

# Indoor Air Pollution

## The Problem

Nearly 2.6 million people died globally in 2016 from harmful exposure to PM2.5 emissions from household use of solid fuels such as wood, coal, charcoal, and agricultural residues for cooking according to estimates by the Global Burden of Disease 2016 (GBD 2016) Project. This makes household air pollution (HAP) one of the leading health risk factors in developing countries.

About 65,000 people died from HAP in Rajasthan in 2016 according to GBD 2016. About 68% of the population in Rajasthan relied on solid fuels for cooking in 2015-16 according to the National Family Health Survey IV (IIPS, 2017) compared to about 40% globally. While 20% of urban households used solid fuels, as many as 85% of rural households did so. About 32% of households used modern cooking fuels in 2015-16 (IIPS, 2017), mainly LPG, up from about 21% in 2005-06 (IIPS, 2008), with substantial growth both in urban and rural areas.

Very few of the households using solid fuels in Rajasthan have adopted improved biomass cookstoves with more efficient, cleaner burning and less pollution (Nielsen India, 2016). Judging from exposure studies in India and around the world, household members' average exposures to PM2.5 may be on the order of 100-200 µg/m<sup>3</sup> among households cooking with solid biomass fuels, depending on cooking location in the household environment (Larsen, 2017). These exposure levels are 5-20 times the WHO's outdoor annual air quality guideline (AQG) of 10 µg/m<sup>3</sup>, and cause serious health effects including heart disease, stroke, lung cancer and respiratory diseases.

Over two-thirds of households in Rajasthan cooked in their dwelling, 6% cooked in a separate building, and over one-quarter cooked outdoors according to the NFHS III 2005-06 (IIPS, 2008). Average rural and urban kitchen concentrations in Rajasthan were estimated at 532 and 514 µg/m<sup>3</sup>, respectively, or about 20% higher than the nationwide average (Balakrishnan et al 2013).

Three interventions are evaluated in this paper in terms of their benefits and costs - promotion of improved biomass cookstoves; free provision of LPG connection to poor households and a 50% reduction of subsidies to LPG fuel.

## Solutions

Interventions	BCR	Annualized Benefit (INR Crores)	Annualized Cost (INR Crores)
Promotion of improved biomass cookstoves	6.5	1,977.3	304.1
Free provision of LPG connection to poor households	3.3	4,714	1,449.9
50% reduction of subsidies to LPG fuel	0.57	996.3	1,755.4

Total costs and benefits are discounted at 5%

The full paper by **Bjorn Larsen** Environmental Economist is available on [www.rajasthanpriorities.com/IAP](http://www.rajasthanpriorities.com/IAP).

## Improved biomass cookstoves

### The Problem

About 68% of the population in Rajasthan relied on solid fuels for cooking in 2015-16 according to the National Family Health Survey IV (IIPS, 2017). While

20% of urban households used solid fuels, as many as 85% of rural households did so.

A survey of over 6,000 households in 20 districts in the state found that practically no households had improved cookstoves (ICS) for biomass burning. All households that used biomass for cooking cooked

over open fire/three stone fire or used traditional mud-stoves of which a majority was fixed stoves in contrast to portable stoves (Nielsen India, 2016).

Air concentrations of PM2.5 from the use of solid biomass cooking fuels often reach several hundred micrograms per cubic meter (µg/m<sup>3</sup>) in the kitchen, and well over one hundred micrograms in the living and sleeping environments.

### The Solution

The intervention aims at promoting the adoption and sustained use of an improved biomass cookstove (ICS), such as a Rocket stove that burns biomass more efficiently and emits less harmful smoke, and that has two burners.

Improved biomass cookstoves are designed to be more energy efficient and to generate less smoke than traditional cookstoves or cooking over open fire. Such stoves therefore have the potential to reduce harmful PM2.5 emissions over the life to the stove.

Costs and benefits are estimated based on an assumed household intervention adoption rate of 30% and a sustained user rate of 65%.

### Costs

Costs include initial cost of stove, cost of stove maintenance over its useful life, and program promotion cost. The applied cost of the stove is Rs. 2,600 (or about US\$ 40), at the high end of Rocket stoves such as Envirofit, Greenway and Prakti (Dalberg, 2013). Annual O&M is assumed to be 5% of stove cost, or Rs. 130 per year. Program cost is assumed to be Rs. 175 per targeted household. With an assumed stove adoption rate of 30%, this translates to Rs. 583 per household that adopts a stove.

Annualized cost per household is estimated at Rs. 985 and total annualized cost of intervention is estimated at Rs. 304 crores based on total intervention beneficiaries of 3.1 million households, i.e., households purchasing an ICS.

### Benefits

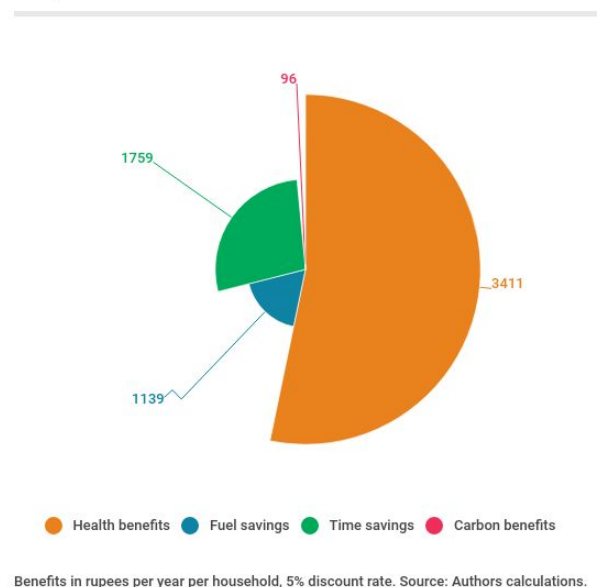
The quantified benefits of the intervention are the value of health improvements, time savings from reduced biomass fuel collection and preparation (or biomass fuel purchases) resulting from the higher energy efficiency of the stoves, reduced cooking time resulting from the improved cookstove, and reduced CO<sub>2</sub> emissions.

Estimated percentage reduction in health effects among beneficiary households is 22% if the

households consistently use the ICS. At a 65% long-term use rate the intervention is expected to avert 2,742 deaths and 5,041 YLDs per year.

The total annualized value of benefits of the intervention is estimated at approx. Rs. 1977 crores, based on valuation of deaths averted, Years of Life Lost (YLL) at 3 times GDP per capita (YLDs are valued at 3 times GDP per capita). The estimate reflects a sustained ICS user rate of 65%. Annualized benefits per household, adjusted by the user rate, are Rs. 6,405 when averted deaths are valued using YLLs valued at 3 times GDP per capita. This includes CO<sub>2</sub> emission benefits.

### Improved biomass cookstoves benefits



## Free provision of LPG connections to poor Households

### The Problem

While over 80% of urban households use clean fuels (mainly LPG) for cooking, only 15% do so in rural areas according to the NFHS IV 2015-16 (IIPS, 2017). Nationwide 24% of rural households use clean cooking fuels. The rates of clean cooking fuel utilization are even lower among the poorer segments of the population.

About 32% of households used modern cooking fuels in 2015-16, mainly LPG, up from about 21% in

2005-06, with substantial growth both in urban and rural areas.

**The Solution**

Government of India has therefore implemented a program (Pradhan Mantri Ujjwala Yojana (PMUY) launched in 2016) that provides free LPG connections (LPG cylinder and auxiliary equipment) free of charge to households below the poverty line (BPL) to encourage these households to switch from solid fuels to LPG. The budgeted cost to the government is Rs. 1,600 per connection.

The intervention assessed in terms of benefits and costs, is therefore free provision of LPG connection to poor households.

Cost and benefits are estimated based on the assumption that 35% of households receiving the intervention will adopt LPG as primary cooking fuel.

**Costs**

The main household cost of using LPG for cooking is the cost of LPG fuel. This is followed by the LPG stove and connection equipment (latter provided for free by the government program). Stove maintenance cost is a minor outlay compared to the other costs.

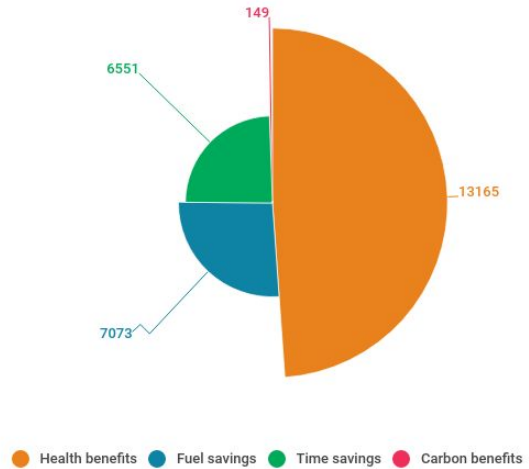
Annualized cost per household is estimated at Rs. 8,285 and total annualized cost of intervention is estimated at Rs. 1,449 crores based on total intervention beneficiaries of 1.75 million households, i.e., households adopting LPG as primary cooking fuel.

**Benefits**

The quantified benefits of the intervention are the value of health improvements, time savings from reduced biomass fuel collection and preparation (or biomass fuel purchases), reduced cooking time resulting from the LPG cookstove, and reduced net CO2 emissions.

The estimated reduction in health effects from the intervention amounts to 4,956 deaths averted and 9,112 YLDs per year. The total annualized value of benefits of the intervention is estimated at 4,714 crores with YLL at 3 times GDP per capita (YLDs are valued at 3 times GDP per capita). Annualized benefits per household that adopts LPG as primary cooking fuel are Rs. 26,937 when averted deaths are valued using YLLs valued at 3 times GDP per capita.

**Benefits of LPG connection**



Benefits in rupees per year per household, 5% discount rate. Source: Authors calculations.

**50 percent reduction of subsidies to LPG fuel**

**The Problem**

LPG fuel retail prices in India are substantially below the market price, as determined by world prices and transportation and distribution cost. LPG retail prices have been increased in the past year, but so has world prices of LPG. The subsidy therefore amounted to about 25% of market price or non-subsidized price as of April 2018.

Increasing the subsidized price of LPG to reduce or eliminate the LPG fuel subsidy is likely to make some households cut LPG consumption and increase the use of solid fuels for cooking. This entails negative health effects. On the other hand, subsidy reduction will reduce the resource allocation inefficiency that subsidies create, simplest measured by the so-called deadweight loss.

**The Solution**

The intervention assessed in this study is a 50% reduction of the LPG fuel subsidy. A reduction in the LPG fuel subsidy raises the effective price of LPG paid by LPG consumers.

Total LPG consumption is consequently expected to decline. The magnitude of decline in LPG

consumption can be estimated by applying a household price elasticity of demand for LPG. A 50% reduction in LPG subsidies, is estimated to reduce total household demand for LPG by 15%. This is equivalent to 15% of the approximately 32% of households in Rajasthan that used LPG as primary fuel for cooking in 2015-16, i.e., around 722 thousand households.

**Costs**

Costs of LPG subsidy reduction are many. Some households will switch back to cooking with solid fuels and thus face the health effects of these fuels as well as sustain increased use of time from biomass fuel collection and cooking. Net CO2 emissions will also increase. These households will also need to purchase a biomass stove. Total annualized cost is therefore about Rs. 1,755 crores.

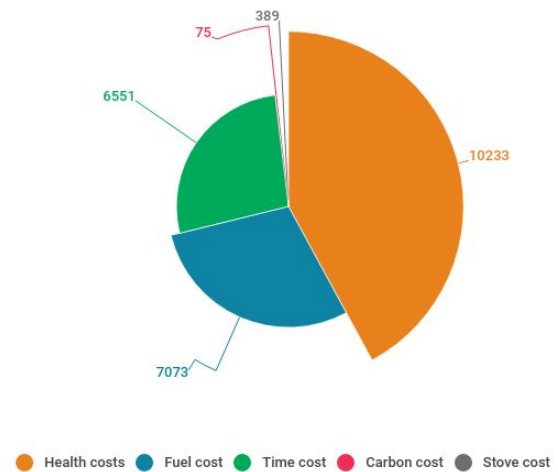
**Benefits**

The main benefit of a subsidy reduction is LPG fuel cost savings among households that no longer will cook with LPG. A second benefit is the welfare gain (or reduced “deadweight loss”) from a supply and demand for LPG fuel at retail prices closer to market prices.

The benefits of LPG fuel subsidy reduction are LPG fuel savings and reduction in resource allocation inefficiency. The LPG fuel saving per affected household is the same as the LPG fuel cost in the

previous intervention. The reduction in resource allocation inefficiency, or reduction in deadweight loss, amounts to Rs. 4.85 billion per year, or Rs. 6726 per affected household and is estimated as discussed in the previous section. Total annual benefit of subsidy reduction is Rs. 996 crores.

**Social costs of reducing LPG subsidy**



Costs in rupees per year per household, 5% discount rate. Source: Authors calculations.