Household Fuels: Climate and Health Impacts

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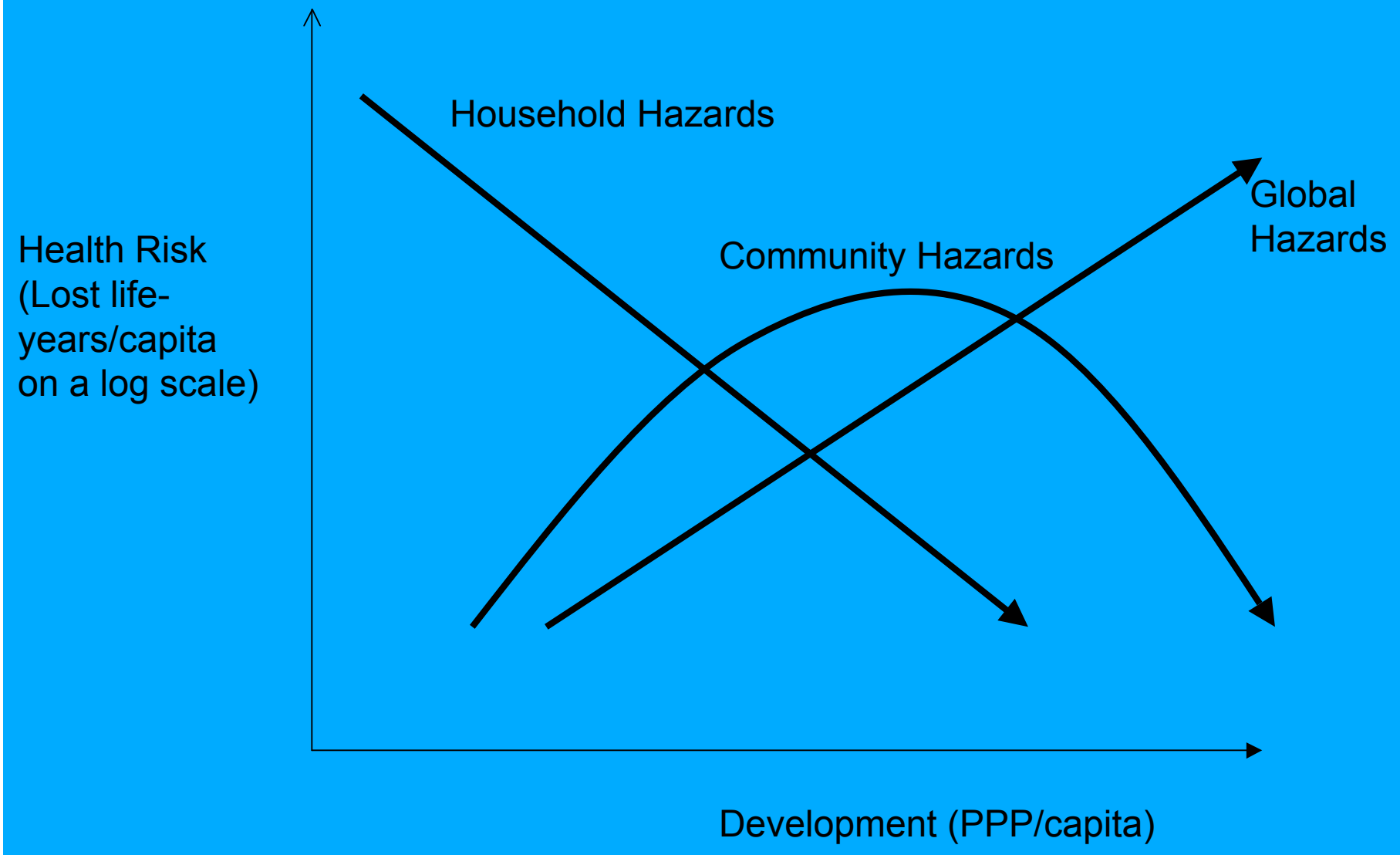
Scandal of the Millennium
The Y2K/Y2B Problem

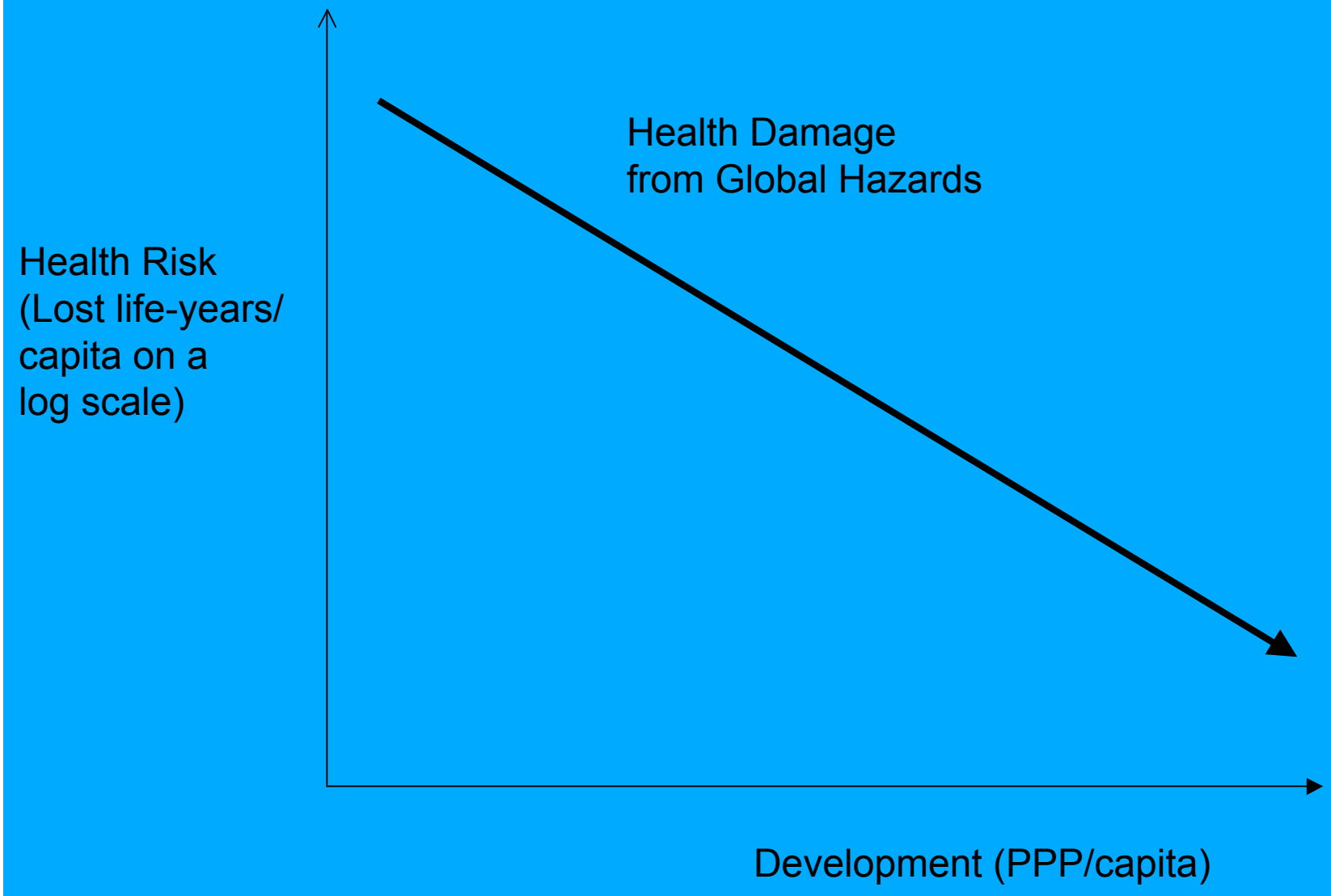
- Although having the richest and most technologically advanced societies in human history, which have brought great wealth, health, and local environmental quality to a larger fraction of humanity than ever before achieved,
  - Earth still has more people living in absolute poverty than anytime in human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



Data from Smith et al., (in press)

Global Environmental Risk Assessment



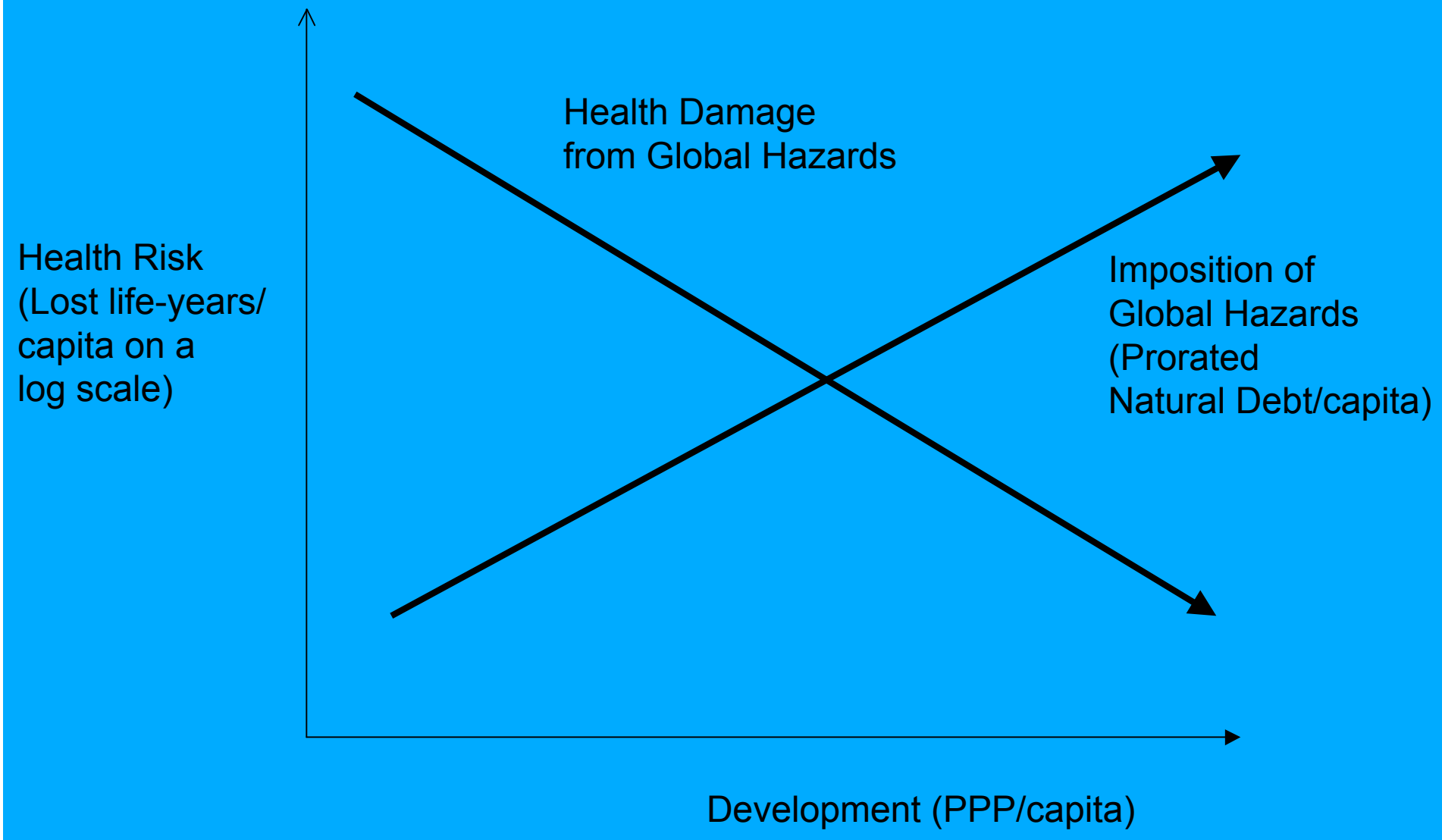
Data from McMichael, et al., 2004

Global Risk Imposed How to measure?

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

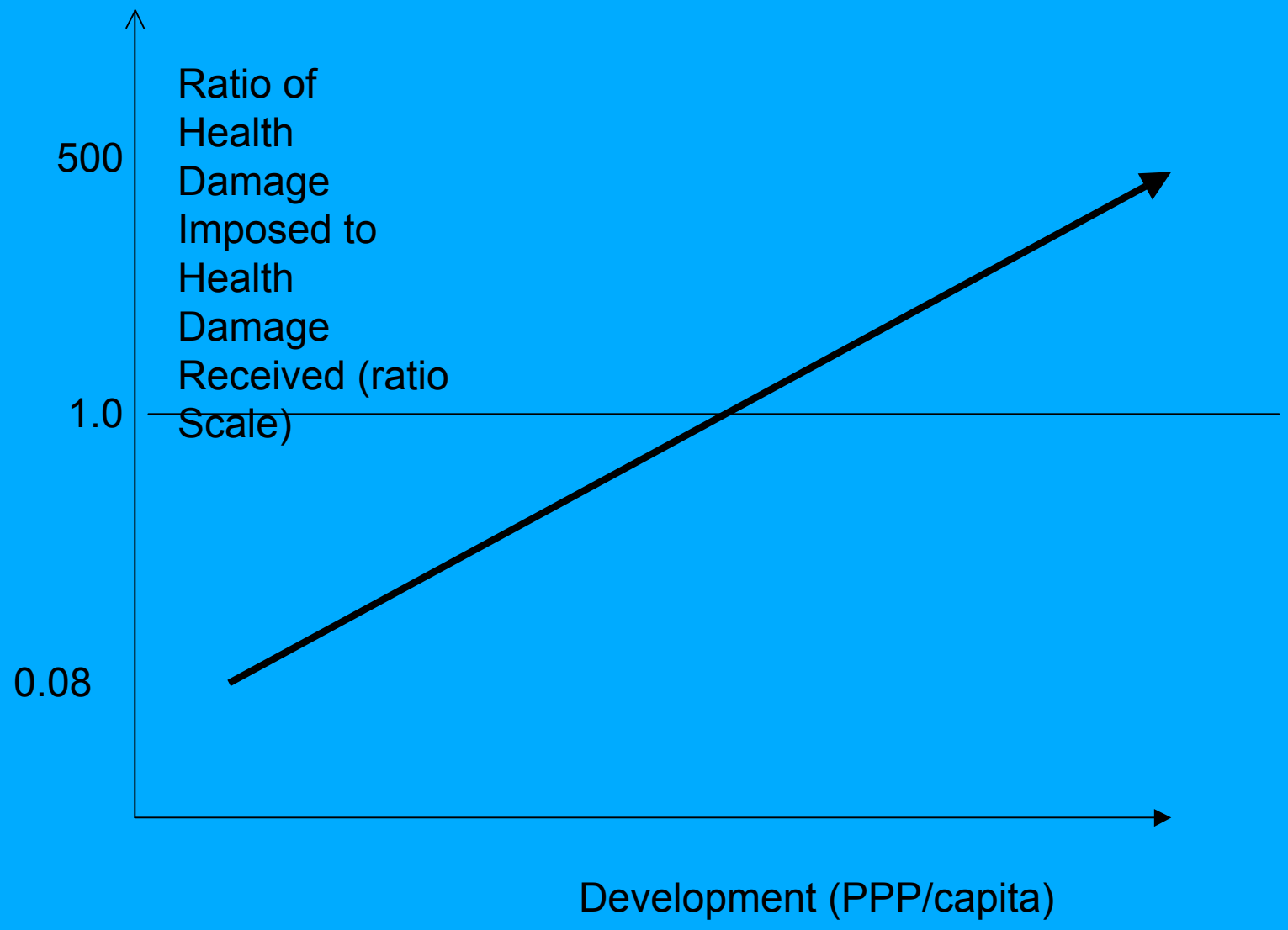
Smith, 1996

Global Environmental Risk Transition

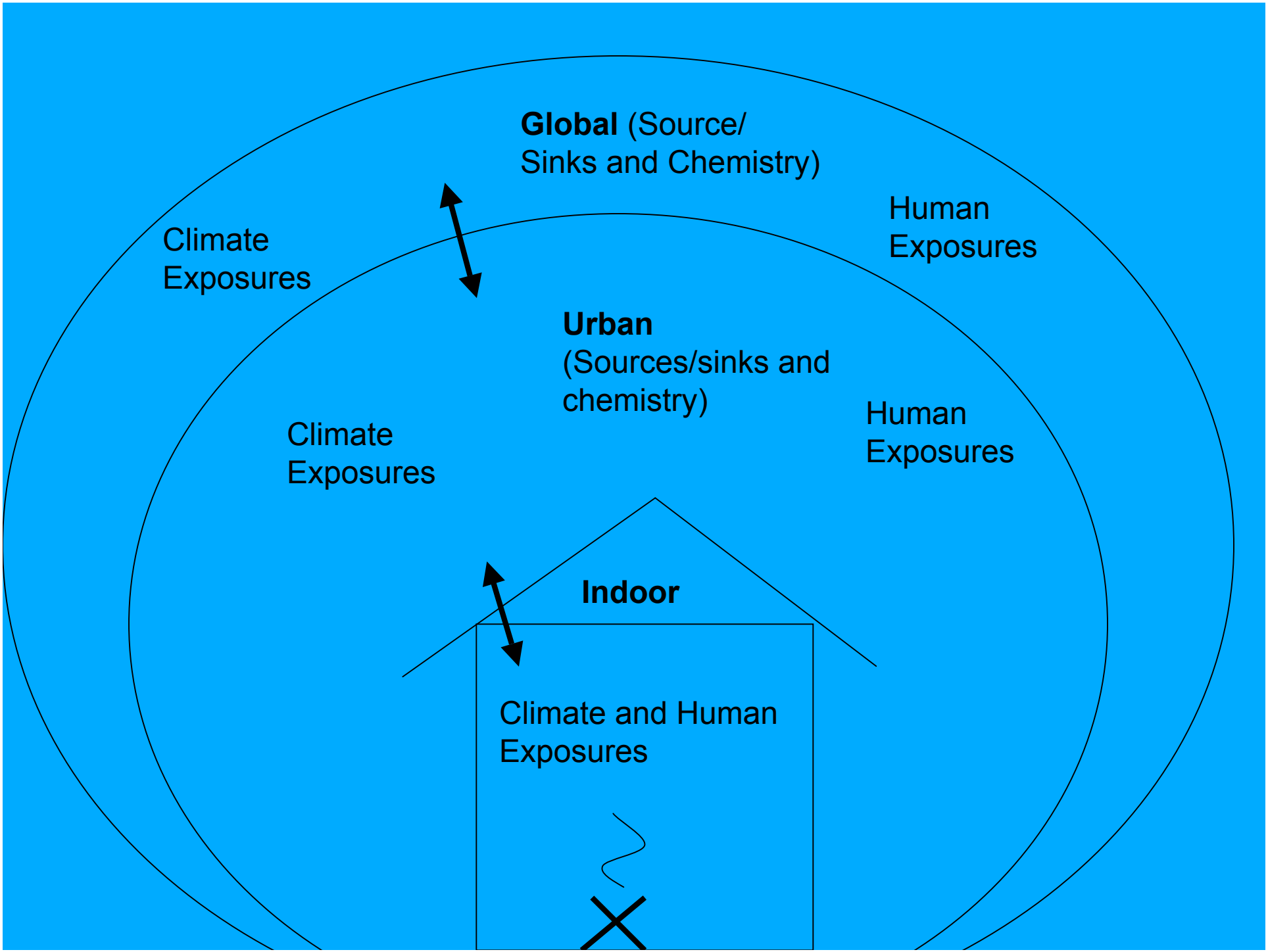


Smith, et al., in press

Global Environmental Equity Ratio

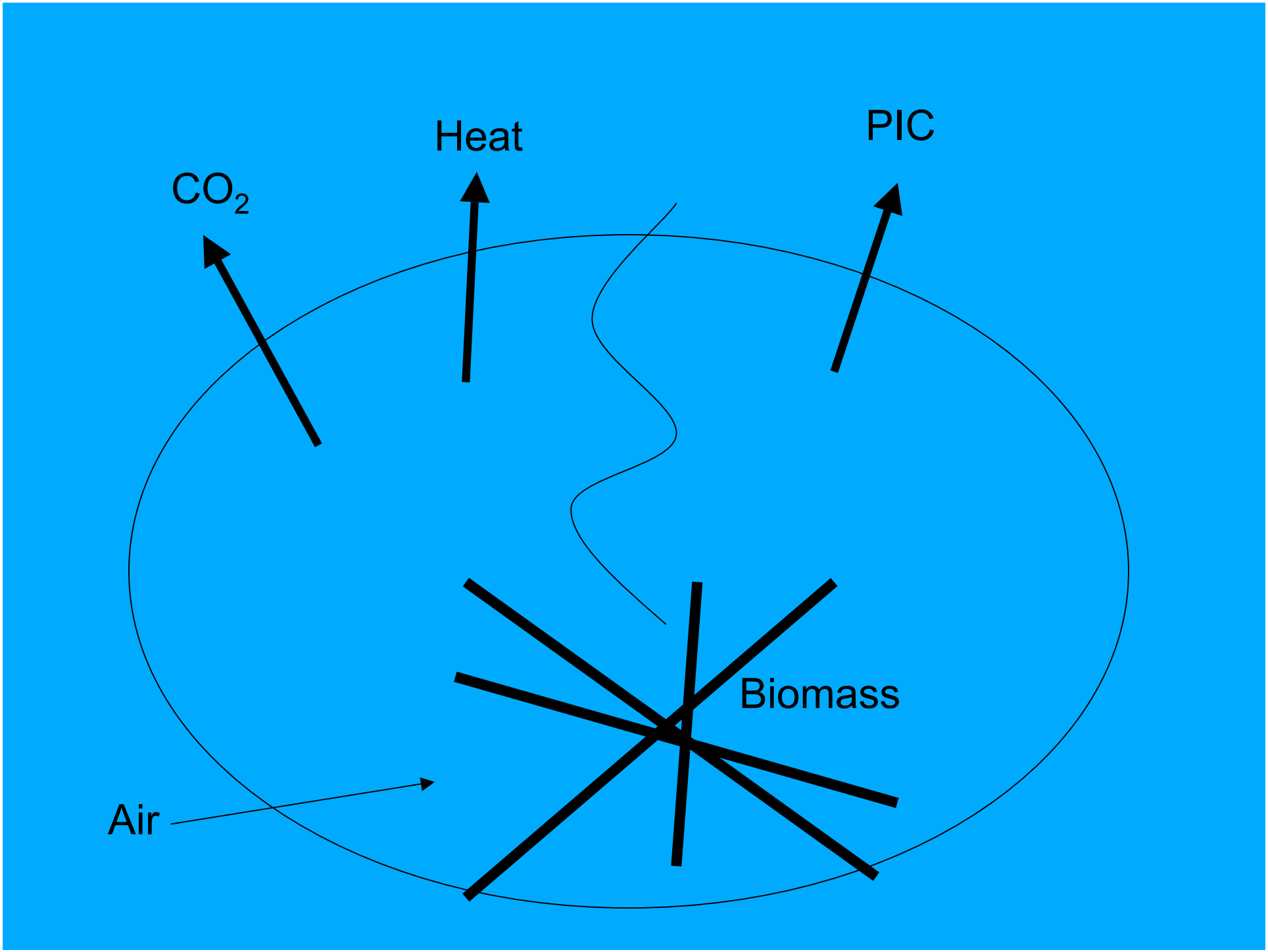


Smith et al., iin press


Global (Source/
Sinks and Chemistry)
Climate
Exposures
Human
Exposures
Urban
(Sources/sinks and
chemistry)
Climate
Exposures
Human
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 signficant, but varying and uncertain fraction is not.
- In MDCs, most is burned at high combustion efficiency, but in LDCs, most is not.


Heat
PIC
CO_2
Biomass
Air

400-450 g carbon as CO_2

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

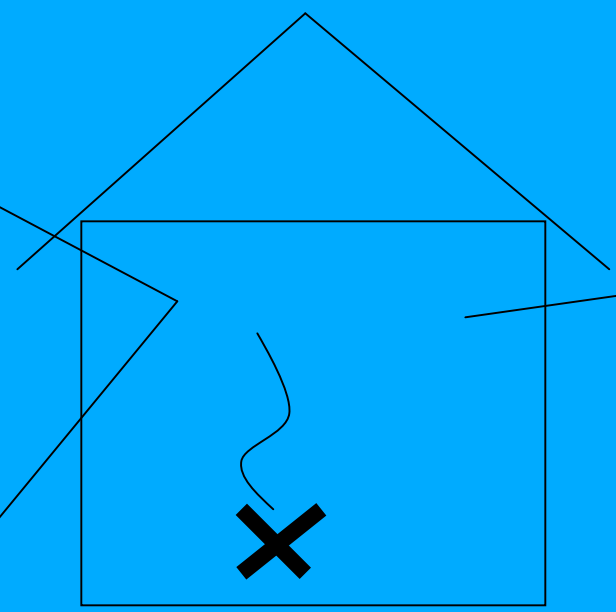
1.6 MT CH_4

19 MT CO

0.03 MT N_2O

2 MT NMHC

1.14 MT BC

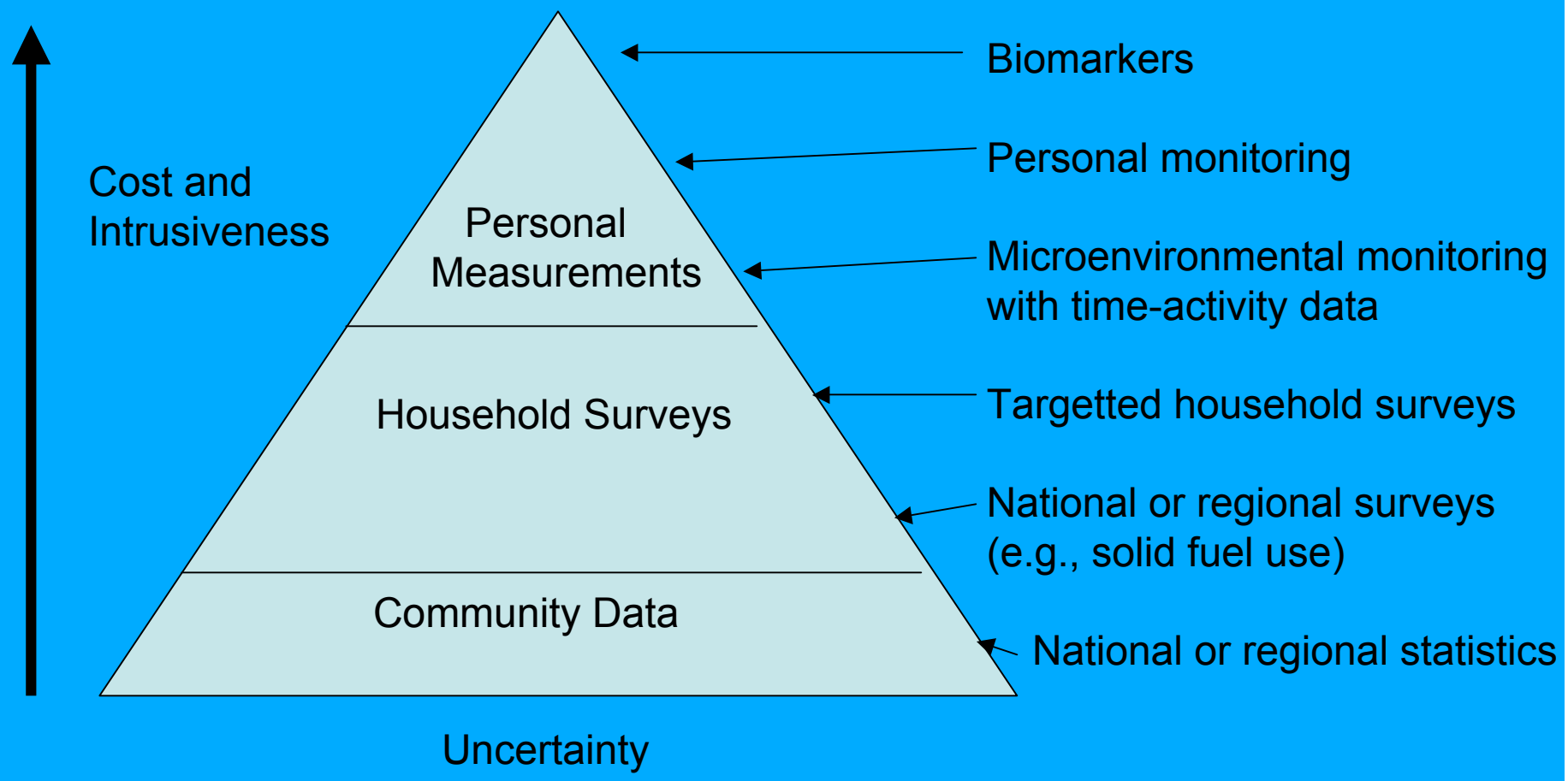


Indoor fine particle levels of hundreds of micrograms per cubic meter

Ventataraman, et al., in preparation

Smith, et al, 2004

Evidence for Health Effects of Household Solid Fuel Use: The Exposure Pyramid



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

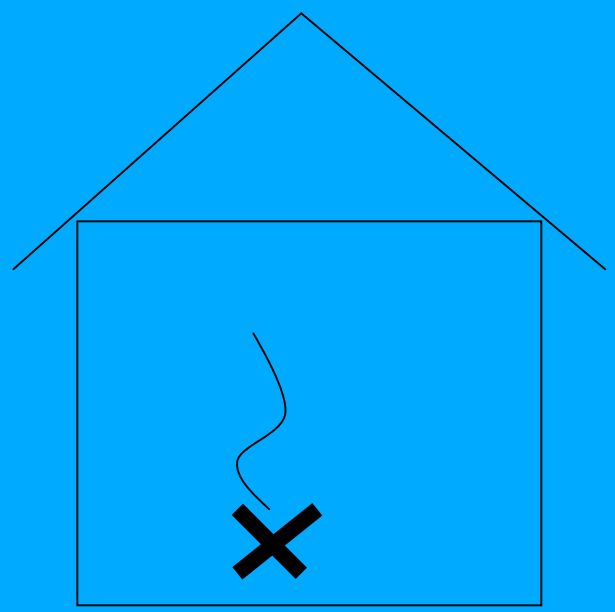
1.6 MT CH_4

19 MT CO

0.03 MT N_2O

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.

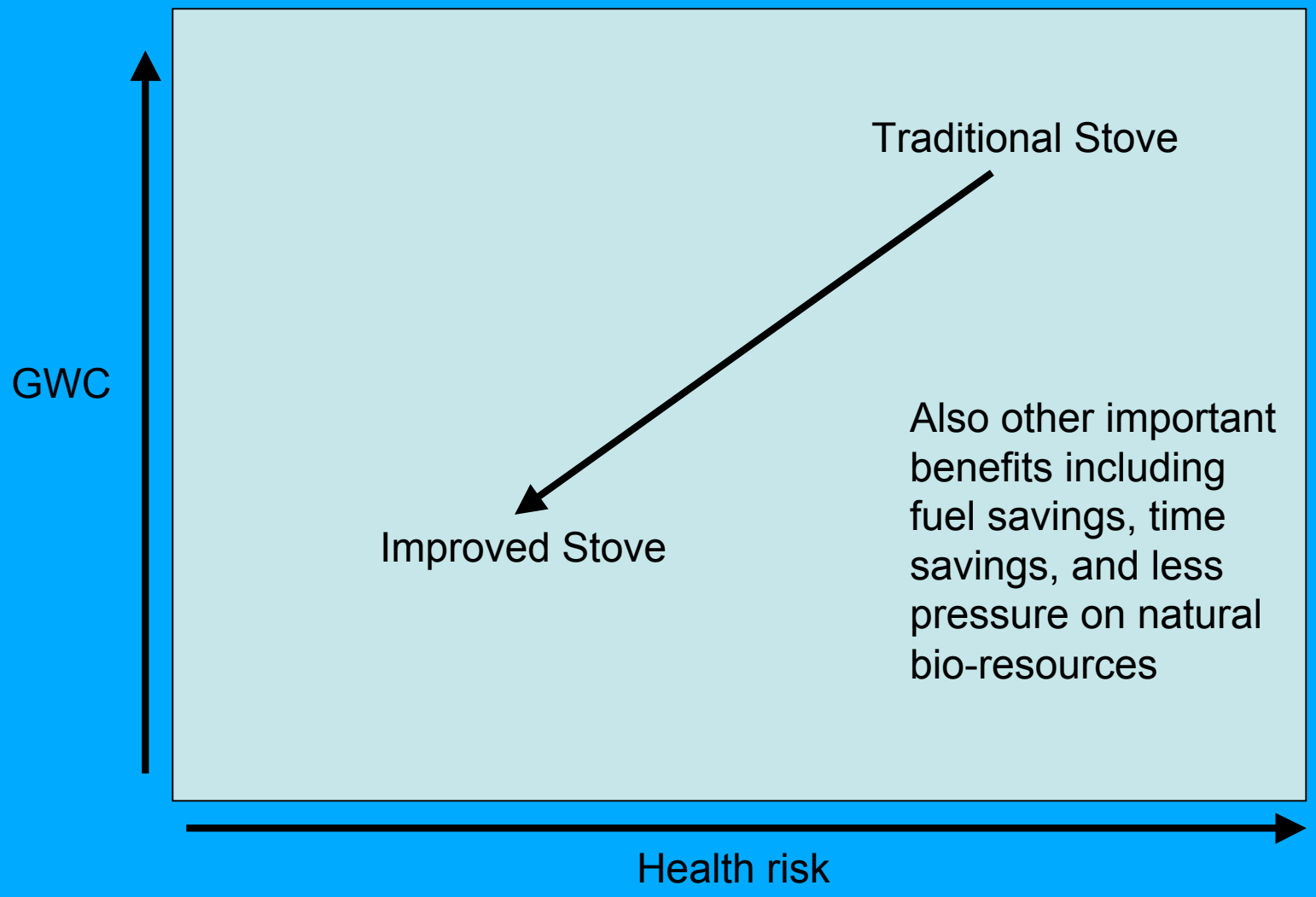
- Each stove produces 3.75 tonnes CO_2 equivalent
- Each stove produces 0.075 lost life-years (one death per 350 stoves)
- If an improved stove
  - Cost $50 (with dissemination infrastructure) and
  - is 66% effective
- Then either
  - CO_2 reduction costs $10 a tonne and health benefits are free, or
  - Health protection costs $1000/life-year and climate protection is free
  - Or?

Large-Scale Reductions

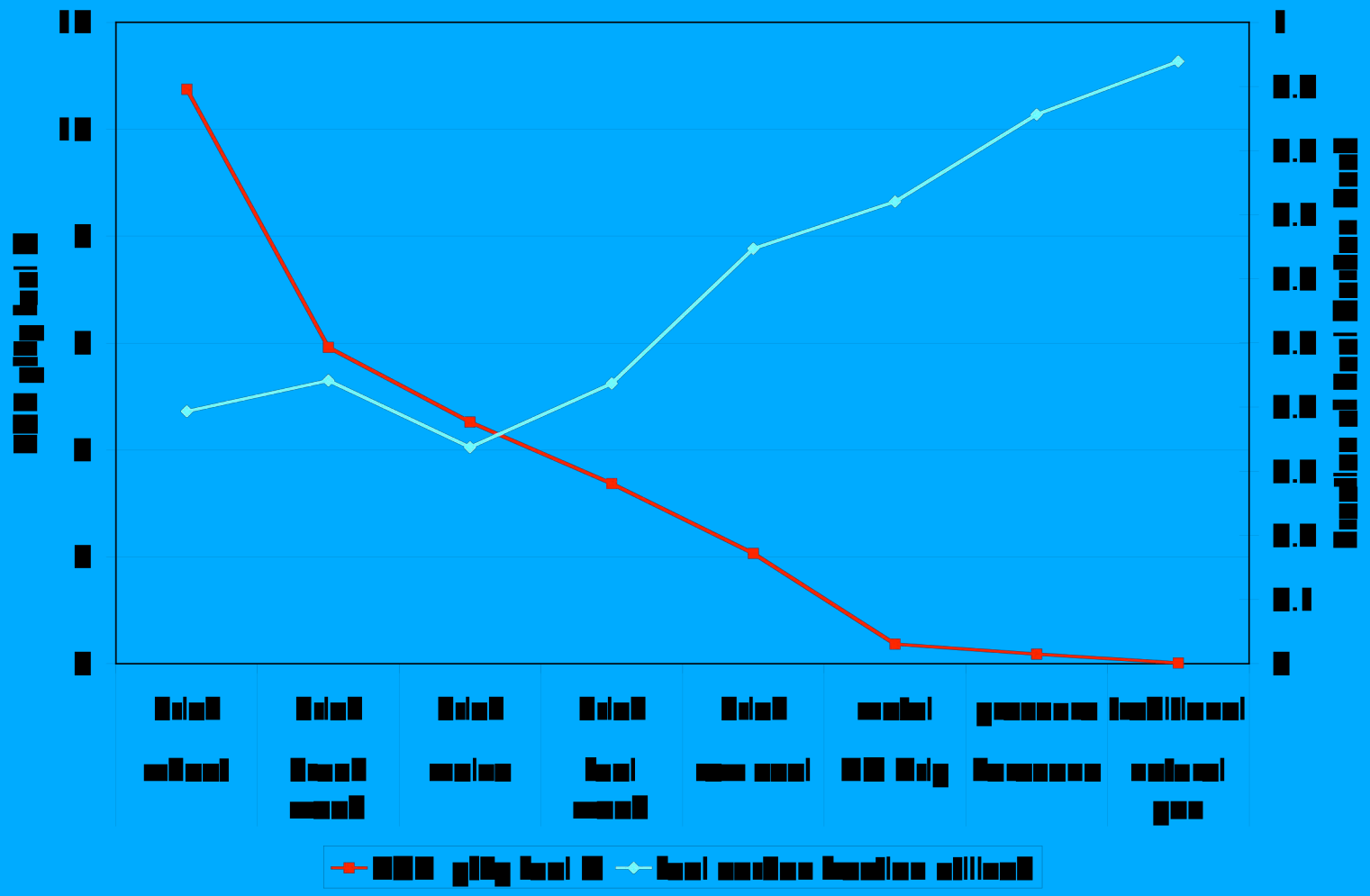
- BAU: The econometric model we developed to project household fuel use indicates a slowly falling fraction of households using solid fuels, but a fairly constant absolute number (the Y2B phenomenon)
- Millennium Development Goals: Indicator for Environmental Sustainability
  - Fraction of households 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


Traditional Stove
GWC
Also other important benefits including fuel savings, time savings, and less pressure on natural bio-resources
Improved Stove
Health risk

Potential for co-benefits in China



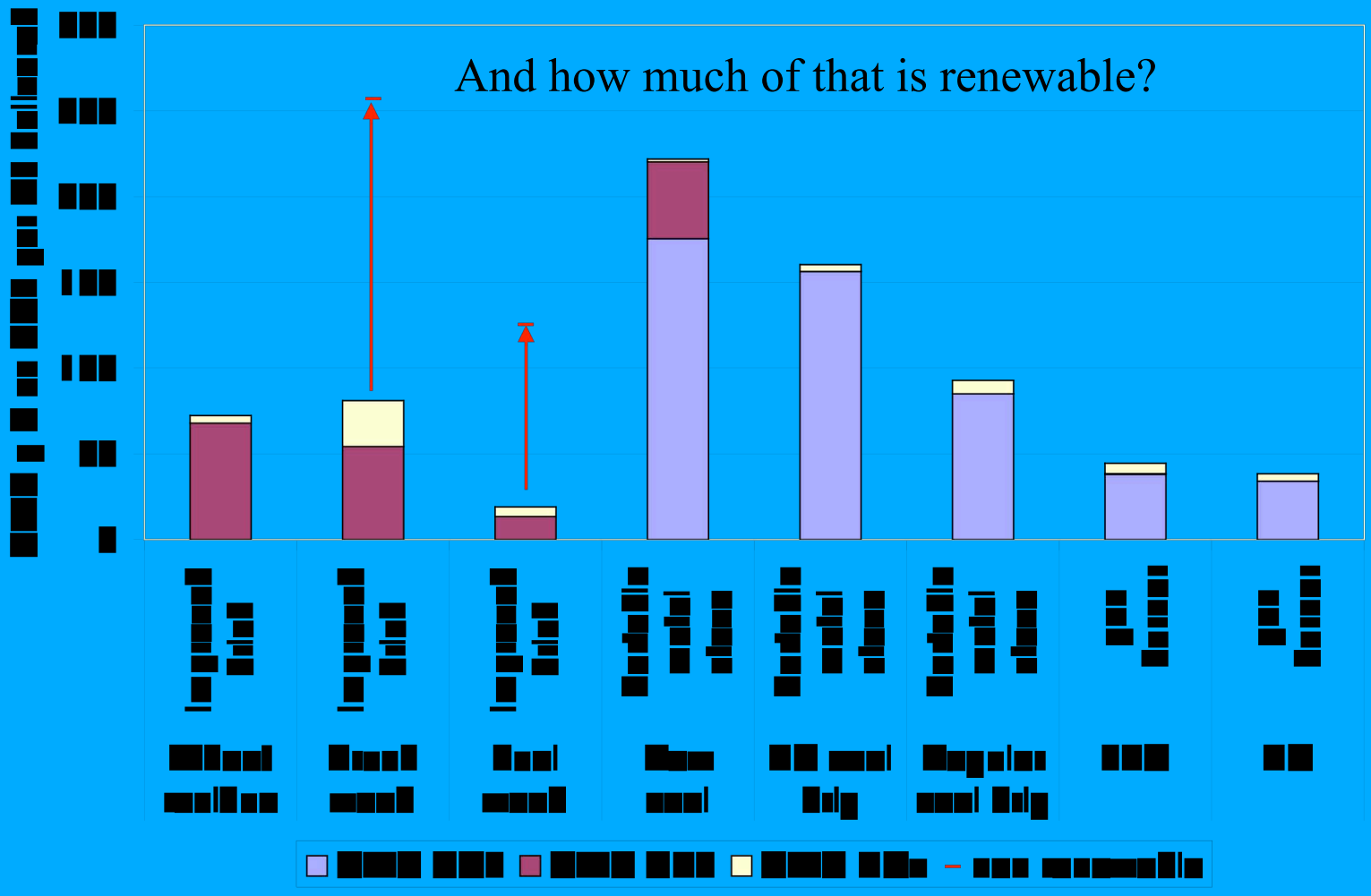
How to Achieve More Rapid Reduction of Household Solid Fuel Impacts #2

- 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

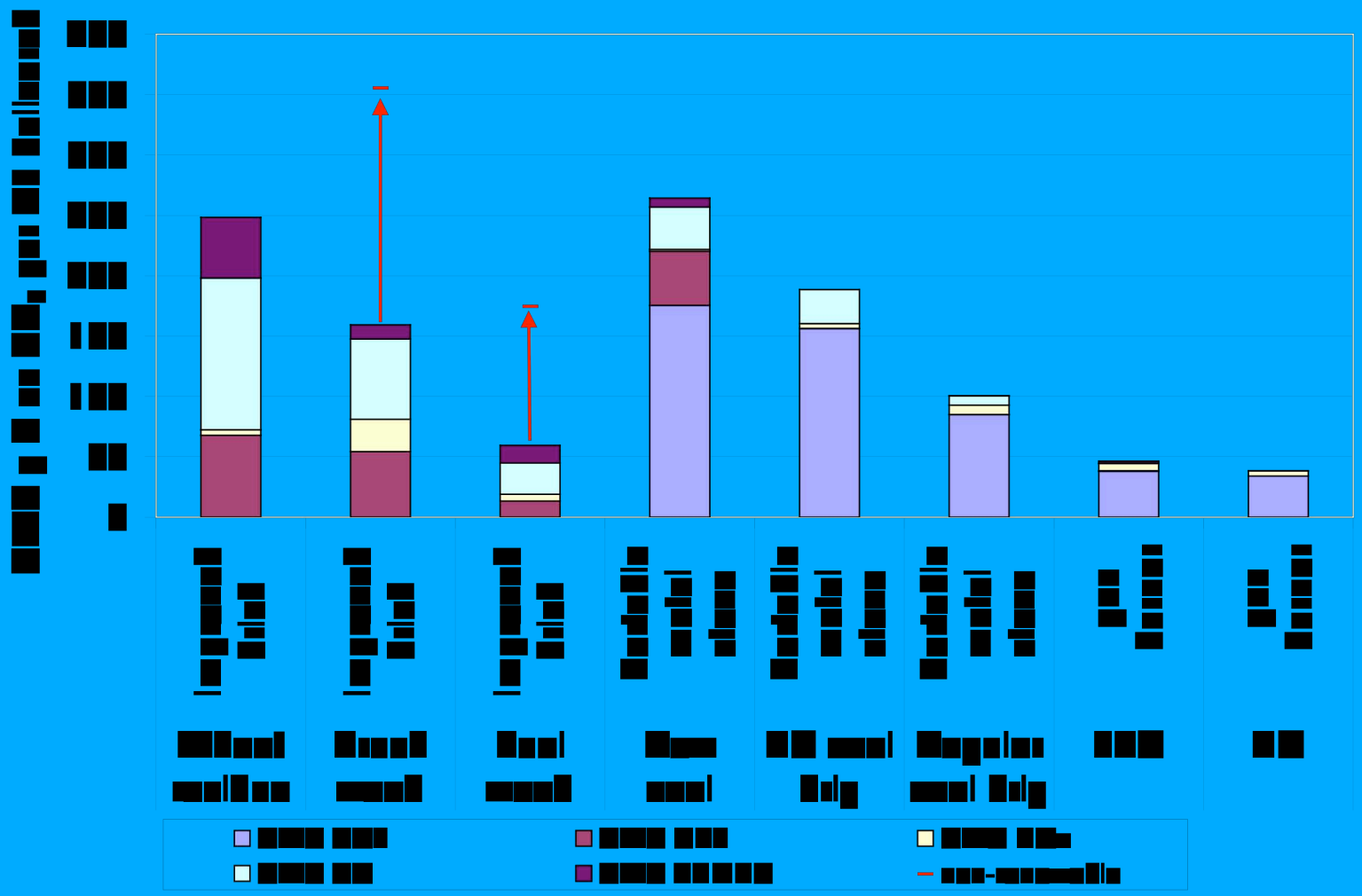
How to Achieve More Rapid Reduction of Household Solid Fuel Impacts #3

- 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_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



20-Year GWC of different household fuels in China: CO_2+CH_4 +NO_x + CO+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

Barriers

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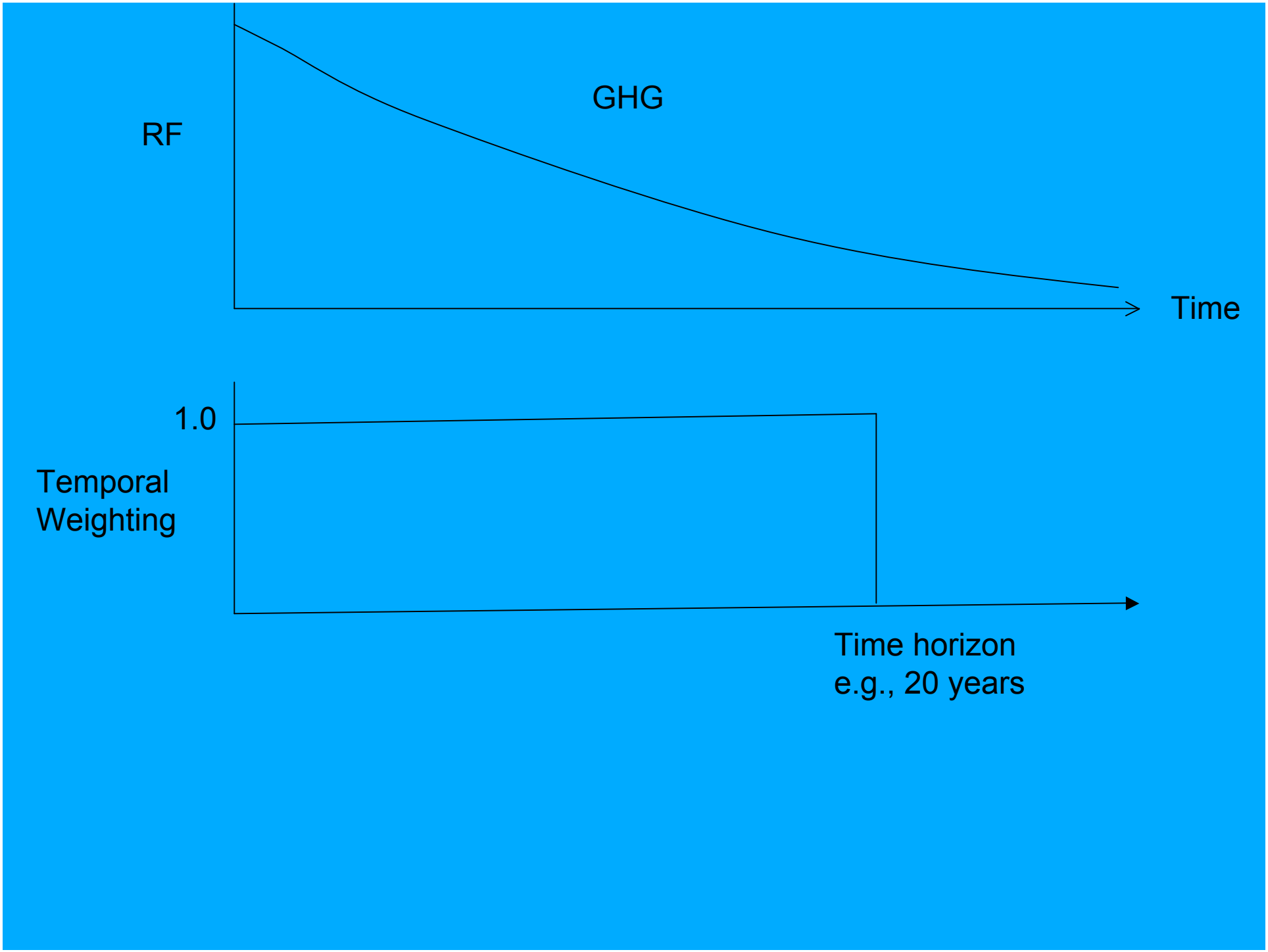
- Health evidence for impacts of household fuel use do not meet strict criteria required by international health community, but this is slowly coming
- GHG/BC inventories not well developed, along with potential of interventions.
- Poor framing of GWC issues by Kyoto, the only game in town
  - Non-CO2 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

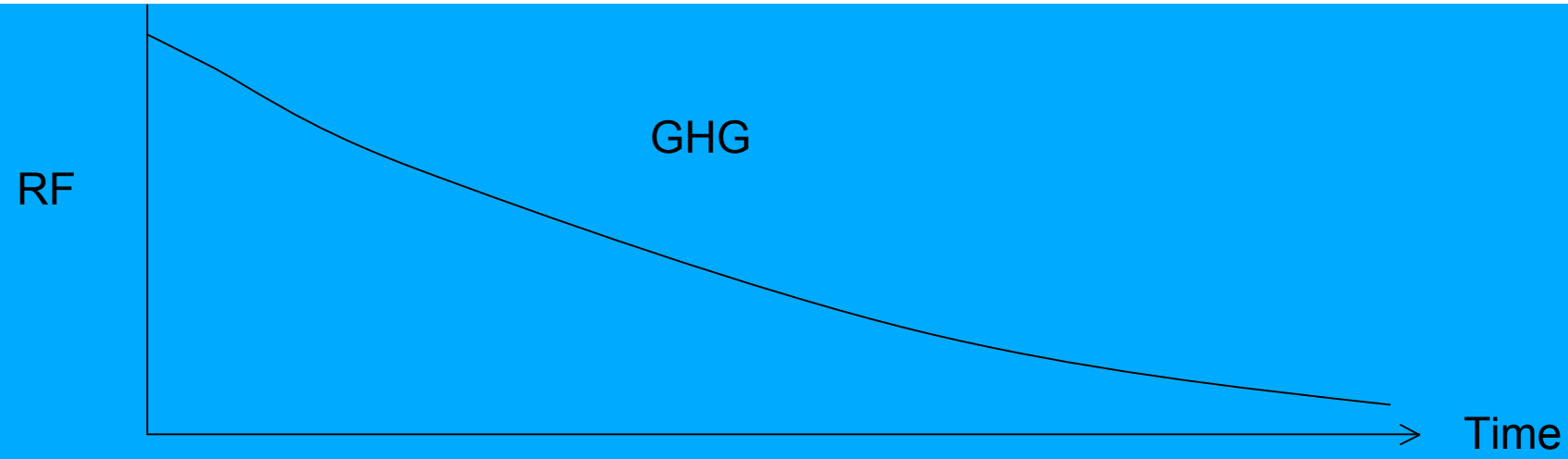
- Why, for example, should we care equally about warming for every year up to 20 years and then care nothing about year 21?

- 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.

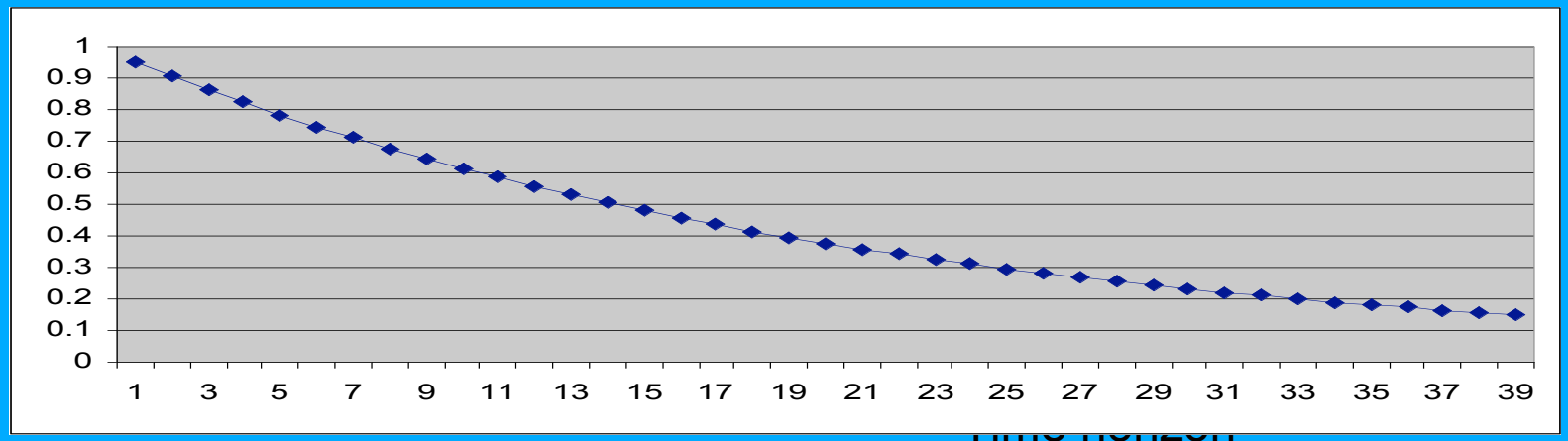

GHG
RF
Time
1.0
Temporal
Weighting
Time horizon
e.g., 20 years

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 GWPs
    - 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



Temporal Weighting



Discount Rate

Barriers

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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 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, 9th most important risk factor globally, 2nd 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