Energy and World Development – Challenges for Health and Climate

> Roy F. Weston Distinguished Lecture in Global Sustainability University of Wisconsin, Madison April 21, 2008

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Growth of world population & affluence since 1850 brought 20-fold increase in energy use, the principal source of CO₂ emissions



1950-2000 was 3.15%/yr, driven mainly by oil & natural gas



Sources and Fates of Human Carbon Emissions – Billion Tons of Carbon Annual Mean: 2000-2005

- Fossil fuels ~ 7.2
- Tropical deforestation ~ 1.7
- Total ~ 8.9

- Uptake by oceans ~
 2.2
- Uptake by terrestrial ecosystems ~ 2.6
- Storage in atmosphere ~ 4.1

IPCC 2007

What is climate?

Climate consists of averages and extremes of

- hot & cold
- wet & dry
- snowpack & snowmelt
- winds & storm tracks
- ocean currents & upwellings

and not just how much & where, but also when.

Why does climate matter?

Climate governs

- Productivity of farms, forests, & fisheries
- Geography of disease
- Livability of cities in summer
- Damages from storms, floods, wildfires
- Property losses from sea-level rise
- Expenditures on engineered environments
- Distribution & abundance of species

Where we're headed without any serious mitigation.

HADCM2 GHG ensemble (2041-70)–(1961-90) Annual Mean Temperature (°C)



Hadley Centre for Climate Prediction and Research

Computer simulation of mid-21st-century warming under Business as Usual

Four short briefings

- What are the direct health effects from climate change?
- What are the implications of climate health effects for world development?
- <u>Co-benefits: achieving both climate and</u> health protection with energy policy
- How important is energy use in affecting climate for the next 20 years?





Figure 8.3. Direction and magnitude of change of selected health impacts of climate change (confidence levels are assigned based on the IPCC guidelines on uncertainty, see http://www.ipcc.ch/activity/uncertaintyguidancenote.pdf).

IPCC WGII, 2007

Comparative Quantification of Health Risks

GLOBAL AND REGIONAL BURDEN OF DISEASE ATTRIBUTABLE TO SELECTED MAJOR RISK FACTORS

Volume 1

Edited by

MAJID EZZATI, ALAN D. LOPEZ, ANTHONY RODGERS AND CHRISTOPHER J.L. MURRAY



World Health Organization Geneva

Published in 2004, 2 vols, ~2500 pp (available on WHO CRA website)

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



Cartogram of Climate-related Mortality (per million pop) yr. 2000



Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR, 2007, <u>Climate change</u> and global health: Quantifying a growing ethical crisis, <u>EcoHealth</u> 4(4): 397–405, 2007.

Health Impacts from Climate Change by Income Level across the World



Smith & Ezzati, 2005

PPP per capita

WHO Comparative Risk Assessment Climate Change Health Impacts as of 2000

- Diarrhea 2.4% of global burden
- Malaria 2%; 6% in some regions
- 17% of protein-energy malnutrition
- 7% of dengue fever in some rich countries
- 150,000 deaths, 99% in poor countries (46% in South Asia)
- 0.4% of all DALYs (lost healthy life years)
- Most (88%) of impact in children under 5
- Not large today, but growing rapidly.
- It is not what is attributable today, but avoidable today that is the concern.

1000 years of Earth temperature history...and 100 years of projection





TODAY

YEAR

-1

Society has three basic options for responding to human-caused climate change

- <u>Mitigate</u> by working to reduce greenhouse gas (GHG) emissions from energy and land use or to capture them from the atmosphere in order to slow or, perhaps, reverse warming
- <u>Adapt</u> by reducing the negative effects of climate change through protecting coastlines, moving populations away from impacted areas, increasing efforts to control climate-related vectorborne diseases, insulating cities from heat stress, and so on.
- <u>Suffer</u>, i.e., given that efforts in the first two arenas above are moving slowly, there is very likely to be suffering, perhaps considerable in poorer parts of the world, because of the climate change committed already
- We will be doing all three, but can reduce the third if we put more effort into the first two.





1. Efficient vehicles 2. Reduced use of vehicles 3. Efficient buildings 4. Efficient coal power plants 5. Gas instead of coal power plants 6. Capture CO₂ at baseload power plant 7. Nuclear power for coal power 8. Wind power for coal power 9. PV power for coal power 10. Capture CO₂ at H₂ plant 11. Capture CO₂ at coal-to-synfuels plant 12. Wind H₂ in fuel-cell car for gasoline in hybrid car 13. Biomass fuel for fossil fuel 14. Reduced deforestation, plus reforestation, afforestation, and new plantations. 15. Conservation tillage for soil management

Health Effects Determined by Several Factors

- Stress imposed,
 - For example environmental changes due to climate change
- Susceptibility to those stresses,
 - For example., how much climate change will produce a doubling of diarrhea deaths in a particular place
- Background disease rate,
 - For example, doubling diarrhea death rates in Madison does not have the same impact as doubling them in Mozambique
- Background nutrition, health surveillance, emergency preparedness, health care delivery, etc.
 - For example, the same strength hurricane in Florida may kill 50 people, but in Bangladesh it will kill 5000



Child Mortality Wedges: 2005-2030



Children in

Bottom Line on Climate Health Effects

- Mostly affect the most vulnerable populations in the world – esp. children in poor countries
- This population already highly impacted ~ 10 million avoidable deaths each year
- Progress is slow in reducing this toll and is threatened by climate change
- Not all diseases affected equally
- Has implications for altering our plans to take climate change into account by both
 - accelerating efforts to do what we should be doing anyway
 - Shifting our priorities among diseases







World Energy Assessment, 2004

First person in human history to have her exposure measured doing one of the oldest tasks in human history

> Kheda Distric Gujarat, India

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



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 *n*-hexane

In US regulatory terminology, there are significant emissions of 3 Criteria Air Pollutants and at least 28 Hazardous Air Pollutants (HAPs)

Plus thousands of other organic compounds

- 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*

ALRI/ Pneumonia (meningitis)

Asthma

Low birth weight

Early infant death

Cognitive Impairment? Diseases for which we have some epidemiological studies Chronic obstructive lung disease

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

Blindness (cataracts, trachoma)

Tuberculosis

Heart disease?

ALRI associated with use of solid fuels: analysis of ~12 observational studies

Subgroup analyses	Odds ratio (95% CI)
All studies	2.3 (1.9- 2.7)
Use of solid fuel	2.0 (1.4-2.8)
Duration of time child spent near the cooking fire	2.3 (1.8- 2.9)
Studies adjusting for nutritional status	3.1 (1.8-5.3)
Studies not adjusting for nutritonal status	2.2 (2.0-3.0)
Children aged <2 years old	2.5 (2.0-3.0)
Children aged <5 years old	1.8 (1.3-2.5)

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



A Chinese Biomass Gasifier Stove Tests show emissions nearly at LPG levels: Low health risk and essentially no greenhouse emissions Winner of Chinese national contest announced March 2007 for best stove meeting

emissions and reliability criteria: cost 300Y





Health and Greenhouse Gas Benefits of Biomass Stove Options





Figure: Smith & Haigler, in press



Smith & Haigler, 2008

The Methane Story: CH₄





Methane

- A much more powerful greenhouse gas (GHG) than CO₂
- Partly due to its direct effect, but also because it creates ozone (O₃), another powerful GHG
- About 100 times more per ton than CO₂ at any one time
- Methane has thus contributed a significant amount to global warming, more than half that of CO₂
- But has a much shorter atmospheric lifetime compared to CO₂
- Thus, changes in emission rates will have a much faster impact to lower warming



Warming in 2005 from emissions since 1750

IPCC, 2007





Methane (cont.)

- Way to reduce warming in the next generation is to put more attention on methane (and other shorter lived GHGs)
- Once the heat enters Earth's systems, it does not matter where it came from
- The rate of warming is as important as the total amount
- Way to slow the rate is to immediately reduce methane emissions
- While working to stop CO₂ in the long run

Warming in next 20 years from this year's emissions



IPCC, 2007

Methane, cont.

- Increases of wide-scale ground-level ozone is becoming a major world problem
- A significant health-damaging pollutant
- Methane emissions are one of its causes
- Reduction of methane emissions, therefore, will help protect health worldwide in the short term

Background Ozone is Growing ...



Ozone trend at European mountain sites, 1870-1990 (Marenco et al., 1994).

... and Will Continue to Grow!

Historic and future increases in background ozone are due mainly to increased methane and NO_x emissions (Wang *et al.*, 1998; Prather et al., 2003).

2100 (IPCC A2) - 2000



Multiple Benefits of Reducing Methane

Reducing ~20% of anthropogenic methane emissions will:

- Be possible at a net cost-savings.
- Reduce 8-hr. average ozone globally by ~1 ppb.
- ➢ Reduce global radiative forcing by ~0.14 W m⁻².
- Provide ~2% of global natural gas production.
- Prevent ~30,000 premature deaths globally in 2030, ~370,000 from 2010-2030.

Mauzerall, 2007

Global Methane Emissions



* USA is ~9% of global anthropogenic emissions.

EDGAR3.2 & Houweling *et al.*, 1999

National Household Solid Fuel Use, 2000



Greenhouse warming commitment per meal for typical woodfired cookstove in India



Indian Households Using Biomass Fuels

2 million tons methane per year of 300 Mt total human emissions

Smith, et al. 2000 Percentage of Households 0-24 25-49 50-74 75-100 unknown

*Source: Census of India 1991

Total CUMULATIVE Greenhouse Gas Emissions in the Year 2002, by Country



Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR, 2007, <u>Climate</u> change and global health: Quantifying a growing ethical crisis, <u>EcoHealth</u> 4(4): 397–405, 2007. Total CUMULATIVE Greenhouse Gas Emissions in the Year 2002, by Country



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International Natural Debt Per Capita



International Natural Debt Per Capita



Ratio of largest to smallest emitters considering both CO_2 and methane $\sim 40x$

C



Conclusion on Methane

- Methane emissions are more important than current official weighting factors indicate because of its large effect over the next generation
- Likely to increase in "value", perhaps during the post-Kyoto deliberations now starting
- Ways to control are quite different from CO₂
- Developing countries have a bigger role
- Methane is emitted as part of the poor combustion process of solid fuels, which also produce much health-damaging pollution
- Improving this combustion offers substantial GHG as well as health benefits in a cost-effective manner

Climate Change and Health

- Climate change adds to the age-old challenges of public health due to
 - poverty
 - inequity
 - ignorance
 - complacency
 - counterproductive personal behavior
 - conflict
 - Infection, and
 - environmental stress
- It threatens to enhance existing risks at every level of development, from
 - heat stress in Barcelona to
 - malaria in Botswana.

CC and Health (cont.)

- In terms of absolute burden of disease, however, it most threatens the poorest and most vulnerable in all societies, closely in inverse proportion to income, wealth, and power.
- The rich will find their world to be more expensive, inconvenient, uncomfortable, disrupted, and colorless;
 - in general more unpleasant and unpredictable, perhaps greatly so.
- The poor will die.

Conclusion

- Perhaps the most telling simple definition of public health is that it is the
 - "Science and art of making people healthy before they are wealthy (and then keeping them that way)."
- Although altering both the rules and the stakes, the emergence of climate change on the world stage reinforces this vision of public health's mission.
- It also reinforces the need to find ways to bring moral sensibilities to bear
- Even the most extreme estimate of the health effects of climate change does not come close to the hundreds of millions of children slated to die already because of our inaction in the next generation.

Food for a Week, Germany



Food for a Week, Darfur Refugees, Chad





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Thank you