

Post-2015 Development Agenda

Colombia Perspectives



Air Pollution

SPEAKER

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Summary: White Paper Report by Bjorn Larsen

According to a study for the World Bank¹, air pollution kills 15,000 Colombians every year. But only about 8,000 of these deaths are from the outdoor pollution that we normally worry about, particularly in cities. 7,000 result from household air pollution, caused by cooking and heating with wood and other solid fuels. This affects mainly rural communities.

In both cities and countryside, the cause is the same: tiny particles in smoke which we breathe in and which can lead to chronic lung disease and acute respiratory infections, lung cancer, heart disease and strokes. This does not just affect Latin America, but is a global problem causing over 6 million deaths worldwide each year².

In Colombia, outdoor air pollution is a real problem, causing about one in 20 of all deaths in the metropolitan areas of Bogota, Valle de Aburra and Cali. But for rural dwellers the situation is much worse; household air pollution is responsible for an alarming 17% of all deaths. More than one in every six deaths is caused by burning wood and solid fuels to cook food and keep warm.

The most dangerous of the airborne particle are known as PM2.5 (particulates less than 2.5 thousandths of a millimetre across) which can penetrate deep into the lung. The World Health Organization (WHO) has set a limit for average outdoor ambient air pollution of 10 micrograms (10 millionth of a gram) of PM2.5 per cubic metre of air (10 $\mu\text{g}/\text{m}^3$). In urban areas, the level may be twice this, and over 60% of the Colombian population is estimated to breathe air which is more polluted than the WHO guideline³.

6 million Colombians – half of all rural households – rely on solid fuels and many others use them as part of their fuel mix. For these households, mainly in the Caribe, Central and Pacifica regions, air pollution is often at least ten times higher than in towns and cities. For the person cooking, average concentrations of PM2.5 breathed day and night are in the range of 11 to 26 times the WHO guideline, a really shocking statistic.

Replacing open fires and traditional stoves with improved cookstoves with chimneys – and maintaining them well - reduces this exposure by half, but the average remains about 80 $\mu\text{g}/\text{m}^3$, still eight times the recommended limit. To make greater improvements, households need to make the transition to the more expensive propane (LPG). Use of gas as the primary fuel is a key reason why urban households are less polluted. If all rural households used LPG, pollution may decline to 25 $\mu\text{g}/\text{m}^3$ or less, but exposure would be perhaps double that if only a fraction of households changed.

Adoption of improved cookstoves would reduce the risk of disease and death by 30%. Going further and using LPG would reduce disease and death by 45-65%.

¹ Larsen, B., and Skjelvik, J.M. 2014. Environmental health in Colombia: An economic assessment of health effects and their costs. Prepared for the World Bank. Washington, D.C., USA.

² Lim, S.S., Vos, T., Flaxman, A.D., Danaei, G., et al. 2012. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, 380: 2224-60, and <http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/>

³ See 1.

Improved cookstoves in Colombia are relatively expensive but there is no reason why they should not be modelled on the successful examples of Mexico, Peru, Guatemala and other countries in the region⁴. Costs there are in the region of 250-400 thousand Pesos, and they burn only about half the amount of wood used in traditional stoves, so there are savings on fuel costs. On the other hand LPG stoves can cost half a million Pesos, and the fuel can cost a further 350 thousand Pesos a year. For both cases, the benefits in health, fuel savings and time more than outweigh the cost.

But the transition to use of gas cannot happen overnight because not all families can afford the cost. A reasonable interim target is to convert half of the households burning solid fuel to improved stoves with a chimney and the other half to LPG stoves. This would reduce the incidence of death and illness by over a third and save 2,750 lives a year. Every thousand Pesos spent on improved stoves would pay back 9,000 Pesos in benefits, while a thousand Pesos spent on LPG stoves would give benefits worth at least 2,500 Pesos. Both would make a real improvement to people's lives.

Converting all households to LPG would save 4,700 deaths a year and reduce disease and death by two thirds. The annual cost would be 673 billion Pesos, but the benefits would be worth three times as much.

The air in many of Colombia's cities is much cleaner than it used to be, but there is still some way to go to reach even the interim WHO air quality standard of $15\mu\text{g}/\text{m}^3$. However, achieving this would be far more expensive than investing in cleaner cooking facilities for rural households. In doing this, it is important to involve whole communities so that pollution is reduced for all households.

⁴ Berrueta, V., Edward, R., and Masera, O. 2008. Energy performance of wood-burning cookstoves in Michoacan, Mexico. *Renewable Energy*, 33(5), 859–870.

White Paper Report by Bjorn Larsen

Colombia Perspectives – Air Pollution

A whopping 6-7 million people die each year globally from pollution of the air by tiny particles that we breathe. These tiny particles inflict chronic lung disease, heart disease, stroke, lung cancer, acute respiratory infections and other illnesses.ⁱ The most dangerous of these particles are less than 2.5 thousands of a millimeter wide and are called PM2.5 (particulate matter of less than 2.5 microns). These particles are found in both the outdoor ambient environment and in the indoor household environment.

About 15,000 people die each year from this air pollution in Colombia according to a recent study commissioned by the World Bank.ⁱⁱ About 8,000 of these deaths are from outdoor ambient air pollution mainly in urban areasⁱⁱⁱ, and 7,000 are from household air pollution caused by cooking and heating with wood and other solid fuels mainly in rural areas. The estimate of deaths from household air pollution is many times higher than previous estimates in Colombia.^{iv} This reflects new evidence of health effects and better methodologies to estimate these effects.^v

Deaths from outdoor ambient air pollution represent 4-6% of all deaths from all causes in the metropolitan areas of Bogota, Valle de Aburra, and Cali. Deaths from household air pollution are an alarming 17% of all deaths from all causes among the population who cook primarily with wood and other solid fuels in Colombia. Overall, deaths from outdoor ambient and household air pollution represent one in every 18 (5.5%) deaths from all causes in the country. This makes air pollution the sixth largest mortality risk factor in Colombia after dietary risks, high blood pressure, tobacco smoking, physical overweight, and physical inactivity and low physical activity, among dozens of factors assessed by the Global Burden of Disease 2010 Project.^{vi}

As global evidence of severe health effects of PM2.5 has been mounting, the World Health Organization (WHO) in 2005 revised its Air Quality Guideline (AQG) for annual average outdoor ambient air pollution concentrations to 10 microgram of PM2.5 per cubic meter of air (10 $\mu\text{g}/\text{m}^3$). In contrast, annual average PM2.5 concentrations were recently about 20 $\mu\text{g}/\text{m}^3$ in Bogota, 25 $\mu\text{g}/\text{m}^3$ in Valle de Aburra, and 15 $\mu\text{g}/\text{m}^3$ in Cali. Nationally, an estimated 60% of the Colombian population breathe air that contains more PM2.5 than WHO's annual AQG.^{vii}

The ambient PM2.5 air concentrations seen today in several major urban areas, such as Bogota and Valle de Aburra reflect a substantial improvement compared to some years ago. Colombia has implemented stringent road vehicle fuel standards, tighter vehicle emission standards, and urban public transport has improved. Further improvements can be made, however. For instance, over 3,000 lives can be saved each year if Colombia ensures that no one is exposed to outdoor ambient PM2.5 concentrations exceeding WHO's third interim air quality target of 15 $\mu\text{g}/\text{m}^3$. But this will in all likelihood be far more expensive than achieving the same health improvements from promoting improved stoves and LPG for cooking in rural areas.

Controlling household air pollution

An estimated 6 million people cook primarily with solid fuels in Colombia today and many other households continue to use solid fuels as secondary fuels. Air pollution in these households is severely health damaging, with pollution levels at often ten times higher than in urban areas. One-third of these households reside in the region Caribe, nearly one-third in the region Central, and nearly 30% in the region Pacifica. Only 6% of the households using solid fuels as their primary cooking fuel reside in the regions of Oriental and Amazonia.

At the rate of decline in the number of households using solid fuels observed from 2005 to 2010, it will take 50-100 years before all households in Colombia are “solid fuel free”.^{viii}

There are two broad options to control household air pollution from use of solid fuels:

- i) adopt improved biomass cookstoves that reduce PM_{2.5} concentrations in the household environment; or
- ii) speed up the transition to propane (LPG) or natural gas which is practically free from PM_{2.5}.

Natural gas networks and use of LPG has successfully expanded in urban areas in Colombia in recent decades. Very few urban households now use solid fuels for cooking. Use of LPG has also expanded in rural areas, but half of rural households continue to use solid fuels as primary cooking fuel.

The vast majority of the households in Colombia that cook with solid fuels do so over open fire or with inefficient traditional, open stoves. The average 24-hours concentrations of PM_{2.5} in the air breathed by the person cooking in these households (personal exposure) are in the range of 115-265 µg/m³ according to recent studies in several countries in Latin America. This is 11-26 times higher than WHO’s recommended level of 10 µg/m³ for annual ambient air quality. The same studies found that 24-hours personal exposures declined on average by over 50% from installation of improved cookstoves with chimney that vents the smoke out of the indoor environment^{ix}

Promoting and adopting improved cookstoves with chimney in Colombia may be expected to yield similar improvements in household air quality, that is a reduction in PM_{2.5} exposure from an average of about 180 µg/m³ when cooking over open fire or traditional, open stove to an average of about 80 µg/m³ after installing and properly operating and maintaining an improved stove with chimney.

The use of LPG for cooking is more expensive than the use of solid fuels, but is much cleaner and therefore more effective in reducing personal exposure to PM_{2.5}. Personal exposures after adopting LPG will, however, depend on the level of pollution in the community from households continuing to use solid fuels as well as level of pollution from other sources. With only a fraction of households adopting LPG, personal exposures may be 50 µg/m³. If all households adopt LPG, personal exposures may decline to 25 µg/m³ depending on the extent of other sources of PM_{2.5} pollution. In very clean communities, personal exposures may be reduced to levels below WHO’s annual ambient AQG of 10 µg/m³.

Adoption of improved cookstoves with chimney reduces the risk of disease and death by around 30% compared to cooking over open fire or traditional. This is substantially less than the reduction in PM_{2.5} exposure of over 50%, and is due to the characteristics of the relationship between PM_{2.5} exposure levels and associated magnitude of risk of disease and death that are found in scientific studies. Adoption of LPG stoves is expected to reduce disease and deaths by 45-65% depending on the level of community pollution. Reaching WHO’s ambient annual AQG would reduce disease and deaths by about 90%.

Table 1. Household cooking stoves and PM_{2.5} pollution exposure

	Open fire, traditional stove	Improved cookstove with chimney	LPG stove (substantial community pollution)		LPG stove (some community pollution)	WHO Ambient Annual AQG
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PM2.5 exposure (µg/m ³)	180	80	50		25	10
Avoided disease and deaths (%)	-	30%	45%		65%	90%

Very little seems to have been done in Colombia in the last decade or two to promote improved cookstoves among households cooking with solid fuels. And improved cookstove markets are underdeveloped and stoves are expensive, reaching as much as one million Pesos for some enclosed stoves with chimney.^x

Improved cookstove programs in other Latin American countries most often promote closed biomass stoves with two or three hot plates and an attached chimney that vents the smoke out of the kitchen and indoor environment. Examples are the Patsari stove in Mexico, the Inkawasi stove in Peru, the Eco-Plancha stove in Guatemala, and the Ecostove in Brazil, Honduras, and Nicaragua.^{xi} These stoves cost 250-400 thousand Pesos including local materials and installation, and provide fuel wood savings of 40-60% relative to cooking on open fire. Prices and efficiencies of stoves ought to be similar in Colombia with some efforts to develop stove markets.

The use of LPG for cooking is more expensive than the use of solid fuels. A full-size LPG stove with multiple burners can cost 500 thousand Pesos, and LPG fuel can cost a household 350 thousand Pesos per year.

Despite these costs, the benefits of improved cookstoves with chimney and use of LPG for cooking by far outweigh the costs. For every Peso spent on improved cookstoves the benefits are in the range of 5 to 20 Pesos. For every Peso spent on LPG stoves and fuel the benefits are in the range of 1.7 to 6.4 Pesos.^{xii} These benefits are health improvements, solid fuel savings and cooking time savings. The costs include initial cost of stoves, maintenance and repair, LPG fuel, and cost of programs to promote adoption of improved stoves and LPG.

In perspective, the benefits per Peso spent on household air pollution control are 3-40 times higher than benefits per Peso spent on several typical measures to control ambient PM2.5 pollution in urban areas. A major reason for this difference in benefits is the benefits of fuel savings and cooking time savings from improved cookstoves and LPG.^{xiii}

Table 2. Pesos of benefits for every Peso spent on household air pollution control

	Improved cookstove with chimney	LPG stove (substantial community pollution)	LPG stove (some community pollution)
Pesos of benefits			
High (VSL)	20	4.8	6.4
Medium (DALY=US\$ 5,000)	9	2.5	2.9
Low (DALY=US\$1,000)	5	1.7	1.8

Note: High, Medium and Low benefits reflect a range in valuation of death and disease. Low: A year of life and year lost to disease is valued at US\$ 1,000. Medium: A year is valued at US\$ 5,000. High: A death is

valued by applying a so called value of statistical life (VSL) that is 50 times GDP per capita, which in the case of air pollution is approximately the same as two times GDP per capita for a year of life.

The message is clear:

- i) Improved cookstoves with chimney should be promoted for adoption by households that currently cannot afford LPG; and
- ii) LPG should be promoted as the best choice whenever households can afford it.

A reasonable *interim* target is to achieve adoption of improved cookstoves with chimney by 50% of the households that currently use solid fuel for cooking, and achieve adoption of LPG stoves by the other 50% of households. A *final* target would be to achieve that all households use LPG, or other clean cooking solutions.

Reaching the interim target would reduce the number of deaths and cases of illness by 38% and save 2,750 lives per year. Reaching the final target would save an additional nearly 2,000 lives per year.

Table 3. Annual health benefits of reaching household air pollution control targets

	Interim target	Final target
Avoided disease and deaths (%)	38%	65%
Avoided number of deaths per year	2,750	4,700

Total annualized cost of reaching the interim target is 386 billion Pesos and total annual benefits are 839 – 2,636 billion Pesos. The cost associated with half of households adopting improved cookstoves is only one-seventh of the cost associated with half of households adopting LPG stoves.

Reaching the final target of 100% adopting LPG costs 673 billion Pesos per year, or 287 billion Pesos more than reaching the interim target. Reaching the final target provides annual benefits of about 1,207-4,285 billion Pesos. This is substantially more than twice the benefits of 50% of households adopting LPG stoves due to the extra benefits of avoiding community pollution when all households convert to LPG.

Table 4. Total annual costs and benefits of reaching interim and final target

TARGET	Costs per year (Billion Pesos)	Total Benefits per year (Billion Pesos)		
		VSL	DALY = US\$5,000	DALY = US\$1,000
50% of those using unimproved cookstoves switch to improved cookstoves	49	1008	440	264
50% of those using unimproved cookstoves switch to LPG cookstoves	337	1628	825	575
100% of those using unimproved cookstoves switch to LPG cookstoves	673	4285	1938	1207

Making the promotion of improved cookstoves and LPG effective and sustainable

Households are more likely to adopt improved stoves or use LPG when they are well informed and understand the full health benefits to be gained, not only for the person cooking but also for the other members of the family who are also exposed to elevated levels of air pollution throughout the household environment.

The magnitude of benefits of improved biomass cookstoves and LPG for cooking depends very much on prevailing pollution levels, and the magnitude of pollution reductions achieved by adoption of new stoves and fuels. This is influenced by multiple factors, such as characteristics of dwellings, cooking location, cooking practices, and activity patterns of household members. These factors can be positively modified by stove promotion programs to enhance the benefits of improved biomass cookstoves and LPG stoves.

The sustainability of pollution reductions are also influenced by the condition of improved cookstoves. Promotion programs need therefore demonstrate and encourage proper use, maintenance and repairs of stoves.

There are advantages to making stove promotion programs community focused. The use of solid fuels by one household affects surrounding households. Smoke is vented out of one household for so to enter the houses of others and also pollute the ambient outdoor air in the community. The ultimate aim must therefore be to achieve “unimproved stove free” and eventually “solid biomass free” communities.

Notes and further readings

ⁱ Lim, S.S., Vos, T., Flaxman, A.D., Danaei, G., et al. 2012. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, 380: 2224-60, and <http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/>

ⁱⁱ Larsen, B., and Skjelvik, J.M. 2014. Environmental health in Colombia: An economic assessment of health effects and their costs. Prepared for the World Bank. Washington, D.C., USA.

ⁱⁱⁱ This estimate is based on ground level ambient air PM2.5 monitoring data in several of the major cities and metropolitan areas in Colombia, as well as extrapolated ambient PM2.5 concentrations for secondary cities and rural areas.

^{iv} Golub, E., Klytchnikova, I., Sanchez-Martinez, G., and Belausteguigoitia, J.C. 2014. Environmental health costs in Colombia: The changes from 2002 to 2010. World Bank. Washington, D.C., USA.

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^v Burnett, R.T., Pope, C.A. III., Ezzati, M., Olives, C., Lim, S.S., et al. 2014. An integrated risk function for estimating the global burden of disease attributable to ambient fine particulate matter exposure. *Environmental Health Perspectives*, 122: 397-403.

^{vi} <http://www.healthdata.org/gbd>

vii See ii.

viii This analysis is based on data from the Colombian household surveys Encuesta Nacional de Demografía y Salud (ENDS 2010; 2005; 2000; 1995).

ix Armendariz-Arnez, C., Edwards, RD., Johnson, Rosas, IA., et al. 2010. Indoor particle size distributions in homes with open fires and improved Patsari cook stoves. *Atmospheric Environment*, 44: 2881-86.

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x Accenture. 2012. Colombia market assessment – sector mapping. Prepared for Global Alliance for Clean Cookstoves. www.cleancookstoves.org

^{xi} Berrueta, V., Edward, R., and Masera, O. 2008. Energy performance of wood-burning cookstoves in Michoacan, Mexico. *Renewable Energy*, 33(5), 859–870.

GACC. 2014. Guatemala country action plan for clean cookstoves and fuels – annexes. Global Alliance for Clean Cookstoves. www.cleancookstoves.org

Winrock. 2008. Peru healthy kitchen/healthy stove pilot project. Winrock International under cooperative agreement with USAID. December 2008.

^{xii} These benefits and costs are based on data for Colombia. Regional estimates are provided in Larsen, B. 2014. Benefits and costs of the air pollution targets for the Post-2015 Development Agenda. Air Pollution Assessment Paper. Copenhagen Consensus Center.
<http://www.copenhagenconsensus.com/post-2015-consensus/air-pollution>

^{xiii} See Larsen, B. (2014) in xii.

Air Pollution in Colombia

Better air?

better health?

for whom?

for how much?

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POST-
2015
CONSENSUS

Questions to ask ourselves

- Does Colombia still have an air pollution problem?
- How big is the problem?
- Who are most affected by this problem?
- Can we do something about it?
- Shall we do something about it?
- What will be the benefits of doing something?
- What are the costs of doing something?
- Are there answers to these questions?

First of all – what air pollution?

- We are talking about:
 - Very small particles – smaller than 2.5 microns in diameter
 - We call them PM_{2.5}
 - They penetrate deep into our lungs
- They cause:
 - Heart disease; Stroke; Lung cancer; Chronic and acute lung diseases
- This is the pollutant that causes 6-7 million deaths per year in our world

So does Colombia have a PM2.5 problem?

- There has been achievements:
 - PM2.5 air quality has improved in for instance Bogota and Valle de Aburra in recent years
 - Natural gas and liquified petroleum gas (LPG) have successfully expanded in urban areas, and even with LPG in rural areas

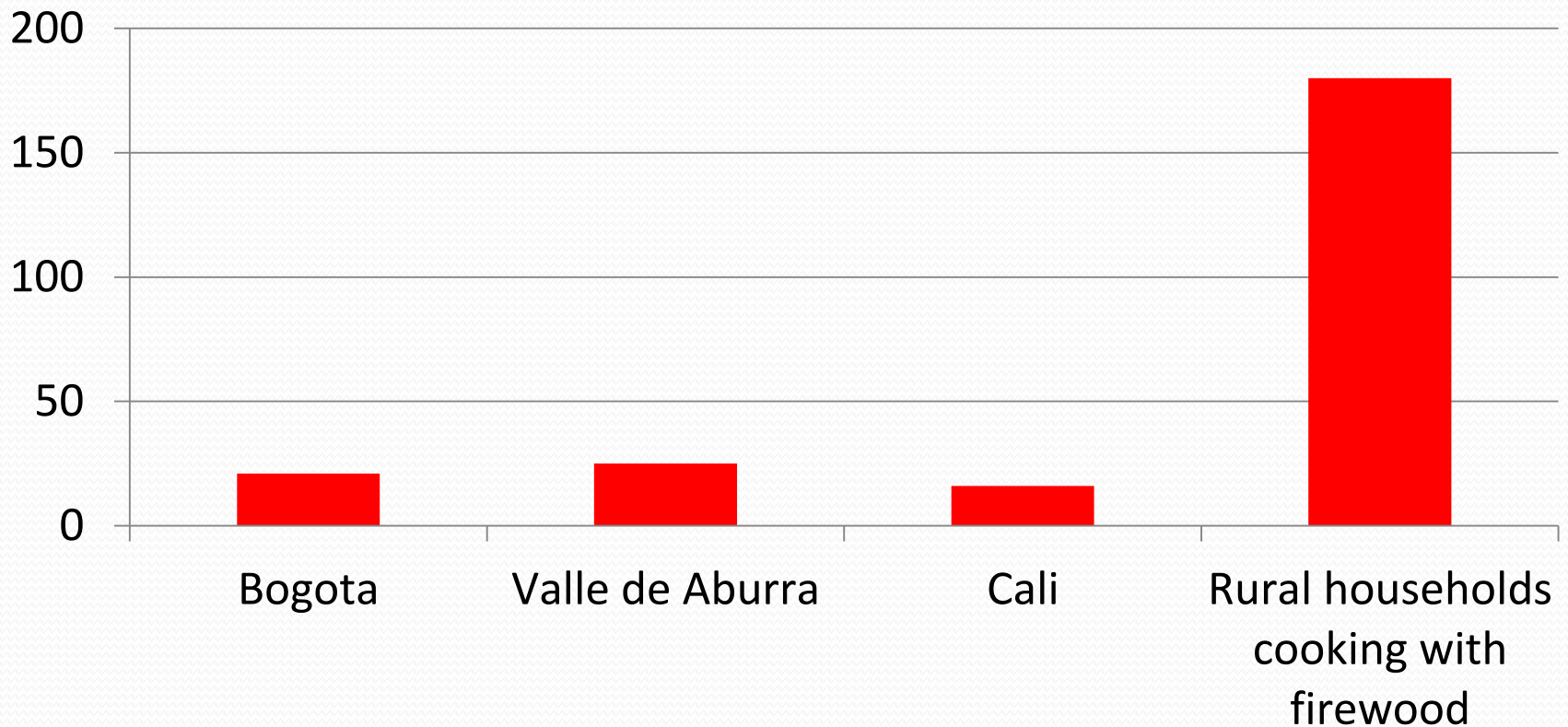
A PM2.5 problem?

- So what is the problem?
 - 60% of the population in Colombia is exposed to outdoor PM2.5 above WHO's annual guideline of 10 microgram per cubic meter of air ($\mu\text{g}/\text{m}^3$)
 - 50% of the rural population still relies on highly polluting fuels for cooking and heating (mainly fuel wood), and mostly cook over open fire and open, traditional stoves

We may ask: So what?

- 15,000 die each year from this pollution
 - ✓ 8,000 from outdoor ambient PM_{2.5}
 - ✓ 7,000 from household PM_{2.5} due to dirty cooking fuels

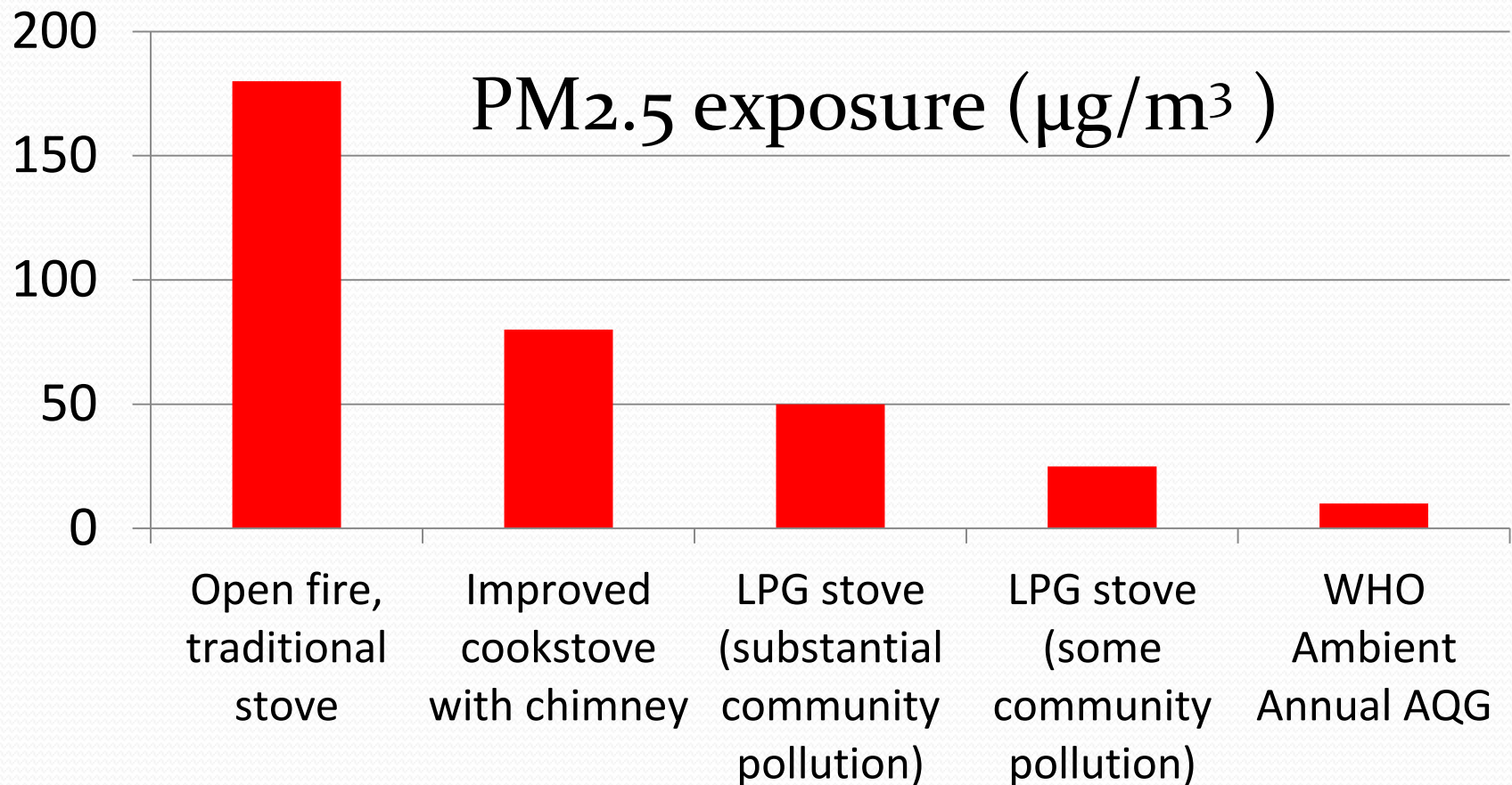
Annual average PM2.5 ($\mu\text{g}/\text{m}^3$)



So who are most affected?

- 6 million people – mainly in rural areas – use solid, dirty fuels as primary fuels for cooking and heating
- They suffer severe health effects:
 - 17% of all deaths among these people are due to use of solid, dirty fuels
 - This is far more than previously understood
 - We are able to make this estimate now that we have more scientific evidence, better methodologies, and better data on exposure to PM_{2.5}

So what can we do about it?

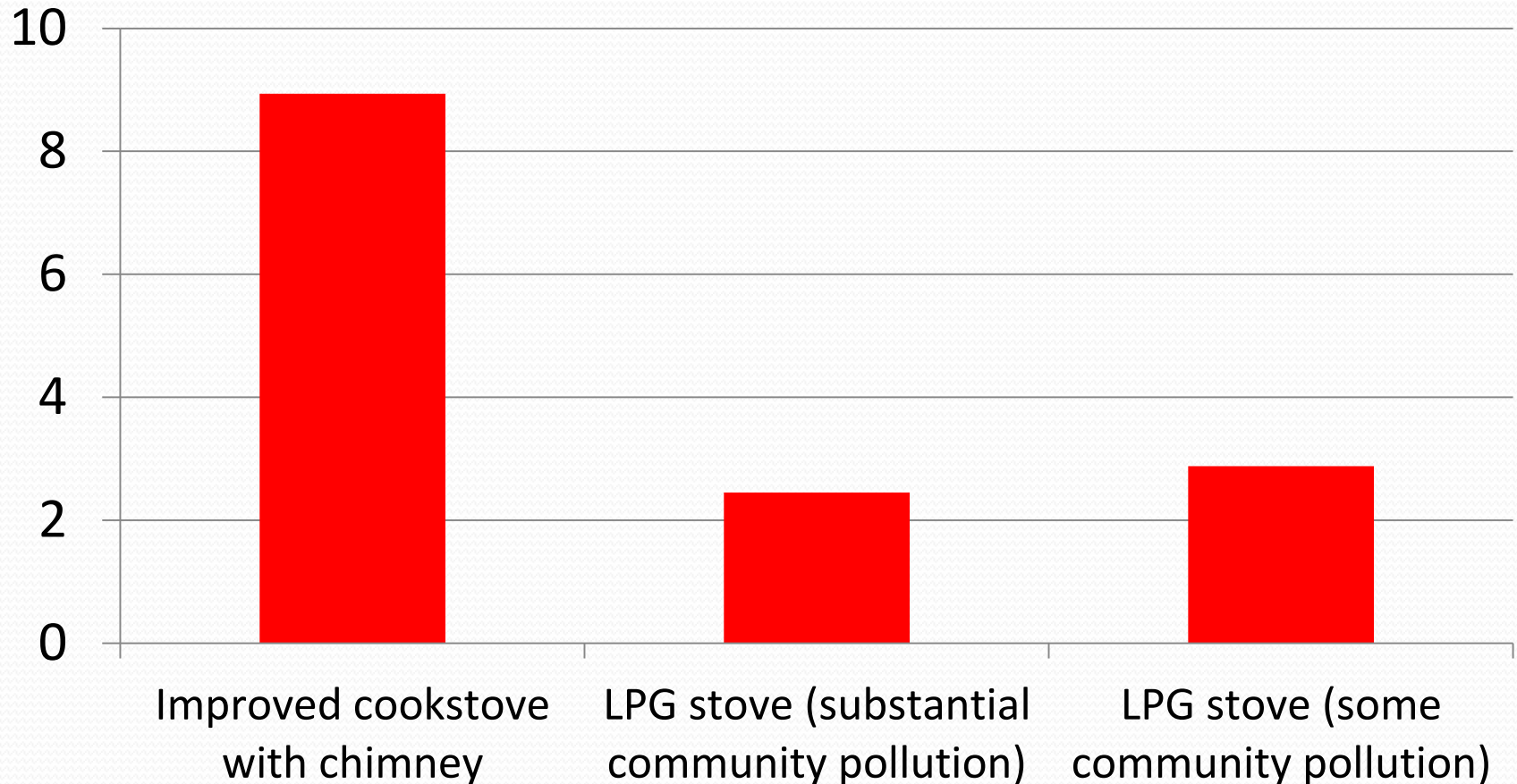


So shall we do something about it?

- One way of answering this question is to find answers to:
 - What are the benefits of solving this problem?
 - What are the costs?

Here we have it:

Pesos of benefits per Peso spent

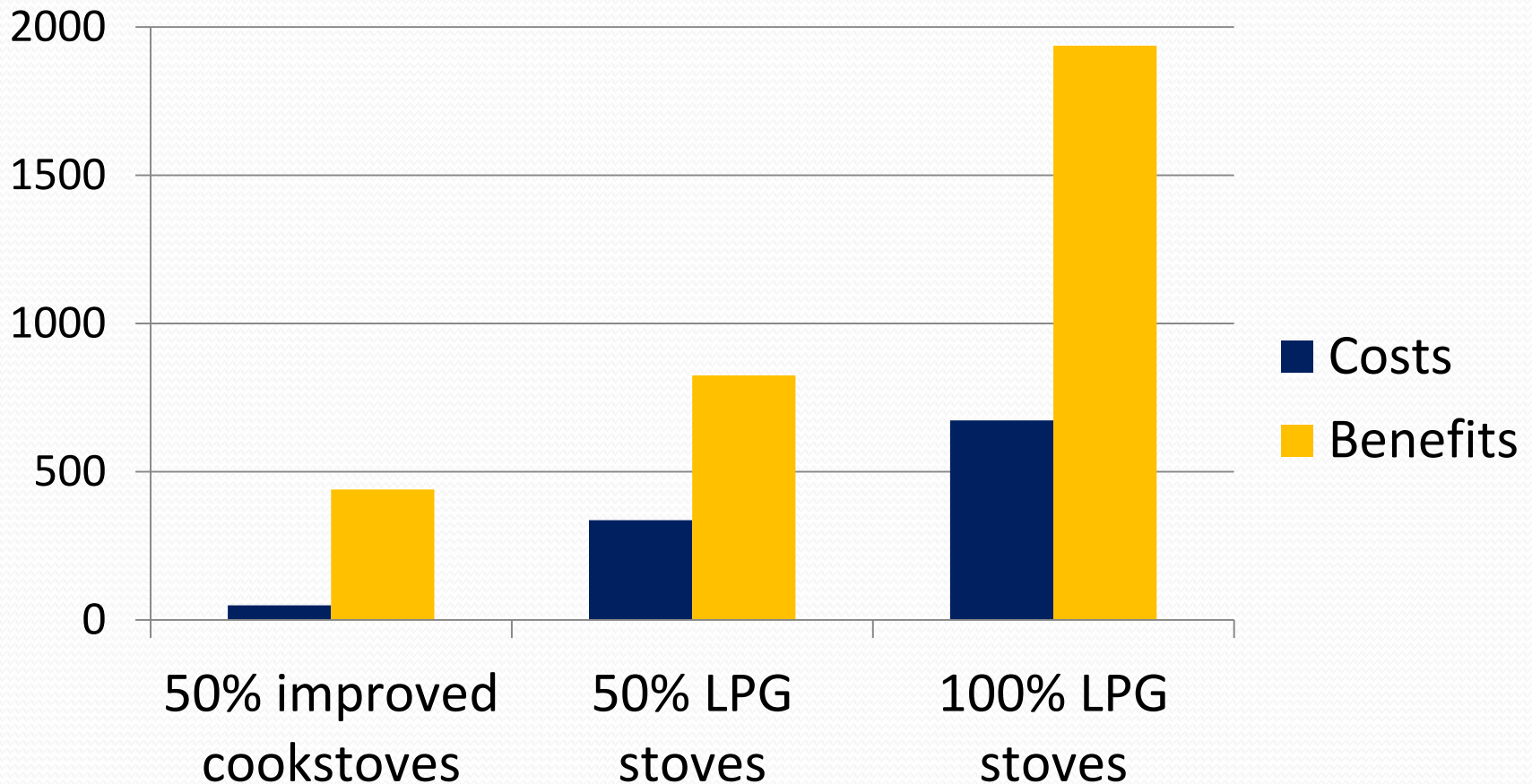


Note: 1 year of life saved is valued at US\$ 5,000

What might be some achievable targets?

- Interim target:
 - 50% adoption of improved cookstoves and 50% adoption of LPG
 - Saves 2,750 lives per year
- Final target:
 - 100% adoption of LPG
 - Saves 4,700 lives per year

Achieving the targets: Benefits and costs (billion Pesos per year)



Note: 1 year of life saved is valued at US\$ 5,000

What can we conclude?

- The benefits per Peso spent on control of household air pollution is greater than on outdoor ambient air pollution.
- High benefit-cost ratios for improved cookstoves.
- But need clean fuels (e.g. LPG) for larger improvements in health.
- Households should be well informed of the enormous health risks of pollution from the use of solid fuels on open fires and traditional cookstoves.
- Programs to promote adoption of improved cookstoves must emphasize proper operation, maintenance and repair of stoves and chimneys.
- There are benefits of making promotion programs community focused with the aim of “unimproved stove free” communities and eventually “solid fuel free” communities.