



ANALYSIS OF THE SATISFACTION OF HOUSEHOLD USERS OF THE IMPROVED COOKING STOVE AND LIQUEFIED PETROLEUM GAS IN KINSHASA, CONGOⁱ

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Abstract:

This study analyses the satisfaction of 148 and 47 households who respectively adopted the improved cooking stove and the liquefied petroleum gas (LPG) in 2020 out of a sample of 1154 households. It sought to identify the critical parameters on which to focus for the continued use of the improved cooking stove and the LPG for cooking. The data was collected via a survey to evaluate the level of satisfaction of households surveyed using the improved cooking stove or the LPG. It emerges from this study that the households using the improved cooking stove are satisfied with this stove, especially the imported brands or those produced by the specialized structures. On the other hand, stoves made by local craftsmen are less appreciated. For liquefied petroleum gas, its price and the difficulties in obtaining it constitute the elements of the dissatisfaction of user households. The Congolese government should make it easier for local craftsmen who are increasingly embarking on the manufacture of improved cooking stoves, on the one hand, and subsidize the price of gas to make it more accessible to most Congolese households who are poor.

ⁱ ANALYSE DE LA SATISFACTION DES MENAGES UTILISATEURS DU FOYER AMELIORE ET DU GAZ DU PETROLE LIQUEFIE A KINSHASA

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Résumé :

La présente étude analyse la satisfaction de 148 et 47 ménages qui ont adopté respectivement le foyer amélioré et le gaz de pétrole liquéfié en 2020 sur un échantillon de 1154 ménages. Elle a cherché à identifier les paramètres critiques sur lesquels il faut se focaliser pour utilisation continue du foyer amélioré et du GPL pour la cuisson. Les données ont été collectées via une enquête sur le niveau de satisfaction de l'utilisation du foyer et/ou du GPL par les ménages enquêtés. Il ressort de cette étude que les ménages utilisateurs du foyer amélioré en sont satisfaits, surtout les marques importées ou celles produites par les structures spécialisées. Par contre, les foyers fabriqués par les artisans locaux sont moins appréciés. Pour le gaz de pétrole liquéfié, son prix et les difficultés pour s'en procurer constituent les éléments de l'insatisfaction des ménages utilisateurs. Le gouvernement congolais devrait accorder plus de facilité aux artisans locaux qui se lancent de plus en plus dans la fabrication des foyers améliorés, d'une part ; et de subventionner le prix du gaz pour le rendre plus accessible à la majorité des ménages congolais qui sont pauvres.

Mots clés : foyer amélioré, GPL, satisfaction, Kinshasa

1. Introduction

It is estimated that around 400 million people use charcoal as their primary cooking and heating fuel worldwide (UNDP and WHO, 2009). In sub-Saharan Africa, more than 80% of urban households use charcoal as their main source of cooking energy, and demand is expected to increase for several decades (Zulu and Richardson, 2013). This trend, coupled with inefficient wood fuel production and consumption practices and the inaccessibility of most households to other forms of reliable and affordable commercial energy, is unlikely to change soon. Thus, the abusive and unsustainable production and use of these fuels lead to negative environmental impacts including deforestation and forest degradation.

The adoption of improved cooking stoves (ICS) by households in sub-Saharan countries is considered to be one of the effective means of fighting deforestation and forest degradation and thus reducing greenhouse gas emissions (Giachewa and Tolerab, 2018; Schure, 2014; FAO, 2017) by the fact that it is more efficient in fuel use than the traditional stove. In addition, the use of this stove can save cooking time, reduce the negative impact on the health of the user due to the reduction of carbon monoxide (CO) emissions in particular and smoke, and improve cooking satisfaction (Barnes et al., 1994, Urmee and Gyamfi, 2014, World Bank, 2011).

Liquefied petroleum gas (LPG) appears to be a suitable alternative to the massive use of wood energy by households. LPG allows food to be cooked faster with fewer emissions of gas. It emits much less sulphur dioxide (SO₂) than kerosene or biomass

(Goldemberg, 2000). It is used by nearly three billion people worldwide (Van Leeuwen et al., 2017).

Given that the Congo Basin forest is subject to deforestation and the exploitation of wood energy is one of the driving forces of this deforestation, the government of the Democratic Republic of Congo (DRC) has taken initiatives to make the production and use of wood energy sustainable. These initiatives include the promotion of ICS and LPG, considering that the DRC had a low percentage of households that use ICS and LPG (Schure, 2014).

A study was carried out in 2020 to estimate the adoption rates of ICS and LPG by Kinshasa households, to highlight the determinants of these adoptions, and to assess their impact on deforestation. Thus, 15.6% and 4% of households out of a sample of 1154 households adopted the ICS and LPG respectively (Belani et al., 2023b). Since the adoption of a new cooking device is seen as a *“complex and dynamic process and one step in a larger process”* (Pareek and Chattopadhyay, 1966) of technology absorption (Murphy, 2001), cultural adaptation and *“appropriation”* of technology (Overdijk and Van Diggelen, 2006), it was necessary to return to the same households after a period to assess the use of the new technologies adopted. More concretely, this evaluation seeks to answer the following questions: does the household that has adopted the ICS or LPG continue to use it? is he satisfied with the use of the object adopted? what are the parameters or factors to be improved to ensure the continuity of their use?

Thus, the present study aims to determine the level of satisfaction of households that have adopted the ICS or LPG. Customer or user satisfaction is the basic principle of the modern concept of marketing which aims to identify priorities for improvement and to follow the evolution of the perception of a product or service over time (Yatnalli et al., 2021). Otherwise, customer satisfaction is the result of the customer's comparison between their initial expectations and their perception of product performance. As a result, customer satisfaction appears subjective, it is based on the perception of the customer, in this case, of the users of the ICS and LPG.

2. Materials and Methods

2.1 Source of data

The data used in this report come from surveys conducted among households subdivided into two groups (adopters of ICS and those of LPG). In fact, the population surveyed in this study is made up of 148 households in the city of Kinshasa in the Democratic Republic that adopted the ICS in 2020 and 47 other households who have adopted LPG, in total a sample of 1154 households (Belani et al., 2023). The heads of these households were interviewed using a questionnaire designed to inform the research questions. Data collection was done using tablets. Kobo Toolbox software was used to design the digital questionnaire and transfer data from the tablets to the server.

To measure the level of satisfaction of the users of ICS and LPG, the respondents were asked to comment on the assertions scored using the Likert scale. The Likert scale

is a psychometric tool for measuring an attitude in individuals, developed by Rensis Likert in 1932. It consists of one or more affirmations (statements or items) for which the person questioned expresses his degree of agreement or disagreement (Alwin and Krosnick, 1991). In the questionnaire used, the proposed Likert scale has five ordinal modalities taking the following values: 5. Totally agree; 4. Agree; 3. Neither disagree nor agree (or neutral); 2. Disagree; 1. Strongly disagree.

2.2 Data analysis methods

Microsoft Excel and the Statistical Package for the Social Sciences (SPSS) were used to analyse the data. The data collected were statistically analysed in absolute and relative frequencies and presented in the form of tables and graphs. For the questions on satisfaction, the aggregate means of the responses are interpreted according to the method proposed by Allen and Seaman (2007) as shown in Table 1.

Table 1: Interpretation

Interval	Interpretation
4.2 – 5.0	Totally agree
3.4 – 4.2	Agree
2.6 – 3.4	Neither disagree nor agree
1.8 – 2.6	Disagree
1.0 – 1.8	Strongly disagree

These analyses made it possible to:

- know the proportion of households that continue to use ICS and LPG;
- identify the reasons for abandoning the use of the ICS and LPG;
- indicate the level of satisfaction of each of the parameters assessed for ICS and LPG.

3. Results

3.1 Use and satisfaction of ICS

This section provides an overview of the daily use of the ICS (Figure 1) by the 148 households in the city of Kinshasa. These households are those who have adopted the ICS out of a sample of 1,154 households surveyed in 2020. This section also presents the level of satisfaction of these households with the use of the ICS.

Of 148 households that adopted the ICS in 2020, 145 continue to use it for cooking food, i.e., 98.3% of adopting households (Table 2). For the 1.7% of households that no longer use the ICS, the only reason given to explain the cessation of use is that their ICS acquired in 2020 is out of use. They wait until they have money to get another one.

Table 2: ICS use by respondents

Use	Effective	Percentage
Keep using	145	98.3%
No longer use	3	1.7%
Total	148	100.0%

Figure 1: Charcoal ICS

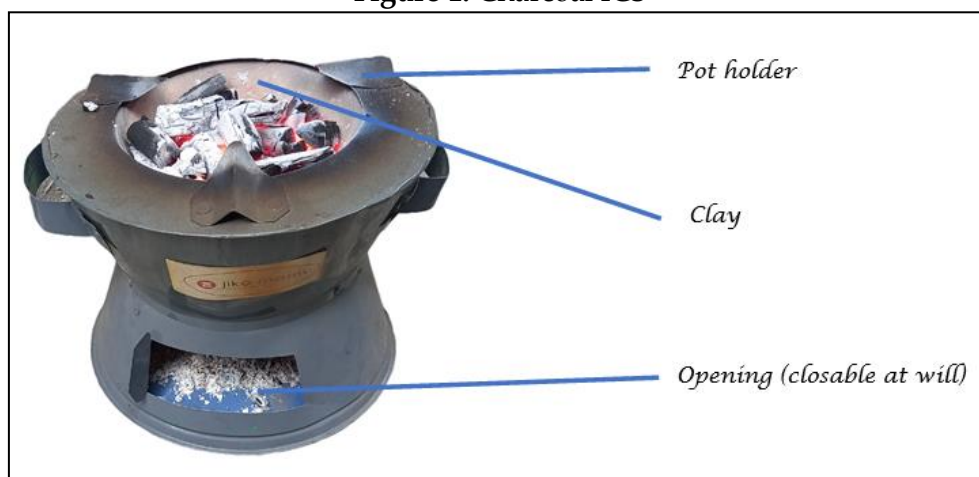


Table 3: Descriptive statistics on ICS user satisfaction (in score)

Parameter	N	Minimum	Maximum	Mean	Standard deviation
The ICS has a long service life	142	1	5	4.32	0.955
The potholder has a long service life	142	1	5	3.81	1.224
The closure has a long service life	128	1	5	3.47	1.104
The clay has a long service life	142	1	5	3.73	1.157
The ICS uses less charcoal than the traditional stove	142	3	5	4.42	0.622
The ICS is quicker in cooking than the traditional stove	142	3	5	3.61	0.695
The ICS emits less smoke than the traditional stove	142	2	4	2.86	0.437
Adjusting the intensity of the fire is easy with the ICS than the traditional stove	142	1	5	3.98	1.182

Note: 5. Totally agree; 4. Agree; 3. Neither disagree nor agree (or neutral); 2. Disagree; 1. Strongly disagree.

Regarding the satisfaction of households of Kinshasa surveyed on the use of the ICS, Table 3 shows that these households fully agree with the two assertions out of eight proposed for evaluation: "The ICS has a long life service" and "The ICS uses less charcoal than the traditional stove" (Figure 2); they agree to five assertions; "The potholder has a long service life", "The closure has a long service life", "The clay has a long service life", "The ICS is fast in cooking than the traditional stove" and "Fire adjustment is easier in the ICS than in the traditional stove". They neither agree nor disagree with a single statement: "The ICS emits less smoke than the traditional stove".

The 145 households out of 148 who continue to use the ICS appreciate its durability. The ICS lasts for a long time because it is manufactured with a sheet of steel, with a minimum thickness of 0.6 mm. So, many of these households declared that they had not changed ICS since 2020. Whereas with the traditional stove, it is rare to exceed one year of regular use. As for the comparison of the quantity of charcoal used between the ICS and the traditional stove for the same use, they affirm that with the ICS the quantity of charcoal used decreases by 30% or even 50% compared to the traditional

stove. They justify this drop in the quantity of charcoal consumed by the configuration of the ICS which contains fewer openings, unlike the traditional stove. This disposition allows the heat emitted during the combustion of charcoal to be channelled toward the opening on which the pot is placed. It minimizes the heat losses that are seen through the openings of a traditional stove. In addition, the clay contained in the ICS allows the heat to be maintained for a long time.

Figure 2: Traditional stove



Apart from the durability of the ICS, the interest was also focused on the components of this ICS: the support on which the pot is placed, the closure (of opening), and the clay. For the pot supports or "ears" which are made with mild steel metal bars that are triangular in shape, on which the pot rests, the interviewed households declare that the only precaution that the user must take is to avoid these pieces being wet during a long time, otherwise, they will rust and then break. For the opening, the device that allows the level of fire intensity to be adjusted, households using ICS are satisfied with both its durability and the possibility of adjusting the intensity of the fire. The closure is one of the innovations brought by the ICS compared to the traditional stove. It is a sliding closing device that can be completely or partially opened depending on the intensity of heat desired during cooking. To put out the fire, just turn it off completely. Unfortunately, some ICS made by local craftsmen do not have them. As for the clay or the ceramic insert, it is considered to have a short service life, particularly those contained in the ICS made by local craftsmen. Indeed, the ceramic insert used in the manufacture of the ICS must be made from a suitable clay and fired between 700°C and 900°C in an oven. However, the ICS made by these craftsmen contains only simple clay not baked in the oven. Regarding the cooking speed, the comparison between the ICS and the traditional stove on the speed in cooking, the surveyed households affirm that the ICS is faster in cooking compared to the traditional stove. This is more significant in case there is a strong airflow when cooking food. This is due to the opening of the ICS.

Regarding the comparison of the quantity of smoke released between the ICS and the traditional stove, all the households interviewed believe that the ICS does not release less smoke than the traditional stove. Curiously, the majority even affirm that both stoves do not emit smoke. They state that both fire pits only emit smoke if the charcoal used is wet or not fully charred.

To close this section, the interest was to know if the 142 households that continue to use the ICS have completely abandoned the traditional stove. The results show that 55 households (39%) continue to use the traditional stove even though they have adopted the ICS. They use the traditional stove as a second stove when preparing two meals simultaneously. Also, they think that the traditional stove is better than ICS to cook certain meals such as braised fish or chicken.

3.2 Use and satisfaction of LPG

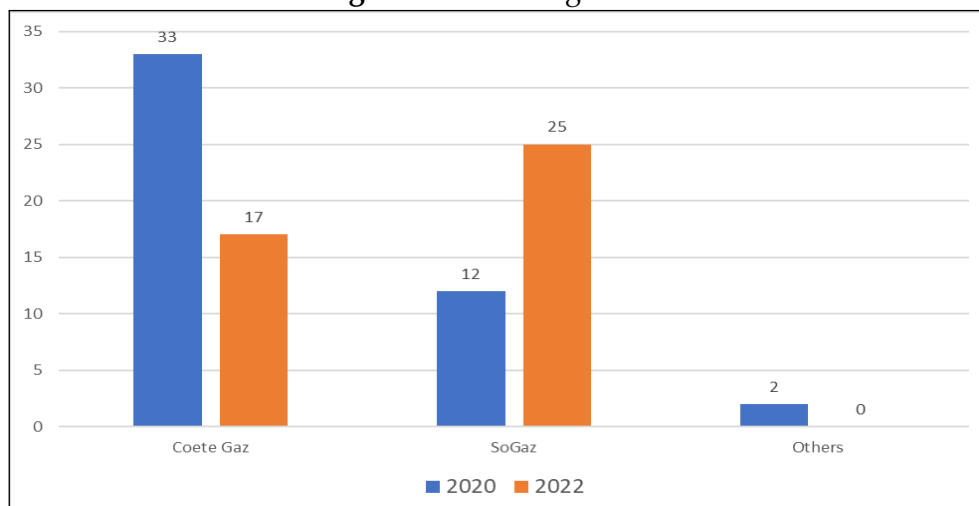
This second section focuses on aspects related to the use of LPG by the 47 households who adopted this fuel in 2020 out of a sample of 1154 households in the city of Kinshasa. It also presents their level of satisfaction with the use of cooking with LPG.

Table 4: Continuity in the use of GPL

Use	Effective	Percentage
Keep using	42	89.3
No longer use	5	10.7
Total	47	100.0

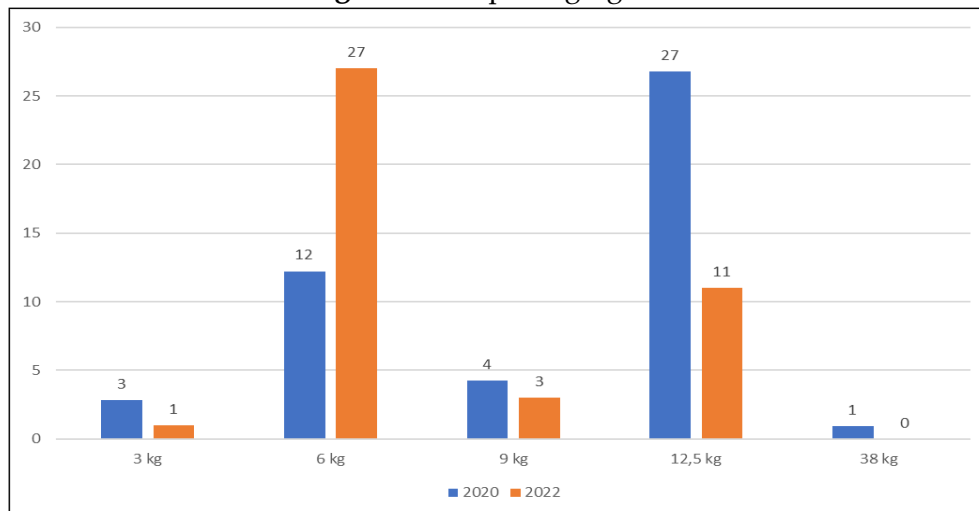
On the continuity use of LPG by the 47 households that adopted LPG in 2020, Table 4 shows that 42 households out of 47, i.e., 89.3%, continue to use it as cooking energy. Thus, 5 households, i.e., 10.7%, have stopped using LPG. Several reasons led these households to no longer use LPG. These include the fear of fire after the unfortunate accident, with the death of men, experienced by a family in the commune of Kalamu in Kinshasa, the unavailability of gas in the usual place of purchase, and the increase in the price of gas.

Figure 3: Brand of gas used



Regarding the brand of gas used by households, Figure 3 compares the current situation and the situation of 2020. It appears that 17 households out of 42, i.e., 40.5%, use gas from COETE-GAZ, the first company to settle in the gas market in Kinshasa, and 25 households out of 42, or 59.5%, use gas from SO'GAZ. Whereas in 2020 the situation was different, the market was dominated by the company COETE-GAZ. In 2020, 33 households out of 47, i.e., 70.21%, were using gas from COETE-GAZ, 12 households out of 47, i.e., 25.53% were using gas from SO'GAZ and 2 households out of 47, i.e. 4.26% were using other brands from abroad. So, from 2020 to 2022, COETE-GAZ saw 5 of its customers stop using its gas and 11 others migrated to SO'GAZ. In addition, the 2 households using other brands in 2020 joined SO'GAZ during the period. This change is explained, on the one hand, by the promotional campaign carried out by SO'GAZ in 2020 and, on the other hand, by the fact that COETE-GAZ has experienced numerous supply difficulties resulting in supply shortages its points of sale around the city of Kinshasa.

Figure 4: Gas packaging used

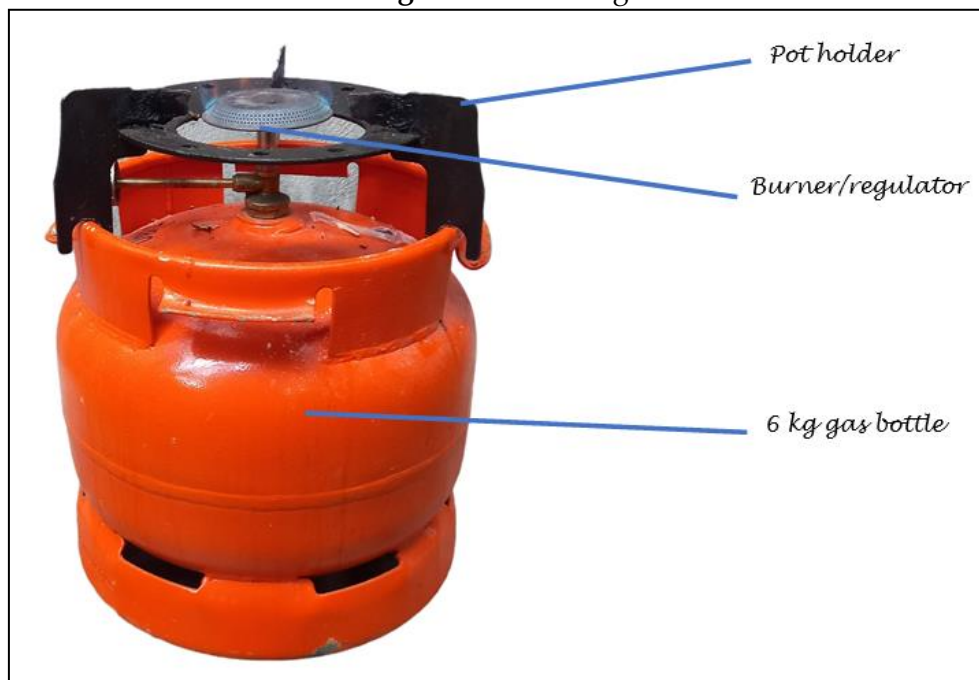


Changing the brand of gas used is not the only change made by LPG users. The type of packaging used has also changed (Figure 4). The notable difference is in the use of the 12.5 kg bottle (Figure 5), which was the most used packaging in 2020 by 27 out of 47 households, i.e., 57% of households surveyed. In 2022 only 11 households out of 42 still use 12.5 kg packaging, i.e., 26% of respondents. While the 6 kg bottle (Figure 6) which was used by 12 households out of 47, i.e., 26%, in 2020, is used in 2022 by 27 households out of 42, or 64% of households surveyed. The main reason given for the change in the type of packaging is the increase in the price of gas. Having difficulty in obtaining supplies of 12.5 kg bottles, the price of which has gone from 42,000 to 54,000 CDF, households are falling back on the 6 kg bottle, the price of which has also increased from 20,000 to 27 000 CDF, which is accessible to their purchasing power even if the quantity of gas is less than half that usually purchased. This situation has probably brought households back to the use of fuelwood to fill the gap.

Figure 5: 12.5 kg gas bottle connected to the stove by the hose



Figure 6: Kit of 6 kg



Regarding satisfaction with the use of LPG by households in the city of Kinshasa, Table 5 shows that the households who continue to use LPG fully agree with two statements out of nine proposed in the evaluation: "the gas stove has a long service life" and "cooking food with gas is faster than cooking with traditional charcoal stove"; they agree, with four assertions; "the burner has a long service life", "the pot support has a long service life", "the hose has a long service life" and "it is easy to adjust the fire of the gas stove". On the other hand, they neither agree nor disagree with two statements: "the

gas supply location is close to the home” and “the gas is always available at the usual point of sale”; finally, they totally disagree with the statement “the price of gas is affordable”.

Table 5: Descriptive statistics LPG user satisfaction (in score)

Parameter	N	Minimum	Maximum	Mean	Standard deviation
The price of gas is affordable	42	1	5	1.62	0.764
The gas stove has a long service life	26	1	5	4.27	1.116
The burner has a long service life	16	1	5	3.80	1.000
The potholder has a long service life	16	1	5	4.05	0.987
The hose has a long service life	26	1	5	3.89	0.900
Cooking food with gas is faster than cooking with a traditional charcoal stove	42	1	5	4.50	0.552
Adjusting the fire of the gas stove is easy	42	1	5	4.14	0.899
The gas supply location is close to the home	42	1	5	2.95	1.081
Gas is always available at the usual point of sale	42	1	5	2.71	1.255

Note: 5. Totally agree; 4. Agree; 3. Neither disagree nor agree (or neutral); 2. Disagree; 1. Strongly disagree.

The 62% of households who use gas stoves, mainly two-plate stoves, are very satisfied with the lifetime of these stoves because most of them have been using the same stoves since they adopted LPG, i.e., two years or more. This satisfaction is greater among users of the COETE-GAZ brand. Because the households that have had to migrate to SO'GAZ have declared that they continue to use the same COETE-GAZ stove even though have changed the gas supplier. We note a tiny minority of households preferred to buy the gas stove sold separately from the bottle at the market or imported from abroad (Angola, Congo-Brazzaville, etc.). This category of households is those who have the 6 kg bottle but prefer to use the stove connected to the gas bottle by the hose. Instead of the burner placed directly on the 6 kg gas bottle, as sold by gas suppliers. For the speed of cooking, the satisfaction is explained by the instantaneous ignition of the gas, also by the large quantity of thermal energy released, and finally the simplicity of adjusting the intensity of the heat during cooking.

Regarding the accessories necessary for the use of LPG, the households surveyed are satisfied with their lifespan. The burner/regulator that 38% of households use with the 3 or 6 kg cylinders, only a minority of households, i.e., 6%, had to change this device since they started using LPG, i.e., say for at least two years. But the problem lies in its price, which rose from 10,000 to 20,000 CDF for the SO'GAZ model. Many respondents said they spent many days to find the replacement burner due to being out of stock at usual points of sale. For the potholder, also used with 3 and 6 kg bottles, although made with metal, a tiny minority of households had to replace it or have it repaired by a fitter. For the hose or pipe that connects the bottle to the gas stove, the households that use it said they have not yet changed. On the other hand, some households have noticed the appearance of cracks in the hose. This is due to the multiple connections and separations

of the hose to the gas cylinder during gas refills. What envisages the change of flexibility in the near future? Regarding the adjustment of the intensity of the fire, the households using LPG judged, for the majority of them, that the device was easy to use. However, a handful of households have observed a malfunction in the handling of the regulator. According to these households, when it is activated to reduce the intensity of the fire, it sometimes happens to have the opposite result, that is to say, a sudden increase in the intensity of the heat. This finding was mentioned a lot more by users of the SO'GAZ brand. However, since this gas supplier changed the burner brand, this malfunction has not been observed.

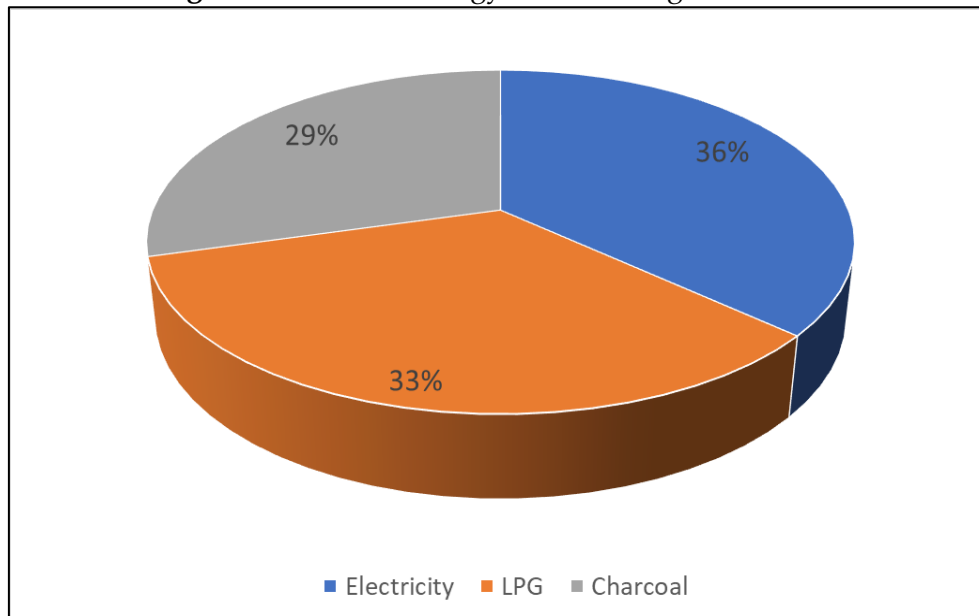
Concerning the aspects related to supply (proximity to the point of sale and availability of gas stocks at the point of sale), the satisfaction of the households surveyed is mixed. The place of supply was previously petrol stations in 2020. In 2022, several additional points of sale, other than petrol stations, were opened in most districts. These are spaces set up in front of shops and other businesses. This distribution strategy is used much more by SO'GAZ. But more will have to be done for the majority of households to be completely satisfied with regard to gas accessibility. Indeed, most of them continue to pay for transport, usually motorcycle taxis, to reach the point of sale. This situation is explained by the fact that it is difficult for them to cover these distances on foot with a heavy load. This supply situation becomes more complicated, especially in the event of a stock shortage at the nearest points of sale. In this case, some households go to very distant sales outlets to get supplies. Others are forced to wait for the usual point of sale to be restocked. In the meantime, they fall back on other sources of cooking energy, mainly charcoal. Some households have agreed with their points of sale so that the gas sellers call them directly by telephone as soon as the point of sale is supplied with gas. Another situation revealed during the investigation is the exhaustion of gas during cooking. This has already happened to 88% of households. In this case, they resort to charcoal while waiting for them to restock. However, a few households said they had a spare bottle in case this situation arose.

Finally, regarding the price of gas, all households are very dissatisfied with it. Already in 2020, the price of gas was estimated to be relatively expensive for many households. Unfortunately, in 2022 an increase of around 35% in the price of gas was observed. This situation has prompted households to reduce their gas consumption. Indeed, the solution for many households is to avoid using LPG for meals that consume a lot of energy (beans, cassava leaves, etc.) and instead use charcoal or an electric stove when electricity is available. The gas is thus reserved for emergency or auxiliary uses (boiling water for lunch or to prepare fufu).

The fact that the price of gas is considered expensive by many households means that LPG is the main cooking energy for only one-third of the users of this fuel. LPG comes only in the second position as the main energy after electricity and it is closely followed by charcoal (Figure 7). Households that have electricity as their main energy state that this energy is permanent in their neighbourhoods. They only use LPG if there is a power outage or in the event of a drop in voltage. For those who still use charcoal,

although they have LPG, they talk about the relatively low cost of this fuel. However, the households surveyed believe that LPG is clean energy, not dirty, and emits no smoke compared to charcoal. In addition, cooking with a gas stove is more convenient and quicker, even compared to the electric stove.

Figure 7: The main energy of LPG-using households



This study focused on one aspect of the common use of LPG. This is the risk of accidents in the use of LPG as cooking energy. Because the risk of the blaze is one of the obstacles to the adoption of LPG (Belani et al., 2023b). It appears from the surveys carried out that 3 out of 42 households, or 7%, declared that they had experienced minor accidents while cooking with LPG. For the first household, the hose had come off and caused the flame to appear, which fortunately was quickly brought under control. For the other two households, the incidents were caused when the gas was lit. The gas cylinder was not properly closed during the last use. This caused a small explosion, without major damage. Thus, the households interviewed declared observing preventive measures explained when purchasing LPG to avoid accidents. It is mainly: to cook in a ventilated place, to close the gas well after use, to avoid flammable objects near the gas stove (candles, aerosol insecticide, etc.) or emitting waves (mobile phones), and to prevent children from touching or approaching the gas stove.

4. Discussion

The results of this study on satisfaction with the use of ICS and LPG by households in the city of Kinshasa having adopted them in 2020 (Belani et al, 2023) appear to be mixed. Concerning the ICS, the households surveyed are on their majority satisfied with most of the aspects of the use of this stove. Only a tiny minority have stopped using it. However, for LPG, the level of satisfaction of households that have adopted it is below expectations.

Tenth of households have stopped using this fuel. So, many challenges must be met to make LPG the main cooking fuel in Kinshasa and more generally in the DRC to replace charcoal.

Regarding ICS, the objective set by the Congolese government in its promotion is to improve the energy efficiency of cooking stoves used by households (DRC, 2013). User satisfaction appears to differ depending on whether the stove used is imported (or manufactured by Congolese structures financed by environmental projects) or produced locally by independent craftsmen. The problems are, for all categories of ICS, mainly in the components (pot support, closure, and clay) that it will be necessary to make good use of them for them to last. However, there is no replacement or repair mechanism for these parts. Improving the quality of ICS made by local independent craftsmen should be a strategy to be put in place by the public authorities to support young craftsmen who are increasingly interested in the production of ICQ. The manufacture of ICS has become a source of employment for young people in working-class neighbourhoods. For this, it will be necessary to structure the sector to allow these young craftsmen to acquire the components of the ICS (sheet metal, clay, etc.) at affordable prices. The results of the study also showed that the adoption of the ICS by households in the city of Kinshasa did not prevent some of them from continuing to use the traditional stove. The specificity of certain dishes requires the exclusive use of the traditional stove. For this cultural aspect, the ICS will have to adapt, in the future, to the needs and requirements of users. These households also declare that the traditional stove constitutes a second stove in case they want to prepare two meals simultaneously. For these households, acquiring two ICSs would be an additional expense that would be difficult to finance. Consequently, acquiring an ICS, given its cost, cannot seem to be a low priority compared to other household needs (Tebugulwa, 2015). For smoke emission, it is established that the ICS produces less smoke than the traditional stove (Armendariz, et al., 2008; Roden, 2009). The carbon monoxide (CO) content of the gaseous emissions produced by the traditional stove varies from 0.3% to 0.9% (Percentage of CO in the air). These percentages are above the European standard of 0.005% maximum (Van Beukering et al, 2007). However, the households surveyed declare that the two stoves, the traditional and the improved ones, do not produce smoke. For this reason, the population should be made aware of the toxicity of the traditional stove, which is often ignored by the population. The public authorities should encourage importers and manufacturers of improved cookstoves to carry out the various performance tests for these cookstoves: WBT (water boiling test), CCT (controlled cooking test), UCT (non-cooking test). controlled) and KPT (performance test in the kitchen). The public authorities should encourage importers and manufacturers of improved cookstoves to apply the "biomass stove safety protocol" (BSSP) to these different cookstoves. This is to assess their safety (Gallagher et al., 2016). In addition to other well-known tests: WBT (water boiling test), CCT (controlled cooking test), UCT (uncontrolled cooking test), and KPT (kitchen performance test).

For LPG, its popularization is part of the Congolese government's objective of providing Congolese households with sustainable access to modern cooking fuels (DRC,

2013). The price of gas refills continues to be the main reason for user dissatisfaction. The increase in the price of gas in early 2022 did not make things easier. Because it is one of the reasons cited by some users for stopping using LPG. Thus, preventing the price of LPG from being beyond the purchasing power of the Congolese people. Thus, a subsidy should be considered to facilitate access to this LPG like in other countries (Karimu et al., 2016). Therefore, the subsidy granted by the Congolese government to the company SO'GAZ to sell Kinshasa households gas kits (bottle and stove) at half price in 2020 should resume and be permanent to allow most of the population to buy this kit. It is attested that any policy tending to reduce the price of the gas kit should be encouraged, as it constitutes an incentive for adoption (Pope et al., 2018).

The distance between the home and the place of supply is another cause of dissatisfaction among households in the city of Kinshasa who have adopted gas as a cooking fuel. On this, the company SO'GAZ has made an effort by multiplying the points of sale in the city of Kinshasa since 2020. The problem arises acutely for the customers of the competing COETE-GAZ, the first company to have installed in the DRC. User households are forced to travel long distances to obtain gas supplies. Thus, the transport cost paid during recharging constitutes an additional cost. LPG suppliers should consider multiplying points of sale to reduce transport costs. Out-of-stock at points of sale is another point of user dissatisfaction. Much more with COETE-GAZ customers than with SO'GAZ customers. These ruptures can be avoided by good programming of the needs of the users in each city, and between the various points of sale in the city. Because, the survey reveals that, at the same time, some points of sale lack gas, but others have it. In addition, since the gas cylinders used by the two main companies, COETE Gaz and SO'GAZ, are not the same and therefore not interchangeable, there is no possibility of using the other competing company in the event that his gas supply company is facing a shortage. Thus, the similarity of cylinders and other materials should be considered. Furthermore, many LPG users are unaware that the gas cylinder used is the property of the gas company and that the amount paid when purchasing the gas kit constitutes a guarantee to be refunded when the customer wants to change LPG company or simply if he no longer wants to use LPG as cooking energy.

Finally, whether for the adoption or satisfaction with the use of the ICS or LPG, regular monitoring should be carried out with a panel of households to follow the main indicators (number of adopters, the quantity of fuel used, deforestation rate, etc.) of the use of ICS and LPG and their impact in relation to the objectives set (DRC, 2013; DRC, 2015). It has been observed that many programs of the extension of ICS or the promotion of clean cooking energies do not achieve their objectives due to a lack of regular monitoring (Manibog, 1984; Keraro, 2014; Asante et al., 2018).

5. Conclusion

The main objective of this research was to identify the critical parameters to be improved in order to ensure the continuity of the use of the ICS and LPG by households in the city

of Kinshasa. The adoption and sustained use of ICS and LPG are critical cooking system performance parameters that need to be monitored, with the rest of the technical requirements, to ensure the sustainability of their benefits.

Thus, for the ICS, its use has entered the habits of households in the city of Kinshasa. Just a tiny minority, 1.7% of users, gave up using this stove because of the inability to renew the equipment after it fell out of use. Regarding satisfaction, the households surveyed are satisfied with the majority of aspects of this use. The most important aspect attested by the household is the small amount of charcoal used with the ICS compared to that used with the traditional stove. This preserves forest resources because the amount of wood energy needed to cook dishes is minimized.

However, for LPG, the situation appears mixed. Indeed, 10.7% of households have stopped using this fuel because of the increase in its price; scarcity and fear of fire are also the reasons behind abandonment. The other reason for dissatisfaction is the difficulty of supply, especially in terms of distance from the point of sale. Nevertheless, households are largely satisfied with the speed of cooking with the gas stove and the solidity of the equipment (stove and accessories).

Thus, the Congolese public authority should make efforts to support this cooking energy sector by granting facilities to local craftsmen who are increasingly embarking on the manufacture of ICS, on the one hand; and to subsidize the price of gas, like other petroleum products (gasoline, diesel, etc.), to allow its use by a large number of households in the DRC.

Finally, regular monitoring should be carried out with a panel of households, not only in Kinshasa but also in the other major cities of the country, to assess the use of ICS and LPG in order to measure and assess the indicators contained in the national program and strategy of the DRC on "Sustainable energy for all by 2030".

Ethical approval statement

We demonstrate that we have adhered to the accepted ethical standards of a genuine research study. We consent to participate and we consent to publish.

Competing interests

We declare that we have no competing interests in this article.

Authors' contributions

Contribution	Author
Conceptualisation	Justin Belani Masamba
Data management	Justin Belani Masamba
Formal analysis	Justin Belani Masamba
Enquiry and investigation	Justin Belani Masamba
Methodology	Justin Belani Masamba
Project management	Charles Kinkela Savy
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Availability of data and materials

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