Burning firewood and charcoal indoors

Air pollution and health risks

Summary

This publication was prepared in March 2017 based on the study *Pollution in closed environments as a risk factor for health: the use of firewood as an aggravating factor*, carried out by the Indoor Pollution Caused by Firewood Group, from Sindigás, in partnership with PUC-RJ and UERJ.

In addition to an extensive review of the scientific literature worldwide, with the analysis of articles published by researchers and renowned institutions, a thorough survey of data generated by Brazilian governmental agencies was carried out, resulting in the most comprehensive study carried out in the country on the use of different forms of cooking and its implications for health and the environment.

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In focus, the health of the population

The results of the preliminary investigation carried out by Sindigás, PUC-RJ and UERJ, on pollution in closed environments as a risk factor for health, point to a public health problem that until today had not been considered with due attention in our country.

Many scientific studies, both observational and intervention, have been developed in recent years, regarding the burning of solid fuels in cooking food and the effects of this practice on the health of the population, in several countries. Gradually, the results being released reveal a serious public health problem worldwide, confirming WHO estimates on the number of premature deaths and chronic illnesses related to this risk factor.

In Brazil, the study by Sindigás/PUC/UERJ - the first with nationwide coverage - reveals only the tip of the iceberg. Further investigations are expected to emerge, using even more comprehensive data and more accurate measurements of the levels of exposure to polluting emissions, which still occur in the daily lives of millions of Brazilian homes.

The deaths resulting from the burning of solid fuels, especially firewood, in the kitchens of Brazilian houses, cause an annual cost for the country greaterthan R$ 3 billion.

What has already been possible to assess, among other equally important details, is that premature deaths resulting from the burning of solid fuels, especially firewood, in the kitchens of Brazilian houses, cause - in addition to the immeasurable suffering for families - an annual cost for the country greater than R$ 3 billion. Actually, this cost is even higher, as the calculation does not include, due to the lack of consistent data, the situations of illness (treatment costs and, mainly, years lost due to disability). It should also be taken into account that diseases caused by smoke from firewood can alienate workers, and force them to retire early, which becomes yet another cost to the government.

Another extremely significant contribution of the study by Sindigás/PUC/UERJ is the fact that it presents solutions that are being adopted by the World Health Organization (WHO), by governments of several countries, and by international entities, such as the World LP Gas Association. These are far-reaching and reasonably low-cost actions, capable of minimizing the impacts of this type of pollution on human health and the environment in general.

Initiatives like these will always receive support by Sindigás, working in collaboration with the Government and the whole of society, to consolidate the use of clean fuels and good sustainable practices in energy management and consumption in our country.

This work points out far-reaching and low-cost solutions that can minimize the impacts of pollution on human health and the environment in general.

Danger inside the house

Air pollution has been a topic of great evidence for several decades, both in the media and in government bodies, international entities, non-governmental entities, universities, research centers, and in the daily lives of citizens who are minimally informed about environmental issues around the world. But few know that the concentration of pollutants is often higher in indoor environments, which are subject not only to pollution from outside, but also to polluting emissions produced on the spot.

In general, indoor environments are more polluted than external environments due to internal sources, mainly the burning of firewood in rustic stoves for preparation of food, in addition to construction materials and various activities.

As we spend most of our lives indoors, it is easy to understand that air quality in these environments is a fundamental factor for our health.

In several parts of the world, at least 4.3 million people die each year because of the use of solid fuels for cooking.

According to the WHO, approximately 7 million premature deaths around the world are caused each year by air pollution (external and internal). And more than 60% of this total corresponds to pollution in residential environments. That is, at least 4.3 million people die from burning solid fuels in stoves with inefficient ventilation, the main source of indoor pollution in various parts of the world. Most of these deaths are due to heart disease, stroke, chronic obstructive pulmonary disease, and lung cancer. In addition to deaths, a significant number of acute respiratory diseases also occur in children.

Scientific researches and possible solutions

Diseases related to air pollution in domestic environments occupy the fifth place in the world ranking. Women and children are most affected by spending more time in their homes, exposed to high loads of pollutants, much higher than the limits recommended by environmental agencies.

The burning of firewood in a rustic stove corresponds to 400 cigarettes per hour.

According to Dr. Kirk Smith, professor of Global Environmental Health at the University of California, Berkeley, the burning of biomass/firewood in a rustic stove, without an appropriate chimney, very common in homes of the poorest classes, corresponds to the burning of 400 cigarettes per hour.

Numerous studies have been carried out in various parts of the world, proving that the burning of solid fuels in the home environment is an environmental risk factor, the health effects of which are severe and can lead those that are more exposed to illness and death.

In addition to indicating the damage to health of this risk factor when compared to less polluting alternatives, many studies have also shown that there are reasonably low-cost solutions that can minimize such effects. Governmental and non-governmental initiatives have been implemented in some countries for this purpose.

About 30 million Brazilians are still exposed on a daily basis to the risks of pollution in their homes.

In Brazil, solid fuels continue to be the main source of energy for some segments of the population, reaching approximately 30 million people daily. But there are still very few scientific studies on the impacts of this practice, which causes environmental, social and public health losses, even resulting in very high costs for the Government.

Investigating the current dimension of this problem in our country is extremely important and necessary. But it is also necessary to create new initiatives and, without delay, intensify existing programs, supporting the transition from daily burning of firewood to the use of more efficient stoves and cleaner fuels.

Millennia of polluting smoke

Since human beings lived in caves, fire brought thermal comfort to homes and began to be used for food preparation. The need for ventilation was already known, both to fuel the fire and to eliminate smoke.

Lung tissue samples from mummies from Egypt, Peru, Great Britain and other places revealed that ancient societies suffered from anthracosis, a darkening of the lungs caused by long exposure to smoke in domestic activities. Smoke was tolerated in homes, as it kept mosquitoes and other pests away. However, poor indoor air quality - with high concentrations of harmful particles - has increased the incidence

of chronic respiratory diseases and the risk of death. Reports by Aretaeus from Cappadocia, Aulus Cornelius Celsus, Pliny the Elder, and other physicians indicate that lung disease was widespread in the classical civilizations of the Mediterranean basin.

Complaints about the effects of air pollution on human health have been registered by the citizens of ancient Athens and Rome. The emissions in these cities, which made the sky dark, came from the combustion processes of houses, smelting furnaces, ceramics and other pre-industrial workshops.

In ancient civilizations, poor indoor air quality already caused chronic and fatal respiratory diseases.

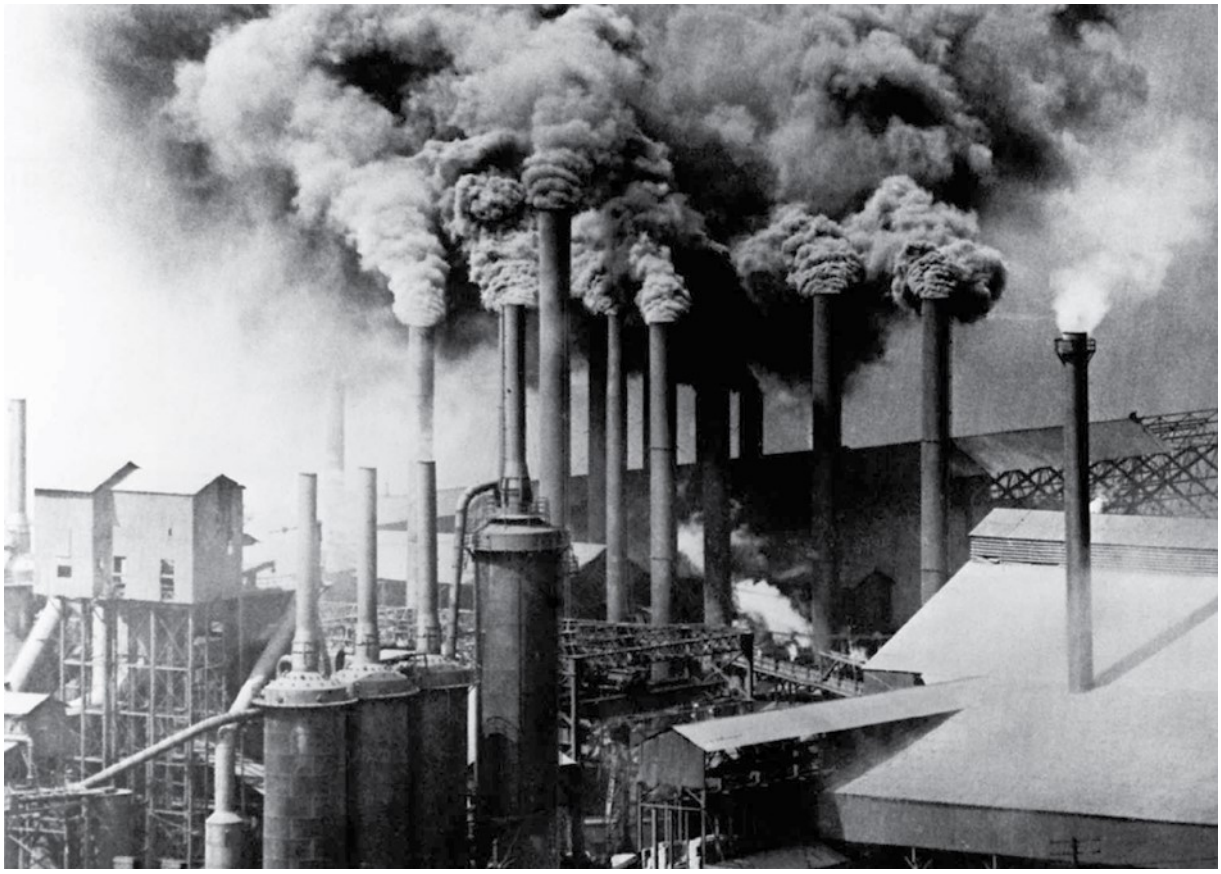
In the Middle Ages (476-1000 AD), people began to worry about the transmission of diseases through the air in closed environments. The smoke from open stoves and fireplaces, especially in small houses, made the air extremely toxic. For this reason, King Charles I (1600-1649), of England, decreed that all houses should have large windows and a ceiling height of 3 meters, for better removal of smoke.

Smoke from open stoves and fireplaces, especially in small houses, in the Middle Ages, made the air extremely toxic.

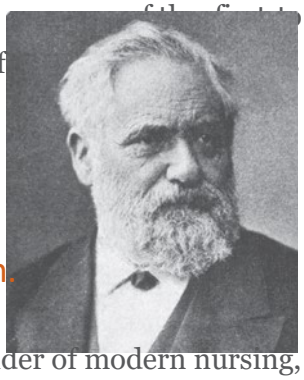
The “Smoke Age”

With the Industrial Revolution, it was so much coal fueling the kilns of factories in Great Britain, Germany, the United States and other countries, that urban air quality worsened like never before. Cities and industries were growing amid the smoke of fossil fuels, producing air pollution that has become a major environmental problem across Europe and the rest of the world. But it was still thought that, inside a house or building, people would be protected.

Indoor air pollution began to be of concern only in industrial environments.



Max von Pettenkoffer (1818-1901), a German chemist and hygienist, [illegible] of the first to recognize the importance of air quality in homes and offices as a way of [illegible] diseases.



It was thought that, within a house or building, people would be protected from pollution.

In the same period, the British Florence Nightingale (1820-1910), founder of modern nursing, during her experiments in hospitals during the Crimean War observed that the spread of diseases among wounded soldiers was greater and faster in crowded and poorly ventilated

y is essential for
es and buildings (offices, factories, hospitals, schools, restaurants,
(buses, automobiles, trains, airplanes, etc.).

Air quality standards for homes

In 2014, the World Health Organization (WHO) launched guidelines for indoor air quality, specific for burning domestic fuel. Some countries, such as Germany and Canada, also already have residential standards.

Brazil is still moving at a slow pace, most likely due to the lack of scientific studies, since we have few laboratories equipped and with qualified personnel, which prevents the development of quality standards.

The Ministry of Health, especially within the scope of the National Health Surveillance Agency, has rules on Indoor Air Quality (QAI) more focused on cleaning air conditioning systems. The maximum values for contaminants present in indoor air are based on recommendations from international and national organizations, adapted to the Brazilian reality. However, it is necessary to carry out experimental studies to define methodology and standards within the country's climatic and socioeconomic conditions.

It is necessary to carry out experimental studies to define patterns within the country's climatic and socioeconomic conditions.

Particles and gases or fumes

Air pollutants, generated by different sources, are numerous and consist of particles of different sizes, fibers, fumes, gases, vapors and bioaerosols (aerial dispersion of organic or inorganic particles that contain all or parts of biological entities, such as bacteria, viruses, fungi or spores).

In general, it is customary to divide these pollutants into particles (solids or drops), and *gases or fumes*.

The particles that are of interest to QAI include the group of respirable particles, cigarette smoke, asbestos fiber, allergens (pollen, fungi, molds, feces and insect parts), and pathogens (bacteria and viruses). On the other hand, the gases and vapors of greatest interest include carbon monoxide (CO), carbon dioxide (CO_2), formaldehyde (HCHO), volatile organic compounds (VOCs), nitrogen oxides (NO and NO_2), and ozone (O_3).

Please find below the most important internal pollutants, their sources of emissions and the damage they cause to human health.

Main internal pollutants, its sources of emissions, and health effects

Pollutant	Source of emission	Effects
Monoxide carbon, CO Asphyxiating gas without color, smell or taste. Produced by incomplete combustion (in the presence of little oxygen).	Boilers, gas or kerosene heaters, gas stoves, wood stoves, fireplaces, cigarettes, cars in garages. Emissions of this gas have decreased with the reduction in cigarette use, and the use of more efficient stoves/heaters.	Reduction in the capacity of the circulatory system to transport oxygen. Worsening of cardiovascular diseases. Headaches and death.
Carbon dioxide, CO_2 Colorless and odorless gas.	Breathing. Exhaled by humans during metabolic processes. Combustion (gases, wood, coal, kerosene, vehicles in garages). Cigarette.	Choking, irritation of the respiratory tract, feeling of suffocation and discomfort, headaches, dizziness and nausea.
Nitrogen dioxide, NO^2 Brownish color. Soluble in water and with a strong acrid smell. It is formed from the combination of nitrogen and oxygen from the air in combustion processes at elevated temperatures.	Burn of kerosene and gases in heaters. Wood and gas stoves. Switched on cars in garages. Cigarette.	At high concentrations, it causes damage to the lungs and increases the problems of respiratory infection. It can cause acute bronchitis and death.
Sulfur dioxide, SO_2 Colorless gas with strong odor, produced during the burning of coal, containing sulfur as an impurity, and other fuels with sulfur. Soluble in water.	Kerosene heaters. Gas and coal appliances. Gasoline, diesel and coal engines with sulfur. In homes, their levels are generally lower than outdoors.	Easily absorbed by the nasal mucous membranes and the respiratory tract, at high concentrations it causes serious problems to the lungs.

Pollutant	Source of emission	Effects
Ozone, O_3 In the Ozone Layer, it filters type B ultraviolet radiation, harmful to living beings. At ground level, it is a polluting gas, which causes an increase in surface temperature, which can cause problems for all living beings.	External air, photocopying machines, electrostatic air filters, photochemical reactions.	Depending on the concentration in the environment, it causes headaches, chest pain, sore throat and cough.
Volatile organic compounds, VOCs The best known types of VOCs are: polycyclic aromatic hydrocarbons (PAH); pentachlorophenol; dichlorodiphenyltrichloroethane (DDT); benzene, toluene and xylenes (BTX); chlorofluorocarbon (CFC - Freons); polybromobiphenyls (PBP); polychlorinated biphenyls (PCB, askarel); and others, components of fungicides and cleaning products. All of them highly toxic; many already have their uses banned.	Present in many products, including plastics, dyes, adhesives, solvents, building materials, paints, varnishes, cigarettes, carpets, furniture, curtains, cleaning and hygiene products, insecticides, fungicides, electronic and photocopying equipment, air conditioning system. They are generated from the burning of fuels, and from different cooking practices (grilling, frying, etc.). Higher temperatures generate more PAH.	Irritation of eyes, skin and respiratory tract, headaches, fatigue, confusion and cancer. PAHs have a carcinogenic potential. In the air, they can be absorbed in particles and inhaled, reaching the lungs. In England, many cases of cancer have been reported in chimney sweepers and workers of the fuel industry, because of benzopyrene, the most well-known PAH.
Particles Most visible form of air pollution. "Particulate material" (PM) is the term most used in air pollution control, and refers to solid particles that can be collected.	They are suspended in the air, in the form of dust, fog, aerosol, smoke and soot. Most common sources: burning biomass (firewood, forests, etc.) or fossil fuel (gasoline, diesel, fuel gases, kerosene, etc.) and cigarettes.	Great influence on the environment and health. Associated with increased mortality by respiratory and cardiovascular diseases, exacerbation of allergies, asthma, chronic bronchitis, and respiratory tract infection.

Pollutant	Source of emission	Effects
Formaldehydes, HCHO	Agglomerates, plywood, insulation, furniture, panels, carpets, cigarettes, electronic equipment, cleaning products.	Irritating to skin, eyes and respiratory tract, cancer and death.
Acetaldehydes, CH_3CHO	Metabolism of alcohol, cleaning products, and cigarette smoke.	Carcinogen and genotoxic.
Radon, Rn	Soil, building materials and groundwater.	Lung cancer.
High toxicity metals Lead, arsenic, mercury, cadmium etc.	Paints, preservatives, external air.	Cancer.
Allergens	Dust, insects, domestic animals, pollen, rodents, dogs, cats and mite feces.	Allergies.
Asbestos	Fire retardant and insulation materials.	Lung cancer, mesothelioma and asbestosis.
Fungi	Soil, plants, food, internal surfaces.	Allergies.
Bacteria and viruses	People, animals, plants, air conditioners.	Allergies, legionnaires' diseases, aspergillosis.

Factors that affect indoor air quality

Beginning in the 1970s, when the oil crisis occurred, the countries of harsh winter, especially in the Northern Hemisphere, adopted heating systems with greater thermal insulation and lower energy consumption. However, the levels of concentration of pollutants increased in these internal environments, due to the low exchange of external/internal air, among other factors, resulting in health problems for its occupants.

It was during this period that the presence of pollutants began to be monitored in closed environments, to assess air quality.

Many products now considered highly toxic - such as formaldehyde, asbestos, tobacco and toxic solvents released by glues - were used on a large scale. Today, these materials are prohibited because they are harmful to health, but current products, even though emitting less, also have the potential to generate pollutants. This is the case of some building materials, finishing, furniture, paints, cleaning and hygiene products, lighting, air conditioning, equipment and fuels used in cooking, which influence air quality.

In Brazil, there is still very little knowledge and training regarding the importance of indoor air quality.

To reduce costs, cheaper materials are used, which do not always have the proper specification. The spaces are smaller, with fewer windows and more occupants. All of these factors lead to a higher level of pollutants.

In Brazil, there is still very little knowledge and training regarding the importance of indoor air quality. Companies and professionals who design, build and maintain buildings must be concerned not only with comfort, but also with health.

Stoves and fuels

The health problems caused by the use of solid fuels, such as firewood and charcoal in residential environments are related to the type of combustion (burning). Complete combustion does not always occur, which generates potentially toxic gases and particulate materials, depending on the amount that is concentrated in the environment during the burning.

The types and levels of pollutants generated by burning during cooking will depend on the equipment used, the conditions of the combustion process (inefficient or poorly built chimneys, leaks in the stove or fireplace exhaust system), and the type of fuel (firewood, LP Gas, kerosene, coal, etc.).

The types of stoves and fuels used directly influence the air quality of a home.

Types of stoves

- *Traditional* (example: three stone stove with burning of solid fuel).
- *Improved or enhanced* (can be done cheaply from local resources, generating less smoke, less darkening of utensils, fuel savings, in addition to being portable).
- *Modern or efficient* (the gas stove, for instance, consumes less fuel and emits less quantities of gases and particles).

The use of inadequate, defective or incorrectly installed devices can cause serious health problems.

Types of fuels

Various fuels are used in households for cooking.

From different sources, they have different impacts on health and the environment.

According to the World Energy Council, the most common fuels for this purpose can be grouped into three categories:

Modern (electricity and LP Gas).

- *Intermediate* (kerosene and charcoal).
- *Traditional* (firewood, dry manure and agricultural waste).

Use of firewood in the world

Firewood has been used as a form of energy since the discovery of fire over 750,000 years ago. Even with the Industrial Revolution (18th and 19th centuries), it continued to be widely used. Currently, it occupies an important part of the world energy matrix, mainly in the poorest countries.

A study carried out by the World Health Organization in 2006, by researchers from the Department of Protection of the Human Environment, evaluated the worldwide rates of use of solid fuels for domestic purposes. In this study, "solid fuel" included coal, charcoal, wood, crops or other agricultural waste, manure, shrubs, grass, straw and others. Some of this data was obtained from WHO and World Bank records; others were estimated using statistical models. The average rate of use of solid fuels is quite high, representing 52% of the total energy used worldwide, mainly for cooking.

In this scenario, Brazil appears with more than twice that of developed countries, 12%, differing from other Latin American countries, such as Argentina, Uruguay, Chile, Venezuela, Ecuador and Cuba, whose rates below 5% are similar to that of developed countries.

The regions with the highest percentage are also considered to be the poorest: Sub-Saharan Africa, Southeast Asia and the Western Pacific Region (between 74 and 77%), with many countries in these regions exceeding 95%.

GUATEMALA | A large comparative study reported important differences in health indicators of newborns, whose mothers were very exposed (burning wood without a chimney), exposed (burning wood with a chimney), or not exposed (gas or electricity) to smoke from solid fuels in households. The authors analyzed data from a sample of 1717 women and their newborn children, residing in households located in six rural and one urban districts, in the province of Quetzaltenango. On average, the weight of newborn children was significantly lower in homes where firewood was used, with or without chimney, compared to households where mothers used electric or gas stoves.

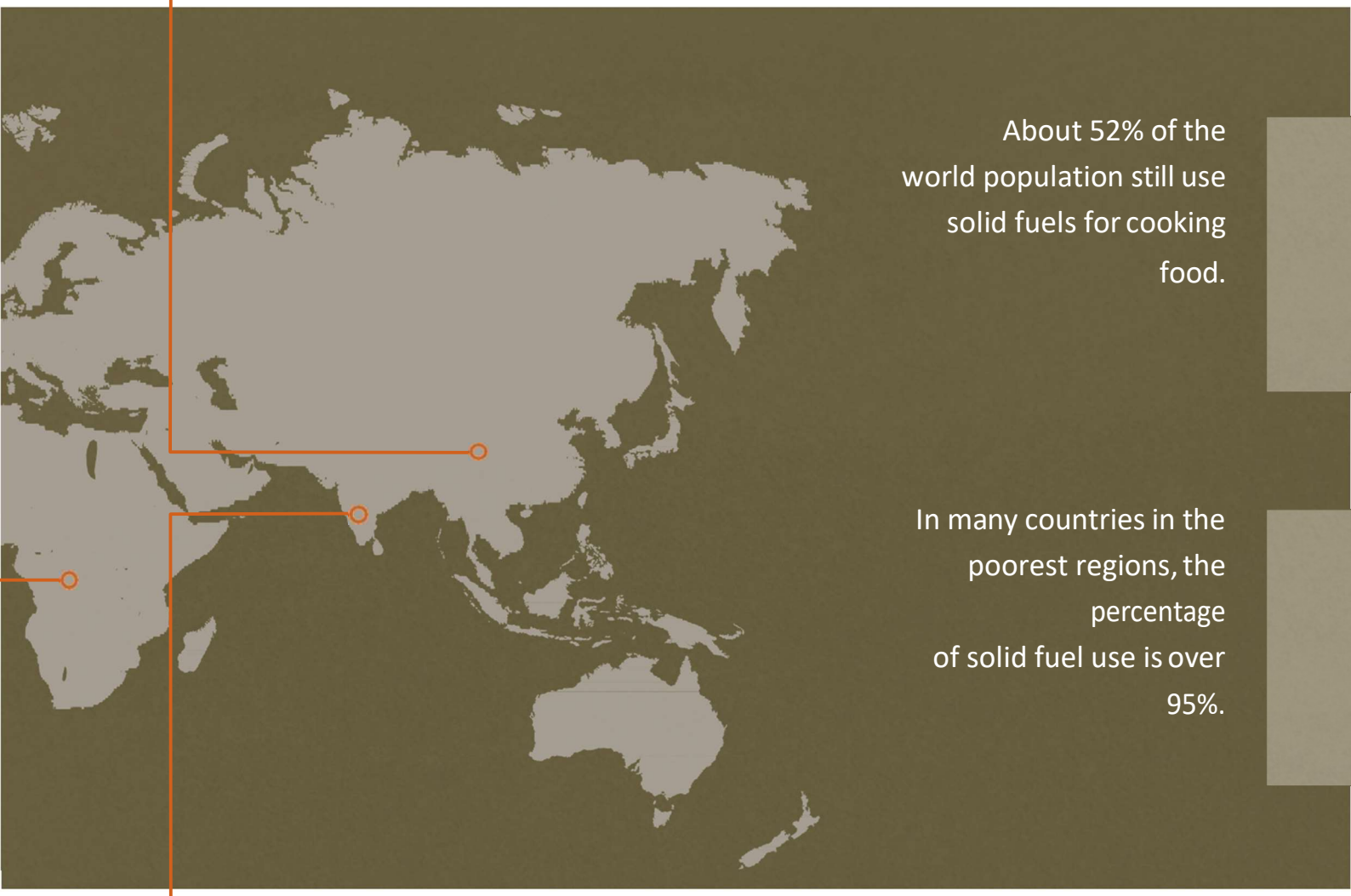
The use of firewood in the world and health risks

Recent studies in several countries have shown a strong correlation between firewood burning in homes and various damages to the health of the population.

We present on this page some examples, among countless others that could be mentioned, focusing mainly on women and children.

SUB-SAHARAN AFRICA | Research carried out in a semi-rural area of the Cameroon region, where 90% of people depend on burning biomass to supply the domestic demand for energy, showed the highest incidence of chronic bronchitis in women who cooked using firewood.

CHINA | Air pollution in households caused by the use of solid fuels was considered the environmental risk factor that is most adverse to health in China, by the authors of a study that reviewed more than 200 scientific publications. The presence of a chronic respiratory disease increases the risk of subsequent diagnosis of lung cancer. One of the surveys carried out in the country specifically focused on non-smoking women in the city of Taiyuan, investigating the role of various pollutants in the incidence of cancer,
and the results were significant.



About 52% of the world population still use solid fuels for cooking food.

In many countries in the poorest regions, the percentage of solid fuel use is over 95%.

INDIA | In a study that analyzed a sample of 1,744 pregnancies,
it was found that women living in households that used firewood for cooking had children with a lower weight, compared to those who used LP gas,
and the incidence of stillbirths was also higher: 4% against 0%.

Percentage of the population using solid fuels, in different regions of the world (according to WHO classification)

AFRICA • 77%

South Africa	18	Gabon	28	Kenya	81
Algeria	<5	Gambia	>95	Central African Republic	>95
Angola	>95	Ghana	88	Democratic Republic of the Congo	>95
Benin	95	Guinea	>95	Rwanda	>95
Botswana	65	Guinea Bissau	95	Senegal	41
Burkina Faso	>95	Lesotho	83	Sierra Leone	92
Burundi	>95	Madagascar	>95	Seychelles	<5
Cameroon	83	Malawi	>95	Swaziland	68
Republic of Cabo Verde	36	Mali	>95	Togo	76
Chad	>95	Mauritius	65	Tanzania	>95
Comoros	76	Mauritania	<5	Uganda	>95
Congo	84	Mozambique	80	Zambia	85
Costa do Marfim	74	Namibia	63	Zimbabwe	73
Eritrea	80	Niger	>95		
Ethiopia	>95	Nigeria	67		

LATIN AMERICA / CARIBBEAN • 16%

Antigua and Barbuda	46	El Salvador	33	Paraguay	58
Argentina	<5	Ecuador	<5	Peru	33
Bahamas	<5	Grenade	48	Dominican Republic	14
Barbados	<5	Guatemala	62	Saint Lucia	63
Belize	43	Guyana	59	Saint Kitts and Nevis	<5
Bolivia	25	Haiti	>95	Saint Vincent and the Grenadines	31
Brazil	12	Honduras	57	Trinidad and Tobago	8
Chile	<5	Jamaica	45	Uruguay	<5
Colombia	15	Mexico	12	Venezuela	5
Costa Rica	23	Nicaragua	58		
Cuba	<5	Panama	33		

EUROPE (CENTRAL AND EAST) • 16%

Albania	50	Estonia	15	Romania	23
Armenia	26	Georgia	42	Russia	7
Azerbaijan	49	Hungary	<5	Tajikistan	75
Belarus	19	Latvia	10	Turkmenistan	<5
Bosnia and Herzegovina	51	Lithuania	<5	Turkey	11
Bulgaria	17	Macedonia	30	Ukraine	6
Kazakhstan	76	Moldavia	63	Uzbekistan	72
Slovakia	<5	Poland	<5		

EAST OF THE MEDITERRANEAN • 36%

Afghanistan	>95	Yemen	42	Morocco	5
Saudi Arabia	<5	Iran	<5	Ornan	<5
Bahrain	<5	Iraq	<5	Pakistan	72
Cyprus	<5	Jordan	<5	Qatar	5
Djbouti	6	Kuwait	<5	Sudan	>95
Egypt	<5	Lebanon	<5	Syria	32
United Arab Emirates	<5	Libya	<5	Tunisia	5

SOUTHEAST ASIA • 74%

Indonesia	72	Bangladesh	88	Nepal	80
Sri Lanka	67	India	74		
Thailand	72	Myanmar	95		

WEST PACIFIC • 74%

Cambodia	>95	Solomon Islands	95	Samoa	70
China	80	Laos	>95	Singapore	<5
Korea	<5	Malaysia	<5	Tonga	56
Fiji	40	Mongolia	51	Vanuatu	79
Philippines	47	Papua New Guinea	90	Vietnam	70

Source: WHO, 2006.

Initiatives to minimize pollution in homes

The high rates of illnesses and deaths caused by the burning of solid fuels call the attention of health authorities around the world, as in the case of the World Health Organization. Governmental and non-governmental initiatives are being developed to solve this problem.

Some programs have been able to implement or support the transition to cleaner fuels. There are also several initiatives focused on the use of more efficient stoves, which reduce the levels of pollutants, without changing the fuel used. However, some studies show that, even with the use of more efficient stoves for burning firewood, the concentrations of pollutants still exceed the limits suggested by regulatory agencies.

Encouraging cleaner fuels

To encourage the use of cleaner forms of energy, some countries have created subsidies for LP Gas and kerosene.

One of the first countries to make use of the subsidy was Senegal, in 1974. The program provided for the removal of the customs tax on the import of all items related to LP Gas, to promote the replacement of charcoal in urban areas.

In India, the government still subsidizes the price of LP gas and kerosene sold by state-owned companies.

Another example worth mentioning is the project carried out by the Indonesian government, where more than 40 million homes have stopped using kerosene to use LP Gas.

Non-governmental initiatives have also been important in encouraging the use of clean fuels. An example is "Cooking for life", a campaign by the World LP Gas Association (WLPGA), which aims at facilitating the replacement of polluting fuels, such as firewood, kerosene and others, with LP Gas. The campaign aims at reaching one billion people by 2030, reducing the number of premature deaths annually by 500,000.

Government and international organization programs seek to encourage the replacement of polluting fuels with LP Gas.

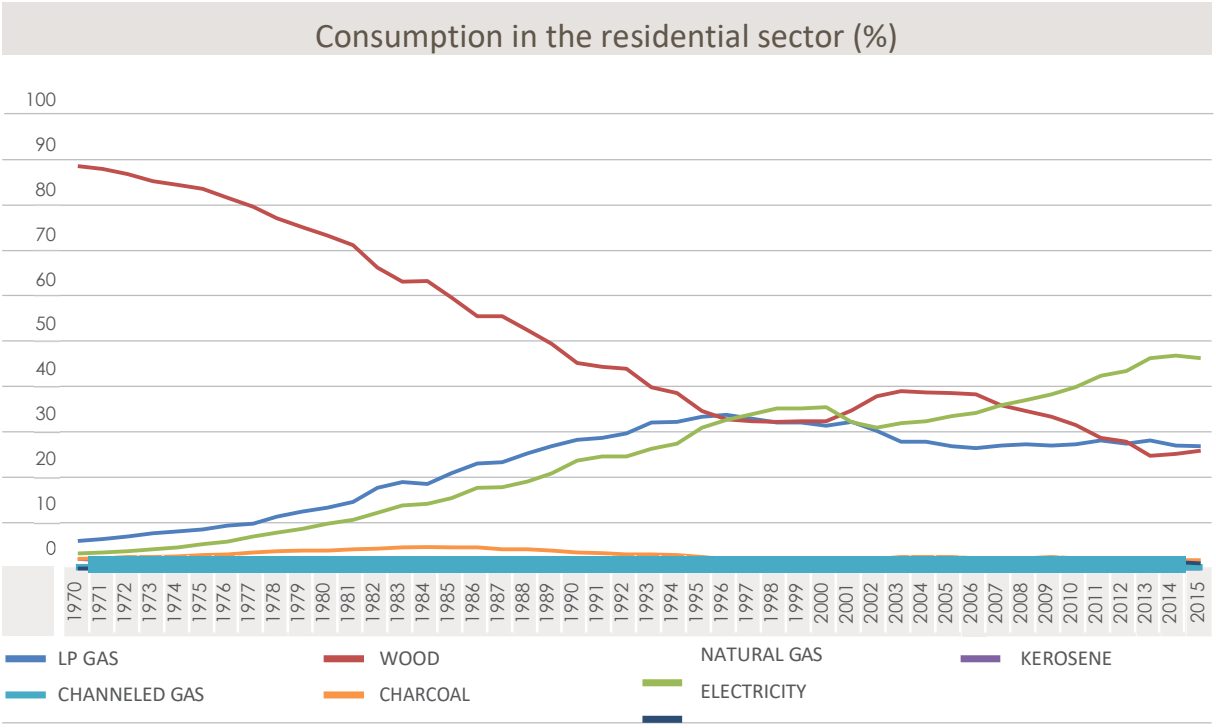
Before launching this campaign, the WLPGA conducted a survey on how ten countries made or plan to make the transition from traditional fuels (such as firewood, coal, charcoal, animal waste and kerosene) to LP Gas, for cooking purposes. The ten countries selected in the study were three in South America (Brazil, Ecuador and Peru), three in Africa (Ghana, Kenya and Senegal), three in Asia (India, Indonesia and Sri Lanka), and Turkey. In general, the programs are able to achieve their objectives when there are subsidies, efficient regulations, and good business practices.

Use of firewood and LP Gas in Brazil

Between the 1970s and 2000s, the use of firewood in Brazil suffered a considerable decline in the residential and other sectors. The ease of access to LP Gas made this change in society possible. It is worth remembering that 56% of the Brazilian population lived in the urban area in the 1970s, and such percentage had grown to 85% already in the mid-2000s.

The subsidies given to LP Gas since the beginning of its production in Brazil, as well as government social programs, such as Bolsa Família and access to electricity, have led to an increase in the use of LP Gas and electricity, with a decrease in consumption of firewood.

However, in the period between 2000 and 2007, firewood again became the most used fuel in the residential sector, surpassing electricity and LP Gas, as seen in the chart below. The reduction of subsidies to LP Gas, making it more expensive and less accessible to the poorest population, was one of the main factors that influenced the return to the use of the old solid fuel. From 2013 to 2015, there is an increase in the consumption of firewood again.



Source: BEN, 2014

There is a direct relationship between purchasing power and the use of cleaner fuels for cooking and other domestic activities.

Studies show that there is a direct relationship between purchasing power and the use of cleaner fuels for cooking and other domestic activities. This fact can be proven by comparing the indices of the poorest population - who earn up to a minimum wage -, which was 23% in the last IBGE census (2010) with the indexes of firewood use registered by BEN (24%).

In Brazil, although a large part of the population still uses firewood as a form of cooking, there are few scientific studies carried out to assess the problems related to this activity, or even governmental programs aimed at improving this scenario.

From North to South, different reasons for using firewood

In the South, the burning of firewood is linked to regional customs and the cold climate. In the North, in addition to being a way of repelling insects, the predominant use of firewood is mainly due to poverty and the lack of access to other forms of energy, as electricity and LP Gas still have a high cost for the poorest populations.

In the Northeast region, where the largest number of wood stoves is located (42% of the total), the lowest income population of the country lives. The main source of firewood in this region is the caatinga, representing almost 50% of the primary energy. Around 80% of the firewood extracted from this biome is used as an energy source, being the main cause of deforestation. Only 3% of this firewood is removed sustainably.

In a study carried out in the North Coast of Paraíba, with eight communities close to Destilaria Miriri, the socioeconomic level of the population and the use of the wood stove and its origin were evaluated. The study showed a monthly income of one to two minimum wages and an average consumption of firewood of approximately 0.8 m^3/ month. The firewood in these communities is taken from forest fragments (Mata Atlântica) close to the residences. It is interesting to note that 24% of families use only LP Gas, and do not use firewood, either because its removal is prohibited, or because they have sufficient income, or because the age of their members does not allow collecting it.

In the Northeast, about 80% of the firewood is taken from the caatinga, being the main cause of deforestation.

Another study carried out in the interior of Piauí demonstrates that easy access and zero cost are decisive in the use of firewood. In the communities surveyed, the stoves are rudimentary, usually located inside the houses and without chimneys, resulting in extremely low energy yield (less than 10%) with a high emission of pollutants, mainly particulates. The low energy efficiency causes greater exploitation of the wood and, consequently, the destruction of native forest and soil erosion, while the pollution of the burning of firewood causes serious health problems. Although 80% of households have a gas stove, they are little used, only for fast cooking of food, while the wood stove is used daily, for lunch and dinner. The firewood

(logs, sticks and dry branches) is collected one to three times a week, close to home. In case of shortage of firewood nearby, animals are used to help with transportation. Although the wood stove is the most used, the users themselves consider it dangerous for children, do not like the excess heat and are bothered by the presence of smoke and the blackness of the pots and walls. Most users use the wood stove as it is more economical.

In several municipalities in the interior, many homes have gas stoves, but they are little used, while the wood stove is used daily, for lunch and dinner.

In the rural area of the municipality of Petrolina, Pernambuco State, in 50% of the homes there was a LP Gas stove; however, the use of firewood predominated. The firewood used to cook food was collected approximately 1 km from the houses, at least three times a week, by women and children, spending an average of two hours on this activity. Firewood is mainly taken from native forest. The stoves, simple and inefficient, in many homes were outside the house.

A study carried out in São João D'Aliança, a small municipality in the State of Goiás, estimated that the average consumption of firewood per household is 10.54 kg, corresponding to 2.53 kg/adult equivalent/day. In this municipality, approximately 19% of households have only a wood stove, 12% have only an LP Gas stove and 69% have both. As seen in other regions, the LP Gas stove is part of most homes, but it is still in the wood stove that most meals are prepared.

A study carried out in four municipalities in the Zona da Mata, in Minas Gerais State, found that, despite having access to electricity and LP Gas, the population used firewood for some purpose. Similar behavior was observed in municipalities from the Paraíba State, where there is also a concomitant use of LP Gas and firewood. In general, the use of one or the other is related to the type of activity. For example, the cooking of beans requires a longer time and therefore it is preferably carried out on a wood stove, just as LP Gas is used for cakes. This behavior has also been observed in other developing countries.

The proximity of forests has been a decisive factor for the use of firewood by the poorest classes. The reduction in the use of firewood in rural communities should be encouraged due to individual and collective benefits, such as: collection time and risk of accidents, exposure to smoke, and the conservation of forests. Firewood collection is usually the task of women and children. In this task they are at risk of injuries and accidents, as well as greater exposure to smoke and burns. It is an activity that takes several hours a week, reducing the time for other productive activities and even school.

The proximity of forests has been a decisive
factor for the use of firewood by the poorest classes.

The cost of home pollution in Brazil

How many lives is Brazil losing due to the burning of firewood or coal in residential kitchens?

How many years of healthy life are Brazilians losing for this reason?

Chronic diseases, disabilities or premature deaths, in addition to being the cause of great pain and suffering for families, represent great losses for the whole country.

These losses can be quantified with the use of a methodology implemented in 1990 by the World Health Organization (WHO), which allows different countries to apply the same parameter in the measurement of the burden of diseases. This standard is DALY (Disability Adjusted Life Years). DALY is equal to a year lived in a situation of disability.

The valuation of the loss of human life is very important for cost-benefit assessments, when planning environmental and health policies.

Loss that can be avoided

An extensive survey of data from all Brazilian states, based on the year 2000 census, was part of the study carried out by specialists from UERJ, PUC-RJ and Sindigás, with the main purpose of calculating the impact on public health of burning of charcoal or firewood for cooking in Brazilian households.

From this data, the number of deaths attributable to indoor air pollution was accounted for. Then, the number of DALYs corresponding to premature loss of these human lives was calculated. The total DALYs was 71,702.

The valuation of these totals is very important for cost-benefit assessments, when planning interventions in environmental and health policies. For this valuation, the concept of Value of a Statistical Life (VOSL) was applied, which has been used more and more in cost-benefit studies in the area of public health (Pearce, 1998).

Based on the US dollar quotation of 10/13/2016, the total annual value attributed to premature deaths associated with the burning of firewood or coal in Brazilian households, is higher than R$ 3 billion per year.

This value refers only to deaths and; therefore, does not include costs with illnesses (medication, care, hospital admissions, inactivity, early retirement, etc.).

Even though it is a partial cost, it is much more than would be necessary for educational campaigns, to alert against the dangers of this pollution that happens inside people's homes, and to encourage the use of clean fuels.

Deaths attributed to the burning of firewood or charcoal at home represent an annual cost for the country of more than R$3 billion.
For much less, educational campaigns to alert against indoor pollution, and to encourage the use of non-polluting fuels, such as LP Gas, would save millions of lives.

Encouraging the replacement of precarious wood stoves with LP Gas stoves, as well as subsidizing the price of gas canisters for the poorest sections of the population, are initiatives that would save the lives of millions of Brazilians who are still exposed to this danger of death, or severe chronic illness.

Advantages of LP Gas for health and the environment

LP Gas is the most suitable to replace solid fuels and kerosene in homes, as it is a cleaner, cheaper and more available fuel due to its ease of transportation. Other fuels that are considered clean (piped gas, biogas, etc.) are not accessible in rural or difficult to access areas, and are more expensive, which makes them unavailable to the poorest population.

Although it is of fossil origin, LP Gas has some physical properties relevant to the environment:

- compared to most hydrocarbons, LP Gas has a low content of carbon for the relation with hydrogen, which means that it generates less carbon dioxide (CO_2) per amount of heat produced;
- it contains more energy per kilogram than most competing fuels; and
- it is not a greenhouse gas.

LP Gas has the highest calorific value when compared to other fuels used for cooking, which means that it needs a smaller amount of fuel to achieve the same result in terms of energy.

On the other hand, solid fuels, such as firewood, have become scarcer, due to the increase in deforestation and the intensification of the necessary surveillance on the illegal use of wood. The daily burning of firewood in homes as the main fuel for cooking food is indicative of a country's socioeconomic level, being a characteristic of developing countries and the poorest segments of the population.

Residential kitchens using biomass fuels have average concentrations of particles and
polluting gases much greater than those using LP Gas.

Most studies to assess the levels of pollutants emitted by the different fuels used in cooking have been carried out in countries in Africa and Asia, where the use of solid fuels is a major cause of premature deaths. In Brazil, there is still no consistent research on the topic.

The results of these studies indicated that kitchens using biomass fuels have much higher concentrations of polluting particles and gases than those using LP Gas.

Lower emission of polluting particles and gases

The table below shows the emission factors for total suspended particles for different fuels used in cooking. Emissions and exposure levels are higher for stoves that use solid fuels (firewood or charcoal), while emissions of fuels considered modern (kerosene and LP Gas) are comparatively lower compared to the others.

Particulate emissions are higher in stoves that use solid fuels
and lower in those that use kerosene and LP Gas.

Total suspended particles (PTS) emission factors per type of fuel

Fuel	PTS	
	g/MJ useful energy	g/kg of fuel
LP Gas	0.0209	0.514
Kerosene	0.0239	0.516
Charcoal	0.5277	2.375
Traditional stove/firewood	0.3776	1.038

Source: Smith 2000; Saga 2004.

An experimental study conducted in a laboratory evaluated particles of different sizes emitted by five types of fuels (firewood, charcoal, manure, kerosene and LP Gas), and the levels of sixteen PAHs (Polycyclic aromatic hydrocarbons). The results of this study showed, among other details, the concentrations of total suspended particles, the percentages of fine particles (with the capacity of deep pulmonary and alveolar infiltration) and the concentrations of total PAHs, in the emissions of each type of fuel:

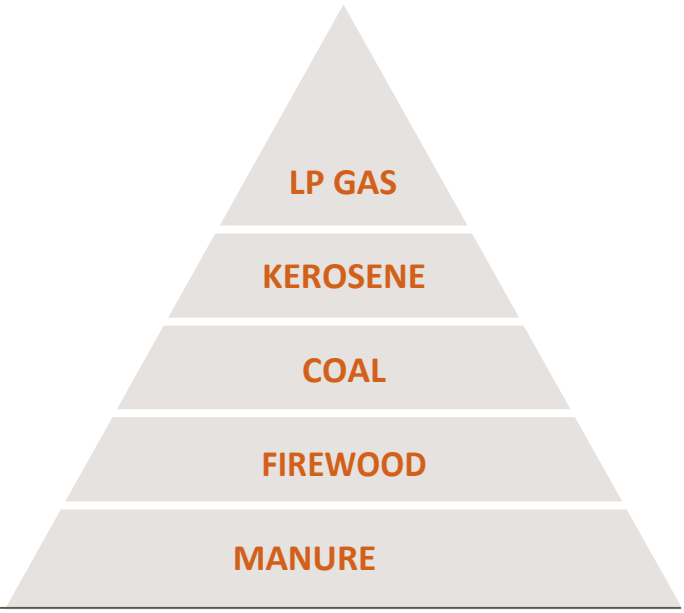
Concentrations of total suspended particles (PTS), percentages, in mass, of fine particles, and concentrations of total PAHs, in emissions of different fuels.

Fuel	PTS concentrations (mg m^{-3})	Percentage of Fine Particles	PAH concentrations (µg m^{-3})
LP Gas	11	48%	1,481
Kerosene	12	57%	2,442
Firewood	155	66%	4,672
Mineral coal	30	77%	3,422
Manure	225	88%	4,047

Source: Tiwari et al., 2013.

According to the experimental study, the comparison of mass concentration emitted by the tested fuels reveals the order of air quality, from the worst (manure) to the best (LP Gas):

Performance of different fuels in relation to air quality during cooking: from the most polluting to the least polluting (upwards).



Source: Tiwari et al., 2013.

With regard to PAHs in the fine fraction, as we have seen, the LP Gas stove generated the least amount compared to the other fuels tested. And also in relation to carbon monoxide (CO), LP Gas had the lowest emission factor, while the highest emission occurs when burning charcoal.

Carbon monoxide (CO) emission factors per type of fuel.

Fuel	CO	
	g/MJ useful energy	g/kg of fuel
LP Gas	0.6076	15.0
Kerosene	0.8186	18.0
Traditional stove/firewood	24.19	66.5
Charcoal	61.13	275.0

Source: Smith 2000; Saga 2004.

LP Gas has the lowest carbon monoxide (CO) emission factor, while the greatest emission occurs when burning charcoal.

How to avoid global warming

Climate changes are caused by polluting gases and particles, emitted mainly by the combustion processes used to generate energy. Emissions of greenhouse gases (GHG), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N2O) are mainly responsible for global warming and, consequently, for climate change. CO_2 represents, approximately, 80% of all GHG emitted, followed by CH_4 and N_2O.

Carbon dioxide is assigned 1 PAG. Methane, 25.
And, in the case of LP Gas, the carbon footprint corresponds to zero!

What is the “carbon footprint” of LP Gas?

“Carbon Footprint” (GWP - Global Warming Potential) is the expression currently adopted to describe the global warming potential, which corresponds to a given product.

Thus, the GWP of a gas is the impact it has on global warming in relation to an equivalent unit of carbon dioxide over a given period of time (typically 20 or 100 years). By definition, carbon dioxide is assigned 1 PAG. Methane, 25. And, in the case of LP Gas, the PAG corresponds to zero.

In other words, direct LP Gas emissions do not contribute to climate change. In the case of methane, the major component of natural gas, emissions before being burned are 25 times greater than those of CO_2, while LP Gas is effective only when it is burned, when it generates CO_2 and other gases, at lower concentrations than other fuels.

Black carbon

Another important contributor to global warming is black carbon (BC). A component of fine particulate material, consisting of pure carbon, BC is formed in the incomplete combustion of fossil fuels, biofuels and biomass, and is emitted both naturally and by human action.

After carbon dioxide emissions, the major contributor to global warming is black carbon emissions.

Approximately 18% of black carbon emissions are due to residential burning of biofuels (wood, for example) in traditional stoves. BC is the second largest contributor to global warming, after emissions of carbon dioxide (CO_2).

The major difference between BC and CO_2 is the time spent in the atmosphere; while BC remains for only a few days or weeks, CO_2 has a life span of over a hundred years. Because a significant part of BC is released into the atmosphere due to the combustion of firewood and coal, replacing these fuels may be a good option for mitigating climate change in the short term.

Despite the significant contribution of BC emissions to climate change, they are not part of the Kyoto Protocol, or other climate regulations and are not assessed in terms of the carbon footprint.

LP Gas's contribution to the emission of BC (black carbon) is negligible. In addition, LP Gas and kerosene stoves showed the lowest PAG values, being even cleaner than improved biomass burning stoves, if they operate with renewable biomass, when BC is considered.

Carbon footprints (including black carbon) for different fuels

Fuel	gCO_2e / MJ (GWP 20)		
	Greenhouse gases	BC and other gases	Total
LP Gas	140	1	141
Processed charcoal	291	62	353
Firewood - carbon neutral	43	725	768
Firewood - non-carbon neutral	431	725	1156
Unprocessed charcoal	1154	5040	6194

Source: Atlantic Consulting, WLPGA website.

LP Gas's contribution to the emission of BC (black carbon) is negligible.

It is not just burning that pollutes

Natural gas emits 50 to 60% less carbon dioxide when burned, in a new and efficient power plant, compared to emissions from a coal plant. However, not only the burning must be taken into account.

American scientists have reported alarming emissions of methane in oil fields from drilling and extraction of natural gas and transportation through pipelines, which calls into question the real environmental benefits of the growing use of natural gas.

The real environmental benefits of the growing use of natural gas are called into question in view of methane emissions from drilling, extraction and transportation.

Fuels with less environmental impact

The results of some studies have shown that most biofuels lead to greater impacts on global warming than ordinary fossil fuels (LP Gas and kerosene), because the characteristics of bad combustion lead to an increase in emissions of methane and other incomplete combustion products.

The biomass used from renewable sources minimizes the greenhouse effect due to the fact that the plants absorb part of the CO_2 emitted during firing, thus compensating for the impact. However, studies show that the rate of deforestation, for this purpose, is higher than the rate of reforestation, and with this firewood is no longer a sustainable alternative.

Based on the results of the most recent studies, and contradicting expectations, fossil fuel options may be the cleanest, both for health and climate change.

Most biofuels have greater impacts on global warming than ordinary fossil fuels. Contrary to expectations, fossil fuels can be the cleanest options, both for health and climate change.

Fuels such as kerosene and LP Gas have the potential to reduce climatic impacts related to residential culinary activities. In the Brazilian scenario, where most of the firewood (around 95%) does not come from renewable sources, and kerosene is not commonly used for cooking, it can be inferred that LP Gas is what currently has the lowest impact.

Furthermore, LP Gas is widely used in numerous applications in the industry, commerce and agribusiness, with the highest levels of economy, energy efficiency, and environmental safety.

The fuel with the least environmental impact among those used to cook food in Brazilian homes is LP Gas.

Glossary

Biomass - is non-fossil organic material, which has chemical energy inside, includes aquatic and terrestrial vegetation, organic waste, agricultural waste, animal manure, and other industrial remains.

Mineral coal - is a fossil fuel resulting from the chemical transformation of the burial of tree trunks, roots, branches and leaves, the process of which takes millions of years to develop.

Charcoal - it is obtained through the process known as carbonization, which consists of burning the wood with controlled presence of air; or by the pyrolysis process, where the wood is subjected to high temperatures in an environment with very little or no amount of oxygen.

Solid fuel - solid materials burnt as fuels.

Biomass solid fuel - wood, animal manure, crop residues and coal.

Natural gas - colorless and odorless, highly combustible and largely composed of methane gas. Natural gas is generated in much the same way as oil, by processes that act on organic matter over millions of years.

A repulsive agent is added to give it a characteristic and unpleasant smell, sometimes described as rotten cabbage, so that even a small leak can be easily detected.

LP Gas - Liquefied petroleum gas is the generic name for mixtures of hydrocarbons (mainly propane and butane) stored in a liquid state. LP Gas is colorless, odorless and heavier than air. A repulsive agent is added to give it a characteristic and unpleasant smell, sometimes described as rotten cabbage, so that even a small leak can be easily detected.

Piped gas – refers to natural gas.

Firewood - defined as rough branches, trunks, logs (logs, wood chips) or any pieces of wood that can be used as fuel.

Collected firewood - from native forests, isolated trees and collected on properties or along highways.

Commercial firewood - firewood from native forests, currently replaced with reforestation firewood, with eucalyptus being the main tree grown for this purpose.

Particulate material - mixture of solid particles and liquid droplets suspended in the air.

The text of this leaflet is based on the study

Pollution in closed environments as a risk factor for health: the use of firewood as an aggravating factor

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