“You could have a Chernobyl a month and it wouldn’t come close to the health impact of burning biomass and coal in the home.”

Dr. Kirk Smith holds a device used to measure air pollution in homes where people cook over wood, coal, cow dung, crops, and other biomass fuels. More than half the world’s households cook with such fuels, with devastating effects on the environment and public health.

Cooking and Climate: The Unfinished Health Agenda of Incomplete Combustion
Authoritative estimates are that the eventual total premature deaths from Chernobyl will be 4000-10,000 after many decades – nearly all from cancer.

How much would 12 Chernobyl-size accidents per year add to the global burden of disease?
Global Burden of Disease from Top 10 Risk Factors
plus selected other risk factors

Percent of All DALYs

0.0%  2.0%  4.0%  6.0%  8.0%  10.0%

Underweight
Unsafe sex
Blood pressure
Tobacco
Alcohol
Unsafe water/sanitation
Child cluster vaccination*
Cholesterol
Lack of Malaria control*
Indoor smoke from solid fuels

Overweight
Occupational hazards (5 kinds)
Road traffic accidents*
Physical inactivity
Lead (Pb) pollution
Urban outdoor air pollution
Climate change

1.6 million premature deaths/year
0.8 million premature deaths/year
0.12 million premature deaths/year
Oldest Pollution Source in Human History
Households Using Solid Cooking Fuels

% of HH Exposed to HAP
- < 5
- 51 - 75
- 6 - 20
- 76 - 93
- 21 - 50
- No Data

For 2005, CRA-10 preliminary
Mixed fuels
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$_2$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 Indian cooking stove

A Toxic Waste Factory!!

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

- Into Pot: 2.8 MJ (18%)
- In PIC: 1.2 MJ (8%)
- Waste Heat: 11.3 MJ (74%)

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

Source: Smith, et al., 2000
Toxic Pollutants in Biomass Fuel Smoke from Simple (poor) Combustion

- Small particles, CO, NO₂
- Hydrocarbons
  - 25+ saturated hydrocarbons such as \textit{n-hexane}
  - 40+ unsaturated hydrocarbons such as \textit{1,3 butadiene}
  - 28+ mono-aromatics such as \textit{benzene & styrene}
  - 20+ polycyclic aromatics such as \textit{benzo(α)pyrene}
- Oxygenated organics
  - 20+ aldehydes including \textit{formaldehyde & acrolein}
  - 25+ alcohols and acids such as \textit{methanol}
  - 33+ phenols such as \textit{catechol & cresol}
  - Many quinones such as \textit{hydroquinone}
  - Semi-quinone-type and other radicals
- Chlorinated organics such as \textit{methylene chloride and dioxin}

Health-Damaging Air Pollutants From Typical Woodfired Cookstove in India.

Typical Health-based Standards

Carbon Monoxide: 150 mg/m³
10 mg/m³

Particles: 3.3 mg/m³
0.1 mg/m³

Benzene: 0.8 mg/m³
0.002 mg/m³

1,3-Butadiene: 0.15 mg/m³
0.0003 mg/m³

Formaldehyde: 0.7 mg/m³
0.1 mg/m³

Wood: 1.0 kg Per Hour in 15 ACH 40 m³ kitchen

Typical Indoor Concentrations

IARC Group 1 Carcinogens

Best single indicator
First person in human history to have her exposure measured doing the oldest task in human history

Kheda District, Gujarat, 1981
Estimated PM2.5 for solid fuel using households in India

USEPA Standard
15 ug/m3

WHO Guideline
10-35 ug/m3

~400 ug/m3 average

Preliminary result from HAP CRA
Balakrishnan et al.
Diseases for which we have epidemiological studies - 2010

- ALRI/Pneumonia (meningitis)
- Low birth weight
- Stillbirth
- Cognitive Impairment
- Birth defects?
- Asthma?

Chronic obstructive lung disease
- Interstitial lung disease
- Cancer (lung, NP, cervical, aero-digestive)
- Blindness (cataracts, opacity)
- Tuberculosis
- Heart disease?
- Blood pressure
- ST-segment

Burns, health and safety impacts of fuel gathering?
Global Burden of Disease from Top 10 Risk Factors
plus selected other risk factors

World Health Organization, 2004

Percent of All DALYs in 2000
### Global Burden of Disease Database and Comparative Risk Assessment
**World Health Organization**

Being completely updated For 2011 release

For household air pollution:
- New exposure assessment modeling
- New outcome estimates based on meta-analyses
  - ALRI, COPD, Lung Cancer
  - Low birth weight, cataracts, cardiovascular
RESPIRE - Randomised 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 μg/m$^3$

Chimney wood stove, locally made and popular with households

Highland Guatemala
MD-diagnosed Acute Lower Respiratory Infection

Approximate Mean PM2.5 exposure in 100s of ug/m³

- Open fire
- Chimney stove

RESPIRE-Guatemala
Chimney stove did not protect all children
Effect of Plancha on PM2.5

- ~90% Reduction, sig.
- ~20% reduction, ns

48-h ug/m³

Log Scale

Open fire

Plancha

Kitchen
Reasons that child personal exposures did not lower as much as kitchen levels:

--Time-activity: the kids do not spend their entire day in the kitchen
--Household (or “neighborhood”) pollution: a chimney does not reduce smoke, but just shifts it outside into the household environment, where the difference between intervention and control households was less
20-month average ground-level PM2.5 from satellite data

Large areas of rural India and China have high ambient air pollution – much from household fuel
NASA INTEX_B Database
Percent PM$_{2.5}$ emissions from households

NASA INTEX_B 2006 (accessed 2010)
Global warming in 2005 due to all human emissions since 1750

**Components of radiative forcing for principal emissions**

- **CO₂** (red bars) and **CH₄**
- Halocarbons: O₃(S) - CFCs, HCFCs, halons
- **N₂O** (red bars)
- HFCs

**Long-lived greenhouse gases**

**Short-lived gases**

- **CO**
- **NOₓ**
- NMVOC

**Aerosols and precursors**

- Sulfate (direct)
- Organic carbon (direct)
- Black carbon (snow albedo)
- Black carbon
- SO₂
- Organic carbon

CO₂ is important for climate, but so are many other greenhouse gases. Several of the non-CO₂, circled, that, unlike CO₂, also have significant health as well as climate impacts. The secondary pollutant, tropospheric ozone.
Household Fuels and Climate

- Climate impacts come from non-renewable biomass and coal, i.e., from net CO$_2$ emissions
- Poor combustion also leads to other emissions such as the relatively well-understood GHGs – methane and nitrous oxide – which are “Kyoto” GHGs
- In addition, a wide range of less well-understood short-lived GH-related emissions are emitted including
  - CO and black carbon – warming agents
  - Ozone precursors – warming But also cooling agents such as sulfates and organic carbon particles
- There are also indirect climate impacts of these pollutants including
  - Reducing carbon capture of forests by ozone damage
  - Darkening of snow/ice by black carbon
Controllable Global Warming from Black Carbon Emissions
Net of OC, Forcings from IPCC, 2007: 0.25 W/m²
Inventory from T Bond Database, V 7.1.1 Feb 2009

- Transport: 24%
- Households: 36%
- Ag Waste: 4%
- Power: 1%
- Forest and Grassland: 6%
- Ships and Aircraft: 2%

~One-third of net black carbon and carbon monoxide emissions globally come from household fuels
~One-sixth of ozone causing pollutants
~One-twentieth of methane
Climate Warming in 2020 Under Present Trends

Unger et al. 2010

Household Biomass
Perfect Storm for Health Impacts

- Highly polluting activity
- Half of world households
- Several times a day
- Just when people are present
- Most vulnerable (women and young children) most likely to be there
In other words, the Intake Fraction is extremely large.

IF is the fraction of material emitted that is actually breathed in by someone.
IF = 1.0
Heart Disease and Combustion Particle Doses

From “Mind the Gap,” Smith/Peel, 2010 and Pope et al., 2009
Heart Disease and Combustion Particle Doses

From “Mind the Gap,” Smith/Peel, 2010 and Pope et al., 2009
MD-diagnosed Acute Lower Respiratory Infection

Where we Want to Be!

Approximate Mean PM2.5 exposure in 100s of ug/m³

RESPIRE-Guatemala
China’s National Improved Stove Program (NISP) 1981-1998

- China Statistical Yearbook, 2001
- Lu Y., 1993
- Smith et al., 1993
- Qiu et al., 1996
- MOE/DOE 1998
- CERS and CAREI 2000
- China Statistical Yearbook, 2001
Improved Stove in Shanxi
India in 2005

71% households use solid fuel for cooking

Venkataramanan et al. 2010

*Includes coal use:
J: 17%; WB: 13%;
C: 2%; O: 2%

Percent of households using biomass as their primary cooking fuel

* Indicates >1% Coal Use
Only blower stoves are sufficiently clean to mimic performance of gas – where we need to be for health.
Only blower stoves are sufficiently clean to mimic performance of gas – where we need to be for health
Alternative Approaches Do Not Target the Vulnerable

- **Geographic Approach**: Targets entire communities, not the vulnerable households. And does so based on criteria not well correlated with vulnerability.

- **Commercial Approach**: Even with subsidies, is almost inversely correlated with vulnerability, starting with the rich, not the poor.

In addition to starting at the top of the income pyramid, therefore, need to find ways to start at the bottom!
Distribution of Household Cooking Fuel by Income in India

160 million households

NFHS, 2006
Vulnerable populations in India now being reached by national programs

- Rural Housing Program
- Women’s Literacy Program
- Rajiv Gandhi Scheme – rural electrification
- Antenatal Care System
Environment

Toxic Tsunami threatening US health
By OUR CORRESPONDENT
Evidence indicates that a wave of toxic material will soon be affecting US populations. As many as half of all households to be exposed to hazards from new technology far exceeding safety standards. Thousands likely to die.

Prosecutors Seek Trial for Berlusconi
By RACHEL DONADIO 8:43 AM ET
Prosecutors filed a request on Wednesday to try Prime Minister Silvio Berlusconi of Italy on criminal charges related to prostitution and abuse of office.

OPINION »

EGYPT
Editorial: The West must press Egypt's vice president to get serious about reform.
Friedman: The events of Tahrir Square are the wave of the future.

WHAT'S POPULAR NOW

- Brian Jacques, Writer of Redwall Series, Dies at 71
- Forgive Me, Father, for I Have Linked
- Dowd: Forgive Me, for I Have Linked
- Bittman: Is 'Eat Real Food' Unthinkable?
- Op-Ed: A Friendship of Values, Not Convenience
- Room for Debate: Why Can't Americans Save?

MARKETS »
S&P 500 1,322.83
Dow 12,241.36
Nasdaq 2,796.29

The New DealB%k
It will wash across the countryside exposing half the United States population to a toxic soup containing

- Dozens of poisonous organic chemicals known to be mutagens, immune system suppressants, severe irritants, blood poisons, inflammation agents, central nervous system depressants, cilia toxins, endocrine disrupters, or neurotoxins.
- Several other chemicals firmly established as human carcinogens.
- Other toxic inorganic chemicals known to cause asphyxiation, stillbirth, infant death, heart disease, and severe acute and chronic lung disease.
The Toxic Tsunami

• It will be the result of a process that pours this toxic soup directly into half of all US homes every day; all year; every year.
• It will expose families to toxic levels much higher those of people living on top of toxic waste dumps, working in most heavy industries, or residing in the dirtiest cities
• These toxic levels will be tens or hundreds of times the levels set by international and national organizations to protect health
• Insidiously, it will target women and young children in these households
Why would it happen?

• Because a technology will be widely promoted that takes perfectly safe natural material and converts 10% of it to toxins in the course of functioning. Sometimes as much as 20%

• The efficiency of the process is extremely low, leading to little human benefit per unit toxin created as well as waste of the natural resource.

• Instead of carefully disposing of this toxic material in safe places, this industry will spread the toxic soup by air right into neighborhoods where people live.

• All this, in spite of there being well-known alternative technologies available producing very little toxin.
What might be the health consequences if this happens?

- A vast epidemic of a respiratory illness that kills faster than SARS or Avian Flu – initiation to death in 2 days in some cases.
- So fast, that trying to apply medical care is often hopeless.
- Estimates are that soon it would be killing at least 1000 children a week, 50,000 a year
- In addition, thousands of children will be severely burned each year because of this technology, many will die
What else?

- Thousands of women would have their breath taken from them as their lung function is slowly eaten away by exposure to the toxins.
- Thus, at tragically young ages they will become unable to breathe normally or do common tasks.
- Alarmingly, once a woman is affected, there is no known medical therapy to reverse the process.
- More than 500 per week, 25 thousand per year, would soon start to die prematurely because their lungs would finally give out.
Anything else?

• Although some effects are known, so little study has been done of this threat that we are unsure of even all the types of health impacts there would be, let alone their scale

• There are strong indications, however, that the burden on households would include many other insidious diseases, such as
  – Significant exacerbation of heart disease, the most important cause of death in the country
  – A major negative impact on babies’ health and survival through reductions in growth before birth
  – Increases in several types of cancer, including lung and throat
  – Damage to the eyesight of tens of thousands
  – A significant increase in tuberculosis, one of the most important and intransigent of the re-emerging infectious diseases

• Based on animal experiments, we can also expect
  – Reduction in child cognitive capacity (learning ability or IQ)
  – Several types of birth defects
What should the response be?

• Full time coverage on CNN and all other news outlets as the disaster unfolds?
• A major effort coordinated by the National Guard to protect the country?
• Emergency legislation in Congress to provide funds for cleaner technologies?
• New laws and regulations to make sure it never happens again?

In fact, nothing will happen – no one will notice
Evidence indicates that a wave of toxic material will soon be affecting US populations. As many as half of all households to be exposed to hazards from new technology far exceeding safety standards. Thousands likely to die.
Everything stated about the Toxic Tsunami is true, as best we know, except for three aspects:

1. It is already happening
2. In half the world’s households, but not US households
3. No industry is responsible... but poverty and complacency

A sin of omission, not commission

But still killing 1.5 million women and children
Wood is the fuel that

• Heats you twice as Thoreau said?
  – 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
Thank You

Publications and presentations available at my website:

Just Google “Kirk R. Smith”