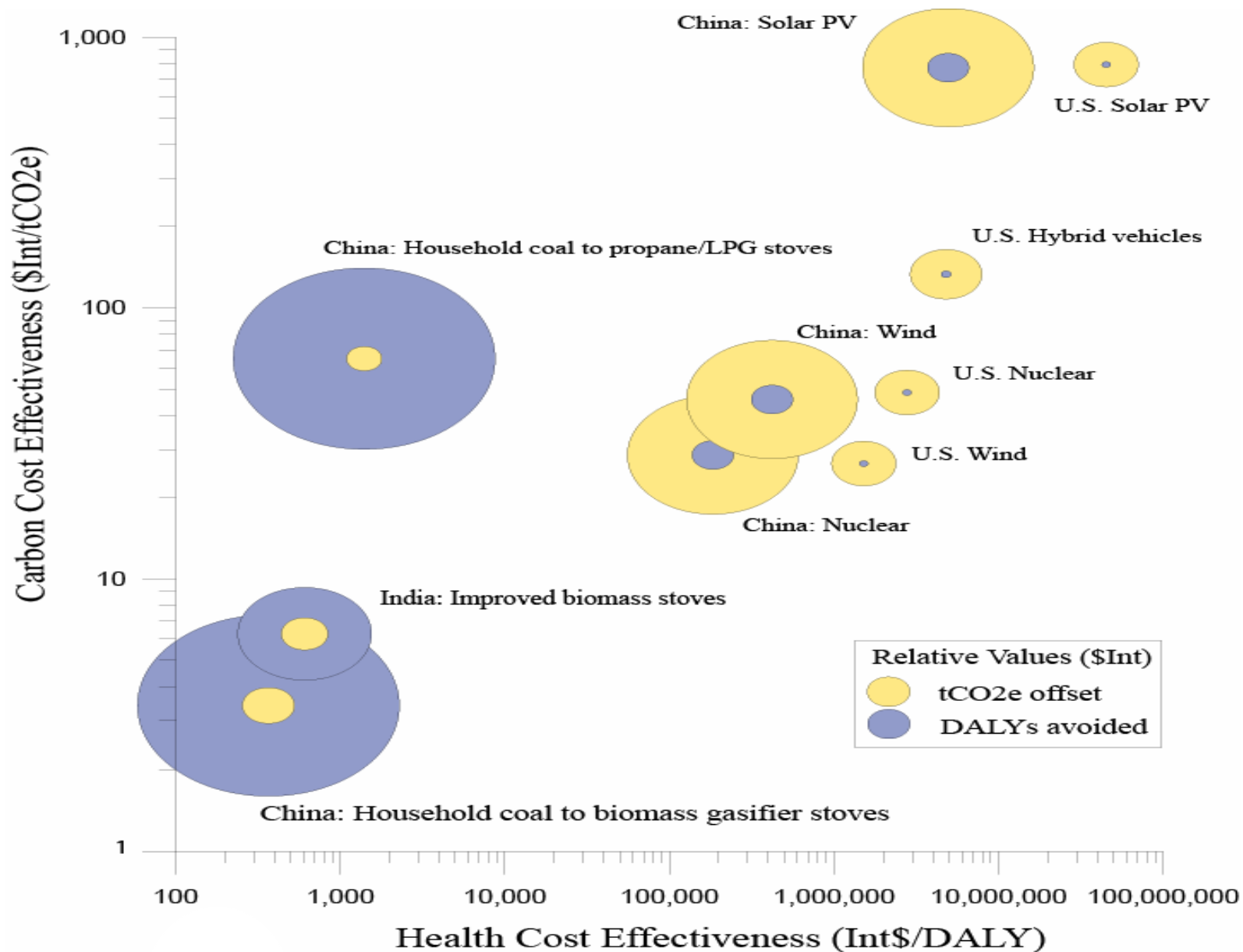
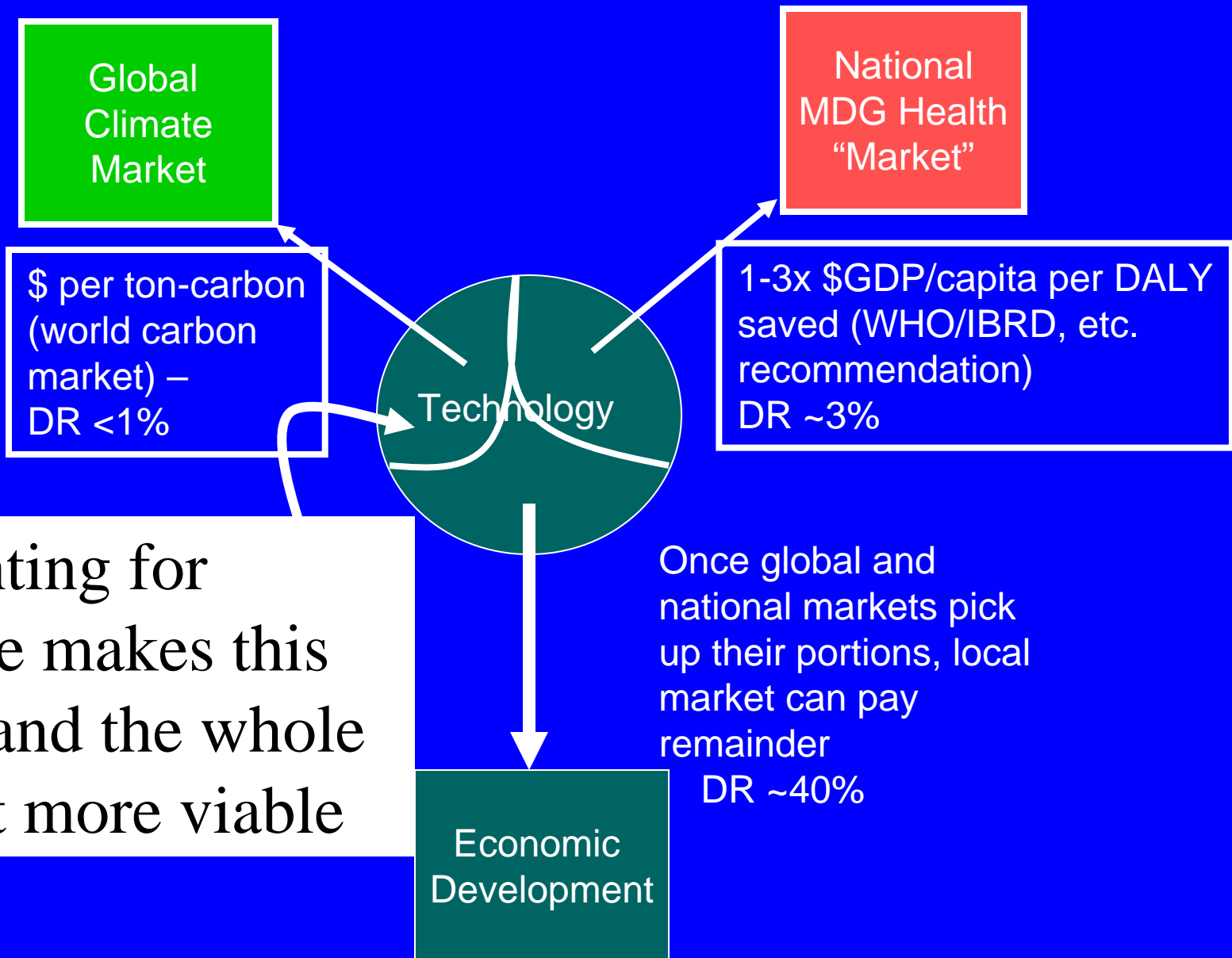
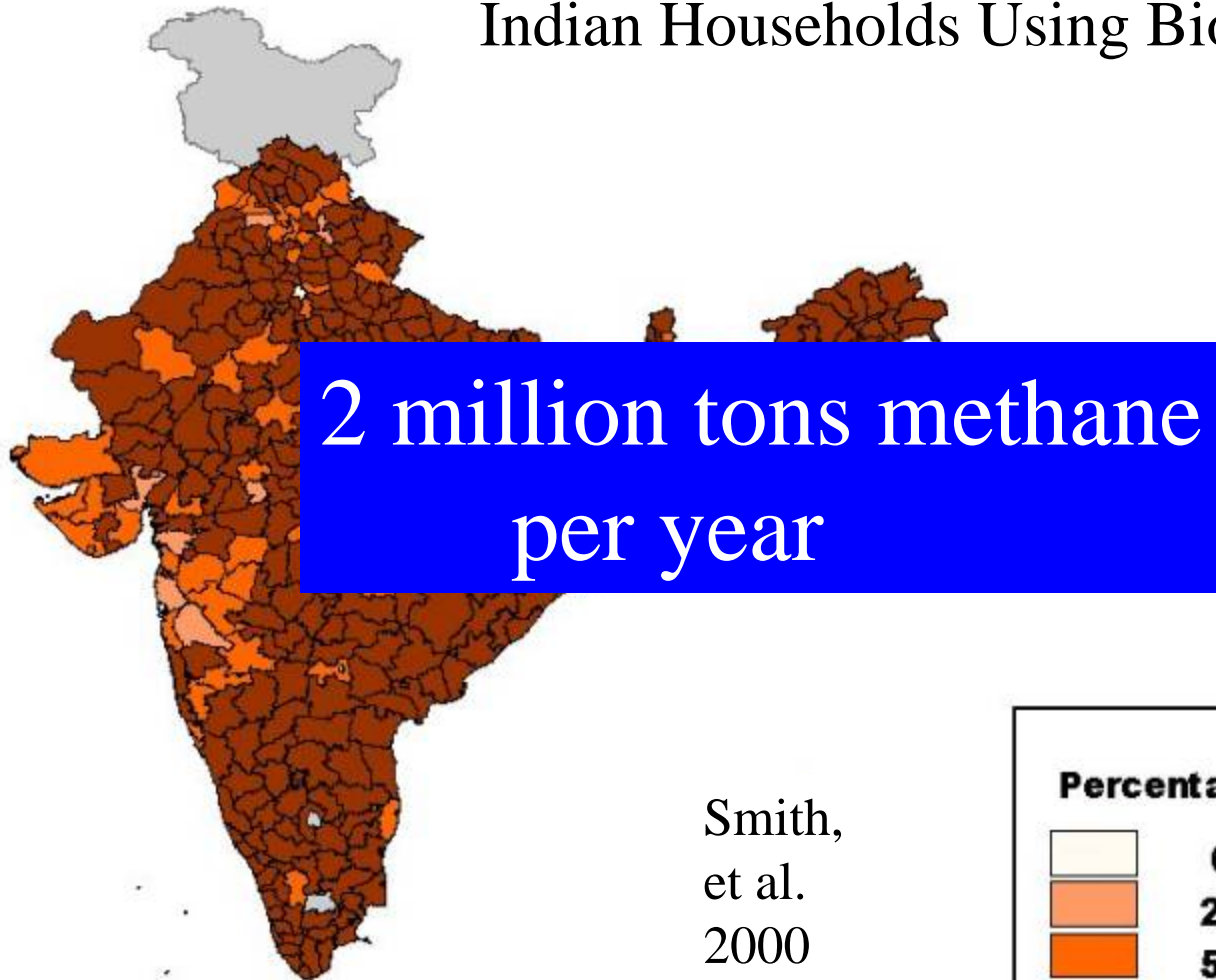


Figure: Smith & Haigler, in press

# Paying for Rural Energy Development



## Indian Households Using Biomass Fuels



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,

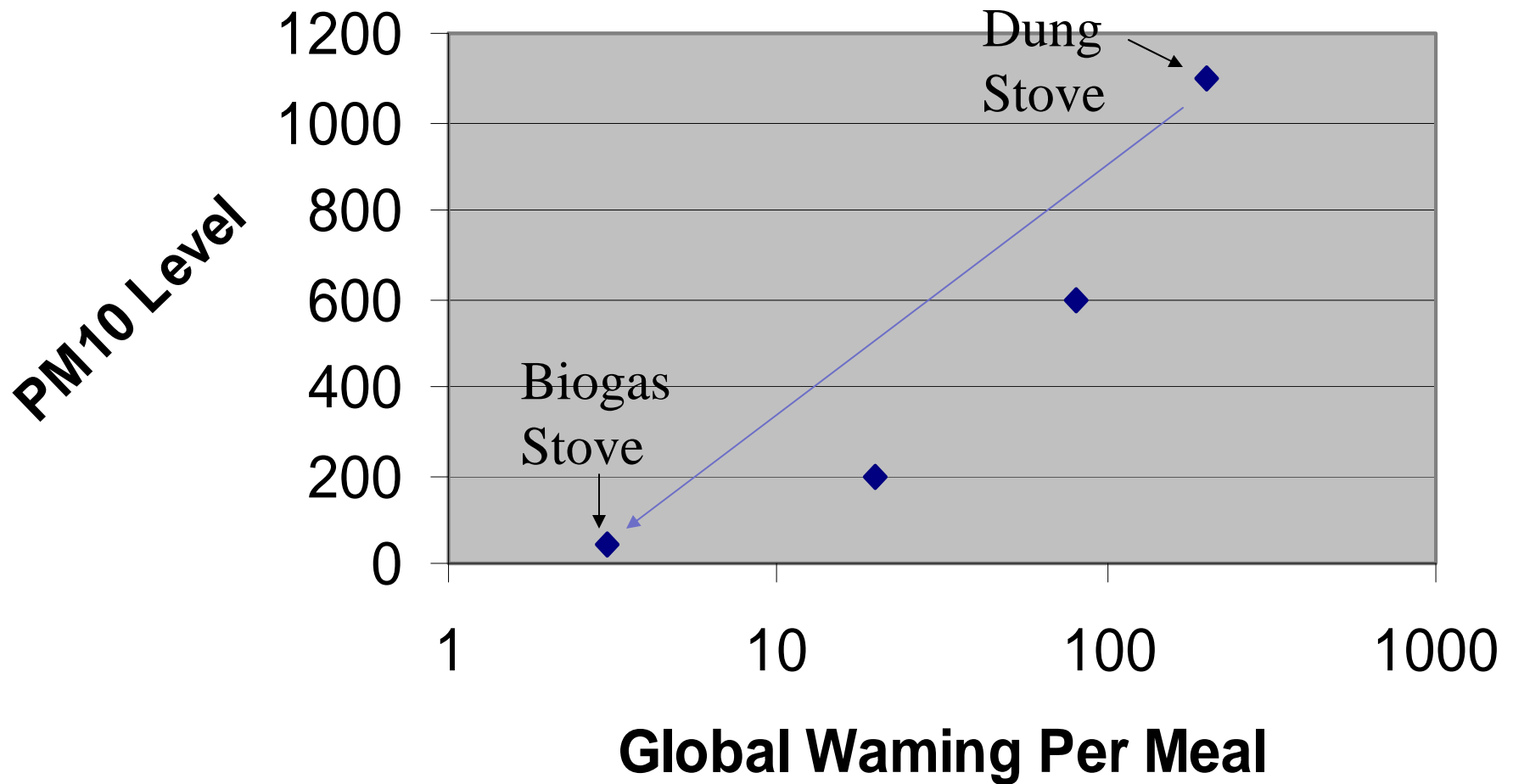
“This should be well promoted.”



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, 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