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Lost in Transition: The Decline of LPG Usage and the Charcoal Renaissance in Urban Senegal

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Abstract

Claims for removing fossil fuel subsidies in the Global South are based on climate and equity concerns, but they can be at odds with improving access to Liquefied Petroleum Gas (LPG) as a clean cooking fuel. We examine the case of urban Senegal where LPG usage rates were among the highest in sub-Saharan Africa in the late 2000s. Using Demographic and Health Survey (DHS) data, we show that LPG usage declined sharply following the removal of subsidies in 2009. Counterintuitively, the decline was not reversed when falling world market prices led to a local price decrease. To explore this puzzle, we use detailed cooking data from surveys we conducted in 2009 and 2019. We find that households change to charcoal after the subsidy removal, but they increasingly use newly promoted energy-efficient charcoal stoves. These stoves make charcoal cooking cheaper and hence the switch back to LPG less attractive. Our results underscore that the energy transition of the poor is highly price responsive – an important insight not only for the debate about fossil fuel subsidies but also carbon taxation.

JEL-Codes: O13, Q41, Q56

Keywords: Energy subsidies; air pollution; energy transition; clean cooking; climate policy

April 2024

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Introduction

In sub-Saharan Africa (SSA), 95% of the rural population and 64% of urban households use firewood and charcoal as their main cooking fuels (IEA et al. 2023). This contributes to forest degradation and climate change as well as the drudgery of firewood collection, mainly for women (Krishnapriya et al. 2021; Jeuland and Pattanayak 2012; Köhlin et al. 2011; Pattanayak et al. 2019; Bailis et al. 2015, Das et al. 2023; Bensch et al. 2021). Biomass cooking is also associated with household air pollution, making it the leading environmental cause of mortality that induces an estimated 3.2 million premature deaths per year globally (WHO 2024). Therefore, the World Health Organization (WHO) calls for the promotion of clean alternatives, mainly Liquefied Petroleum Gas (LPG). Following this logic, LPG subsidization has been pursued in several countries (Gould et al. 2024). Without such policies, biomass cooking will probably remain high in SSA for the decades to come (Rose et al. 2022). Yet, LPG subsidies get swept up in another more general debate about fossil fuel subsidies, which are heavily contested because they are considered a fiscal burden detrimental to the climate, while benefits accrue mostly to the better off (Rentschler and Bazilian 2017; Parry et al. 2021; Martinez-Alvarez et al. 2022).

The present paper examines the often-neglected intersection of the fossil fuel subsidy debate and WHO's clean cooking goal. We look at urban Senegal, which was an LPG success story up to the early 2000s with usage rates among the highest in SSA. The government directly subsidized the LPG price by about 35% until the subsidy was officially abandoned in 2009. We track retail prices of LPG in Senegal and show that they increased considerably after the subsidy removal. We then examine subsequent usage rates based on nationally representative fuel use data from the Demographic and Health Surveys (DHS) and find that LPG usage declined sharply after the subsidy was removed. Households abandoning LPG after 2009 switched to charcoal, the predominant biomass fuel in urban Senegal and across SSA (Rose et al. 2022). After 2012, prices fell again because of decreasing world market prices. Counterintuitively, this did not lead to a recovery in LPG usage rates.

To investigate this further, in 2019 we conducted a follow-up to a household energy survey, ten years after the initial data collection in 2009 (see Bensch and Peters 2013), focusing on two major urban areas, Dakar and Kaolack. This survey is not nationally representative, but it

contains more detailed cooking data. We corroborate the transition away from LPG after the subsidy removal. The intriguing finding is that households did not only switch to charcoal, but also to a more efficient stove type. That energy-efficient biomass stove (EEBC), called *Jambar*, has been promoted by a Governmental program since 2006. EEBCs reduce the price of cooking with charcoal on a per-meal basis, and thereby make cooking with LPG relatively less attractive. This might explain why people did not switch back to LPG as expected when prices decreased a few years after the subsidy removal.

Our paper speaks to the ongoing debate on fossil fuel subsidies but also taxing carbon in the Global South. We contribute to a growing literature showing that pricing instruments significantly shape fuel choices, which might have adverse consequences (Rentschler and Bazilian 2018). Several case studies show that subsidized LPG prices result in increased LPG usage (Asante et al. 2018; Thoday et al. 2018). Limited evidence exists on the consequences of subsidy removal. Another important pricing instrument is carbon taxation. Because charcoal and firewood are hard to tax, it is likely that taxing carbon would increase LPG prices but not woodfuel prices. Carbon pricing simulations for sub-Saharan Africa and South Asia assume considerable negative price elasticities of LPG demand (Cameron et al. 2016; Leimbach et al. 2018). Our paper, in line with Greve and Lay (2023), and Salehi-Isfahani et al. (2015) confirm this assumption. Moreover, our paper complements the literature on household-level determinants of fuel and stove adoption (see Bensch et al. 2015; Jeuland et al. 2020; Kar et al. 2024; Lewis and Pattanayak 2012).

Results

Data

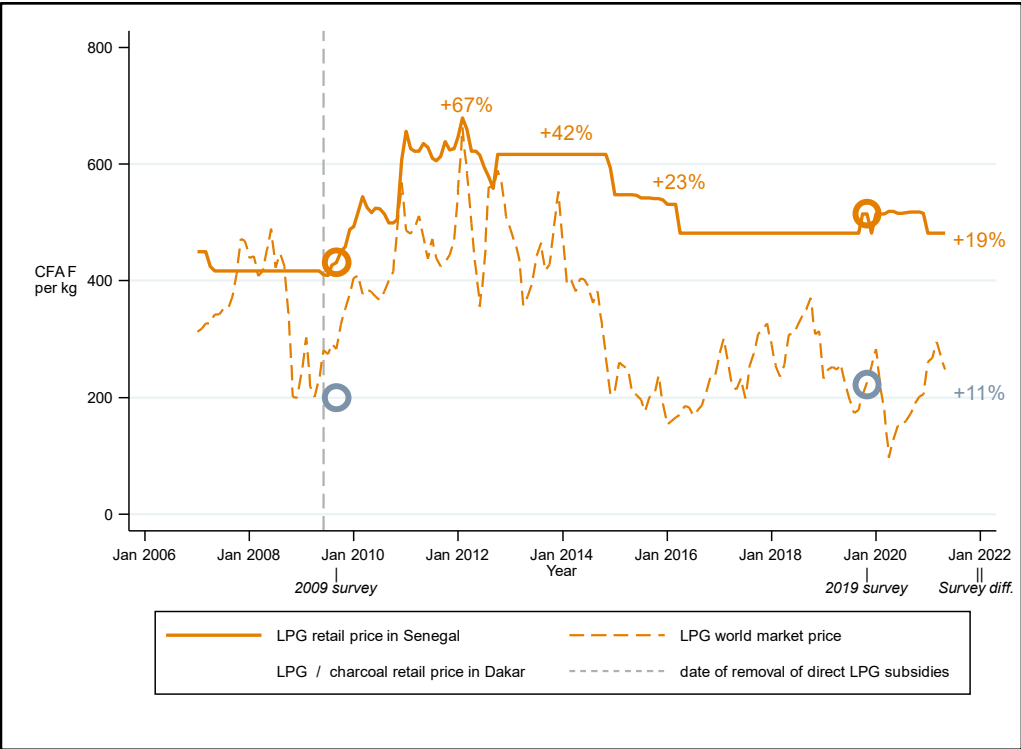
Our results mainly rely on two data sources. The Demographic and Health Surveys (DHS) data is nationally representative with an urban sample size ranging between 1,200 and 3,800 households over the years. Regarding cooking, it offers information on the households' primary fuel only. In contrast, our self-collected household energy data captures simultaneous usage of multiple fuels and includes information on stove types used. We collected this data in 2009 among a random sample of 624 households from neighbourhoods where charcoal usage was common, thereby excluding a small number of better-off neighbourhoods. In 2019,

we re-contacted the same households as in 2009, now via phone. We managed to re-interview 178 households, resulting in a tracking rate of 29%. Although we find no indication for non-random attrition, we emphasize that the restricted sample and strong attrition limit the representativeness of our data (more details about the survey data are included in SI Appendix).

LPG subsidies and prices over time

Since the 1980s, the Senegalese government had subsidized LPG usage through import duty exemptions on LPG stoves and cookware, which was later extended to fuel subsidies of small cylinders for residential usage, amounting to 35% and more of the LPG price. In 2009, the government officially removed the direct LPG subsidy (IMF 2010). LPG prices surged between 2009 and 2012 in response to this reform (see Figure 1), even though the subsidy removal was accompanied by an exemption from the value added tax and customs duties. The LPG price started to decrease in 2013. Compared to pre-2009 prices, nominal prices were 67% higher in 2012, 42% higher in 2015 and only 19% higher from 2016 on.

Figure 1: LPG prices over time

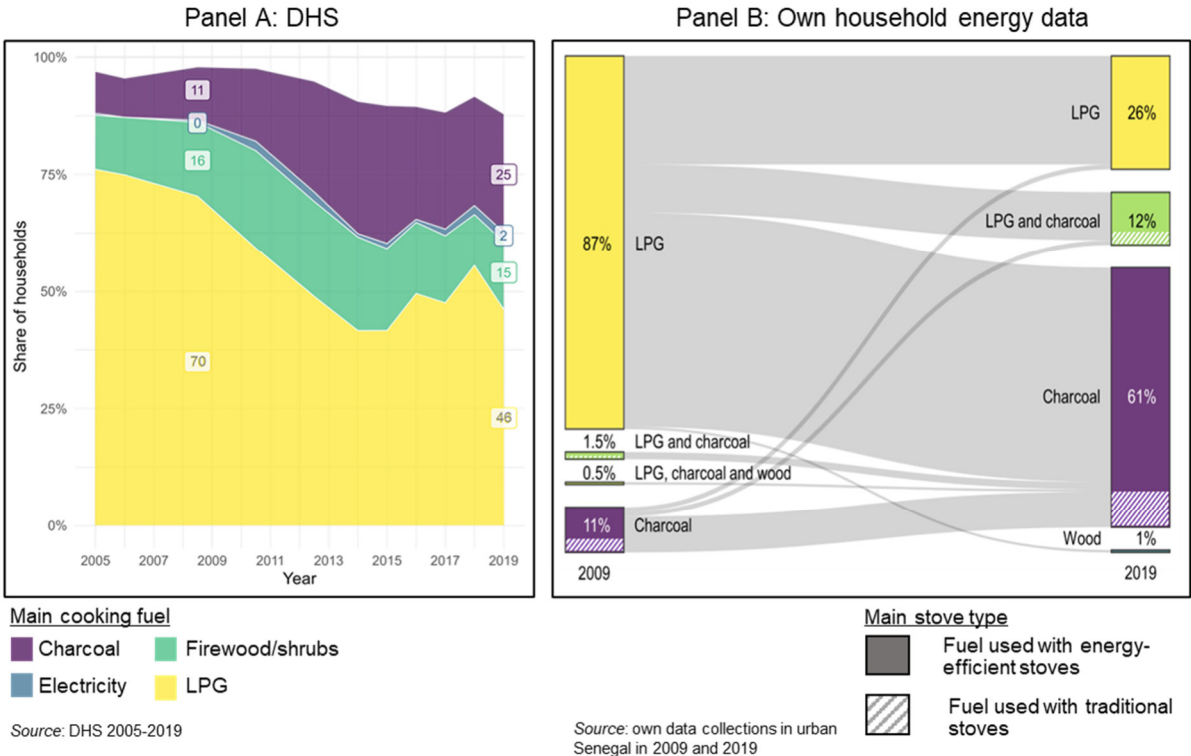


Note: Prices in local currency. The circles (2009 and 2020) indicate prices obtained from our data collections in 2009 and 2019. We approximate the LPG world market price using the North Africa Contract Price. Percentage changes are LPG and charcoal retail price increases relative to September 2009. Sources: ANSD; Kojima (2021).

LPG usage over time

The DHS data reveals that after the subsidy removal, the share of households mainly using LPG decreased from 70% in 2009 to 49% in 2012 (see Panel A of Figure 2). LPG usage rates declined further after 2012, even though the LPG price started to decrease. In 2014, LPG usage rates were at 40%, before they recovered modestly. Yet usage rates remain around 50%. It can also be seen in Panel A of Figure 2 that the decline in LPG usage was predominantly absorbed by charcoal, not firewood. Prices on the informal charcoal market are said to follow local LPG prices, which is roughly confirmed by our self-collected charcoal price data in Figure 1, suggesting an 11% increase compared to 2009. It is therefore surprising to see the persistent shift from LPG to charcoal after the subsidy removal, despite a subsequent LPG price decrease and no apparent regime shift in charcoal prices.

Figure 2: Evolution of main cooking fuels in urban Senegal



Our household energy data presented in Panel B of Figure 2 broadly confirms the fuel use transition in urban Senegal, recalling that our data comes from a non-representative sub-sample that excludes better-off neighbourhoods and other cities than Dakar and Kaolack. While more households switched from LPG to charcoal in our sample than in the DHS sample,

our more detailed data allows to show that most of these new charcoal users switched to EEBCs, which are used as main stoves by 62% of our 2019 sample (non-shaded areas for groups *Charcoal* and *LPG and Charcoal*). We see a similarly strong decline in share of food preparations with LPG when we account for simultaneous fuel usage. Different EEBCs exist; a Senegalese model, the *Jambar*, was promoted by a Governmental program in urban Senegal. It saves around 25% of charcoal per meal compared to traditional stoves under day-to-day cooking conditions (Bensch and Peters 2013). Beginning in 2006, the promotion program has invested to strengthen the *Jambar*'s supply chain, by training producers, ensuring material supply, and conducting marketing activities.¹ The now widespread usage of this EEBC offers a potential explanation for the persistence of lower LPG usage rates: The improved efficiency of the *Jambar* reduced costs of cooking with charcoal, making charcoal more attractive relative to LPG.

Discussion

Using World Bank's three-tier classification of access to modern cooking (ESMAP 2020), the LPG-charcoal switch we observe corresponds to a massive decline in *modern* cooking energy access from almost 90% in 2009 to around 30% in 2019. The other interesting feature of our analysis is that many households do not fall back to what ESMAP would call *traditional* cooking, but by adopting EEBCs they are now on the *transitional* cooking rung of the energy ladder. Our study suggests that relative fuel price dynamics influenced these fuel choices, and that these dynamics are shaped by direct and indirect stove and fuel subsidies as well as the efficiency of the available charcoal stoves.

Some caution is advisable in interpreting the subsidy removal in 2009 as an isolated shock. The LPG retail price in Senegal has always been influenced by various factors, both from local dynamics on refinery markets and global price events (Dafrallah 2009). Also, until today the government has repeatedly intervened in the market to stabilize prices. The surge in retail prices following the subsidy removal, though, is a matter of fact. What strengthens our interpretation of ascribing the price increase and the decline in usage rates to the subsidy removal is that Senegal's shift in cooking fuel usage stands out when compared to trends in

¹ The project's monitoring data document a rise in annual *Jambar* sales from 30,000 to 60,000 between 2008 and 2012, which is roughly consistent with the usage rates we observe (see annual planning and progress reports with some related project information, available at: <https://endev.info/downloads>).

other countries in the region. Looking at IEA data, per-capita LPG consumption in Ghana and Côte d'Ivoire increased from 2005 to 2019 by 220% and 266%, respectively, while Senegal experienced a decrease of 12% in the same period.

The main insight for policy is that pricing policies should be handled with particular care if they affect fuels used by people who are transitioning out of energy poverty, not least cooking fuels. This should be considered, first, with respect to LPG subsidies, which is arguably a reasonable policy from both an environmental and welfare perspective (Gould et al. 2024). It should, second, also be considered when discussing carbon taxation in SSA. A particular crux here is that traditional fuels, firewood and charcoal, also contribute to greenhouse gas emissions to the extent they are not extracted sustainably from forests. However, since these fuels are collected and marketed informally, they can hardly be taxed. Therefore, a carbon tax can only be levied on LPG. In line with similar evidence (Greve and Lay 2023), our findings suggest that a carbon tax would hence likely push households back to the use of traditional fuels, with questionable effects for mitigating emissions but clearly adverse effects for people's health.

On this note, our results also open another potential route for future energy policies: Charcoal, in principle, can be turned into a sustainable fuel. This is unlikely to happen under the status quo because charcoal is mostly used in inefficient and polluting stoves and produced in an inefficient and unregulated manner. Yet, our finding of widespread EEBC usage raises hope that efficiency gains are possible on the demand side – a finding that is in line with Bensch et al. (2021) who gauge carbon mitigation potentials of EEBC for SSA. If in addition the supply side can be regulated in a way that charcoal is produced sustainably, it could become a carbon-neutral component of the sustainable energy transition for the growing urban population. It would require significant investments into technology and regulation in a highly informal and complex sector (FAO 2017). Investments that might be worthwhile because charcoal production creates jobs and income in otherwise often economically deprived rural areas (Putti et al. 2015; Schure et al. 2014, Vollmer et al. 2017).

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Supporting Information for

Lost in transition: The decline of LPG usage and the charcoal renaissance in urban Senegal

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I. Information on survey data

Demographic and Health Survey (DHS)

Survey questions:

Beyond information on whether the location is urban (hv024), we use data collected with the following one question from the DHS survey:

hv226. What type of fuel does your household mainly use for cooking?

Answer options:

1. Electricity
2. LPG
3. Natural gas
4. Biogas
5. Kerosene
6. Coal, Lignite
7. Charcoal
8. Wood
9. Straws/shrubs/grass
10. Agricultural crop
11. Animal dung
12. No food cooked in household
13. Other

Sampling:

The DHS survey in Senegal employs a two-stage stratified areal sampling method, initially selecting clusters from Enumeration Areas using systematic sampling with probability proportional to size, where the size of the Primary Sampling Unit (PSU) is determined by the number of households. This is followed by a systematic sampling of sufficient households per cluster, ensuring representation at the national level, in urban and rural areas, and across the country's four major eco-geographical regions.

Weights:

DHS provides a sampling weight for households (hv005). It is defined as the inverse of its household selection probability multiplied by the inverse of the household response rate in the stratum.

Own household energy data

Survey questions:

We use data collected with the following four questions from our own household energy survey:

Q.1 Which of these **[STOVES]** do you have at home?

- 1.1 Trois pierres
- 1.2. Os
- 1.3 Foyer à Gaz
- 1.4 Foyer Malgache
- 1.5 Foyer Malgache Thé
- 1.6 Sakkanal Mono
- 1.7 Sakkanal Multi
- 1.8 Jambar Thé
- 1.9 Jambar Jegg Charbon (p)
- 1.10 Jambar Jegg Charbon (m)
- 1.11 Jambar Jongoma Charbon (g)
- 1.12 Jambar Jegg Bois
- 1.14 Ban Ak Suuf
- 1.15 Nopale
- 1.16 Bili
- 1.17 Bili Amélioré
- 1.18 Fourneau Banco
- 1.19 Autre

Q.2X [where X represents the stove from Q1] How many [stove from Q1] do you have in the household?

Q.3 How many meals do you prepare per week (excluding reheating, outside of Ramadan)?

Q.4X How many of these meals do you prepare with the [stove from Q1] per week?

The questionnaire was written exclusively in French and enumerators spontaneously translated questions depending on the respondent's mother tongue to Poular, Wolof, Mandingue and Diakhanke.

Sampling:

For the 2009 survey, sixteen neighbourhoods in Dakar and four in Kaolack serve as the primary sampling units. They were selected in collaboration with experts from the Government of Senegal and the GIZ project called FASEN to represent different penetration levels of energy-efficient biomass cookstoves, while excluding downtown areas Grand Dakar and Dakar Plateau, where cooking with woodfuels is uncommon. The first wave of data occurred in September 2009, involving a door-to-door random walk method to sample 508 households from Dakar and 116 from Kaolack.

For the 2019 survey, we implemented a short phone survey. Out of the 624 households surveyed in 2009, 576 households had provided their phone number and consent to be re-contacted. However, people frequently change their mobile phone operator and number, which adds to the general difficulties of reaching survey respondents via phone surveys. Additionally, factors such as migration and mortality further affect the ability to recontact individuals in longitudinal studies, not least if such a time lag exists between survey waves. Five local enumerators tried to reach households via phone over the course of two weeks.

Weights:

We do not apply weights for this data.

Attrition:

In the 2019 survey, we eventually managed to interview 178 households, 147 in Dakar and 31 in Kaolack, resulting in a tracking rate of 29%. The strong substantial attrition rate of 71% between the two survey waves affects statistical power and the validity of comparisons across the surveys. To assess the extent of systematic attrition, particularly concerning EEBC ownership, we conduct Probit and Linear Probability Model (LPM) estimations, regressing attrition status on socio-economic variables that could potentially drive attrition. Overall, we do not find indications for socio-economic factors strongly affecting participation in our follow-up survey, acknowledging that these factors were measured ten years ago and may not be fully conclusive about the situation at the time of attrition. In any case, given the high attrition rate, we refrain from making causal claims in our analyses, but rather conduct robust and careful descriptive analyses of the data collected.