# AIR QUALITY

## missing the wood for the trees

### Indoor pollution is SA's most serious air quality problem

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# AIR QUALITY: MISSING THE WOOD FOR THE TREES

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# 1. Introduction

When examining South Africa's air quality, the media and activists focus too often on mining and industrial pollution and the liability of corporations and state-owned enterprises. While this scrutiny is not wrong, it loses sight of a problem that is not only more prevalent but much more difficult to solve: indoor air pollution.

Throughout the country, but mainly in rural areas, one-third of South African households burn solid fuels – wood, cow dung, vegetable waste and coal – to cook and keep warm, according to a study published in the *South African Medical Journal*.[1] These fires envelop many households in "swirling pawls of thick choking smoke", according to a recent Department of Environmental Affairs (DEA) document.[2]

After taking into account ventilation, about 20% of the country's households are exposed to indoor smoke pollution. The burden falls most heavily on the black population. Low indoor air quality affects 24% of black households, 9% of coloured households and only 1% of white or Indian households, according to the study.

By most measures, the foul air circulating inside the homes of South Africa's poor is worse than the ambient dirty air found scarring a few industrial hot spots. Significant progress has been made with electrification, reaching about 76% of households.[3] But the poor cannot always afford electricity: even some electrified households continue to burn solid fuels for cooking and heating.

Environmental activists expect air quality laws to fix this problem. In the last few years they have bemoaned delays in the implementation of the 2004 Air Quality Act and the 2012 National Framework for Air Quality Management. Deficient regulatory competence is partly responsible for these delays. But the blame goes further: to postponements granted to large companies, notably Eskom. As a result, South Africa's comprehensive legislation on ambient air quality remains more an ideal than effective practice.

If the government has had limited success in reining in a handful of large polluters, what hope is there that regulation can clean the air inhaled by the millions of poor people who burn solid fuels not only because they are cheaper than electricity, but too often the only available option?

Fortunately, solutions exists to help purify indoor, which the government, the private sector and individuals can adopt. These include wider electrification, better methods for starting coal fires, cleaner stoves and chimneys, increased ventilation, and low-smoke fuels. Given the limited scope of state assistance, this paper proposes that the government assist the private sector to market and sell affordable equipment and methods to clean household air.

# 2. Air quality: sensationalism versus reality

## 2.1. No national air quality problem

Reliable and comprehensive statistics about air pollution, whether indoor or outdoor, are hard to find. Surveys and estimates are often incomplete, outdated, based on sparse information and sometimes inconsistent with each other. Despite these drawbacks, a comprehensive look at the information yields context and perspective.

1 Rosana Norman, et al., Estimating the burden of disease attributable to indoor air pollution from household use of solid fuels in South Africa in 2000, *South African Medical Journal*, (August 2007).
2 Department of Environmental Affairs, Draft Strategy to Address Air Pollution in Dense Low-Income Settlements, Government Gazette, (24 June 2016)
3 Pepukaye Bardouille, Toward universal energy access: Designing a new household electrification strategy for SA, EE Publishers, (30 June 2014).

It also exposes the superficial, sensational and piecemeal treatment that environmental lobby groups and much of the media apply to air quality.

In 2005 the environment department published the most recent major report on South Africa's air quality for the United Nations Commission on Sustainable Development.[4] In this document, the department claims that "South Africa does not have a national air quality problem." It admits, however, that "a number of air pollution 'hot spots' exist around the country where severe air quality problems occur."

The 2004 Air Quality Act called for the establishment of National Air Pollution Priority Areas. So far, the environment department has identified three such areas. The Vaal Triangle Airshed Priority Area, declared in 2006, covers the southern parts of Gauteng and the northern Free State provinces. The Highveld Priority Area, named in 2007, covers parts of Mpumalanga and western Gauteng. In 2012, the DEA identified the third priority area, the Waterberg-Bojanala Priority Area, covering parts of the Limpopo and North West provinces.

Substantial evidence exists that ambient air pollution in the first two regions exceeds South Africa's air quality standards. Current or planned industrial and mining activities in the third area could cause pollution to exceed limits in the future, the department warned.[5]

The government's claimed absence of a national air quality problem might seem surprising to a public more accustomed to sensational media headlines. No one doubts the validity or need for news reports on industrial pollution. But often these stories overgeneralise the breadth of the problem. Too frequently they gloss over other sources of contamination that are as damaging to human health, if not more so.

In a May 2014 joint press release, environmental non-governmental organisations (NGOs) Earthlife Africa and groundWork denounced "Johannesburg's Dangerous Air" for exceeding World Health Organisation (WHO) safety limits.[6] A media headline from the same year extended this admonition to the whole country: "SA air pollution exceeds WHO limits".[7]

These stories neglect to mention that 98% of all cities of 100,000 inhabitants or more in low- or medium-income countries such as South Africa fail this test.[8] In high-income countries the failure number drops to 56%, which is still more than half of all cities. Overall, 80% of cities fall short of the WHO's aspirational standards.

The DEA's most recent country report[9] to the United Nations Commission on Sustainable Development, published in 2010, barely mentions air quality. It admits that South Africa's reliance on coal-based energy "is a risk, both economically and environmentally". It laments the "serious repercussions" suffered by the mining industry – responsible for half of South Africa's foreign exchange earnings – during the 2008 power crisis when electricity supplied to mines was cut by up to 50%.

4 Department of Environmental Affairs and Tourism, South Africa Country Report, Fourteenth Session of the United Nations Commission on Sustainable Development, (September 2005)
5 Department of Environmental Affairs, Draft Strategy to Address Air Pollution in Dense Low-Income Settlements, Government Gazette, (24 June 2016)
6 Earthlife Africa, groundWorks, Johannesburg's Dangerous Air , press release, (24 May 2014)
7 eNCA, SA air pollution exceeds WHO Limits, (16 September 2014)
8 World Health Organisation, WHO Global Urban Ambient Air Pollution Database (update 2016)
9 United Nations, South Africa Country Report for the Eighteenth Session of the United Nations Commission on Sustainable Development (CSD-18), January 2010

This formal nod to the energy and extractive industries recognises both their economic value and their operational constraints. It is significant because it justifies the postponements the government has since granted to major industrial players, including Eskom, for meeting Air Quality Act (AQA) emissions rules.

After announcing in February 2015 that 37 companies had applied to postpone their compliance deadlines, the DEA granted delays of not more than five years to 16 Eskom power plants, four Sasol plants, four PPC cement operations, four Shell plants, two Anglo Platinum smelters, two Total facilities, and one facility each owned by Engen, Chevron and float glass manufacturer PFG.[10] The DEA granted these postponements only after the companies submitted compliance road maps explaining how and when they would meet national air quality standards, as required by law.

Although the Air Quality Act permits postponements, Greenpeace described these applications as "a full-on assault from the country's major polluters"[11] on South Africa's air pollution legislation.

An editorial by Saliem Fakir and two other writers for the World Wide Fund for Nature (WWF), published in March 2015 on the *Daily Maverick* site, is misleadingly headed: "Air pollution – sadly, it's here to stay".[12] The article prioritised industrial pollution first among the air quality issues that need to be addressed.

## 2.2. The extent of outdoor air pollution

Mining and industrial operations are responsible for high levels of outdoor air pollution in certain areas in South Africa.

Industries, coal-burning power plants and all fuels when combusted release several kinds of harmful emissions: ammonia, benzene, carbon monoxide, nitrogen dioxide, ozone, sulphur dioxide and particulate matter. Airborne particulate matter of 10 microns or less, known as PM10, is small enough to pass through the throat and nose and enter the lungs. PM10 is a useful measure of overall pollution levels.

The WHO recommends annual mean limits for PM10 of 20 micrograms per cubic metre, and a maximum of 50 micrograms per cubic metre over any 24-hour period.[13] As a developing country under significant economic pressure, South Africa's own standard for annual average PM10, in effect since January 2015, is more tolerant: twice the WHO recommendation at 40 micrograms per cubic metre. Twenty-four-hour averages are permitted to rise to 75 micrograms per cubic metre.[14] This is a reduction from the previous standard of 50 and 120 micrograms per cubic metre.

The WHO Global Urban Ambient Air Pollution Database[15] draws its information from the South African Air Quality Information System (SAAQIS)[16], operated by the DEA. The WHO database includes information from the DEA's 13 pollution monitoring stations which audit the three "priority areas". Eight of these fail South Africa's standards: Hartbeespoort, Johannesburg, Mpumalanga, Sebokeng, Secunda, Tshwane, Vereeniging

10 Department of Environmental Affairs, Media Statement for Minister's announcement of decisions for applications for postponement of compliance time-frames for minimum Air Quality Emission Standards, (24 February 2015),
11 Melita Steele, South Africa's Pollution Laws Under Full Assault, Greenpeace, (7 October 2014).
12 Saliem Fakir, Ellen Davies & Desmond D'Sa, Air pollution – Op-Ed: Air pollution-sadly – it's here to stay. Daily Maverick, (24 March 2015).
13 World Health Organisation, Fact Sheet No. 313: Ambient (outdoor) air quality and health, (March 2014)
14 Government Gazette, Department of Environmental Affairs, National Ambient Air Quality Standards, (23 December 2009)
15 World Health Organisation, Global Urban Ambient Air Pollution Database, (updated 2016)
16 South Africa Air Quality Information System (SAAQIS)

and Zamdela. Only five meet South Africa's more relaxed guidelines: Diepkloof, Ermelo, Middleburg, Waterberg and Witbank.

Not one of the 13 meets the more rigorous WHO criteria.

As can be seen in Table 1, the annual average concentration of PM10 at South African monitoring stations in these 13 regions is 54 micrograms per cubic metre, or 35% higher than the national standard. This exceeds Brazil's average of 34 micrograms per cubic metre, yet falls below China's and India's averages of 84 and 107 respectively.

The WWF article emphasises the problem of ambient air pollution. It cites two health assessments released by Eskom under a Promotion of Access to Information Act request filed in 2014 by the Centre for Environmental Rights. One of the surveys, conducted in the coal fields of Mpumalanga in 2006, blamed emissions from coal-fired power stations for 17 deaths and 661 respiratory hospital admissions.[17]

These statistics, however, ignore the stifling indoor air pollution generated when a third of the country's households burn solid solid fuels such as coal, wood or dung to cook and keep warm. The WWF article went further and explicitly dismissed prioritising indoor air pollution, although it causes more life years lost (to ill health, disability or early death) than outdoor air pollution, primarily because it affects children more severely.

***Table 1:** Urban Ambient Air Pollution, Annual City/Town Means*

| REGION | PM10 (µg/m³) | DATE | REGION | PM10 (µg/m³) | DATE |
|---|---|---|---|---|---|
| Diepkloof | 39 | 2014 | Secunda | 54 | 2014 |
| Ermelo | 33 | 2014 | Tshwane (Pretoria) | 63 | 2014 |
| Hartbeespoort | 119 | 2014 | Vereeniging | 58 | 2014 |
| Johannesburg | 85 | 2011 | Waterberg | 37 | 2014 |
| Middleburg | 24 | 2014 | Witbank | 30 | 2014 |
| Mpumalanga | 61 | 2013 | Zamdela | 56 | 2014 |
| Sebokeng | 42 | 2014 | | | |
| Average for 13 documented regions in South Africa | | | | 54 | |
| Average for 45 documented regions in Brazil | | | | 34 | |
| Average for 210 documented regions in China | | | | 84 | |
| Average for 112 documented regions in India | | | | 107 | |

**Source:** Global Urban Ambient Air Pollution Database (May 2016)

## 2.3. Ambient air quality versus indoor air quality

The WHO blamed exposure to air pollution for killing about 8m people worldwide in 2012. Of these, more than half, or 4.3m, died from exposure to dirty indoor air, while 3.7m died from diseases resulting from polluted outdoor air.[18]

17 Yvonne Scorgie, et al., Eskom Mpumalanga Highveld Cumulative Scenario Planning Study, (October 2006)
18 World Health Organisation, Burden of disease from ambient and household air pollution, (2012)

A 2016 DEA report[19] blames lack of electricity in rural areas and its unaffordable costs in the cities for keeping the poor dependent on solid fuels. The PM10 levels in "most residential household fuel burning areas" exceed national air quality limits, the report says. "The health effects associated with exposure to indoor air pollution also have economic implications due to huge expenditures in the health sector."

Siyavuya Sigutya, a factory worker, knows this problem first hand. "People are suffering and going to hospital because they do not have electricity," he complains. Mr Sigutya lives in Concordia, a township on the wooded slopes above Knysna. Its residents live in shacks made of timber or corrugated iron. They burn wood for cooking and heating.

In her 2012 PhD thesis[20] written for the Faculty of Science at the University of Johannesburg, Yvonne Scorgie breaks down health expenses related to air quality: "Household fuel burning was estimated to be responsible for about 68% of the total health costs estimated across all conurbations, vehicle emissions for 13%, industrial and commercial fuel burning for 13%, and power generation for about 6%."

André Joubert, an unemployed man in his late 60s, shares a one-room corrugated-iron and wood shack with his wife, daughter and four young grandchildren in Concordia, Knysna. The family burns wood on a small, indoor fireplace built with cinder blocks and topped with a corrugated-iron cooking surface. They open the shack's door to blow out the burning smoke. During the day, they keep the children outdoors, weather permitting. "It's not healthy for them," Mr Joubert says, "but because we have no electricity we have no choice, especially when it rains so much outside."

It is obvious to the Jouberts that the air inside their home is more toxic than the air outside, a fact confirmed by the 2007 MRC study: "Although attention to air pollutant emissions is dominated by outdoor sources, human exposure is a function of the level of pollution in places where people spend most of their time. Human exposure to air pollution is therefore dominated by the indoor environment."[21]

# 3. Indoor air quality

## 3.1 Health effects of indoor air pollution

Some 20% of South Africa's households suffer the health effects of exposure to contaminated indoor air. It may cause or contribute to chronic obstructive pulmonary disease, lung and other cancers, tuberculosis, cataracts, low birth weight and perinatal mortality, asthma, ear infections, cardiovascular disease, and most seriously, acute lower respiratory infections (ALRI) in children.[22],[23]

ALRIs are the world's single leading cause of death among children less than five years old and among the top four killers of South Africans under five. Indoor air pollution accounts for the deaths of 1,400 South African children per year.[24]

19 Department of Environmental Affairs, 2nd South Africa Environment Outlook: Executive Summary (2016). See also 2nd South Africa Environment Outlook: Chapter 10, Air Quality (2016)
20 Yvonne Scorgie, Urban Air Quality Management and Planning in South Africa, Ph.D. diss.,University of Johannseburg, (2012)
21 Rosana Norman, et al., Estimating the burden of disease attributable to indoor air pollution from household use of solid fuels in South Africa in 2000, *South African Medical Journal,* (August 2007).
22 Esther Duflo. et al., Indoor Air Pollution, Health and Economic Well-being, (February 2008)
23 Brendon Barnes, et al., Household energy, indoor air pollution and child respiratory health in South Africa, *Journal of Energy in Southern Africa,* (February 2009)
24 Brendon Barnes, et al., Household energy, indoor air pollution and child respiratory health in South Africa, *Journal of Energy in Southern Africa,* (February 2009)

"Young children are more susceptible to ALRI through indoor air pollution exposure" for several reasons, write Brendon Barnes, et al., in the *Journal of Energy in Southern Africa*. "The epithelial linings of children's lungs are not fully developed resulting in greater permeability of pollutants, their immune systems are not fully developed thereby limiting the body's defence against infection, they have higher respiration rates and they have a larger lung surface area per kilogram of body weight thus breathing in approximately 50% more (polluted) air under normal breathing conditions compared to adults. In addition, from an exposure perspective, children tend to follow their caregivers around, for example, through carriage on their caregivers' backs."[25]

With electricity available widely in urban areas, the problem is mostly concentrated in rural areas and informal settlements, and almost exclusively among South Africa's black population. Women and young children suffer the most. Women spend more time cooking by the fires. Nearby are their children, whose bodies are not fully developed.[26]

Studies in Kenya and India have shown that exposure to harmful particulates (PM10) in rural kitchens near cooking fires can be as much as 1,000 times higher than global or national air quality standards, according to a 2008 paper co-written by Esther Duflo, an economist at the Massachusetts Institute of Technology.[27]

Not far from the Jouberts, Rosie and Joseph Mpudana run a chicken plucking business. To remove the feathers, the couple spend their day plunging the birds into a large drum filled with boiling water. A fire beneath this barrel keeps the liquid bubbling and steaming.

Speaking through a translator, Rosie says they try to make the fire outdoors when possible. Still, breathing is difficult, even outdoors, she complains. Much of the wood they burn is scrap, which is often coated with paint, creosote or varnish, and sometimes impregnated with wood preservatives.

These home fires, whether inside or out, spew smoke filled with toxic fumes. They release a similar array of pollutants as those discharged by coal-powered plants and other industries that burn fossil fuels. Open fires as well as poorly-designed coal or wood stoves without airtight fittings expel significant levels of human carcinogens.[28] Inadequate ventilation exacerbates the concentration of smoke.[29]"My eyes are bad, and so are my wife's eyes," Mr Joubert complains. "I think it is because of the smoke in the house every day."

Barnes et al. emphasise that much more research is needed on the effects of indoor air quality on health.[30] For example, the link between air quality and acute lower respiratory infections in children is well-established. However specific studies with large enough sample sizes that link changes in ALRI incidence with indoor air quality have not been made.

25 Brendon Barnes, et al., Household energy, indoor air pollution and child respiratory health in South Africa, *Journal of Energy in Southern Africa*, (February 2009)
26 Esther Duflo. et al., Indoor Air Pollution, Health and Economic Well-being, (February 2008)
27 Esther Duflo. et al., Indoor Air Pollution, Health and Economic Well-being, (February 2008)
28 Washington State Department of Ecology, Health Effects of Wood Smoke (updated 1997 & 2004)
29 Rosana Norman, et al., Estimating the burden of disease attributable to indoor air pollution from household use of solid fuels in South Africa in 2000, *South African Medical Journal,* (August 2007).
30 Brendon Barnes, et al., Household energy, indoor air pollution and child respiratory health in South Africa, *Journal of Energy in Southern Africa,* (February 2009)

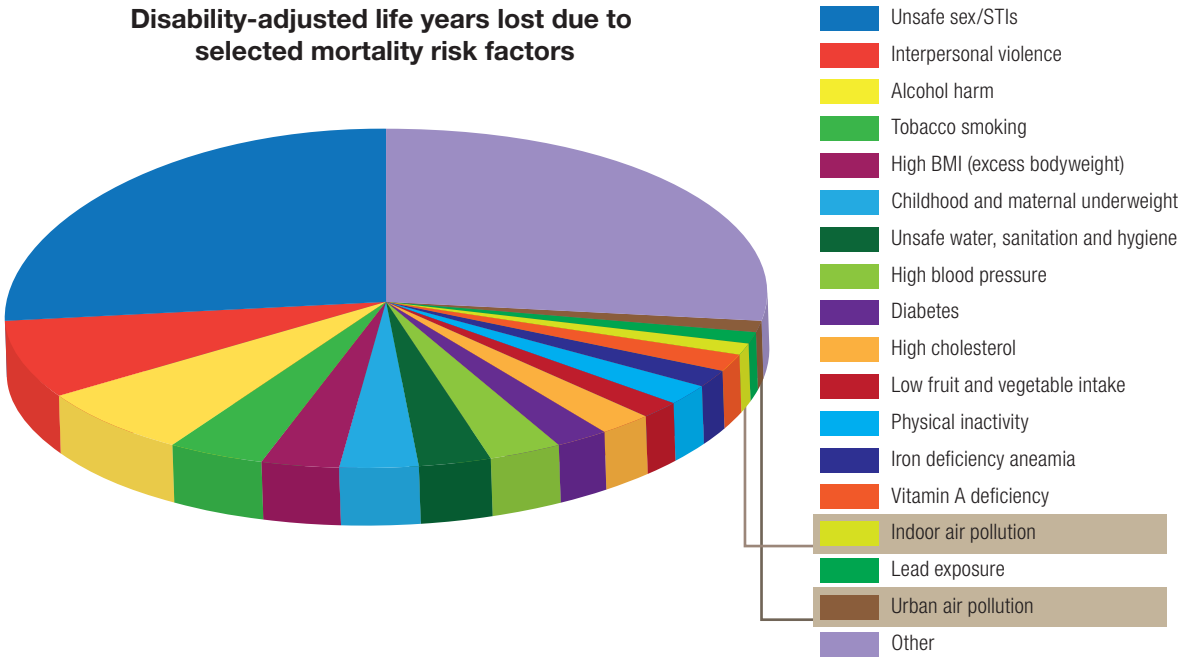
## 3.2. Air pollution compared to other health risk factors

A 2007 Medical Research Council (MRC) report showed that nearly 2,500 people, or 0.5% of all deaths in the 2000 study year, died from exposure to indoor smoke from solid fuels.[31] This is lower than the 4,637 people, or 0.9% of the population, who died as a result of outdoor air quality in 2000.[32]

The MRC study cautions that its figures may be low for many reasons: unreliable reporting as affordability changes during the month and households use different fuels; conservative assumptions that excluded tuberculosis, heart disease and asthma and ignored the compounding effect of smoking, HIV/Aids and malnutrition; and the difficulty of measuring proximity to a source of indoor smoke.

In January 2008, the MRC released a publication that identified and ranked mortality risk factors by measuring the loss of healthy life years.[33] This differs from counting actual deaths since it considers not just how many people die, but how young they die. Using the same information from the year 2000, this peer-reviewed study confirms that indoor air pollution is more toxic than ambient air pollution. Even so, these hazards rank only 15th and 17th on the list of all mortality risk factors (see Figure 1).

**Figure 1:** Air pollution compared to other health risks




**Source:** Medical Research Council's Burden of Disease Research Unit, South African Comparative Risk Assessment 2000, January 2008

Unsafe sex and sexually-transmitted infections are by far the highest risk factors for the loss of healthy life years, followed by interpersonal violence and alcohol harm. Even when combined, indoor and outdoor air pollution account for less than 1% of all healthy life-years lost in South Africa.

31 Rosana Norman, et al., Estimating the burden of disease attributable to indoor air pollution from household use of solid fuels in South Africa in 2000, *South African Medical Journal,* (August 2007).
32 Rosana Norman, et al., Estimating the burden of disease attributable to outdoor air pollution from household use of solid fuels in South Africa in 2000, *South African Medical Journal,* (August 2007).
33 Medical Research Council, 17 Risk Factors, South African Comparative Risk Assessment Summary Report, (January 2008)

The small relative magnitude of air pollution exposes the lopsided pressure environmental lobbyists exert on big industry. It is right that groups such as the Centre for Environmental Rights lean on government to implement the Air Quality Act[34]. Projects such as the "Bucket Brigade" to help communities monitor air quality near industrial polluters are excellent contributions to promoting healthy air quality standards.[35]

However, a single-minded focus on the mining and industrial sectors – especially in a precarious economy – is distorted. It lacks the required perspective. It ignores problems much closer to home for many ordinary South Africans. It risks dismissing solutions with a higher benefit-to-cost ratio that could significantly improve the health of South Africans, particularly the poor.

"If you look at it (air quality in South Africa), the problem is in the home," the DEA's air quality management chief director, Thuli Mdluli, told *Business Day*'s Sue Blaine.[36] "If you invested (money assigned to industrial pollution control equipment) in the community to stop home burning, it would have a far higher impact on human health."

The burden of disease blamed on contaminated indoor air is greater than all other sources of air pollution combined, as discussed above. However, even when combined, dirty indoor and outdoor air contribute only a fraction of a percent of the country's healthy life years lost to avoidable risk factors. This perspective is essential in designing and prioritising potential solutions.

## 3.3. Economic and other consequences of indoor air quality

Alexander Virgil, a labourer who lives in Concordia, Knysna, says exposure to wood smoke may have caused his cataracts, which were recently removed in an operation. "It helped me with my eyesight these last six months," he says, "but after I came out of the hospital I couldn't go to work for a few weeks."

Although health affects productivity, research has not conclusively measured the direct impact of household air pollution on economic well-being, according to the Duflo study.

It stands to reason, however, that reducing indoor air pollution would improve health. This would lead to savings in doctors' bills, a big chunk of the very poor's expenditures. If households are in better health, adults miss fewer days of work and children miss fewer days of school. The Duflo study concludes that "gains from reducing air pollution within the household can, in fact, be quite large."

In addition, burning more efficient forms of fuel – such as gas or electricity – would reduce the lost hours spent scavenging for something to burn, time better spent working or studying. It might conserve South Africa's landscape.

Concordia, like the rest of Knysna, lies on the southern edge of South Africa's largest remaining old-growth forests, nestled with the Garden Route National Park. When asked where they find their firewood, Mr Joubert points to the tree-covered hills surrounding the town.

Concordia dwellers fan out each day to the nearby forest looking for wood. This back-bending task takes two or more hours each day, reports Wellington Dyimi, another Concordia resident.

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34 Centre for Environmental Rights, Help! People are breathing here, (2 July 2014)
35 groundWork, Slow Poison: Air Pollution, Public Health and Failing Governance, (June 2014)
36 Sue Blaine, Improving air quality starts in the home, *Business Day* (24 April 2014)

Like other poor South Africans, the Joubert and Dyimi families are dependent on cheap, readily-available fuel. They are spoiling South Africa's woodlands, scouring the areas near their homes in search of anything to burn.

They are not only harming their surrounding environment, but creating dangerous living conditions too. Small home fires can turn into huge conflagrations consuming swathes of dense shack settlements built of flammable material, killing and maiming children and adults.

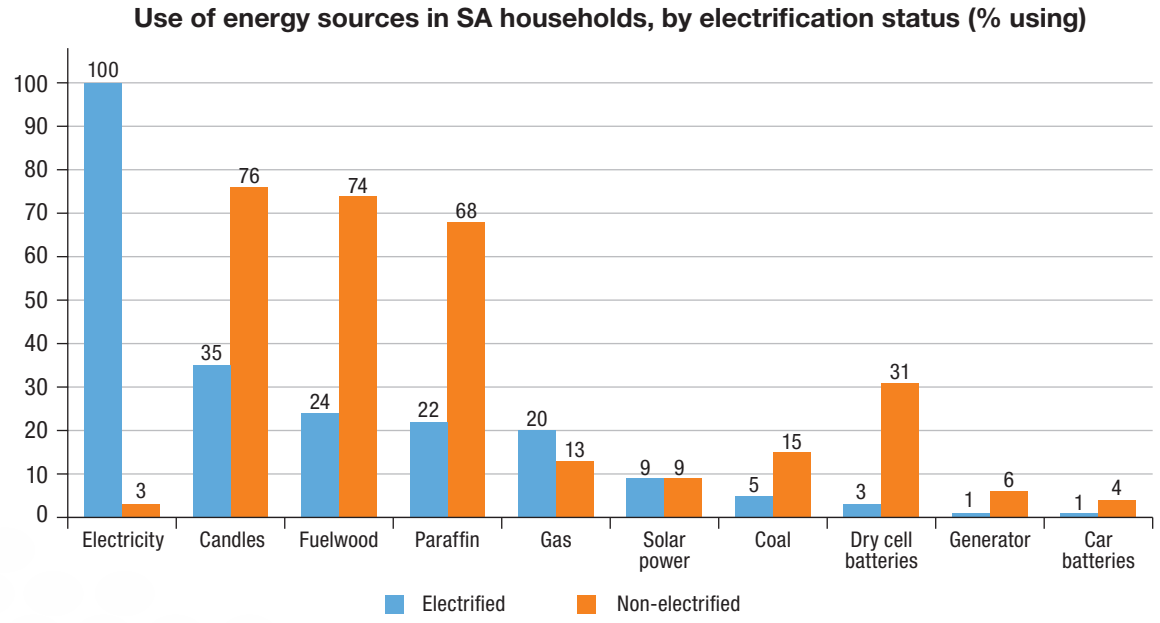
Indoor air pollution from burning solid fuels harms the health of about one-fifth of South Africa's population and countless acres of this country's landscape. Research needs to quantify the overall impact on well-being, including economic prosperity, environmental degradation and other factors. But no one can deny that the poor are victims of the contaminated indoor air they breathe.

# 4. Solutions to indoor air quality problems

## 4.1. Electrification

Electrification is the cleanest way to reduce indoor air pollution. In the last 20 years, South Africa has made dramatic progress, extending access to electricity to 76% of households in 2014 compared to 34% in 1994. However, about 3.4m households remain off the grid.[37]

**Figure 2:** Households with access to electricity are far less likely to use solid fuels such as wood and coal for heating and cooking.




**Source:** SASAS Energy related behaviour and perception survey (2012)

Unsurprisingly, households with access to electricity burn fewer candles and burn less wood, coal and paraffin for heating and cooking (see Figure 2).[38]A study published in the *Indoor Air* journal in 2004 confirmed that electrified homes had lower levels of air pollution – especially inferior amounts of respirable particulate matter

37 Pepukaye Bardouille, Toward universal energy access: Designing a new household electrification strategy for SA, EE Publishers, (30 June 2014)
38 Department of Energy, A survey of energy-related behaviour and perceptions in South Africa, (2012)

and carbon monoxide – than unelectrified homes.[39] If found that the proportion of dwellings with detectable 24-hour levels of particulate matter was 48.1% in unelectrified homes, nearly twice the 24.5% found in electrified homes.

Supplying electricity to informal settlements is difficult because many of these townships arise unplanned as rural migrants quickly populate areas that are often unsuitable for habitation and without proper infrastructure, according to a 2012 publication by Sustainable Energy Africa, a non-profit group that promotes energy development on the continent.[40] This creates other challenges related to: affordability, collecting consumption charges; weaning customers off free electricity from illegal connections; supplying electricity to the flood plains; and community engagement.

Since 2003, qualifying poor South African households have been entitled to a free basic electricity ration of 50 kilowatt-hours (kWh) per month.[41] This small allocation, however, falls far short of users' expectations, according to a survey conducted in Buffalo City, a municipality that offers this free energy.[42] Although 69% of respondents conceded that free basic electricity improved health, they also griped that 50kWh per month is totally insufficient for their needs. Only 9% of indigent families were found to be living within their free basic electricity allocation. Considering that a one-bar space heater consumes 1kWh per hour, and a small hot plate uses even more electricity, the inadequacy of a free ration to meet the needs of the poor is obvious.

The DEA's recent draft strategy[43] for addressing air pollution in poor communities says little about free basic electricity apart from stating that "government will explore new ways of providing electricity subsidies".

## 4.2. *Basa njengo Magogo*

Lighting cleaner indoor coal brazier fires is another way of improving household air and a good practice to adopt while making the transition to electricity. The Department of Minerals and Energy (now known as the Department of Energy), the Nova Institute, a Pretoria-based NGO that promotes healthy household practices, and Sasol, a petrochemicals company, have jointly developed a new method called *Basa njengo Magogo* ("light a fire like a grandmother").[44]

It is named after Gogo Maria Nebelungu Mashinini from eMbalenhle on the Mpumalanga Highveld who is credited with perfecting the technique. The method calls for covering the coal with dry twigs and paper and then lighting this kindling from the top, instead of from the bottom. By creating a hot zone at the top of the fire, less smoke is emitted per unit of coal combusted.[45] First piloted in 2003 in Orange Farm, south of Johannesburg, the DEA has since rolled it out to other areas.[46]

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39 H.B. Röllin, et al., Comparison of indoor air quality in electrified and unelectrified dwellings in rural South African villages, *Indoor Air,* (June 2004)
40 Trevor Gaunt, et al., Informal Electrifcation in South Africa: Experience, Opportunities and Challenges, Sustainable Energy Africa, (2012)
41 Department of Energy, Electricity Basic Services Support Tariff (Free Basic Electricity) Policy, Government Gazette (4 July 2003)
42 Jephthe Mvondo, Impact of Access to Free Basic Electricty on Households' Poverty in Buffalo City Municipality, master's thesis, University of Fort Hare, (December 2010)
43 Department of Environmental Affairs, Draft Strategy to Address Air Pollution in Dense Low-Income Settlements, Government Gazette, (24 June 2016)
44 Nova Institute, Basa Magogo Project
45 Henry Nuwarinda, Air Pollution Study of a Highveld Township During a Basa Njengo Magogo Rollout, minor diss., University of Johannesburg, (21 November 2007)
46 Department of Environmental Affairs, Deputy Minister Rejoice Mabudafhasi launches the Winter Clean Fires Campaign "Basa Njengo Magogo"

The *Basa njengo Magogo (*BnM) method of lighting coal fires significantly improves indoor air quality, research shows.[47] In the Orange Farm pilot, 76% of households reported less smoke in the homes, while 67% reported less smoke in the streets after one month of adopting this practice.

The energy department later appointed the Council for Scientific and Industrial Research to compare the emissions of four grades of coal and anthracite using the granny method and the traditional bottom-up lighting procedure. The researchers found that BnM fires were ready for cooking in 12 minutes, compared to 55 minutes for the traditional method. Particulate emissions were up to 92% lower using top-down ignition and used 20% less coal, which means poor households could save considerably.

Despite BnM's success, people resist adopting new practices and improvements in household air may not persist. As one study makes clear, behavioural change interventions "fail far more often than they succeed".[48]

The DEAs' latest draft strategy understands this reluctance: "People tend to use what they know, and mostly what has always been used. With a wide variety of energy technologies developed, some people are not aware of the many options they have. Meanwhile those who know about the technologies fail to trust them to the point of investing in them. In instances where intensive and extensive awareness campaigns have been rolled out, retention of methods remains a challenge. With *Basa njengo Magogo* (BnM), for example, the method was widely campaigned, accepted by communities but some retention studies still shows [sic] that some people return to their old ways of doing things."[49]

## 4.3. Low smoke fuels

Researchers have evaluated other potential practices to make cleaner indoor fires.[50] The energy department conducted a field test of three low-smoke fuels intended to replace low-grade coal for residential use in 1997, in Qalabotjha near Villiers in the Free State. The study concluded that combustion of low-smoke fuels reduced air pollution by as much as 63%. These findings suggests that low-smoke fuels may prove effective for improving indoor air quality.[51]

## 4.4. Improved cooking devices

A 1996 study compared five different wood-burning cooking devices in a laboratory setting. It evaluated an open fire built on the ground, an 'improved' open fire built on a raised grate, a one-pot metal stove, a two-pot metal stove and a two-pot ceramic stove. Cited by Mr Barnes, et al. in the *Journal of Energy in South Africa* in 2009, it found that emissions for the improved open fire and the two-pot ceramic stove were lower by 41% and 44% respectively.[52] Notably, the metal stoves emitted more pollutants than even the open fire, which the Barnes study notes is a warning that better technology does not necessarily lead to cleaner pollution outcomes.

47 L.J. Le Roux et al., Reduction in air pollution using the "basa nejengo magogo" method and the applicability to low-smoke fuels, *Journal of Energy in Southern Africa*, (August 2009)
48 Brendon Barnes, Behavioural Change, Indoor Air Pollution and Child Respiratory Health in Developing Countries: A Review, *International Journal of Environmental Research and Public Health,* (25 April 2014)
49 Department of Environmental Affairs, Draft Strategy to Address Air Pollution in Dense Low-Income Settlements, Government Gazette, (24 June 2016)
50 Brendon Barnes, et al. Household energy, indoor air pollution and child respiratory health in South Africa, *Journal of Energy in Southern Africa,* (February 2009)
51 Johann P. Engelbrecht, et al., Modelling PM10 aerosol data from the Qalabotjha low-smoke fuels macro-scale experiment in South Africa, *Ecological Modelling,* (2000)
52 G. Ballard-Tremeer & H.H. Jawurek, "Comparison of five rural, wood-burning cooking devices: efficiencies and emissions, *Biomass and Bioenergy,* (1996), cited in Brendon Barnes, et al. Household energy, indoor air pollution and child respiratory health in South Africa, *Journal of Energy in Southern Africa,* (February 2009)

Compared to the 75% improvements in indoor air quality from electrification and the top-down fire-lighting method and the high results from using low-smoke fuels, improved stoves are less effective.

## 4.5. Housing insulation

In the early stages of the Reconstruction and Development Programme, the government built about 3m houses without ceilings, concedes the DEA's 2016 draft air pollution strategy.[53] Since 2009, the government has been pushing for energy-efficiency in low-cost homes and now recommends "solar passive design" principles to moderate indoor temperatures. The goal is to reduce energy needs, particularly for indoor heating. The efficiency of these designs depends on house orientation, insulating building materials and features such as longer roof overhangs and ventilation.

A 2004 small-scale study in Benoni and Lady Grey compared energy-efficient low-cost houses to conventional homes. It found that energy-efficient dwellings were more comfortable and that households saved money on heating expenses and time, particularly women.[54] Participants also reported that they were sick less often and that their children coughed less in energy-efficient homes. A small reduction in CO2 achieved in these energy-efficient units was a reflection of the fuel used for space heating.

## 4.6. Liquefied petroleum gas (LPG)

Liquefied petroleum gas (LPG) is "amongst the cleanest fuels available for household use" and can cut household emissions related to fossil fuels by a "significant margin", according to the DEA."[55]

LPG bottles remain expensive, especially for the poor. Although the price of this gas is regulated, the DEA believes more people would use it if the costs of purchasing and refilling LPG cylinders were regulated, too. "As with electricity, means to make subsidies available to low-income groups in densely populated areas must be sought."

It is unclear why the government believes regulating the price of a service will lower the cost to consumers. If the profit margins to gas suppliers are reduced, the price difference to consumers would likely be marginal and could prompt retailers not to stock LPG cylinders at all.

## 4.7. Biogas digesters

Biogas is a methane-rich mixture produced by the anaerobic digestion of organic waste such as livestock manure, plant matter and sewerage. Biogas digesters can be used as an alternative energy for cooking, heating and lighting. Digesters are similar in function to septic tanks,[56] which can be adapted relatively easily to capture biogas.[57]

But in South Africa, only about 310,000 households have the technical ability – farmers without electricity but with access to water and who own at least four cows – to participate in a rural biogas programme, according to a feasibility study cited by Mark Wells, an industrial engineer involved with renewable energy firms.[58]

53 Department of Environmental Affairs, Draft Strategy to Address Air Pollution in Dense Low-Income Settlements, Government Gazette, (24 June 2016)
54 M Wentzel, Quantifying benefits of energy efficient house design through monitoring of specified air quality and household energy activity, *Journal of Energy in Southern Africa,* (May 2006)
55 Department of Environmental Affairs, Draft Strategy to Address Air Pollution in Dense Low-Income Settlements, Government Gazette, (24 June 2016)
56 Bio-Systems SA, Septic tank systems
57 BiogasPro AGAMA, AGAMA Biogas Digesters Can Replace Septic Tanks
58 G. Austin & J.N. Blignaut, "South African National Rural Domestic Biogas Feasibility Assessment", (November 2007), cited in: Mark Wells, The Integrated Biogas Agro-Ecological Farming Revolution, (10 March 2009)

South Africa has some large commercial biogas plants and small units for domestic use. However, for the most part, subsidies buttress this technology, which is still under research.[59] It is still not a financially feasible investment for a rural household, concluded a 2014 study. But its broader socio-economic benefits – reduced fuel costs, less time collecting wood and cooking, and healthier indoor air – warrant further research and consideration of government support.[60]

## 4.8. International indoor air quality initiatives

South Africa is far from the only country with a serious indoor air quality problem from burning solid fuels. Over 3 billion people use polluting, inefficient energy for cooking alone, a figure that has barely changed in the last decade, according to a 2016 WHO report.[61]

In Kenya, the Intermediate Technology Development Group, a United Kingdom-based charity that is now known as Practical Action, evaluated the effects of various ventilation systems to improve indoor air.[62] Surprisingly, it found that windows made little difference, while smoke hoods led to the biggest improvement, slashing particulates and carbon monoxide by 75% and 78% respectively. Openings under roof eaves reduced particulates by 60% and carbon monoxide by 28%. Stoves tapered particulates by 54% and carbon monoxide by 42%.

These substantial reductions in noxious indoor air led to improved well-being. This meant fewer sick days, smaller doctors' bills and more time to engage in economic activities, including the manufacture and sale of smoke hoods, stoves, windows and frames for roof eaves. People who used fuel-efficient stoves saved even more by purchasing less kerosene. Women participants found that their status rose as other community members approached them for advice on house and kitchen improvements. As the demand for firewood declined, the pressures on the forests also receded.

Improved ventilation, however, has significant drawbacks, the study noted, particularly in winter when it lowers indoor temperatures. It also compromises privacy.

In Pakistan, a project to develop smoke-free stoves has generated a thriving business for some villagers, who manufacture the earthenware devices using freely available construction materials such as soil, rice husks and donkey dung.[63] Besides dramatically clearing indoor air, the stoves are also more efficient, reducing the time spent cooking and gathering wood by 40% to 45%. This represents a saving of several hours each day that could be spent more productively.

In rural Sri Lanka, Practical Action has piloted biogas solutions to indoor cooking using methane from animal dung.[64] In addition to a clean source of fuel, the digesters also generate excellent fertiliser for crops.

59 Alicia van der Merwe, The State of Waste to Energy Research in South Africa (October 2014)
60 Michael T. Smith et al., The financial and economic feasibility of rural household biodigesters for poor communities in South Africa (February 2014)
61 World Health Organisation, Burning Opportunity: Clean Household Energy for Health, Sustainable Development, and Wellbeing of Women and Children, (2016)
62 Intermediate Technology Development Group, [now known as Practical Action], Reducing indoor air pollution in rural households in Kenya: working with communities to find solutions, (1998-2001)
63 Zofeen Ibrahim, Pakistan: Smoke-free Stoves a Godsend for Village Women, Inter Press Service News Agency (25 February 2010)
64 Practical Action, Poo power: cow dung can be used as fuel

In Guatemala, government, private manufacturers, NGOs, donors and universities are developing a comprehensive plan to reduce premature deaths from exposure to open fires inside homes.[65] The project demonstrates the potential for cooperation between communities and the public and private sectors to improve cooking fuel efficiency and thus indoor air quality and health.

In Bangladesh, a 2006 World Bank study evaluating the effects of exposure to indoor air pollution found that children and adolescents – particularly in the poorest and least-educated households – suffer most.[66] It proposed a simple, inexpensive and effective solution: increase children's outdoor playing time from three hours to up to six hours, and concentrate those outdoor times during peak cooking periods.

Another study, also in Bangladesh, examined the factors that influenced the adoption of cleaner, safer cookstoves.[67] It found that health arguments were more convincing than the prospect of saving time. Unsurprisingly, price also proved to be a major factor in the decision to adopt new technology. However, nearly one-third of the study group rejected free cookstoves (even without additional installation costs). The poor believe new expensive technologies are more appropriate for community leaders who are richer and more educated, the study found.

## 4.9. Cost-benefit analysis

In 2006 four economists, led by Anthony Leiman, a professor at the University of Cape Town, set out to evaluate policy and practices to reduce the healthcare costs associated with air pollution.[68] In their cost-benefit analysis, they measured financial costs, as well as broader economic consequences such as employment.

Top-down fuel ignition (*Basa njengo Magago*) proved to be the most cost-effective intervention of the 32 they considered. Stove maintenance and replacement, housing insulation and electrification were also effective, though much less so than the granny's low-tech fuel ignition method.

Perhaps surprisingly, the study also found that measures to curb industrial pollution – such as desulphurisation of power station emissions, renewable wind energy, reducing the sulphur content of vehicle fuel and conversion of petrol vehicles to liquid petroleum gas – provided the least environmental bang for the economic buck.

The Leiman study found that most proposed industrial interventions failed a simple cost–benefit test. Instead, efforts to improve air quality should begin in the home. Further industry controls, they argued, are not yet justifiable in terms of health care benefits as weighed against costs.

65 Global Alliance for Clean Cookstoves, Guatemala Country Action Plan for Clean Cookstoves and Fuels (May 2014)
66 Susmita Dasgupta, et al., Who suffers from indoor air pollution? Evidence from Bangladesh (October 2006)
67 Allison McCann, Indoor air pollution and health in developing countries: An intervention study in Bangladesh, Stanford Woods Institute for the Environment
68 Anthony Leiman, et al., Reducing the healthcare costs of urban air pollution: The South African experience, *Journal of Environmental Management,* (July 2007)

**Table 2:** Economic Benefit-to-Cost Ratio for Selected Air Quality Interventions

| | |
|---|---|
| Top down ignition – Highveld roll out | 177.0 |
| Top down ignition – all conurbations | 120.1 |
| Stove maintenance and replacement – 5% of all households | 16.5 |
| Stove maintenance and replacement – 20% of all households | 16.5 |
| Housing insulation – 5% of all fuel burning households | 7.9 |
| Housing insulation – 20% of all fuel burning households | 7.9 |
| Housing insulation – 5% of Highveld fuel burning households | 6.0 |
| Housing insulation – 20% of Highveld fuel burning households | 6.0 |
| Electrification of paraffin burning households | 1.3 |
| Electrification of all unelectrified households | 1.2 |
| Phasing out leaded petrol | 1.0 |
| Conversion of 10% of petrol vehicles to LPG | 1.0 |
| Conversion of 20% of petrol vehicles to LPG | 1.0 |
| Emission reductions for coal-fired boilers | 0.8 |
| Reducing sulphur content of diesel to 50 parts per million | 0.5 |
| Low-smoke fuels | 0.4 |
| Renewable wind energy | 0.3 |
| Desulphurisation of Sasol Secunda power station emissions | 0.1 |
| Desulphurisation of all power station emissions | 0.0 |

**Source:** Anthony Leiman, et al., "Reducing the healthcare costs of urban air pollution: The South African experience", *Journal of Environmental Management* (July 2007)

Ms Scorgie's thesis also concludes that low-cost or existing technologies such as the BnM top-down fire-lighting method, stove maintenance, electrification and housing insulation could yield "significant financial and economic benefit".[69]

Prescriptive, voluntary and market-based measures could ensure economically-efficient reductions in health care costs. "Minor emission reductions within the domestic fuel burning sector would result in relatively significant reductions in direct health spending," Ms Scorgie writes. "Substantial emission reductions would need to be realised within the power generation sector to achieve equivalent decreases in health spending. This indicates that the most cost-effective interventions are likely to be within the domestic fuel burning sector."

## 4.10. Private sector opportunities and solutions

A market gap exists to provide low-cost and culturally-appropriate tools to purify the air in people's homes. Clean cook stoves, fuels and other new technology and practices "must be affordable, socially acceptable, easy to use, widely available, durable, and most of all … desired," notes the DEA draft strategy."[70]

69 Yvonne Scorgie, Urban Air Quality Management and Planning in South Africa, Ph.D diss., University of Johannesburg, (2012)
70 Department of Environmental Affairs, Draft Strategy to Address Air Pollution in Dense Low-Income Settlements, Government Gazette, (24 June 2016)

This is an opportunity for the private sector to make a difference given the slow progress of government programmes and the lack of resources among non-governmental organisations.

Besides the obvious opportunity for large companies to use their corporate social responsibility programmes to sponsor successful interventions, as discussed above, smaller entrepreneurs could create profitable businesses.

The challenge is to make these health, time and cost-savings benefits understandable to target households. If marketed correctly, these products and programmes could create an economic motive to invest in better stoves, ventilation and fuel.

The project in Kenya, for example, reported increased income through the manufacture of smoke hoods, stoves, windows and frames for eaves spaces.[71] Artisans trained to sell such solutions could earn incomes, too.

Women in Pakistan are earning an income building improved earthenware stoves.[72] While the profits may appear meagre to larger companies or richer people, the poor and unemployed can exploit these small-business opportunities to improve their livelihoods.

In Guatemala, the government approached companies to buy improved cooking equipment and cleaner fuels to improve their staff's health and productivity.[73] Other activities included building alliances between government, NGOs and micro-finance institutions to provide accessible, acceptable credit for consumers of clean cooking solutions. Guatemala also strengthened distribution networks between the private sector, NGOs and official structures responsible for ensuring cleaner cookstoves and fuels.

In its only mention of indoor air, South Africa's Air Quality Act, requires national departments, provinces and municipalities to address the effects of fossil fuels in people's homes.[74]It does not make provision for the private sector to offset indoor air quality improvement programmes against their own air quality compliance levels. Neither does the Air Quality Offsets Guideline, published in March 2016.[75]

However, a 2015 DEA discussion document[76] considers offsets for interventions to improve indoor air quality. Eskom is a big backer of these trades and is already looking into how it can participate through a pilot study in Kwazamokuhle, near Hendrina, where one of its power stations is located, according to the discussion document. This Eskom project will examine ceiling and wall insulation, energy-efficient stoves, LPG heaters and stoves, and subsidised electricity.

It is undoubtedly in the parastatal's self-interest to promote offsets. These trades could save the power company billions of rands while it delays installing costly equipment to reduce air emissions. These savings could also keep down consumers' electricity bills.

71 Intermediate Technology Development Group, [now known as Practical Action], Reducing indoor air pollution in rural households in Kenya: working with communities to find solutions, (1998-2001)
72 Zofeen Ibrahim, Pakistan: Smoke-free Stoves a Godsend for Village Women, Inter Press Service News Agency, (25 February 2010)
73 Global Alliance for Clean Cookstoves, Guatemala Country Action Plan for Clean Cookstoves and Fuels, (May 2014)
74 National Environmental Management: Air Quality Act 39 Of 2004, Southern African Legal Information Institute,
75 Department of Environmental Affairs, Air Quality Offsets Guildeline, Government Gazette, (18 March 2016)
76 Department of Environmental Affairs, Discussion Document on Environmental Offsets, (June 2015)

In discussions with government, environmental groups have objected to offsets arguing that complying with outdoor air quality regulations should be required.[77]

Yet legal provisions that would permit companies to reduce their cost of regulatory compliance by funding innovative indoor air quality programmes could work, but only if these offset programmes are transparent and subject to independent oversight to limit corruption.

Despite the opposition of environmental groups, it is heartening that the DEA's 2016 draft strategy recognises the potential value of indoor air quality offsets and proposes that polluting industries finance projects to clean indoor air through these trades.[78]

Without these extra funds, the government would have to shoulder these costs alone. With these incentives, the private sector could be spurred to develop manufacturing, distribution and installation skills for improved cook stoves, smoke hoods, insulation and ventilation solutions.

The key will lie in developing business models that provide profitable opportunities for large companies and small entrepreneurs to sell solutions that work and are affordable to the urban and rural poor. After all, convincing people to buy such solutions is the challenge of all business, whether the target market is rich or poor.

The trade-off of air pollution offsets for indoor air quality improvements would be economically and environmentally justified for three reasons: indoor air quality is a more significant contributor to the overall burden of disease than ambient air quality; the regulations on air quality standards already exist; and projects to improve indoor air show a higher benefit-to-cost ratio than interventions for ambient air.

## 5. Conclusion

The focus of government, environmental activists and the media has concentrated on the ambient air pollution in a handful of hot spots. No one doubts that the pollution levels in many of these industrial areas exceed both national and WHO standards. But South Africa is not exceptional: 98% of cities in the low- and medium-income world exceed the WHO's standards.

Household air pollution generated by burning solid fuels for cooking and heating is a much greater concern. The levels of harmful fumes produced by indoor fires can be much higher than found outside large industrial plants. It accounts for higher healthcare costs, hinders adult productivity, lowers school attendance among children and degrades the environment.

Indoor and outdoor air quality, even when combined, contribute less than 1% to the national disease burden.

Projects to purify indoor air include ongoing electrification, promoting a better way to light coal fires, improved cooking stoves, smoke hoods and low-smoke fuels. International research has shown that ventilation, community-manufactured low-smoke stoves and biogas digesters can significantly lower air pollution and

77 Department of Environmental Affairs, Environmental Offsets Discussion Document Workshop:Summary of Proceedings, (31 March 2015)
78 Department of Environmental Affairs, Draft Strategy to Address Air Pollution in Dense Low-Income Settlements, Government Gazette, (24 June 2016)

demand for solid fuels. However, studies show that people resist adopting new technologies and behavioural change may be difficult to sustain in the longer term.

An economic analysis shows that cleaning household air is more economical and yields greater social and health benefits than attempts to reduce industrial pollution. Private sector incentives may improve the quality, reach and long-term success of projects to clean the air in people's homes. Offsets could balance the dividends from indoor air pollution improvement projects against the costs of legislated emissions obligations.

## About the author

Ivo Vegter[79] is an independent South African journalist, columnist, author and speaker.

He has been a journalist since 1993, and has been a columnist for the independent news site *The Daily Maverick*[80], since its inception as a print magazine in 2006. He has a wide purview including economics, politics, technology and environmental matters.

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80 Daily Maverick
81 Extreme Environment: How Environmental Exaggeration Harms Emerging Economies