Ignoring PIC is Ignoring the Poor

Presentation by

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Workshop on
Instrumental Methods for Verifying Carbon Offsets in Improved Stove Programs

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School of Public Health

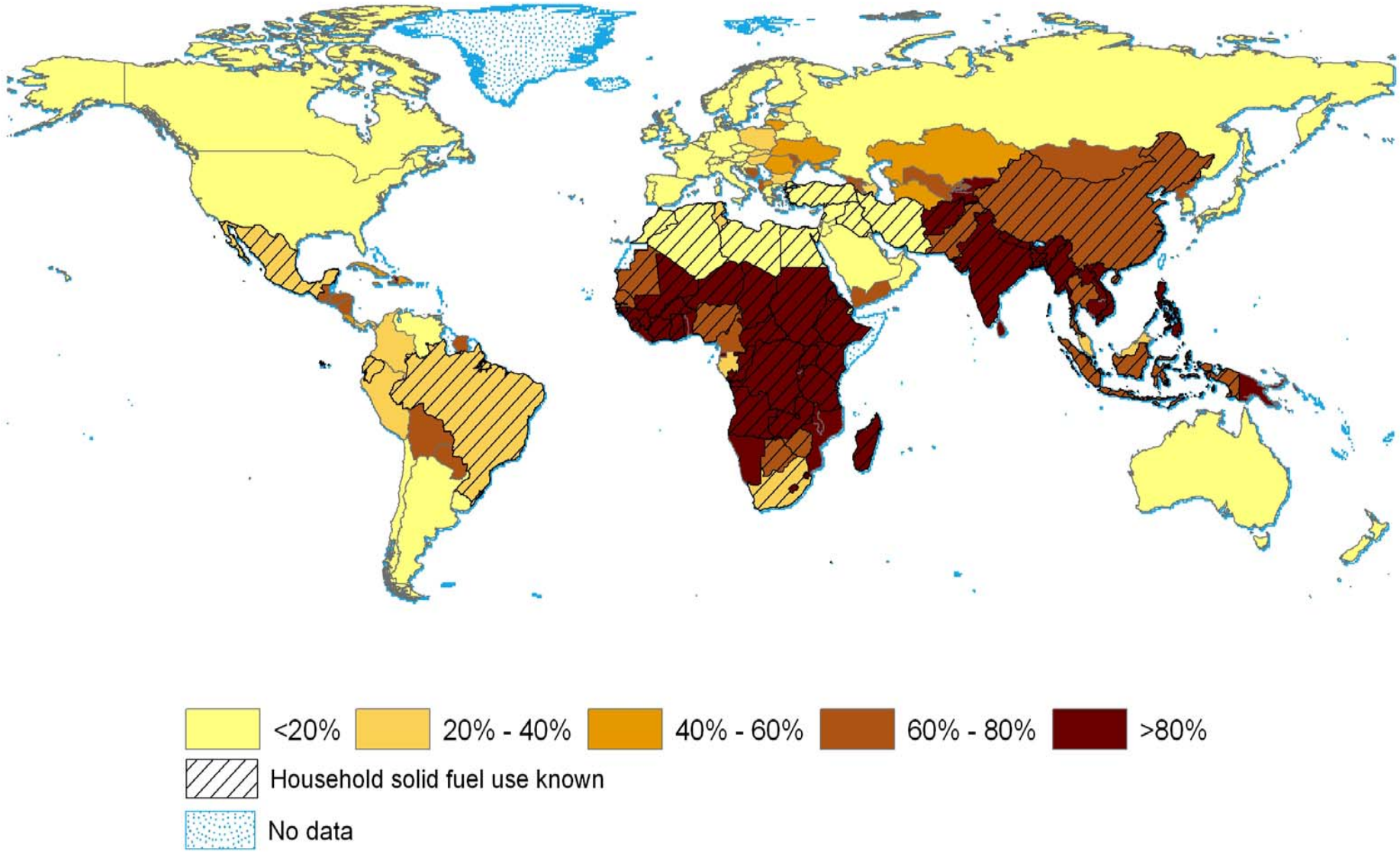
“Wood is the fuel that warms you twice” - true?

- Once when you chop it: 20 kJ/kg
- Once when you burn it: 20 MJ/kg

but also

- When it warms you through radiative forcing in the atmosphere: 20 GJ/kg
- Indeed, biomass is the fuel that can warm you as many as four times: breaking, burning, forcing, and fever.

National Household Solid Fuel Use, 2000



China rural energy situation complex:

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GREENHOUSE GASES FROM BIOMASS AND FOSSIL FUEL STOVES IN DEVELOPING COUNTRIES: A MANILA PILOT STUDY

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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%

Stove Efficiencies

- Fuel use (overall efficiency-OE) is function of two internal efficiencies OE = NCE * HTE
- Nominal Combustion Efficiency (NCE) = percent of fuel carbon released as CO_2
- Heat transfer efficiency (HTE) = OE/NCE
- NCE = $CO_2/(CO_2$ + PIC) -- on a carbon basis
- PIC = products of incomplete combustion

Nominal Combustion Efficiencies in Indian Stoves

- Gas: ` 99% (98-99.5)
- Kerosene: 97 (95-98)
- Wood: 89 (81-92)
- Crop residues: 85 (78-91)
- Dung: 84 (81-89)

Smith, et al., 2000

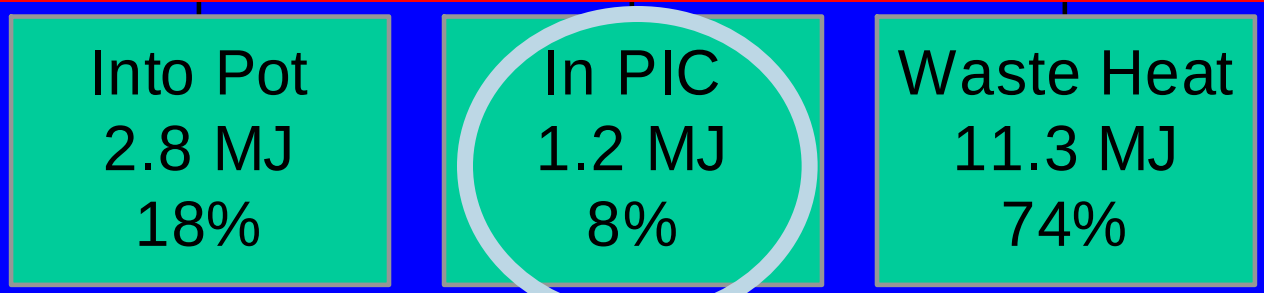
How can less fuel mean more pollution?

Stove	Overall Efficiency	Heat Transfer Efficiency	Nominal Combustion Efficiency
Traditional	14	15	97
“Improved”	27	30	90
Change = 73% more pollution per meal!	27/14 = 1.93x fewer kg fuel per meal		(1-0.90)/ (1/0.97) = 3.33x more PIC per kg fuel

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

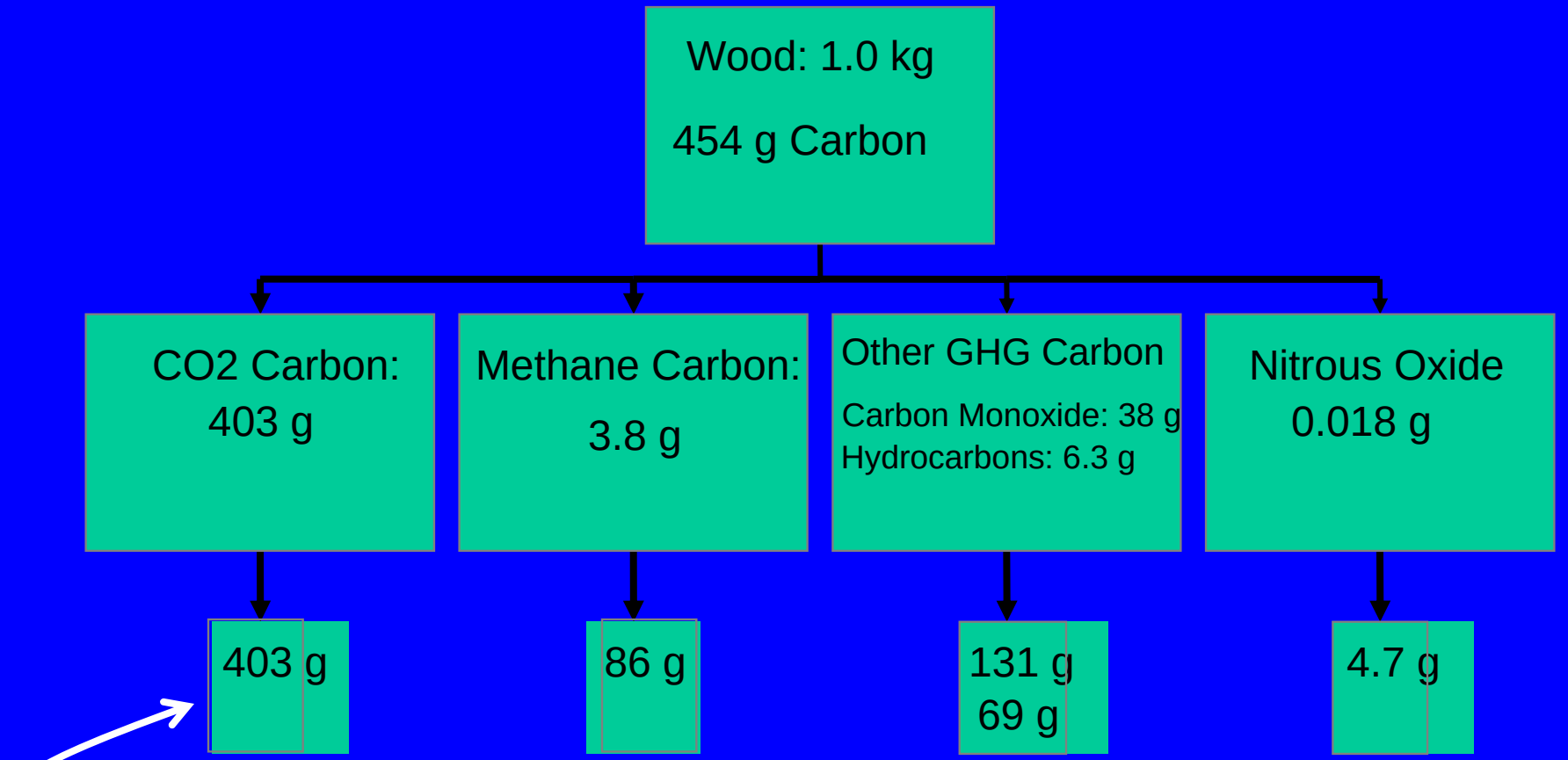
Cancer (lung, NP, cervical, aero-digestive)

Blindness (cataracts, trachoma)

Tuberculosis

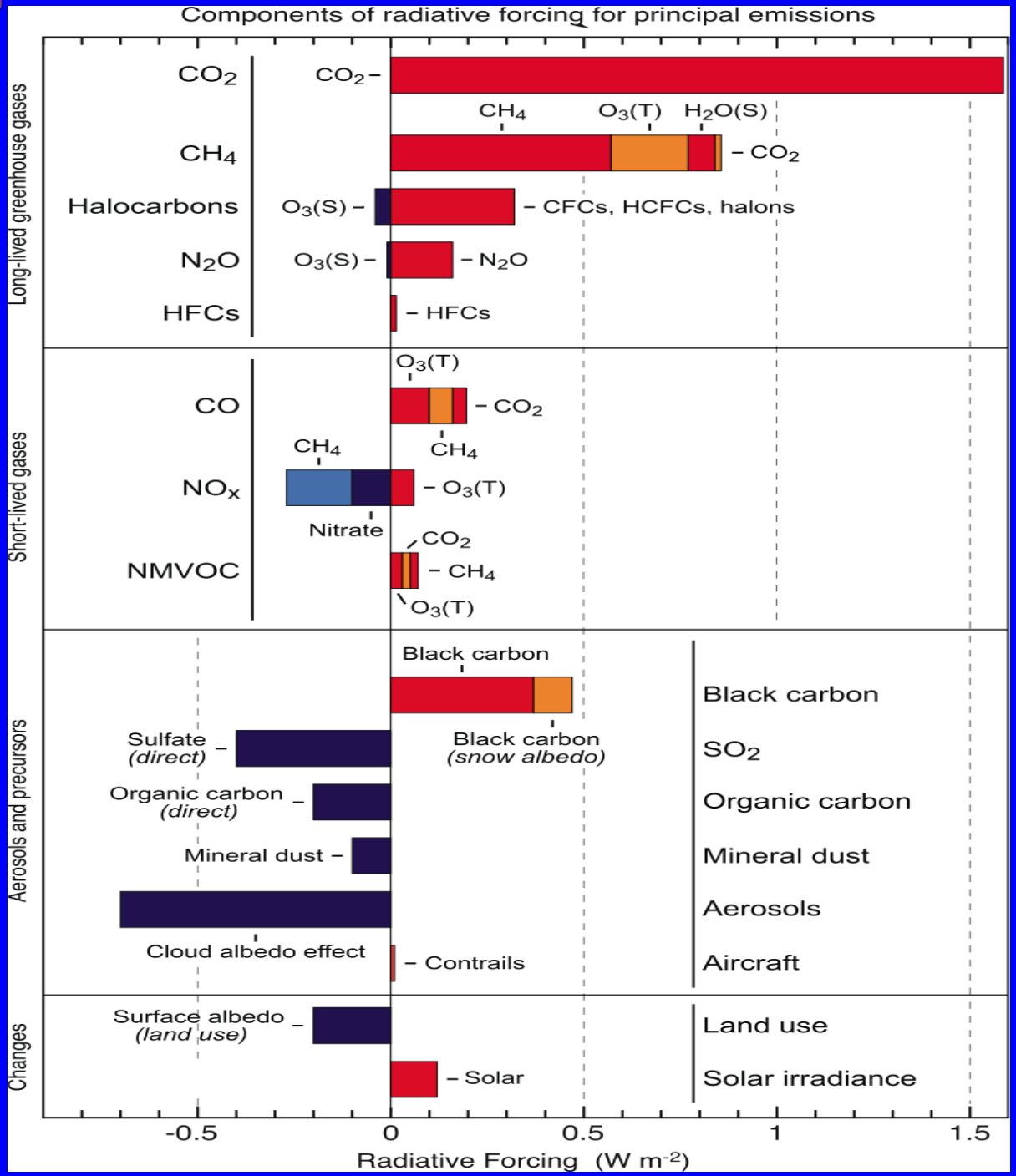
Heart disease

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



Global warming commitments of each of the gases as CO_2 equivalents

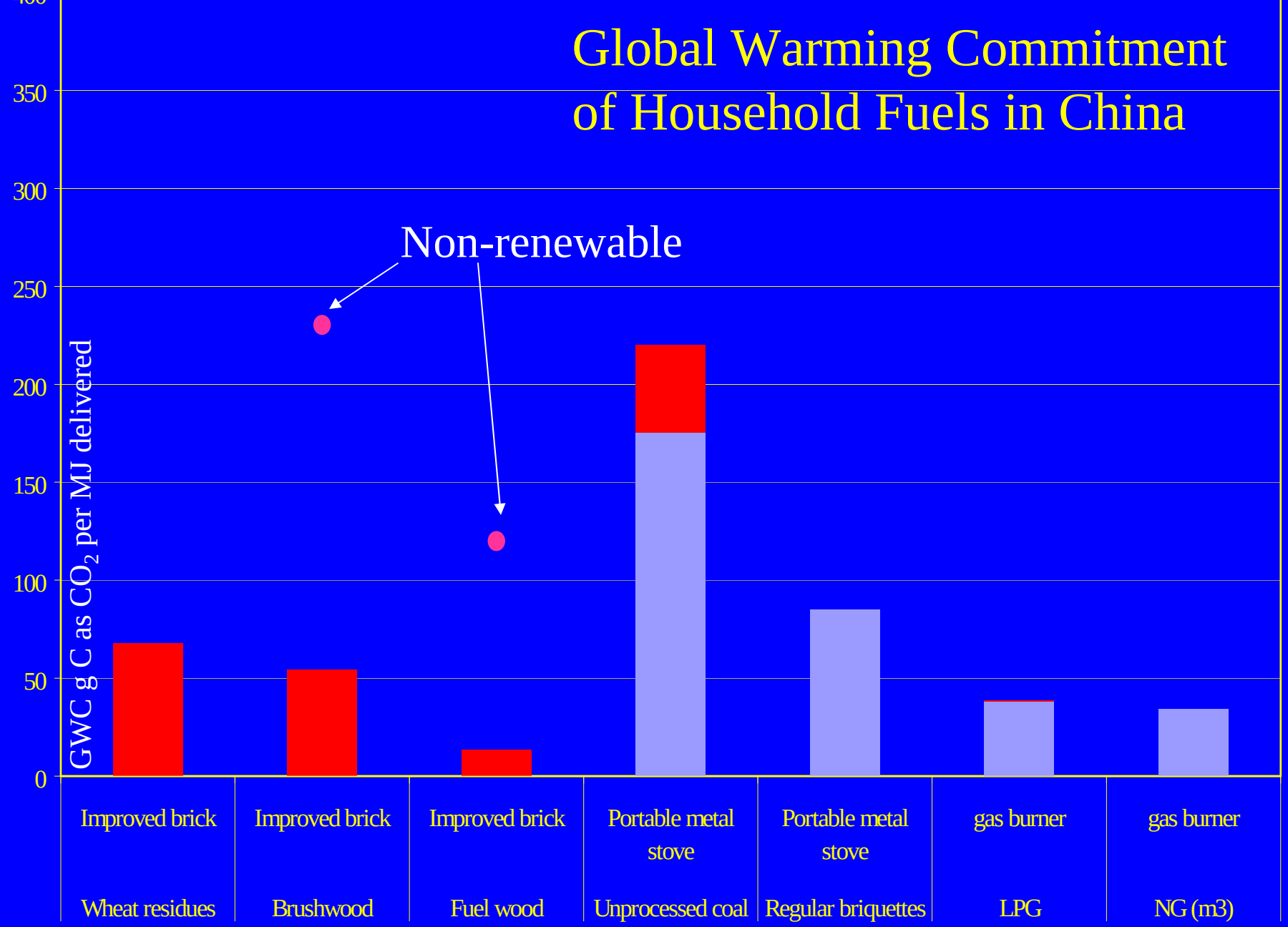
Source: Smith, et al., 2000



Radiative forcing in 2005 from emissions since 1750

IPCC, 2007

Global Warming Commitment of Household Fuels in China



How can GHG savings be attained with improved household biomass stoves?

- Move from non-renewable to renewable fuels
- Improving fuel efficiency
- Improving combustion efficiency

Move to Renewable Fuels

- Much of China's rural population uses coal for heating/cooking – growing in other countries
  - May be opportunities actually to switch
  - Particularly advantageous in switching away from poisonous coals
- Kerosene and LPG are the next fuel up the energy ladder in many countries
  - With large price increases, may actually be able to entice people to move back to biomass if advanced stoves are available.
  - Advantageous to governments in countries with large fuel subsidies, e.g., India and Indonesia
- May be able to convince some funders that advanced biomass stoves deserve credits because they keep people in biomass longer, i.e., delay or prevent movement to coal/kero/LPG

Decrease fuel use

- Crop residues/dung
  - As these are grown and must be disposed of in any case, a difficult argument to make, i.e., crop residues are CO_2 neutral
- Wood fuel
  - "Compared to what" (CTW) criterion is difficult to fulfill here – what happens if wood is not burned
    - Protects forest sufficiently to allow carbon stock to grow
    - Stays in "forest" and maintains carbon stock
    - Falls to ground and decays
    - Burns in next forest fire
    - Etc

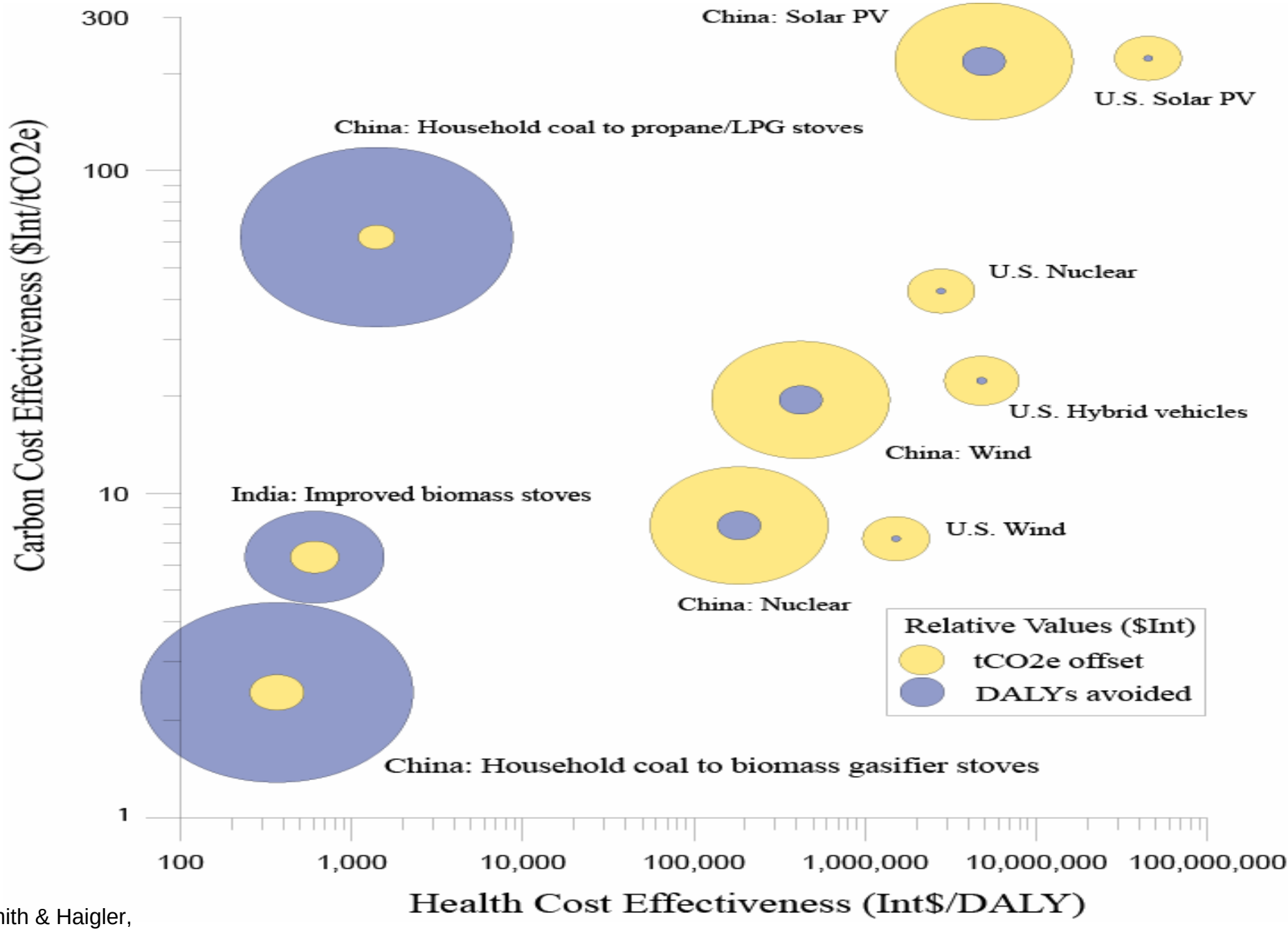
Increase combustion efficiency

- Crop residues/dung
  - Reducing PIC from stove is always good but there may be a CTW issue.
    - Burned in field instead?
    - Turned into soil?
    - Somehow subject to anaerobic decay – methane released? Burning may be better
- Wood fuel
  - Reducing PIC from stoves is always good and CTW issues seems less difficult, but not absent
    - Wood may be burned anyway in forest fire or other way
    - Some portion of wood may anaerobically decay

A Chinese Biomass Gasifier Stove

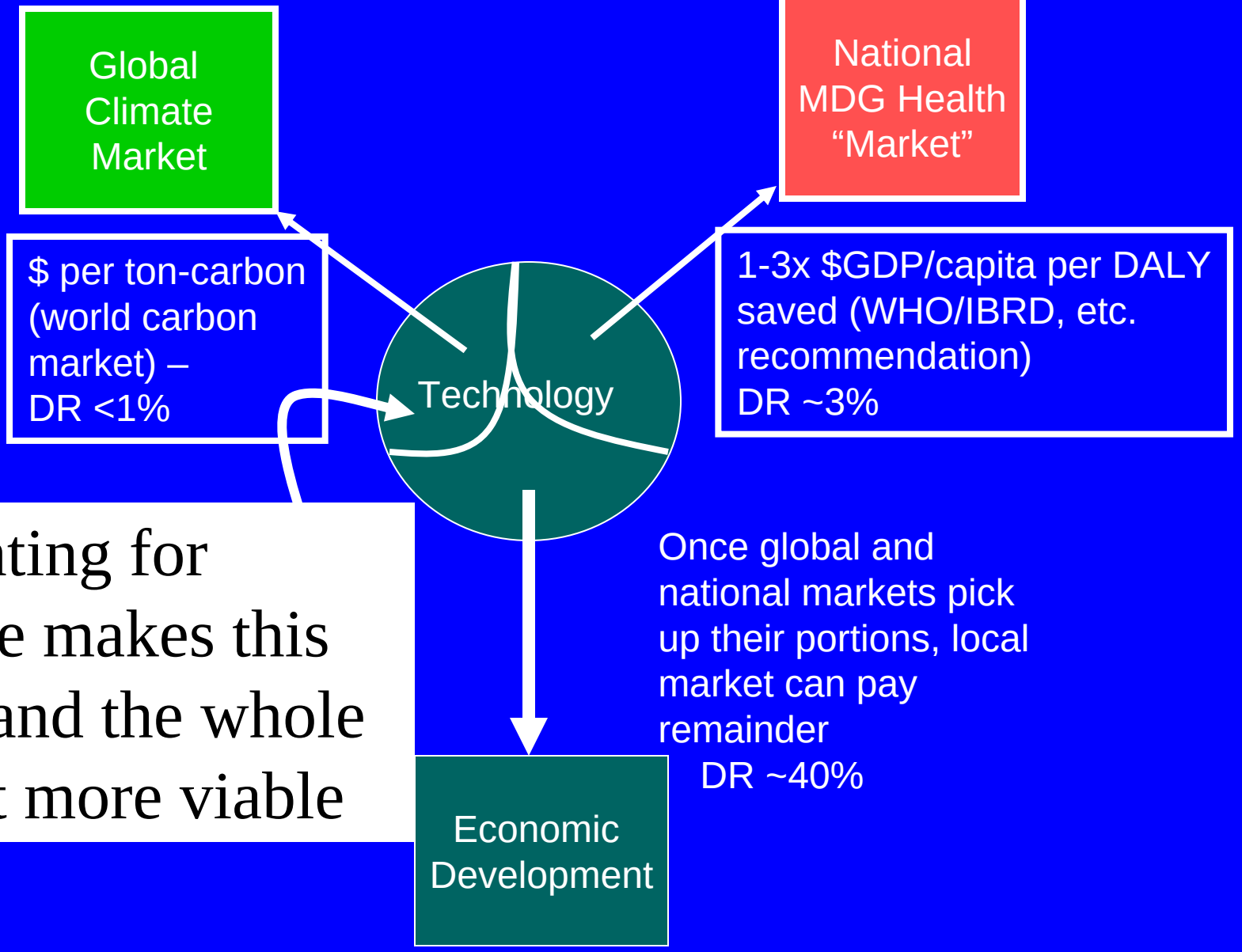
Tests show PIC emissions nearly at LPG levels.

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



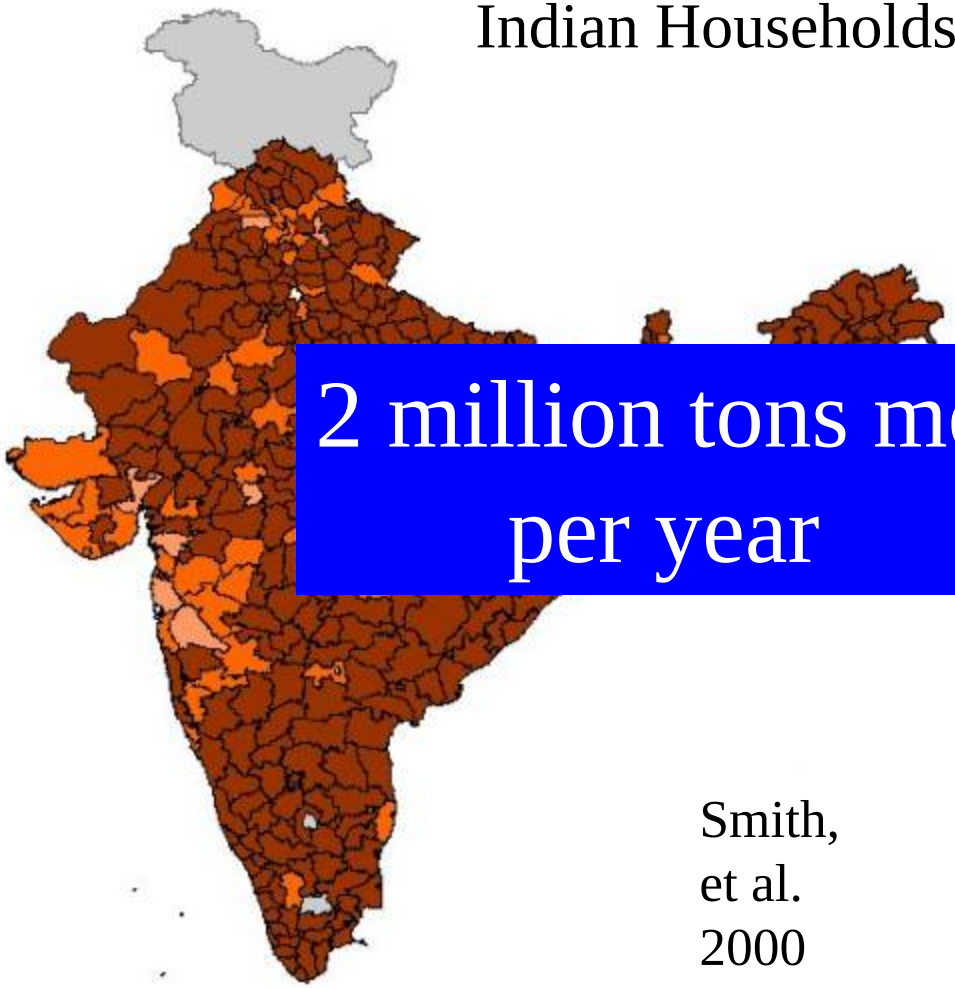
Smith & Haigler,
in press

Paying for Rural Energy Development



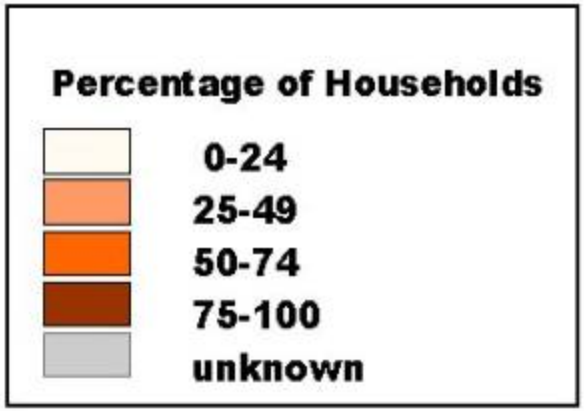
Accounting for methane makes this bigger and the whole concept more viable

Indian Households Using Biomass Fuels



2 million tons methane per year

Smith,
et al.
2000



*Source: Census of India 1991

Conclusion

If you are going to put carbon into the atmosphere, the best form is CO_2 – anything else is worse from both climate and health standpoints

or

Get rid of PIC and
you make the world a better place