Biomass Cookfuels and Health in Nigeria:

What is the problem and where is it going?

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The three major solid fuels
Population Cooking with Solid Fuels in 2010 (%)

~74% in Nigeria
Nigeria
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%
Toxic Pollutants in Wood Smoke from Simple (poor) Combustion

- Small particles, CO, NO₂
- Hydrocarbons:
  - 25+ saturated hydrocarbons such as n-hexane
  - 40+ unsaturated hydrocarbons such as 1,3 butadiene
  - 28+ mono-aromatics such as benzene & styrene
  - 20+ polycyclic aromatics such as benzo(α)pyrene
- Oxygenated organics:
  - 20+ aldehydes including formaldehyde & acrolein
  - 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

Typical open cookfire releases 400 cigarettes per hour worth of smoke

Source: Naeher et al, J Inhal Tox, 2007
How much PM$_{2.5}$ is unhealthy?

• WHO Air Quality Guidelines
  – 10 ug/m$^3$ annual average
  – No public microenvironment, indoor or outdoor, should be more than 35 ug/m$^3$

• National Standards
  – USEPA: 12 ug/m$^3$
  – China: 35 ug/m$^3$
  – India: 40 ug/m$^3$
Typical Annual PM$_{2.5}$ Levels

- Worst city in the world: $\sim$150 ug/m$^3$
  - Average: $<$30 ug/m$^3$
  - Accra: $\sim$50 ug/m$^3$
The world’s most polluted cities are in India

PM 2.5 (micrograms per cubic meter) in the most polluted cities worldwide in 2014

- Delhi: 153
- Patna: 149
- Gwalior: 144
- Raipur: 134
- Karachi: 117
- Peshawar: 111
- Rawalpindi: 107
- Khormabad: 102
- Ahmedabad: 100
- Lucknow: 96
- Firozabad: 96
- Doha: 93
- Kanpur: 93
- Amritsar: 92
- Ludhiana: 91

Source: WHO
Typical Annual PM$_{2.5}$ Levels

- Worst city in the world: $\sim$150 ug/m$^3$
  - Average: $<30$ ug/m$^3$
- Worst village households: $>2000$ ug/m$^3$
  - “Average” village household: $\sim300$ ug/m$^3$
Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013

GBD 2013 Risk Factors Collaborators*
The Energy Ladder: Relative Pollutant Emissions Per Meal

Smith, et al., 2005
Relative disability-adjusted life years (DALYs) are a measure used to quantify the global burden of disease. The chart shows various health-related factors and their associated DALYs, with LPG (Low Global Burden) being highlighted as a benchmark. Further analysis is required to understand the specific contributions of each factor to the global burden of disease.
Nigeria, Both sexes, All ages, 2013

Malnutrition

Unsafe sex

Air pollution

WaSH

Alcohol & drug use

High blood pressure

Dietary risks

High body-mass index

Occupational risks

HIV/AIDS & tuberculosis
Diarrhea/LRI/other
NTDs & malaria
Maternal disorders
Neonatal disorders
Nutritional deficiencies
Other group I
Neoplasms
Cardiovascular diseases
Chronic respiratory
cirrhosis
Digestive diseases
Neurological disorders
Mental & substance use
Diabetes/urog/blood/endo
Musculoskeletal disorders
Other non-communicable
Transport injuries
Unintentional inj
Self-harm & violence
~70,000 premature deaths each year
Nigeria, Both sexes, All ages, 2013

DALYs

Household air pollution

Ambient particulate matter

Ozone

Switch cause group
Add cause
HIV/AIDS & tuberculosis
Diarrhea/LRI/other
NTDs & malaria
Maternal disorders
Neonatal disorders
Nutritional deficiencies
Other group I
Neoplasms
Cardiovascular diseases
Chronic respiratory
Cirrhosis
Digestive diseases
Neurological disorders
Mental & substance use
Diabetes/urog/blood/endo
Musculoskeletal disorders
Other non-communicable
Transport injuries
Unintentional ini
Self-harm & violence
War & disaster
Percent of primary ambient PM$_{2.5}$ from household cooking fuels – population weighted

~30% in Nigeria

Chafe, et al., 2014
Will Development Take Care of it?

• Nigeria’s population has been growing at 2.7% per year
• Use of clean fuels also growing at 2.7%
• So we are doing ok?
• No, number of people in biomass-using households has gone from 70 to 120 million people in 20 years.
• Rapidly going backward!
Nigeria – History of Cookfuel Use

Millions

- Population
- Biomass Users
- Non-biomass Users

1990 2000 2010
Increasing Prosperity and Development

Decreasing Household Air Pollution

Very Low Income

Low Income

Middle Income

High Income

Ag res - 10%

Kerosene - 5%

Biogas - 0.3%

LPG - 20%

Elec < 1%

PNG < 1%

Non-solid fuels

Solid Fuels

Wood - 64%
“Improved” Biomass Stoves

- Most stove programs to date have focused on fuel efficiency
- Although beneficial, fuel efficiency is only weakly related to emissions
- None have come close to being as clean as gas
Increasing Prosperity and Development

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Non-solid fuels

Solid Fuels

Household Energy Ladder

- 1.0

- ~4

- ~400
Why does it have to be so clean?
Integrated Exposure-Response: Outdoor Air, SHS, and Smoking Relative Risk

**Ischemic Heart Disease**

**HAP Zone**

Secondhand Tobacco Smoke

Outdoor Air Pollution

ug/m³ annual average PM$_{2.5}$
Risk Curve for PM$_{2.5}$ and Child ALRI risk

WHO IT-1 (35 µg/m$^3$ PM$_{2.5}$)
Recent trends give us an idea where we are going if nothing is done.
Nigeria
Household air pollution from solid fuels
Both sexes, All ages

Deaths

How do we help people move into this realm?
Paradigm #2

Making the clean available:
The India Case Study
India already spends ~6 billion USD to promote LPG

• Seen as a political and economic burden
• But can be considered a major asset to promote clean fuels even further among the poor
• To do so, however, requires
  – Eliminating leakage to non-household sector
  – Target to poor – take away from rich
Programme to date

• Stage I: began Jan 1 this year
  – Direct Bank Transfer: largest in human history
  – In Guinness Book of World Records
  – Possible due to digital revolution

• All LPG now sold at market rate.
  – Leakage is greatly reduced
  – LPG sales rapidly rising in commercial sector

• Reduction of perhaps one billion USD in cost to government

• Subsidies now more targeted
Stage II: April 2015

- National “Give it up” campaign
- Better off asked to give up their LPG subsidy
- Transfer to a poor household
- Deposit for cylinder and regulator supplied by CSR funds from Oil Companies
- >4 million households have done so
- Rising at 30k per day
Now no more smoke-induced tears for our mothers while cooking
- 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: 2nd October 2015 | Venue: Dumka Airfield Ground, Dumka, Jharkhand | Time: 1:00 pm

Times of India
Oct 2, 2015

Gandhi’s Birthday
Give it up, cont.

- 10 million households expected to join by end of next year
- Even with current low LPG prices, this amounts to some two billion USD switch of resources from middle class to the poor
- Remarkable sea change in LPG situation in short order
LPG expansion, cont.

• Phase III: Next year?
  – Change from opt out to opt in system
  – Expect to go from 70+% of rich claiming subsidy
  – To less than 30%

• Ministry of Petroleum wants to have 100 million new LPG users by 2025
In 20 years, 17 million Nigerians took up clean fuels, mainly LPG.

If the growth rate had been 2x: 50 million would have taken it up.

At 3x, 120 million would have done so.
Increasing Prosperity and Development

Decreasing Household Air Pollution

Very Low Income

Low Income

Middle Income

High Income

Solid Fuels

Non-solid fuels

Wood

Crop Waste Dung

Solid Fuels

Kerosene

Alcohol, Biogas/solar

Liquefied Petroleum Gas

Natural Gas

Electricity
Impacts | Climate Forcing

Direct radiative forcing by BC emissions from kerosene lamps

Globally averaged forcing
20 mW/m²
(Cl: 8, 48)

Comparison:
Biomass: 60
Diesel: 85
1.5 mW/m² on snow

Negative Forcing by OC offsets by only 0.5%

7% of global BC forcing from all energy-related emissions
Indonesia’s Shift from Kerosene to LPG
Of course

• Just providing affordable access to LPG or other fuel does not mean people instantly switch

• However, since 60% of world uses gas and/or electricity it argues strongly that the rest eventually will.

• Is clearly what is needed in long term – why not sooner rather than later?
Subsidy or ?

• Health sector does not refer to programs to vaccinate or provide maternal care to the poor as “subsidies” but rather

• Social investments

• In order for public support of clean fuels to be termed social investments, they need to be far better targeted than in the past.

• Modern IT technology provides ways to do so
New Directions

• Work to help target subsidies
  – Embrace modern IT to do so

• Work with others to explore entirely different distribution modes
  – Including at the community level

• Develop marketing for enhancing use after adoption
  – Shorten “stacking” period
What about climate?
Carbon Balance in Traditional Indian Wood Stove Acacia wood
90% combustion efficiency

Wood: 1.0 kg
420 g Carbon

CO₂ Carbon: 380 g
PIC Carbon:
CO: 29 g
CH₄: 3.0 g
TNMOC: 5.2 g
Char/Ash Carbon: 1.6 g
Particle Carbon
0.9 g

In this improved stove, 1.0 kg fuel would deliver 2.7 MJ energy to the pot
Carbon Balance in Typical LPG Stove
99.4% combustion efficiency

Wood: 1.0 kg
825 g Carbon

- CO₂ Carbon: 820 g
- PIC Carbon: CO: 1.1 g, CH₄: 0.4 g, TNMOC: 3.3 g
- Char/Ash: 0 g

Particle Carbon: 0.1 g

1.0 kg of LPG in this stove would deliver about 23 MJ to the pot
Global warming commitment per MJ energy delivered to cooking pot

- Dung: 377 grams Carbon as CO₂
- Non-renewable Wood: 236 grams
- Crop Residues: 162 grams
- Renewable Wood: 85 grams
- Kerosene: 49 grams
- LPG: 37 grams
- Biogas: 2 grams
Fraction non-renewable in woodfuel harvesting

Bailis et al. 2015
120 million: Far more than anytime in Nigerian history. And growing!
Many thanks
For publications
and presentations:
Just “Google”
Kirk R. Smith