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Cooking fuels and the push for cleaner alternatives: a case study from Burkina Faso

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Introduction: More than 95% of the population in Burkina Faso uses some form of solid biomass fuel. When these fuels are burned in traditional, inefficient stoves, pollutant levels within and outside the home can be very high. This can have important consequences for both health and climate change. Thus, the push to switch to cleaner burning fuels is advantageous. However, there are several considerations that need to be taken into account when considering the use and promotion of different fuel types.

Objective: In the setting of the semi-urban area of Nouna, Burkina Faso, we examine the common fuel types used (wood, charcoal and liquid petroleum gas (LPG)) in terms of consumption, energy, availability, air pollution and climate change.

Results and conclusion: Although biomass solid fuel does offer some advantages over LPG, the disadvantages make this option much less desirable. Lower energy efficiencies, higher pollutant emission levels, the associated health consequences and climate change effects favour the choice of LPG over solid biomass fuel use. Further studies specific to Burkina Faso, which are lacking in this region, should also be undertaken in this area to better inform policy decisions.

Keywords: *biomass*; *fuel*; *Burkina Faso*; *air pollution*; *climate change*; *wood*; *liquid petroleum gas*

Received: 4 September 2009; Revised: 24 September 2009; Accepted: 2 October 2009; Published: 11 November 2009

Biomass fuels, which include wood, charcoal, crop residues and animal dung, are among some of the most widely used for cooking and heating, particularly in developing countries. Reliance on these materials can lead to numerous economic, environmental, social and health problems. Also, other problems that have already arisen may worsen. For example, increasing levels of biomass harvesting and combustion in response to the energy needs of growing populations can have important impacts on the global carbon cycle and consequently climate change. This growing population also faces the problem of having to invest ever-increasing amounts of time and effort to gather these fuels as resources become scarcer, particularly when harvested non-renewably (1, 2).

From indoor to outdoor air pollution

Air pollution is an international issue because of the transnational movement of pollutants across continents and oceans (3). Local sources usually only comprise part of the concentrations of particulate air pollutants in cities (4). However, an overlooked aspect of air pollution is indoor exposures. It has been estimated that 80% of the total global exposure to airborne particulate matter occurs indoors in developing nations (5). Indoor air pollution, when vented outside from biomass stoves, can also produce significant local outdoor pollution, particularly in dense urban neighbourhoods (6–8).

The bulk of the global indoor air pollution exposures stem from two sources: environmental tobacco smoke and the combustion of solid biomass fuels for cooking and heating (6). However, the burning of biomass fuels is usually conducted under less than ideal conditions, which leads to the incomplete combustion of this material and the subsequent release of a number of compounds, which can be detrimental to health (7) and the environment. These include carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), non-methane hydrocarbons (NMHC), nitric oxide (NO), ammonia (NH_3), particulates and inorganics (9).

Another by-product of incomplete combustion is black carbon or soot. Soot, when released into the atmosphere, blocks and absorbs solar radiation, which can greatly

Citation: Global Health Action 2009. DOI: 10.3402/gha.v2i0.2088

contribute to solar heating (10). Additionally, soot can mix with other aerosols to produce other products of incomplete combustion (PICs), which, in some cases can multiply associated effects (10, 11). Open biomass burning is estimated to be responsible for approximately 42% of black carbon emissions (12).

Many of the by-products of the incomplete combustion of solid biomass fuels are important in terms of climate change. Therefore, interest in the links between solid biomass fuel use and climate change has been growing (8, 13–15). Importantly, the contribution of biomass solid fuel to greenhouse gas (GHG) emissions and its implications for climate change should not be underestimated (9, 15).

Health consequences of biomass smoke exposure from cooking

A further critical consideration of solid biomass fuel use is the associated health effects. Approximately 1.5 million deaths every year from respiratory infections can be attributed to the environment, including the effects of indoor and outdoor air pollution (16). Acute respiratory infections (ARI) in children are one of the leading causes of infant and child morbidity and mortality (17–19). Detailed studies have found strong correlations between the maternally reported number of hours per day children under two years spent by the fire and the incidence of moderate and severe ARI cases in rural Nepal (20). Open wood-fires were also a signficant risk factor for ARI among children under three years in a study in Zimbabwe (21). Additionally, girls in the Gambia under five years of age carried on their mother's backs during indoor cooking were found to have a six times higher risk of ARI than other children in the study, which was more than the risk from exposure to environmental tobacco smoke (22).

Chronic obstructive pulmonary disease is another outcome of exposure to high levels of air pollution (23). For example, studies in Nepal (24) and India (25, 26) found that non-smoking women who cooked on biomass stoves had a higher prevalence of this condition than women who used biomass stoves less. Studies in China and one in Japan have also found associations between biomass fuel use and lung cancer. Thirty-year-old women in Japan cooking with straw or wood had an 80% increased chance of having lung cancer later in life (23). Likewise, a study in China found strong associations between lung cancer and use of biomass-burning stoves (27).

At-risk groups

The health risks posed by biomass smoke exposure are generally borne by women and children. There are very few activities that involve as many person-hours as cooking, which is done in every household every day in most of the world, primarily by women (28). The risks from biomass smoke exposure are also high in young children as they spend large amounts of time with their mothers (8). Children carried on their mother's backs or lap during cooking are often exposed to emissions from biomass fuel combustion from early infancy (22). Coupled with the fact that children's immune systems are still developing and that they have higher mass-specific inhalation rates than adults, biomass smoke exposure could be an important factor affecting the occurrence of diseases (29).

Addressing the problem

In an effort to address this problem, people have been encouraged to move up the 'energy ladder' and use cleaner burning, more efficient fuels as a way to combat the problems associated with the use of biomass solid fuels (23). The energy ladder is made up of several rungs that represent fuels such as wood, charcoal, gas and electricity. Traditional fuels like dung, crop residues and wood typically occupy the lowest rungs. Charcoal, kerosene, gas and electricity represent the higher rungs, in sequential order (30). The cleanest and most desirable fuel substitutes include kerosene, liquid petroleum gas (LPG) and electricity. Wood typically releases 50 times more particulates, CO, formaldehyde, nitrogen oxides and polycyclic aromatic hydrocarbons during cooking than gas (23).

However, as the energy ladder is ascended and emissions decline, fuel costs increase and the availability of these materials also decreases (30). Household income has been shown to be the most important determinant of the choice of household energy in the developing world. Thus, the use of traditional fuels and poverty is very closely interlinked (31). Halving the number of people worldwide cooking with solid fuels by 2015 through the introduction of LPG would cost approximately 13 billion USD per year and provide an economic benefit of 91 billion USD per year (32), a worthwhile investment. Unfortunately, the prediction is that, in the future, the majority of those using biomass will continue to do so in the short and medium-term. However, shortages in supplies stemming from socio-economic and environmental problems will, at the same time, render this option less feasible (23).

Unfortunately, little information exists as to the consumption, availability and climate change effects of different types of fuel used in Burkina Faso, a country with extremely high levels of biomass use (33, 34). Here, we examine the consumption, energy, availability, air pollution and climate change aspects of some of the most commonly used fuels, such as wood, charcoal and LPG, in Burkina Faso. Within this context, we then discuss some of the beneficial and detrimental aspects associated with the use of these fuels and how these could be used to introduce energy policies in Burkina Faso.

Case study: air pollution in Nouna, Burkina Faso

Burkina Faso

Burkina Faso is a landlocked country located in Western Africa made up of 45 provinces with an area of 274,200 km^2 (35). Approximately 14.4 million people live in Burkina Faso and the current growth rate is 3% per year since 2006 (36, 37). Eighty-one percent of the population live in rural areas (35). Burkina Faso is one of the poorest African countries with 45% of the population living below the poverty line on approximately 1 USD per day in 2006 (36). The average per capita public expenditure on health care is 5.12 USD, which falls far below the Commission on Macroeconomics and Health's recommended minimum for essential health intervention of 30–40 USD per capita per year in developing economies (38).

Over 95% of Burkinabé households use biomass fuels (32). It has been estimated that over 21,500 deaths every year in Burkina Faso are attributable to exposure to indoor biomass smoke (39). The disability adjusted life years (DALYs) associated with indoor air pollution in Burkina Faso were estimated to be 58 per 1,000 capita per year in 2002 compared to 1.7 DALYs per 1,000 capita per year for outdoor air pollution (39). The burden of disease attributable to solid biomass fuel use in Burkina Faso is approximately 8.5% (34).

Nouna, Burkina Faso

Nouna is a semi-urban town located in the Kossi province in northwest Burkina Faso, approximately 300 km from the capital city of Ouagadougou. There are two seasons: the rainy season runs from June to October and the dry from November to May. Like most of Burkina Faso, Nouna is inhabited mainly by subsistence farmers. Previous studies have indicated that biomass fuel use in Nouna is also very high (>98%) (33). Most households (86%) were found to cook outside in the dry season; however, many preferred cooking in sheltered corners or against walls which tended to concentrate smoke from the fires close to the house (33). Those who did not cook outside, cooked indoors in kitchens with mud roofs and tiny windows with little ventilation. Over half of the households in the study (58%) exclusively used biomass for cooking while 40% used a mix of biomass and other fuels. Only 2% did not use biomass and cooked exclusively with other fuel types. Additionally, 92% of the households in the study burned biomass solid fuel in traditional, three stone stoves. Combined, these factors resulted in very high pollutant exposures and an increased burden of ARI in children (33).

Wood, charcoal and liquid petroleum gas (LPG)

Consumption

As one of the most widely used fuels in Nouna, wood is an important solid biomass fuel. In a recent study, over 98% of households used wood for cooking (Table 1). Daily and yearly wood consumption in Burkina Faso was slightly lower than the daily (1.79–4.46 kg/capita/day) and yearly (9.3 Tg) wood consumption measured in a study in Zimbabwe (40). However, it must be noted that more recent consumption rates for Burkina Faso could be higher. Differences were also found between rural and urban areas. In rural environments, wood consumption was higher at 1.0 kg/capita/day compared to urban areas (0.6 kg/capita/day) (41). Kituyi et al. (42) also reported differences in firewood consumption rates between rural (2.14 kg/capita/day, weighted average) and urban (0.14 kg/capita/day, weighted average) areas in Kenya.

Charcoal was also reported as being used extensively in Nouna. Not surprisingly, urban areas in Burkina Faso were found to use more charcoal than rural areas (0.030 kg/capita/day and 0.013 kg/capita/day, respectively) (41). In Kenya, the mean weighted average consumption of charcoal was 0.37 kg/capita/day in urban areas and 0.26 kg/capita/day (42).

As far as we are aware, no information exists as to the consumption rates of LPG in Burkina Faso. In the Nouna study, less than 3% of households reported using LPG for cooking. A similar finding was also echoed in Kenya where LPG rates were 0.007 kg/capita/day (42).

Table 1. Type of fuel reported among respondents in Nouna[a]

Fuel type[b]	Respondents reporting use (%)[b]	Daily consumption rate (kg/capita/day)	Yearly national consumption
Waste (e.g. crops and dung)	0.9	N/A	N/A
Wood	98.2	1.48 (41)	5.64 Tg (41)
Charcoal	72.9	0.03 (41)	0.13 Tg (41)
Liquid petroleum gas	2.3	N/A	N/A
Electricity	0.0	N/A	500,000 MWh (44)

[a]Respondents from the Demographic and Surveillance System (DSS) survey on demographics and health from a catchment area of approximately 1,775 km^2 covering 74,000 households (43).

[b]Out of a sample of 221 respondents. Many households reported using multiple types of fuel. (Yamamoto unpublished, 2009).

Table 2. Energy and efficiency of different fuel types typically used in India (46)

Fuel type	Stove types	Energy (MJ/kg)	Thermal efficiency[b]
Wood	Three stone	15.1–15.5[a]	0.18–0.29
	Traditional mud		
	Improved vented mud		
	Improved vented ceramic		
	Improved metal		
Charcoal	Angethi[c]	25.7	0.18
LPG	LPG stove	45.8	0.54

[a]Depending on wood type (e.g. acacia, eucalyptus and roots).
[b]Thermal efficiency is a combination of combustion and heat transfer efficiency.
[c]Galvanised iron bucket combined with mud/concrete and a grate.

Energy

Biomass contributes between 10 and 12% of the overall energy in the world, although this varies with very low percentages in industrialised countries and values of 50% or more in developing countries (45). As presented in Table 2, a study in India using several stove and fuel combinations (46) found that the energy and efficiency of fuels varies widely. Depending on the type of stove used, conversion efficiencies of biomass fuels typically range between 8 and 18% (45). Energy losses, particularly with traditional stoves like those used in Nouna, are largely in the form of heat and the PICs, including CO, NO and particulates. Additionally, the moisture content of solid biomass fuels can also affect the amount of energy and PICs produced. Air-dried wood has water content between 12 and 20% and a heating value of 13–16 MJ/kg (45). New, freshly harvested wood can have a moisture content of 50% or more, which reduces the heating value to less than 10 MJ/kg (45) and greatly increases the amount of PICs produced. High combustion efficiency, such as found in fuels higher on the energy ladder, may result in lower PICs (15). Taken together, these factors all affect the amount of energy that reaches the cooking pot.

Women in Nouna reported cooking on average 1.6 meals per day during the rainy season. In India, it was estimated that the amount of energy needed to cook one meal was approximately 1 MJ (46). If we use this assumption, as we lack estimates for Burkina Faso, we can estimate that a woman will require 1.6 MJ per day to cook meals for her family. Taking into account the thermal efficiencies listed in Table 2, households would need approximately 0.4–0.6 kg of wood per day just for meals. These crude estimates may even be much higher when other factors such as the size of the family or the type of food cooked are taken into account. Conversely, as the energy and thermal efficiency of LPG is much greater than that of wood, it is estimated that only 0.06 kg of LPG is required to produce the same amount of energy. Thus, much less fuel is needed to cook the same meals.

Availability

In terms of the exploitable quantity of ligneous fuel, Burkina Faso is estimated to have approximately 4.5 tonnes/capita/year (41). Wood fuel production estimates for Burkina Faso were 9,150,000 m^3 in 1994 (47). However, this is probably not evenly distributed, which may lead to shortages and surpluses in different parts of the country. Wood, and particularly charcoal, can be economically transported from rural areas to urban areas (45), which may offset some of these disparities. Nonetheless, biomass fuel is poorly characterised because it is not traded in markets and is generally used or gathered locally (non-commercially) and is therefore not part of national statistics (45).

At the local level, fuel is available and can be purchased from the Nouna market. A ‘charette’ of 500 kg of wood costs approximately 2,500 CFA (5.62 USD) locally. In comparison, a 100 kg bag of charcoal is 1,500 CFA (3.37 USD) and a 6 kg cylinder of LPG approximately 5,000 CFA (11.23 USD) (Ouédraogo, personal communication). Using the above crude estimates, the approximate cost of cooking 1.6 meals per day over the course of a year in Nouna would be between 730 and 1,092 CFA (1.64–2.45 USD) using wood, 1,895 CFA (4.25 USD) using charcoal and 19,732 CFA (44.28 USD) using LPG. Therefore, LPG is out of reach of many households who survive on less than 72,690 CFA (162.43 USD) per year (48).

Wood can also be gathered for free from nearby sources. However, gathering wood is a time-consuming activity. For example, women in a rural area of Sri Lanka were forced to walk an average of 5.8 km to collect firewood when an irrigation project brought about widespread environmental damage and tree destruction (2). The time expended on this chore alone was 4.7 hours per week. Thus, in an effort to reduce the time demands for fuel collection, women began to carry average loads of 24 kg (2). The consequences of increased gathering time for fuels can be the substitution of inferior fuels, reductions in the amount of wood used and the cooking of fewer meals, which in turn can lead to less income, rest, space and water heating as well as hygiene. Fewer special foods may also be prepared for the ill, pregnant or children and the elderly (49). Nonetheless, biomass fuels are usually available and inexpensive, making them attractive alternatives especially for the rural poor (17, 33, 42, 50, 51).

Both wood and LPG can pose additional hazards to health that also need to be considered. For example, gathering wood fuel can be linked to increased risk of assault or natural hazards (49). Similarly, burns were

Table 3. Emission factors associated with different fuel types (15)

Fuel type	Stove efficiency	CO_2 (g/kg)	CO (g/kg)	CH_4 (g/kg)	RPM[a] (g/kg)
Wood	0.20	1,620	99	9.00	2.00
Charcoal	0.30	2,570	210	7.80	1.70
LPG	0.70	3,190	25	0.01	0.10

[a]Respirable particulate matter.

responsible for several injuries, particularly among children, from cooking appliances, steam or other gases in a study in Iran. Fatalities were also recorded in the study from fires related to the manipulation of gas equipment for cooking or heating (52).

Pollution

The health effects associated with exposure to biomass pollutants are well known (19, 49, 53). These pollutants stem from the incomplete combustion of wood, charcoal and LPG, which releases several by-products in addition to heat. These include CO_2, CO, CH_4, particulates like black carbon and other organic compounds (Table 3, (15)). Extremely high levels of pollutants can occur with the burning of biomass fuels for cooking. The mean concentration of PM_{10} measured in the kitchens during the day of 148 households in Nouna was 4.06 mg/m^3 (0.020–45.94 mg/m^3). The overall PM_{10} concentrations greatly exceeded the maximum 24 hour limit of <50 µg/m^3 recommended by WHO (54). Levels recorded in Nouna kitchens also exceeded those reported in studies in rural India and South Africa, Mexico and Mozambique (31, 55–57).

CO levels were also very high in the kitchens and sleeping rooms of households in Nouna. The mean area concentration of CO in 121 kitchens and sleeping areas combined was 17.02 ppm (0.13–90.27 ppm). These CO concentrations were within the ranges reported by others (57–60). A study by Naeher et al. (61) in Guatemala found that the concentration of CO released from gas stoves, improved stoves and open fires was 1.5, 2.4 and 6.7 ppm, respectively. Similarly, Smith et al. (62) also observed decreasing levels of CO emitted with ascension of the energy ladder. Per meal, combusted wood residues typically release 19 g/MJ-d CO per meal as opposed to LPG, which releases only 1.0 g/MJ-d CO.

Climate change

In terms of the global carbon cycle, biomass combustion emits between 1,800 and 4,700 Tg carbon per year, compared to fossil fuels, which emit 5,700 Tg carbon per year. Biomass combustion therefore has an important role in the global carbon cycle (9). The human consumption of biomass fuels are estimated to represent between 20 and 40% of all biomass combustion globally. It is also estimated that 1–3% of all human-generated global warming is from the household burning of biomass fuels (15). In terms of specific pollutants, this is a global contribution of between 1–5%, 6–14% and 8–24% of all CO, CH_4 and total non-methane organic compounds, respectively (15). Table 4 presents the estimated mean daily global warming commitments weighted by 20-year global warming potentials (GWPs) from three stone (wood) stoves and charcoal stoves from a study in Kenya. The relative contributions of biomass combustion in West Africa to atmospheric emissions are 46% (CH_4), 42% (CO), 44% (NMHC) and 32% (CO_2) (Table 5; (41)).

It is assumed that biomass fuels, if renewably harvested, are GHG neutral. However, biomass is not merely combusted into CO_2, which is subsequently taken up by vegetation (64). As much of the carbon of biomass is produced as PICs, which have higher GWPs than CO_2, low-efficiency stoves can produce warming if even the biomass is renewably harvested (4, 13, 49, 64, 65). PICs from biomass burning were found to have a GWP 110% that of CO_2, over a 20-year period (15).

In particular, black carbon is an important PIC in terms of climate change as its effects are stronger than climate gases, such as CH_4, chlorofluorocarbons, nitrous oxide and even ground-level ozone (10). Moreover, black carbon may also have an effect on precipitation levels and melting when it falls on ice or snow by reducing reflectivity and increasing the absorption of solar radiation (12, 66). Currently, it is estimated that approximately 15% of the excess radiative forcing and 40% of the net warming occurring is from black carbon (12, 67). It has also been suggested (68) that biomass burning is the largest source of black carbon in India. In Africa, over

Table 4. Mean daily global warming commitments (g C in CO_2 equivalent weighted by 20-year GWPs) from household biomass combustion by stove type in Kenya (14)

	CO_2	CO	CH_4	NMHC[a]	Total GHG[b]
Three stone fire	5,450	1,920	701	240	8,310
Charcoal	4,300	3,120	2,201	230	9,850

[a]Non-methane hydrocarbons.
[b]Greenhouse gases.

Table 5. Emission factors for biomass combustion by fuel type and location (g C or N/kg dry wood)

Location	Fuel type	CO_2	CO	NO	Source
Zimbabwe	Wood	450	43	0.52	(40)
West Africa	Wood	400	30	1.5	(41, 63)
	Charcoal making and burning	290	55	8.5	(41, 63)

80% of black carbon emissions are estimated to stem from domestic biomass burning (12).

There is also concern about the environment in places where biomass use is the primary source of energy in developing countries (69). Unsustainable fuel wood use may lead to deforestation (40) and desertification (49). As a result, biomass, soil, land and water resources degrade (45). Changes in land cover and flora have also been noted over the last 30 years in Burkina Faso; however, this is thought to be due to intensified grazing pressure and increases in livestock density (70) rather than biomass fuel harvesting.

Discussion

In comparing the relative benefits and drawbacks of biomass and fossil fuels such as LPG, the winner may seem obvious. However, it is important to consider several aspects within the context of Burkina Faso since such a large proportion of the population uses biomass fuels. The switch to cleaner burning fuels is not likely to be quick or even feasible in the near future, given the economic constraints and availability of solid biomass fuels.

There are some advantages associated with biomass use. Biomass can be sustainable for the environment and climate if they are combusted at a high level of efficiency and renewably harvested (45). Also, biomass combustion usually results in low sulphur and nitrogen emissions. This, in turn, produces fewer particles and less acid precipitation. Additionally, other toxics such as mercury, lead, arsenic, fluorine are less in biomass fuels, compared to other fuel types. Ash by-products can also be recycled back to the areas in which biomass was harvested (45).

As a form of stored solar energy, biomass is more reliable and readily available than wind or direct solar energy. Additionally, biomass is not usually affected by energy crises as it is produced, harvested and used locally. Biomass is also widely accepted, provides employment, contributes to infrastructure and promotes conservation (45). Moreover, fuel demand is not usually the primary driver behind deforestation in developing countries (45, 51). Instead, the demand for agricultural land, road building or other land-use changes are largely responsible (45, 51). Significant amounts of wood for domestic use are collected from trees around houses, fields and roads. These sources are not included in national forest statistics and do not show up on remote sensing surveys. Consequently, if fuel demand seems to exceed local forest growth rates, deforestation may not actually be taking place (49).

Other environmental problems in countries like Burkina Faso are also thought to be attributable to changes in land use rather than the non-renewable harvesting of household fuels, although this may also have an impact. Desertification, for example, may be linked to fuel demand. However, desertification could also be due to climate change, grazing intensification, land-use shifts and industrial fuel harvesting (e.g. forest kilns) (49).

Another consideration is that as rises in energy prices make fossil fuels unaffordable for the poorest households (4, 23), biomass is one of the only available options in Burkina Faso. Economic considerations and not health or environmental aspects are likely dictating households' choice of fuels in these regions. Thus, efforts to introduce more expensive fuels into households will likely not be feasible without considerable subsidies.

Nevertheless, there are several drawbacks in using biomass fuels. Air pollution, particularly indoors, is associated with numerous health effects. One of the most obvious ways to address this issue is to encourage the use of cleaner burning fuels. In moving up the energy ladder, the first step is usually from wood to charcoal or kerosene and the second to LPG (15). Even small movements up the energy ladder will bring some improvements in terms of indoor air pollution exposure (23). If all the current users of biomass (two billion) switched to LPG, the net reduction in exposure would be larger than the current exposure to all fossil fuel emissions (18). Moreover, using liquid or gases with premixed air to achieve high combustion efficiencies could further reduce exposures (64). Another way to reduce air pollution exposures is to use more efficient stoves. Thus, even if cleaner burning fuels are out of the reach of many poor households, introducing more efficient stoves can be a worthwhile long term investment (71–74).

Solid biomass fuel harvesting and combustion can also have important impacts on the global carbon cycle and climate change. As PICs such as black carbon and CH_4 have higher GWPs than CO_2, solid biomass fuels burned inefficiently may not be GHG neutral, even if they are harvested renewably (75). Given the short lifetime of black carbon (weeks), reducing emissions could be a way to mitigate global warming in the near future, address regional climate issues and decrease the retreat of sea ice and glaciers (10, 12). Moreover, Baron et al. (12) argue that controlling black carbon emissions can be a cost-effective means of improving health and alleviating some of the effects of global warming, although this suggestion is not without debate (67, 76).

Furthermore, switching to LPG may not result in an exponential rise in emissions of GHGs. It has been estimated that switching everyone from biomass fuel to LPG would only result in a less than 2% increase in global GHG emissions (18). It has also been argued that petroleum resources are sufficient to supply all household energy needs worldwide. Petroleum supply stresses are predicted to stem from other sectors (4, 18).

There are also good arguments for exploring the development of renewable and sustainable energy as they have the potential to take advantage of local conditions (e.g. sun and wind). Biogas may also be a good alternative as it produces significantly lower concentrations of pollutants (50, 64). Biogas is renewable, has high thermal and combustion efficiencies and low global warming commitments (64). However, there are currently few of these technologies available to replace biomass on the scale needed. Thus, the introduction of LPG in these areas may be more feasible (18).

Clean energy also provides access to education, health care and household resources. Children who do not have to collect biofuels can attend school (4, 62). Switching to cleaner fuels could also free up time for women to engage in income-generating pursuits (4).

The introduction and promotion of cleaner energy for cooking, particularly in developing countries like Burkina Faso, can have several benefits. Encouraging households to switch to LPG would result in the consumption of less fuel per meal and less time spent gathering fuel, which could be expended on other activities such as attending school or participating in microprojects. LPG is available in places such as Nouna, although it is still not within the affordable range of many households, which is an important drawback. Another significant consideration is the availability and affordability of LPG in rural areas. Nonetheless, global supplies of petroleum are estimated to be sufficient to accommodate the needs of domestic users, even if all those currently using biomass switched to LPG (18).

Perhaps one of the strongest arguments for helping households to switch to cleaner fuels is related to pollution and their associated health outcomes. As the burden of disease attributable to biomass use in Burkina Faso is estimated to be 8.5% (34), reductions in exposures are warranted. In particular, at-risk groups such as women and young children who bear the brunt of such exposures could stand to greatly benefit from switches to LPG or other cleaner burning fuels.

Lastly, reductions in biomass solid fuel pollutants have the potential to impact climate change as well. Black carbon and other PICs can have significant impacts in terms of radiative forcing, precipitation and sea ice melting (10, 67). Policies promoting reductions in the levels of PICs may mitigate some of these effects. Thus, the effects of such policies are advantageous for health and the climate – a little known co-benefit from the perspective of the mitigation debate (77).

Conclusions

Though biomass use has some advantages and is likely to continue in the short to medium-term in Burkina Faso, other energy options should also be explored. From a health, societal and climate change perspective, the burning of biomass solid fuel in inefficient stoves is highly undesirable. Policies encouraging households to move up the energy ladder are warranted and necessary. Also, as limited information specific to Burkina Faso is available, research regarding fuel use and energy consumption patterns and availability is desirable to aid in the development of effective policies.

As clean fuel initiatives will require coordinated efforts, governments and other organisations also need to plan to ensure adequate, reliable provisions and services. Initiatives to encourage households to move up the energy ladder may include stove intervention programmes and subsidised fuel prices. The exploration of sustainable and renewable energies is also a key consideration in clean energy initiatives.

According to Wilkinson et al. (4), the inequity in the access of rich and poor countries to clean fuels is an injustice. As such, providing poor households with affordable access to cleaner alternatives should be paramount. Interventions and policies are key to the successful introduction of cleaner burning fuels among developing countries like Burkina Faso that heavily depend on biomass.

Acknowledgements

The authors would like to thank the participants of the study as well as the Deutsche Forschungsgemeinschaft Graduiertenkolleg 793 (German Research Foundation) for funding this research.

Conflict of interest and funding

The authors have not received any funding or other benefits from industry to conduct this study

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