

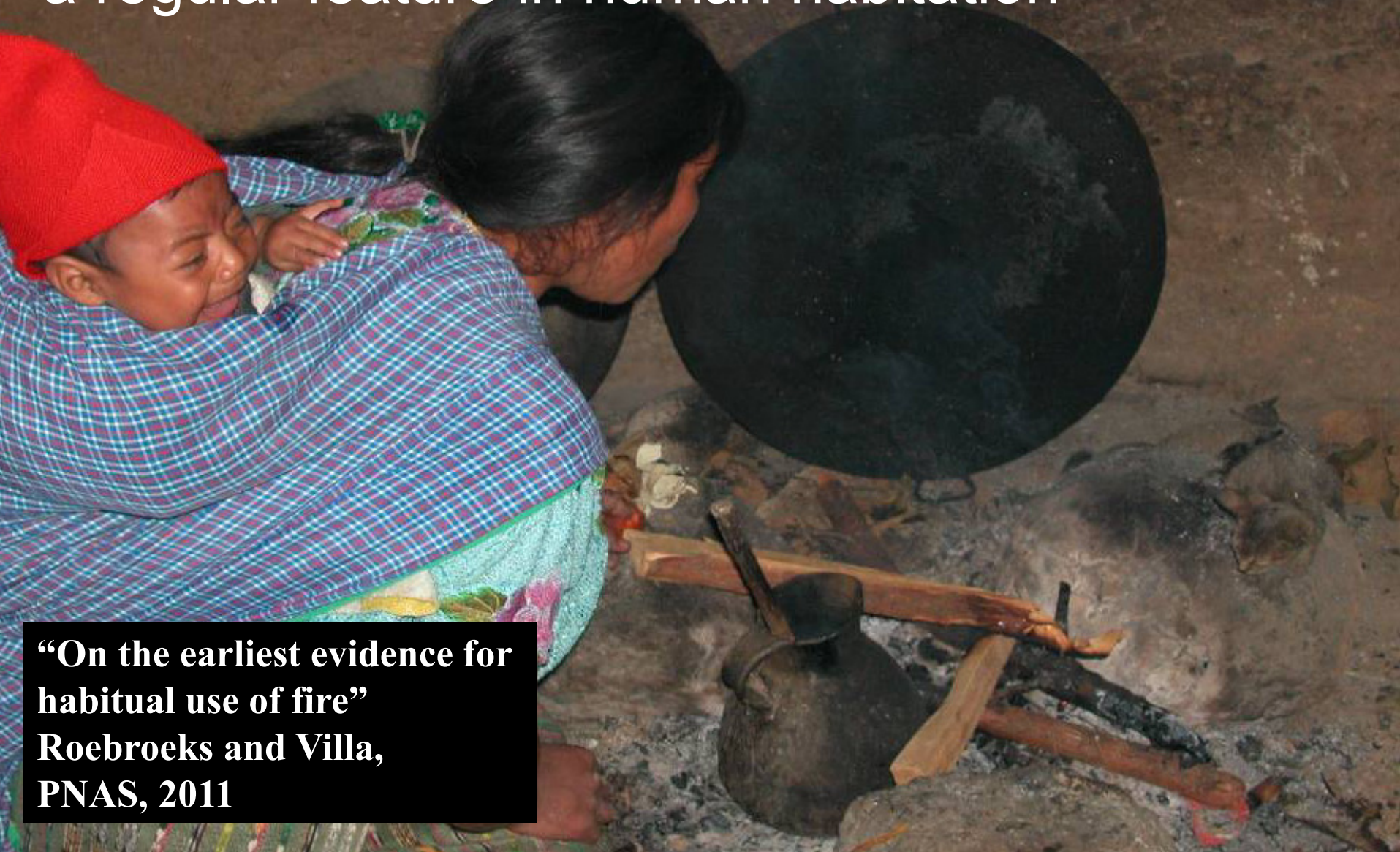
# **Uso de la leña: Implicancias en salud y clima**

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University of California, Berkeley**

# Road Map

- Global history of wood fuels
- Brief discussion of what pollution is involved and why.
- New results on health effects
- And on climate impacts
- Promising new technologies to reduce the impacts substantially

300-400 thousand years ago, the hearth became a regular feature in human habitation



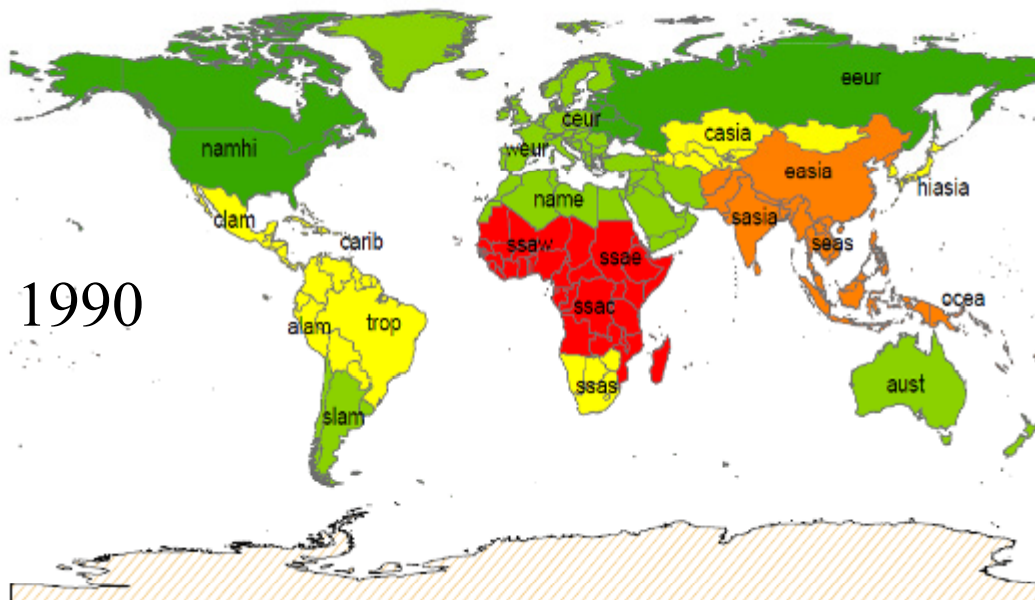
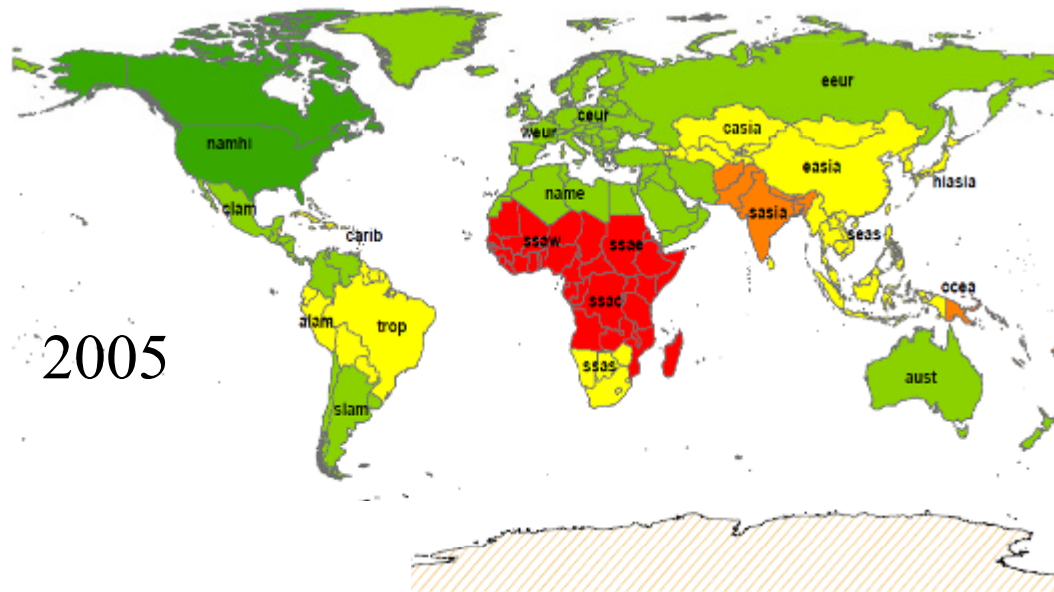
**“On the earliest evidence for habitual use of fire”  
Roebroeks and Villa,  
PNAS, 2011**

Three main types of household solid fuel

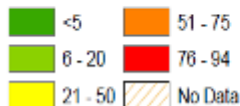




# Households using biomass or coal to cook today

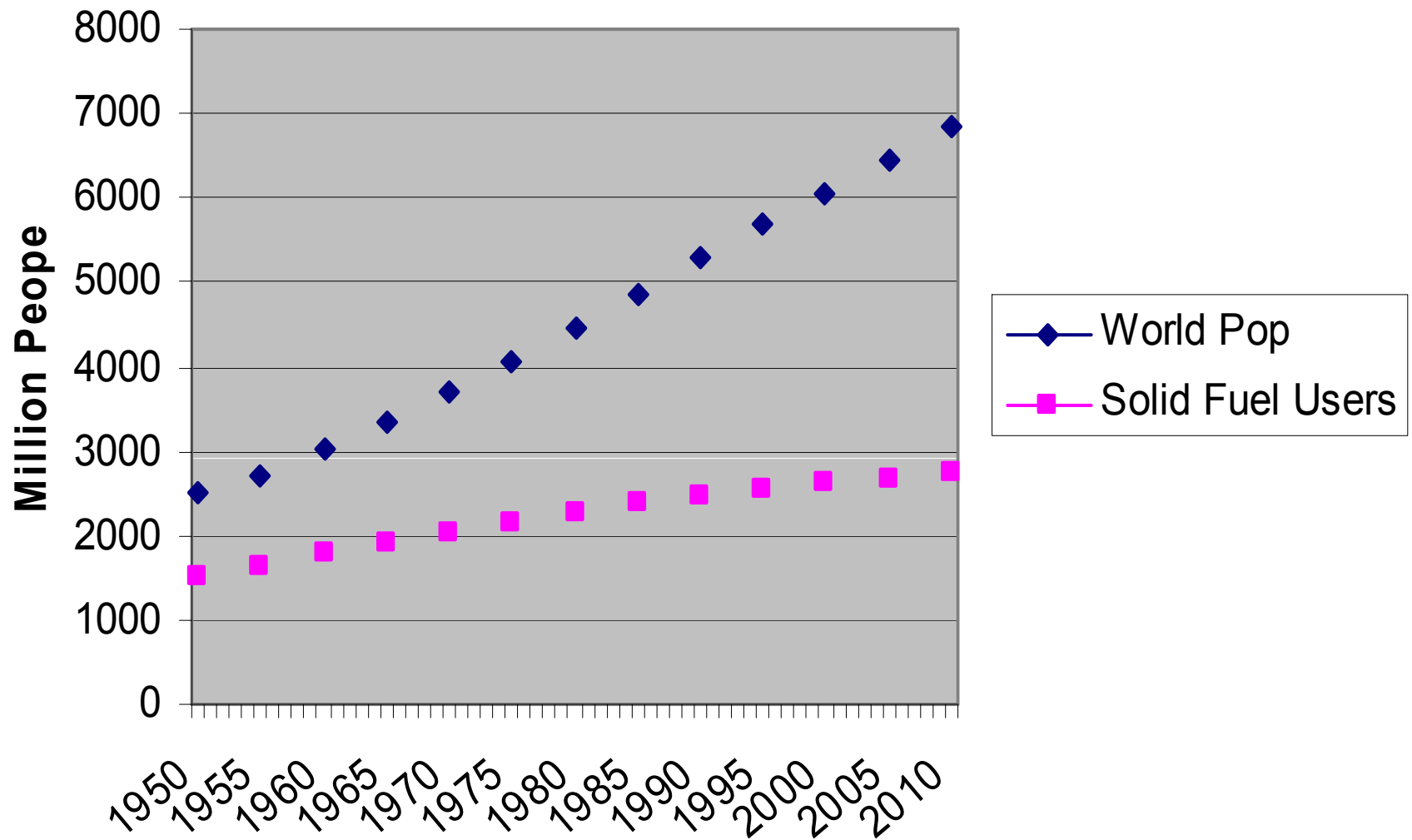


% of HH Exposed to HAP



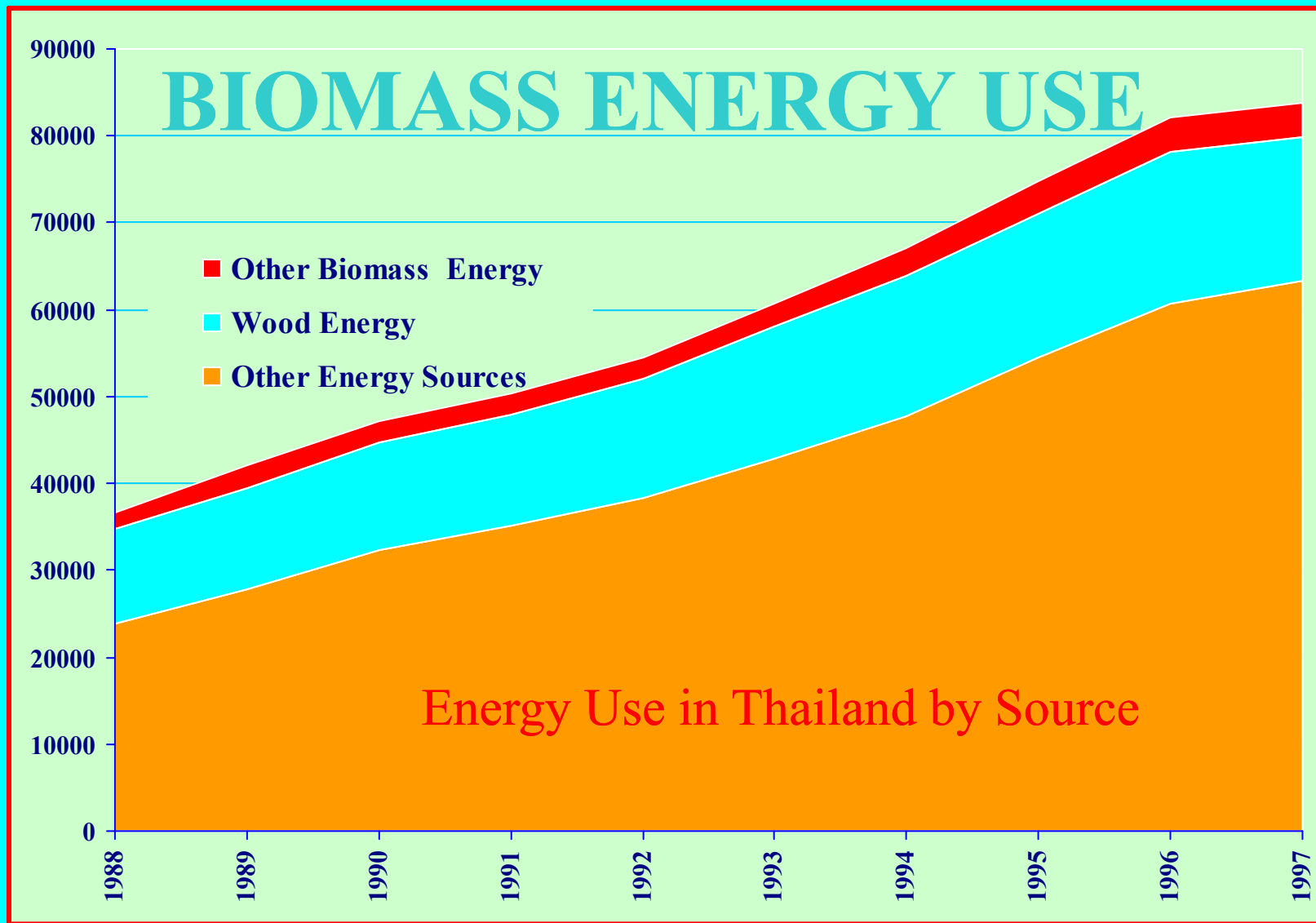
Comparative Risk Assessment (CRA)  
2011- preliminary,

# World Population Using Solid Fuel for Cooking



# Biomass Cooking in History

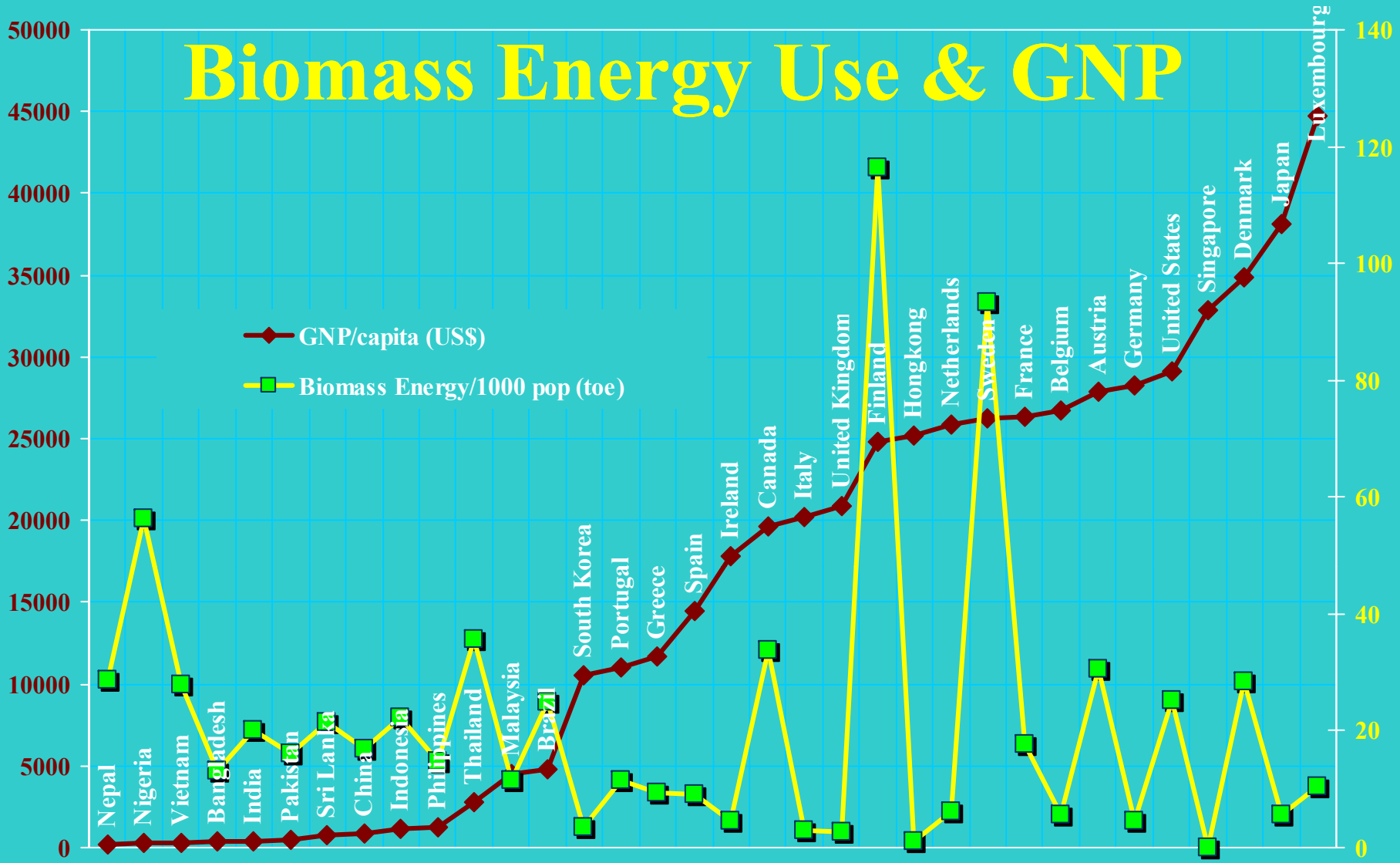
- **Today, ~40% use solid fuels, about 2.7 billion people**
- **Although the percentage is dropping, the absolute number is still rising.**
- **Perhaps 10-15 million people a year are added to the total each year.**
- **Indeed, there are more people using solid fuels today for cooking than the total world population in 1950**
- **Or any year previously**



Source: RWEDP

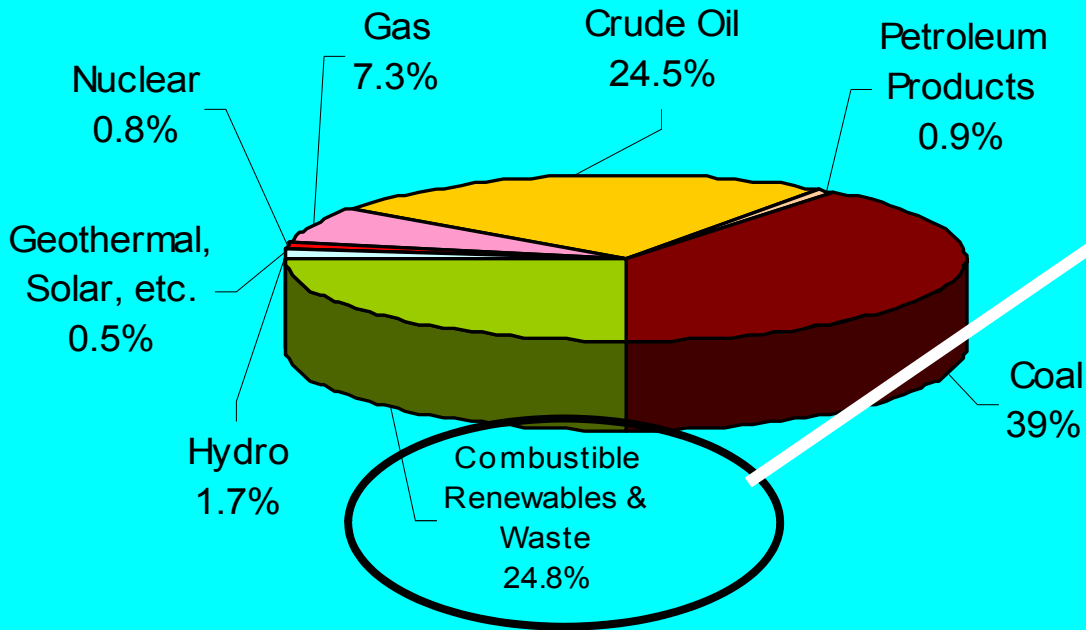


# Biomass Energy Use & GNP



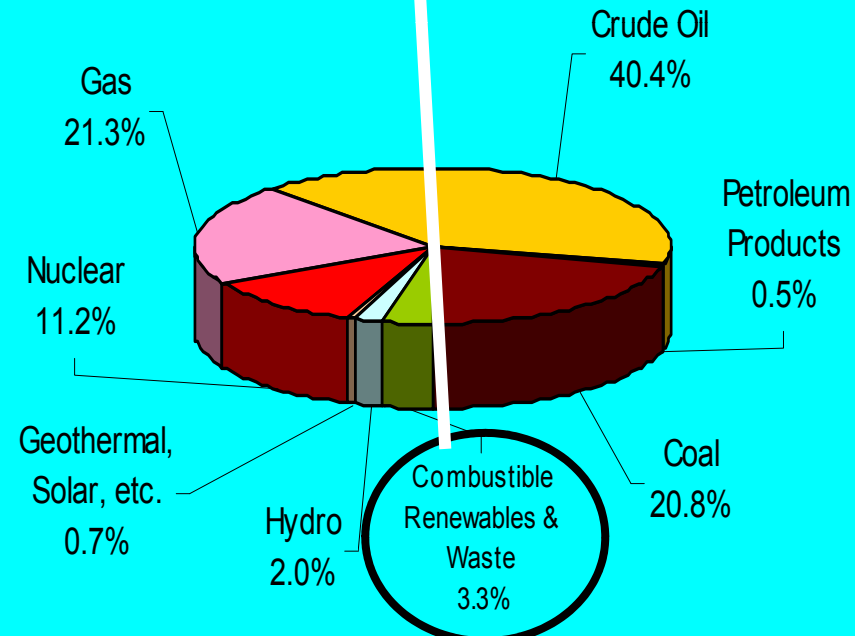
Source: RWEDP

# Asia Pacific shares of 2.31 Gtoe



Approximately  
equal per capita  
consumption!

# OECD shares of 5.33 Gtoe



# Cumulative Percent of World Population

0 50 100

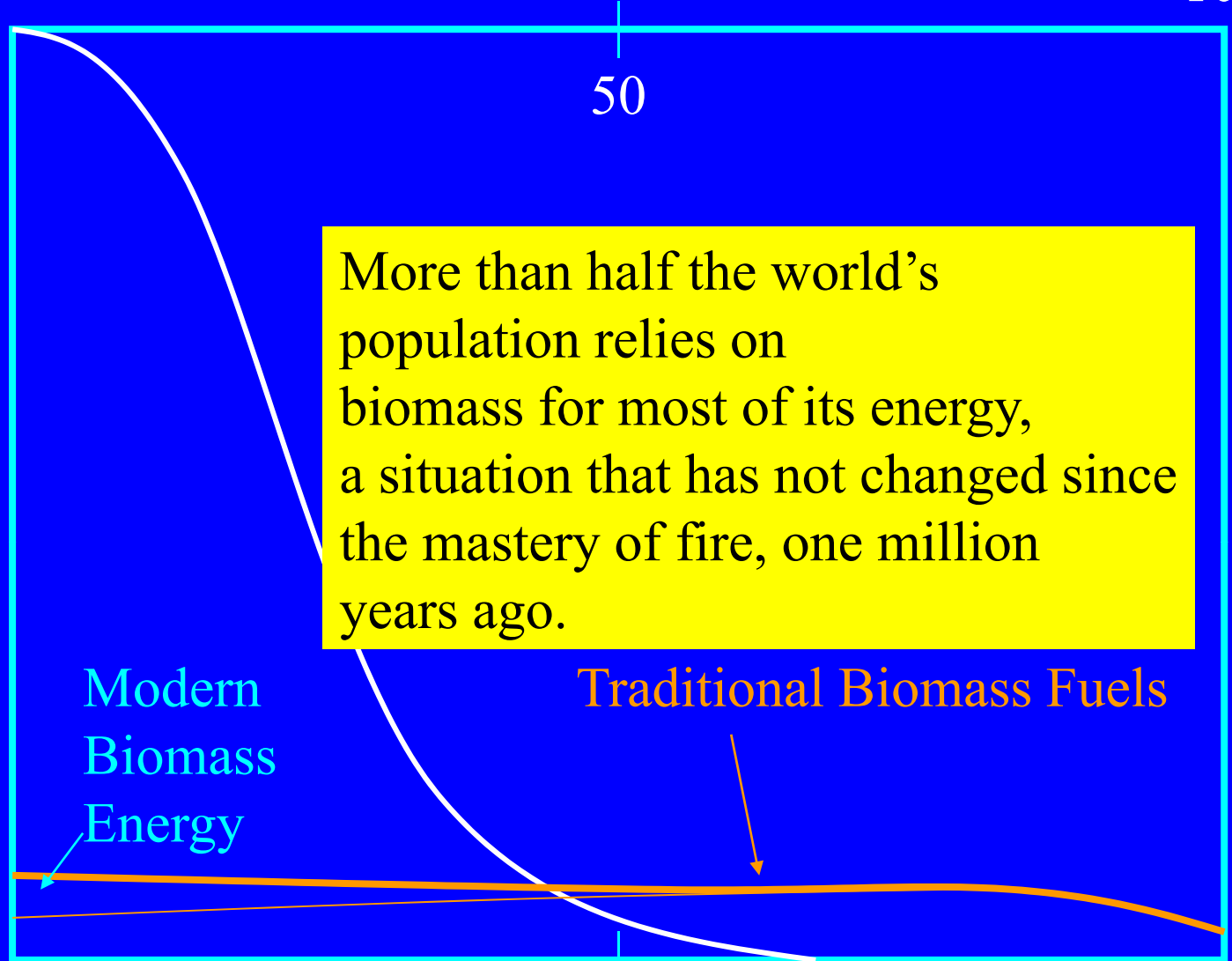
Energy per capita

More than half the world's population relies on biomass for most of its energy, a situation that has not changed since the mastery of fire, one million years ago.

Modern Biomass Energy

Traditional Biomass Fuels

Income



# 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)?

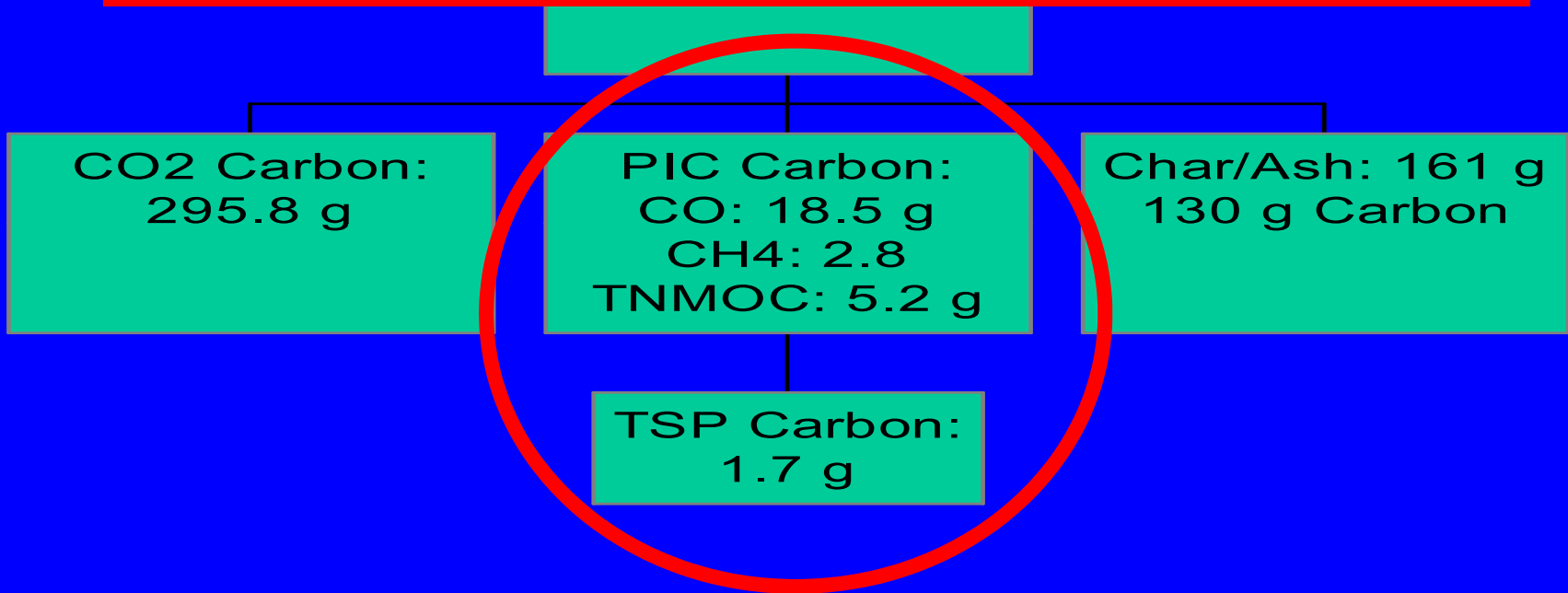


Reason: the combustion efficiency is far less than 100%

# Carbon Balance:

A Toxic Waste Factory!!

Typical biomass cookstoves convert 6-20% of the fuel carbon to toxic substances



Nominal Combustion Efficiency = 89%

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

Organics known to be mutagens, immune system suppressants, severe irritants, inflammation agents, central nervous system depressants, cilia toxins, endocrine disrupters, or neurotoxins.

Several chemicals firmly established as human carcinogens.

Other toxic inorganic chemicals.

- 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*



# Size Distribution of Biomass Smoke Particles

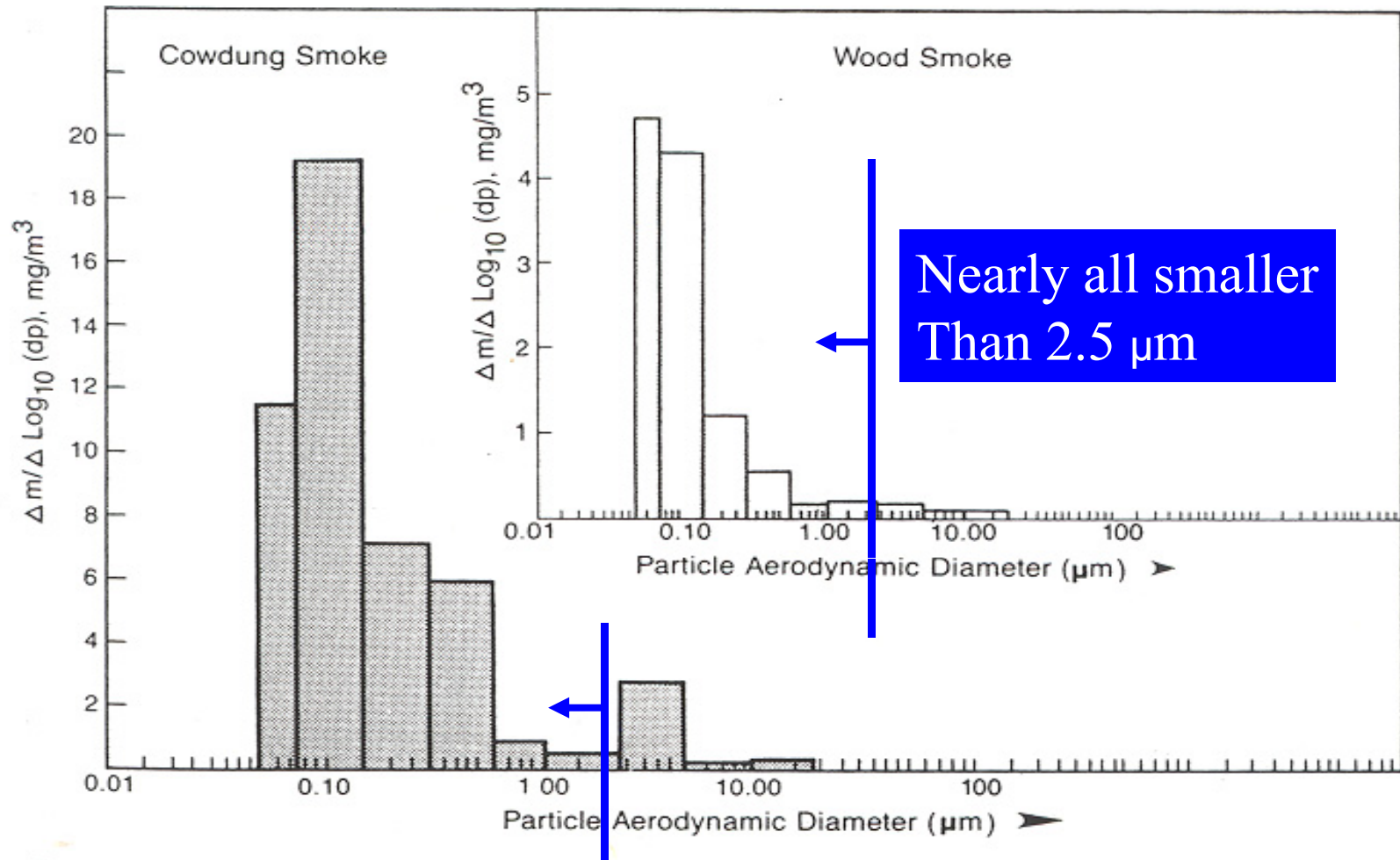


Figure 2.2. Size distribution of woodsmoke and dungsmoke particles. Measurements taken in the East-West Center simulated village house as reported in Smith *et al.* (1984b). (Figure prepared by Premlata Menon.)

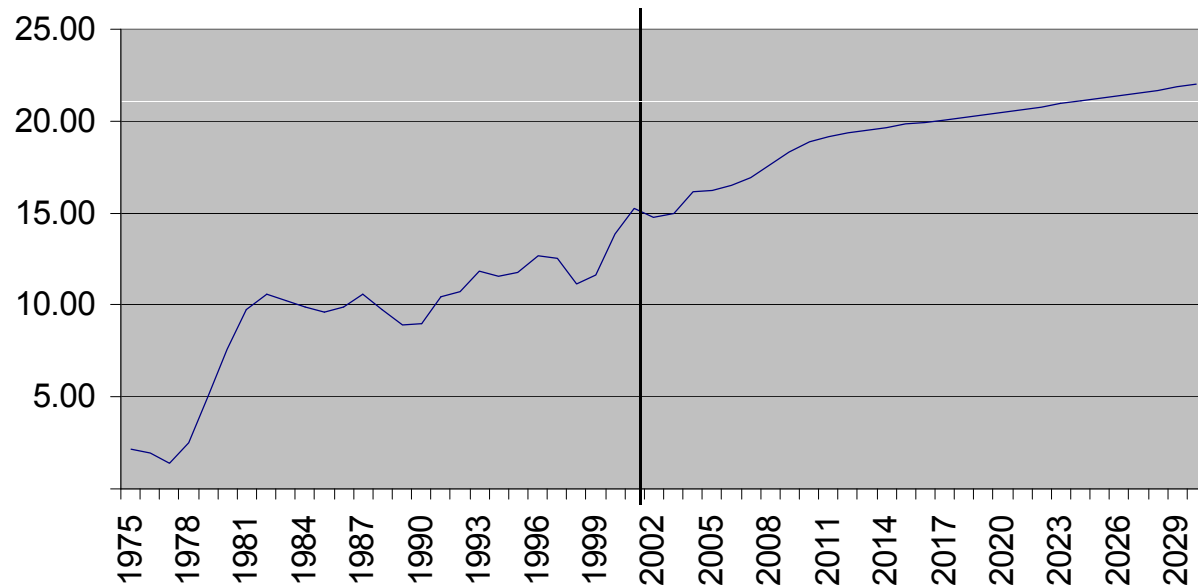
# Outdoor Pollution from Woodsmoke

## Example of Canada\*

- All mobile sources: 61,151 tonnes
- All industrial sources: 68,057 tonnes
- 105,271 tonnes from household woodstoves

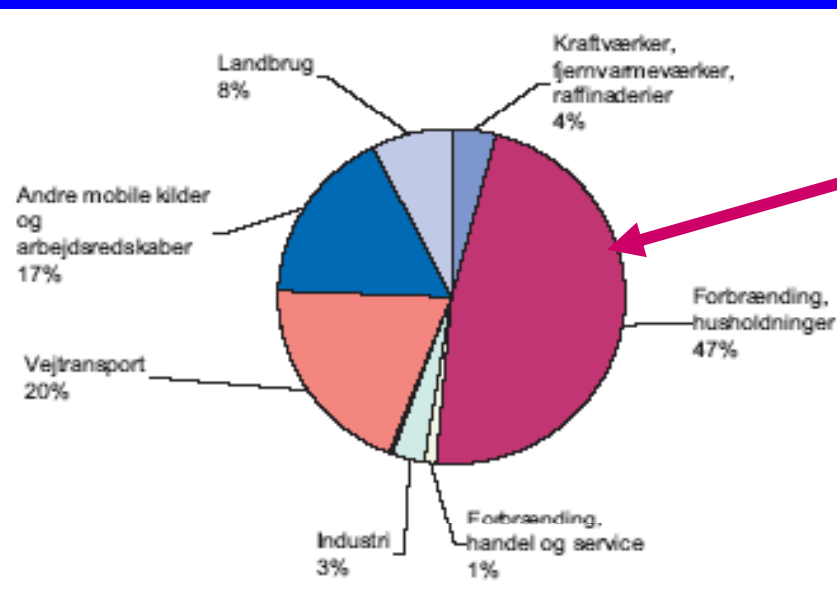
\*2009: PM<sub>2.5</sub> emissions

# Wood use in Denmark



50% increase  
since 1990

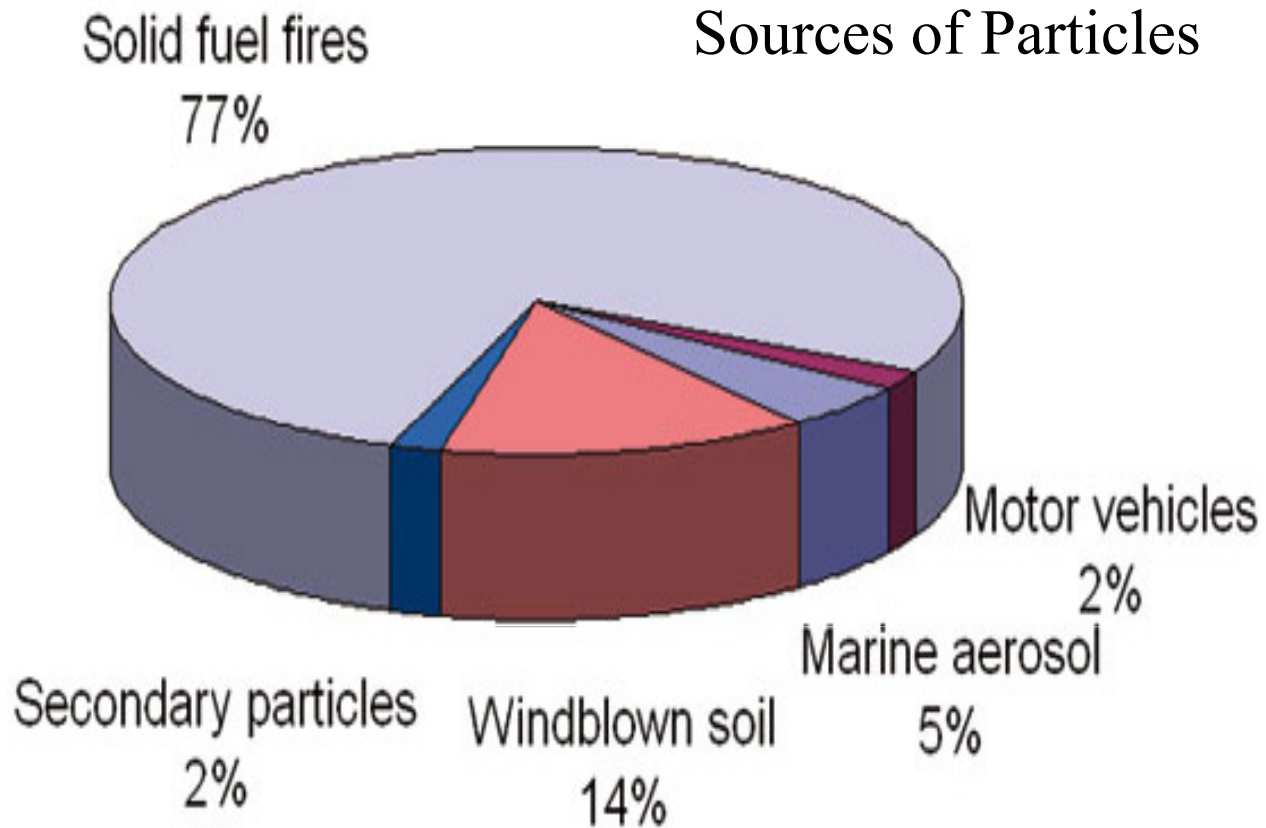
Total energy use  
only increased  
by ~7% (IEA)



In 2005, household wood-burning was responsible for 47% of all small particle ( $PM_{2.5}$ ) emissions in Denmark!

# Masterton, New Zealand, 2004

Receptor model



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One reason household air pollution  
causes so much ill-health is

The Intake Fraction  
is large

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IF is the fraction of material emitted  
that is actually breathed in by someone



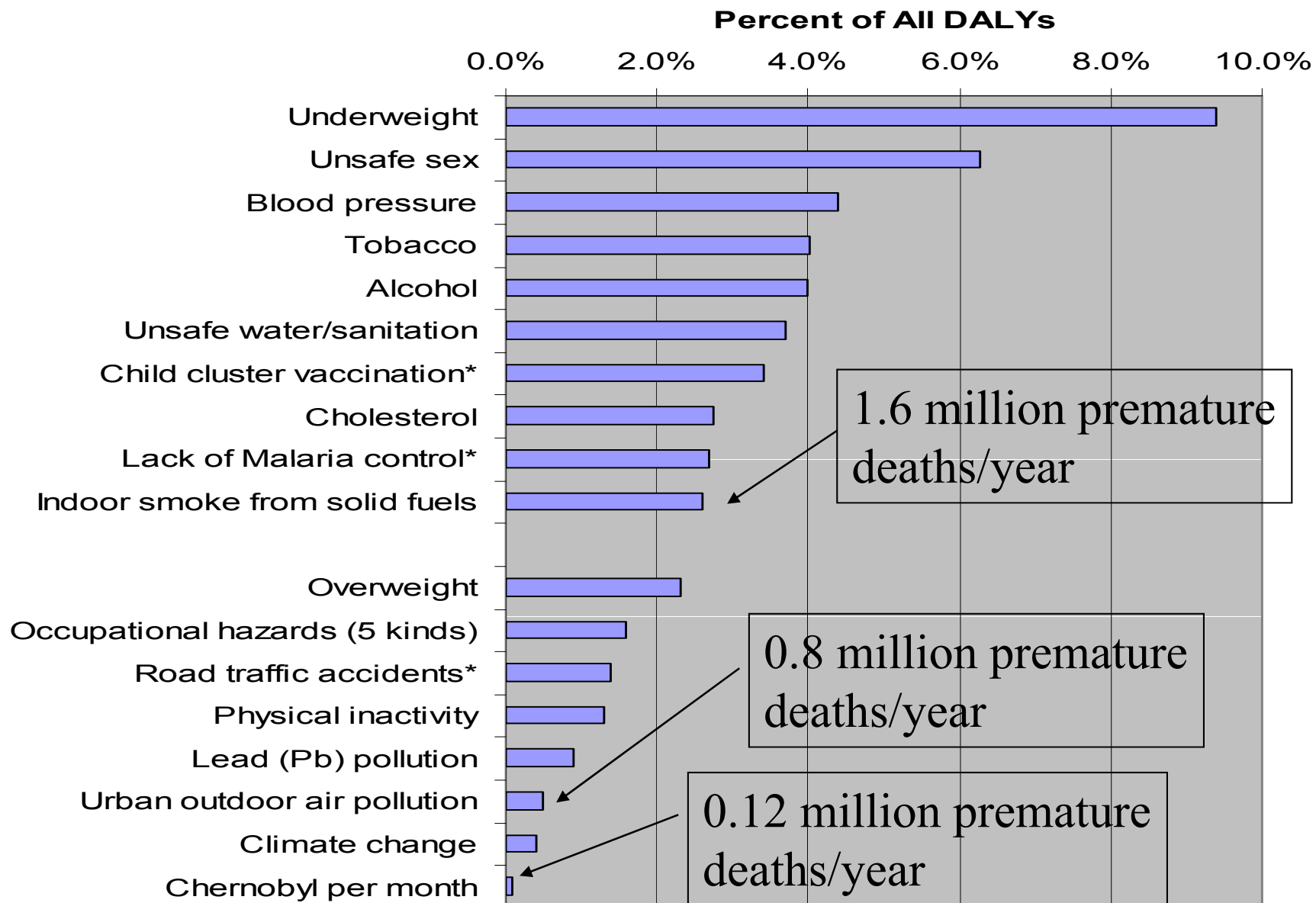
IF = 1.0



# Intake Fraction is High for Household Woodsmoke Emissions

- **The estimated iF (units: per million) is 13-15 (for wood smoke) These iF estimates are comparable to or slightly larger than iF values for urban vehicle emissions.**
- **Our results emphasize the importance of urban wood smoke as a source of PM<sub>2.5</sub> exposure and highlight the comparatively large population exposure from woodsmoke emissions.**
- **Environmental Science and Technology, 2009**

# Global Burden of Disease from Top 10 Risk Factors plus selected other risk factors



Diseases for which we have good studies for outdoor particle pollution

ALRI/  
Pneumonia

Low birth weight

Stillbirth

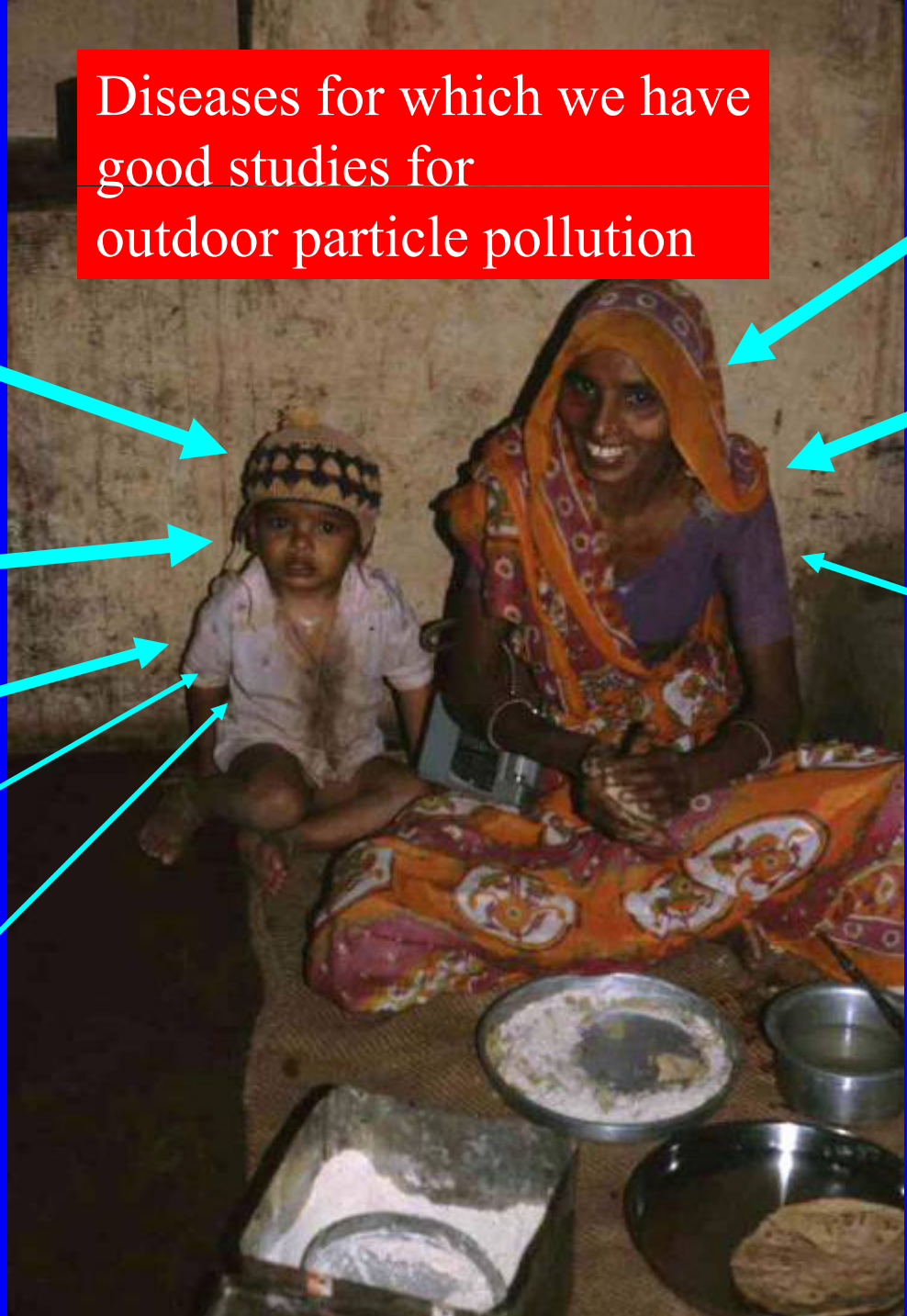
Cognitive Impairment

Asthma

Heart disease and stroke

Lung Cancer

Chronic obstructive lung disease



# RESPIRE – Randomized trial (n=518)

Impact on pneumonia up to 18 months of age



Traditional open 3-stone fire:  
kitchen 48-hour  $PM_{2.5}$  levels of  
600 - 1200  $\mu g/m^3$



Chimney wood stove, locally made  
and popular with households

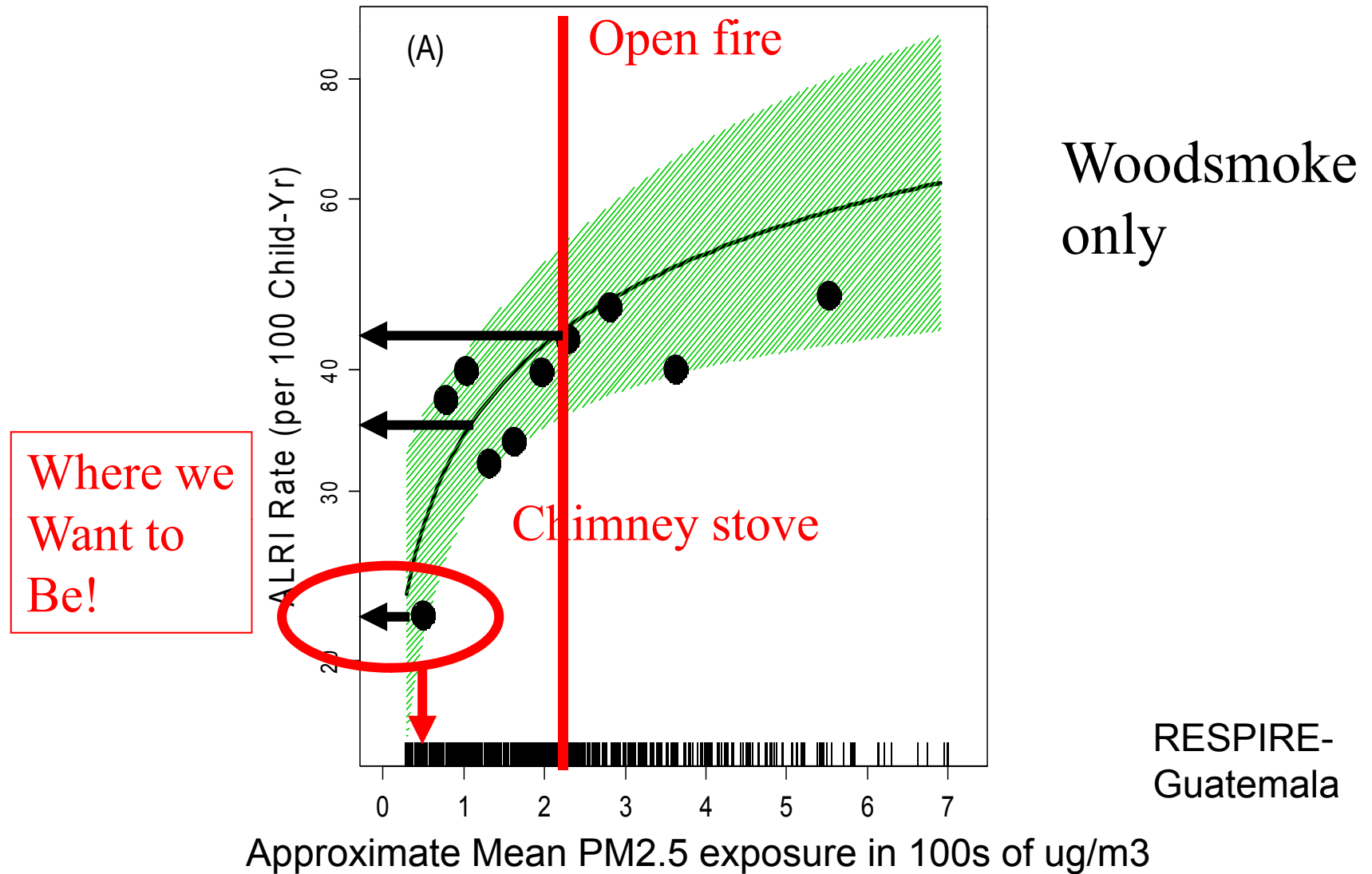




Tubito

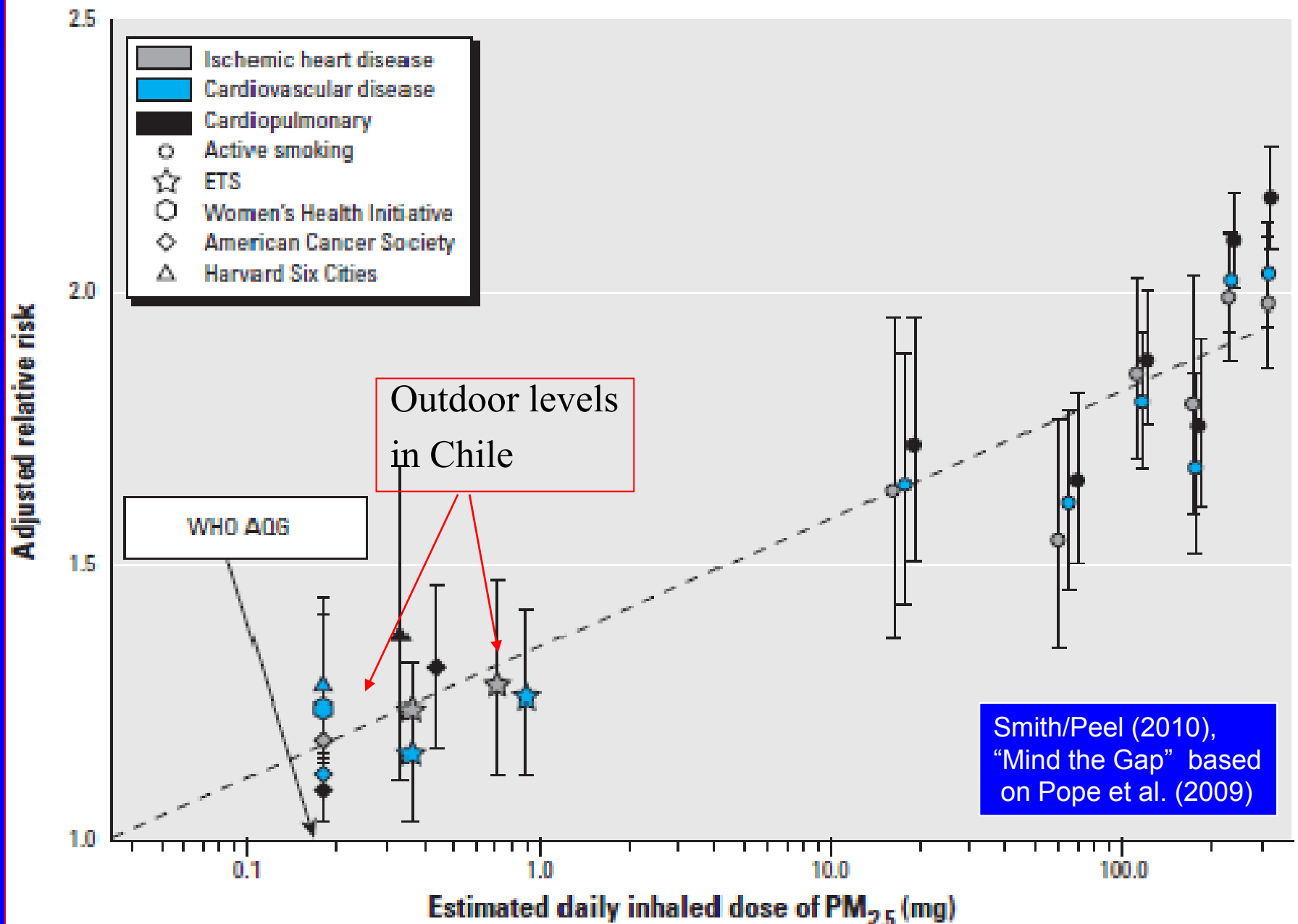
Tubito

# MD-diagnosed Acute Lower Respiratory Infection



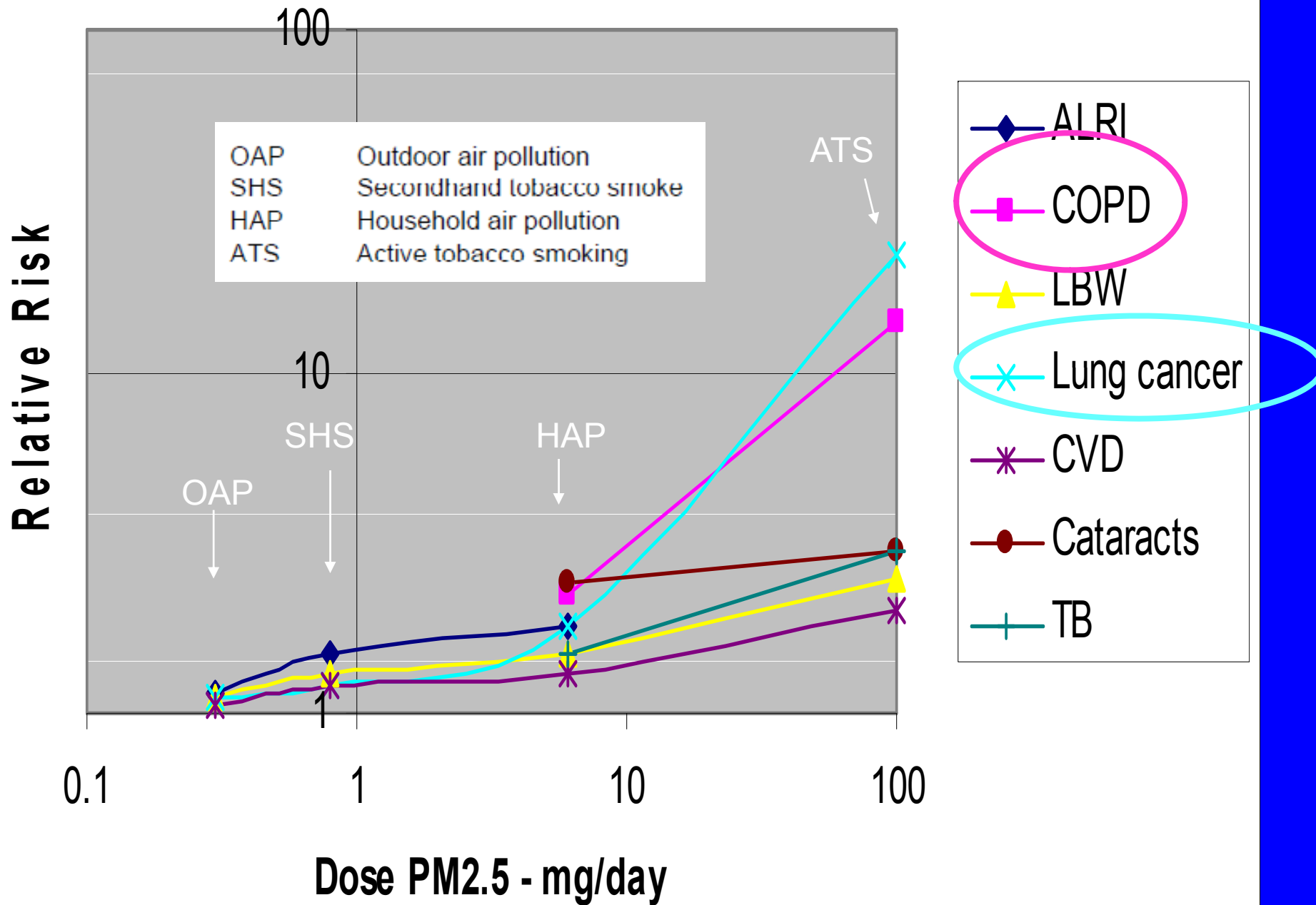


# Heart Disease and Combustion Particle Doses



# Argument from consistency across combustion particle exposures for CVD

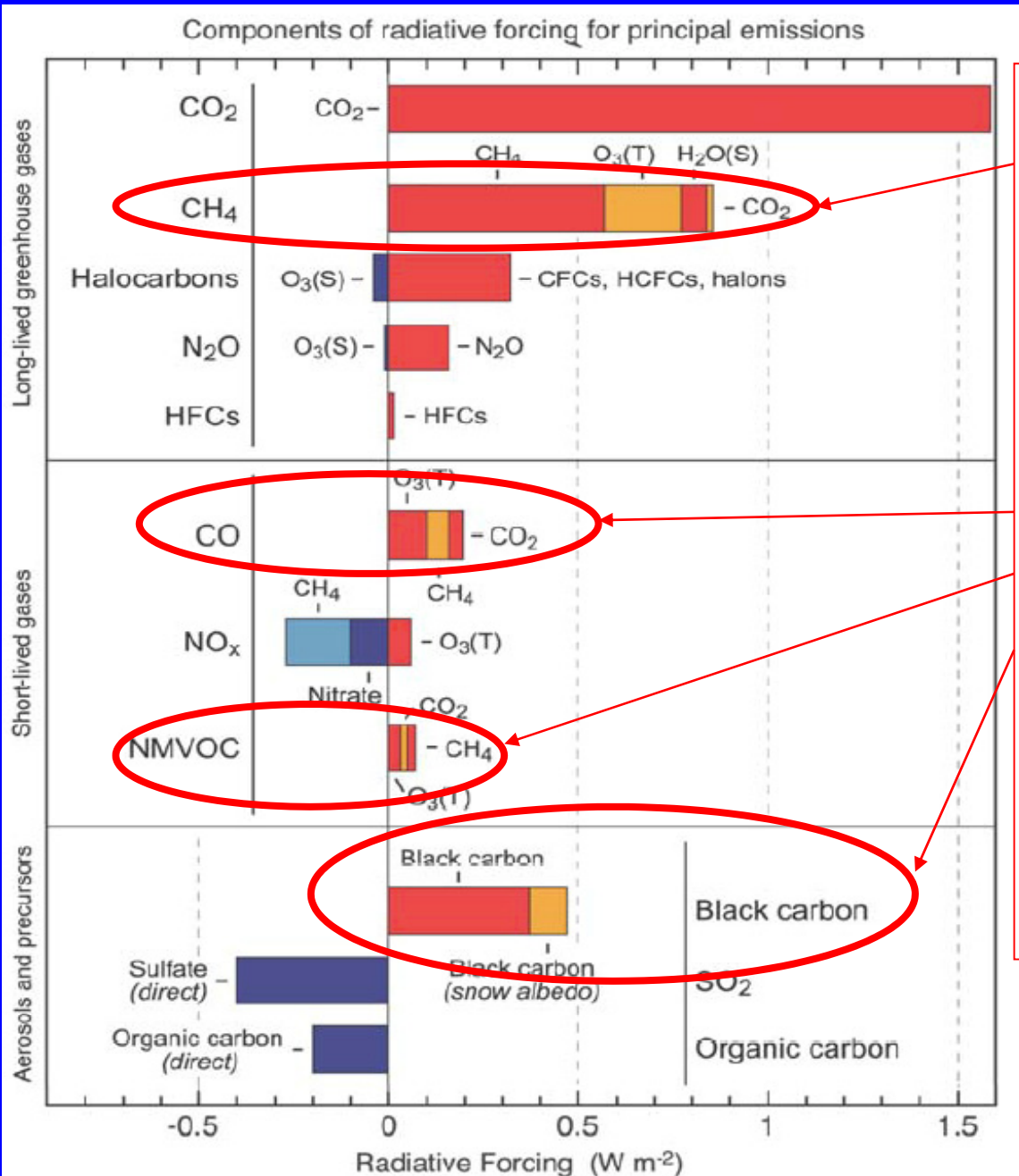
- Fine combustion particles are best measure of risk in each setting and seem to have similar effects per unit mass across the four source types
- Remarkable consistency across 3 orders of magnitude of dose measured in mg/day of  $PM_{2.5}$
- Provide evidence for intermediate levels of exposure where no studies have been done yet.



# Household Woodsmoke is So Damaging for Health because

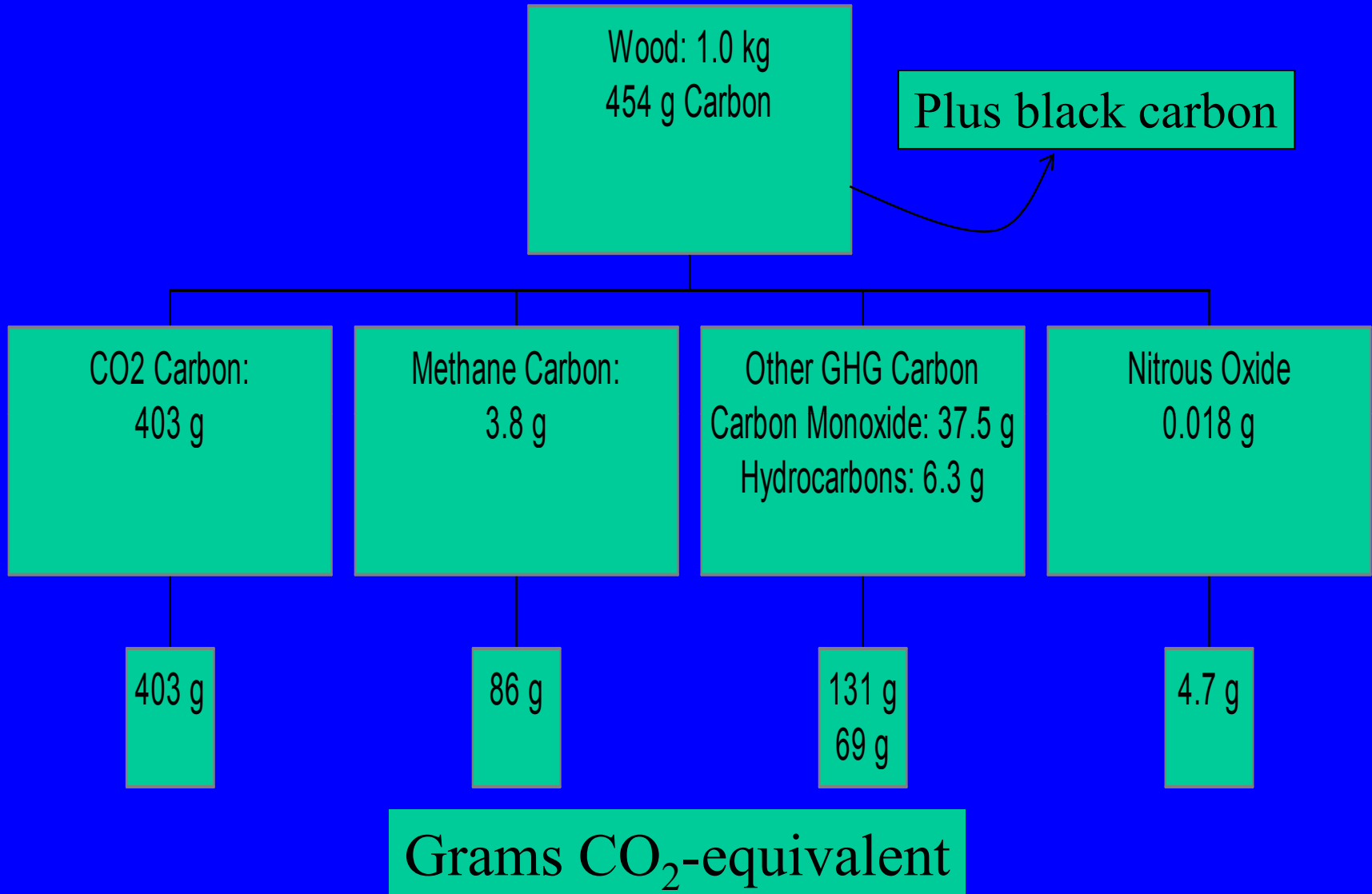
- Large emissions of particles due to poor combustion
- Right near where people live
- At the times when people are present
- Often at times when pollution does not disperse well – cold winter nights
- What about climate?

# Global warming in 2005 due to all human emissions since 1750



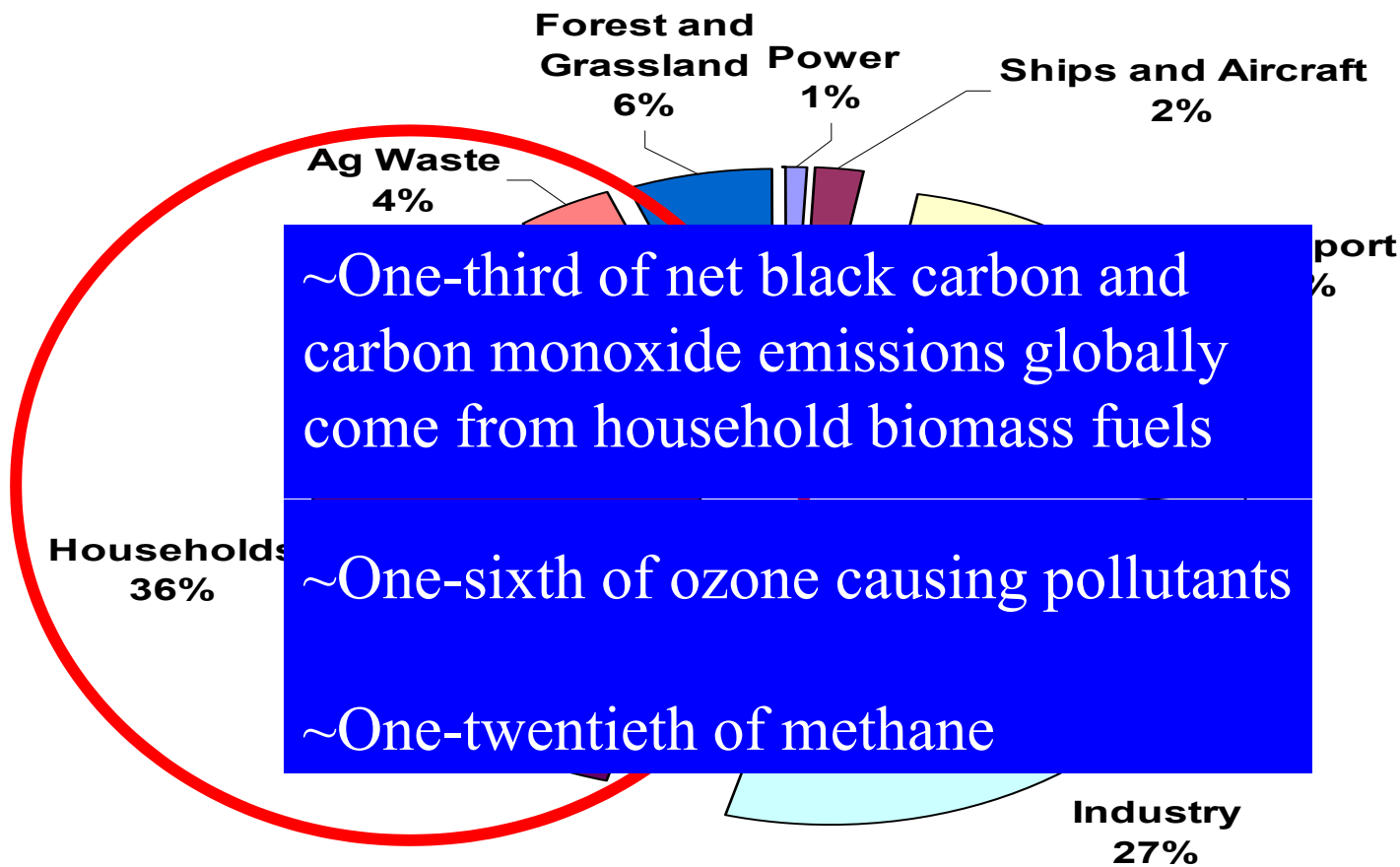
CO<sub>2</sub> is important for climate, but so are many other pollutants, including the ones circled that, unlike CO<sub>2</sub>, also have significant health as well as climate impacts. These are all products of Incomplete combustion that also have health impacts

# Greenhouse warming from wood fire

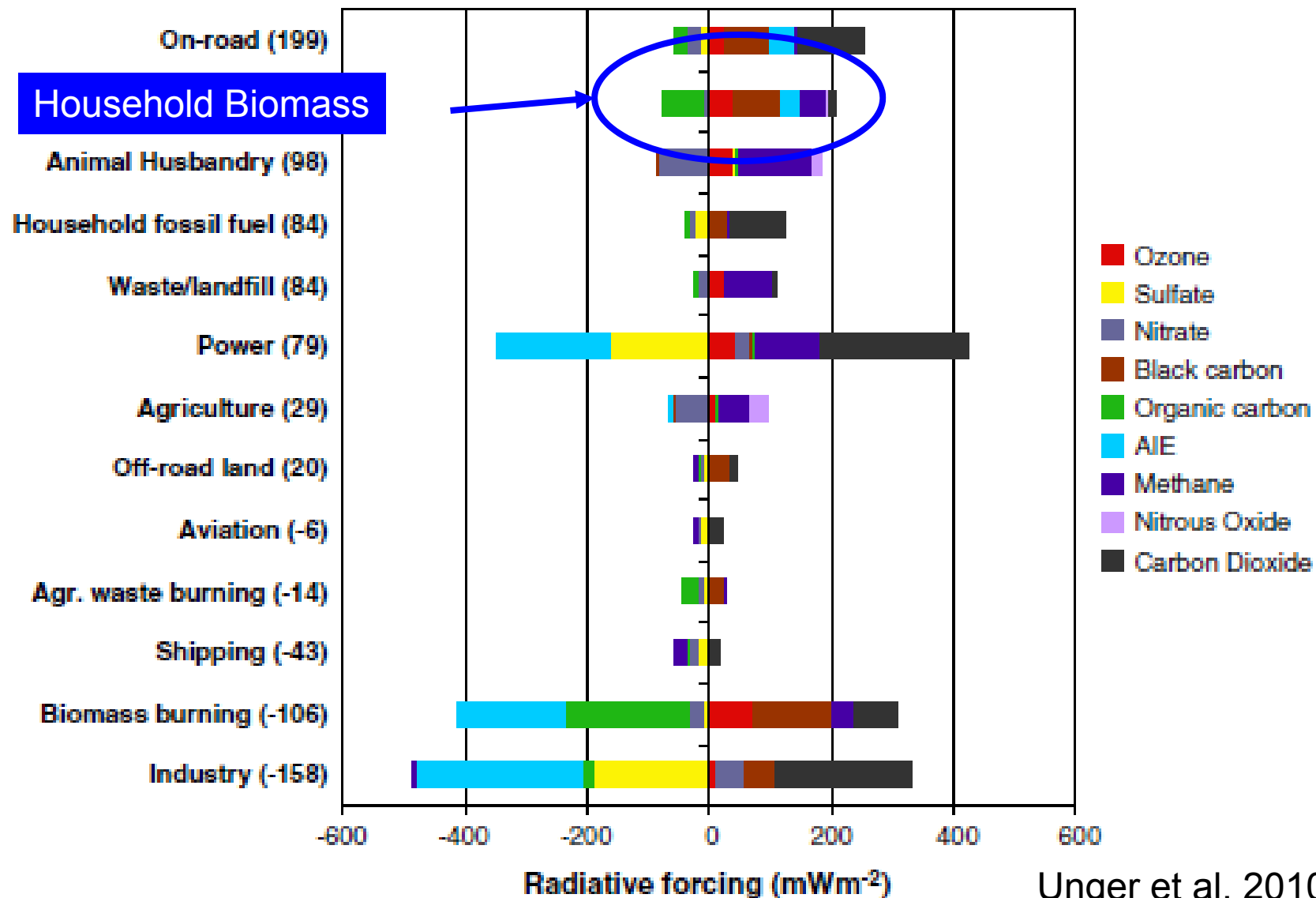


# Controllable Global Warming from Black Carbon Emissions

Net of OC, Forcings from IPCC, 2007: 0.25 W/m<sup>2</sup>  
Inventory from T Bond Database, V 7.1.1 Feb 2009



# Climate Warming in 2020 Under Present Trends





# How low can woodstove emissions be?

- USEPA standard is 4.1 g/hr of PM<sub>2.5</sub> for heating stoves – not low enough
- Can they meet the proposed 2 g/hr limit in Chile?
- Requirement for cookstoves even greater, since released indoors
- Much recent international work to reach very low levels



# Fan Semi-Gasifier Stove

(two-stage combustion)

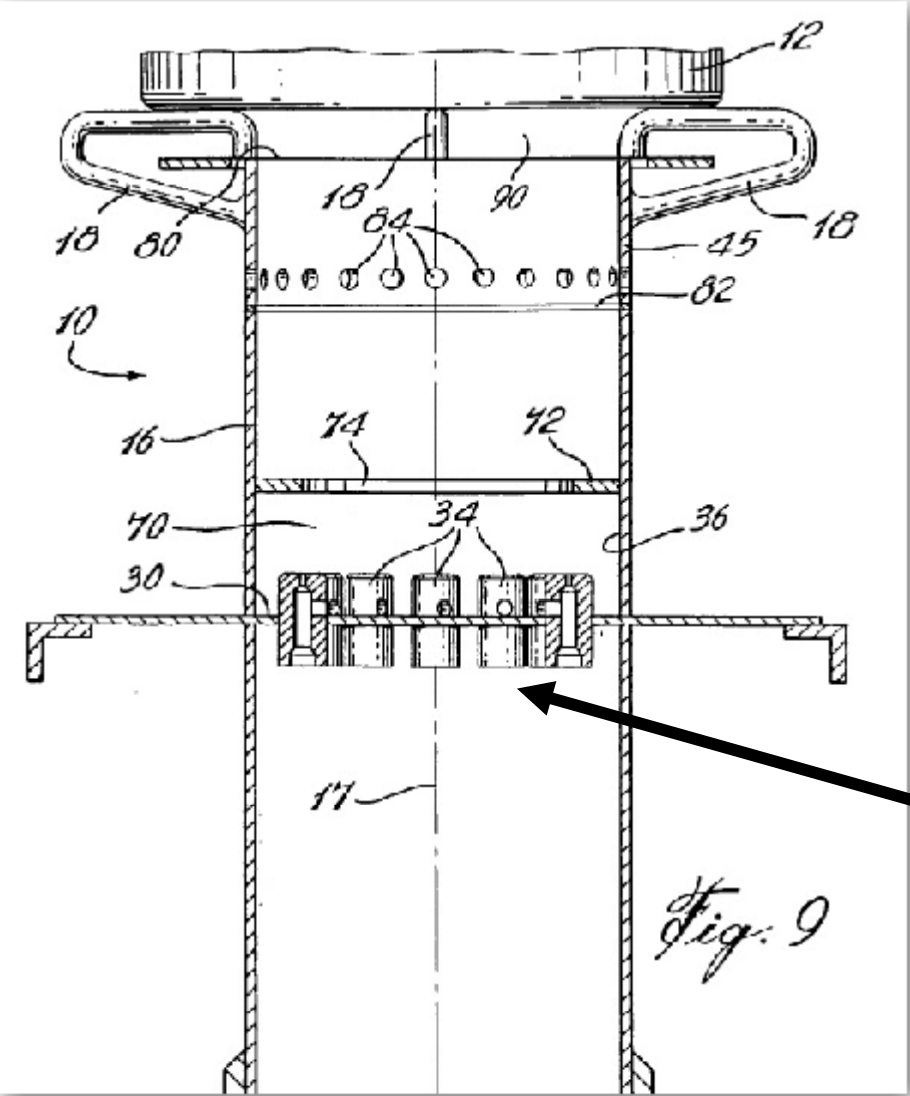
Stove-Use Monitor

Fan control

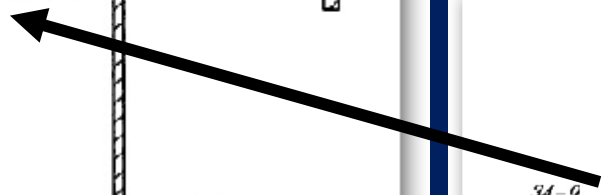
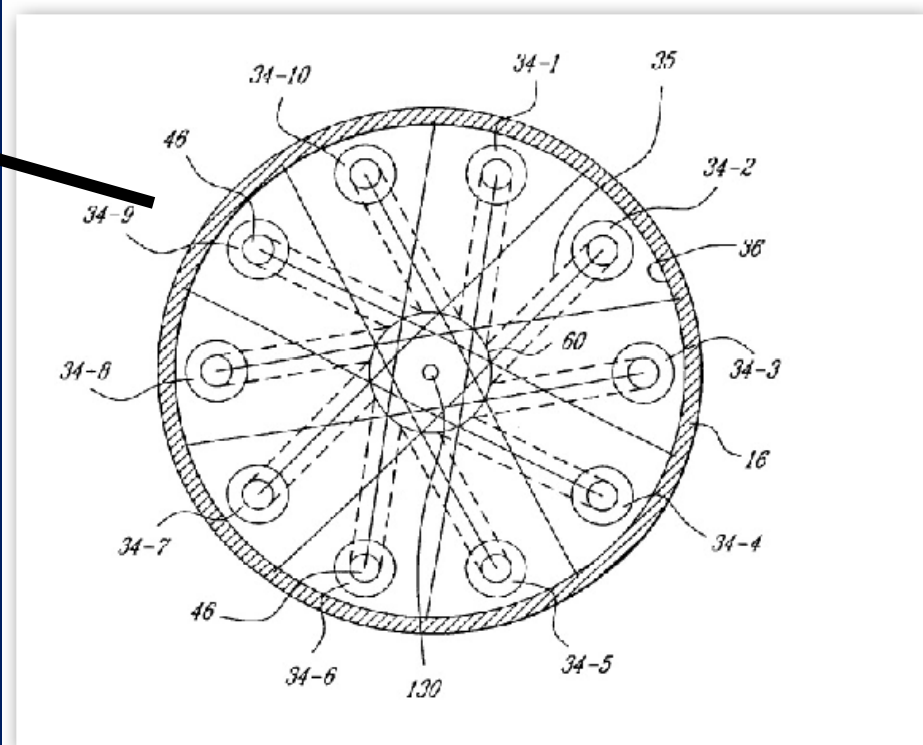
# Turbococina

- Developed by Rene Nuñez
- Precision engineered stainless steel stove
- Controlled forced air with fan and baffles
- Optimized fuel/air ratios and temperatures
- In pilot phase in El Salvador

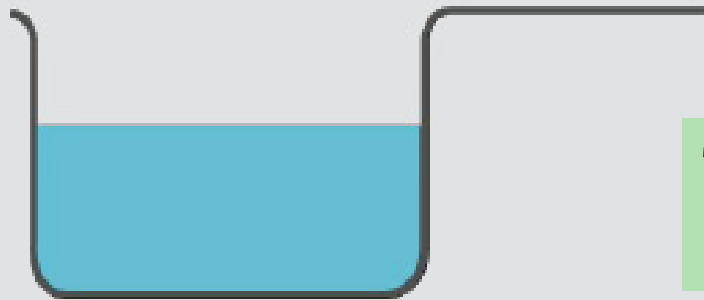




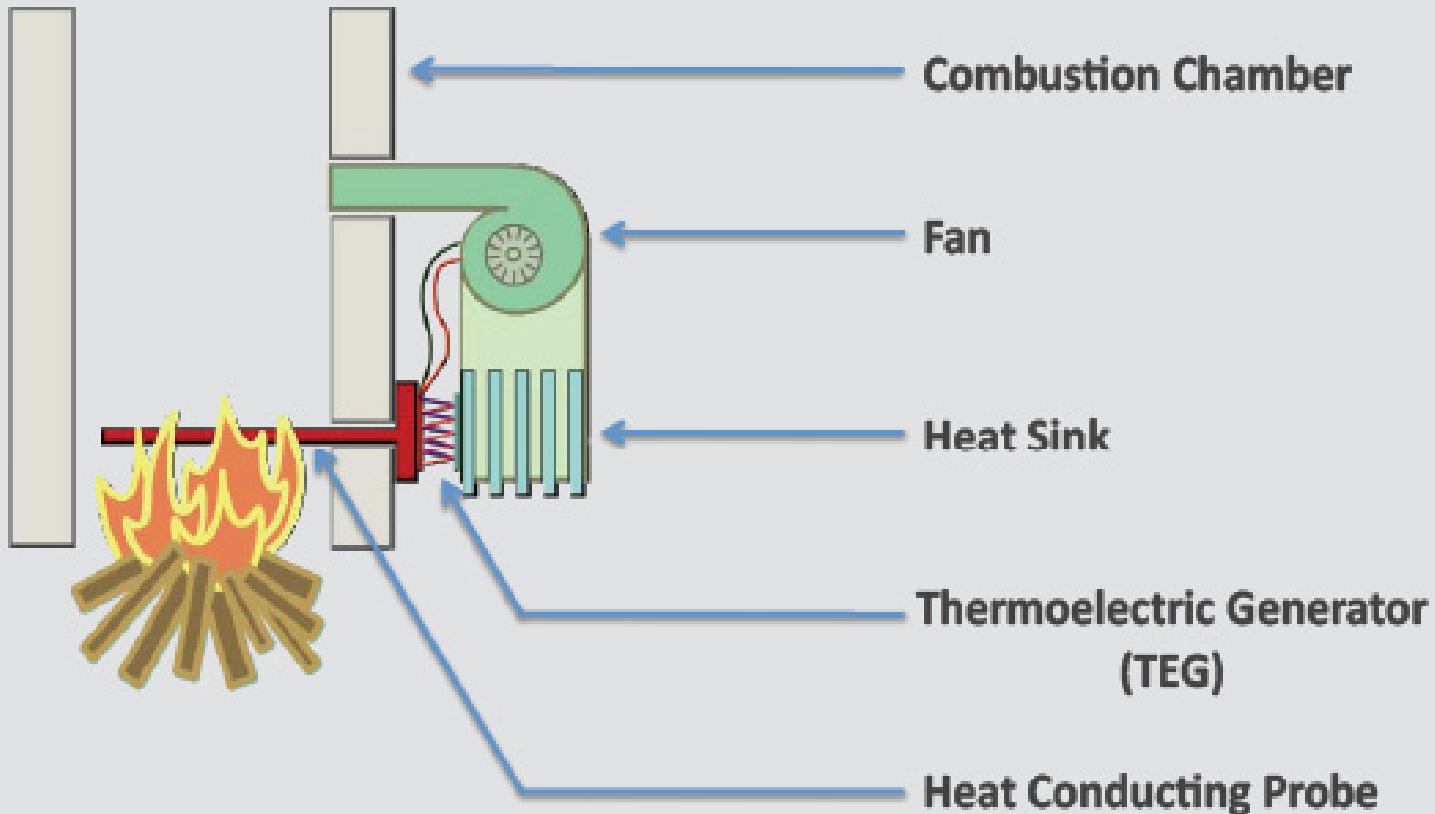
Turbococina  
US patent



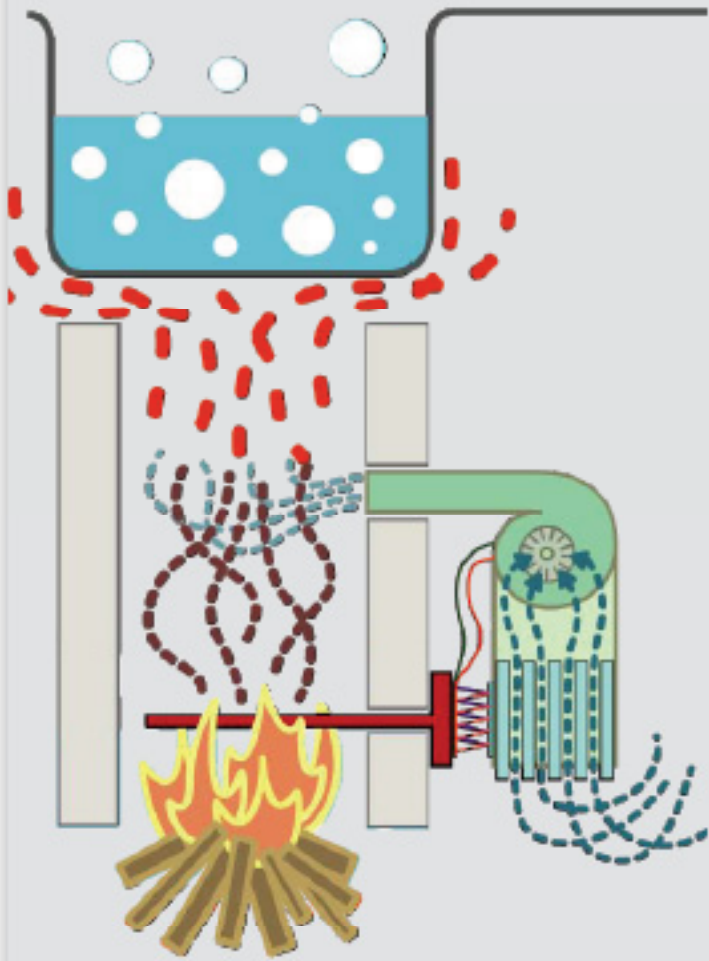
# What if there is no electricity?



Thermoelectric Generator (TEG)







### **Minimizes TEG cost**

- probe conducts optimal amount of heat to TEG

### **Fast startup**

- probe heats quickly because it is near to initial heat source

### **Efficient**

- fan cools heat sink
- heat sink pre-warms air
- waste heat returned to system

### **Applicable to many stove designs**

- not dependant on a conductive burn chamber
- can be a modular component

BioLite Company Design

# Is Wood the Fuel that

- Heats you twice, as some say?
  - Once when you chop it and
  - Once when you burn it
- Or four times?
  - The fever from respiratory infection and
  - Global warming
- Better combustion will get rid of the second pair

# Many thanks

Publications and presentations available at my website:

<http://ehs.sph.berkeley.edu/krsmith/>

Or just Google “Kirk R. Smith”