Household Fuels: Climate and Health Impacts

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Scandal of the Millennium
The Y2K/Y2B Problem

- Although having the richest and most technologically advanced societies in human history, which have brought great wealth, health, and local environmental quality to a larger fraction of humanity than ever before achieved,
  - Earth still has more people living in absolute poverty than anytime in human history

- Y2B; Why, at Y2K, do we still have 2 Billion people living in absolute poverty, with inequity increasing for many populations?

- Another reason to look busy:
  - While solving the global environmental problems that modern society has brought upon us,
  - We had also better find better ways to deal with the Y2B
  - Fortunately, there are ways to move on both at once in cost-effective manners.
Environmental Risk Transition

Health Risk (Lost life-years/capita on a log scale)

Household Hazards

Community Hazards

Global Hazards

Development (PPP/capita)

Data from Smith et al., (in press)
Global Environmental Risk Assessment

Health Damage from Global Hazards

Health Risk (Lost life-years/capita on a log scale)

Development (PPP/capita)

Data from McMichael, et al., 2004
Global Risk Imposed
How to measure?

• Use Natural Debt = current atmospheric burden of GHGs due to past operation of the economy

• Cumulative $\text{CO}_2$ emissions depleted by natural processes per current capita.

• Typical NDs in early 1990s
  – USA: 120 tonnes carbon
  – UK: 85 tonnes
  – India: 4 tonnes

Smith, 1996
Global Environmental Risk Transition

Health Risk (Lost life-years/capita on a log scale)

Health Damage from Global Hazards

Imposition of Global Hazards (Prorated Natural Debt/capita)

Development (PPP/capita)

Smith, et al., in press
Global Environmental Equity Ratio

Ratio of Health Damage Imposed to Health Damage Received (ratio Scale)

Development (PPP/capita)

Smith et al., in press
Climate Exposures

Global (Source/Sinks and Chemistry)

Urban (Sources/sinks and chemistry)

Human Exposures

Climate Exposures

Indoor

Climate and Human Exposures
Biomass Fuels
Wood, Crop Residues, and Dung

- Consumption per capita broadly similar across incomes (e.g., OECD = LDC Asia)
- In MDCs, a small fraction of total energy, but in LDCs it can be a significant fraction
- In MDCs, most use in industrial settings, but in LDCs most use in households
- In MDCs, most is renewably harvested (net CO2 neutral), but in LDCs a significant, but varying and uncertain fraction is not.
- In MDCs, most is burned at high combustion efficiency, but in LDCs, most is not.
1 kg wood

500 g carbon

400-450 g carbon as CO₂

Rest are Products of Incomplete Combustion (PIC)

--80% of which is CO

--Remainder divided among thousands of other PIC

1 kg wood
500 g carbon
Annual Toll from Incomplete Household Combustion in India
160 million biomass stoves in traditional cookstoves

1.6 MT CH₄
19 MT CO
0.03 MT N₂O
2 MT NMHC
1.14 MT BC

Indoor fine particle levels of hundreds of micrograms per cubic meter

Ventataraman, et al., in preparation

Smith, et al, 2004
Evidence for Health Effects of Household Solid Fuel Use: The Exposure Pyramid

- **Community Data**
  - National or regional statistics

- **Household Surveys**
  - Targeted household surveys
  - National or regional surveys (e.g., solid fuel use)

- **Personal Measurements**
  - Microenvironmental monitoring with time-activity data
  - Personal monitoring
  - Biomarkers

- **Uncertainty**

- **Cost and Intrusiveness**
Evidence

• Exposure: only handful of studies around world using measurements, but many national studies of household fuel use

• Exposure/response relationships (epidemiologic risks): A dozen or more for COPD in women; pneumonia in young children; and lung cancer (from coal only)

• A few studies only for TB, cataracts, adverse pregnancy outcomes, asthma, and other cancers. None yet for heart disease
Annual Toll from Incomplete Household Combustion in India
160 million biomass stoves in traditional cookstoves

300 + 300 MT CO$_2$ Equivalent

1.6 MT CH$_4$
19 MT CO
0.03 MT N$_2$O
2 MT NMHC
1.14 MT BC

440,000 premature deaths (65% pneumonia in children; 35% COPD mainly in women)

Indoor fine particle levels of hundreds of micrograms per cubic meter

Ventataraman, et al., in preparation

Smith, et al, 2004
160 million biomass stoves in India.

- Each stove produces 3.75 tonnes CO₂ equivalent
- Each stove produces 0.075 lost life-years (one death per 350 stoves)
- If an improved stove
  - Cost $50 (with dissemination infrastructure) and
  - is 66% effective
- Then either
  - CO₂ reduction costs $10 a tonne and health benefits are free, or
  - Health protection costs $1000/life-year and climate protection is free
  - Or?
Large-Scale Reductions

• **BAU:** The econometric model we developed to project household fuel use indicates a slowly falling fraction of households using solid fuels, but a fairly constant absolute number (the Y2B phenomenon)

• **Millennium Development Goals: Indicator for Environmental Sustainability**
  - Fraction of households using solid fuels
  - No targets or timetables set
  - No mechanism in place to provide reliable annual estimates
How to Achieve More Rapid Reduction of Household Solid Fuel Impacts #1

• Improved Stoves
  – Current improved stoves just have chimneys
    • Often actually increase total emissions, but can lower exposures to some degree
    • Unproven, but exciting, potential of gasifier stove technology with dramatically lower emissions
    • May need to combine with fuel processing, as in other sectors
Health risk

GWC

Traditional Stove

Improved Stove

Also other important benefits including fuel savings, time savings, and less pressure on natural bio-resources
Potential for co-benefits in China
How to Achieve More Rapid Reduction of Household Solid Fuel Impacts #2

• Improved Local Fuels – gases and liquids from biomass
  – Biogas (biological gasification) works well, but potential is limited by resources and climate
    • GHG implication not clear because of potential of methane leaks
  – Other technologies exist for converting biomass, but none are near economic or otherwise practical for most settings
How to Achieve More Rapid Reduction of Household Solid Fuel Impacts #3

- Improved Fuels –Accelerate movement up energy ladder to clean fossil fuels, i.e. LPG and kerosene
  - Resisted by NGOs and agencies because not “renewable” and leads to additional pressure on petroleum fuel cycles
  - But, because of substantial PIC (non-CO\textsubscript{2} GHG) from direct biomass combustion, LPG may actually have lower GWC than renewably harvested biomass
  - It certainly does if biomass is not renewably harvested
  - Half percent/year increase in fuel efficiency of world auto fleet would “release” all fuel needed for household cooking within 10 years – it is not households that stress petroleum supplies
  - Cost is real issue, however.
20-Year GWC of different household fuels in China: “Kyoto” CO$_2$+CH$_4$+NO$_x$

And how much of that is renewable?
20-Year GWC of different household fuels in China: $\text{CO}_2 + \text{CH}_4 + \text{NO}_x + \text{CO} + \text{TNMHC}$
Barriers

• Y2B not on radar, although MDGs help
• Health evidence for impacts of household fuel use do not meet strict criteria required by international health community, but this is slowly coming
• GHG/BC inventories not well developed, along with potential of interventions.
Sources of Uncertainty in Household Emission Inventories

- Number and size of devices – m
- Type of devices – m
- Type and amount of fuel used – m
- Fuel quality - m
- Use cycle – l
- Emission factors – m → s

Level of uncertainty: s – small; m – medium; l - large
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• GHG/BC inventories not well developed, along with potential of interventions.
• Poor framing of GWC issues by Kyoto, the only game in town
  – Non-CO2 gases (CO, NMHC, etc., and BC
  – Time Horizons
Time Horizons

• Does reflect need to weight effects over time, but does so in odd, physically and economically unrealistic manner

• Why, for example, should we care equally about warming for every year up to 20 years and then care nothing about year 21?

• Smooth functions are needed and the most well developed is the discount rate with each year’s warming reduced by $1/(1+ R)$ from the year before, with $R =$ discount rate, which commonly varies from 3-10% in large-scale project analyses.
Time horizon e.g., 20 years
Discount rates

• Benefits and costs need to be discounted in same fashion or distortions occur in decisions (undesirable outcomes)
  – Consider zero or very low discount rates (long time horizons) for GWP
    • Since the funds we might use are discounted at a few percent or more, we might as well just invest the money and in 10 years we would have more to spend on GHG control rather than spend anything today
    • We might spend all our funds on very small sources/gases that have very long lifetimes, ignoring problems in near term
Barriers

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  – Non-CO2 gases and BC
  – Time Horizons
• Household fuels not generally considered in trading mechanisms
• No good way to include co-benefits—global warming and health—let alone time savings, women’s status, ecological protection, etc.
Are biomass fuel emissions significant in the global context?

- 2-5% of CH$_4$ emissions
- 6-15% of CO emissions
- 8-25% of hydrocarbon emissions
- 4-8% of all human-generated global warming from gases
- Significant contributor of BC
- Significant contributor to ill-health, 9$^{th}$ most important risk factor globally, 2$^{nd}$ among environmental risk factors
Global Combustion Mismanagement

- Sticking burning stuff in your mouth
- Letting it burn in your home
- Letting it burn in your community
- Putting toxins in it before burning
- Burning it on your planet faster than natural depletion mechanism work
Global Combustion Mismanagement

- Smoking
- Indoor air pollution from solid fuel use
- Urban outdoor air pollution
- Lead in gasoline and other fuels
- Climate change

- Total = about one in seven of all deaths in the world occurs prematurely because of PIC