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Baseline and feasibility assessment for alternative cooking fuels in Senegal

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1818 H Street NW, MSN U11-1102
Washington DC 20433
Telephone: 202-458-7955
Fax: 202-522-2654
Website: [http:// www.worldbank.org](http://www.worldbank.org)
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Acronyms and abbreviations

ABPP	Africa Biogas Partnership Programme
ACCES	Africa Clean Cooking Energy Solutions
ANEV	National Agency for Ecovillages
ANSD	Senegalese National Agency for Statistics and Demography
BRADES	Bureau de Recherche/Action pour le Développement Solidaire
CERER	Centre for Study and Research in Renewable Energy
CFAF	West African CFA Franc (\$1=479 CFAF on May 5, 2014)
COPD	chronic obstructive pulmonary disease
CRAT	Centre Régional Africain de Technologie
CSPLP	Monitoring Unit of the Program to Fight Poverty (Cellule du Suivi du Programme de Lutte Contre la Pauvreté)
CSS	Compagnie Sucrière Sénégalaise
DGIS	Directorate General for International Cooperation (the Netherlands)
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
ENDA	Environmental Development Action in the Third World
ESP	École Supérieure Polytechnique de Dakar
ETHEC	Entreprise des Travaux Hydrauliques et de Construction
FGD	focus group discussion
GACC	Global Alliance for Clean Cookstoves
GDP	gross domestic product
HH	household
HIVOS	Humanist Institute for Cooperation, the Netherlands (Humanistisch Instituut voor Ontwikkelingssamenwerking)
IAP	indoor air pollution
ICS	improved cookstoves
LPDSE	Lettre de Politique de Développement du Secteur de l'Énergie
LPG	liquefied petroleum gas
LPSSCD	Lettre de Politique du Sous-Secteur des Combustibles Domestiques
MEF	Ministère de l'Economie et des Finances (Ministry of Economy and Finance), Senegal
MJ	megajoule
NGO	nongovernmental organisation
OMVS	Senegal River Basin Development Authority (Organisation pour la Mise en Valeur du Fleuve Sénégal)
PERACOD	Program for the Promotion of Sustainable Energy, Rural Electrification and Sustainable Supply of Household Fuels
PNB-SN	National Domestic Biogas Programme of Senegal (Programme National de Biogaz Domestique de Sénégal)
PPO	pure plant oil
PROGEDE	Sustainable and Participatory Energy Management Project (World Bank)
SME	small and medium enterprise
SN-GNP	National Domestic Biogas Programme of Senegal
SNV	Netherlands Development Organization
TLU	tropical livestock unit
UCAD	University Cheikh Anta Diop de Dakar
U-IMCEC	Mutual Savings and Credit Union (Union des Institutions Mutualistes Communautaires d'Epargne et de Crédit)

WACCA West African Clean Cooking Alliance
WAEMU West African Economic and Monetary Union (also known as UEMOA, or Union
Economique et Monétaire Ouest Africaine)



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Executive Summary

More than 90 per cent of the rural population in Senegal relies on solid fuel – charcoal and firewood in particular, but also dung and agricultural residues – to meet its household cooking needs. In the 1970s, Senegal began a liquefied petroleum gas (LPG) subsidy programme that is widely regarded as a success story of inter-fuel substitution. Following the withdrawal of these subsidies in 2009, however, the market for LPG experienced a significant setback. Households in the capital, Dakar, tend to use a mix of cooking fuels, but their use of charcoal has gradually increased in recent years in response to the drop in LPG usage.

This dominance of biomass usage in Senegal has resulted in significant adverse economic, health, social, and ecological impacts, and measures are urgently needed to promote a range of alternative household cooking fuels that are both cleaner and more sustainable.

Against this background, the World Bank commissioned this study to assess the feasibility of promoting the use of a number of alternative cooking fuels in Senegal, which were pre-identified for possible support under its Sustainable and Participatory Energy Management Project (PROGEDE II). Four alternative fuels were analysed in terms of their potential for adoption by households for cooking, each in a different region of Senegal: (a) briquettes in Dakar, (b) ethanol in Saint-Louis, (c) biogas in Kaolack, and (d) pure plant oil (PPO) in Tambacounda.

The study includes a baseline assessment of household cooking fuels in Senegal, including a number of alternative fuels, as well as an analysis of their potential supply chains. Its objective is to inform a range of relevant stakeholders – in particular the Ministry of Energy and Mines in Senegal, the World Bank's PROGEDE II, nongovernmental organisations, investors and private sector companies – about strategies to increase production of and access to these alternative fuels.

The study also presents important lessons on each alternative fuel deriving from household surveys in each region, a review of the relevant literature, interviews with stakeholder organisations, and focus group discussions (FGDs).

Briquettes in urban and peri-urban Dakar

Senegal's capital is likely to be one of the most important demand centres for any alternative fuel commercialised in the country in the future. Although consideration should be given to what factors would lead to an increase LPG utilisation by both urban and peri-urban households in the Dakar region, in the context of alternative fuels, an understanding of the still relatively high (and growing) use of biomass fuels, particularly biomass briquettes, is important. The use of briquettes could partially or even wholly replace charcoal and firewood in both urban and peri-urban households in Dakar – and, if used within more efficient stoves, could offer a cleaner-burning and cheaper alternative without the necessity of major behavioural change.

We estimate that the sale price of briquettes in Dakar, which will depend on transport costs, will fluctuate between CFAF 150 and 200/kg. At CFAF 20.2 per megajoule (MJ), briquettes cost about half of the price of charcoal and two-thirds the cost of LPG in Dakar. Retailers will likely be able to sell briquettes easily once end users start to appreciate the benefits, in particular the fact that briquettes compare highly favourably with charcoal for cooking, without having any major disadvantages provided they are produced to a high quality.

The study concludes that there is high potential to create a vibrant market for briquettes in Dakar. The main challenges are likely to be (a) achieving the same quality of production

compared to charcoal and (b) scaling up production to meet potential demand, as the current supply chain is still fairly informal and contributes to only a small percentage of fuel used for household cooking.

Finally, the study suggests that a national awareness-raising campaign be conducted, focusing first on the urban centres of Dakar, Saint-Louis and Kaolack. Targeting urban and peri-urban households, the campaign would highlight the performance qualities of briquettes, the money and time saved by their use, and the potential long-term health benefits.

Ethanol in urban Saint-Louis

The study finds similarly clear potential for the development of an ethanol market in Saint-Louis. This could bring a range of social, economic and health benefits both to urban households and to the businesses involved in ethanol production. An initial ethanol market would be likely to target (a) urban charcoal users who use LPG as a secondary fuel and (b) LPG users who could benefit from using a more affordable fuel.

Due to what would probably be ethanol's comparatively high initial selling price of CFAF 320 per litre, it is likely that it would be affordable only in urban households in Saint-Louis. In terms of cost per MJ, in the Saint-Louis region briquettes (CFAF 15.1/MJ) would remain the lowest-cost option, followed by ethanol (CFAF 22.9/MJ), charcoal when used with improved stoves (CFAF 23-53/MJ) and LPG (CFAF 31-38.3/MJ).

This study recommends that a pilot project be conducted through an initial collaboration with the Senegalese sugar cane company, Compagnie Sucrière Sénégalaise (CSS). This would aim to supply 1,500 households with ethanol by using the 550,000 litres of 'head' ethanol produced (and currently wasted) by CSS's ethanol plant in the city of Richard Toll.

Biogas in rural Kaolack

The study finds that although rural Kaolack has the right social and agricultural conditions for the penetration of biogas technology to occur, it lacks sufficient awareness of the benefits of the technology to really reach scale. The newly-established national government biogas programme, designed to allow rural households to adopt biogas systems using subsidies and loans, aims to overcome some of the existing barriers to take-up. However, it is also recommended that the Senegal government should stimulate not only demand but also supply – by supporting the development of a range of biogas suppliers that are currently unable to construct the biogas systems or to train end users to maintain them efficiently.

In the Kaolack region there is good level of awareness around biogas, and many households have expressed a strong interest in adopting the technology. However, the survey reveals a lack of awareness of the national biogas programme, the benefits of which have not been enjoyed by the majority of the population.

The research discovered that if the subsidies and loans that are available were accessed, on the basis of current consumption rates and fuel costs in Kaolack, the cost of a 4 m³ biodigester could be paid back in 1-1.3 years. In addition, the survey reveals that households in the region are used to accessing both formal and informal loans, suggesting a potential for developing a specific microcredit mechanism for households willing to purchase biodigesters and for entrepreneurs willing to invest in biogas.

However, the region still lacks biogas technology suppliers, and the few that do exist suffer from low profit margins. This stems from a weak demand, mainly constrained by the low purchasing power of households, coupled with the high upfront cost of the technology. Senegal's national biogas programme needs to become active at the regional level. Local enterprises and micro-finance organisations need to be fully involved to enable households

to access loans and subsidies. Finally, the government should look at alternative solutions suggested by stakeholders involved in the sector, and develop a capacity building strategy to address enterprises' need not only for technical assistance, but also for business management skills.

Pure plant oil in Tambacounda

Although the region has the appropriate environmental conditions for the production of PPO, in particular using the plant *Jatropha curcas*, PPO's application as a household cooking fuel does not seem to be a feasible option for Senegal. This has been demonstrated by the lack of success of earlier initiatives which have attempted to introduce PPO (particularly *Jatropha*) for cooking in the region.

The Tambacounda region is well endowed with biomass resources and, in terms of household cooking fuels, charcoal and firewood are the least-cost options. The price per megajoule of biomass ranges from CFAF 5 (for charcoal used with an improved stove) to CFAF 11.8 (for charcoal used with an inefficient stove). This compares to CFAF 31.2 to CFAF 38.3/MJ for LPG, and PPO obtained from *Jatropha* which costs CFAF 700 per litre or CFAF 35.4/MJ.

It is therefore very unlikely that PPO use would significantly increase in uptake vis-à-vis other biomass fuels unless it becomes more competitive in terms of affordability and quality, particularly from the perspective of emissions and usability. It is also unlikely that the minority of LPG users in Tambacounda will switch to using PPO, for which there are no significant economical and cleanliness advantages. Alternative uses of PPO are possible, however, such as powering machines and basic electrification.

The following is a summary of feasibility for the four alternative fuels in the four regions.

		Briquettes (Dakar)		Biogas (Kaolack)	Ethanol (Saint-Louis)		PPO (Tambacounda)	
		urban	peri-urban	rural	urban	rural	urban	rural
Demand	Need for cleaner fuels	yellow	green	green	green	green	green	green
	Awareness/reputation	red	yellow	green	yellow	red	red	red
	Economics	green	green	yellow	yellow	red	yellow	red
Supply	Production capacity	yellow	yellow	yellow	green	green	red	red
	Potential business	yellow	green	green	green	yellow	red	red
	Distribution	green	green	yellow	yellow	red	red	red
	Feasibility	Medium	high	high	high	low	low	low

Note: green=high, yellow=medium, red=low

Introduction

Most of Sub-Saharan Africa continues to rely overwhelmingly on traditional fuels and cooking technologies, both of which are a major cause of death and illness as well as a range of socio-economic and environmental problems. More than 90 per cent of the rural population of Senegal relies on solid fuels – charcoal and firewood in particular, but also dung and agricultural residues – to meet its household cooking needs. In the 1970s, the government of Senegal began a liquefied petroleum gas (LPG) subsidy programme that is widely regarded as a success story of inter-fuel substitution. Following the withdrawal of these subsidies in 2009, however, the market for LPG experienced a significant setback. Today, households in the capital, Dakar, tend to use a mix of cooking fuels, but their use of charcoal has gradually increased in recent years, generally in response to the drop in LPG usage.

The primary objective of this study is (a) to establish a baseline for the current level of penetration of four alternative cooking fuels in Senegal in a number of pre-identified regions, and (b) to assess the feasibility of adopting them in those regions. The four fuels are briquettes from charcoal dust and agricultural residues; ethanol, mainly from sugar cane residue (that is, molasses); pure plant oil (PPO) from locally grown, oil-bearing plants such as *Jatropha curcas*; and a household biogas system using mainly livestock waste.

The inception phase allowed the study team to review the relevant background information, including key documents, and to collect and compile the secondary data relevant to the research objectives. The baseline assessment provided information not only on current levels of penetration of alternative fuels and stoves, but also on the existing cooking situation of households in the four pre-identified areas of Senegal. The baseline and feasibility assessments provided comprehensive information on urban and rural domestic fuel use and cooking stove acquisition, ownership, management, utilisation, consumer preferences, willingness and ability to pay, and gender roles related to household energy issues.

This study can help stakeholders understand the potential for scaling up each of these alternative fuels in the four regions as well as in the country as a whole as well as facilitate Senegal's move toward the sustainable and extensive use of appropriate alternative cooking fuels.

Chapter 1 provides a synthesis of the background information collected during the inception phase, while Chapter 2 presents the methodology used for the baseline, focus group discussions and key informant interviews. Chapter 3 presents the structure for chapters 4–7, which elaborate on the findings and recommendations for each fuel and region, including an analysis of the demand, supply and costs. The final chapter summarises the report's recommendations.

1. Overview of the household cooking sector in Senegal

This chapter presents background information on household cooking and alternative fuels in Senegal while introducing the energy and cooking sector of the country.

1.1 Geography, economy and population

Senegal has a surface area of 196,712 km² and a population of 12 million. Geographically and politically it is divided into 14 *régions* and subdivided into 45 *départements*, 103 *arrondissements*, 110 municipalities, 320 *communautés rurales* and 13,212 villages.



Figure 1.1 Map of Senegal and its regions

Source: CIA 2012.

Senegal's key export industries are phosphate mining, fertiliser production and commercial fishing. It is currently carrying out iron ore and oil exploration, although it still relies heavily on donor assistance and foreign direct investment to stimulate its economy.

Until around 2012, Senegal's GDP was composed of agriculture (15.3 per cent), industry (22.7 per cent) and services (61.9 per cent) (CIA 2012).

Senegal's rural population is 7.3 million, comprising approximately 700,000 rural households in over 13,000 villages (see Table 1.1). Whilst the total urban population is less (at just over five million in 2010), urbanisation is increasing fairly rapidly, and is expected to continue to do so (ANSD 2010).

Rural households are generally dispersed, with 75 per cent of Senegal's population living in villages of fewer than 500 inhabitants, 23 per cent living in villages of 500–2,500, and only 2 per cent of rural population living in villages of over 2,500.

Region	Regions chosen for the study				
	Dakar	Kaolack	Saint-Louis	Tambacounda	Senegal
Population (2010)	2,592,191	795,906	894,000	651,018	12,509,434
Men	1,297,350	388,079	438,205	325,122	6,175,077
Women	1 294 841	407 827	455 795	325,896	6,334,357
Population (%)	20.7	6.4	7.1	5.2	100
Land area (km²)	546	5,265	18,981	42,638	196,722
Land area (%)	0.3	2.7	9.6	21.7	100
Population density (households/km²)	4 748	151	47	15	64
Urban population	2,520,054	252,067	393,696	135,579	5,186,098
Rural population	72,137	543,839	500,304	515,439	7,323,336
Percentage of urbanisation (2010)	97.2	31.7	44	20.8	41.5

Table 1.1 Population trends in Senegal and target areas for the study

Source: ANSD 2010.

Senegal has a fairly diverse ethnic variation. Wolof is the largest single ethnic group (43 per cent); others include the Fula (a nomadic, pastoral community herding cattle, 24 per cent) and Tukulor (differing from the Fula only by the sedentary nature of their society, 24 per cent), the Serer (15 per cent), Lebou (10 per cent), Jola (4 per cent), Mandika (3 per cent) and a number of other smaller communities.

1.1.1 Geography and vegetation cover

Situated in coastal West Africa, Senegal has a total area of 196,712 km², including 4,190 km² of rivers and waterbodies. (This is important in the context of irrigation for crops, including 'energy crops' used to make biofuels.) The nation borders Mauritania to the north and Mali to the east along the Senegal River, whilst to the south-east and south, more or less following the Casamance River, it borders Guinea and Guinea-Bissau, respectively. The Gambia penetrates into the country for more than 320 km from the Atlantic coast eastwards along the river with the same name. Senegal is a relatively flat country, essentially one of plains and plateaus, with a maximum altitude of 400 m.

Senegal's water resources include rivers (in particular the Senegal, Gambia and Casamance), Guiers Lake, Anambé Basin, Sine, Saloum, and Ferlo Dead Valleys. Although these resources – up to hundreds of billions of cubic metres – depend on rainfall variability, they provide strong agro-pastoral development opportunities, such as the irrigation potential of 350,000 hectares along the Senegal, Gambia and Falémé rivers (OMVS 2013). This is of particular relevance to biomass purposely grown for fuel production, including wood and charcoal (which in turn affects briquetting production), ethanol, pure plant oil, and biogas.

1.1.2 Climate

Senegal's Sudano-Sahelian climate features a dry season from November to May and a humid (rainy) season from June to October, caused respectively by northeast winter winds and southwest summer winds. Average annual rainfall ranges from 1,200 millimetres in southern Senegal to 300 millimetres in the north. Temperatures range from 15°C in January in the northwest to a maximum of 42°C in May along the eastern border with Mauritania. The mean temperature roughly increases from west to east, from 25°C to 30°C. These climatic

variables significantly affect the types and intensity of vegetation in the country, and thus the types and quantities of fuels (including alternative fuels) that can be produced (Enda 2010).

1.1.3 Agriculture and livestock

Forty two per cent of Senegal (81,560 km²) is agricultural land, of which 69.3 per cent (56,500 km²) is under pasture. However, although farming involves almost 75 per cent of the working population, it constitutes only 15 per cent of GDP. A significant proportion of Senegal's farmland consists of small family farms, which have an average cultivated land size of 4.3 hectares. This means that 70 per cent of Senegal's agricultural holdings constitute 33 per cent of the cultivated land area.¹ Senegal's main agricultural areas are situated in the regions of Thiès, Diourbel, Fatick and Kaolack, the latter two being cut through by the *bassin arachidier* (groundnut basin). The main agricultural products are peanuts, millet, corn, sorghum, rice, cotton, tomatoes and green vegetables.

Livestock contributes to the livelihood of around 30 per cent of Senegalese households. Pastoralists and agro-pastoralists mainly raise cattle, sheep and goats; their participation in the meat market is marginal. Most Senegalese rural households are involved in traditional (that is, small-scale) poultry raising. Measured in tropical livestock units (TLUs),² cattle constitute 60 per cent of Senegal's livestock, and sheep and goats just over one quarter,³ all of which can be important suppliers of the feedstock for biogas production. The total livestock population in terms of TLUs increased by nearly 20 per cent over the past decade, showing its potential importance for biogas in the future, particularly if it continues to grow. Senegal's livestock density (according to 2005 data) results in 0.36 TLU per hectare agricultural land and just over 12 TLU per agricultural holding. Cattle density decreases to the north, east and southeast. The highest densities are found in the Casamance, south of the Gambia, and in the area roughly marked by the cities Thiès–Louga–Kaolack–Mbour (the *bassin arachidier*), which is of most relevance for biogas production (SNV 2007).

1.2 Access to modern cooking fuels in Senegal

There is an overwhelming reliance across most of sub-Saharan Africa on traditional fuels and traditional cooking technologies, which are a major cause not only of death and illness but also of a range of environmental problems. In Senegal, the use of traditional fuels (wood and charcoal) is putting great pressure on forests and contributing to the degradation of the environment (see below for some examples of this).

Although the government of Senegal, hoping to reduce this dependence on traditional fuels, subsidized LPG supplies for more than two decades, the subsidy was withdrawn in 2009, a move which – along with supply disruptions – has already led to a decline in LPG usage. The current access rate for LPG is still only approximately 28 per cent of the overall population, with about six million people having no access to 'modern' fuels despite the population growth. Approximately 83 per cent of the rural population and 58 per cent of the urban population still cook with solid fuels (see Table 1.2) including charcoal, firewood and animal dung.

¹ Senegal Agricultural Census 1998–99 (Ministry of Agriculture, Senegal, 2000).

² TLU conversion factors: cattle 1.00, sheep and goats 0.15, pigs 0.20, horses 0.80, donkeys 0.70, camels 1.40.

³ Senegal's livestock comprises 3.2 million head of cattle, 9.3 million sheep and goats, 330,000 pigs, 525,000 horses, 412,000 donkeys, 4,000 camels and 21.8 million poultry.

Percentage of population with access to modern fuels	Year				
	1990	2000	2010	2010 Rural	2010 Urban
	19	35	49	17	86

Table 1.2 Access to modern cooking fuels in Senegal

Source: World Bank and SE4All (2013).

According to a recent study (World Bank 2013b), charcoal is the most common fuel used overall, followed by LPG in urban areas and firewood in rural areas; Box 1 discusses common perceptions of each. Seventy-one percent of households currently use at least one improved or clean solution such as Jambaar stove, Malaagi stove or LPG stove.

Box 1. Basic perception of currently used fuels in Senegal

Firewood: A traditional and very affordable fuel. Mostly used by rural households, it is considered as a dirty fuel which requires hard work.

Charcoal: An interesting compromise between fuelwood and gas. Charcoal is perceived as affordable and widely available by urban households.

Liquefied petroleum gas (LPG): The ideal fuel. A large majority of non-users indicate they would immediately switch to gas if they could afford it.

Source: World Bank 2013b

In 2013, Senegal was ranked twelfth in the sub-Saharan Africa region in terms of access to modern fuels, as shown in Figure 1.2.

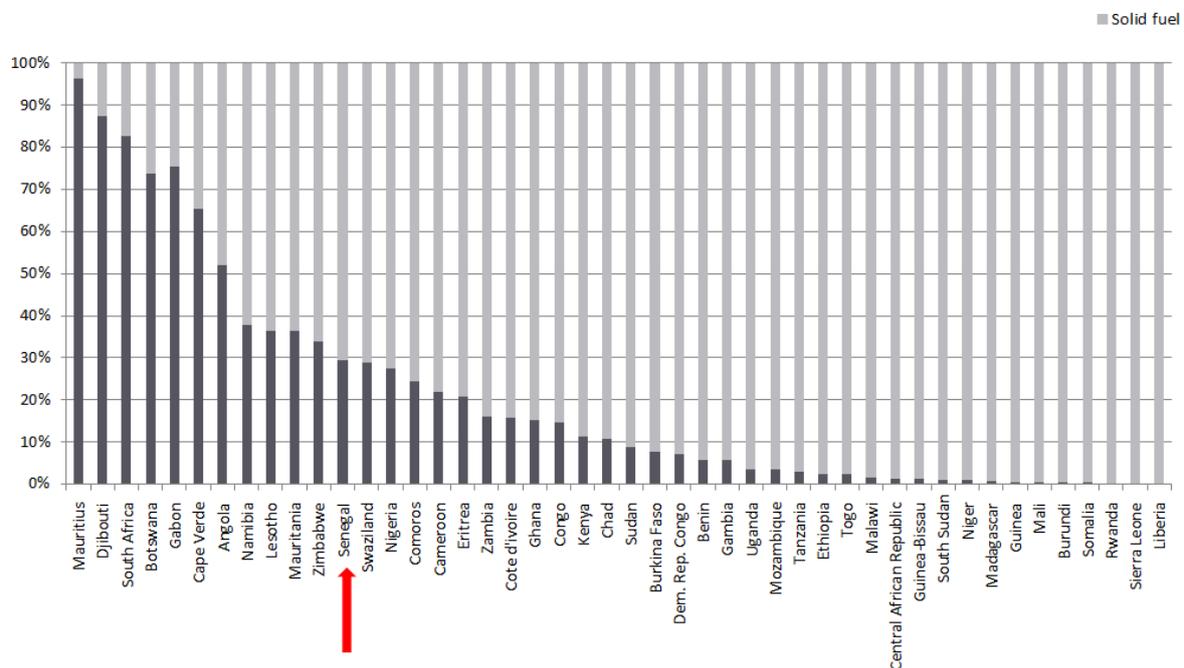


Figure 1.2 Ranking of Senegal in Sub-Saharan Africa with respect to usage of modern fuels (latest year available, 2009–10 on average)

Source: World Bank (2013a).

Senegal's use of modern cooking fuels is above average for the sub-Saharan Africa region. In particular, as Figure 1.3 shows, between 2000 and 2005 there was an approximate 40 per

cent increase in total consumption, from 100,000 tonnes (or metric tons) to almost 140,000 tonnes.

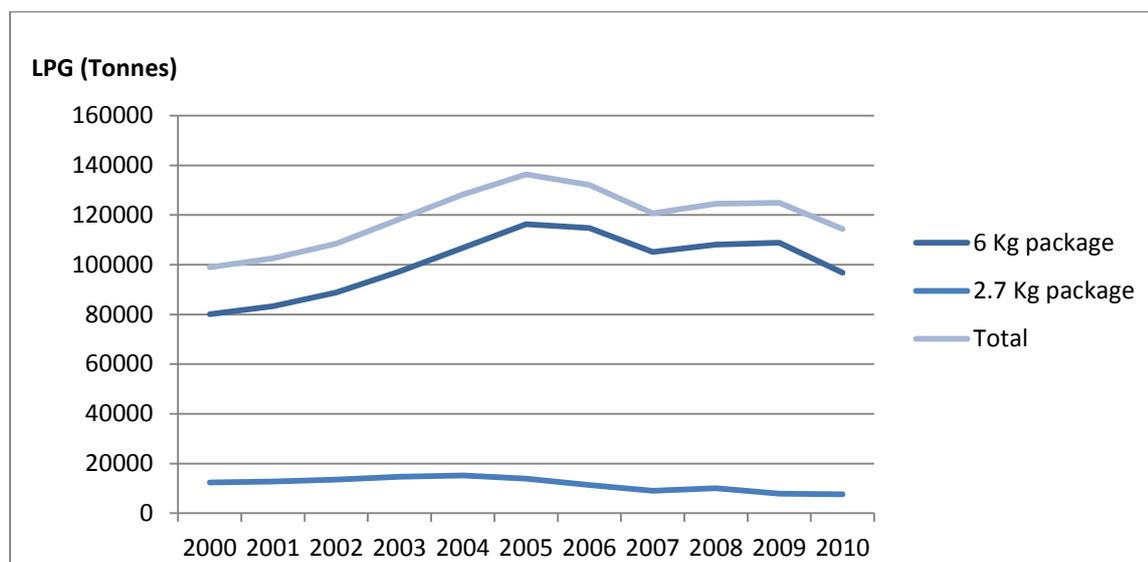


Figure 1.3 LPG consumption in Senegal, 2000–10

Source: Commission Nationale des Hydrocarbures.

However, Senegal’s progress has reverted in recent years, following the phasing out of the LPG subsidy in 2009 as well as an energy crisis from 2007 to 2010, during which the country also experienced stock shortages resulting from supply problems. National LPG consumption fell from 33 per cent in 2002 to 28 per cent in 2011 at the same time as charcoal consumption increased from 5 per cent to 11 per cent (see Figure 1.4).⁴

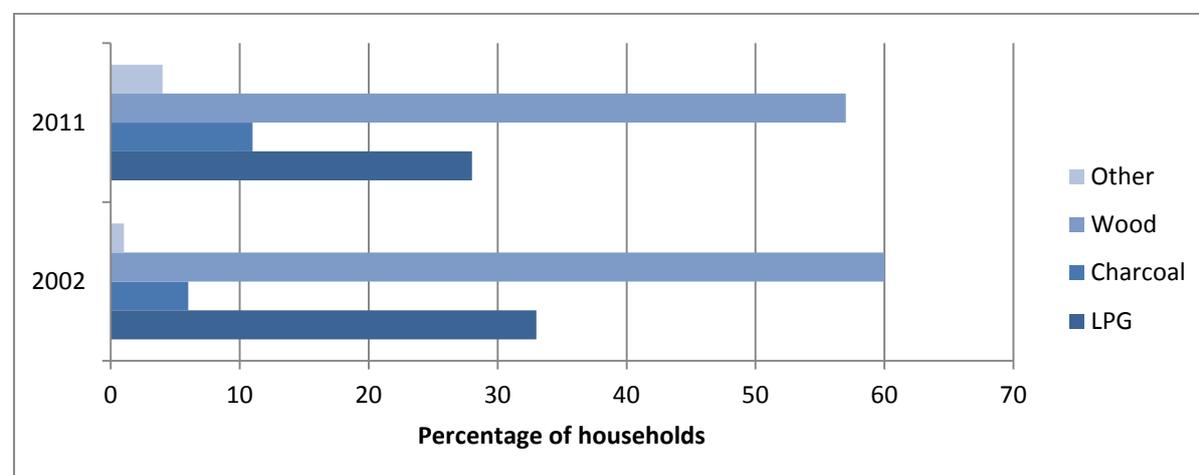


Figure 1.4 Senegal household fuel mix in 2002 and 2011

Source: World Bank 2013a.

⁴ It is important to note that a large percentage of the households analysed as part of this study were charcoal users. Although this is not necessarily indicative of the country as a whole, they are believed to be the household type most likely to switch to using alternative cooking fuels, due to the fact that they currently pay for their fuel rather collect it for free. In addition, as this study shows, most households cook with a range of fuels, making the picture of one-dimensional fuel consumption somewhat reductive.

This dependence on solid fuels has dramatic consequences on the health of both rural and urban populations (see Figure 1.5). However, health is not the only issue. The time spent collecting firewood is significant, at an average of 3.1 hours per day (World Bank 2013a), as well as education and gender issues. Affordability is another important issue, with Senegal having one of the highest charcoal prices in Africa (see Figure 1.6).

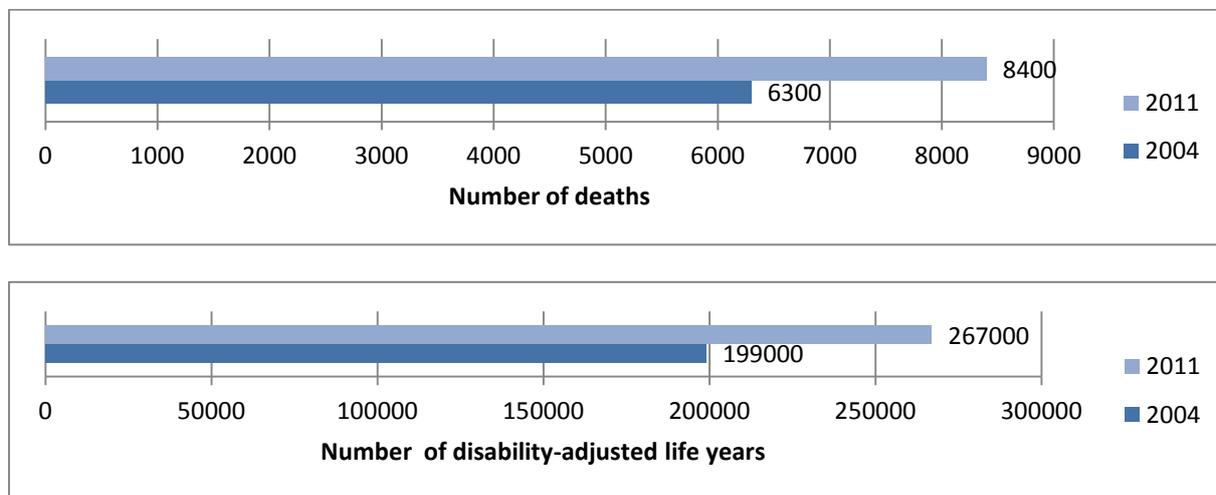


Figure 1.5 Senegal disease burden related to indoor air pollution from solid-fuel cooking

Source: World Bank 2013b.

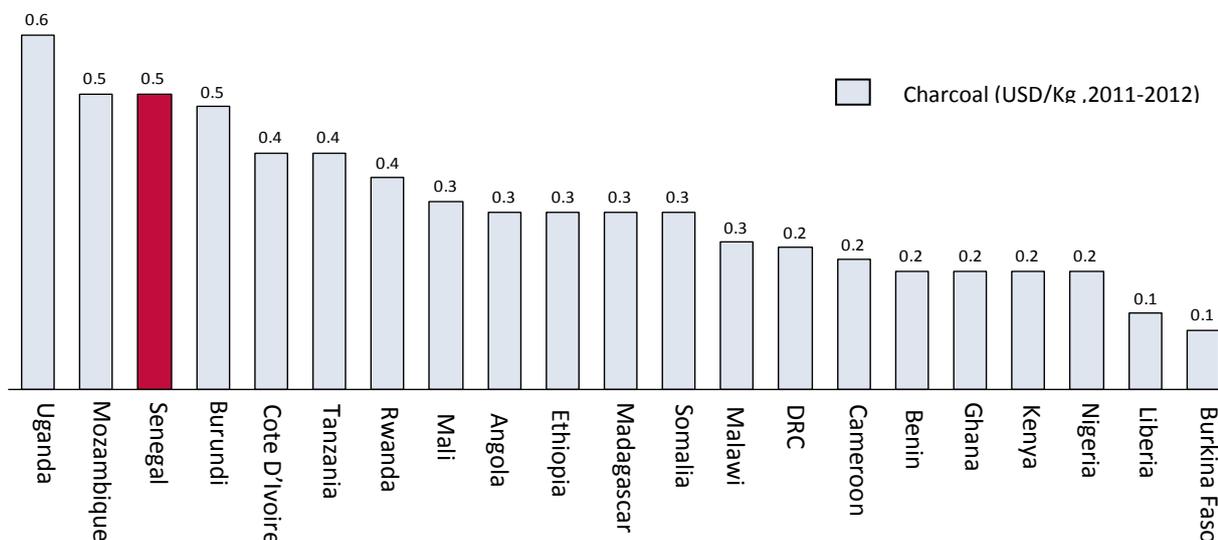


Figure 1.6 Charcoal price in Senegal and in selected African countries

Source: World Bank (2013b).

The significant economic, social, and ecological effects of this dependence on biomass for household cooking, summarised here, explain the need to take action to promote alternative cooking fuels that are more efficient and sustainable:

- 40,000 hectares of forest are lost every year, mainly due to the cutting down of trees for firewood, as well as to forest fires and desertification;
- The price of traditional fuels (in particular firewood and charcoal) has more than doubled in the last 10 years;

- More than 8,000 people die annually from diseases caused by indoor air pollution;
- 45 per cent of Senegal's primary energy demand comes from biomass (31 per cent is directly used as firewood and 14 per cent in charcoal production);
- Exposure to harmful emissions can have a strong negative impact on education and gender, particularly when women and children are predominantly involved in the collection of fuels and cooking.

This report focuses on the current usage of traditional and alternative fuels in Senegal, in an attempt to understand how best to scale-up the adoption of these cleaner and more efficient fuels in the most sustainable and cost-effective manner. Clean cooking fuels and technologies are crucial for improving health and reducing environmental degradation, and this study presents a valuable contribution towards ensuring that Senegal is at the forefront of efforts to scale up the use of clean cooking technologies.

1.2.1 Clean cooking programmes in Senegal and relevant stakeholders

The Senegalese household cooking sector is dominated by a number of stakeholders who lead several major initiatives. Of note is the Ministry of Energy's domestic energy division, which has developed a number of relevant policies. However, there remains a lack of policies focusing specifically on the promotion of alternative fuels through (a) private sector development and (b) targeted subsidies. Evidence has shown that these two factors are significant in enabling sectoral change to take place.

Three main policy documents currently outline household cooking initiatives in Senegal:

- **Lettre de Politique de Développement du Secteur de l'Énergie 2012 (LPDSE 2012).** The objective of this policy is to achieve 50 per cent household access to modern energy services by 2015, as set out within the United Nations Millennium Development Goals (MDG) framework. The letter also sets a 15 per cent target for market penetration of renewable energy sources and biofuels.
- **Lettre de Politique du Sous-Secteur des Combustibles Domestiques 2010 (LPSSCD 2010).** This policy aims at ensuring the long-term supply of household cooking energy for urban and rural households while protecting forest resources and the environment. Specifically, it seeks to managing forest exploitation; promote alternative energies; adapt institutional, regulatory and fiscal frameworks; and circulate good practices. Four strategic lines of intervention were developed to achieve specific, well-defined results such as increasing and regenerating forest areas, fighting illegal wood fuel and charcoal production, increasing fiscal revenues, and building public-private partnerships using specific revenue sources allocated to increasing energy access and fighting poverty.
- **Loi sur les Biocarburants (biofuels law).** Passed in December 2010, this decree defined specific rules regarding biofuel production in such areas as sources, pricing, tax and customs procedures, promotion and packaging. It allows the use of certified seed while forbidding the use of genetically modified seed and food crops for biofuel production.

Senegal's household cooking sector is broadly characterised by a relatively weak and informal private sector network, and by initiatives led mostly by the government and funded by international institutions. The following are the main institutions involved:

- The World Bank's **Sustainable and Participatory Energy Management Project (PROGEDE)** is an improved-cookstove programme implemented by the Senegalese

government (first phase 1999–2008) with funding from the International Development Association (World Bank), the Netherlands' Directorate-General for International Cooperation and the Global Environment Fund. Its second phase (2010–2016) is being funded by the World Bank and the Nordic Development Fund. PROGEDE seeks to modernise the household cooking fuels and cookstove markets through the differentiation of a range of fuels, improvement of the supply chains and support for appropriate energy regulations. The target of the second phase is the dissemination of 420,000 improved biomass stoves throughout the country.

- **PERACOD**,⁵ a programme for the promotion of sustainable energy, rural electrification and sustainable supply of household fuels, is funded by BMZ and led by GIZ under the supervision of the Senegalese Ministry of Energy. It started in 2004 and is due to end in 2015, and its objective is to contribute to a lasting improvement in access to of rural energy services, with a focus on renewable energy (such as home solar systems) and the development of a sustainable supply of household fuel.
- **The National Agency for Ecovillages (ANEV)**⁶ was created by the Senegalese government in 2008, and includes an active component which promotes improved cookstoves in 20 established 'ecovillages'. This was due to close at the end of 2013.
- **The Centre for Study and Research in Renewable Energy (CERER)**⁷ is a research institute of the University Cheikh Anta Diop of Dakar (UCAD). Established in 1980, the centre's mission is to research and develop renewable energy technologies which enhance the nation's energy independence, economy and environment, and to educate students, practitioners, and the public about the results. The main areas of research include bioenergy fuels. CERER has recently been selected by the Global Alliance for Clean Cookstoves (GACC) as a regional testing centre for household cooking technologies; it also provides capacity building and carries out the testing of laboratory equipment.
- **The National Domestic Biogas Programme** (Programme National de Biogaz Domestique de Senegal; PNB-SN) is a national umbrella organization for local NGOs working on biogas, and is managed by the Senegalese government. It is currently offering a subsidy and loan system for household biogas systems.

A number of other global and regional initiatives are also being implemented. They include:

- **The Global Alliance for Clean Cookstoves (GACC)** is an international organisation working on increasing access to improved cookstoves and clean fuels in developing countries. Currently working in West Africa, including Senegal, the Alliance is leading the establishment of international standards for cookstove quality and performance and is providing capacity building for regional testing laboratories, including CERER.
- The **ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)** is currently leading the development of the regional **West African Clean Cooking Alliance (WACCA) initiative**, which aims to provide access to efficient, sustainable and affordable cooking energy throughout the entire ECOWAS region, including Senegal. Its main objectives are to promote the policies and regulatory framework

⁵ Promotion de l'Electrification Rurale et de l'Approvisionnement Durable en Combustibles Domestiques.

⁶ Agence Nationale des EcoVillages.

⁷ Centre d'Etudes et de Recherches sur les Energies Renouvelables.

relevant to clean cooking initiatives in the ECOWAS region; to enhance capacity and support and harmonise standards and labelling practices; and promote networking and knowledge sharing in terms of technologies and innovations within the region.

- At the national level, WACCA will assist in mapping existing initiatives on fuel and cooking equipment, and in updating national strategies for cooking energy. By identifying solutions and bottlenecks, this initiative will facilitate the local production of equipment and fuels as well as markets for both. Key elements of the initiative will be the establishment of financing mechanisms and the implementation of awareness campaigns. WACCA is implemented jointly with several technical partners, including ETC-ENERGIA,⁸ GACC, the Austrian Energy Agency, GERES,⁹ GIZ, and the International Centre for Energy, Environment and Development (ICEED).

⁸ The International Network on Gender and Sustainable Energy, hosted by the Dutch ETC Foundation.

⁹ *Groupe Energies Renouvelables, Environnement et Solidarités.*



2. Approaches and methodology

Following an initial review of existing literature on the household cooking sector in Senegal, the study team held discussions with a range of relevant organisations and reviewed the status of the main alternative fuels available – especially biogas, briquettes, ethanol and pure plant oil (PPO). From this baseline it was then possible to define which regions to select for fieldwork.

The study approach and methodology were then refined and finalised, in particular the development of the survey instruments and the sample selection and design, including the pre-testing and revision of the data collection tools. These included both household surveys from the demand side and key informant interviews and focus group discussions from the supply side. This chapter provides a detailed outline of the methodology and the tools used for this baseline and feasibility study.

2.1 Alternative fuel region selection and design

The survey was conducted in four representative regions, one region for each of the four alternative fuels chosen. Although other regions also have potential for the production and purchase of these alternative fuels, resource constraints restricted the study to one region per fuel.

The regions were chosen using the following criteria:

- The availability of feedstocks for each alternative fuel type;
- The status of the alternative fuel sector in each region, including any existing supported programmes;
- The availability of relevant technologies for the processing and distribution of each alternative fuel;
- The status of private sector involvement in the production and distribution of each alternative fuel;
- The potential market size for each alternative fuel, based on the prices of each fuel and stove technology and the number of purchasing households; and
- The socio-cultural acceptability of each fuel and the potential for scale-up.

After initial discussions with a range of stakeholders, it was decided to focus on the following main alternative fuel types, one in each of the four regions studied:

- *Briquettes*. Briquettes are already being produced in both Kaolack and Saint-Louis, and both of these regions were investigated. Household surveys were conducted in Dakar to investigate the potential of briquette use, mainly as a replacement for charcoal. The potential for briquette production depends mainly on (a) the availability of suitable potential feedstock, (b) the availability and production of technologies and (c) the efficiency of distribution and retail networks. In Saint-Louis, the main briquetting resources available are charcoal dust, the typha plant, and *balle de riz* (residue from rice processing); in Kaolack and Diourbel the main resource is the peanut shell (these are the main peanut producing regions of the *bassin arachidier*, or groundnut basin).
- *Ethanol*. Because ethanol is currently produced in only one location in Senegal – namely, the urban area of Richard Toll in the Saint-Louis region – household questionnaires and focus group discussions (FGDs) were conducted in that region. (Household questionnaires were also completed in Dakar to understand the potential

demand for ethanol in the capital.) In addition, key informant interviews were carried out in Saint-Louis, to gather information about production from sugar cane and other feedstocks, such as cashew nut fruit in the area of Casamance.

- *Biogas*: Biogas is currently being produced in several regions of Senegal, including Thiès, Kaolack, Fatick, Kaffrine and Louga, where a number of companies manufacture and install systems and several organisations support its uptake. After an assessment of the market potential (suitable farming households with enough animals, market development of biogas in each region, maturity of its current production), it was decided to conduct household surveys, FGDs and key informant interviews in Kaolack.
- *Pure plant oil*: PPO is produced in several regions of Senegal. Although still at quite an early stage of development, PPO production is believed to be most advanced in Tambacounda. Household questionnaires, FGDs and key informant interviews were thus carried out in this region.

2.2 Survey tools

2.2.1 The household questionnaire

The study team developed a comprehensive household questionnaire designed to elicit information on a range of relevant issues for each household, including socio-economic characteristics, current energy usage, and likely ability to take up a range of alternative fuels.

The *socio-economic characteristics* are those related to cooking habits or able to influence, either directly or indirectly, cooking conditions. These include the identification of the respondent and their location; their household demographics; their education, including literacy and education enrolment; their household characteristics, including construction material, number of rooms and layout of the cooking area; their employment and occupation; their income, consumption and expenditure; their ownership of assets (including land, livestock); their access to basic services (specifically health, water and education); their ownership of indicative appliances, such as radios, televisions and mobile phones; their membership of formal and informal associations and networks (such as saving and credit cooperatives and microfinance institutions); and the dynamics of their purchasing decisions.

The *cooking energy characteristics* include the household's energy use, expenditure, use and ownership of cooking appliances; cooking fuel acquisition (including type of cooking fuels, consumption level and expenditure); mode of acquiring cooking fuels (purchased or collected); household members responsible for cooking fuel acquisition and family meal preparation; time and distance travelled to collect or purchase cooking fuels; time spent cooking each day; major types of foods cooked; satisfaction level with and limitations of current cooking fuels and cookstoves; problems associated with existing cooking fuels and stoves (indoor air pollution, fire hazards, etc.); the prevalence of respiratory or health issues related to household cooking; their awareness of alternative fuels and clean cookstoves; their anticipated attributes of clean cooking solutions by households (in particular alternative fuels and clean cookstoves); and their willingness and ability to pay for clean cooking solutions.

The team chose 320 households and divided them into rural and urban households, depending on the type of alternative fuel and the region, as highlighted in Table 2.1. Sampling was carried out using a two-stage 'cluster sampling' approach, where clusters (villages or enumeration units) were selected during the first stage, and households were

randomly selected in the second stage. In each of the four regions, 80 households were assessed, in both urban and rural areas.

Region	Urban households	Rural households	Peri-urban households	Total	Reasoning
Saint-Louis	60	20	0	80	Saint-Louis is one of Senegal's main cities, and both ethanol and briquettes are produced here. Although there are many rural households in Saint-Louis, the main users of ethanol are likely to be in urban areas.
Kaolack	20	60	0	80	Kaolack is one of the main regions where biogas has been introduced. It has great potential here; a number of companies are already installing biogas systems. (Kaolack is also believed to have great potential for biomass briquettes, which are also produced here.)
Tambacounda	40	40	0	80	Although several PPO crops (in particular <i>Jatropha</i>) have been planted in many regions of Senegal, the production of the oil possibly most suitable for household cooking is believed to be most advanced in Tambacounda, where PROGEDE have been working.
Dakar	40	0	40	80	None of the alternative fuels are produced in Dakar, nor are they likely to be produced here at a significant level in the future. Dakar is likely to be one of the most important demand centres for briquettes, ethanol and PPO in the future; household surveys were thus completed here, mainly in the urban and peri-urban areas.

Table 2.1 Distribution of households and methodology for selection

The questionnaire took an average of one hour to complete, with four enumerators working in each region (Figure 2.1) to complete an average of seven questionnaires per day. The enumerators were trained to ensure they understood the questions and completed each questionnaire within the allocated time.

2.2.2 Focus group discussions

The study team also held focus group discussions to gain more qualitative information about groups of households. The discussions, each of which involved between 10 and 15 individuals, were conducted in each of the four study regions.

2.2.3 Key informant interviews

Finally, the team interviewed informants to gather information about the supply side for each of the main alternative fuels. Informants included manufacturers of alternative-fuel cookstoves (such as those that burn briquettes), fuel distributors and retailers, potential alternative-fuel producers (sugar estates, sugarcane growers, plant oil growers and agricultural cooperatives), and other key stakeholders such as bi- and multilateral organisations and government institutions.

In total, 30 interviews took place, with an average of 7–8 interviews for each of the four alternative fuels (biogas, briquettes, ethanol and PPO). Table 2.2 lists some of the relevant organizations working in the regions where the use of each alternative fuel is significant.

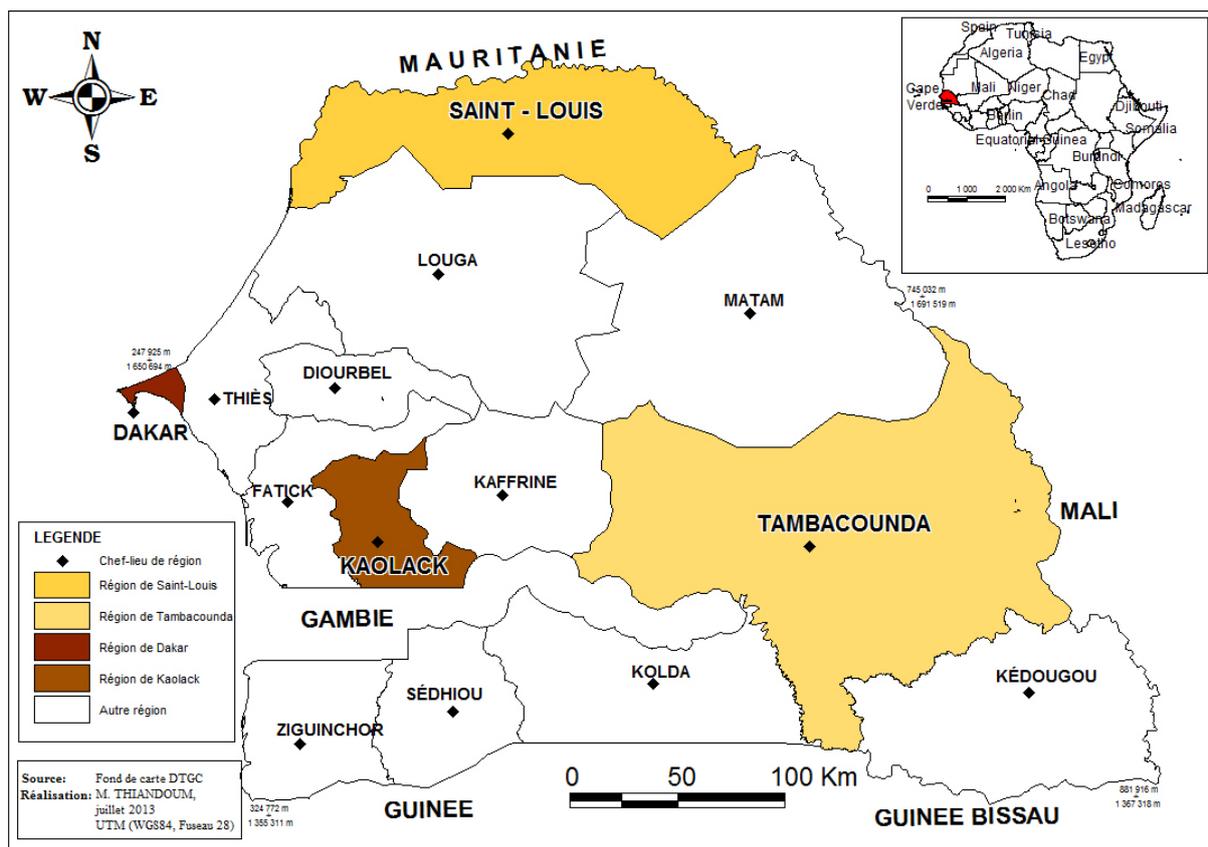


Figure 2.1 Map of Senegal highlighting the four regions of this study

Organization	Relevance	Region
ABS Group	biogas	Dakar
ANSD	regional agencies	Dakar, Tambacounda, Kaolack, St Louis
BAMTARE	sesame and <i>Tournesol</i> plant oil	Tambacounda
BIOECO	biogas	St Louis, Matam
BRADES	briquettes	St Louis
Bio-Terre	briquettes	Diourbel (Ndem)
CERER	research and fuel testing	Dakar
COPEOL/CARBOSEN	briquettes	Kaolack
CSS	Ethanol	St Louis (Richard Toll)
Energy direction	Minister of Energy	Dakar
Entreprise Rassoul	biogas	Tambacounda
ETHEC	biogas	Kaolack
NEO	<i>Jatropha</i> plant oil	Gossas (Fatick)
PERACOD	domestic fuel and rural electrification	Dakar
PROGEDE	domestic fuel, PPO	Dakar, Tambacounda
PNB	biogas	Dakar
SEMIS	domestic fuel/consultant office	Dakar
SODEFITEX	cotton stem briquettes	Tambacounda
SOPREEF	<i>Jatropha</i> plant oil	Fatick (Sokone)
TNS	consultant office	Dakar

Table 2.2 Key informant meetings

2.3 Pre-test and revision of the data collection tools

The survey instruments were then tested in urban and peri-urban areas of Dakar to ensure that (a) respondents could understand them completely; (b) the questions were in the most logical sequence; (c) the interviews were of the appropriate length; and, in particular, (d) the interviews yielded the answers needed for a thorough assessment of each alternative fuel. Some changes were made to the survey, particularly in respect to the clarity of wording and modification of the response options to ensure that the data could be easily recorded and transferred to the database. Certain questions, or parts of questions, were also added or omitted.

2.4 Survey methodology

Next, collaborators in the field from ENDA Energie were hired as local enumerators to complete the household questionnaires in each of the four regions, under ENDA's supervision. ENDA also carried out the focus group discussions and key informant interviews for each fuel type in each of the main regions. Table 2.3 shows the overall survey timeline.

Dates	Region	Activities
10 June	Dakar	Pre-testing of household questionnaire and identification of enumerators
17–21 June	Dakar	The following activities were carried out in each of the four regions: <ul style="list-style-type: none">• Training of four enumerators• 80 household surveys• Two focus group discussions (either in urban, rural or peri-urban areas, depending on the regions and fuels)• Discussions and key informant interviews with stakeholders, relevant local organizations and institutions;• Collection of market data to verify the existence of the different fuels and cooking stoves and their prices
23–28 June	Tambacounda	
29 June – 3 July	Kaolack	
4–8 July	Saint-Louis	
8–14 July	All regions	Data entry and analysis

Table 2.3 Survey timeline (2013)

3. Feasibility of alternative household cooking fuels in Senegal

As discussed in Chapter 2, four regions were selected from preliminary findings that showed a potential correlation of each region with one of four alternative fuels; surveys were conducted accordingly. **Chapters 4-7** present the survey results, with each chapter divided as follows:

- **Introduction.** A brief introduction to the specific fuel in the region.
- **Background.** Information on the demographic, economy and geography of the region.
- **Household cooking.** A description of the current household cooking characteristics (including fuels and stoves used in urban and rural areas) of each region.
- **Potential demand for the alternative fuel.** Identification of the main problems in the current domestic energy context, and thus of the gaps the alternative fuels may be able to fill. This is broken down into three sections:
 - **Perceptions of current stoves and fuels.** An understanding of what households consider as the main problems with their current fuels and stoves, thereby giving direction on what criteria alternative fuels should cover;
 - **Drivers for acquiring new fuels and stoves.** Reasons given by the surveyed households for adopting a new alternative fuel;
 - **Willingness to pay for new fuels and stoves.** To assess whether the fuels will be able to penetrate the market, it is critical to understand households' willingness to pay for the new fuel. This section also includes findings from current expenditures and access to finance;
- **The supply side.** Assesses the supply side, including the current contextual situation and supply chains;
- **Conclusions and recommendations.** Assesses the feasibility of each alternative fuel in the region with specific recommendations for its deployment. Includes a cost comparison of current fuels/stoves and an analysis of the fuels from the end user perspective, whilst also looking at the supply side where possible.

Finally, **Chapter 8** presents final conclusions and recommendations.



4. Briquetting in urban and peri-urban Dakar

None of the alternative fuels included in this study are produced in Dakar – and, because the city lacks the required primary resources, they are not likely to be at significant scale in the future. Senegal's capital city is nevertheless likely to be one of the most important demand centres for briquettes thanks to its large population and relative wealth.

However, this potentially large latent demand depends on a range of factors, including the city's population growth (estimated by ANSD at 3.4 per cent in 2012) and the changing demand for types of cooking fuel within the city. There has, for example, been a recent reduction in demand for LPG following the elimination of the LPG subsidy and its consequent gradual increase in price, as well as the more frequent interruptions to its supply.

Concomitant with this fall in LPG usage, charcoal usage in Dakar has increased. However, the price of charcoal has also been increasing, mainly due to the introduction and enforcement of forestry fees and the long distances that they need to be transported from where it is produced. This increasing cost of raw materials (wood from trees) may be an important influence on charcoal demand in the near future. This will have a knock-on effect on the acceptance and usage of any alternative fuels that might be introduced in the near term, particularly within a largely unregulated market, which is the current situation for the household cooking sector in Senegal.

4.1 Background

The population of the Dakar metropolitan area grew from 374,700 in 1961 (right after independence in 1960) to 2.77 million in 2005. Estimates are that it is growing at an average rate of over 2 per cent per year, and is likely to have a population of five million by 2025 (see Table 4.1).

Dakar region	Year				
	1976	1988	2002	2009	2010
Resident population	892,127	1,488,941	2,167,793	2,535,169	2,592,191
Rate of population increase (%)	-	4.4	2.7	2.8	2.25

Table 4.1 Growth of the resident population in Dakar region, 1976–2010

Source: ANSD 2010.

Despite recent efforts to slow urbanisation in Senegal through a range of decentralised development opportunities, the Dakar region is now home to 24 per cent of the Senegalese population even though it occupies only 0.28 per cent of its land area (see Figure 4.1). Economically, this region is the dominant centre of the country, containing more than 80 per cent of Senegal's permanently registered employees and more than 90 per cent of employees in the transport, finance, and industry sectors.



Figure 4.1 Map of Dakar, Senegal

Any rapidly growing urban population faces a range of challenges to ensure that the basic needs of its population are met: housing, work, and food, and a range of energy resources, including cooking fuels. According to the Monitoring Unit of the Program to Fight Poverty (Cellule du Suivi du Programme de Lutte Contre la Pauvreté, or CSPLP), part of the Senegalese Ministry of Economy and Finance (Ministère de l’Economie et des Finances; MEF), the Dakar region, with a household poverty rate of 12 per cent, is the least poor of the 14 regions that make up Senegal.¹⁰ While this is in itself not very surprising – the region’s relative wealth is what attracts so many people to it – its large population means that, if the absolute number of poor people is calculated, the Dakar region comes out as second poorest, just beneath the rural regions of Fatick and Louga.

There are also significant income disparities between different parts of the city. For example, in the department of Pikine nearly 24 per cent of households do not have the means to earn CFAF 5,610 per month (required to purchase the minimum daily food intake of 2,400 calories per person), and so have no spare income to pay for clean cooking fuels. An understanding of this range of wealth between different areas of the Dakar region is essential when considering any new programme designed to support alternative cooking fuels.

Furthermore, although approximately 50 per cent of the total monetary income for the whole country is concentrated in Dakar, poor households in the region derive the majority of their income from relatively uncertain and irregular sources: the informal sector (27 per cent), private sector business (24 per cent) and remittances from abroad (12 per cent). This makes life quite precarious, and planning more difficult, particularly when considering the switch to a new, uncertain cooking fuel, or whether to invest in a new cookstove (such as that needed for briquettes). A clear, significant advantage to doing so must be presented first.

¹⁰ CSPLP, “Region de Dakar” (Ministry of Economy and Finance, Senegal: n.d.). This document is the source of the remainder of this section.

4.2 Household cooking

Peri-urban households in the Dakar region rely on three main sources of fuel for cooking: LPG, charcoal and firewood. Many households use a range of these fuels, with different combinations of each depending on income level.

From the mid-1970s until 2009, the Senegalese government encouraged the transition from charcoal to LPG for households through the use of subsidies and promotion campaigns. In 1974, the government began a programme of equipment subsidies to reduce the price of LPG stoves and fuel tanks, followed in 1977 by a subsidy on the gas itself. Small (2.7 kg) subsidised LPG canisters and the stoves needed for its use were made widely available in an attempt to overcome the obstacle of 'lumpy' (large) payments often cited as a major obstacle to poorer urban households wanting to switch to LPG or electricity.

In 2009, the national government, advised by the West African Economic and Monetary Union (WAEMU), decided to phase out subsidies for LPG to align Senegal with the relevant regulations in the rest of the region. It is still the case that LPG is still widely available in peri-urban areas of the country and a well-functioning distribution network is in place. However, the reality for the peri-urban poor in the Dakar region remains bleak in relation to LPG usage. Their relatively low income levels, combined with the progressive withdrawal of the governmental LPG subsidy and an unpredictable supply market, have all had a detrimental effect on their LPG consumption levels. Even though the national demand for LPG is still relatively high, its demand by poor households fell after the subsidy withdrawal.

Although LPG is an appropriate cooking fuel, its price even when subsidised is beyond the reach of the poor in the Dakar region, and a cheaper 'improved' alternative fuel, such as briquettes, may thus be more appropriate. Table 4.2 summarises the main positive and negative issues surrounding LPG usage in the Dakar region.

Positives	Negatives	Typical causes of issues	Good practices	Bad practices
<ul style="list-style-type: none"> • Rapid and efficient • Clean • Economical • Available 	<ul style="list-style-type: none"> • Limited access due to prohibitive cost • Frequent shortage 	<ul style="list-style-type: none"> • Low population income level • Reduction of governmental aid and increase in cost • Price dependent on oil market • Weak warehousing ability • Tardiness in compensating the subsidy • Speculation by local suppliers creates shortages 	<ul style="list-style-type: none"> • Available in different tank sizes: 2.75 kg, 6 kg, 9 kg, 12 kg and 38 kg • Subsidy on small LPG tanks (2.75 kg, 6 kg) to promote access by poor • Locally available • Cooking accessories widely available • Free-market approach gives healthy competition 	<ul style="list-style-type: none"> • Speculation on sale prices • No control mechanism for the governmental subsidy • High government tax on oil-derived products

Table 4.2 Summary Matrix of LPG usage in peri-urban households of Dakar, Senegal

Source: ENDA 2008.

The survey found that LPG is always used by almost 80 per cent of urban households and occasionally by 10 per cent. In peri-urban areas, however, LPG is always used by only 38 per cent of households and occasionally by 23 per cent. Electricity is not used for cooking purposes at all in either urban or peri-urban households, mainly due to its high cost.

The other main fuel of choice for peri-urban households in the Dakar region is charcoal, which is easy to use and widely available. It can also be bought in small quantities, which better matches the purchasing patterns of many poor households. Charcoal is also used as a backup fuel for LPG when there are shortages, or when a household's savings are inadequate for purchasing a new cylinder (see Figure 4.2).

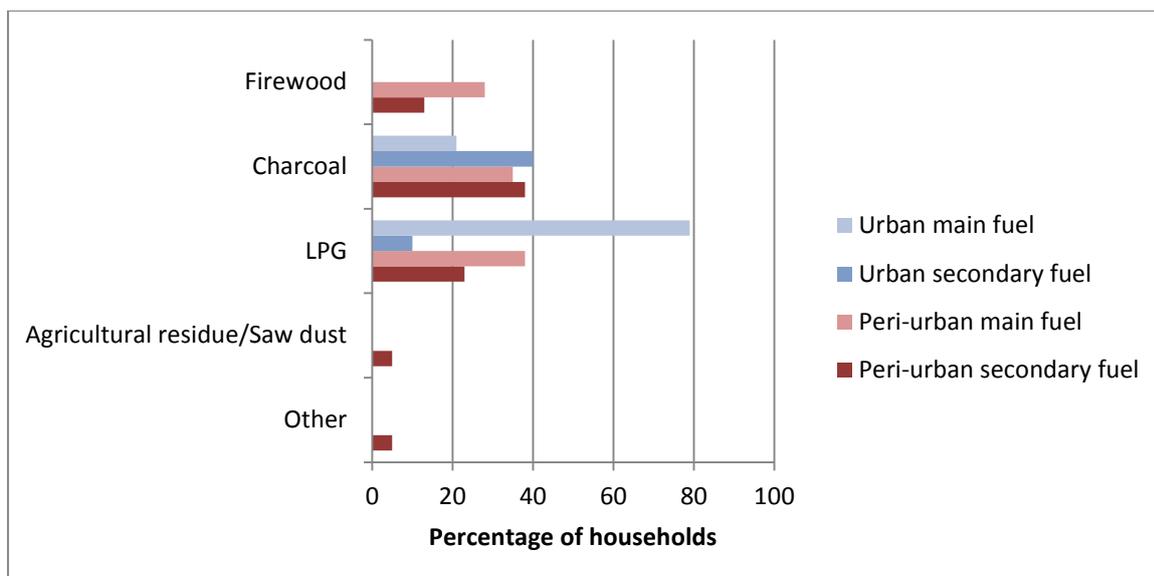


Figure 4.2 Cooking fuels in Dakar.

Note: The total for secondary fuel is less than 100 per cent because not all households use more than one fuel.

Although charcoal is fairly accessible, its price is closely associated with (a) the season and (b) the costs associated with transportation from the production sites, which are often more than 500 km from Dakar in the forested regions of Tambacounda and Kolda. Another significant issue is the liberalisation of the charcoal market, as the national government believes that self-regulation will lead to improved productivity. Charcoal market actors along the supply chain have taken advantage of this lack of government regulation and sell the charcoal at inflated prices in Dakar, claiming that rising oil prices have led to high transportation costs. In addition, inefficiencies and lack of technical expertise in the production of charcoal has resulted in very low productivity. This could be remedied by the government imposing quotas and production licences, but to date it has not done so. Charcoal is still always used by about 20 per cent of urban households in the Dakar region and occasionally by 40 per cent of households. In peri-urban areas this proportion is much higher, with 35 per cent of households always using charcoal (and 38 per cent occasionally using charcoal).

Firewood, the third most popular household cooking fuel in peri-urban households, is mostly used as a backup during shortages of LPG or charcoal. It is also perceived as being more appropriate for cooking traditional meals. However, the use of firewood in the generally small peri-urban households results in the highest emission levels of any of the fuels, causing serious health hazards such as respiratory ailments and eye irritation. In addition, firewood is generally only used with the traditional three-stone stove. This is highly inefficient and results in high long-term costs for the peri-urban households in the Dakar region who use it, and who have to purchase most of their firewood rather than collecting it (as is done in rural areas). It is important to note that the same regulations regarding the collection and transportation of charcoal also apply to firewood, with similar implications for biomass briquette production and distribution.

In urban households in the Dakar region firewood is no longer used on a permanent basis: LPG and charcoal are the main fuels used. In contrast, firewood is always used by 28 per cent of peri-urban households and sometimes used by 13 per cent of peri-urban households. When firewood is collected rather than purchased, in peri-urban areas of Dakar it is mainly

sourced from the household's own farmlands (45 per cent) or from their own homesteads (45 per cent), whereas in urban areas the consumption of firewood is marginal. The average peri-urban household's consumption of firewood is relatively low – an average of just 31 kg per month, of which 13 kg (42 per cent) is collected. This results in an average monthly expenditure on firewood of CFAF 1,389. This fairly low firewood consumption (around 1 kg per day in the peri-urban region of Diakhiratt) can be explained by the fact that it is used as a secondary (together with charcoal or LPG) or tertiary fuel (with both charcoal and LPG). Finally, agricultural residues are used by only 5 per cent of peri-urban households, and not at all by urban households.

In the Dakar region, the use of household cooking fuels in peri-urban and urban areas largely follows the same broad trends, particularly when compared with the disparity between rural and urban areas in other regions of the country. This is important to note when planning programmes to promote alternative fuels in Dakar, as it means that interventions within both urban and peri-urban regions can be developed along the same lines.

Household cooking and gender

Compared with other regions of Senegal, Dakar presents some significant differences regarding the decision-making process associated with household cooking technologies and fuels, in particular concerning the social dynamics within urban areas and the traditional gender-focused division of labour. Although men still have an important role in the decision-making process as it applies to household cooking, women are increasingly involved. For example, the decision regarding stove acquisition is made entirely by women in only 20 per cent of peri-urban households, whereas in 44 per cent of urban households women are responsible for which stove is chosen. In 15 per cent of peri-urban areas and 18 per cent of urban areas it is a shared decision between men and women to a lesser extent; in 20 per cent of peri-urban households (against only 3 per cent in urban households) it is a decision shared equally by all members of the household.

4.3 Potential demand for briquettes

4.3.1 Perceptions of current cooking fuels and stoves

Compared with other regions of Senegal, a lower proportion of households in Dakar said they were dissatisfied with the fuel they use for cooking. This is particularly true in urban Dakar, and is mainly due to the relatively high penetration of LPG (Senegal's preferred cooking fuel¹¹) and charcoal (generally considered to be cleaner and more user-friendly than firewood). Figure 4.3 summarises the main reasons given by households for their dissatisfaction with their cooking fuel.

¹¹ According to a recent report, LPG is perceived as the ideal fuel because it is ready to use, reliable and clean (World Bank 2013b).

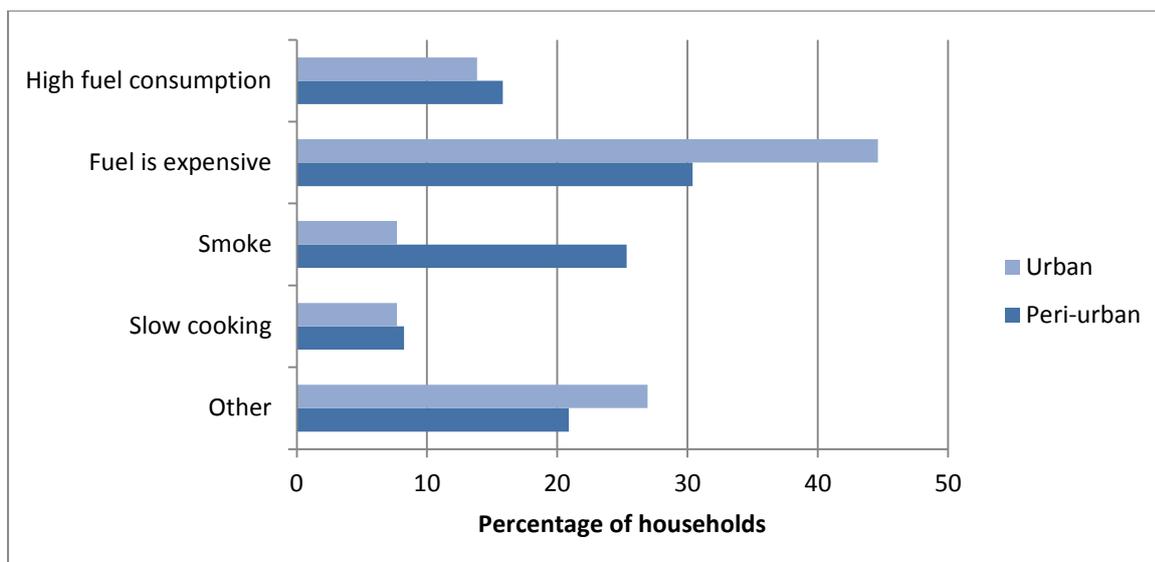


Figure 4.3 Reasons for dissatisfaction with current fuels in the Dakar region

Overall, the followed are the main issues related to household cooking fuel use in the Dakar region:

- Almost half of peri-urban households and urban households in the Dakar region are dissatisfied with their cooking fuel with high prices of the fuel cited as the primary reason.
- Smoke is a more significant problem in peri-urban areas. This can be explained by the relatively high use of LPG in urban areas as well as the differences in kitchens and the location where cooking takes place, which tends to be better in urban areas.
- Cooking time is a minor issue for both urban and peri-urban households;
- In both peri-urban and urban areas, all respondents state that only women are exposed to the health issues of smoke, with eye infections, coughing and respiratory problems being the main health problems (amongst these, 53 per cent and 40 per cent of peri-urban and urban households respectively consider eye infection to be a major issue; 53 per cent and 20 per cent of peri-urban and urban households respectively consider coughing to be a major issue, and 28 per cent and 25 per cent of peri-urban and urban households respectively considering respiratory problems to be a major issues).

From these responses it is clear that most of the problems relate to the use of solid fuels (charcoal and firewood). LPG is the preferred cooking fuel, with the only problems associated with it being ones of cost and accessibility. Although it is important to consider how the use of LPG can be extended within both urban and peri-urban households in the Dakar region, the still relatively high (and growing) use of biomass fuels is important in the context of an analysis of alternative fuel usage. It is unlikely that any of the alternative fuels will be cleaner burning or easier to use than LPG (although they may be as good or almost as good, and can compete on price), but they could constitute a preferred option to charcoal and firewood in both urban and rural areas of the Dakar region. The use of briquettes could replace charcoal and firewood in both urban and peri-urban households and, if used within more efficient stoves, could offer a cleaner burning and cheaper alternative without requiring major behavioural change.

4.3.2 Drivers for purchasing new household cooking stoves

When considering the future promotion of briquettes within the Dakar region, it is important to consider insights and lessons learned from the promotion and penetration of improved biomass cookstoves. At the same time, the usage and performance of briquettes is very similar to that of charcoal and useful links can be made from analysing charcoal markets. The following presents a summary of the main insights into household usage of improved biomass cookstoves in the Dakar region (see also Figure 4.4):

- There is already a relatively high level of awareness of improved cooking fuels in urban and peri-urban areas of the Dakar region, with 95 per cent of peri-urban and 93 per cent of urban households aware of the benefits of improved cookstoves. Almost all households in both areas would like to own an improved stove;
- The desire to reduce household fuel expenditure is by far the main reason (77 per cent in peri-urban and 90 per cent in urban households) that respondents say would encourage them to acquire an improved stove;
- Time saved during fuel collection (14 per cent in peri-urban and 13 per cent in urban households) is the second most important reason;
- Other reasons, including those relating to health issues (smoke, cleanliness) are marginal.

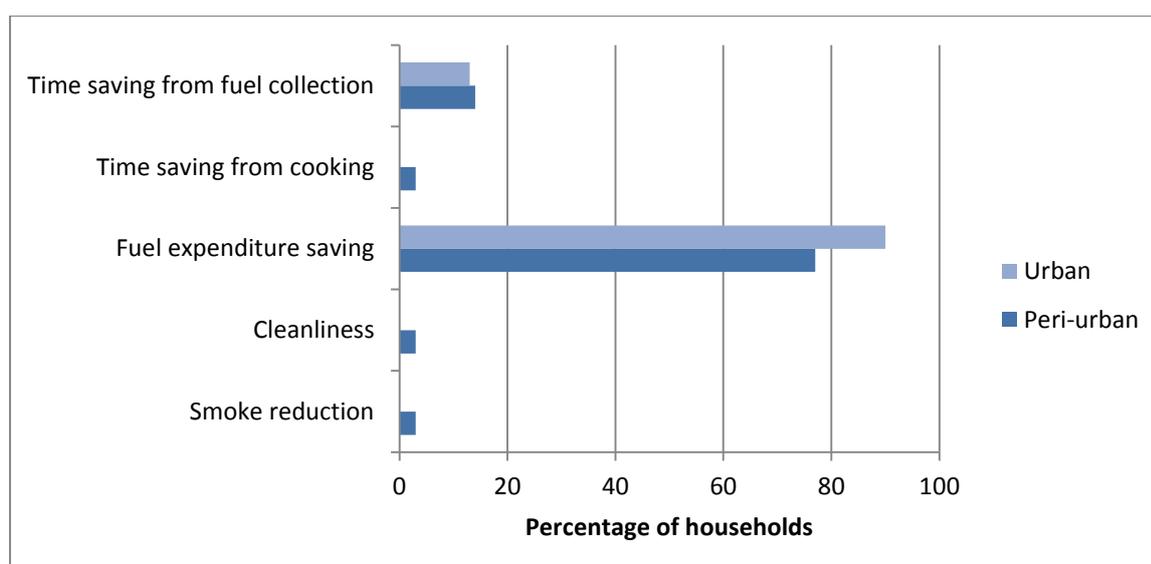


Figure 4.4 Reasons for adoption of improved stoves

These main insights are very important when considering the potential uptake of briquettes within the Dakar region. Briquettes tend to be cheaper than charcoal, while either reducing (or at least not increasing) cooking time. However, despite the potential benefits of, and opportunities for, the use of alternative fuels in the region – particularly briquettes – little awareness of them currently exists:

- Only 25 per cent of peri-urban households were aware of any type of alternative cooking fuel including briquettes.
- Urban households were able to identify a much larger spectrum of cooking fuels, including biogas (55 per cent), briquettes (45 per cent), PPO (45 per cent) and ethanol (27 per cent).

This level of awareness of alternative fuels in the Dakar region, particularly in urban areas, can be used as starting point for a programme on the promotion of alternative fuels in

Senegal, and will be very useful when starting a targeted marketing campaign. It will be important to identify the main information sources accessed by people in each region so that the information on each fuel, particularly briquettes in Dakar, can be distributed.

Once informed of the potential benefits of briquettes, most households in both peri-urban and urban areas declared an interest in accessing them, giving the following specific reasons for choosing to switch to briquette use (see also Figure 4.5):

- Savings to household cooking fuel expenditure is the most important factor given in households in both urban and peri-urban areas (89 per cent and 72 per cent respectively);
- Other reasons, in particular smoke and cleanliness, which are noted as being important problems with their current stoves, are only of marginal importance in terms of any alternative fuels being promoted.

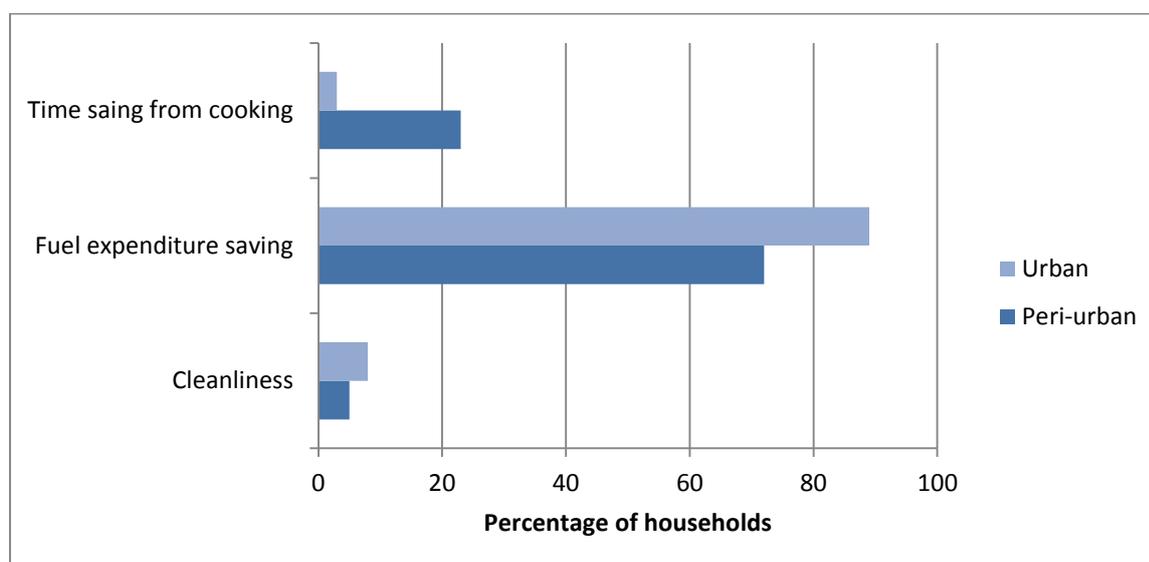


Figure 4.5 Drivers for using alternative fuels in peri-urban and urban areas

Any efforts to raise awareness of alternative fuels, particularly briquettes, should take into consideration the perception of most households regarding fuel price and fuel expenditure. Rather than taking into account the long-term benefits – chiefly improved health and time saved – most households think in terms of day-to-day purchases. It is important that future programmes work to promote the long-term benefits, particularly to households who may not otherwise see past the day-to-day exigencies.

4.3.3. Willingness to pay for new fuels and stoves

The relative importance of household expenditure on energy use (and in particular on household cooking equipment) is a good indicator for understanding the uptake of improved cookstoves and alternative fuels in Senegal and how energy access affects livelihoods. The survey reveals that urban households allocate a higher proportion of their monthly budget to energy than do peri-urban – a monthly allocation of CFAF 17,193 (US\$34) in urban areas, and CFAF 11,940 (US\$24) in peri-urban areas. These figures are even higher when cooking stoves are included (CFAF 19,333 (US\$39) and CFAF 13,572 (US\$27) in urban and peri-urban areas, respectively).

Despite the fact that in urban areas the household energy budget is higher, energy expenditure as a percentage of total expenditure is similar to that in peri-urban areas (10.24 per cent in peri-urban areas and 10.74 per cent in urban areas).

When asked about their willingness to pay for alternative fuels, households generally suggested amounts lower than their current monthly expenditure on energy (see Figure 4.6). This is an issue that needs to be overcome.

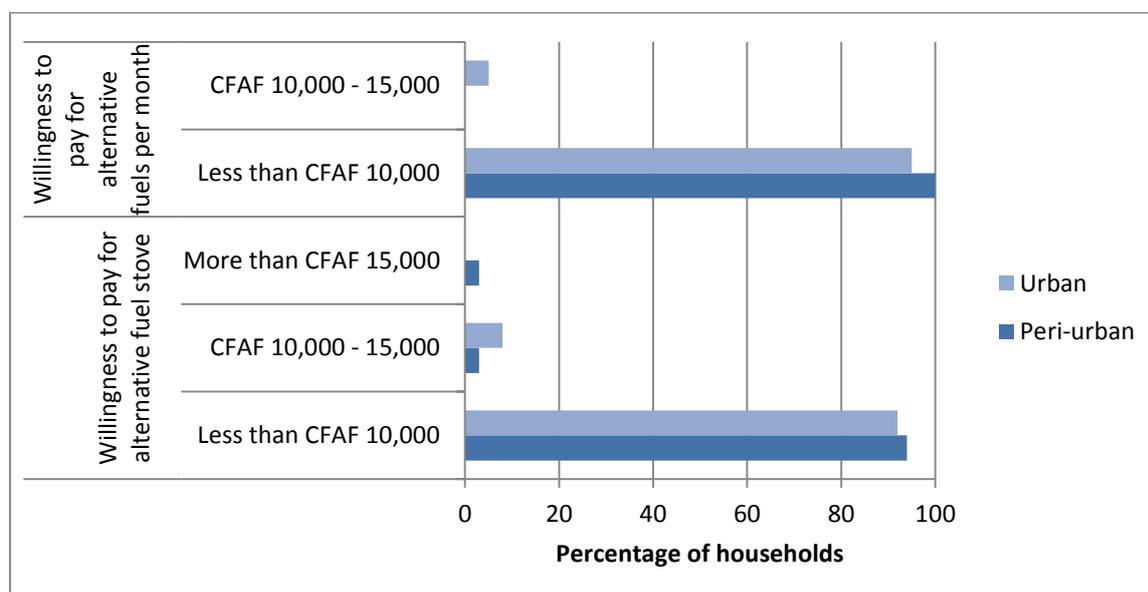


Figure 4.6 Willingness to pay for alternative fuels and stoves in Dakar region

The results indicate that CFAF 10,000 (US\$20) should be regarded as a threshold of a household’s willingness to pay for an alternative fuel stove: all peri-urban households and 95 per cent of urban households say that they are not willing to pay more than CFAF 10,000. The evidence suggests that stoves costing more than CFAF 10,000 (US\$20) will be limited to a niche of higher income households, unless an alternative fuel stove can convince households otherwise, either on its performance or quality. Therefore a programme to support the development of a thriving briquette market in the Dakar region needs to support market actors in producing a stove with a market price below US\$20 – which seems possible based on the price of improved stoves suitable for briquettes currently being produced in Senegal. In addition, the average household monthly expenditure on an alternative fuel, such as briquettes, should also not exceed CFAF 10,000 per month.

Compared to other regions of Senegal, a much higher percentage of households in the Dakar region deal with both formal and informal financial service organisations, both as savers and borrowers. More than half (53 per cent) of urban households have used formal financial institutions to save, with only 3 per cent using informal institutions. In peri-urban areas, however, only 25 per cent have saved with formal financial institutions and 13 per cent with informal institutions (Figure 4.7). The number of households who have used credit from formal sources is slightly lower, but is still about 40 per cent for urban and 25 per cent for peri-urban households. Thirty per cent of urban and 25 per cent of peri-urban households are members of credit and savings cooperatives.

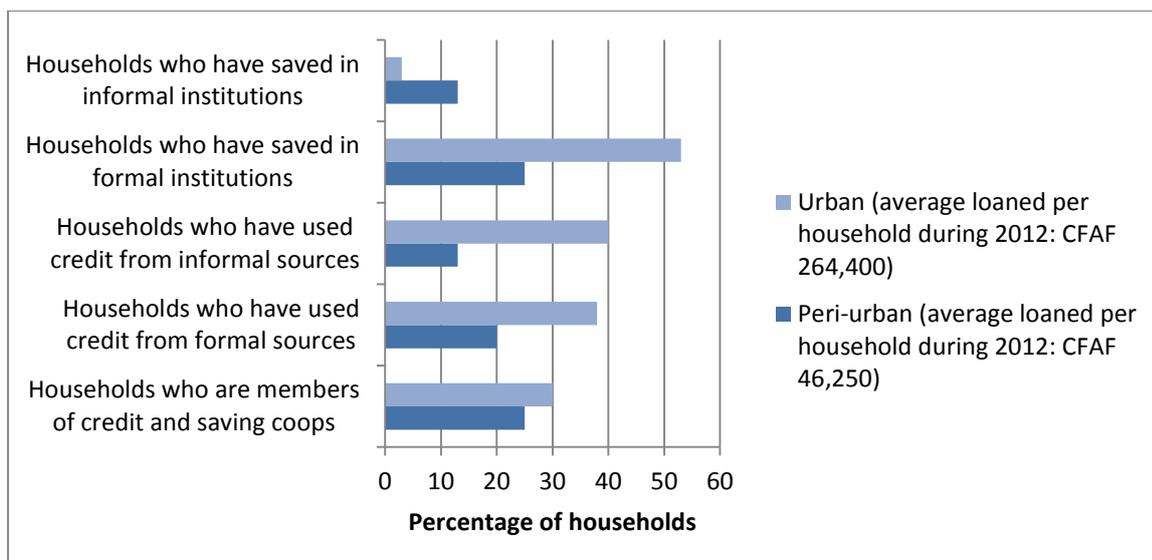


Figure 4.7 Savings and loans using formal and informal institutions in Dakar

This is very important when considering a new alternative fuel programme in the Dakar region because credit is likely to be an important factor in enabling households to purchase improved briquette stoves costing more than US\$20. The Dakar region has relatively well-developed formal and informal savings and loan systems that can be supported in developing specific loan packages for alternative fuel stoves. This will also be important when considering the development of a vibrant supply side for briquette production to support local entrepreneurs who may need loans to set up companies to produce and distribute the briquettes and stoves. (See Section 4.4.)

The demand-side data generally indicates that there is considerable potential demand for alternative fuels, particularly for briquettes from both urban and peri-urban households within the Dakar region.

4.4 Supply side

The briquetting fuel sector in Senegal is still in its infancy, with a relatively limited number of technologies in use by only a couple of producers – in particular BRADES, based in Saint-Louis. Briquette production was also tested by CARBOSEN, based in Kaolack. The availability of potential feedstocks for briquette production is, however, quite large: they can be produced from a range of agricultural and biomass materials, including rice husks, cotton plants, peanut and cashew nut shells and reeds, in addition to the more typical feedstocks of charcoal dust and sawdust. The development of an entire supply chain – from the collection and production of the feedstocks to the production, distribution and retailing of the briquettes – offers important opportunities for job creation and income production.

Although BRADES and Bio-Terre in Ndem, still produce briquettes, several other companies that were involved in the sector until recently have encountered serious problems, resulting in them ceasing production. Of note amongst these are CARBOSEN and Pronatura (see Box 2 and Figure 4.8).

Box 2. Briquettes producers in Senegal

Since its creation in 1992 in Kaolack, **NOVASEN** has focused on sorting and selling groundnuts. In 1999, it started the production of oil and now is the second largest mill in the region after SUNEOR (former SONACOS). In 2013, only the oil production sector of NOVASEN changed its name and is now trading as **COPEOL**.

CARBOSEN was established in 2008 with the objective of deriving value from unused peanut husks. It was a joint venture between NOVASEN, which provided the feedstock, and CARBO, a European company that has mastered the industrial kiln technology. However, despite developing a good reputation for briquette quality, they were not able to produce the briquettes for very long because the equipment was purchased from the Netherlands without technical manuals, and some parts were not adapted for use with peanut shells. (According to key informants, briquette production also started without any feasibility or market study.) However, thanks to CARBOSEN's respected reputation there is still potential for the business to develop in the future

BRADES is a small company based in the town of Saint-Louis. It has been producing biomass briquettes and improved cookstoves since 2007, with support from PERACOD (which is in turn supported by GIZ). BRADES is a family business with six full-time staff and five part-time staff. It produces high-quality briquettes from charcoal dust, although it recently started testing other raw materials including carbonised agricultural residues and reeds, which are abundant in the Saint-Louis region. Although it is currently attempting to mix charcoal dust and *Typha australis*, production costs seem relatively high and may lead to technical constraints. Tests are also being carried out using rice husks.

BRADES produces an average of approximately 12 tonnes of briquettes per month, which are sold in sacks of 1 to 25 kg. Two to three tonnes per month are sold directly from the factory and nine to ten tonnes in local markets in Saint-Louis. The market price is approximately CFAF 150/kg (although this varies between retailers) and CFAF 100/KG when purchased directly from the BRADES factory site, which is far less than the average price for charcoal of CFAF 350/kg.

Eighty per cent of BRADES's market for briquettes is in Saint-Louis, with the remainder in Thiès and, to a lesser extent, Dakar. Even though this is a relatively new market, demand is growing steadily, mainly due to its highly competitive price. BRADES believes there is great potential to increase production, especially as it is now starting to use additional resources, particularly processed reeds and agricultural residues, such as rice stalks and husks. However, the company has several problems to overcome, including transportation and equipment challenges. They currently obtain the charcoal dust from several different locations where it is stored and processed for distribution; it is generally delivered to the factory every couple of days.

In Tambacounda, a small company, **Rassoul**, created in 2011, is considering producing briquettes from charcoal residues. The company has faced technical problems with its machinery, however, and is considering partnership with a private company, **SODEFITEX**, which already has its own briquetting project using cotton stems and has carried out research on briquetting from cotton stems and biofuels from sunflowers over the past four years.



From left to right: the main steps of the supply chain:

- Charcoal dust collection;
- Briquette production using a simple technology press;
- Packaging; and
- Mobile commercialisation using carts in Saint-Louis.

(Source: BRADES)

Figure 4.8 BRADES: main briquetting production steps

Briquettes are not yet sold in Dakar on a commercial scale. According to briquette producers BRADES, COPEOL/CARBOSEN in Saint-Louis, SODETIFEX in Kaolack and Bio-terre in Ndem, the current price for briquettes is respectively CFAF 75 and CFAF 100/kg when sold locally. However, the wholesale price for retailers in other regions, according to producers' estimation, is around CFAF 150/kg. This means that users would have to pay more than CFAF 150 (probably around CFAF 200/kg) to buy briquettes in Dakar. They are thus likely only to be used mostly in urban areas, and by wealthier households in peri-urban areas, predominantly as a replacement for charcoal.

The study identified four main factors resulting in the failure of these briquetting initiatives. These would almost certainly be overcome with support from a well-designed market development programme:

1. lack of household awareness of the products, leading to low demand;
2. lack of consistency in the quality and supply of the briquettes;
3. need for special stoves for briquettes, which are not always available for purchase;
4. briquettes produced from rice husks are not liked. This is due to their relatively low calorific value (compared to charcoal), which results in a much lower cooking speed and excessive production of ash.

A wide variety of feedstock can be used to produce briquettes suitable for cooking, although, as highlighted above, some (such as that obtained from rice husk straw) may not perform as well as charcoal. Table 4.3 summarises the feedstock potential for briquette production from a range of materials, and highlights the large quantities of agricultural residue available in Senegal.

Material	Area (ha)	Potential biomass (MT)	Potential briquette production (MT)
Groundnut shells	770,000	175,000	73,500
Rice husks	-	13,000	-
<i>Typha Australis</i>	6,500	900,000	65,000
Cotton stems	40,000	45,000	18,000
Millet, sorghum and maize stems	1,100,000	4,500,000	1,600,000

Table 4.3 Feedstock potential for charcoal briquettes

Source: PERACOD 2010.

The potential for producing briquettes from groundnut shells is also believed to be great, particularly in the Kaolack region, where groundnuts are produced on a large scale. The supply chain for briquettes produced from groundnut shells involves a limited number of stakeholders with significant financial assets from their income from groundnut production (this is despite the technology required for groundnut briquetting process being more complex than that needed to produce charcoal dust). At the level of production and commercialisation, the main stakeholder used to be CARBOSEN, which recently went out of business (see Box 2 on previous page).

Compared to charcoal, charcoal dust briquettes seem to offer a significantly more affordable option for households. This is of particular relevance, as most households surveyed in the Dakar region cited affordability as the major driver when considering a new cooking fuel.

At BRADES in Saint-Louis region, the wholesale selling price is less than one-third that of charcoal, and still less than half the price when sold in the markets in Saint-Louis. The main challenge is likely to be around the quality of production compared to charcoal, and being able to scale up production to meet the potential demand, as the current supply chain is still fairly informal and only contributes to a very small percentage of household cooking usage. In Saint-Louis, BRADES currently only produces 25 tonnes of briquettes per month, which is far below the needs of the city, let alone the potential demand from the Dakar region. They say that their current production is only around 50 per cent of their capacity, but even if they reach this target it is still fairly low overall, considering the potential market in the urban centres of Saint-Louis and Dakar.

4.5 Conclusions and recommendations

Because of its large population and the relative wealth of its households, Senegal's capital city is likely to be one of the most important demand centres for any alternative fuel commercialised in the country. Many households use a range of fuels (LPG, charcoal and firewood) in different combinations depending on their income level.

Compared with other regions of Senegal, fewer households expressed dissatisfaction with their cooking fuels, particularly in urban Dakar, a result mainly of the relatively high penetration of LPG. Despite its ease of use and low emissions, however, LPG is considered to be a relatively unaffordable fuel for most poor households in urban and peri-urban in Dakar. Charcoal is quite accessible, but its price is closely associated with the season as well as transportation costs.

Although it is important to consider how LPG can be further utilised within both urban and peri-urban households in the Dakar region, the still relatively high, and growing, use of biomass fuels is important in the context of alternative fuels; the use of briquettes could start to replace charcoal and firewood in both urban and peri-urban households of Dakar, and if

used within more efficient stoves, could offer a cleaner burning and cheaper alternative, without requiring major behavioural changes.

Enhancing demand

- Any marketing campaign for briquettes should highlight their potential monetary savings, as this is the main reason households give for shifting to a new cooking fuel;
- As long as a steady supply of the briquettes can be established and the quality of production can be maintained at relatively high levels, the demand for briquettes is likely to grow rapidly once the end users become more aware of their existence.
- To scale up demand for briquettes, it is recommended that a national, urban-focused, awareness-raising campaign be started, initially focusing on the urban centres of Dakar, Saint-Louis and Kaolack. The campaign will target both urban and peri-urban households, highlighting the performance qualities of briquettes as well as the potential long-term benefits in terms of time-saving and health.
- A programme to support the development of a thriving briquette market in the Dakar region needs to support market actors to produce a stove with a market price below CFAF 10,000. This seems feasible based on the price of improved stoves suitable for briquettes currently being produced in Senegal.

Improving production

- The main challenges are likely to be (a) maintaining the quality of production compared to charcoal and (b) scaling up production to meet the potential demand, as the current supply chain is still fairly informal and contributes to only a very small percentage of household cooking usage.
- All potential feedstock resources for briquette production need to be carefully mapped out throughout Senegal, including all agricultural and waste resources, to get an understanding of the potential future production and spatial distribution of the available resources.
- Tests need to be carried out on different potential briquetting feedstock to understand how they compare (from the end users' perspective) to charcoal – especially with respect to quality such as heat of combustion, level of emissions, speed of cooking and ash production.
- Further research is needed on a range of briquetting technologies to ensure that all the available feedstocks can be turned into high-quality briquettes that meet end-users' requirements.
- Building on the success story of BRADES, a range of SMEs in different regions of Senegal should receive capacity building that enables them to set up briquetting production companies. This should include technical support as well as business model development to ensure they can set up sustainable and appropriate briquetting businesses.
- To further support the development of the briquetting sector, the government of Senegal needs to start tackling the unregulated and illegal production of charcoal.

Creating a strong supply chain

- An important opportunity for job creation and income production in Senegal lies either in the development of an entire supply chain or in integration with other supply

chains, such as that for charcoal. This would involve everything from the collection of the feedstocks (such as charcoal dust) to production, distribution and retailing efforts.

- The large-scale transportation of the briquettes from their place of production (in areas of significant agricultural residue and charcoal production) can be based on the current transportation routes used by charcoal. However, because these transportation avenues to Dakar are largely unregulated by the national government, this may lead to over-inflated prices and a lack of supply responding to demand.
- A greater level of regulation of the transportation of all biomass fuels (including charcoal, firewood and briquettes) is needed to increase the transparency of the sector, to try to eliminate the corrupt practices and money flows, and to reduce current market distortions that are pushing up the prices of the biomass fuel sector, mainly in the transportation sector.

Pricing

Briquettes are not yet sold in Dakar at any significant level; in Saint-Louis the price is CFAF 100/kg wholesale and CFAF 150/kg in local markets. In Kaolack, CARBOSEN estimates the sale price of briquettes to be CFAF 75/kg. In Dakar the price will vary, depending on the transport price, but is likely to be between CFAF 150 to 200/kg. Considering the price of charcoal – which is about the same in Dakar as briquettes when purchased in 50 kg bags, but can be much higher when bought in small quantities (around CFAF 250/kg) – retailers are likely to be able to sell briquettes relatively easily once the end users start to understand their benefits.

Figure 4.9 shows the relative prices of a range of household cooking fuels against the calorific value of the fuels. Briquettes are significantly cheaper than most other fuels, and still compare very favourably against the cost of charcoal, used both with traditional and improved cookstoves.

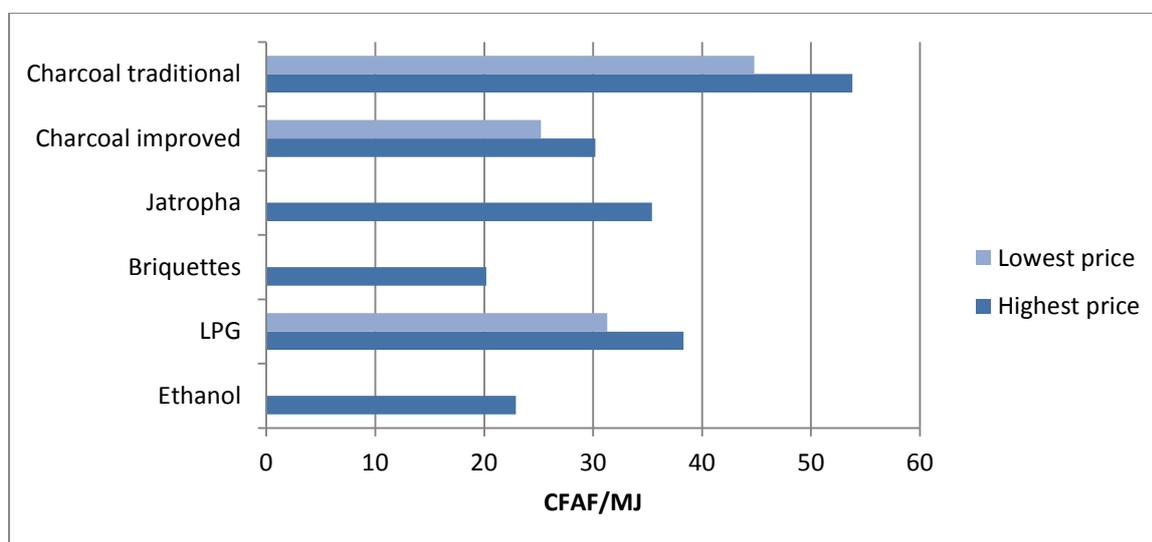


Figure 4.9 Cost comparisons in Dakar (cost per megajoule)

Note: The prices shown for ethanol and Jatropha oil are those in their region of production rather than in Dakar. See Annex A for methodology.

Dakar does offer a good potential market for briquettes, as the price of charcoal is much higher in other urban centres, in particular Saint-Louis and Kaolack. These areas outside the capital are nevertheless likely to be the most likely initial market for briquettes, due to the

potentially higher profit margins for the briquettes in these areas. The market for briquettes in Dakar will develop once these more lucrative markets are served.

The relatively well-developed formal and informal savings and loan systems in Dakar could be supported in developing specific loan packages for producers and distributors of alternative fuel stoves.

Overall conclusions

The market barriers to briquetting in urban and peri-urban Dakar can be overcome by developing a positive enabling environment for briquette production, suitable standards and quality control, tax incentives, and awareness-raising programmes, as well as a range of supporting services including appropriate credit and capacity building support.

If these are addressed, a thriving supply chain of briquette producers, distributors and retailers can be developed to serve the potentially significant demand in Dakar. The producers will need to supply high-quality briquettes that are clean, burn efficiently, and are affordable in relation to the other main fuels (charcoal and firewood) against which they will be competing. The focus group discussions made it clear that briquettes could be perceived as being a 'charcoal-plus' fuel, in the sense that households use them in a similar way to charcoal, whilst being slightly more efficient and cleaner burning, and fairly comparable in price.



5. Ethanol in urban Saint-Louis

Evidence from recent studies in Madagascar and Kenya has shown that ethanol is both a clean burning fuel (it produces very low levels of both carbon monoxide and particulate matter) and a popular alternative among local households (Practical Action Consulting/WB 2011, Practical Action Consulting/UNDP 2011). It generally does not burn at as high a temperature as LPG, but it is easy to use and is significantly cleaner burning than kerosene and biomass fuels.

Although ethanol can be produced from the distillation of a variety of sugar and starch-based crops, in Africa it has traditionally been made from sugar cane molasses, an often underutilised by-product of sugar production. The main region of sugar production in Senegal is around the town of Richard Toll, north of Saint-Louis, where the country's main sugar producer, CSS (Compagnie Sucrière Sénégalaise), is based. CSS's annual production of molasses is estimated at 42,000 tonnes, with an estimated ethanol annual production of 20 million litres per year.

Despite the production of ethanol in the region, there is as yet no market for it as a household cooking fuel. However, in Saint-Louis there is potential for such a market to develop, as highlighted by the recent gradual penetration of briquettes as a substitute for charcoal in the city of Saint-Louis.

5.1 Background

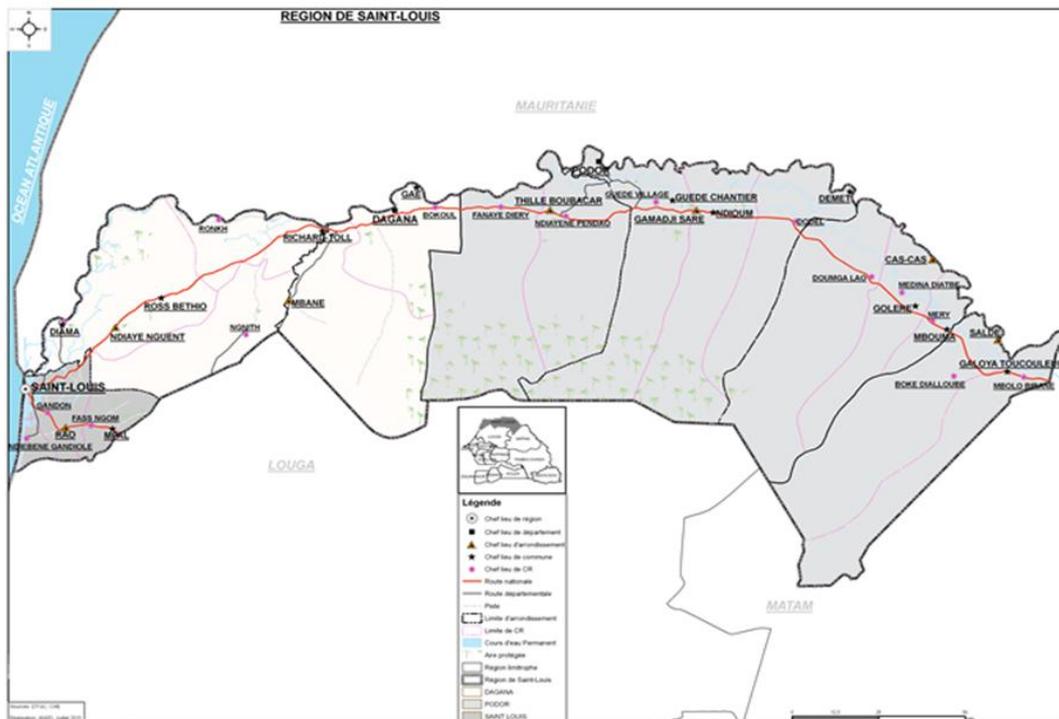


Figure 5.1 Map of the Saint-Louis region

The Saint-Louis region (the main city is also Saint-Louis) is located in the northern part of Senegal (Figure 5.1). It covers an area of 19,034 km² and has an estimated population of over 900,000 (ANSD 2010). It is divided into three departments and seven districts, nineteen municipalities and eighteen rural communities. This is a strategic region of Senegal because of its location, its economic importance and its local resources: the Senegal River and its

tributaries, Lake Guiers, the Diama dam, and the two largest agro-industrial units in the country.

Saint-Louis has a long tradition in both fisheries and livestock, with its extensive pastoral and forested areas and its community of fisherfolk whose experience and expertise is known beyond the borders of Senegal. The history and culture of Saint-Louis make it an attraction for tourists. In terms of timber and forest resources, major initiatives are being undertaken to address the serious threat of desert encroachment.

5.2 Household cooking

The experience of other sub-Saharan countries, such as Kenya, Mozambique and Ethiopia, has proved ethanol as a cooking fuel to be better suited to urban than rural populations. There are a number of reasons for this, such as households' ability to pay, the pre-existence of supply networks, and the fact the method of using ethanol is similar to that of other modern fuels such as LPG, which is used more by urban than rural households. However, the survey was designed to assess the potential for ethanol use among both urban and rural populations, resulting in the following main findings (see also Figure 5.2):

- In rural Saint-Louis, the energy consumption pattern is typical of that of rural Senegal, with most households using firewood as their main source of fuel (89 per cent) and charcoal as a secondary fuel. It would clearly be difficult to shift those rural households to a modern fuel such as ethanol.
- Nevertheless, in urban areas LPG is the main fuel for over 60 per cent of households, followed by charcoal and firewood. However, most urban households also use charcoal as a secondary fuel to cook their meals.
- Of particular note is that briquettes are currently being used by 5 per cent of urban households, mainly because of (a) the establishment of the small briquette manufacturing company BRADES, and (b) the active promotion of briquettes, particularly under the GIZ-supported PERACOD programme.
- In terms of firewood stoves, open, three-stone fires predominate, particularly in rural areas, and to a much lesser extent in urban areas, where firewood is often used as tertiary fuel. Traditional enclosed stoves are used by about 10 per cent of rural households; only 5 per cent use improved firewood stoves.
- In terms of charcoal stove usage, the proportion of charcoal users equipped with simple charcoal stoves is almost the same across the region, with 74 per cent in rural areas and 75 per cent in urban areas. However in urban areas, 16 per cent of households are equipped with improved charcoal stoves, whilst none are using such stoves in rural areas.
- Women collect all the firewood in 87 per cent of households in rural areas; in the remaining 13 per cent the task is shared between women and men. The average distance travelled to collect firewood in rural areas is 2.3 km.
- In both urban and rural areas, cooking is done predominately by women, with the permanent support of female children (32 per cent in rural areas and 52 per cent in urban areas).
- Only 16 per cent of rural households cook outdoors in an open space, against 20 per cent of urban households. This indicates that indoor air pollution is likely to be an

acute problem in both rural and urban areas, although to a slightly lesser extent in urban areas.

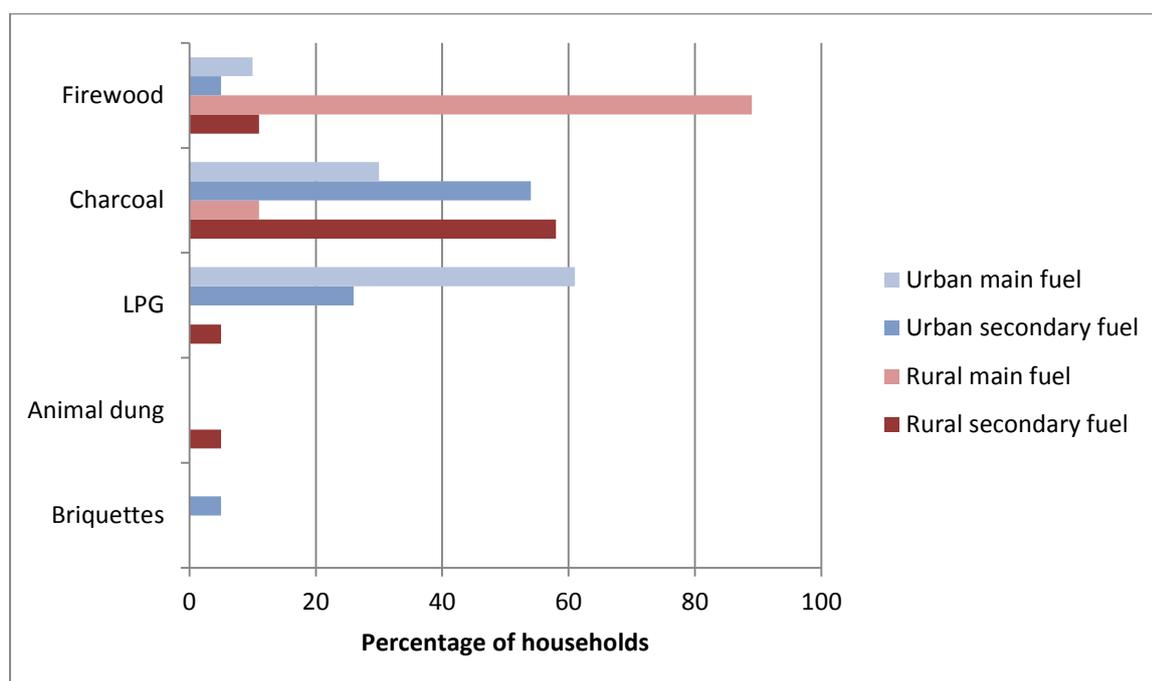


Figure 5.2 Cooking fuels in Saint-Louis

These findings indicate that there are three main segments of domestic cooking in Saint-Louis: rural households using firewood, urban households using LPG and urban household using charcoal. A programme to establish a new market for ethanol fuel will have most success if it targets charcoal users who use LPG as a secondary fuel and LPG users who will prefer a cheaper clean fuel, as these are households who are already purchasing fuels but would be interested in a high-performance fuel if it can compete on price.

5.3 Potential demand for alternative fuels

Because ethanol is not currently produced or sold as a household cooking fuel in Senegal, it is impossible to assess its demand. However, based on our understanding of the demand for other alternative fuels in Senegal, coupled with insights gained from the household survey, it is possible to certain conclusions regarding its potential penetration into the cooking sector in the region.

5.3.1 Perceptions of current stoves and cooking fuels

Most of the households surveyed (67 per cent in urban areas and 84 per cent in rural areas) are currently not satisfied with their cooking fuel: smoke is considered to be the main issue in rural areas, whilst the high cost of fuel is the main issue in urban areas (see Figure 5.3). Long cooking times is another significant issue for both rural and urban households. They can be related to the fact most of them use inefficient stoves, but also to the type of food they cook, such as the Senegalese national dish *thiebou-diène* (rice and fish), which requires a long cooking time.

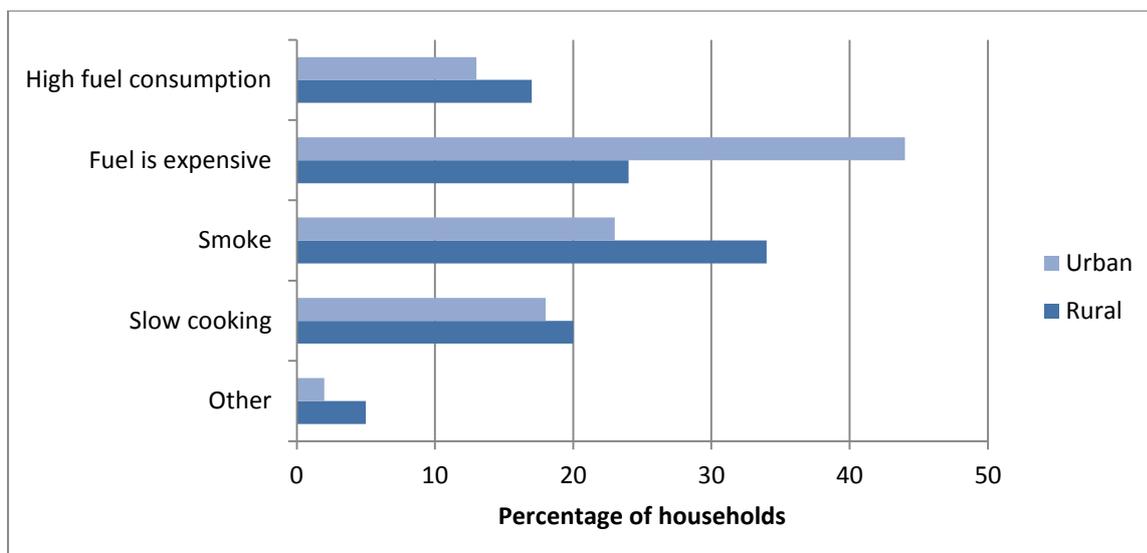


Figure 5.3 Reasons for dissatisfaction with current fuels in Saint-Louis

5.3.2 Drivers for purchasing new household cookstoves

With regard to alternative cooking fuels in rural and urban areas households, 68 per cent and 70 per cent, respectively, have heard of alternative cooking fuels. Briquettes are by far the best known alternative cooking fuel among rural households, most likely as a result of the manufacturing facilities for briquettes in this region coupled with a promotion campaign for fuel substitution which includes competitive prices for briquettes. There is little knowledge of other fuels apart from biogas, which is known by a small minority (16 per cent of rural and 36 per cent of urban households).

Rural households are not familiar with ethanol, and only 7 per cent of urban households have heard of the possibility of using ethanol as cooking fuel. However, 16 per cent of the surveyed urban households, on hearing of its relative cleanliness and ease of use, declared they would like to use it. This finding provides a clear indication that any ethanol initiative in the region would require an intense awareness and marketing campaign. A good indication of what such a campaign should emphasise is suggested by the fact that, according to this survey, the reasons for switching to alternative fuels, including ethanol, are mainly fuel expenditure savings (74 per cent and 53 per cent in rural and urban areas, respectively) and, to a lesser extent, time saving for cooking and fuel collection (Figure 5.4).

This in turn shows that, to penetrate both urban and rural areas in Saint-Louis, ethanol must be priced to be economically competitive with current fuels. More broadly, for ethanol as a household cooking fuel to be successful in Senegal, it must perform well in terms of cooking speed, cleanliness and lack of emissions, as well as overall ease of use.

5.3.3. Willingness to pay for new fuels and stoves

To assess whether ethanol could penetrate the Saint-Louis market, it is critical to understand people's willingness to pay for the new fuel compared with their current expenditure.

In Saint-Louis, rural households consume an average of 98 kg of firewood each month. Monthly expenditure, however, is only CFAF 5,278, as approximately 25 per cent of firewood is collected. In urban areas, the picture is very different; although average monthly consumption of firewood is just 10 kg (around one-tenth that of rural areas), expenditure is CFAF 1,262. Urban households relying on LPG expect to spend CFAF 16,000 per month in fuel.

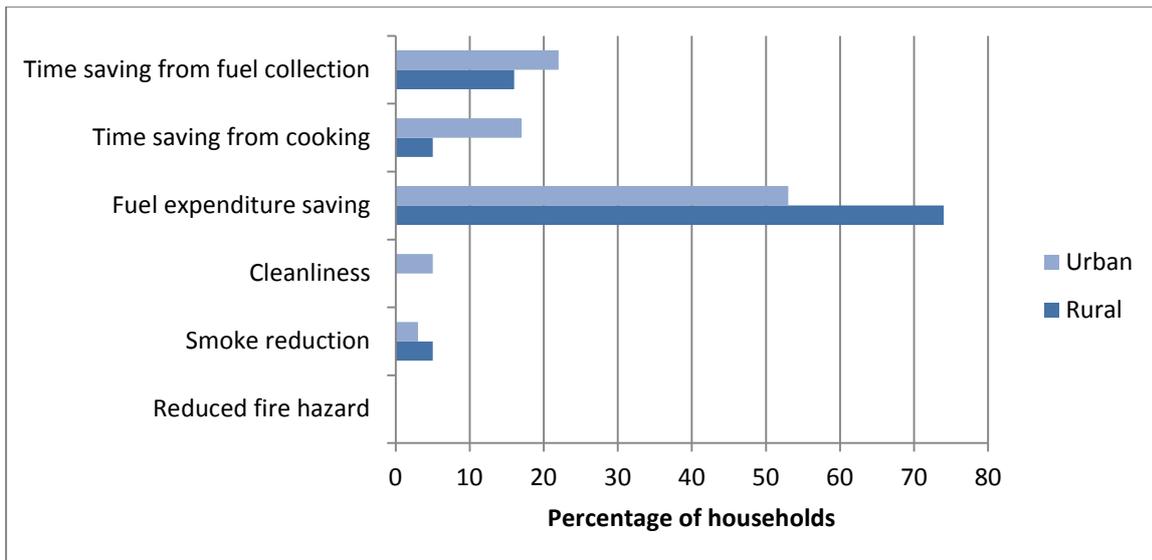


Figure 5.4 Drivers for using alternative fuels in rural and urban areas.

From the survey it emerged that almost two-thirds of urban households (72 per cent) and almost 85 per cent of rural would not pay more than CFAF 10,000 for an ethanol stove (see Figure 5.5). By including the focus group discussion in the survey results, ethanol appears affordable only to the urban population, as they would be able to pay more in monthly fuel purchases than rural population (CFAF 7,000–10,000 as opposed to CFAF 5,000–7000), and would be more willing to pay over CFAF 10,000 for a stove.

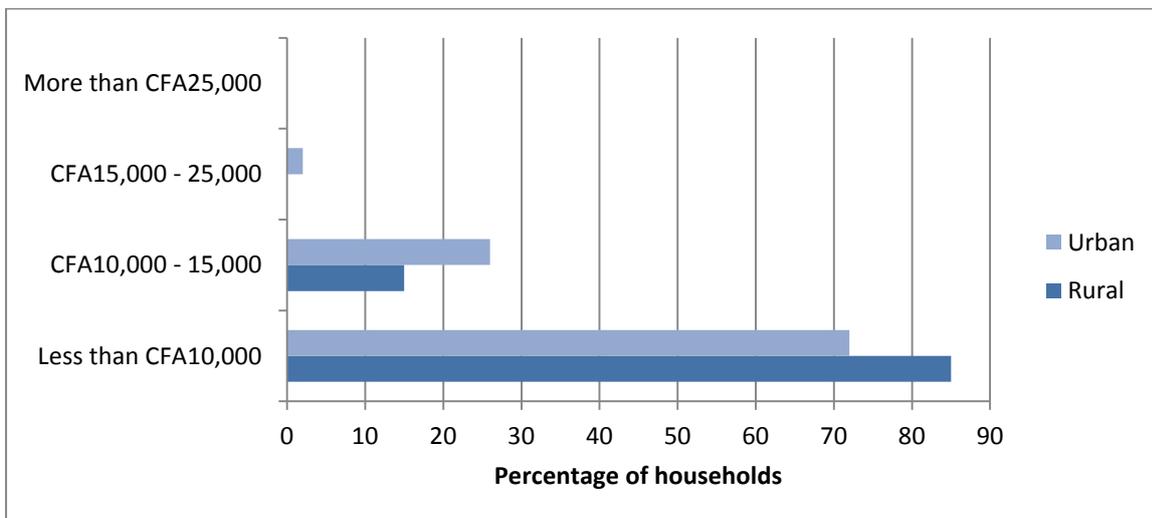


Figure 5.5 Willingness to pay for an ethanol stove (CFAF/month) in Saint-Louis

The experience of ethanol household cooking programmes in other African countries (particularly Kenya, Madagascar and Ethiopia) indicates that in the short-term, ethanol stoves would probably need to be imported, until local capacity has been developed to produce efficient and safe ethanol stoves in Senegal. As imported ethanol stoves are likely to cost US\$30–60 (CFAF 2,700–5,400), it is likely that many potential ethanol users would need access to some form of credit to purchase an ethanol stove. It is worth noting that most urban and rural households (54 and 79 per cent, respectively) have already accessed some form of saving-credit schemes in the past, even though this tends to have been through informal institutions (see Figure 5.6).

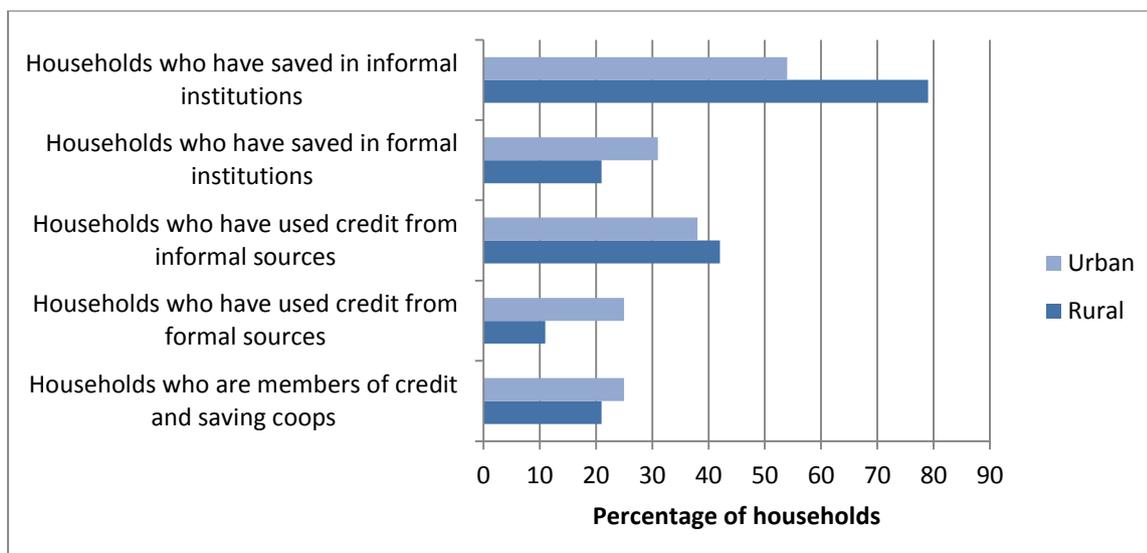


Figure 5.6 Savings and loans using formal and informal institutions

The average size of loans taken out by households in the previous year varies from CFAF 65,656 in rural areas to CFAF 214,737 in urban areas, with the proportion of the average loan amount to the average annual income being 3 per cent for rural households and 4 per cent for urban households.

Rural households use loans mainly for farming activities, in particular for fertiliser, whilst urban households use them for a variety of household expenses, including social services such as health and education.

In Saint-Louis, households were unaware of the potential use of ethanol as a household fuel. Many, however, expressed a willingness to try it if it were made widely available, accessible, affordable and easier to use.

5.4 Supply side

5.4.1 Ethanol production

CSS has already invested CFAF 4.6 billion in an ethanol facility with an annual capacity of 21.5 million litres located in Richard Toll, about 130 km from Saint-Louis city. This is the only large-scale production unit in the country, although it is not devoted to producing ethanol for energy usage (see below). CSS has been in operation since 1970, but started the ethanol production unit only in 2007. The ethanol is produced entirely from molasses, a by-product of producing sugar from sugarcane.

Industrial ethanol (that is, containing more than 96 per cent alcohol) is currently sold mainly to the pharmaceutical and cosmetic industries. Senegal's largest consumers are local companies, which absorb more than 51 per cent of production; companies from neighbouring countries¹² purchase the remainder (CSS interview).

¹² These include Burkina Faso (which absorbs 30 per cent of exports), The Gambia, Ghana and the Ivory Coast.

However, the 'head'¹³ of ethanol production cannot be sold to industries because of its low 90–95 per cent alcohol content. According to CSS, about 550,000 litres of ethanol 'head' is produced every year that is neither used nor sold. This type of ethanol is ideal for use as a cooking fuel and it could be targeted towards the household cooking market.

CSS does not disclose the production and selling costs for bulk purchases. However, while the selling price for industrial ethanol is CFAF 470 per litre, CSS suggested that the price of head ethanol is CFAF 320 per litre. A further advantage is that there are currently no specific taxes on head ethanol (such as those duties on alcoholic beverages which exist in other countries). CSS is currently burning off the 550,000 litres of head ethanol and they expressed to the study team a clear willingness to provide the amount needed to any operator or researcher wanting to investigate further.

The market for ethanol as a household cooking fuel also depends on the cost of ethanol cookstoves, whether they are imported or manufactured locally. These are generally more expensive than charcoal cookstoves

5.4.2 Ethanol distribution

If demand can be created for ethanol as a household cooking fuel, the potential solutions for its distribution will depend on the available packaging options, which have not yet been investigated as it has never been tried. Again, CSS expressed a clear interest in any recommendations for this. Looking at existing distribution networks in the country, two possible options present themselves for distribution of ethanol:

- distribution to urban households in a manner similar to that of kerosene, which is also a liquid;
- using the same companies and distribution channels as those used by LPG. In this way it could be distributed to small and medium enterprises – such as bakeries, restaurants and hotels – that also typically pay for their cooking fuels, and are interested in fuels that have a lower environmental and health impact.

5.4.3 Ethanol stoves

Because ethanol is a new fuel in Senegal, it is necessary to maintain its reputation by avoiding the dissemination of low-quality stoves. However, the manufacture of ethanol stoves is generally quite complex, and the cost of production will be passed on to the consumer, with a consequent effect on the market for ethanol. The local production of household ethanol stoves has been considered in Mozambique, Kenya and Ethiopia, but at the moment prototypes have been produced only in Kenya. The only verifiably safe ethanol stoves are currently produced in Europe. Potential importers would do well to liaise with Project Gaia¹⁴ and CleanStar Mozambique,¹⁵ which have successful experience with importing stoves in Africa.

Although the cost of such a stove is likely to be prohibitive for a large percentage of Senegal's population, local manufacture should be considered only at a second stage, when the market for ethanol has shown its potential.

¹³ The *head* is the fraction of ethanol produced as a by-product of pure ethanol (100 per cent alcohol). It still has some water content and thus a lower alcohol content.

¹⁴ <http://projectgaia.com/wp/project/more/>.

¹⁵ <http://www.cleanstarmozambique.com> (site currently under construction).

5.5 Conclusions and recommendations

The findings of this study show clear potential for the development of an ethanol market in Saint-Louis. This could result in several social, economic and health benefits, not only to households but also to businesses involved in ethanol production.

An initial ethanol market would likely target both LPG users and urban charcoal users who use LPG as a secondary fuel. Most members of these groups use simple stoves for their daily cooking needs, and the resultant health issues affect mostly women and children.

In the Saint-Louis region, briquettes remain the least cost-option in terms of price per megajoule, followed by ethanol and charcoal when used with improved stoves. Saint-Louis also has a comparative advantage in terms of transport, given the existence of an ethanol plant in the region as well the existing production of briquettes, albeit on a small scale.

Furthermore, following the removal of the LPG subsidy, charcoal used with improved stoves has become cheaper when considering the calorific value (although charcoal used with a traditional stove remains the most expensive cooking fuel option).

If one takes as given CSS's suggested price of CFAF 320 per litre, on the basis of other studies indicating an average household consumption of 1 litre per day, CFAF 9,600 would be required to cover the monthly cooking fuel expenses for an average urban household. This is in line with the benchmark of CFAF 10,000 that emerged from the discussions with urban households, which would make ethanol competitive with both LPG and charcoal used in efficient stoves, when considering the cost per megajoule, as highlighted in Figure 5.7.

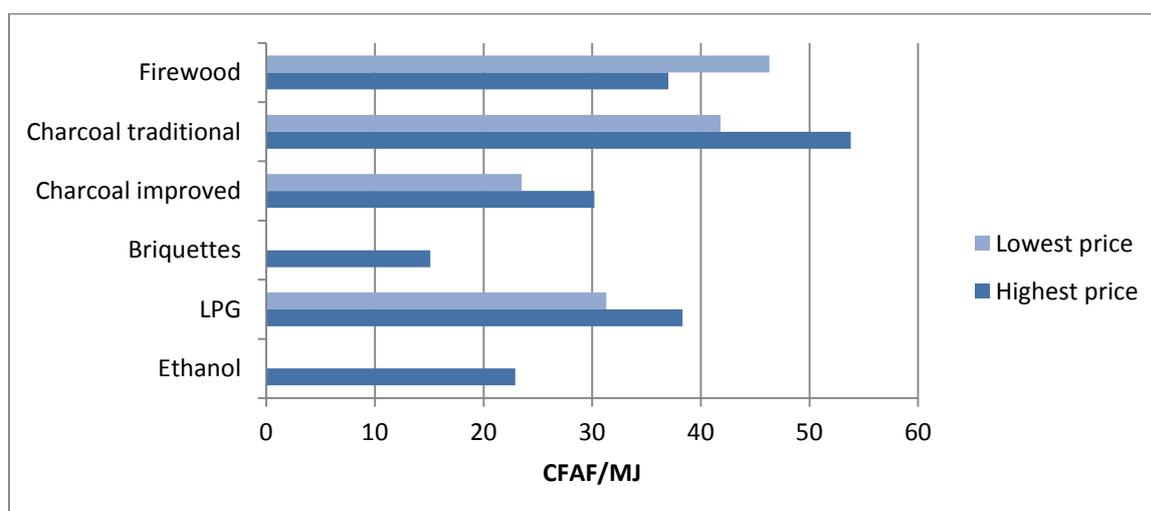


Figure 5.7 Price per megajoule of cooking fuels in St Louis (CFAF)¹⁶

The main barrier for the penetration of ethanol will be the cost of the stove, which is much more expensive than that of improved charcoal stoves or an average LPG stove. For instance, even ethanol stoves in Mozambique, which benefit from a subsidy, cost US\$30 (CFAF 15,000), which is two to two-and-a-half times the price of an improved charcoal stove in Saint-Louis. Most households will have difficulty paying the entire price in cash, particularly in peri urban and rural areas.

¹⁶ See Annex for methodology.

The focus group analysis shows that loans, particularly those obtained through *tontines* (traditional credit societies), have already been used for the purchase of improved stoves. For small amounts, the study showed that such traditional financial mechanisms are the preferred channel. Some women currently pay a weekly instalment of CFAF 700, taking less than six months to pay back loans for improved stoves with an average price of CFAF 5,000. For an ethanol stove, a nine-month period to pay back the loan should be considered. At an interest rate of 18 per cent, this would result in nine monthly instalments of CFAF 1794/month. This would be in line with both (a) the capacity of low-income households and (b) current practice of micro-financial institutions in Senegal, including interest rates.

The study shows that there is potential for a pilot study for 1,500 households in urban Saint-Louis, with the aim of distributing 1 litre per household per day. CSS expressed a clear interest in testing this market and in seeing the 550,000 litres of 'head' ethanol commercialised. This could be a good place to start piloting the market. After that, production can be considered either by CSS or other interested investors.

Of course, although ethanol is currently fairly competitively priced, a functional supply chain is required, and links with the kerosene and LPG supply chain should be considered. As ethanol for cooking is almost completely unknown in Saint-Louis, a campaign targeting urban households should be launched before starting any commercialisation pilot.

Finally, lessons from initiatives in other countries, including Kenya, Madagascar and Mozambique, can be applied in Senegal by government, NGO and private sector actors. Production can be piloted in the Saint-Louis region. The recommendations for stakeholders interested in exploring ethanol for cooking in Senegal are as follows:

- The long-term commercial viability of ethanol production depends on (a) the ability of the producer to access an affordable and reliable supply of source materials (in this case molasses from sugar cane production) and (b) the existence of a stable market for the ethanol fuel and its co-products, such as ethanol cookstoves.
- Any organization deciding to pilot ethanol in Saint-Louis should include these measures:
 - Add flavours and colour to the ethanol to make it unattractive for human consumption.
 - Standardise the packages and labelling.
 - Learn the lesson of previous studies, namely, that the design of the ethanol stove matters.
 - Factors associated with obtaining the fuel, such as access and price, are also significant.
- One of the main problems with using ethanol as a household cooking fuel is its high flammability. It needs careful handling and usage (like kerosene and LPG, which are equally flammable). If an ethanol pilot is to be conducted, it is vital that the stove used is a high quality one, and that it is tested, and ideally used first in a similar context.
- Most households are unaware that they can use ethanol for cooking. There is thus a clear opportunity to create a strong reputation around it.
- The experience of other countries seems to indicate that ethanol can be produced at a price similar to that of charcoal. If this were the case, it would be likely to generate a high demand as it is much more user-friendly than charcoal and burns more cleanly.

- If ethanol can be produced in sufficiently large quantities at a competitive price, it could complement LPG in other urban areas, including Dakar. However, for this to happen a long-term development strategy is required. This would include the establishment by the authorities of an attractive framework (i.e., favourable regulations, tax incentives, and so on) for the private production of ethanol specifically for use as a household cooking fuel, as well as for suitable stoves and awareness-raising campaigns to create the demand from end users.



6. Biogas in rural Kaolack

Biogas is generated when any organic matter (such as animal dung, crop residues or kitchen waste) is fermented in the absence of oxygen. Biogas contains around 60 per cent combustible methane (along with carbon dioxide and traces of other gases), and it is this gas which can serve as a convenient fuel for a variety of applications such as cooking, lighting and motive power. In addition, the bio-slurry (the biological residue left over after the gas is produced) can be used – either directly or as a composting agent – as organic manure to improve soil fertility.

Biogas technology thus produces a very clean burning fuel as well as a high-quality organic fertiliser, and benefits households from the perspective of improved energy services, agricultural production and improved health and sanitation, as well as a range of gender- and environment-related benefits. It is also significantly cheaper in the long run than most other cooking fuels because, once the biogas production system has been installed, the gas is produced almost without cost.

Although Senegal's history of biogas technology dates back to the 1950s, it was only in the mid-1970s that it began to take off, with the introduction of two Indian, floating drum-model biogas digesters. These were established by the Senegal branch of Caritas, in Thiadiaye, Fatick region (although most digesters were at first installed for demonstration and research purposes only). The main actors in the development of biogas technology in Senegal include École Supérieure Polytechnique de Dakar (ESP), Centre Régional Africain de Technologie (CRAT), Centre d'Études et de Recherches sur les Energies Renouvelables (CERER), and Environmental Development Action in the Third World (ENDA Energy).

The technical potential of household-scale biogas digesters in Senegal is estimated to be between 170,000 and 400,000, (SNV 2007). Kaolack is one of the most important regions for biogas for a number of reasons: the level of work on biogas to date, the livestock present in the region, and the number of biogas enterprises already active in the region. At the same time, however, a number of factors need to be addressed, such as livestock breeding methods, poor knowledge of the technology and the lack of involvement of microfinance institutions. To promote the dissemination of biogas, the government of Senegal has recently started to subsidise biogas digesters.

6.1 Background

The Kaolack region, with a population of about 1,066,000, lies on the border with The Gambia to the south (Figure 6.1). The capital, Kaolack city, is a port on the Saloum River. It is a major peanut marketing and exporting centre, and has a large peanut oil factory and a number of other important industries, including brewing, leather tanning, cotton ginning and fish processing.

The region is predominantly rural, however, with about 80 per cent of the population employed in agro-pastoral practices. A recent socio-economic analysis revealed a marked difference between rural and urban Kaolack (SNV 2007). However, as biogas technology is only really appropriate for those rural and peri-urban households with domestic livestock (at least two cows), this study assesses only the potential of domestic biogas within rural households.

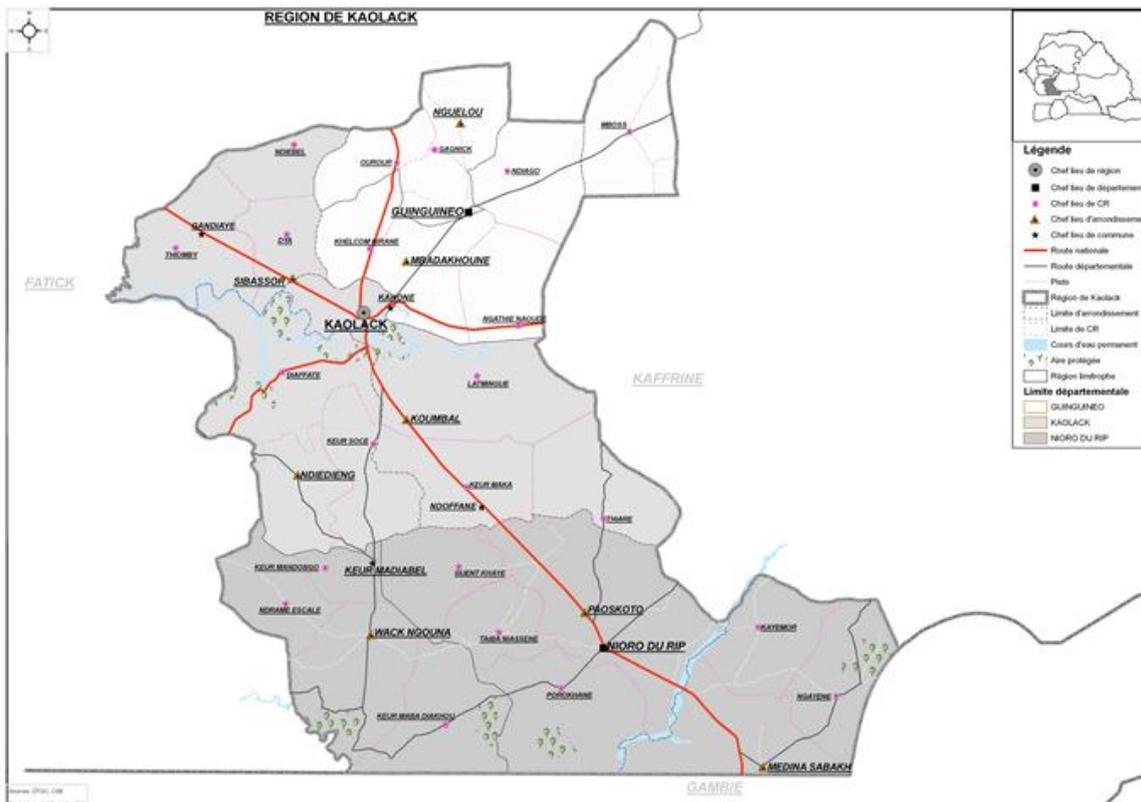


Figure 6.1 Map of Kaolack

Unusually for Senegal, the difference in levels of educational achievement between urban and rural Kaolack is not significant. There is, however, a poverty gap: the annual urban income (CFAF 3,500,000) is approximately 3.2 times higher than that of rural areas (CFAF 1,082,212). The rate of access to a potable water supply is 100 per cent in urban areas and 82 per cent in rural areas, with the average time taken and distance travelled by rural households to access it being an average of two minutes and 140 metres, respectively. Women are entirely responsible for collecting water in both urban and rural areas.

Kaolack is one of the main agricultural regions of Senegal, part of the *bassin arachidier* (groundnut basin) and home to the production of a range of cash crops, including peanuts, rice and cotton. Agricultural activity, particularly farming, is the primary employment for 43 per cent of rural households, while trade makes up 40 per cent of the employment of urban households (ANSD 2010). Salaried employment within the local administration is the second most important source of livelihood for both rural (18 per cent) and urban (25 per cent) households. Other employment opportunities for rural households include trade (17 per cent), other diversified sources of livelihood (15 per cent), and daily labour (5 per cent). About 15 per cent of urban households earn their livelihood from daily labour.

In rural areas, 98 per cent of all households own the home they live in, a good indication of the potential for long-term investments made by rural households, such as biogas digesters.

6.2 Livestock production

As Figure 6.2 shows, most of the surveyed rural population of Kaolack own livestock, with almost 30 per cent possessing cattle. About 45 per cent of surveyed households already collect the dung from their livestock, either for composting (32 per cent) or for direct

combustion (13 per cent). More than half collect the waste from their cattle sheds or inside their homesteads, while 12 per cent collect it from open grazing areas.

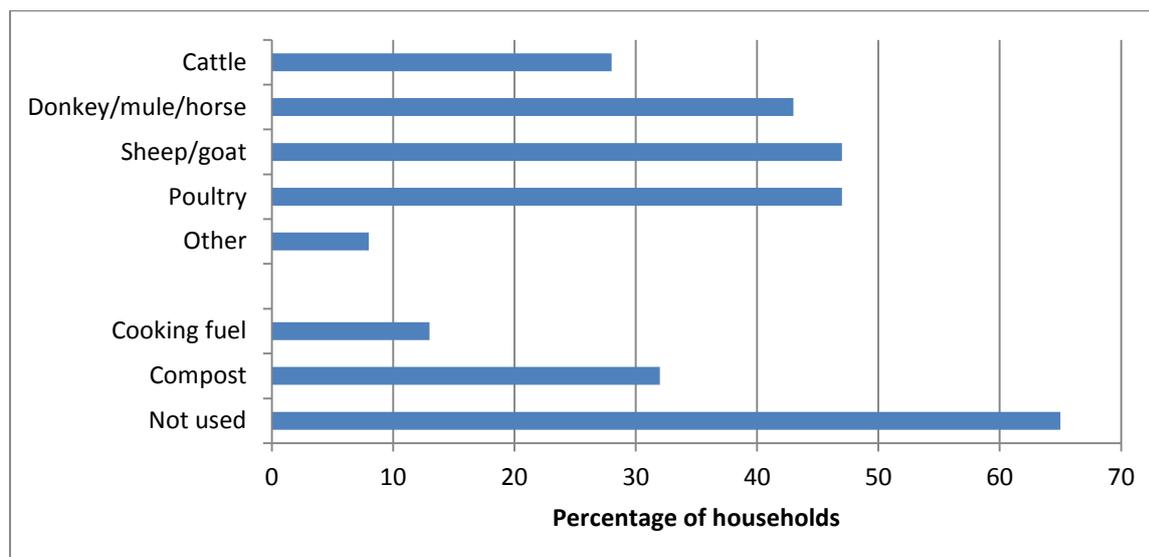


Figure 6.2 Types of livestock and use of animal waste in Kaolack region

Note: The livestock total is higher than 100 per cent because some households own more than one type of livestock.

These conditions all constitute positive indicators for the potential uptake of domestic biogas in the Kaolack region.

6.3 Household cooking

The rural Kaolack energy consumption pattern is typical of many other parts of rural Senegal, with firewood being the main domestic cooking fuel (Figure 6.3).

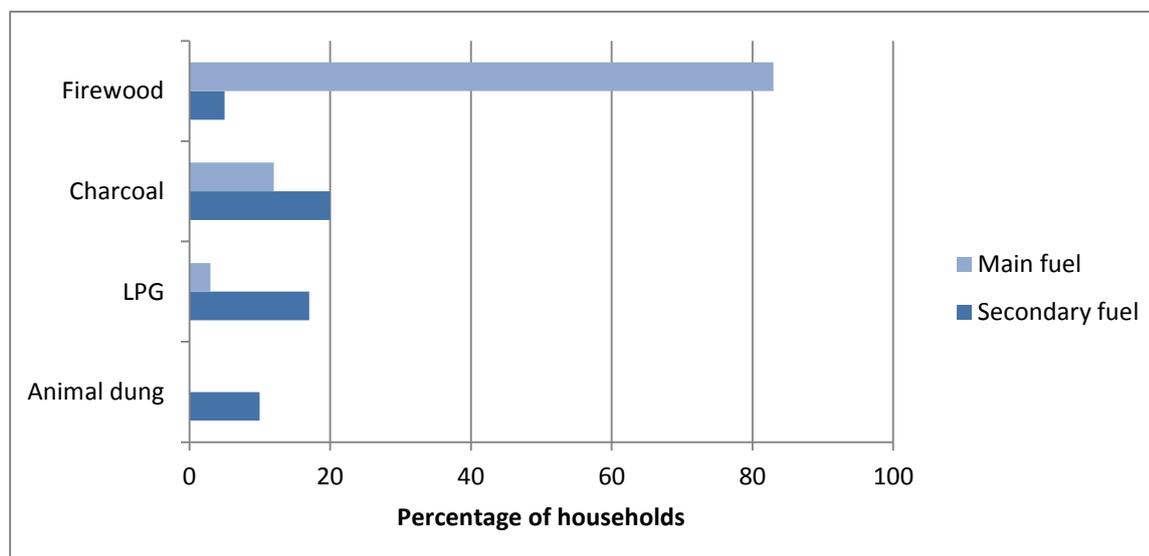


Figure 6.3 Cooking fuels in rural Kaolack

Firewood is the main source of cooking fuel for everyday use for 83 per cent of rural households, while charcoal and LPG are used on a daily basis only by 12 per cent and 3 per cent of rural households, respectively. A small minority (3 per cent) uses agricultural residues as a tertiary cooking fuel.

As expected, the ownership of cookstoves in the Kaolack region directly correlates with the rate of fuel usage. The traditional three-stone cookstove is the predominant technology in rural households, with 73 per cent using it to burn firewood (Figure 6.4). It is, however, interesting to note that 13 per cent of rural households have already adopted improved cookstoves, with a much lower percentage (5 per cent) using an enclosed traditional stove. Traditional and improved charcoal stoves are owned by only 20 per cent and 12 per cent of rural households respectively.

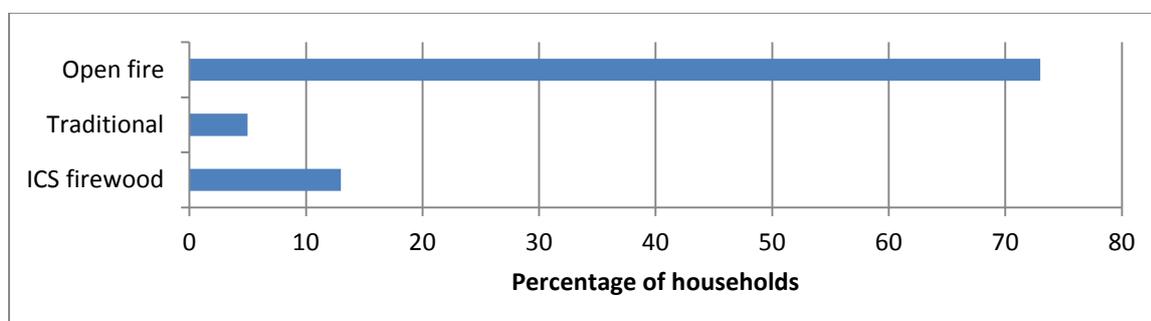


Figure 6.4 Types of stove used for cooking with firewood in rural Kaolack

6.4 Potential demand for new fuels

6.4.1. Perceptions of current stoves and cooking fuels

Ninety-eight per cent of surveyed rural households reported dissatisfaction with their current cooking fuels and stoves. The main reasons given are related to smoke, long cooking times, high fuel consumption and the high cost of fuels (Figure 6.5).

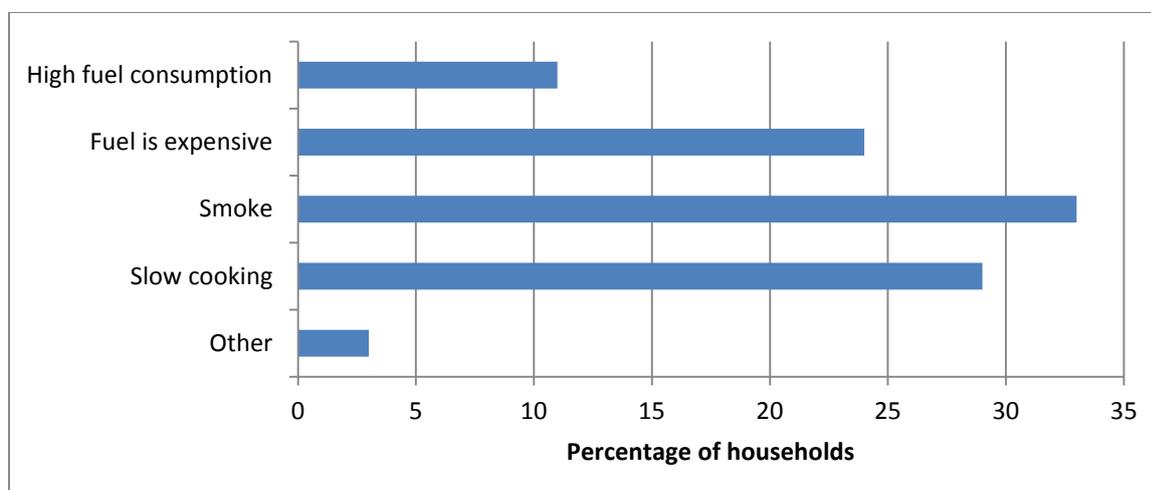


Figure 6.5 Reasons for dissatisfaction with current fuel and stove in rural Kaolack

Note: This is based on the 98 per cent of households not satisfied with their cooking technology and fuel.

In rural Kaolack the cost of cooking is ranked third, as cooking fuels are collected, thereby incurring no monetary expense for a significant proportion of the households. In rural households, smoke is the most important issue, followed by cooking time. An additional issue which emerged from the focus group discussions was that the availability and price of current fuels is strictly dependent on the season (that is, the price is higher during the rainy season).

6.4.2 Insights into biogas in the region

Biogas is a well-known technology in rural Kaolack: of the approximately half of all households who are familiar with any alternative fuels, all have seen a biodigester. The alternative fuels that the households want to use seem to be based on prior knowledge of the fuels (biogas is amongst the best known alternative fuel technologies in the region): of the 63 per cent of households who are aware of alternative fuels, 92 per cent chose biogas, and only 8 per cent chose briquettes.

The reason for choosing biogas is primarily for saving on fuel expenditure, followed by cleanliness and smoke reduction (see Figure 6.6). This contrasts with what is stated by households as their main issues with current cooking fuels, but it shows that they perceive biogas as a free fuel, and that they understand the potential to pay back the initial upfront cost. Safety, in the sense of reduction of fire hazard, is also one reason why households would choose this technology.

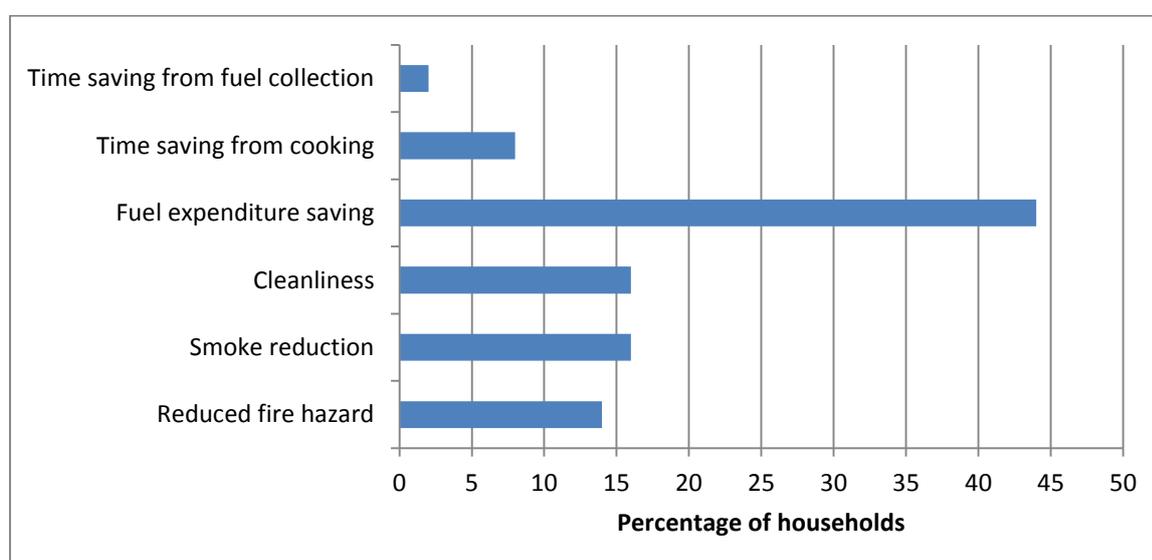


Figure 6.6 Drivers for using biogas in rural and urban areas

According to one woman interviewed in the focus group discussions who has seen a family in her village using a biodigester, the technology is useful because it produces free fuel, without smoke; it cooks fast; and it is easy to operate; the technology clearly has a good reputation among households. Although this is an indication of a potential high demand for biogas in the region, it is also clear that not all the households would be willing to have a biodigester even if they could afford one.

Biodigesters need attending to daily to shift the waste and slurry. In determining how best to promote the technology, it is useful to understand how households would absorb this additional work requirement. The survey revealed that in 37 per cent of households the digester will be operated only by the men (husband and sons), in 21 per cent by women (wife and daughters), and in most cases by varying members of the family (Figure 6.7).

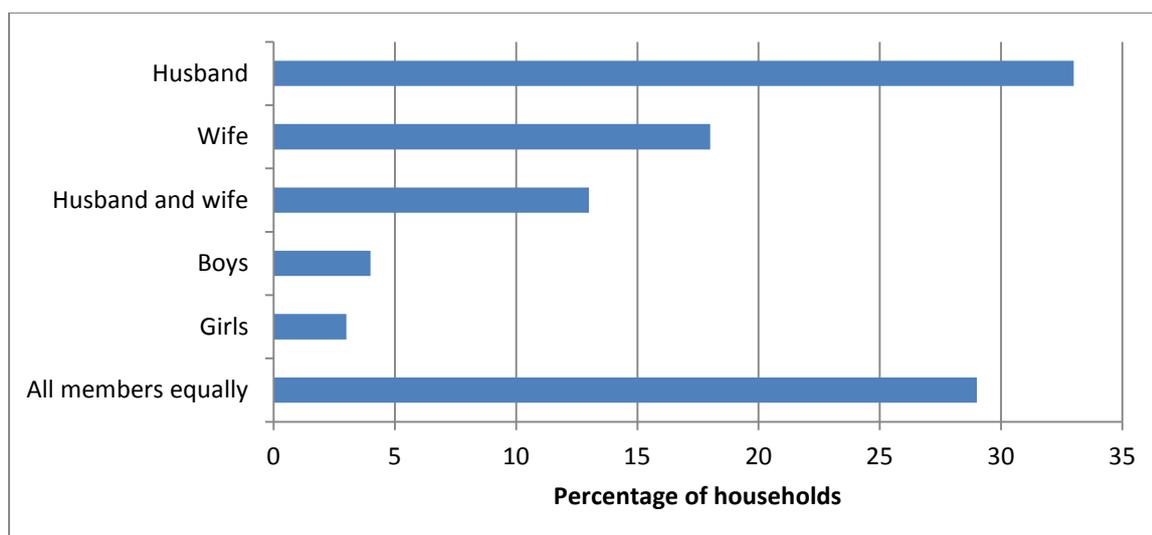


Figure 6.7 Household division of labour for biogas operation

Although these figures indicate a balanced approach to sharing the work, it would be necessary to know the situation of each individual household and the daily tasks of its members to determine whether the operation would in fact be carried out equally.

6.4.3 Willingness to pay for new fuels and stoves

Buying a biodigester would represent a significant investment for the average small holder in Senegal. To design an effective, targeted marketing campaign, it is thus important to understand who is the household's main decision maker in regard to the purchasing of large items.

In terms of who makes the decisions about major household purchases (including new stoves) in rural Kaolack, the survey shows there to be a fair balance between husbands and wives (Figure 6.8). This means any marketing campaign should target both genders in order to stimulate demand.

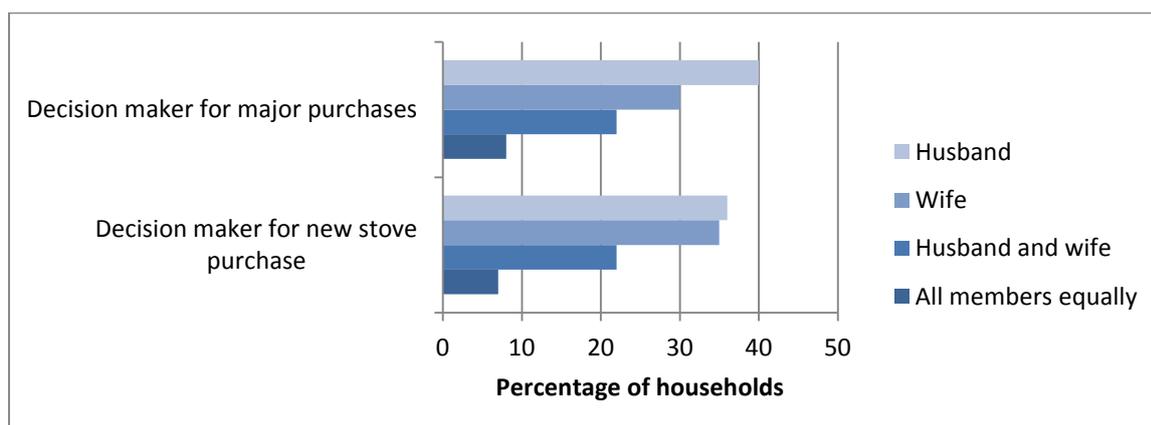


Figure 6.8 Decision makers for major purchases and stove purchases in rural Kaolack

The ratio of total household expenditure to energy expenditure for cooking (including equipment) is a good indicator when assessing the budgets households allocate to their energy needs and how such decisions affect their livelihood. The survey shows that an average of CFAF 8,212 per month is devoted to cooking fuels in rural Kaolack. As shown in Figure 6.9, most of households who consume firewood both purchase and gather it. The

average household consumption of firewood is 233 kg per month; the monthly expenditure for this is CFAF 4,429 as approximately 32 per cent of firewood (74 kg) is collected.

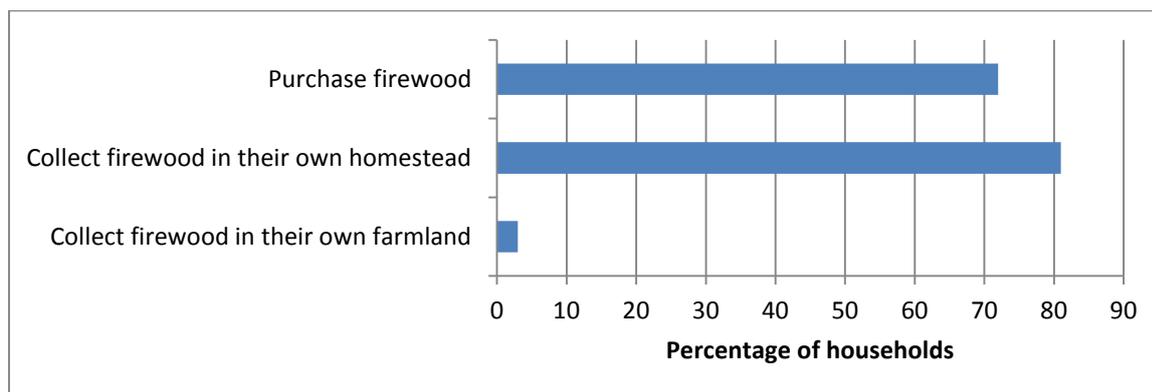


Figure 6.9 How firewood is procured in rural Kaolack¹⁷

In rural areas, firewood is generally collected by women (72 per cent), who travel an average distance of 1.7 km to do so. This shows that firewood, despite being the main fuel, is still available within a reasonable distance of the area investigated by this report, and presents a potential barrier to the uptake of biodigesters.

Because households are used to either collecting their own fuel or paying for it on a daily or weekly basis, a typical barrier to accessing biogas is the initial upfront cost. In contrast to other alternative fuels, biogas requires a significant initial expense to cover both the construction of the biodigester and the purchase of an appropriate stove. It is thus necessary to consider how much a household is able to spend and whether it can access external finance. It is also essential to determine how long it would take households to recoup the initial cost through the savings in fuel purchasing over time.

As Figure 6.10 shows, households were asked how willing they would be (a) to pay for an alternative cookstove which is clean and cooks fast and (b) to pay monthly for an alternative fuel such as biogas. Although 15 per cent said they would not be willing to pay anything, most (60 per cent) are willing to pay up to CFAF 10,000 for a stove and CFAF 10,000 for the fuel per month, and 25 per cent are willing to pay more than CFAF 10,000.

However, from focus group discussions it emerges that CFAF 5,000 is the actual price households are willing to pay per month for alternative fuels, and around CFAF 4,000 is what they would pay for an alternative stove. A good means of calculating actual ability to pay is to match these figures with a household's current expenses: the result is that in rural Kaolack the average household would spend between CFAF 5,000 and CFAF 10,000 per month on domestic energy.

¹⁷ The figures are higher or less than 100 per cent as some of the households both purchase and collect firewood.

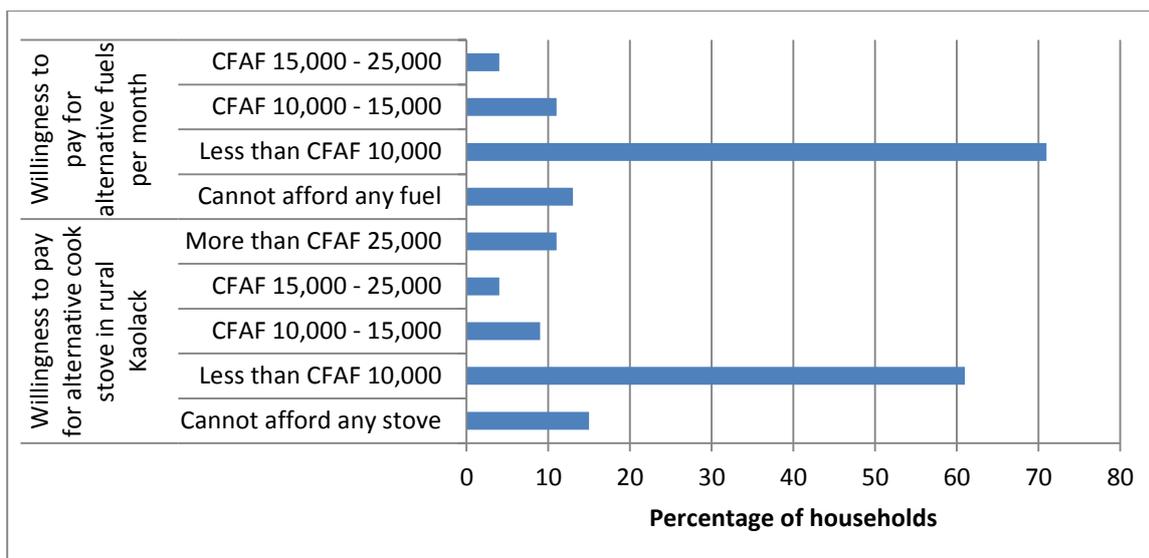


Figure 6.10 Willingness to pay for alternative cookstoves and fuels in Kaolack (per month)

Although past experience has shown that biodigester use would allow people to recoup their initial expense within a few years and to cook for free after that, most rural households do not have enough cash to cover the upfront capital cost. An assessment of (a) access to loans and (b) household experience of saving and loan management would help when considering ways to scale up dissemination of biodigesters in the region.

The survey findings (Figure 6.11) indicate that in Kaolack 22 per cent of rural households are members of credit and saving cooperatives and that 22 per cent have used credit from formal sources. About 37 per cent have accessed informal sources of loans. Significantly, the average total for loans taken out in 2012 by the households surveyed was CF AF 102,983. This indicates that most households need to borrow either from formal or informal sources to cope with their total expenditure on household and professional activities.

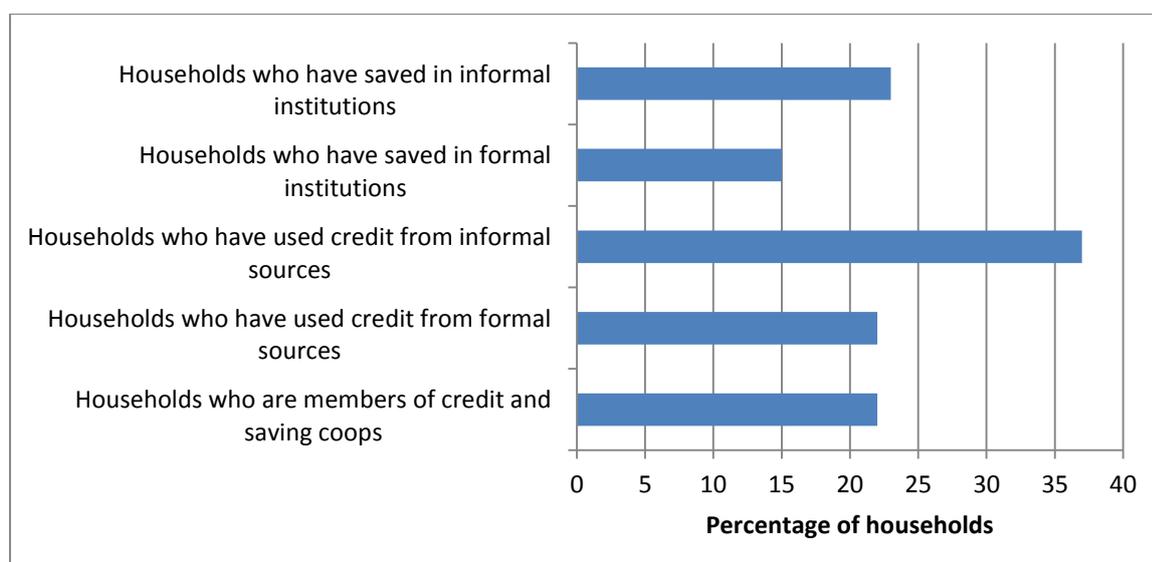


Figure 6.11 Experience with formal and informal credit and savings and loans in Kaolack

As shown in Figure 6.12, most loan applications in both rural and urban areas (as indicated by the survey category 'other') are for petty trade, house construction, poultry, health and consumable household goods. These account for 59 per cent of loan applications in rural

areas and 83 per cent in urban areas. Loans for farm inputs (fertiliser, seed, purchase of livestock) are also common, mainly in rural areas. These findings show that households in the region are used to accessing both formal and informal loans, and that there is therefore potential for developing specific microcredit systems for households willing to purchase biodigesters.

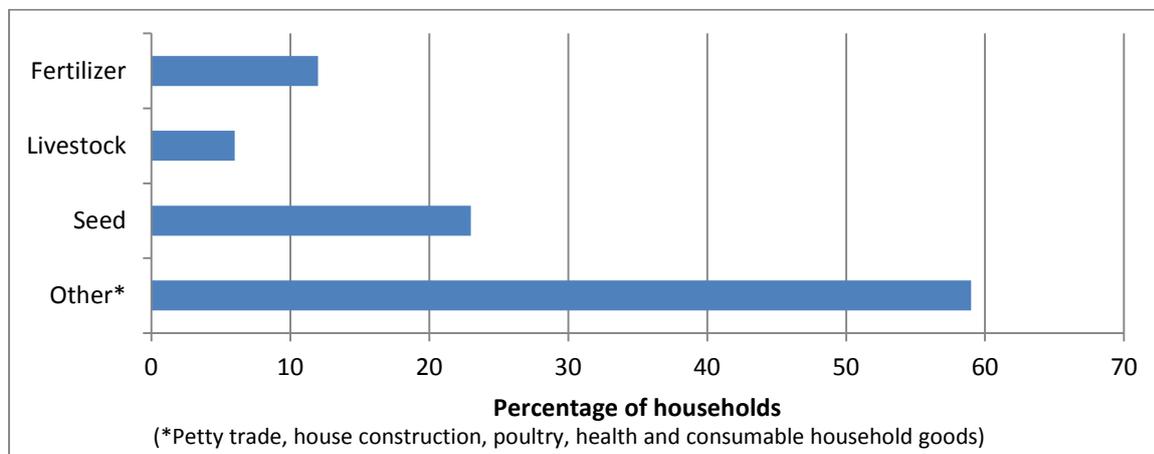


Figure 6.12 Applications of credit in Kaolack

6.5 Supply side

Biogas is currently being used in a number of regions of Senegal, overseen by the National Domestic Biogas Programme of Senegal. Several biogas technologies are already in use, including the fixed dome and plastic varieties, with the main feedstock generally being cow dung. For the smallest household biogas unit (4 m³), a minimum of two cows are required. As Figure 6.13 shows, the pace of biogas implementation in Kaolack has dropped in the last two years, although the demand remains.

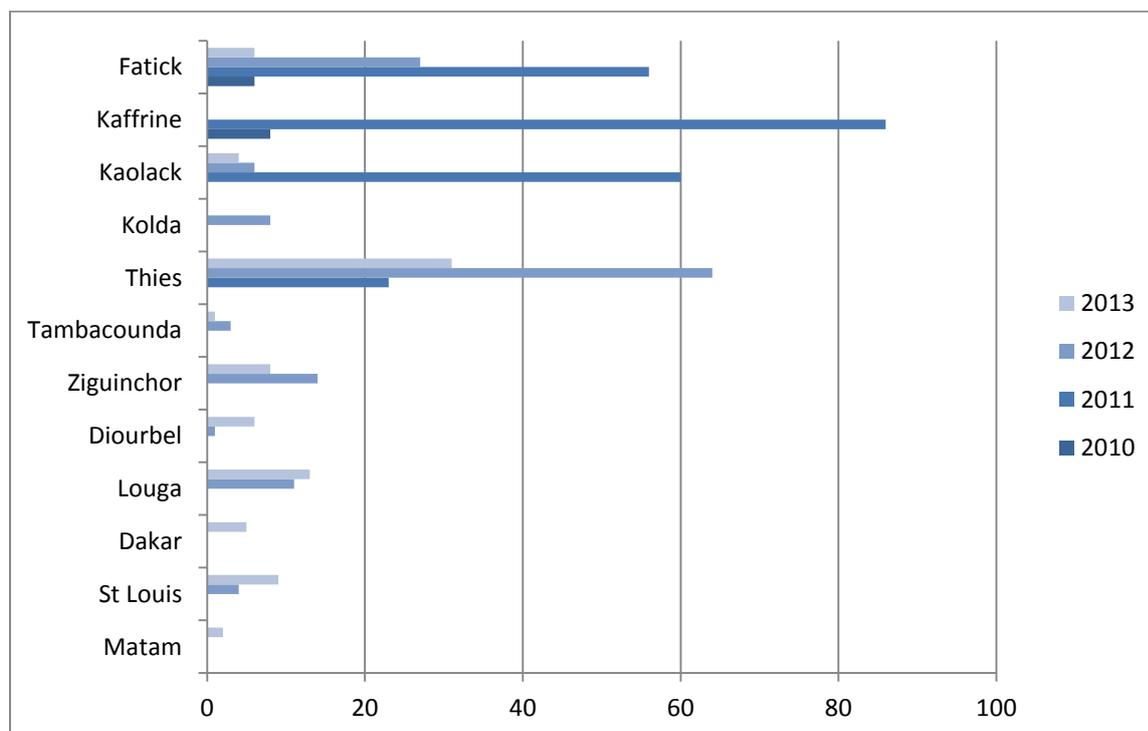


Figure 6.13 Number of biodigesters built in Senegal, by region

Source: SNV 2013.

Assuming the existence of sufficient feedstock and water, the key barrier is cost. In this light, Senegal's existing biogas programme (Box 3) is an important asset. The programme has estimated the technical potential at between 175,000 and 400,000 installations, sufficient for the development of a manufacturing sector in Senegal. According to a previous study (SNV 2013), around 30,000 households in Kaolack would be suitable for biogas use.

Before the subsidies were introduced, the investment costs for a fixed dome biogas installation in Senegal ranged from CFAF 612,000 for a 4 m³ installation to CFAF 892,000 for a 10 m³ installation. Construction using stabilised clay blocks rather than brick would reduce investment costs to CFAF 406,000 and CFAF 591,000, respectively (SNV 2007).

In June 2013, around 460 biodigesters were installed with PNB-SN support. The aim is a target of 7,000 in five years. Many development programmes (such as Senegal's ecovillages) include biogas in their technology package not only to address energy issues but also to extend the use of organic fertiliser (provided by the biodigester effluent) in agriculture. Biogas could thus experience real diffusion through the enlargement of the grant; the market approach in the dissemination of biogas has led to the emergence of micro enterprises specialising in the field of biogas.

Box 3. The National Domestic Biogas Programme

The National Domestic Biogas Programme of Senegal (Programme National de Biogaz Domestique de Senegal; PNB-SN) was launched started in 2009 with the financial support of the Netherlands government via the Directorate General for International Cooperation (DGIS), and managed by Humanist Institute for Cooperation (HIVOS) of the Netherlands for all six countries of the Africa Biogas Partnership Programme (ABPP). SNV was responsible for providing technical support.

The programme's market-based approach promotes the development of a mix of private and public organizations: the state, the builders or construction companies, financial institutions, local authorities, and the communities or beneficiary households. Given that the income level of the target households is low, and that the average cost of acquiring a biodigester is currently CFAF 450,000, the programme has established a funding mechanism to allow microfinance institutions to lend to companies that construct biodigesters (such as ECB) as well as to households that wish to buy them.

Indeed, the programme has an agreement with the Mutual Savings and Credit Union (Union des Institutions Mutualistes Communautaires d'Epargne et de Crédit; U-IMCEC) to provide financial support up to a maximum of CFAF 1.5 million for a credit group and CFAF 500,000 for individual credit over 12 months (the possibility of exemption may not exceed 18 months). The programme also benefits from financial support from the government of Senegal in the form of a grant (Table 6.1). Taking into consideration the subsidies in place and current prices, the investment costs range from CFAF 355,000 for a 4 m³ unit to CFAF 730,000 for an 18 m³ unit. Because the fixed subsidy of CFAF 160,000 is irrespective of size, it will be proportionally higher for small-scale units. For instance, the selling price of an 8 m³ biogas digester is CFAF 449,773; a subsidy would account for 36 per cent of this. For an 18 m³ unit the subsidy will be only 22 per cent of the price.

PNB-SN's first five-year phase ended in December 2013. The program is now in a transitory phase (2014) during which the next five-year phase is being designed.

	4 m ³	6 m ³	8 m ³	10 m ³	12 m ³	14 m ³	16 m ³	18 m ³
Selling price	353,575	402,622	449,773	512,884	588,883	643,278	694,406	728,973
Subsidy from the government	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
In-kind contribution of the beneficiary	52,741	68,845	85,386	107,266	118,043	137,155	147,290	154,480
Cash contribution of the beneficiary	140,834	173,777	204,386	245,617	310,840	346,123	387,116	414,493

Table 6.1 Biogas subsidies for different digester sizes (CFAF)

In the Kaolack region biogas digesters are installed by Entreprise des Travaux Hydrauliques et de Construction (ETHEC). Created in 2011, ETHEC can install three to four biogas units a month. The feedstock used is cow dung, as it is the case in most biogas units. So far the company has installed eighteen units, of which five are 10 m³ and thirteen are more than 10 m³. The average profit per unit is around CFAF 100,000 (US\$200). Interviews with company representatives show that (a) installation costs and (b) the promotion campaign are the main constraints to the scale-up of biodigesters and ETHEC's business. According to them, one possible option to overcome the financial constraint would be a subsidy proportional to the size of the unit, rather than a lump sum as it is now.

If applied, loans and subsidies designed by the National Domestic Biogas Programme could really speed up the penetration of the technology in Kaolack. One biodigester with 4 m³ capacity can produce up to 1.44 m³ of biogas per day, which is enough to keep a single burner stove going for 3.5 to 4 hours. Assuming that 80 per cent of the gas produced (1.15 m³) is used per day, it will replace 6 kg of firewood or 2 kg of charcoal (Table 6.2).

Type of fuel Sources	Quantity saved per day	Cost per unit	Total cost saved per day	Total cost saved per year	Payback period with subsidy of CFAF 160,000
Firewood	6 kg	CFAF 67	CFAF 402	CFAF 146,730	1 year
Charcoal	2 kg	CFAF 250	CFAF 500	CFAF 182,500	1.3 years

Table 6.2 Payback period of 4 m³ capacity biodigester showing the cost and savings

Table 6.2 shows that a household which is able to pay the upfront cost of the biogas system with the help of the subsidy would be able to pay back the cost of the biodigester in about a year. However, because most households are unable to afford the initial capital cost, they would need to access the loan scheme provided by the national programme. With CFAF 140,834 credit provided over 18 months to cover the cash contribution of the beneficiary, plus the subsidy of CFAF 160,000 from the government and an in-kind contribution from the beneficiary of CFAF 52,741, a household would pay CFAF 7,777 per month for 18 months. This is only slightly higher than the average amount rural households pay for cooking fuel in Kaolack, and only slightly above the price most households indicated they are willing to pay for clean fuels. This means that after one and a half years the household would have a free supply of biogas, as well as the bio-slurry produced as a waste product, which would reduce the expense of fertiliser.

6.6 Conclusions and recommendations

The study shows that rural Kaolack has the right social and agricultural conditions for the penetration of biogas technology. However, it still lacks sufficient awareness of the benefits of the technology to really reach scale. Although the newly-established national biogas programme provides subsidies and facilitates loans, it is also recommended that Senegal should stimulate demand by supporting the development of a range of biogas suppliers in the region that are currently unable either to construct the systems or to train end users to maintain them sufficiently.

- In Kaolack region, there is a good level of awareness around biogas and households clearly express their interest in the technology. However, the survey reveals a lack of awareness around the national biogas programme amongst households; the benefits of which have not yet been widely enjoyed by the population.
- The research shows that if the subsidies and loans were accessed, and considering current fuel consumption and costs, the cost of a 4 m³ biodigester could be paid back in 1-1.3 years. The survey also reveals that households in the region are used to accessing formal and informal loans, suggesting a potential for developing a specific microcredit mechanism for households willing to purchase biodigesters as well as for entrepreneurs willing to invest in biogas.
- There remains a lack of biogas technology suppliers in the region, and the few that exist suffer from low profit margins. The low margins are (a) due to weak demand, which is constrained by low household purchasing power (versus the high up-front cost of the technology); and (b) as a result of poor business management capacity.
- Looking at the potential of domestic biodigesters in Kaolack, the need is clear for a wider range of companies operating in the sector.
- The survey clearly demonstrates that governmental subsidy would not suffice to make the upfront cost feasible for most households, but that specific loans under the National Biogas Programme can be accessed by households to make up the shortfall. The survey also shows that households in the region are used to accessing both formal and informal loans, suggesting a potential for developing a microcredit mechanism specifically for households willing to purchase biodigesters, and for entrepreneurs willing to invest in biogas. The government should look at alternative solutions suggested by stakeholders involved in the sector; a suggestion from one entrepreneur from Kaolack is to make the subsidy proportional to the size of the biodigester rather than a lump sum.
- The National Domestic Biogas Programme needs to make its presence felt at the regional level. Local enterprises and micro-finance organizations need to be fully involved in facilitating household access to loans and subsidies.
- Although this study focused on the feasibility of biogas in Kaolack, the findings give wider indications regarding the economics of cooking in the region, as shown in Figure 6.14.

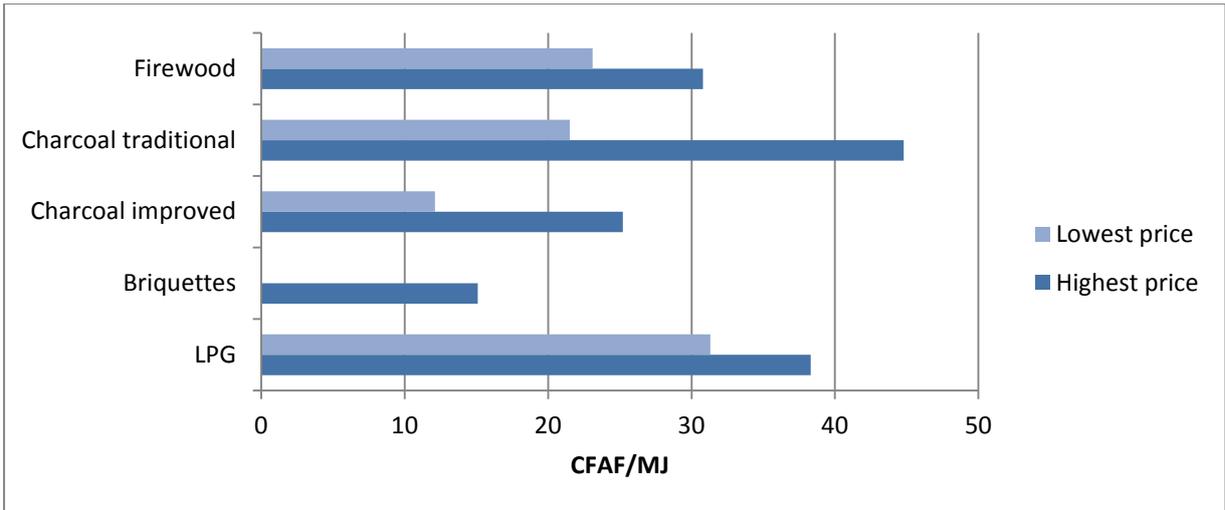


Figure 6.14 Cost comparison of different fuels in Kaolack

Note: See Annex A for methodology.

Briquettes and charcoal used with improved stoves are the least-cost option in the Kaolack region. However, this is not so for charcoal if it is purchased in small quantities, which is a least cost option only when it is purchased in minimum quantities of 50 kg and used with an improved stove.

Overall, as stated earlier, it is recommended that the government should aim to stimulate demand not only through subsidies and loan facilitation, but also by supporting the development of a range of biogas suppliers in the region.

7. Pure plant oil in Tambacounda

There is a great deal of literature available on the plant *Jatropha curcas*, particularly as its original selling point was that it can grow on marginal lands (although evidence later emerged that yields thus achieved are much lower than those obtained from fertile land). The pure plant oil (PPO) extracted from the *Jatropha* seeds can be used to power basic diesel engines (such as those used for water pumps and on multi-functional platforms), and in Senegal this is its main use. There is no relevant experience of using *Jatropha* oil for cooking.

Although PPO crops, particularly *Jatropha*, have been planted in many regions of Senegal, the production of oil that might be suitable for household cooking is believed to be most advanced in Tambacounda, where PERACOD have been working.

7.1 Background

Tambacounda region is located in Eastern Senegal, on a sparsely populated Sahelian plain (see Figure 7.1). The population is about 605,000 and the climate characterised by two seasons: the rainy season from June to October and the dry season from November to May. The capital city of the region (also Tambacounda) has an estimated population of 80,000 people.

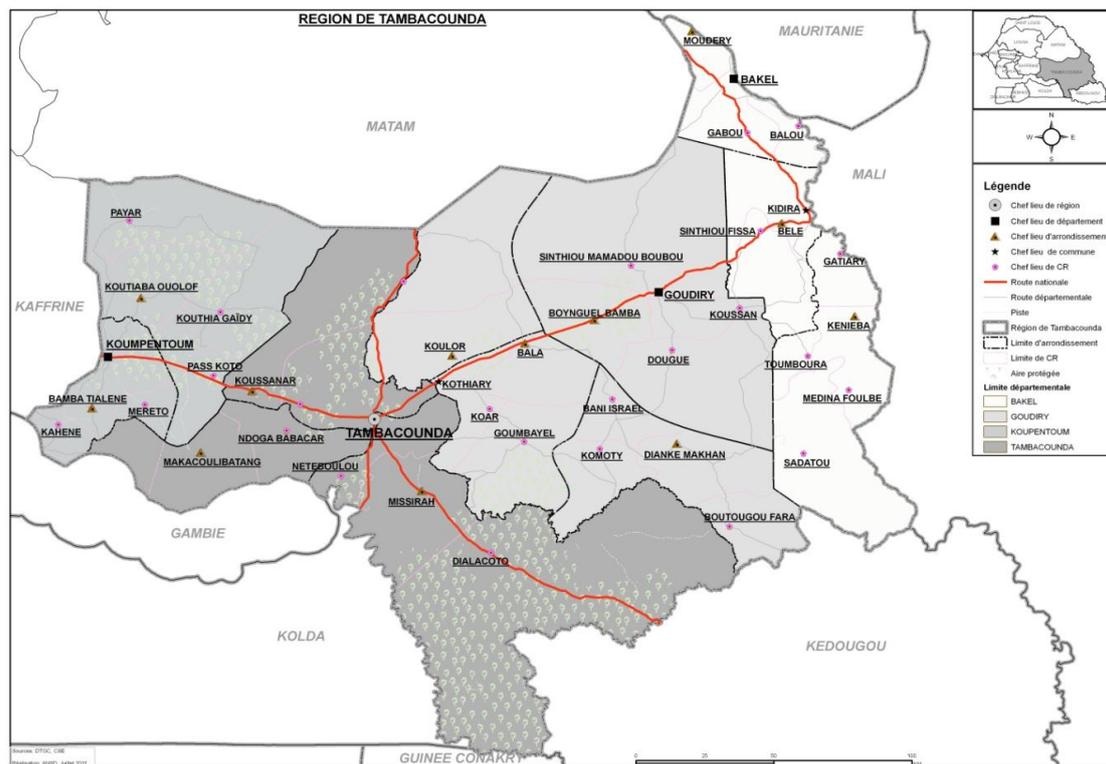


Figure 7.1 Map of Tambacounda region

Agriculture provides the majority of the employment and dominates the economy, with a focus on cash crops such as cotton and peanuts. In the southern part of the region the mining industry plays a role, with tourism being focused around the Niojkola-Koba National Park.

7.2 Household cooking

The energy consumption pattern in rural Tambacounda is typical of that of rural Senegal, in that a predominance of firewood is used for household cooking. In urban areas, there is a tendency to use a mix of fuels (LPG, charcoal and firewood), with the survey confirming the role of charcoal as being dominant in urban areas. LPG is used on an irregular basis by 10 per cent of urban and 3 per cent of rural households (see Figure 7.2). The phasing out of LPG subsidies in 2009, combined with high poverty levels and the close physical proximity to firewood and charcoal resources, explains the relatively low rate of LPG penetration in this rural area of Senegal. On the one hand, according to one of the women interviewed, LPG is available to buy in shops but is expensive and does not last as long as charcoal, which is more economical. On the other, the message obtained from focus group discussions with people from rural Tambacounda was that LPG is almost non-existent in rural areas, with only a few households using gas, and there are general difficulties in buying and refilling the gas cylinders, which requires a long walk to the main city. The problem is thus not just one of economics but also of availability of supply.

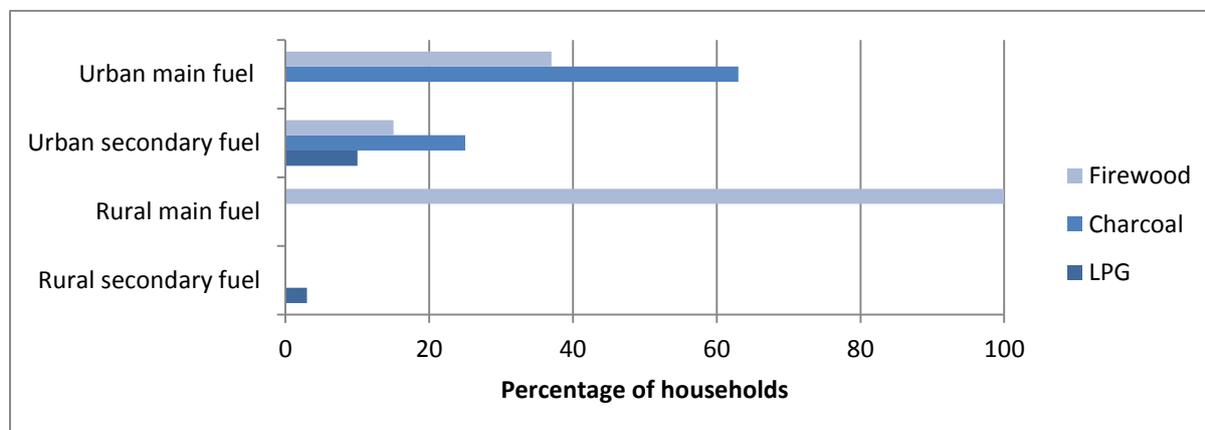


Figure 7.2 Household cooking fuels used in Tambacounda region

In rural areas, a higher proportion of households – 85 per cent in rural Tambacounda against 23 per cent in urban areas – benefit from having a separate indoor kitchen (see Figure 7.3). This lower figure can be explained by the scarcity of space in the city, where most of households (70 per cent) cook outside the house. However, indoor air pollution is reported to be an acute problem for both rural and urban households: rural (95 per cent) and urban households (83 per cent) report health problems due to cooking practices.

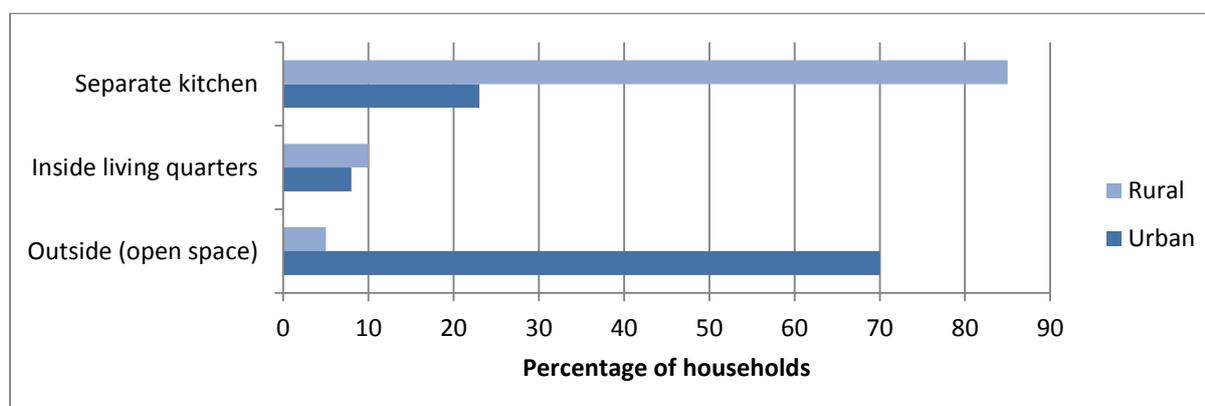


Figure 7.3 Distribution of households by type of cooking place

Traditional stoves and open three-stone fires are the predominant equipment used in urban and rural areas by those whose main fuel is firewood. Despite the high price of charcoal, it is the main fuel for 60 per cent of urban households, and the use of traditional stoves (the simple charcoal stove or metallic stove) remains predominant, with 80 per cent of urban charcoal users using this type of stove and only 13 per cent having an improved charcoal stove. All the surveyed rural households use firewood, with only 5 per cent using an improved cookstove, while the majority (78 per cent) use a fixed traditional stove and 17 per cent still cook on a three stone fire.

7.3 Potential demand for new fuels

7.3.1 Perceptions of current stoves and cooking fuels

Of the households surveyed, all of the rural and 80 per cent of the urban ones expressed dissatisfaction with the cooking fuel they use. In common with the other regions of this study, urban and rural households had different reasons for this dissatisfaction, which extends to the type of stove they use (Figure 7.4).

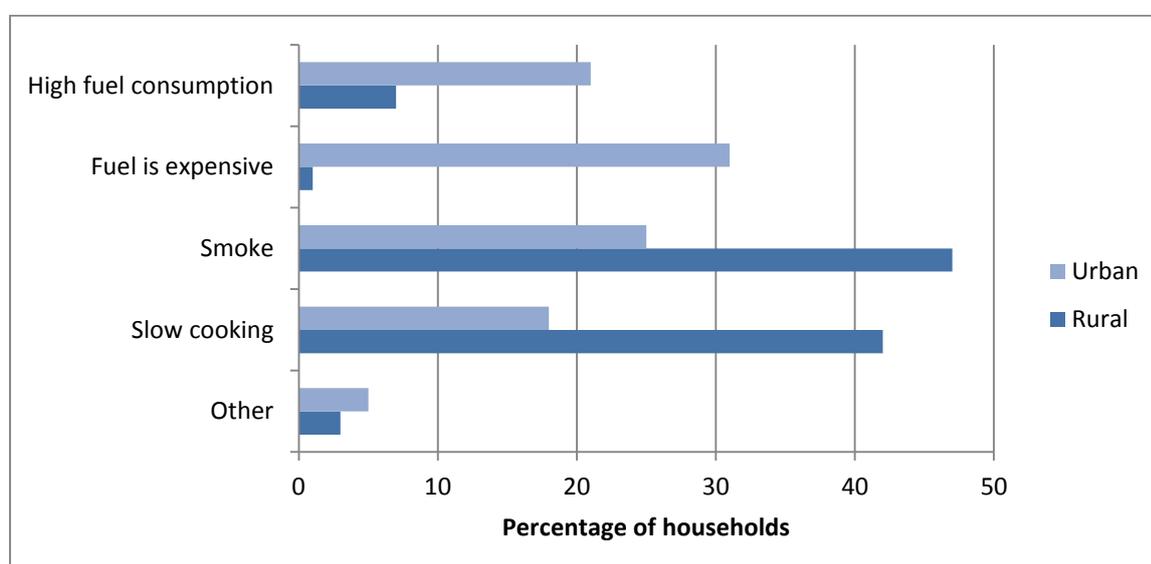


Figure 7.4 Reasons for dissatisfaction with current cooking solutions

In urban areas, fuel cost is the main issue, unlike in rural areas where cooking fuels are generally collected without incurring major monetary expense. In rural areas, adverse effects on health and extended cooking time cause the most dissatisfaction. These would be an important constraint to the market development of alternative fuels in rural areas, in particular for PPO.

The lower proportion of households in urban areas expressing dissatisfaction with levels of smoke emission and the slow rate of cooking can be ascribed to the different types of fuels used, as well as where the cooking takes place and the cooking practices, which to a large extent explain the health problems. Eye infections, respiratory problems and coughing are the main health problems reported by households, with some disparities according to the geographical location.¹⁸

¹⁸ Ninety-six per cent and 80 per cent of rural and urban households, respectively, experience eye infection as a major issue. Respiratory problems are reported by 90 per cent of rural households and 53 per cent of urban

7.3.2 Drivers for purchasing new household cooking fuels and stoves

As a number of *Jatropha* initiatives in the region have been unsuccessful, it is useful to understand the context in terms of PPO's visibility and reputation in Tambacounda.

Of the 60 per cent of urban households that are aware of alternative fuels, 63 per cent are aware of PPO; this compares to 43 per cent of rural households.

However, very probably because of PPO's poor reputation in the region, although most households – 80 per cent of rural and 88 per cent of urban – expressed a desire to use alternative fuels, only 23 per cent of urban and 3 cent of rural households declared any interest in using PPO for household cooking. Of note is the relative interest in using biogas and briquettes in this region, something that should be harnessed to build links with different regional initiatives (Figure 7.5).

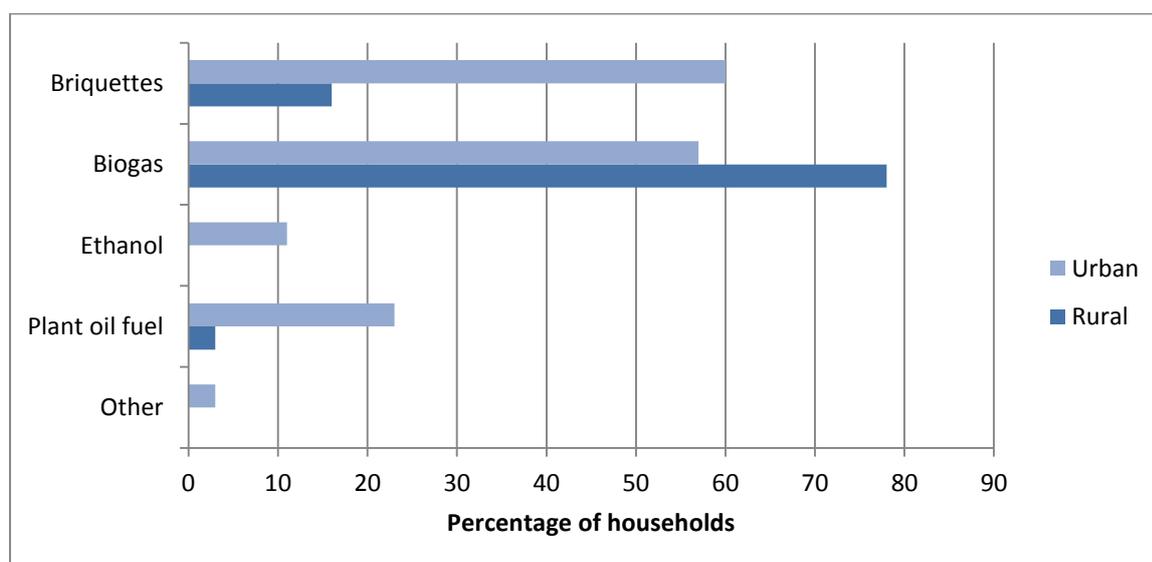


Figure 7.5 Willingness to use alternative fuels in urban and rural Tambacounda

When asked what would induce them to switch to their preferred alternative fuels, both urban and rural households gave as their main reasons (a) time saved when cooking and (b) fuel expenditure savings (Figure 7.6). Paradoxically, despite respondents in urban areas purchasing most of their fuel, about 50 per cent of urban households reported fuel collection time savings as a reason for their willingness to switch to alternative cooking fuels. At the moment, because no PPO household cooking stoves are available in any country in West Africa, it is not clear whether it would be more efficient and cleaner than an improved charcoal stove. In addition, if the oil is not well processed, it is likely to perform worse than charcoal in addition to being more expensive.

households. Numbers are similar for coughing, reported by 93 per cent of rural households and 55 per cent of urban households.

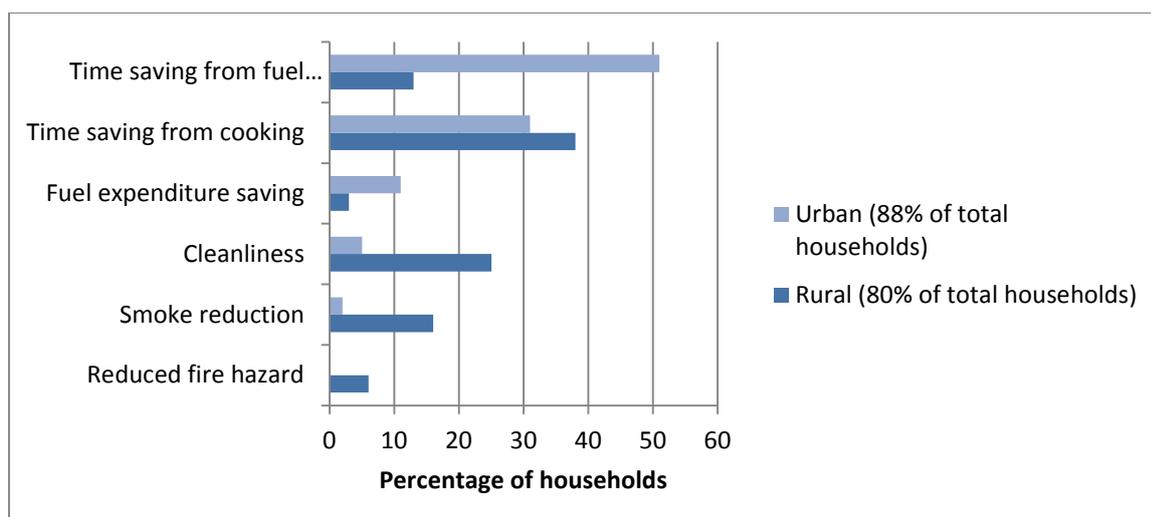


Figure 7.6 Drivers for choosing alternative fuels

7.3.3 Willingness to pay for alternative fuels and stoves

Compared to other regions of Senegal, fuel expenditure in Tambacounda is relatively low. In rural Tambacounda, only 1.5 per cent of total household expenditure is devoted to energy, while in urban areas this figure, although much greater at almost 12 per cent, is still comparatively low.

This sharp difference between urban and rural households is due to the fact that cooking fuels in rural areas are mainly collected and therefore not considered as a cost. Urban households devote a much higher budget to energy (CFAF 6,632 per month) than rural households (CFAF 625 per month). These figures are even higher when the cost of cooking equipment (mainly stoves) is included.

Because many households do not know the specific differences and benefits of different alternative fuels, the survey asked about their willingness to pay for a fuel which would bring them the general benefits of an alternative fuel (such as clean and fast cooking and reliable supply). From their responses, it emerged that the majority of both urban and rural households would not pay more than CFAF 10,000 per month for fuel and no more than CFAF 10,000 for an alternative fuel stove. However, from the focus group discussions it was possible to restrict the benchmark of monthly expenditure to CFAF 5,000 (Figure 7.7). In addition, according to the household interviews, urban households would need to access credit for this, while rural households suggested a seasonal payment system, due the irregularities of their incomes from agricultural production. These alternative methods of payment need to be investigated further.

An analysis of the total household income and total expenditure shows that on average both urban and rural households need to borrow either from formal or informal financial services to cope with the total household and professional financial needs. Overall, 28 per cent of rural households and 20 per cent of urban households belong to credit and savings cooperatives. However, savings are limited to a minority of both urban and rural households. The total household borrowing seems quite high when compared with the total annual income – particularly in rural areas, which confirms the rural-urban poverty gap. In rural areas, total loans were estimated at CFAF 77,250 (US\$154.5), which is more than 18 per cent of their total income. In urban areas, this ratio is slightly under 10 per cent, with households having accrued loans totalling CFAF 101,350 (US\$202) against a total annual income of CFAF 1,034,048.

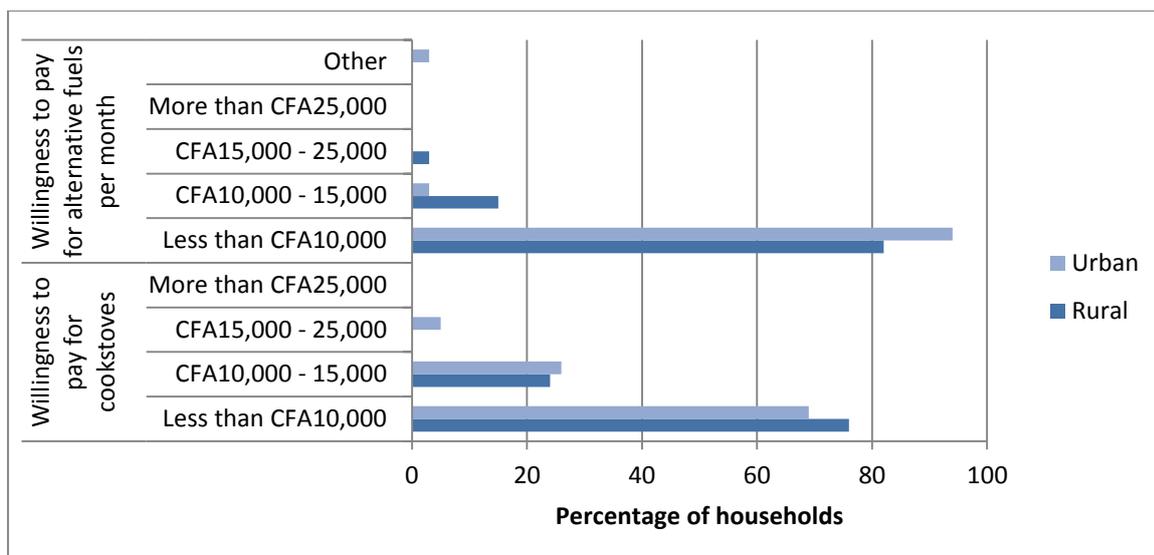


Figure 7.7 Willingness to pay for alternative fuels and cookstoves in Tambacounda

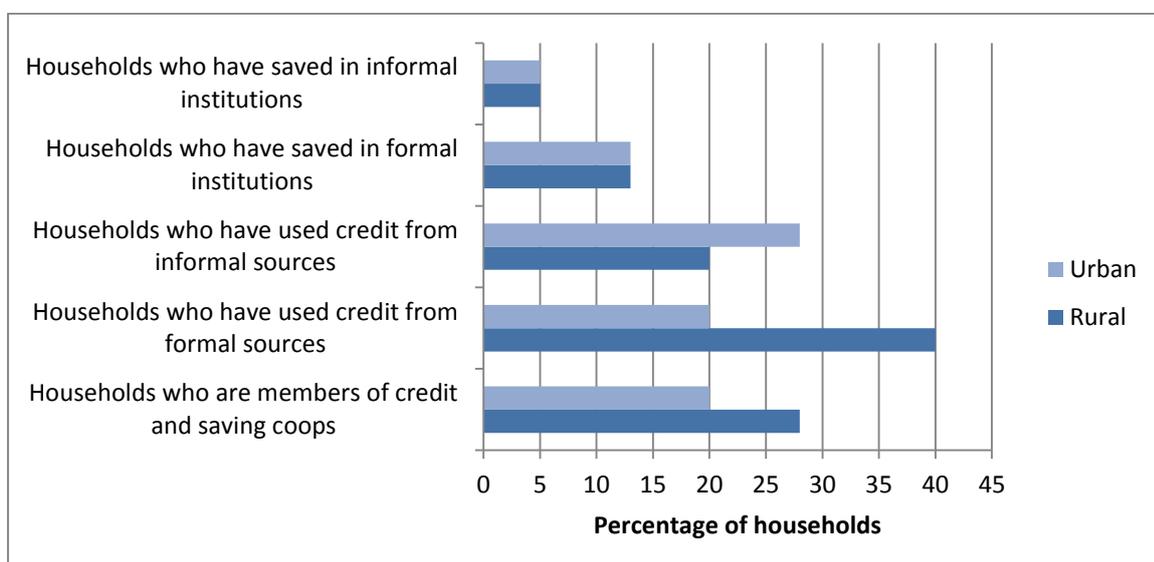


Figure 7.8 Savings and loans using formal and informal institutions in Tambacounda

Households' attitude towards credit varies directly with their location in rural or urban areas. In rural areas, loans are almost entirely taken on to support on farming and livestock-related activities, whilst in urban areas only 29 per cent of the credit pertains to livestock. The remainder of loans are taken out for other purposes, such as for the purchase of household equipment, including cookstoves.

Although there is a definite need for clean cooking solutions in Tambacounda, the survey findings clearly indicate that both urban and rural households in the region are not interested in PPO. Other solutions, such as briquetting in urban areas and biogas in rural areas, are likely to be considerably more appropriate and more easily accepted.

7.4 Supply side

The production of PPO in Senegal has been going on for a number of years. It has mainly been obtained from the *Jatropha curcas* plant, and a number of organisations, including the United Nations Development Programme (UNDP), have helped support the sector, in

particular under their regional programme on multifunctional platforms for productive uses of energy. As well as being used in diesel generators that have been adapted, PPO can also be used directly in household cookstoves, such as the PROTOS stove developed by Bosch Siemens (although this initiative has since gone out of business). The production and potential use of PPO have been piloted – particularly in the rural regions of Tambacounda, Kolda and Kédougou, where PROGEDE are currently working – although there are major issues in securing a good supply of feedstocks on which the PPO is based.

Production of PPO from *Jatropha* is specifically featured in Senegal’s agricultural strategy (ENDA 2010). With regard to the supply chain and irrespective of the end use (cooking fuel, transport, electricity generation) the Ministry of Agriculture has set up the following principles:

- *Jatropha* producers should receive sufficient financial incentives;
- The majority of shares should be owned by Senegalese private capital along the whole supply chain;
- Because land is the responsibility of local authorities, there should be no lease or sale to developers of biofuel.

In the Tambacounda region, over 600 hectares in *Jatropha* have been planted by PROGEDE and private operators. The initial objective of biofuel production was for local consumption; however, today the only current market in the region is the production and selling of seed to processors outside Tambacounda that extract the oil for uses other than cooking.

PROGEDE has been involved in *Jatropha* plantations for biofuel production since 2003. Working with local artisans, PROGEDE has also developed a stove for cooking with *Jatropha*, although this stove never quite reached the market, and the study team found no information on how well it performs in relation to other household cooking stoves.

The current estimated price for one litre of *Jatropha* oil is CFAF 700, which equates to a price of CFAF 35/MJ (about three times the price per megajoule of charcoal in the region). Discussions with local PROGEDE staff make it clear that a real market for *Jatropha* oil for cooking, and its related stove, has never really developed in Tambacounda, and is unlikely to do so in the future.

According to an interviewee¹⁹, the main reasons for lack of penetration of PPO in the region were technical:

- During PROGEDE 1, a traditional, locally manufactured press was used to extract the oil from *Jatropha* seeds. The oil was then dirty and very smoky when burnt. For this reason households could not see the benefits of this cooking solution.
- During PROGEDE 2, technical issues were caused by lack of knowledge transfer to local technicians: the processing machinery was imported, but without the sufficient technical support.

According to Mr Diouf, for these reasons farmers have lost faith in *Jatropha* oil and have started to uproot their plantations. During the last four years, some research has been carried out into the potential of PPO extracted from sunflower, sesame and cotton plants. Evidence of its potential as a household cooking fuel has not emerged, however, so it is unlikely that it will become commercially viable in the short term.

¹⁹ Maïmouna Diouf, a local employee of PROGEDE, was interviewed in July 2013.

7.5 Conclusions and recommendations

With most of rural population of Tambacounda relying on firewood, and most urban households relying on charcoal and firewood (most of which is not harvested efficiently or sustainably), there is an immediate need for action to create a market for more sustainable cooking solutions in the region.

However, quite early on during the interviews and surveys it became clear that there is no current market potential for PPO as a household cooking fuel in Tambacounda. Although there is a clear need for alternative fuels in the region, using PPO for cooking does not seem to be a feasible solution, at least not in the near future, and particularly considering the poor reputation of *Jatropha*.

In addition, the Tambacounda region is very well-endowed with biomass resources, making charcoal and firewood the least cost options, even when charcoal is used with an improved stove. As shown in Figure 7.9, charcoal and firewood are from three to seven times cheaper than *Jatropha* oil. It is therefore very unlikely that PPO will displace or be used as complimentary to traditional biomass (firewood and charcoal), particularly when the benefits of using PPO (such as its clean burning potential and its ease of use) have not been shown. The development of biogas might be considered as an alternative option.

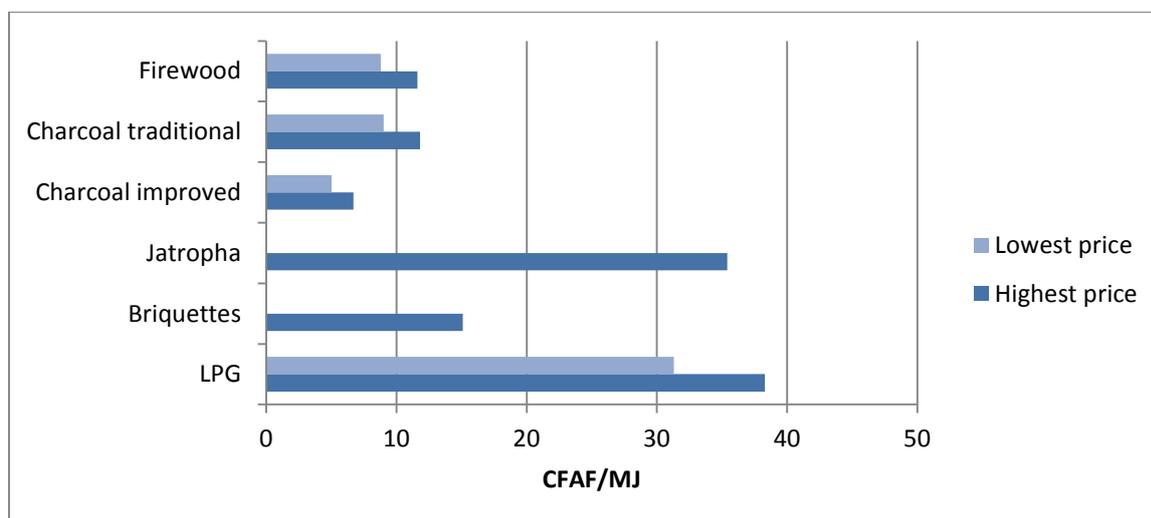


Figure 7.9 Cost comparison of different fuels in Tambacounda

Note: see Annex A for methodology.

Although not planned as part of this study, a demand for biogas (already present in the region) and briquetting clearly emerged. Further analysis of the feasibility of (a) extending the use of these two fuels in the region and (b) linking of them to initiatives in other regions of Senegal (particularly Saint-Louis and Kaoloack) and at national level is thus recommended.

PPO seems to have a great production potential; however, despite all the initiatives that have been developed so far, it has been fairly unsuccessful. Lessons from the pilots conducted in Senegal and the surrounding region provide important information for the future development of PPO, but so far the existence of a viable market for it as a cooking fuel has not been proved.

Finally, it is recommended that before any programme on household cooking using PPO starts, more research is needed to test PPO as a household cooking fuel, including the potential development of a suitable stove. Such research would increase understanding of

how well it performs in terms of emissions, efficiency and ease of use from a household perspective. Before this is done, it is recommended that of the four alternative fuels assessed, PPO be given the lowest priority.



8. Final conclusions and recommendations

8.1 Briquettes in urban and peri-urban Dakar

The capital of Senegal is likely to be one of the most important demand centres for any alternative fuel commercialised in the country. Although it is important to consider how the utilisation of LPG can be extended within both urban and peri-urban households in the Dakar region, an understanding of the still relatively high (and growing) use of biomass fuels is important in the context of alternative fuels, particularly biomass briquettes. The use of briquettes could partially or wholly replace charcoal and firewood in Dakar's urban and peri-urban households and, if used with more efficient stoves, could offer a cleaner burning and cheaper alternative without the need for major behavioural change.

It is estimated that the sale price of briquettes in Dakar will depend on the transport price, and will fluctuate between CFAF 150 and CFAF 200 per kg. In Dakar, the comparison of cost per megajoule (MJ) shows that CFAF 20.2 per MJ is about half the cost of charcoal and two thirds that of LPG. Thus, it should be relatively easy for retailers to sell briquettes once the end users start to understand their benefits, in particular that briquettes compare very favourably with charcoal for cooking, with no major disadvantages provided they are produced to a high quality.

To scale up the demand for briquettes and develop a market, the following recommendations should be considered:

- A national, urban-focused, awareness-raising campaign should be started, initially focusing on the urban centres of Dakar, Saint-Louis and Kaolack. It would target both urban and peri-urban households, highlighting the performance qualities of briquettes as well as money savings and the potential long-term benefits in terms of time savings and health.
- A stove with a market price of under CFAF 10,000 should be developed for the Senegal market. This seems feasible, based on the price of improved stoves suitable for briquette use currently being produced in Senegal.
- The main challenges are likely to be (a) maintaining the quality of production compared to charcoal and (b) scaling up production to meet potential demand. The current supply chain is still fairly informal and only contributes to a very small percentage of household cooking usage; further research on a range of briquetting technologies is thus needed to ensure which feedstock can be turned into high-quality briquettes that meet the requirements of the end users.
- Business and technical capacity building needs to be carried out to support a range of small and medium enterprises (SMEs) in different regions of Senegal, allowing them to set up briquetting production companies.
- Available feedstock for production of briquettes should be mapped out throughout Senegal and quality of different feedstock tested relative to charcoal.
- To further support the development of the briquetting sector, the government of Senegal must begin to tackle the unregulated and illegal production of charcoal.
- The development of an entire supply chain (or the integration to other supply chains, such as that for charcoal) – from the collection and production of the feedstock (such as charcoal dust collection) to production, distribution and retailing – offers an important opportunity for job creation and income production. The large-scale

transportation of the briquettes from their place of production, in the areas of significant agricultural residue and charcoal production, can be based on the current transportation routes used by charcoal.

- The relatively well-developed formal and informal savings and loans systems in Dakar could be supported in developing specific loan packages for alternative fuel stoves.

In conclusion, if a number of market barriers can be overcome and a positive enabling environment for briquette production developed – including the development of standards and quality control, tax incentives, and awareness-raising programmes, as well as a range of supporting services including appropriate credit and capacity-building support – then a thriving market chain of briquette producers, distributors and retailers should emerge to supply the potential significant demand in urban and peri-urban households of Dakar. The focus group discussions made it clear that briquettes could be perceived as a ‘charcoal-plus’ fuel, in the sense that they are used by households in a similar way to charcoal whilst being slightly more efficient and cleaner burning, and fairly comparable in terms of price.

8.2 Ethanol in urban Saint-Louis

The findings of this study show a clear degree of potential for the development of an ethanol market in Saint-Louis. Ethanol use offers households a range of social, economic and health benefits and provides opportunities for businesses involved in its production.

The development of an initial ethanol market should target existing LPG users and urban charcoal users who use LPG as a secondary fuel. Most cook with simple stoves, and the related health issues affect mostly women.

In the Saint-Louis region, briquettes (CFAF 15.1/MJ) remain the least-cost option in terms of CFAF per MJ, followed by ethanol (CFAF 22.9/MJ) and charcoal used with improved stoves (CFAF 23–53/MJ).

Assuming that the current price of CFAF 320 per litre does not decrease (this price is suggested by CSS), and based on results from other studies that show an average household consuming one litre of ethanol per day, a total of CFAF 9,600 would cover the monthly cooking fuel expenses for an average urban household. This is in line with the benchmark of CFAF 10,000 that emerged from discussions with urban households, and would make ethanol competitive with both LPG and charcoal used with improved stoves.

One of the main barriers to penetration of ethanol is the cost of the stove, which is much more expensive than either the improved charcoal stove or an average LPG stove. For example, a subsidised ethanol stove in Mozambique costs US\$30 (CFAF 15,000), approximately two to two-and-a-half times the price of an improved charcoal stove in Saint-Louis. Any marketing initiative could consider offering the option of a nine-month period to pay back the loan needed to purchase an ethanol stove. Assuming an interest rate of 18 per cent, this would result in nine monthly instalments of CFAF 1,794/month, which is in line with (a) the capacity of low income households and (b) the current practice of micro-financial institutions in Senegal. Alternatively, bundling of the stove with the sale of ethanol is another possibility, which would enable payment for the stove in instalments through the purchase of the fuel.

The recommendations are as follows:

- CSS has expressed an interest in testing this market and particularly in seeing the 550,000 litres of 'head ethanol' commercialised. This means there is potential for starting a market for 1,500 households in urban Saint-Louis (at 1 litre per household per day).
- Of course, although ethanol is currently fairly competitively priced, a functional supply chain needs to be developed. Links with the kerosene and LPG supply chain should be considered.
- As ethanol for cooking is almost completely unknown in Saint-Louis, a campaign to target urban households should be launched before starting any pilot or commercialisation.
- Finally, it is also possible that if ethanol can be produced in sufficiently large quantities, and if the price is competitive, it could start to displace or complement LPG in other urban areas, including Dakar. However, to make this a reality, a long-term development strategy is required, including the establishment by the authorities of an attractive framework for the private production of ethanol as a household cooking fuel, as well as for suitable stoves and awareness-raising campaigns to create the demand from the end users.

8.3 Biogas in rural Kaolack

The study shows that rural Kaolack has the right social and agricultural conditions for the penetration of biogas technology; however, it still lacks sufficient awareness of the benefits of the technology to really reach scale. Although the newly-established National Domestic Biogas Programme aims to promote household use of biogas systems through the provision of subsidised systems and loans, it is recommended that the government of Senegal support the development of a range of biogas suppliers in the region that are currently either to (a) construct the biogas systems or to (b) train the end users to maintain them.

The study shows that:

- There is a good level of awareness around biogas in the Kaolack region, and many households are clearly interested in the technology. However, awareness of the national biogas programme is lacking, and its benefits are thus not being enjoyed by the households for which it was designed.
- If the subsidies and loans were accessed, considering current fuel consumption and costs, a 4 m³ biodigester could be paid back in 1-1.3 years. The survey also reveals that households in the region are used to accessing both formal and informal loans, suggesting the potential for developing a specific microcredit mechanism for households willing to purchase biodigesters as well as for entrepreneurs willing to invest in biogas.
- There are insufficient biogas technology suppliers in the region, and the few that do exist suffer from low profit margins due to weak demand. The main constraint is the low purchasing power of the majority of households, coupled with the high up-front cost of the technology.

The recommendations of this study are as follows:

- The National Domestic Biogas Programme should further support the development of biogas enterprises in Kaolack, providing a wide range of services from installation to maintenance.
- To stimulate demand, the government of Senegal should develop a programme to support the development of a range of biogas suppliers in the region. The national biogas programme needs to become active at the regional level. Local enterprises and micro-finance organisations need to be fully involved so that households can access loans and subsidies.

8.4 Pure plant oil in Tambacounda

With the majority of the rural population relying on firewood and most of the urban households using charcoal for cooking, in Tambacounda there is an immediate need for action to provide access to sustainable cooking solutions. However, although the region has the right conditions for PPO production, its application for cooking does not seem to be feasible. Attempts to use other PPOs besides *Jatropha* for cooking have also been fairly unsuccessful. Indeed, as Tambacounda region is well-endowed with biomass resources, charcoal and firewood are the least-cost options. It is therefore very unlikely that alternative cooking fuels will displace traditional biomass.

Insights from producers showed that the quality of oil produced was low for various technical reasons. The prices per megajoule of biomass range from CFAF 5 (for charcoal used in improved stoves) to CFAF 11.8 (for charcoal used in inefficient stoves), and from CFAF 31.2 to CFAF 38.3/MJ for LPG. PPO obtained from *Jatropha* is now sold at CFAF 700 per litre, or CFAF 35.4/MJ. It is therefore very unlikely that the production of PPO will displace traditional biomass fuels unless they prove to be competitive both in terms of affordability and quality, particularly from the perspective of emissions and usability. It is also unlikely that the minority of households using LPG in Tambacounda will shift to *Jatropha*, again, unless the economical and cleanliness advantages could be demonstrated.

Although in Tambacounda the survey focused on the feasibility of PPO, results revealed a clear demand both for biogas (already in use in the region) and briquettes. We thus recommend further analysis of the feasibility of (a) stimulating demand for these two fuels in the Tambacounda region and (b) integrating them with similar initiatives, both in other regions and at the national level.

8.5 Feasibility of introducing alternative fuels in the four regions

Table 8.1 summarises the potential feasibility for immediate short term up-scaling for each of the four alternative fuels assessed in each of the regions examined in the study.

		Briquettes (Dakar)		Biogas (Kaolack)	Ethanol (Saint-Louis)		PPO (Tambacounda)	
		urban	peri-urban	rural	urban	rural	urban	rural
demand	Need for cleaner fuels	yellow	green	green	green	green	green	green
	Awareness/reputation	red	yellow	green	yellow	red	red	red
	Economics	green	green	yellow	yellow	red	yellow	red
supply	Production capacity	yellow	yellow	yellow	green	green	red	red
	Potential business	yellow	green	green	green	yellow	red	red
	Distribution	green	green	yellow	yellow	red	red	red
	Feasibility	Medium	high	high	high	low	low	low

Table 8.1 Feasibility levels of the four alternative fuels in the four regions

Note: green=high, yellow=medium, red=low

The study demonstrates that (a) not all alternative fuels have an equal potential for dissemination and uptake in Senegal, and that (b) there is much greater potential for immediate action and short-term dissemination of briquetting in the urban and peri-urban areas of Dakar and in rural Kaolack, and of ethanol in urban Saint-Louis.

The conclusions are:

- The penetration of briquettes in Dakar is highly feasible.
- There is a good opportunity for testing ethanol in Saint-Louis, as both supply and demand conditions there are ideal.
- The development of a biogas market in rural Kaolack has high potential, but it will depend on tailored financing schemes being developed.
- PPO for cooking is not a feasible option in Tambacounda, where further analysis of the potential of biogas use should be carried out.

A number of general conclusions can be drawn from the four regional assessments. These include:

- The geographical location of households (particularly between rural, peri-urban and urban areas) as well as their social characteristics (whether they are poor or more affluent) has a significant impact on the demand and potential for each of the alternative fuels assessed. Because of this variability, any national-level promotion plan for each of the four alternative fuels under consideration will need to be carefully tailored to meet these differences.
- Many rural households continue to see domestic energy as a free commodity, even if they clearly identify smoke and time as serious issues related to their fuel utilisation and collection. Before the penetration of alternative fuels can be realistically considered, a longer-term strategy – one that focuses on awareness creation and supply chains for alternative fuels – would be more appropriate for this section of the population.

- Field results show a strong correlation between willingness to pay and awareness of alternative fuels. An important recommendation is to develop well-grounded marketing campaigns to increase demand for alternative fuels. This will in turn lead to the increased willingness of households and small businesses to invest in these fuel production technologies and stoves.
- Awareness-raising campaigns and marketing initiatives should focus on the key benefits of alternative fuels, in particular the cost savings and time savings (both in terms of cooking and collecting firewood) they present, along with the health benefits resulting from reduced emissions.



Annex A. Methodology for calculation: prices, efficiency and calorific values

1. Prices

The prices for firewood and charcoal shown in Table A-1 are extrapolated from the survey data and expressed in terms of in CFAF/MJ of useful energy. According to the survey, there are sharp price differences according to region, particularly for firewood and charcoal. All prices were converted into CFAF/MJ to get the relevant cost comparisons, taking into consideration (a) calorific value, (b) efficiency of equipment and (c) various assumptions on the prices depending on the fuels.

Saint-Louis		Tambacounda		Kaolack		Dakar	
Firewood prices							
<i>Per unit sold</i>	<i>Per kg</i>	<i>Per unit sold</i>	<i>Per kg</i>	<i>Per unit sold</i>	<i>Per kg</i>	<i>Per unit sold</i>	<i>Per kg</i>
1,000 per 10 kg	100	100 per 5.25 kg	19	200 per 3 kg (large logs)	66.6	NA	NA
2,000 per 25 kg	80	5,000 per 200 kg	25	100 per 2 kg (small logs)	50	NA	NA
Charcoal prices							
300 per 1 kg pot	300	100 per 1.5 kg pot	66	250 per 1 kg pot	250	NA	250
3,500 per 15 kg bag	233	2000-2500 per 50 kg bag	40-50	6,000 per 50 kg bag	120	NA	NA
9,000 per 50 kg bag	180	5,000 per 100 kg bag	50	NA	NA	NA	NA
LPG prices							
2,200 per 2.7 kg tank	814	2,200 per 2.7 kg tank	814	2,200 per 2.7 kg tank	814	NA	814
4,000 per 6 kg tank	666	4,000 per 6 kg tank	666	4,200 per 6 kg tank	700	NA	666
Price of alternative cooking fuels							
<i>Briquettes</i>							
150		150/kg		150/kg		200/kg	
<i>Jatropha</i>							
non-relevant		700/l		non-relevant			
<i>Ethanol</i>							
320		non-relevant		non-relevant		320/l	

Table A-1. Fuel prices in the four regions (CFAF)

LPG prices are fixed. However, there are some minor differences according to region:

- Prices for charcoal briquettes are based on information supplied by Brades. This is still a limited market. Assuming large-scale production, detailed calculations need to be carried out;
- Currently there is no market either for ethanol as a cooking fuel or for Jatropha oil. Prices were obtained from ENDA and the producers. The price of Jatropha was estimated at CFAF 700 per litre and ethanol at CFAF 320 per litre.

2. Efficiency

The efficiency figures in Table A-2 are based on the literature for, and consultant experience with, stove technologies in Senegal in particular and in West Africa in general.

Type of stove	Efficiency	Average efficiency
Three-stone	10–14%	12%
Traditional charcoal	16–20%	18%
Improved charcoal	30–34%	32%
LPG, ethanol, Jatropha PPO	45–55%	50%

Table A-2. Average efficiency of various stove types

For each type of stove there are no differences in energy efficiency across the four regions.

3. Calorific values

The respective average calorific values are as follows:

- Firewood: 18 MJ/kg
- Charcoal: 31 MJ/kg
- LPG: 42.5 MJ/kg
- Briquettes : 31 MJ/kg
- Ethanol: 28 MJ/litre
- *Jatropha*: 39.5 MJ/litre²⁰

²⁰ <http://www.jatrofuels.com/170-0-Calorific+Values.html>.

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