Household Energy, Air Pollution, and Health

### Kirk R. Smith

Professor of Global Environmental Health School of Public Health, UC Berkeley

Collaborative Clean Air Policy Centre India Habitat Centre, New Delhi

## **Standards for Comparison**

- WHO Guideline health effects found above this level – 10 ug/m3 annual average
- US standard: 12 ug/m3
- Chinese standard: 35 ug/m3
- Indian standard: 40 ug/m3



## Delhi's pollution in 2016 – note effects of 1) the holiday (Diwali) and 2) crop residue burning

### PM2.5 concentrations in $\mu$ g/m3

box plot = measured hourly avgs from all public continuous monitoring stations ribbon plot = WRF-CAMx model forecasted hourly avgs for ~2000 1km x 1km grids over Delhi

#### PM2.5 concentrations in $\mu$ g/m3

box plot = measured hourly avgs from all public continuous monitoring stations ribbon plot = WRF-CAMx model forecasted hourly avgs for  $\sim$ 2000 1km x 1km grids over Delhi



### REGION: Urban Built-up Area of NCR Delhi Modeled PM2.5 Source Contributions in $\beta g/m3$



# India is Leading the Way

- Report of the Steering Committee on Air Pollution and Health Related Issues, Ministry of Health and Family Welfare, December 2015
- First Ministry of Health in the world to pay attention to air pollution and put into national health context
- Mandate was health, not pollution from particular sources or in particular places – thus not indoor or outdoor, rural or urban, but integrated human exposure (non occupational)





5 Page 8

#### Population using solid fuels (%), 2010 Total



The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement. Data Source: World Health Organization Map Production: Public Health Information and Geographic Information Systems (GIS) World Health Organization



© WHO 2012. All rights reserved.



### 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  $H_2O$  when it is combined with oxygen (burned)?



Reason: the combustion efficiency is far less than 100%

Toxic Pollutants in Wood Smoke from Simple (poor) Combustion

- Small particles, CO, NO<sub>2</sub>
- Hvdrocarbons

Typical biomass cookstove releases 300-400 cigarettes per hour worth of smoke

- 33+ phenols such as *catechol* & *cresol*
- Many quinones such as *hydroquinone*
- Semi-quinone-type and other radicals

Source: Naeher et al, J Inhal Tox, 2007

• Chlorinated organics such as *methylene chloride* and *dioxin* 

#### Does Not Take Much Time in Villages to See Smoky Households

### Health-Damaging Air Pollutants From Typical Woodfired Cookstove in China.





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

~6900 ug/m3 during cooking >500 ug/m3 24hour --50 times WHO guideline

> Kheda District, Gujarat, 1981



State-wise estimates of 24-h kitchen concentrations of PM2.5 in India

Solid-fuel using households

Balakrishnan et al. 2013 (SRU group)

### The Environmental Health Pathway





Burnett et al., EHP. 2014, Integrated Exposure-Response Functions



#### India, Both sexes, All ages, 2016



### India, Both sexes, All ages, 2016



# Remember

- Numbers are highly uncertain here are central estimates
- And changing with new models and databases
- Some health outcomes not included
  - Low birth weight/prematurity
  - TB/asthma
  - Other cancers: cervical, etc.
  - Diabetes, arthritis, low IQ



## Satellite-based ambient PM<sub>2.5</sub>





25

van Donkelaar et al, EHP 2010

# What has been done-#1 Wait for development to work.

- Percent using solid fuel slowly declines with development alone (no special policies)
- But in India, the number of people exposed has never declined



ropulation (minimus)



Fig. 1. Distribution by state of households using biomass or coal as their main cooking fuel in 2005. From (IIPS, 2007).

1990:85%: 700million peopleusing solid fuels

2010: 60%: 700 million people

~1980 700 million people in entire country

# What has been done #2: Make the available clean

- Many hundreds of "improved" biomass stove programs over ~60 years
- Including major national programs in China and India in the 1980/90s covering ~200 million households in all
- And in India, Peru, Mexico, Nepal, Honduras, and other countries today
- Hundreds of NGOs, big and small, promoting stoves around the world over the decades



# Unfortunately

- The cleanest "improved" biomass stoves have been disseminated to only a few tens of thousands of households in the world
- And, in spite of much progress, as yet, no "improved" biomass stove in the world comes close to the boundary between solid and nonsolid fuels
- Thus, none seem clean enough to be reliably truly health protective in household use
- But more effort is still warranted.

### Risk Curve for PM<sub>2.5</sub> and Child ALRI risk



### **Conceptual Indian Energy Ladder**



**Increasing Prosperity and Development** 

# New Paradigm

Making the clean available

Liquefied Petroleum Gas - LPG

Except in USA, a mixture of butane and propane

In USA, the butane is used to enhance gasoline – thus just propane

Liquefies just above ambient pressure and thus easy to store and ship

Derived from natural gas production and off-gases from oil refining

World supply greatly increased due to "fracking" Classic LPG Cylinder and Stove









Centre for Occupational and Environmental Health (MAMC)

#### **nternational Conference**

on Occupational and Environmental Health





Centre for Occupational and Environmental Health (MAMC)

# International Conference Occupational and Environment

13-14 December 2013 New Delt

KIRK R. SMITH

VIVEK RAE
# Give It Up campaign

- Middle class gives up their LPG subsidies
- Health is the message "make a poor man's kitchen clean"
- Extensive social marketing
  - Modi and other celebrities in speeches, media ads, bill boards, etc
  - SMS messages
  - Fairs, athletic events, posters, skits, etc
  - Website linking those giving up to those receiving: middle class to poor



: Initiated by

#### Ministry of Petroleum & Natural Gas

Government of India

Feel the Joy of Giving





- Shri Narendra Modi, Hon'ble Prime Minister

#### Shri Narendra Modi

Hon'ble Prime Minister

shall distribute

LPG connections to 5000 BPL families under the GiveltUp campaign



Date: 2<sup>nd</sup> October 2015 | Venue: Dumka Airfield Ground, Dumka, Jharkhand | Time: 1:00 pm



Times of India Oct 2, 2015

## Gandhi's Birthday

## MyLPG website: Feb 24, 2016



## Total no of customer who have Giveitup subsidy

We appreciate your action of giveitup. It truly demonstrates your care and concern towards the less privileged. Your example will surely motivate millions. Annual Savings accrued till now (₹ 13976740800)



1	State :	All States	۲	Consumer No :			SUBMIT			
(	Consumer Name			Consumer No		St	ate			
	Sankar Baidya			52311		An	Andaman And Nicobar			
I	Ratan Chandrakar			13006		An	Andaman And Nicobar			
	Y.md. Shahul Hameed			45830		An	Andhra Pradesh			

Search By:   Giveitup Champion   Beneficiary							
earch Name:	LPG Id: 3						
SEARCH SHOW ALL							
#Giveitup CHAMPION	BENEFICIARY						
MUNIAMMAL	MISHRI DEVI GURJAR						
J.RAY CHOUDHARY	BALE . MALLAIAH						
KALAISELVI. V. MRS.	SHIV. KUMAR						
SHREE RAJA GOVIND SINGH KHANDI	ELA RIYAJ . AHMAD						
MOHD.SHAHID	A. RASHID S/O KARIMULLA						
SAFIQ	EESVAR . SINGH						
MAHENDRA PRASAD TRIPATHI	VIJENDRA . JATAV						

## Union Budget 2016: Govt announces LPG connection for women of BPL households

TNN | Feb 29, 2016, 11.52 AM IST

Curso Seguridad Nacional Estudia Seguridad Nacional en USA 100% Online y en Español.Infórmate online.nuc.edu/Curso-JCriminal



Stock Market Crash 2016 Stock Market's "Day of Reckoning" is Fast-Approaching. Shocking www.thesovereigninvestor.com

Ads by Google

orld Health

anization



Union Budget 2016: Govt announces LPG connection for women of BPL households EW DELHI: The government On Monday announced a new initiative to provide cooking gas to women members of BPL families with state support.

"I have set aside a sum of Rs 1000 crore in Union Budget 2016 to meet the initial cost of providing these LPG connections," finance minister

# LPG expansion, cont.

- Ujjwala Campaign: April 1, 2016
  - Extend past GIU with more incentives
  - To reach a total of 50 million below poverty line households in 3 years
  - Plus 50 million other households
  - 1.2 billion USD devoted by Indian Gov
  - 250 million USD/year from middle class
  - 10,000 new distributors being hired
  - A huge enterprise!

### **Conceptual Indian Energy Ladder**



**Increasing Prosperity and Development** 

# India: What happened?

#### **Millions**



# India: What happened?





## India: What If?

#### **Millions**



# Of course

- Just providing affordable access to LPG or other clean fuel does not mean people instantly switch 100%
- However, since 60% of world uses gas and/or electricity it argues strongly that the others will eventually follow.
- Is clearly what is needed in long term why not sooner rather than later using techniques learned from other health sectors?

## **Economic Issues #1**

- Give it Up brilliant idea to turn an economic embarrassment into an asset
- What other middle class subsidies might be applied this way as well?
- We are exploring in the case of California
  - Vehicle registration
  - Homeowner exemption

## Economic Issues #2

- For health assistance to the poor, we do not refer to taxpayer expenses as "subsidies" but "social investments"
- Primary health care, vaccines, baby delivery services, etc.
- Only when the assistance is untargeted, as it has been for LPG, are we forced to accept the negative term "subsidies"

# Subsidy or ?

- In order for public support of clean fuels to be termed social investments, they need to be far better targeted than in the past.
- Give it up helps, but far more targeting is needed
- Insufficient income tax coverage to use this metric
- Use of modern asset-based indicators from national surveys offer some hope
- Embrace modern IT to do so

– JAM: bank accounts, ID card, mobile phone

## Targeting subsidies can save money

- Eliminating subsidies to upper 2-3 quintiles
- Keeping current levels for those in the 4<sup>th</sup> (and maybe 3<sup>rd</sup>)
- Increasing in the bottom quintile by~100 Rs a cylinder
- Would keep everyone's clean household fuel cost less than 4% of income
- And cost the government less than the current system

## If we could differentiate income quintiles

Quintile Class	Monthly Household Consumption Expenses (MHCE)	Amount of LPG required per month (@ 8.9 cylinders (14.2kg) per household-year)	Price of LPG per kg (cylinder cost) to keep the % expenditure on fuel below 4%
Quintile 5 (Top 20			
%)	15882	11	58 (820)
Quintile 4	11675	11	42 (600)
Quintile 3	9739	11	35 (500)
Quintile 2	8580	11	31 (440)
Quintile 1 (Bottom			
20 %)	6980	11	25 (355)

Tripathi, in prep

## **Economic Issues #3**

- How to include non-financial factors in policy assessments
- Without drifting off the table in credibility
- Extended cost-effectiveness analysis is one approach
- Understanding effects by income quintile is important

#### Disease Control Priorities 3<sup>rd</sup> Edition, Vol 7, World Bank

## Injury Prevention & Environmental Health



#### Published today, Oct 27, 2017



2



#### Household Energy Interventions and Health and Finances in Haryana, India: An Extended Cost-Effectiveness Analysis

Ajay Pillarisetti, Dean T. Jamison, and Kirk R. Smith

## **Extended Cost Effectiveness Analysis**

- Haryana, a poorish state near Delhi
- Evaluate clean cooking options
- Include value of time savings based on the Rural Employment Scheme – actually available alternative use of time in much of rural India
- Best estimates of costs savings to households of improved health

#### Figure 12.3 Averted Private Expenditure for Each Class of Intervention Over the Proposed Five-Year Intervention Lifetime



Note: LPG = liquefied petroleum gas; Q = quintile. Negative values indicate net costs to households. However, the upper quintiles are voluntarily giving up their subsidy in the GIU campaign. Annex 12A, figure 7 shows the per household costs and savings by income quintile and intervention scenario.

## **Economic Issues #4**

- Application of conditional cash transfer (CCT) methods
- Working with pregnant women in Maharastha, a group already receiving many CCT benefits
- We are applying the "pink key"

# Birthweight 10 studies – half in South Asia

- Exposure to smoke from biomass cookfires associated with 86 gram reduction in birthweight
- Compared to clean fuel



#### Amegah, PLOS One, 2014



#### Conditional cash transfer enabled by novel stove use monitor

#### System components

Sensing harness consisting of two silicon diodes connected to the burners and to a female headphone jack mounted on the front of stove

The Pink Key / datalogger – a PIC chip with basic data-logging capability and onboard diode to provide a reference temperature.

An algorithm based on a hot and cold threshold, a time above threshold limit, and an event-clustering constant

The Pink Key outputs the total sensing time between downloads, the time each burner is in use, and the total numbers of meals cooked across burners

Households receive a voucher every two weeks; funds are deposited automatically into the woman's bank account



#### Sample Stove Use Monitoring Data





# Collaborative Clean Air Policy Centre

New Delhi info@ccapc.org.in http://ccapc.org.in/

# Collaborative Clean Air Policy Centre

Joint Activity of Indian Institute of Technology Delhi Sri Ramachandra University Chennai The Energy and Resources Institute (TERI) University of California Berkeley and UrbanEmissions.com – knowledge partner

info@ccapc.org.in http://ccapc.org.in/

# Mission

## • The CCAPC

- evaluates, and compares policy options for dealing with India's health-damaging air pollution of all types,
- provides a platform for institutions to work together to solve problems and recommend policy, and
- works to develop capacity to address the policy implications of air pollution in the country.

# Many thanks

For publications & presentations: Just "Google" Kirk R. Smith





## A 450 million litre-per-year corn ethanol plant in South Dakota



Source: Tollefson (2010, *Nature* 451, 880–883)

## **Biomass Resources and Use**




Page 73



Page 74