POST-2015 CONSENSUS

Post-2015 Development Agenda

Mexico Perspectives

Air Pollution

SPEAKER

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Summary: White Paper Report by Bjorn Larsen

According to the World Bank, air pollution kills nearly 33,000 Mexicans every year. Nearly 20,000 of these deaths are due to outdoor air pollution, mainly in towns and cities. The remaining 13,000 are from household air pollution, caused by cooking 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 year.

Air pollution is a real problem in Mexico, causing about one in 17 (5.9%) of all deaths in the country. It is the eighth largest cause of death, after factors such as diet, overweight, high blood pressure, alcohol and drugs, smoking and lack of exercise.

The most dangerous of the airborne particles 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 (thousandths of a gram) of PM2.5 per cubic metre of air (10μg/m^3). However, average concentrations in Mexico City are about 25μg/m^3, and in the range 20-36μg/m^3 in Puebla, Toluca and Monterrey.

This level of pollution is moderate, but at least 10,000 lives a year could be saved by reducing outdoor ambient PM2.5 concentrations to 15μg/m^3, the interim WHO target. But this would be far more expensive than saving similar numbers of lives by reducing indoor air pollution.

Over 16 million Mexicans – more than one in every eight – cook primarily with firewood or charcoal and many households use them as secondary fuels. Pollution levels in these rural households can be 6-15 times higher than in urban areas and this can severely damage health. For the person doing the cooking, concentrations of PM2.5 in the air breathed in are 11-26 times higher than the WHO recommendation.

Simply replacing open fires and traditional stoves with improved cookstoves with chimneys reduces this exposure by half, but the average remains about 80μg/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 areas are less polluted. If all rural households used LPG, pollution may decline to 25μg/m^3 or less, but exposure would be perhaps double that if only a fraction of households changed.

Adoption of improved cookstoves would reduce PM2.5 exposure by half and reduce the risk of disease and death by 30%. Going further and using LPG would reduce disease and death by 43-64%. And reaching WHO's air quality target would cut deaths and disease by 90%.

Improved cookstoves such as the Eco-Stove in Hidago state cost 2,200 Pesos, but 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 cost 3,000 Pesos, but the fuel can cost a further 3,000 Pesos a year.

For both cases, the benefits in health plus fuel and savings more than outweigh the cost. On average, investing a Peso in improved stoves would produce benefits worth over eight Pesos. For conversion to LPG,

the benefits would be worth two Pesos or more. LPG is definitely the best choice, but not all households will currently be able to afford it.

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. Both would make a real improvement to people's lives. This would reduce the incidence of death and illness by 37% and save 4,700 lives a year. The total cost would be approximately 9 billion Pesos each year, but benefits would be valued at about 25 billion Pesos.

Converting all households to LPG would save a further 3,400 lives each year. The total cost would be some 16 billion Pesos a year, but annual benefits would rise to nearly 40 billion Pesos. Part of this increase is due to the elimination of wood fires, leading to cleaner air in the community.

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.

Nearly 33,000 people die each year from this air pollution in Mexico according to a recent study commissioned by the World Bank.[ii] Nearly 20,000 of the deaths are from outdoor ambient air pollution mainly in urban areas[iii], and nearly 13,000 are from household air pollution caused by cooking with wood and other solid fuels. The estimate of deaths from household air pollution reflects new evidence of health effects and better methodologies to estimate these effects.[iv]

Deaths from outdoor ambient and household air pollution represent one in every 17 (5.9%) deaths from all causes in Mexico. This makes air pollution the eights largest mortality risk factor in the country after dietary risks, high fasting plasma glucose, physical overweight, high blood pressure, alcohol and drugs, tobacco smoking, and physical inactivity and low physical activity, among dozens of factors assessed by the Global Burden of Disease 2010 Project.[v]

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 $\mu g/m^3$). In contrast, annual average PM2.5 concentrations were recently about 25 $\mu g/m^3$ in the metropolitan area of Mexico city, and in the range of 20-36 $\mu g/m^3$ in Puebla, Toluca, and Monterrey.[vi] Nationally, an estimated 80% of the Mexican population breathe air that contains more PM2.5 than WHO's annual AQG.

Although ambient air quality in many Mexican cities is moderate, further improvements can be made. For instance, about 10,000-11,000 lives can be saved each year if Mexico ensures that no one is exposed to outdoor ambient PM2.5 concentrations exceeding WHO's third interim air quality target of 15 $\mu g/m^3$. But this will in all likelihood be far more expensive than achieving the same health improvements by promoting improved stoves and LPG for cooking to reduce household air pollution.

Controlling household air pollution

Over 16 million people, or about 13.5% of the population, cook primarily with firewood or charcoal in Mexico today and many other households continue to use these fuels as secondary fuels. Air pollution in these households is severely health damaging, with pollution levels often 6-15 times higher than in urban areas. The population cooking primarily with firewood or

charcoal declined from approximately 21% in 1990 to 17% in 2000, and to 14.5% in 2010 according to population census data.

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

i) adopt improved biomass cookstoves that reduce PM2.5 concentrations in the household environment; or
ii) speed up the transition to propane (LPG) or natural gas which is practically free from PM2.5.

The vast majority of the households in Mexico that cook with solid fuels do so over open fire or with inefficient traditional, open stoves. The average 24-hours concentrations of PM2.5 in the air breathed by the person cooking (personal exposure) are in the range of 115-265 $\mu g/m^3$, according to recent studies in Mexico and other countries in Latin America. This is 11-26 times higher than WHO's recommended level of 10 $\mu g/m^3$ 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 [vii]

Promoting and adopting improved cookstoves with chimney in Mexico among those who cook with firewood over open fire or in a traditional stove may be expected to yield similar improvements in household air quality, that is a reduction in PM2.5 exposure from an average of about 180 $\mu g/m^3$ when cooking over open fire or traditional, open stove to an average of about 80 $\mu g/m^3$ 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 PM2.5. 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 $\mu g/m^3$. If all households adopt LPG, personal exposures may decline to 25 $\mu g/m^3$ depending on the extent of other sources of PM2.5 pollution. In very clean communities, personal exposures may be reduced to levels below WHO's annual ambient AQG of 10 $\mu g/m^3$.

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 PM2.5 exposure of over 50%, and is due to the characteristics of the relationship between PM2.5 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 43-64% 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 PM2.5 pollution exposure

	Open fire, traditional stove	Improved cookstove with chimney	LPG stove (substantial community pollution)	LPG stove (some community pollution)	WHO Ambient Annual AQG
PM2.5 exposure ($\mu g/m^3$)	180	80	50	25	10
Avoided disease and deaths (%)	-	30%	43%	64%	90%

Improved cookstove programs in Mexico and 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, and provide fuel wood savings of 40-60% relative to cooking on open fire. Examples are the Patsari stove in Mexico, the Inkawasi stove in Peru, the Eco-Plancha stove in Guatemala, and the Ecostove in Honduras, and Nicaragua.[viii] These types of stoves, such as the Eco-Stove in the state of Hidalgo in Mexico cost 2,200 Pesos, including local materials and installation.

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 around 3,000 Pesos, and LPG fuel can cost a household over 3,000 Pesos per year depending on the amount of fuel consumption.

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 6 to 13 Pesos. For every Peso spent on LPG stoves and fuel the benefits are in the range of 1.7 to 3.3 Pesos.[ix] 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 1-40 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.[x]

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)	12.5	2.8	3.3
Medium (DALY=US$ 5,000)	8.4	2.0	2.3
Low (DALY=US$1,000)	6.2	1.7	1.7

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). A very conservative VSL equal to 25 times the GDP per capita in Mexico is applied, reflecting that the use of solid fuels is predominantly in the poorer areas of the country.

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 37% and save 4,700 lives per year among the households that now cook primarily with firewood. Reaching the final target would save an additional 3,400 lives per year.

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

	Interim target	Final target
Avoided disease and deaths (%)	37%	64%
Avoided number of deaths per year	4,700	8,100

Total annualized cost of reaching the interim target is approximately 9 billion Pesos and total annual benefits are 19 - 34 billion Pesos. The cost associated with half of households adopting improved cookstoves is only one-eighth of the cost associated with half of households adopting LPG stoves.

Reaching the final target of 100% adopting LPG costs 16 billion Pesos per year, or 7 billion Pesos more than reaching the interim target. Reaching the final target provides annual benefits of about 27 – 52 billion Pesos. This is 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	1.0	12	8	6
50% of those using unimproved cookstoves switch to LPG cookstoves	8	22	16	13
100% of those using unimproved cookstoves switch to LPG cookstoves	16	52	36	27

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. 2015. Environmental health in Mexico: 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 Mexico, as well as extrapolated ambient PM2.5 concentrations for secondary cities and rural areas.

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[v] http://www.healthdata.org/gbd

[vi] See ii.

[vii] 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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Zuk, M., Rojas, L., Blanco, S., Serrano, P., et al. 2007. The impact of improved wood-burning stoves on fine particulate matter concentrations in rural Mexican homes. *J Exposure Sci and Environ Epidemiology,* 17:224-32.

[viii] 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.

[ix] These benefits and costs are based on data for Mexico. 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

[x] See Larsen, B (2014) in ix.

Air Pollution in Mexico

Better air?

better health?

for whom?

for how much?

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Questions to ask ourselves

- Does Mexico have an air pollution problem?
- How big is the problem?
- Who are most affected?
- Can we do something about it?
- Shall we do something?
- What will be the benefits?
- What are the costs?
- 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 PM2.5
  - 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 Mexico have a PM2.5 problem?

- There has been achievements:
  - PM2.5 air quality has improved in several urban areas
  - Liquefied petroleum gas (LPG propane) have successfully expanded in urban areas, and even in rural areas

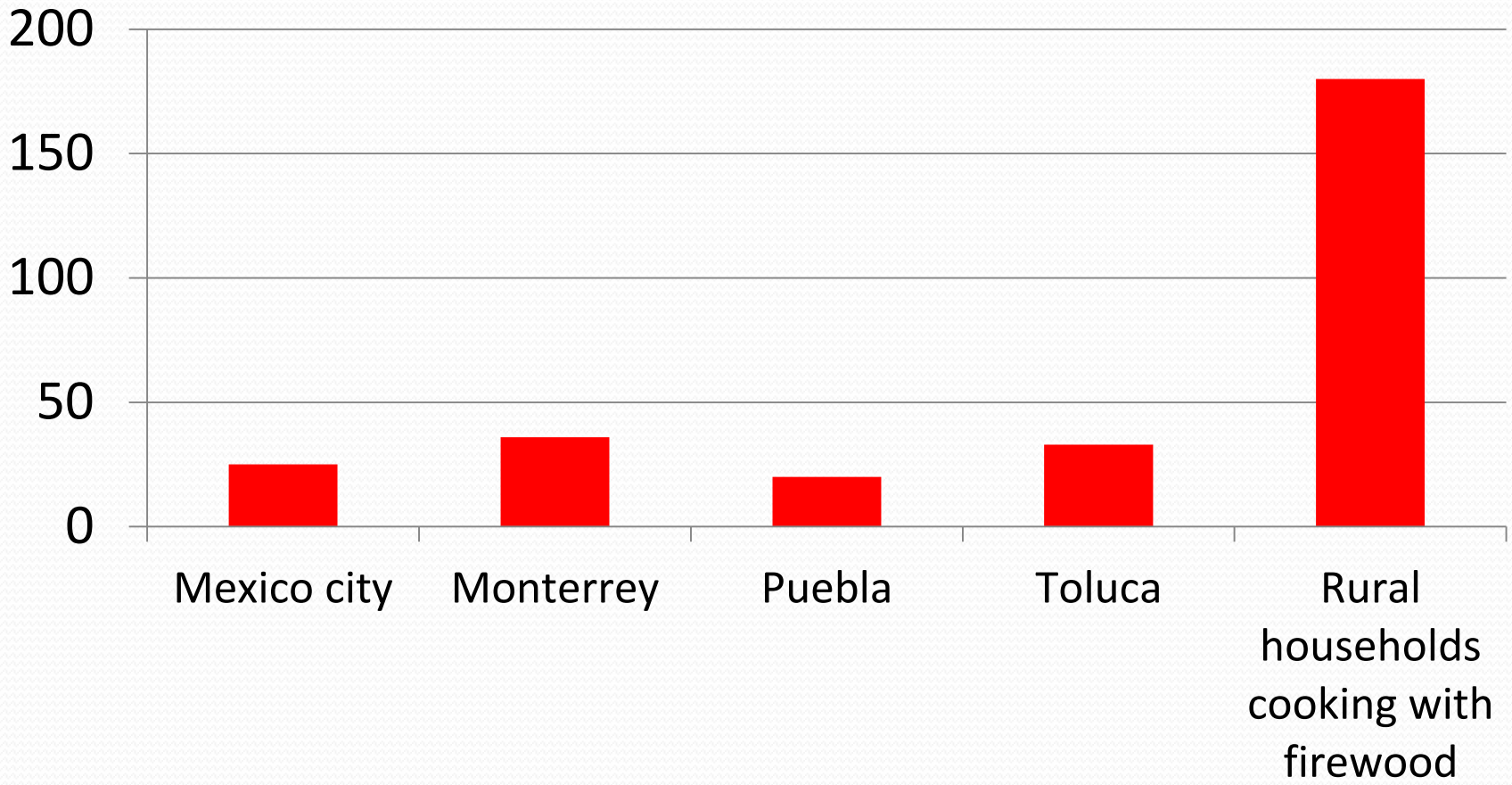
A PM2.5 problem?

- So what is the problem?
  - 80% of the population in Mexico is exposed to outdoor PM2.5 above WHO's annual guideline of 10 microgram per cubic meter of air ($\mu g/m^3$)
  - Over 13% of the 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?

- 33,000 die each year from this pollution
  - ✓ 20,000 from outdoor ambient PM2.5
  - ✓ 13,000 from household PM2.5 due to dirty cooking fuels

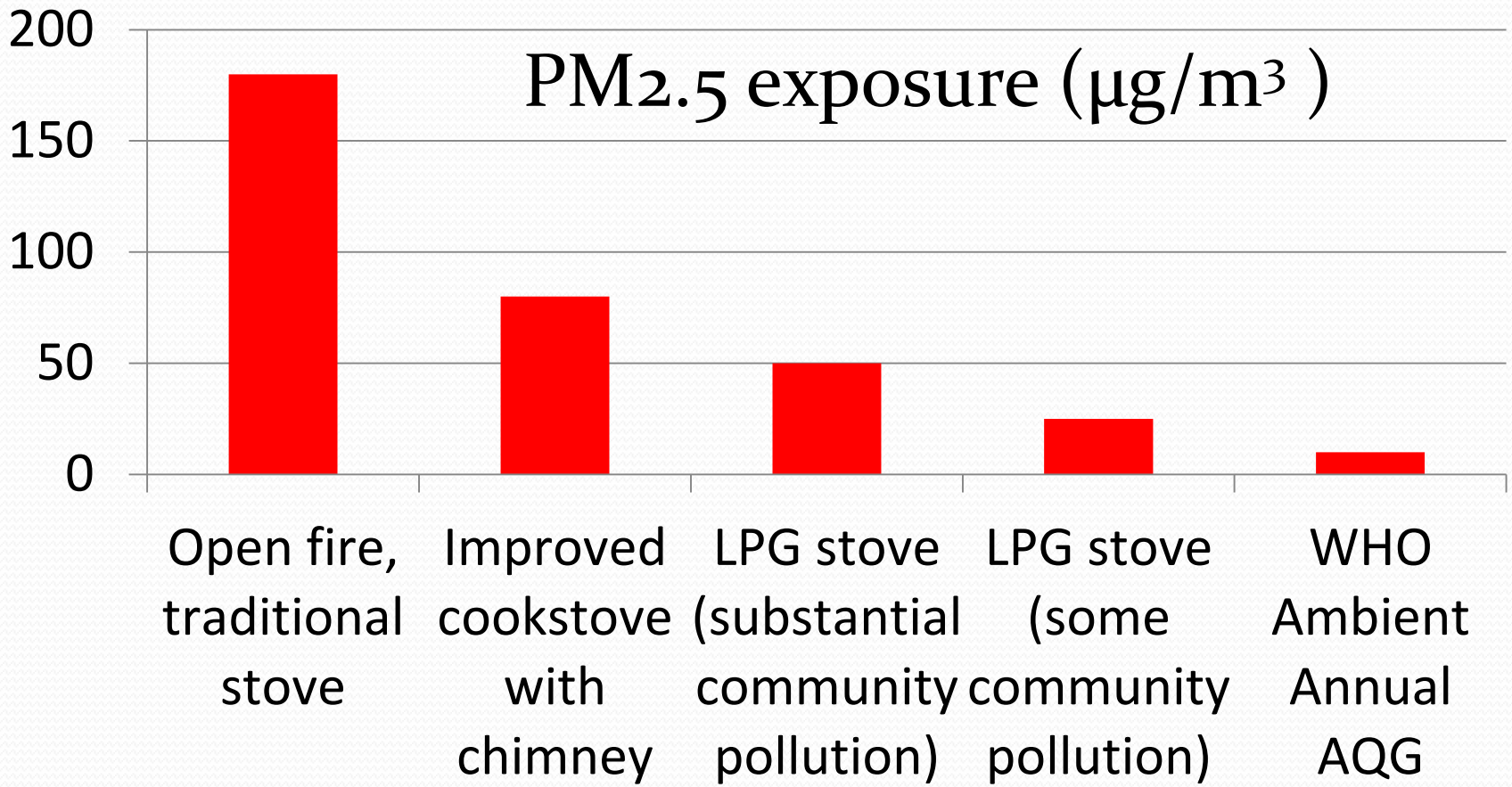
Annual average PM2.5 (μ/m^3)



So who are most affected?

- Over 16 million people – mainly in rural areas – use solid, dirty fuels as primary fuels for cooking
- 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 PM2.5

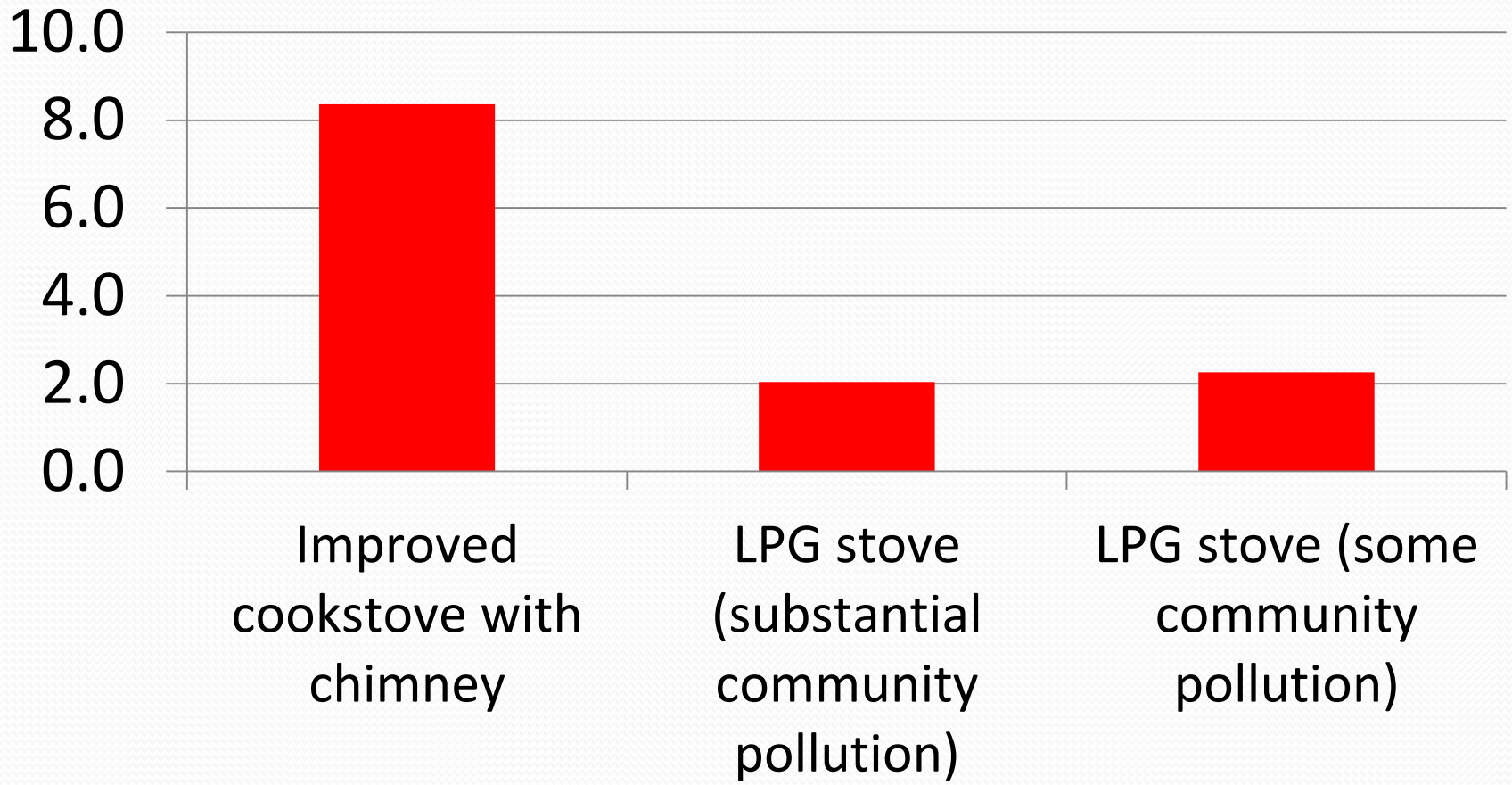
So what can we do about it?



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



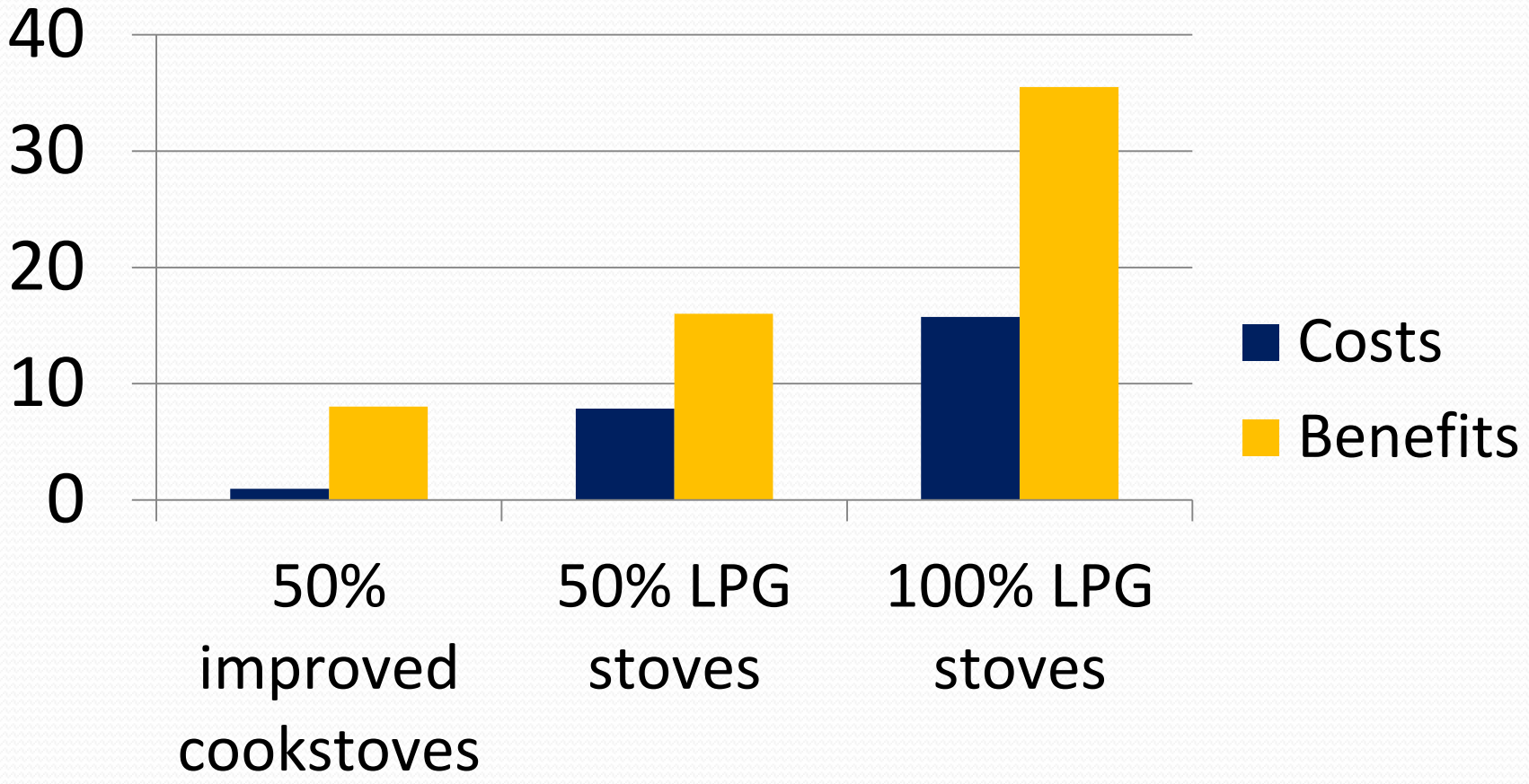
Note: 1 year of life saved is valued at US$ 5,000

What might be some achievable targets?

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

- Final target:
  - 100% adoption of LPG
  - Saves 8,100 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.