

# Scaling up clean cooking in urban Kenya with LPG & Bio-ethanol

*A market and policy analysis*

June 2018



# Executive summary

## Majority of Kenyans still cook with dirty fuels that cause significant health and environmental damage, despite cleaner options

- Charcoal, kerosene, and firewood still dominate the Kenyan market
- These fuels are major contributors to respiratory diseases, carbon emissions, and deforestation
- The Government of Kenya (**GoK**) has stated its ambition to transition Kenya to modern, clean fuels
- The urban market presents the most immediate opportunity to transition Kenyans to cleaner fuels, such as LPG and Bio-ethanol

## LPG has penetrated Nairobi and higher-income households; Bio-ethanol can be an attractive clean fuel for lower income households

- While modern, clean fuels are now more available, there are challenges with consumer awareness, affordability and accessibility
- LPG penetration has increased rapidly over the past five years, especially in Nairobi – the benefits are well-publicized
- While less known about, liquid Bio-ethanol is now increasingly viable as an urban cooking solution, driven by innovations in technology and distribution

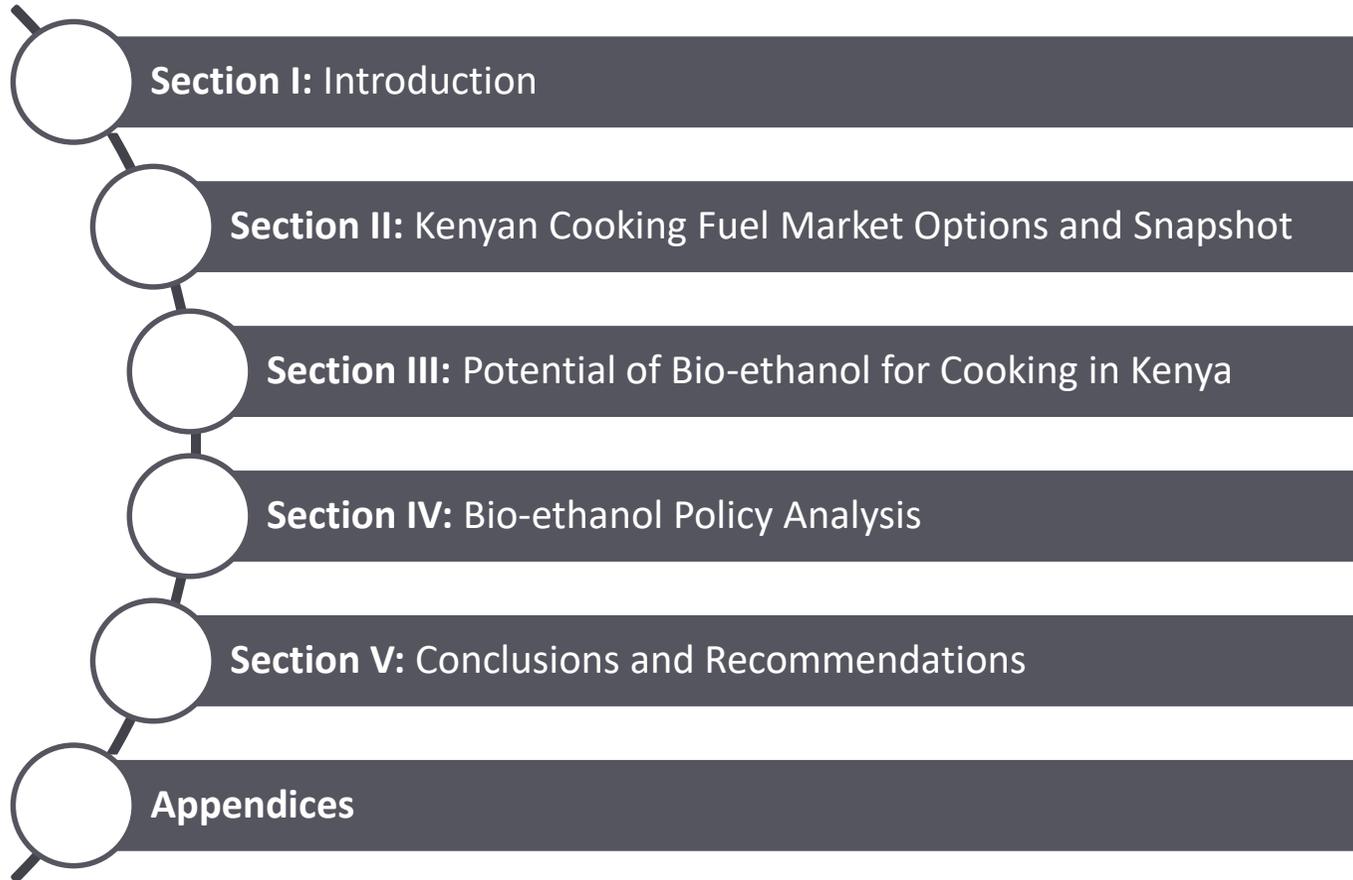
## Eliminating VAT and import tariffs can make Bio-ethanol among the cheapest<sup>1</sup> cooking fuel options in Kenya

- Despite having equivalent benefits to LPG, the cost of Bio-ethanol is inflated by 25% import tariffs and 16% VAT treatment
- This treatment is in stark contrast to LPG – which enjoys effective tax rate of zero – and kerosene, at 9% import duties and zero-rated VAT<sup>2</sup>
- If GoK made (denatured technical) Bio-ethanol zero-rated for VAT and eliminated tariffs, it would be among the cheapest cooking fuel options in Kenya and could displace charcoal and kerosene

**Unlike other clean fuels, Bio-ethanol can be produced domestically over time, which would spur industrial growth while delivering positive social and economic benefits**

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# SECTION I: INTRODUCTION

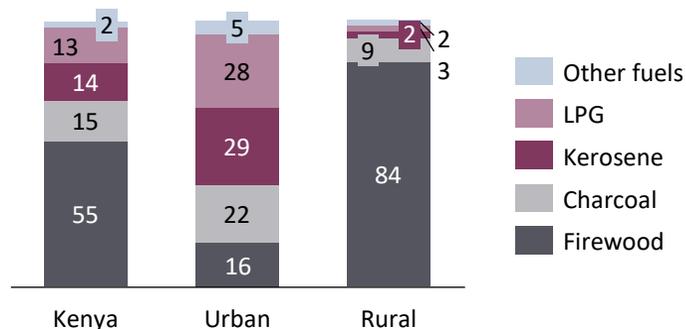
This study was developed to:

- 1. Position the cooking fuel market within the wider context of the Government of Kenya's and others' efforts to improve the welfare of Kenyans across a variety of dimensions**
  - Vision 2030 aims to transform Kenya into a newly-industrializing, middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment; much progress has been made (e.g., in the areas of healthcare, education, and housing)
  - However, despite the continued advocacy efforts of various stakeholders, additional strides are needed to ensure that all Kenyans have access to affordable clean cooking options
- 2. Evaluate Kenya's urban household cooking fuel sector and understand the ways in which customers are under-served by traditional fuels, which continue to dominate over more modern, clean fuel alternatives**
  - Traditional dirty fuels dominate fuel use in Kenya: ~85%<sup>1</sup> of Kenyans rely on these for cooking
  - Continued dependence on these fuels has negative impacts on health, environmental, and other social outcomes
- 3. Profile the available modern cooking fuel options based on emerging technologies and trends**
- 4. Highlight Bio-ethanol cooking fuel as a viable and scalable modern cooking fuel with the potential to be sold at prices affordable to the majority of urban Kenyans currently relying on kerosene and charcoal**
  - Bio-ethanol and LPG are the most feasible alternatives to traditional fuels, offering Kenyans a clean and efficient cooking experience
  - While LPG is generally well-understood and is being actively promoted by the government, Bio-ethanol requires further exploration and can be complementary to LPG as a modern cooking fuel for Kenyans
- 5. Recommend strategies for enabling private sector-led modernization of the cooking fuel sector – with a focus on Bio-ethanol – to deliver maximum social, environmental and economic benefits for the public**

# The urban Kenyan cooking fuel market is estimated at USD 600m – USD 800m per annum, and remains dominated by dirty fuels

In urban Kenya, the majority still use charcoal and kerosene; this number is much higher when fuel 'stacking' is included

**Primary Cooking Fuel Used in Kenyan Households in 2017**  
(% of population)



This report focuses on the opportunity for Bio-ethanol to serve the urban Kenyan population (market estimated at ~\$600-800mn\* per annum with full fuel transition).

The majority of Kenyans currently paying for cooking fuels live in urban Kenya

- Most fuel used in rural areas is gathered and not purchased (e.g., 84% of households use firewood as their primary fuel)
- Market-driven approaches for expanding the use of modern fuels are unlikely to take hold in these areas in the short term
- In urban areas, on the other hand, over 80% of households are already purchasing cooking fuel and are prime targets for modern fuel use

Kenyan urban households are now ready for rapid uptake of clean, modern fuels

**Primary Cooking Fuel Used in Kenyan Households in 2017**  
(households, millions)



Within modern fuel options, Bio-ethanol and LPG are the most feasible today; Bio-ethanol is the least understood

- LPG is well-understood, already promoted by the Government, and enjoys strong consumer recognition
- Bio-ethanol is relatively unexplored and has achieved lower penetration thus far
- Electricity will become increasingly important to the overall cooking mix; however, for now, only higher income consumers can afford the expensive but efficient electric stoves that are needed to make electric cooking viable

\*This market size estimate is based on current urban population size, fuel use patterns, estimated household consumption/spend (based on average efficiencies of cookstoves/fuels in the market), and market price data for urban Kenya  
Source: Kenya Integrated Household Budget Survey (2018), National Bureau of Statistics

## SECTION II: KENYAN COOKING FUEL MARKET OPTIONS AND SNAPSHOT

### The majority of urban Kenyans rely on charcoal fuels and harmful kerosene for their cooking needs

- Charcoal (22%), kerosene (29%), and LPG (28%) are the dominant “primary” cooking fuels in urban Kenya as of 2017
- Stacking, i.e., the use of multiple fuels/stoves, is a widespread phenomenon in Kenya; charcoal and kerosene use is thus much more common than primary cooking fuel data indicates – e.g., 2-3x urban households using charcoal vs. number that use charcoal a primary cooking fuel
- Nairobi is distinct from urban Kenya, with far higher share of households using LPG (44%) and kerosene (47%) as primary cooking fuels (2017). Kerosene is the dominant fuel of the Nairobi poor<sup>1</sup>

### Continued dependence on dirty fuels poses serious health, environmental, and socio-economic costs for Kenya

- 8-10% of early deaths are attributable to indoor air pollution from charcoal and wood cooking in Kenya; this excludes the unquantified but likely substantial negative effects of kerosene cooking on lung function, infectious illness and cancer risks, as well as burns and poisonings
- Kenya loses 10.3 million m<sup>3</sup> of wood from its forests every year from unsustainable charcoal and wood fuel use
- Household biomass fuel use contributes >22 million tonnes of CO<sub>2</sub> eq each year (as high as 35 MT CO<sub>2</sub>eq including fuel production emissions), which is equivalent to 30-40% of total Kenya GHG emissions<sup>1</sup>

### Kerosene and charcoal remain dominant in urban Kenya due to the relative affordability and availability of these fuels and accompanying stoves

- Kerosene is currently the lowest cost mainstream cooking fuel in urban Kenya; charcoal bought in small amounts (i.e., tins) is the most expensive cooking fuel, but charcoal bought in bulk by middle class consumers, i.e., in 40 kg bags, can be a fairly affordable option
- In terms of accessibility, kerosene and charcoal are currently omnipresent in urban Kenya – there are over 1,500 kerosene dispensing points in Nairobi alone and anecdotal evidence suggests that most people in Nairobi live within a 50-150 meter walk from a charcoal seller

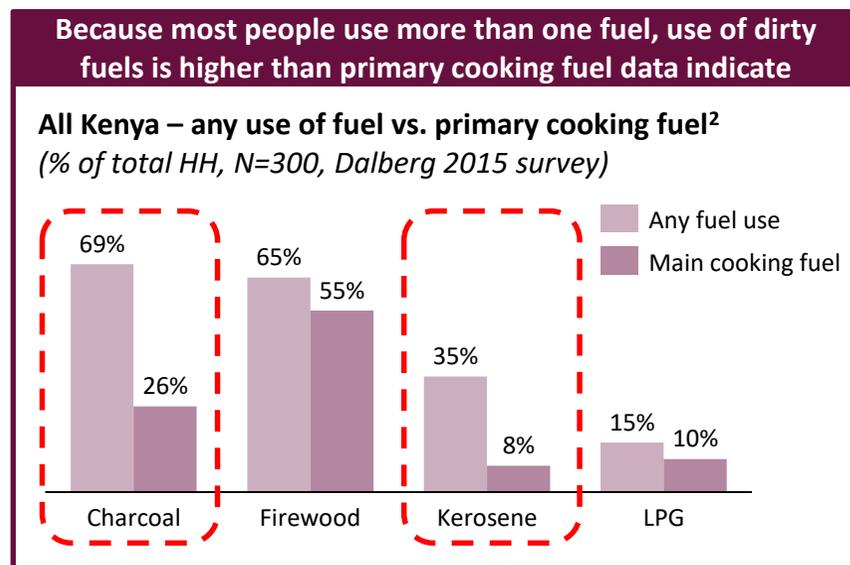
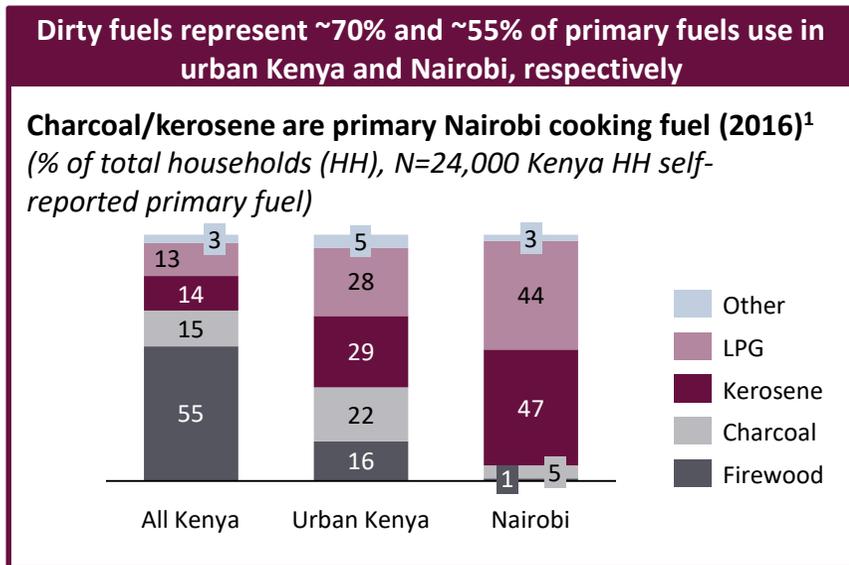
### Clean modern cooking fuels are available in Kenya, but they have not yet overcome consumer awareness, affordability and accessibility barriers in order to become scalable and significantly reduce use of traditional fuels

- LPG is well understood and increasingly common in urban Kenya, but despite continued investments in capacity, LPG is a solution that is unlikely to become the primary fuel for the majority of urban population due to high costs and limited availability outside of Nairobi. LPG also has a weak perception of safety as a fuel resulting from poor safety practices of the illegal grey market LPG re-fillers (estimated at 30-50% of market)
- Electricity for cooking is not viable today in Kenya and has minimal penetration (~2% in urban Kenya) due to the high costs of efficient electric cookstoves (\$200+) of the type that could make the costs of electric cooking comparable to alternatives
- Liquid Bio-ethanol is an emerging option, but has low awareness, is only available in select geographies via early stage enterprises, and is relatively high cost due to unfavorable tax and tariff treatment relative to cooking fuel alternatives like charcoal, kerosene, and LPG

(1) Dalberg estimate based on bottom up build-up of Kenya cooking emissions based on fuel mix, average fuel volumes, and standard emission factors including CH<sub>4</sub> and NO<sub>2</sub>, but excluding BC. Note that WRI CAIT total CO<sub>2</sub> emissions for Kenya (2013) are estimated at 60.53 MT CO<sub>2</sub>eq total, which we believe is an underestimate as the number only includes <8 MT CO<sub>2</sub>eq of cooking related emissions. Our revised model suggests that the Kenya total emissions are actually in the 75-88 MT CO<sub>2</sub>eq range based on the most up to date cooking fuel mix and up cooking fuel combustion and charcoal production emission factors that are aligned with CDM defaults for Kenya

Source: Statistics repeated and sourced on following pages

# Despite increased LPG use, most households still use multiple fuels and dirty fuels – charcoal, kerosene, and wood – still dominate urban Kenya



**Use of LPG has increased significantly since its introduction, especially in Nairobi; however, dirty fuels still dominate cooking in urban Kenya**

- LPG share has increased 3-4X since the early 2000s; data across this time period shows that, even in urban area, LPG use is concentrated amongst those earning a higher income
- ~70% of Kenyan households in urban areas use firewood, charcoal, or kerosene as their primary fuel

**Most households use multiple fuels in any given week so, even where LPG penetration is high, households are still cooking with charcoal and kerosene**

**Higher use of LPG among high-income Kenyans suggests that lower-income Kenyans need an alternative that can deliver similar benefits to LPG, while competing with charcoal and kerosene on price**

Source: (1) Kenya Integrated Household Budget Survey (2018), National Bureau of Statistics; (2) Dalberg proprietary Kenya energy access survey, N=300 (2015)

# Continued dependence on these dirty fuels poses serious health, environmental, and food insecurity risks for Kenya

## Impact of using biomass fuel for cooking

### Health



- **Indoor air pollution:** 728k Disability-Adjusted Life Years (DALYs) and 16.6k deaths annually, **8-10% of early deaths** in Kenya<sup>1</sup>, likely a substantial underestimate of the full disease burden as many negative cooking health effects have not yet been quantified (e.g., burns, eye diseases, physical injuries from carrying firewood, etc.)
- **Lower respiratory tract disease** is the third largest contributor of deaths in Kenya while pneumonia is a major cause of death to children under the age of five, largely due to indoor air pollution<sup>1</sup>

### Environment



- **Deforestation and forest degradation:** Kenya loses **10.3 million m<sup>3</sup> of wood from its forests** every year from unsustainable charcoal and wood fuel use, a major contributor to the 0.3% per year deforestation rate<sup>2</sup>
- **GHG emissions:** Household fuel use in Kenya contributes **22-35 million tonnes of CO<sub>2</sub> eq** each year, which is equivalent to **30-40% of total Kenya GHG emissions<sup>2</sup>**

### Food insecurity



- **Food insecurity:** deforestation, resulting from the use of dirty fuels, exacerbates food insecurity and harms the agriculture sector. Kenya's five forest water towers feed filtered rainwater to rivers and lakes and provide **over 75 per cent of the country's renewable surface water resources<sup>3</sup>**

Note: DALY is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death

Source: (1) 2016 Global Burden of Disease data; (2) Dalberg bottom up estimate triangulated with WRI CAIT (2013) Kenya GHG emissions estimates available at [https://www.climatelinks.org/sites/default/files/asset/document/2017\\_USAID\\_GHG%20Emissions%20Factsheet\\_Kenya.pdf](https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID_GHG%20Emissions%20Factsheet_Kenya.pdf); (3) UN Environment, "Deforestation costing Kenyan economy millions of dollars each year and increasing water shortage risk", 2016; Dalberg analysis

## Charcoal is particularly harmful as it contributes more to household air pollution, GHG emissions, and deforestation than other fuels

| IMPACT   | Wood  | Charcoal  | Kerosene  |
|--|---|---|---|
| <b>Health</b><br>(deaths and DALYs due to household air pollution from PM2.5)                        | ~2k avoidable deaths<br>165k aDALYs   | ~3k avoidable deaths<br>~250k aDALYs  | ~2-3k avoidable deaths<br>~160k aDALYs  |
| <b>Environment &amp; climate</b><br>(GHG emissions)  | 2.5-4.4 tonne CO <sub>2</sub> eq /<br>urban HH annually   | 3.6-5 tonne CO <sub>2</sub> eq /<br>urban HH annually   | 1 tonne CO <sub>2</sub> eq /<br>urban HH annually   |
| <b>Social opportunity costs</b><br>(time opportunity costs to fuel collection, cooking and cleaning) | 0.8-1.3 avoidable hrs per day<br>per urban HH   | 0.3-0.4 avoidable hrs per day<br>per urban HH   | No time poverty impact  |
| <b>Household and macro- economics</b>  | <ul style="list-style-type: none"> <li>• Foregone incomes for avoidable time spent cooking and cleaning</li> <li>• Tax revenue loss for government given informality of market</li> </ul> | <ul style="list-style-type: none"> <li>• Foregone incomes for avoidable time spent cooking and cleaning</li> <li>• Avoidable spending on expensive fuel</li> <li>• Tax revenue loss for government given informality of market</li> </ul> | <ul style="list-style-type: none"> <li>• Cost to economy of illicit mixing of kerosene with diesel</li> <li>• Negative balance of payments effects due to kerosene imports</li> </ul> |

## Charcoal and kerosene remain dominant in urban Kenya because of wide availability and relative affordability...

Relatively low costs and wide availability for dirty fuels, but such fuels are increasingly expensive

| FUEL            | Affordability & availability assessment  |
|-----------------|--|
| <b>Wood</b>     | <ul style="list-style-type: none"> <li>Abundant and largely free in rural areas for collectors, though 20-30% of rural HHs buying at least some of their firewood<sup>1</sup></li> <li>Firewood is increasingly scarce and expensive in urban Kenya, particularly Nairobi (e.g., &gt;\$0.50 / kg), but still fairly low cost (e.g., \$0.15 / kg in Kisumu, \$0.10-0.15 / kg in most rural and peri-urban Kenya)<sup>2</sup></li> <li>Traditional and moderately improved firewood stoves are free or very low cost (&lt;\$10)</li> </ul> |
| <b>Charcoal</b> | <ul style="list-style-type: none"> <li>Widely available in urban Kenya (e.g., charcoal available within 50 – 150m of most homes in Nairobi)<sup>3</sup></li> <li>Increasingly expensive as forests recede (prices rose from \$0.10/kg to \$0.35-0.50 / kg in Nairobi in past decade, doubling in just past 3-5 years)<sup>4</sup></li> <li>Major poverty premium – 20-30% higher cost from buying charcoal in 2kg tins vs. 40kg bags<sup>5</sup></li> </ul>  |
| <b>Kerosene</b> | <ul style="list-style-type: none"> <li>Widely available throughout mass-market neighbourhoods at hyper-local distribution points (e.g., 1500+ points in Nairobi alone)<sup>6</sup></li> <li>Most affordable and lowest cost fuel in urban Kenya currently</li> <li>Often only truly affordable option for poorest urban residents (e.g., kerosene is primary fuel for 70-80% of slum households in Nairobi)<sup>7</sup></li> </ul>   |

Note: Given combined affordability and accessibility constraints, electricity as a cooking fuel not explored in detail in this report.

Source: (1) Dalberg proprietary research; (2) Koko and Dalberg; (3) Dalberg field research; (4) Dalberg survey and proprietary charcoal price tracker; (5) Dalberg and Koko research; (6) Koko Networks estimate; (7) Yonemitsu (2014) for Kibera and K. Muindi (2016) for Korogocho and Viwandani slums

## ... but advantage of traditional fuels vs. clean fuels is fast eroding

Clean fuels face availability and affordability challenges, but both gaps are closing

| FUEL               | Affordability & availability assessment   |
|--------------------|---|
| <b>LPG</b>         | <ul style="list-style-type: none"> <li>Fuel availability is fairly widespread in <b>Nairobi</b> (&gt;40% use LPG as primary fuel and &gt;60% have LPG stove)<sup>1</sup>; <b>for urban Kenya as a whole</b>, availability is projected to increase – Kenya Pipeline Company (KPC) plan to more than double LPG storage capacity by 2020</li> <li>LPG is largely unaffordable as a primary fuel for bottom 50-70% <b>across urban Kenya</b> and prices have been unstable (\$1.25 to 1.75 / kg over course of 2017)<sup>2</sup></li> <li>High upfront stove/cylinder costs (&gt;\$100 for 2-burner)<sup>2</sup></li> </ul>   |
| <b>Electricity</b> | <ul style="list-style-type: none"> <li>Not widely available: residential grid provisioned for lighting only; major capex investment required</li> <li>Electricity costs too high for mass-market electric cooking (uptake ~5% in Nairobi, ~2% in urban Kenya)<sup>1</sup></li> <li>Efficient electric stoves are priced uncompetitively (&gt;\$200) for stoves that bring costs of electric cooking within realm of other fuel alternatives<sup>2</sup></li> </ul>  |
| <b>Bio-ethanol</b> | <ul style="list-style-type: none"> <li>Denatured Bio-ethanol* for cooking currently only available from a handful of providers that are all currently at nascent or pilot scale (i.e., KOKO Networks, Leocom, Safi International), but about to scale quickly – e.g., 1000 KOKO Points going live across Nairobi in late 2018<sup>3</sup></li> <li>Cooking with lowest cost Bio-ethanol on Kenya market is slightly more expensive than kerosene, on par with LPG, and below cost of 4kg tin charcoal -- would be lowest cost option if tax and tariff regime was equal to other fuels<sup>4</sup></li> <li>Bio-ethanol stoves are fairly low cost (\$45 for 2-burner) compared to clean alternatives like LPG<sup>4</sup></li> </ul> |

\* Bio-Ethanol cooking fuel is a clear liquid made from ~95% ethyl alcohol, 5% water, violet dye, and an industry-standard bittering agent (Bitrex) which irreversibly makes this fuel unfit for human consumption; Excludes alcohol-based 'gels', which are typically higher-cost and lower-power fuels.

Note: Given combined affordability and accessibility constraints, electricity as a cooking fuel not explored in detail in this report.

Source: (1) Christian Aid (2017) survey, (2) Dalberg field research, (3) Koko Networks, (4) Dalberg analysis

## Modern cooking fuels are available in Kenya, but they have not overcome consumer awareness, affordability and accessibility adoption barriers

|                              | LPG  | Bio-ethanol  |
|------------------------------|--|--|
| <b>Appliances</b>            | Mix of 1-burner 'meko' and 2-burner stove kit (including hose, pressure regulator, cylinder)   | Mix of 1-burner and 2-burner Bio-ethanol stoves from KOKO, SAFI, CleanCook   |
| <b>Fuel</b>                  | <ul style="list-style-type: none"> <li>• Imported</li> <li>• Available in cylinders of 3kg, 6kg, 13kg</li> </ul>   | <ul style="list-style-type: none"> <li>• Imported and domestically produced</li> <li>• Available in 1 &amp; 5L pre-packaged bottles (or as little as 350mL in refillable 2.3L canister – KOKO Networks)</li> </ul>                 |
| <b>Players</b>               | <ul style="list-style-type: none"> <li>• Total (TotalGaz)</li> <li>• Hashi</li> <li>• Kenol Kobil (K Gas)</li> <li>• Kenyan Pipeline company (infrastructure)</li> <li>• Pay-as-you-go LPG pilots – (e.g., PayGo Energy, Envirofit SmartGas, KopaGas)</li> </ul>   | <ul style="list-style-type: none"> <li>• KOKO Networks</li> <li>• Leocom</li> <li>• Safi International</li> <li>• Prosol Limited</li> <li>• IR&amp;D Africa Limited</li> </ul>   |
| <b>Key barriers to scale</b> | <ul style="list-style-type: none"> <li>• High upfront stove and cylinder costs</li> <li>• High ongoing fuel costs (especially given LPG not widely available in smaller quantities)</li> <li>• Safety concerns by some customers</li> <li>• High capital expenditures required for scaling necessary infrastructure</li> </ul> | <ul style="list-style-type: none"> <li>• Relatively high ongoing fuel costs due to VAT and tariffs vs. other fuel alternatives that do not face such duties</li> <li>• Very low levels of consumer and market awareness</li> </ul> |

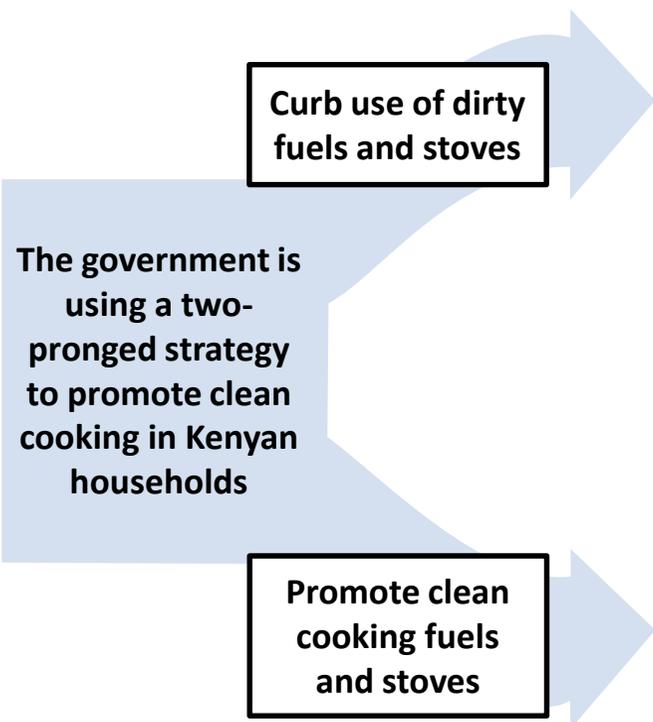
**LPG is well-understood. Liquid Bio-ethanol is a complementary, emerging cooking fuel solution that is described and analyzed in more depth in the following section of this report**

# Bio-ethanol delivers environmental impacts comparable to LPG while requiring consumers to pay lower upfront costs and allowing smaller purchase sizes

| Category  | Impact of switching to Bio-ethanol  | Impact of switching to LPG  |
|---|---|---|
| <br><b>Environmental</b>                 | <ul style="list-style-type: none"> <li>• <b>Up to 30 trees saved</b> per HH annually from switching from charcoal<sup>1</sup></li> <li>• <b>Slows down rate of deforestation</b> and, consequently, its impact on <b>food insecurity</b></li> <li>• <b>0.7-3.3 tonne reduction in GHG emissions</b> per HH per year from switching from kerosene and charcoal respectively<sup>2</sup></li> </ul> | <ul style="list-style-type: none"> <li>• <b>Up to 30 trees saved</b> per HH annually from switching from charcoal<sup>1</sup></li> <li>• <b>Slows down rate of deforestation</b> and, consequently, its impact on <b>food insecurity</b></li> <li>• <b>0.5-3.1 tonne reduction in GHG emissions</b> per HH per year from switching from kerosene and charcoal respectively<sup>2</sup></li> </ul> |
| <br><b>Health</b>                        | <ul style="list-style-type: none"> <li>• <b>~0.25 DALYs</b> saved per HH per three year intervention period from switching from charcoal and kerosene</li> <li>• <b>Reduction of ~50 deaths per 25,000 households</b> from reduced indoor air pollution<sup>3</sup></li> <li>• Safety risks of storage, handling and use are lower for a liquid than pressurized gas</li> </ul>                   | <ul style="list-style-type: none"> <li>• <b>~0.25 DALYs</b> saved per HH per three year intervention period from switching from charcoal and kerosene</li> <li>• <b>Reduction of ~50 deaths per 25,000 households</b> from reduced indoor air pollution<sup>3</sup></li> </ul>  |
| <br><b>Economic / opportunity costs</b> | <ul style="list-style-type: none"> <li>• <b>Distributed in smaller volumes, making it more accessible to lower-income users</b></li> <li>• Existing domestic Bio-ethanol sector could be expanded, <b>creating formal, taxable jobs and boosting smallholder farming income</b></li> <li>• <b>20-40 mins saved per HH per day</b> from switching away from charcoal<sup>4</sup></li> </ul>        | <ul style="list-style-type: none"> <li>• <b>Higher upfront costs</b> and requires purchasing in <b>larger bundle sizes</b></li> <li>• <b>20-40 mins saved per HH per day</b> from switching away from charcoal<sup>4</sup></li> </ul>   |

Source: (1) Calculations based on FAO, "Logistics of Charcoal Production", 2010; (2) bottom up build of HH emissions at point of fuel consumption and including fuel production w/ average emissions factors - charcoal stove used is KCJ; (3) assumes average 50 ug/m<sup>3</sup> 24hr emissions of 50 for both LPG and Ethanol based on lab data, field data ranges are 15-71 ug/m<sup>3</sup> for LPG, 30-100+ for ethanol, but field numbers not applies to apples given ambient pollution variation; (4) Koko data triangulated with Project Gaia reports for CleanCook in Madagascar and Tanzania; independent reports for Haiti; SafiJiko in Kenya; evidence seems to point to comparable LPG and Ethanol stove cooking times

# The Government of Kenya has intervened to promote LPG; policy action is now needed to level the playing field for Bio-ethanol



- **‘Kerosene-Free Kenya’ campaign** aims to phase out the use of kerosene for lighting and cooking, and replace it with clean energy sources, including plans to increase taxes on kerosene. This would also reduce the illicit use of kerosene to dilute diesel
- **Efforts to regulate the charcoal industry** by providing support for sustainable production and community forest management are minimizing impact of charcoal use

- GoK has **introduced fiscal incentives to reduce costs of clean cooking**
- **VAT zero-rating for LPG** has reduced prices and **Mwananchi Gas Project** subsidizes cost of cylinders
- **Remaining duties and VAT on Bio-ethanol** stoves and fuel adds cost to customers

|           | Policy support      | LPG                                 | Ethanol                             |
|-----------|---------------------|-------------------------------------|-------------------------------------|
| FUEL      | Remove import duty  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|           | VAT zero-rating     | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
| APPLIANCE | Reduce import duty  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|           | Remove VAT          | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
|           | Subsidize appliance | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |

**To date, Bio-ethanol for cooking has not been as much a target of government intervention despite being a high-impact clean fuel option, mainly due to limited private sector activity**

## SECTION III: POTENTIAL OF BIO-ETHANOL FOR COOKING IN KENYA

**The health, environmental, and other social impacts of transitioning from more traditional fuels (e.g., firewood, charcoal, and kerosene) are well documented; while LPG has enjoyed more visibility and promotion in Kenya, the potential benefits of transitioning to Bio-ethanol are also significant at a HH level**

- Switching from charcoal to either Bio-ethanol or LPG could save up to 30 trees and reduce 3-5 tonnes of GHG emissions per household
- Bio-ethanol and LPG have average PM2.5 emissions much lower than those of traditional fuels
- Transitioning all kerosene and charcoal users in Nairobi to Bio-ethanol could result in up to 2mn tonnes GHGs and 200,000 DALYs averted annually
- This transition would also counteract deforestation and its negative effects on agricultural yields and food insecurity

**Bio-ethanol can also deliver additional economic benefits**

- As local demand is unlocked and the necessary investments are made, the existing local technical alcohol industry could be expanded to serve this demand, creating jobs across the value chain
- While these will displace jobs in the charcoal value chain, they will generally be of higher-quality and better paying, and potentially taxable, providing the government with additional resources to invest other job creation activities for displaced persons

**Bio-ethanol is becoming cost-competitive and scalable as a cooking solution, given innovations that leverage localized distribution technology and existing downstream infrastructure**

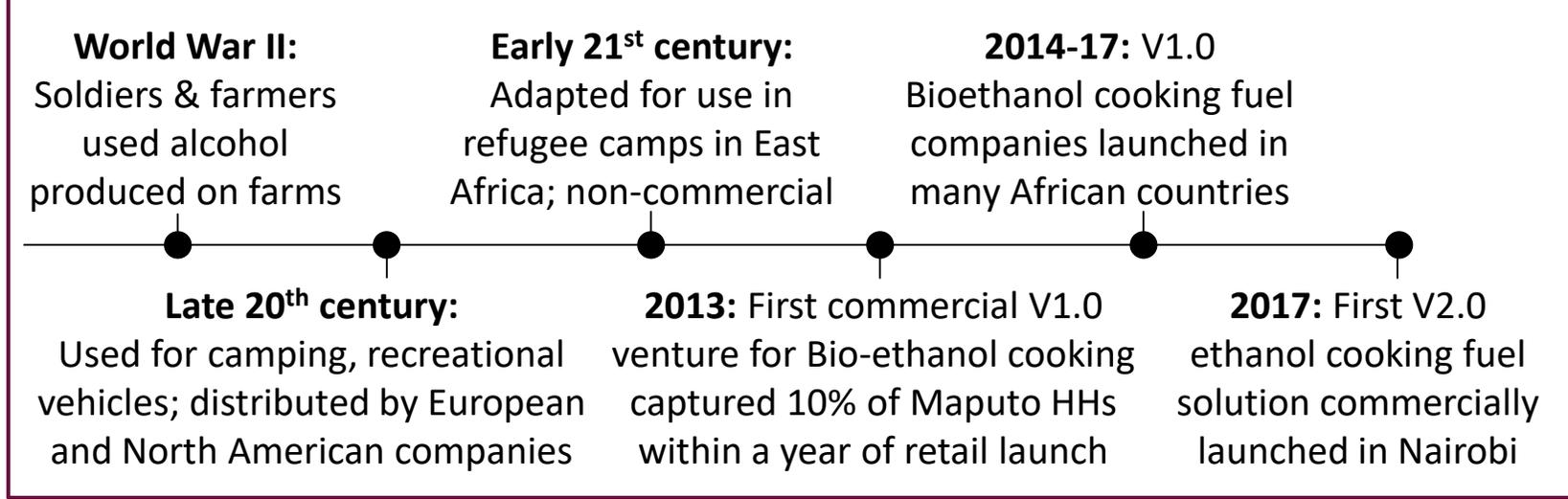
- Bio-ethanol V2.0 model has shrunk logistics costs between the landed cost and final price to customer, with taxes now driving ~25% of final price
- Bio-ethanol V2.0 can be scaled with significantly lower capital expenditures than required for scaling LPG

**The partnership between Vivo Energy, a downstream fuel trading company, and KOKO Networks, a hardware and software technology company enabling the last-mile distribution of Bio-ethanol fuel, is the leading example of V2.0 in Kenya**

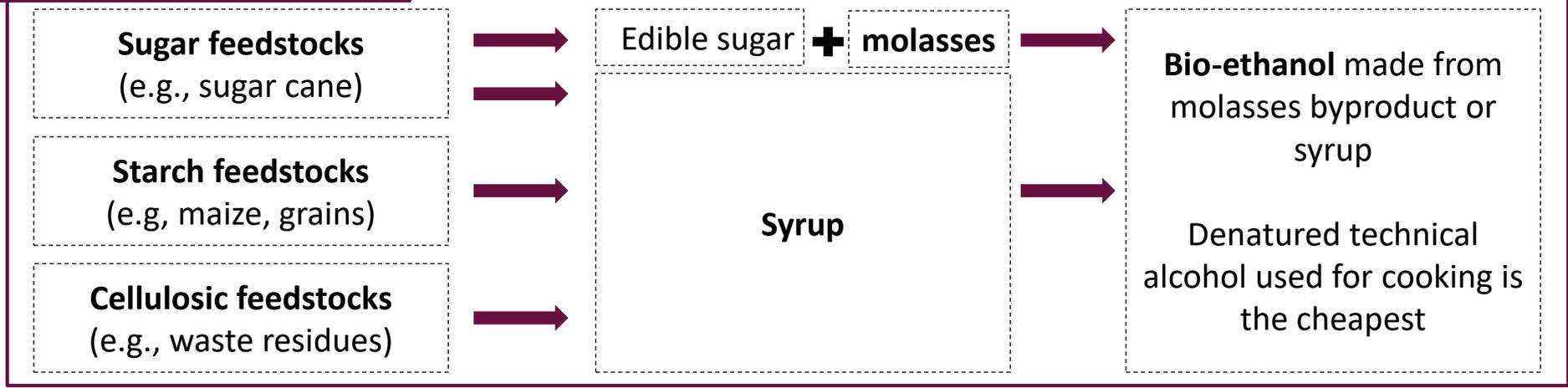
- Leveraging existing fuel infrastructure, sales points, and mobile and cloud technology, KOKO's model delivers fuel closer and more cheaply to customers
- Vivo Energy uses KOKO technologies to safely and efficiently add a new line of liquid fuel to its existing downstream infrastructure
- With this model, Bio-ethanol is sold to customers at \$0.85 / L

# Alcohol-based cooking has a decades-long history, but only in niche markets

## History of Bio-ethanol



## Bio-ethanol production



Source: Expert interviews.

# A transition of all kerosene / charcoal users in Nairobi to Bio-ethanol could result in ~2mn tonnes GHGs, 200K DALYs, and 1,500 deaths averted p.a.

A full transition of kerosene and charcoal users to Bio-ethanol in Nairobi alone would help towards achieving the Sustainable Development Goals



~200,000 DALYs and 1,500 deaths averted<sup>3,4</sup> over a three year intervention period



Difficult to quantify given poor data, but most **time savings** from collection, cooking, and cleaning **will accrue to women**



USD 60mn in annual consumer savings<sup>4</sup>



Reduction of 2mn tonnes of CO<sub>2</sub>eq emissions<sup>1</sup>

This represents 2-3% of Kenya's annual GHG emissions and **10% of Kenya's 2030 GHG reduction goal**<sup>2</sup>

Note: (1) Kyoto particles and black carbon CO<sub>2</sub> equivalents;

Source: (2) Kenya's Intended Nationally Determined Contribution, Ministry of Environment and Natural Resources, 2015. (3) HAPIT model; (4) Dalberg Nairobi impact model. See Appendix B for methodology.

# Recent innovations enable Bio-ethanol to undercut dirty fuels and quickly scale



**V1.0 Centralized Bottling Approach**

|                                      |   |  |   |  |   |
|--------------------------------------|---|--|---|--|---|
| Large, centralized bottling facility | Expensive, thick plastic disposable bottles | Low-capacity trucks transporting bottles from central facility and across long distances | Small shops & high fast-moving consumer goods (FMCG) industry margins | Pour from bottle; wipe up spillage; discard bottle | Cash and clipboards; stock on consignment, leading to stockouts |
|--------------------------------------|---|--|---|--|---|

**V2.0 Smart Fuel ATM Network Approach**

|   |   |  |  |   |   |
|---|---|--|--|---|---|
| Distributed storage in customised tanks at existing petrol stations | Zero recurring packaging costs as fuel distributed in bulk form | Small retrofitted fuel tankers for last-mile, slashing logistics costs | Fuel ATMs inside shops with low fuels-industry margins for shopkeepers | Safely dock reusable, valve-controlled canister with ATM & stove<br><br>No spillage, no plastic waste | 100% digital payments; automated inventory management |
|---|---|--|--|---|---|

**“V2.0 Smart Fuel ATM” approach leverages technology and downstream fuels infrastructure to remove over 50% of supply chain costs within the traditional “V1.0 Centralized Bottling” approach**

# V2.0 approach enables Bio-ethanol to now scale competitively with other fuels

|   | Charcoal                           | Kerosene                         | LPG  | Bio-ethanol V1.0  | Bio-ethanol V2.0   |
|---|------------------------------------|----------------------------------|--|---|--|
| <b>Fuel retail price</b>                                      | \$0.30 - \$0.45 / kg <sup>1</sup>  | \$0.75 - \$0.85 / L <sup>2</sup> | \$1.70-1.75 / kg for 6kg, 13kg cylinders, >\$3.00 / kg for PAYG LPG <sup>3</sup>       | \$0.90 - \$1.10 / L with small volumes of Kenyan fuel >\$1.48 at large scale with imported Bio-ethanol <sup>4</sup> | \$0.85 / L sustainable at scale with imported Bio-ethanol, including \$0.21 / L of VAT and import tariffs <sup>4</sup> |
| <b>Annual cooking cost for average Nairobi HH<sup>6</sup></b> | \$207 - 249                        | \$224                            | \$233  | \$234 – 297 (with locally-produced Bio-ethanol)<br>\$385 (at scale w/ imported Bio-ethanol*)                        | \$220 - 230  |
| <b>Stove retail price<sup>7</sup></b>                         | \$7 KCJ, \$25 - 35 Burn/ Envirofit | \$6 - \$20                       | \$40-50 for 1-burner, \$100-120 for 2-burner (incl. hose, regulator, cylinder deposit) | \$50 - \$70 for 2 burner stove (SAFI, Dometic)  | \$45 for 2 burner and \$30 for 1-burner (KOKO)   |

**“V1.0 Centralized Bottling” approach has difficulty competing at scale, once limited volumes of Kenyan Bio-ethanol are absorbed and imports are required**  
**“V2.0 Smart Fuel ATM” approach delivers cost savings that are a critical enabler of scale.**

Source: (1) Business Daily Africa, “More pain for poor as charcoal price its Sh 2,500 a bag”, 2018; (2) Business Daily, “ Gas Prices Fall by Over Sh 600 in 2015”; (3) Timetric LPG data 2018; (4) KOKO Networks pricing data 2018; (6) Based on 3,500 MJ per HH per year – this is a triangulated figure based on: World Bank Development Research Group, “Household Cooking Fuel Choice and Adoption of Improved Cookstoves in Developing Countries”, 2014; University of Nairobi and Plank Institute for Chemistry, “Biofuel consumption rates and patterns in Kenya”, 2002; O’Sullivan and Barnes, “Energy Policies and Multi-topic Household Surveys, 2007; Dalberg Nairobi fuel household survey 2018 (7) Stove prices from Dalberg field research

## V2.0 Case Study: Vivo Energy Kenya uses KOKO technologies to safely add a 4<sup>th</sup> line of liquid fuels to its existing infrastructure and increase its reach



**Vivo sources and stores both domestic Bio-ethanol and foreign imports, using KOKO technologies to ensure visibility of fuel flows**

- Bio-ethanol is stored in dedicated underground tanks at urban petrol stations
- Stations install KOKO's Smart Depot System to control and manage fuel flows



**Vivo MicroTankers equipped with KOKO's Smart Tanker System perform last-mile delivery to KOKOpoint Fuel ATMs located in neighbourhood shops**

- KOKOpoints are refueled via a secure external refilling box, located on the outside of the shop
- A vapor recovery line ensures no escape of vapor at any point – all vapor is safely transferred back to the Vivo service station



**KOKO technologies capture data across the fuel supply chain and facilitate payments**

- KOKO's Network Operations Centre ensures complete visibility and control across the fuel supply chain
- KOKOpoint sensors transmit technical health, safety, inventory and transaction information in real-time
- KOKO Settlement & Payments System automates and de-risks payment flows between Vivo and retailers

## V2.0 Case Study: Leveraging sales points, and mobile / cloud tech, KOKO's model delivers fuel closer and more cheaply to customers



**KOKOpoints are deployed densely across the city, inside neighbourhood shops and convenience stores**

- KOKOpoints are located within a short walk of target households.
- Shopkeepers become KOKO Agents, with KOKOpoint installed in shop under franchise agreement.



**At a KOKOpoint, customers order stoves and use their reusable “smart-valve” canister to safely purchase fuel**

- New customer orders an Bio-ethanol stove (1- or 2-burner) from local KOKOpoint or via mobile
- Stove and canister are ready for customer collection the next day
- Customers pre-pay and top-up KOKO account using mobile money – entire system is cashless
- Vapor-tight “smart-valve” system ensures that fuel can only be obtained from a KOKOpoint or added to a stove with the canister

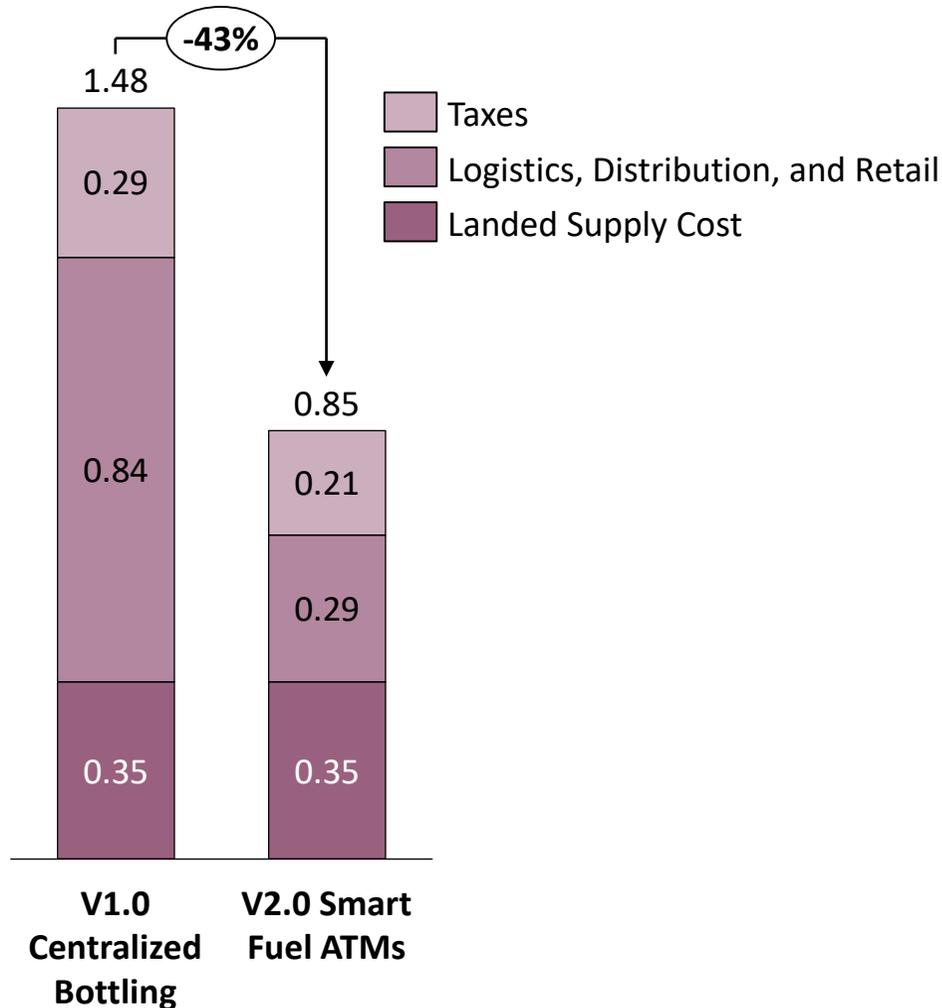


**KOKOpoint syncs to customer's KOKO account and allows purchases of as little as ~350mL**

- Chip inside canister instantly recognises customer details, syncing with customer's KOKO account
- KOKO's dispenser-based distribution model allows customers to buy fuel from as little as KES 30/bundle (~350ml)
- Customer selects fuel volume to buy; no penalty for buying smaller amount

# V2.0 innovations mean that Bio-ethanol can be delivered at scale to the customer at a price up to ~40% less than the V1.0 approach

Supply chain margins for Bio-ethanol  
(% of total cost)

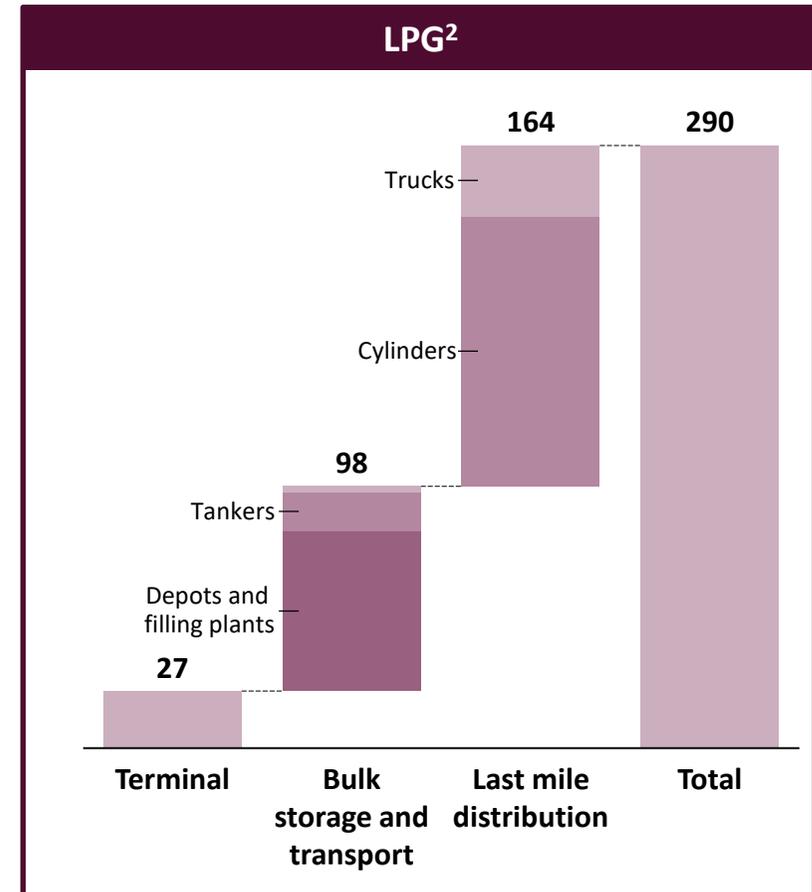
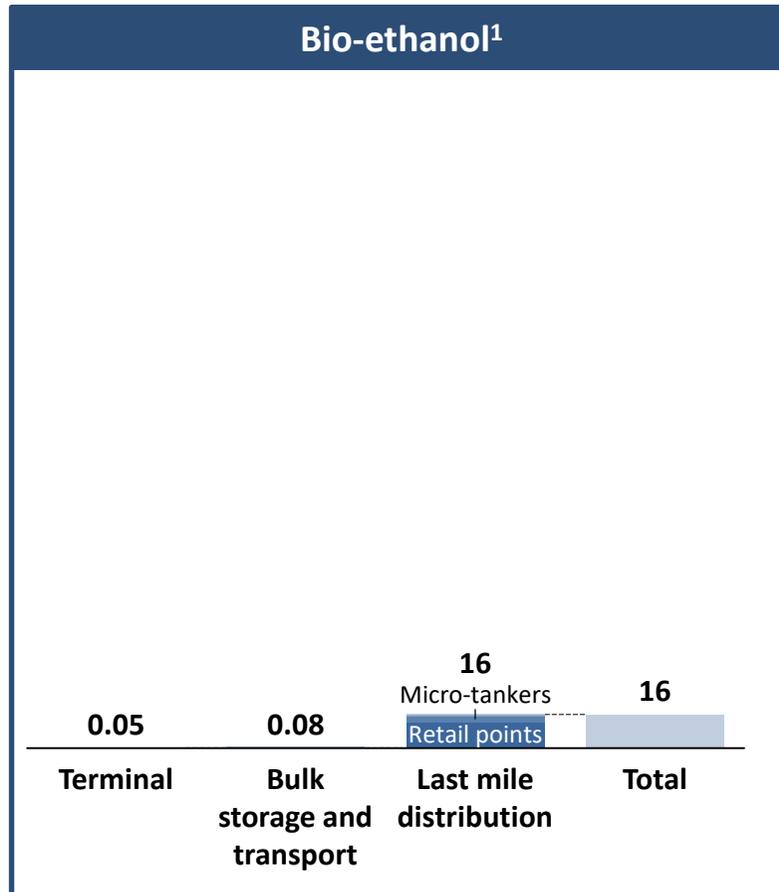


**Bio-ethanol V2.0 costs are significantly lower than those of Bio-ethanol V1.0**

- Leveraging existing downstream infrastructure can **cut down bulk storage and transport costs by ~90%**
- Technology-enabled distribution can **reduce combined distribution and retail costs by ~45%**
- Aside from landed supply cost, taxes drive the retail price of Bio-ethanol V2.0

# Bio-ethanol V2.0 can be scaled with significantly lower capital expenditure than required for scaling LPG

Incremental investment required to extend supply to 2 million additional HHs in urban Kenya, (USD million)



**Capex requirement for scaling LPG in Kenya is 18x that of Bio-ethanol V2.0 model**

Note: Terminal includes: LPG: terminal capacity increase, Bio-ethanol: fuels lines from ship to port.

Source: (1) KOKO Networks business model assumptions, expert interviews; (2) GLPG Kenya Market Assessment, 2013.

## Section IV: Bio-ethanol policy analysis

**Bio-ethanol is a scalable clean fuel option – especially using latest technologies – but taxation is affecting customers' ability to access fuel at lowest possible cost**

- Given the limited local production of technical Bio-ethanol, imports will be necessary to meet the potential demand in the short- to medium-term
- Only 1.8m L of viable technical Bio-ethanol are produced Kenya versus a potential demand of ~120mn L in Nairobi alone
- Technical Bio-ethanol faces 16% in VAT and 25% in duties compared to 0% for most other fuels, with the exception of kerosene, which faces a 9% excise duty; this inflates the cost at which Bio-ethanol cooking fuel can be sold to customers
- In fact, Kenya ranks below other sub-Saharan African countries in terms of Bio-ethanol-friendly policy, with combined duties and VAT of 41% for Bio-ethanol, vs. an average of 33% for 21 sub-Saharan African countries for which data was available
- These taxes and tariffs now drive ~25% of Bio-ethanol retail price

**In the long run, Bio-ethanol could be produced locally after first proving demand using imports**

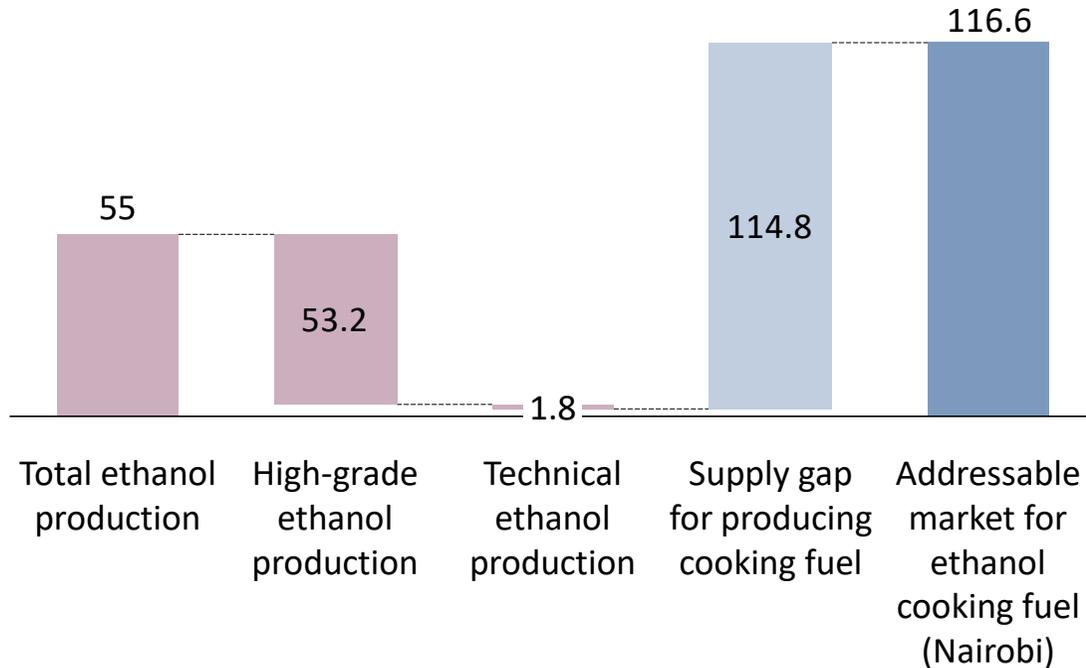
- Scaling the local industry will require a phased approach as potential investors (i.e., those likely to provide the project finance to build more dedicated Bio-ethanol plants in Kenya) will want to see a track-record of demand
- Once this demand is unlocked with a reliable supply of imports, domestic production will follow to serve it

**Tax concessions would accelerate unlocking the Bio-ethanol cooking fuel opportunity by levelling the playing field and making prices more competitive**

- Levelling the playing field by granting denatured technical alcohol a VAT-zero rating and eliminating related tariffs would make Bio-ethanol fuel the cheapest option, providing Kenyans with an affordable alternative to traditional fuels and delivering up to a USD60mn saving to customers annually
- Plans to increase taxes on kerosene and recent spikes in local Kenyan charcoal prices due to local logging bans reinforce the need for cheaper alternatives for the lowest income users

# Given the limited local production of technical Bio-ethanol, imports will be necessary to meet the potential demand in the short- to medium-term

Bio-ethanol volumes in Kenya (million liters per year)



Currently, most of the Bio-ethanol produced locally is high-grade Bio-ethanol used by the beverage industry, and not for cooking; at **1.8 million<sup>1</sup> liters of local technical Bio-ethanol production, only ~1.5% of just Nairobi's potential addressable market<sup>2</sup> would be served**

**Building up the local industry for industrial Bio-ethanol would require first unlocking demand; tax concessions could facilitate this by allowing Kenyan customers to purchase Bio-ethanol at prices lower than charcoal and kerosene**

(1) Accounts for 3-5% of total ethanol production from the top three ethanol plants in Kenya (2) Assumes full transition away from charcoal and kerosene to Bio-ethanol as a primary cooking fuel for the top 50% households by income

# Duty and VAT for denatured technical Bio-ethanol imports are much higher than those applied to other cooking fuels

## Kenyan duty and VAT rates for cooking fuels

| FUEL                            | Effective duty  | Effective VAT    |
|---------------------------------|-----------------|------------------|
| Charcoal                        | N/A             | N/A <sup>1</sup> |
| LPG                             | 0%              | 0%               |
| Kerosene                        | 9% <sup>2</sup> | 0%               |
| Denatured technical Bio-ethanol | 25%             | 16%              |

**Bio-ethanol is at a major disadvantage compared to the rest of the fuel sector; duty + VAT represents 25% of the retail price to the customer<sup>3</sup>**

Note: (1) Most charcoal consumed in Nairobi is supplied through informal markets hence virtually no tariff or taxes are collected (2) Based on 7.25 KES excise duty charged on a liter of kerosene (3) KOKO Networks retail analysis

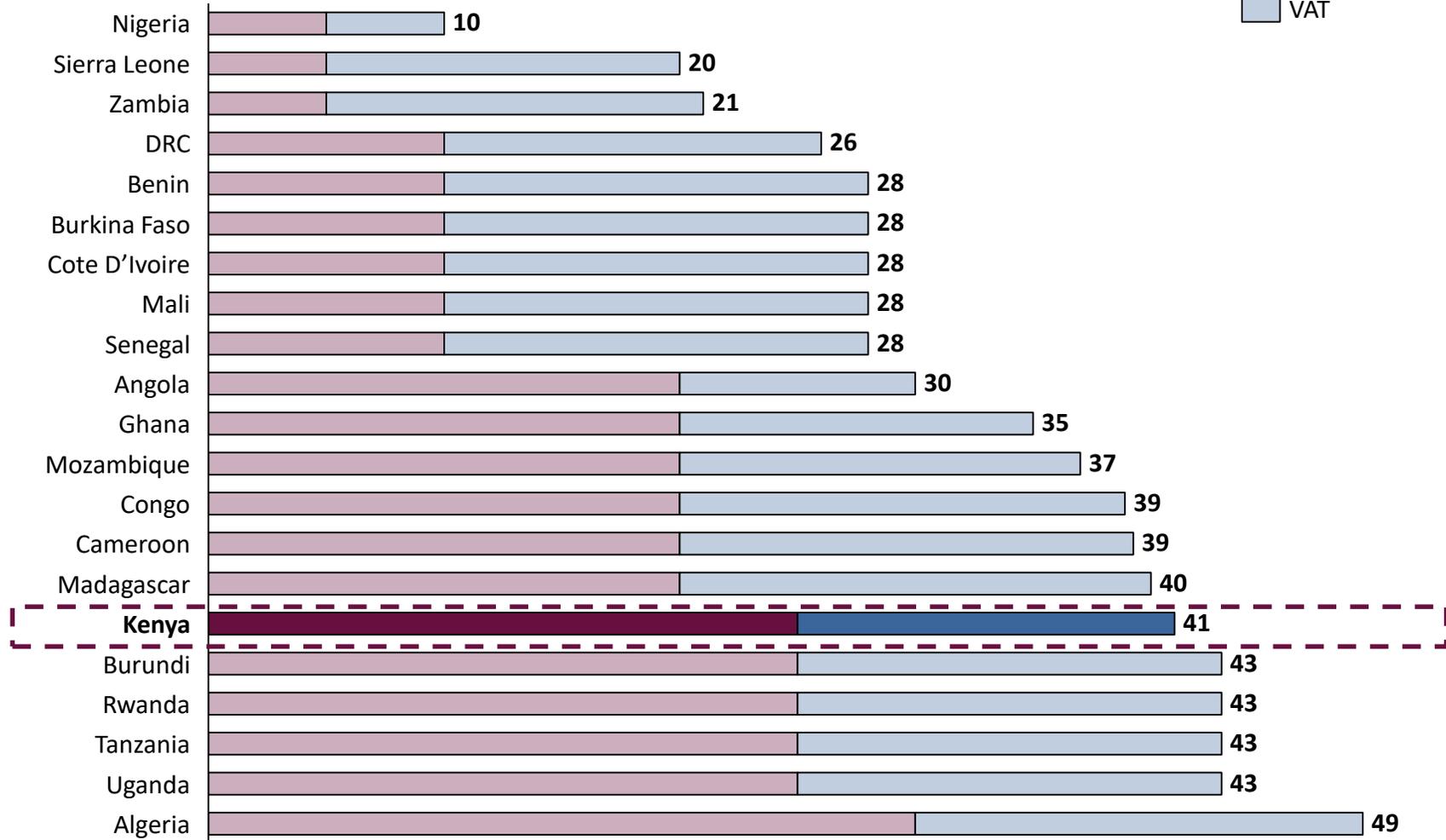
Source: Petroleum Institute of East Africa; World Integrated Trade Solution; PwC, Overview of VAT in Africa

# In fact, Kenya ranks below other Sub-Saharan African countries in terms of Bio-ethanol-friendly policy

## Duty and tax burden on imported denatured Bio-ethanol

Subset of 21 SSA nations, reflecting duties + taxes, %

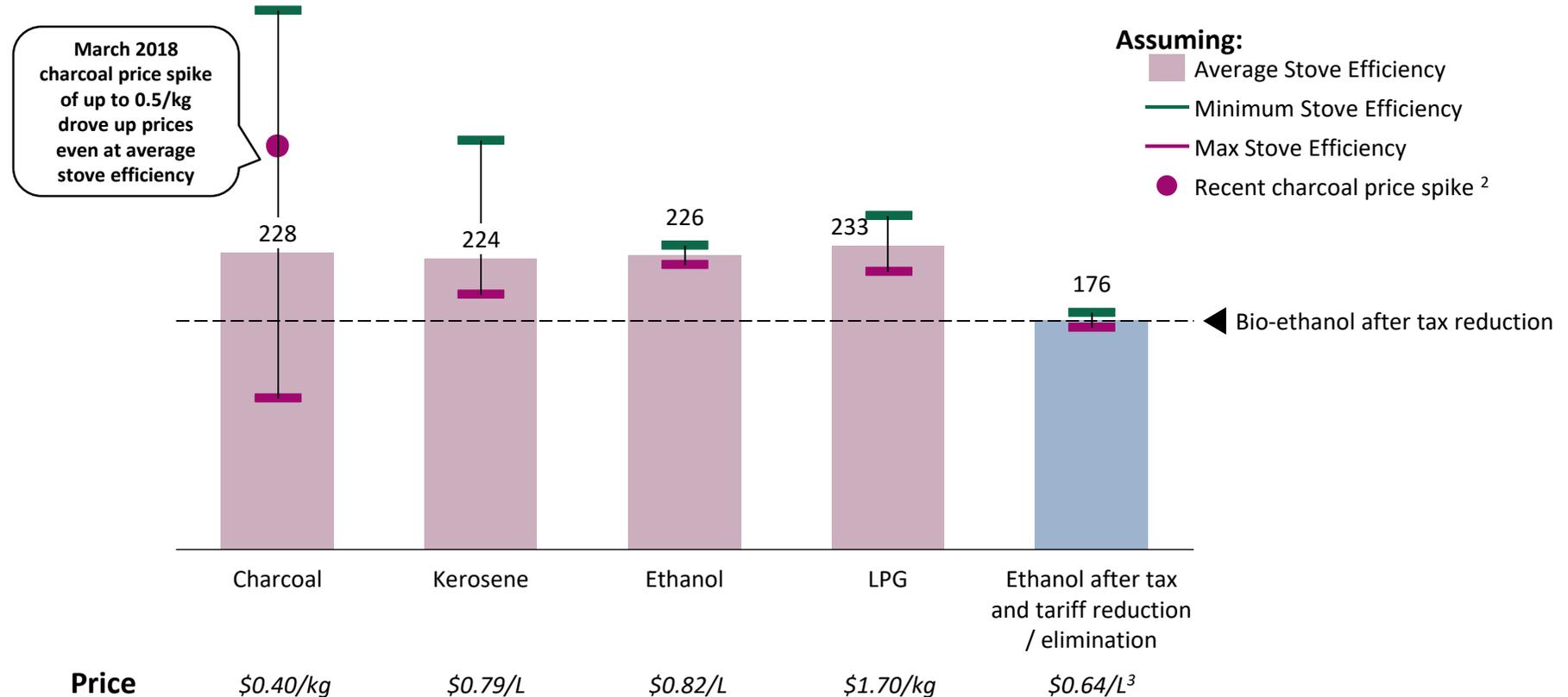
Import tariff  
VAT



# Granting Bio-ethanol a VAT-zero rating and eliminating tariffs would make it the cheapest cooking fuel option for Kenyans

Average annual fuel expenditure by fuel type to meet 3,500 MJ fuel consumption of a typical Nairobi household<sup>1</sup>

USD / year



(1) 3,500 MJ is triangulated figure based on: World Bank Development Research Group, "Household Cooking Fuel Choice and Adoption of Improved Cookstoves in Developing Countries", 2014; University of Nairobi and Plank Institute for Chemistry, "Biofuel consumption rates and patterns in Kenya", 2002; O'Sullivan and Barnes, "Energy Policies and Multi-topic Household Surveys, 2007; Dalberg Nairobi fuel household survey 2018

(2) Recent price spike in charcoal price reach \$0.5/kg and continue to rise; this is due to a ban on illegal logging introduced by the government in addition to the expected upswing during the wet season

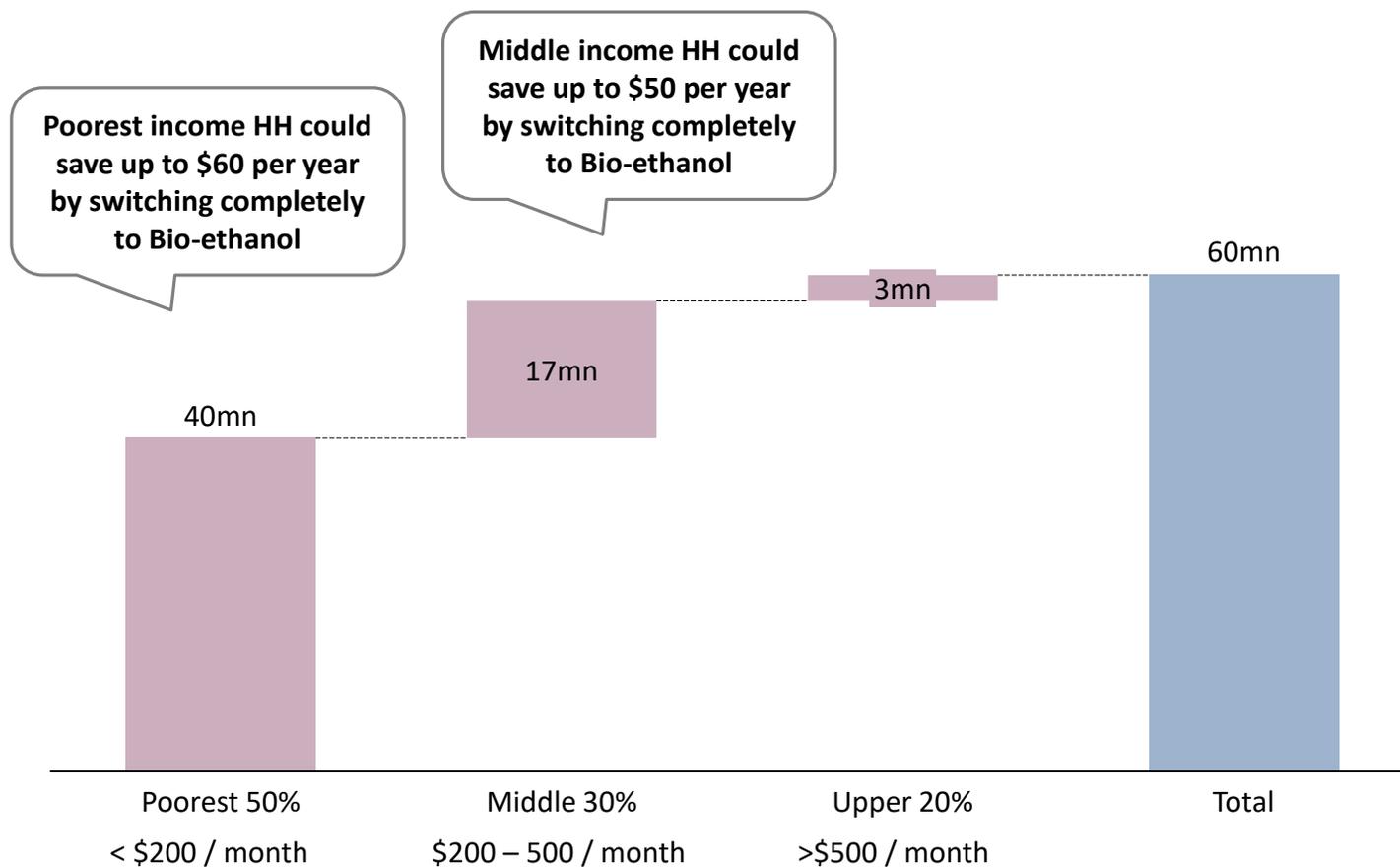
(3) Assumes V2.0 model and using imported Bio-ethanol

# This reduction in taxes and tariffs could lead to savings of up to USD 60mn per year for consumers in Nairobi, if they switch to Bio-ethanol

Aggregate household savings by income segment with 100% charcoal and kerosene households switching to Bio-ethanol<sup>1</sup>

USD per year

New Bio-ethanol price: USD 0.64/L

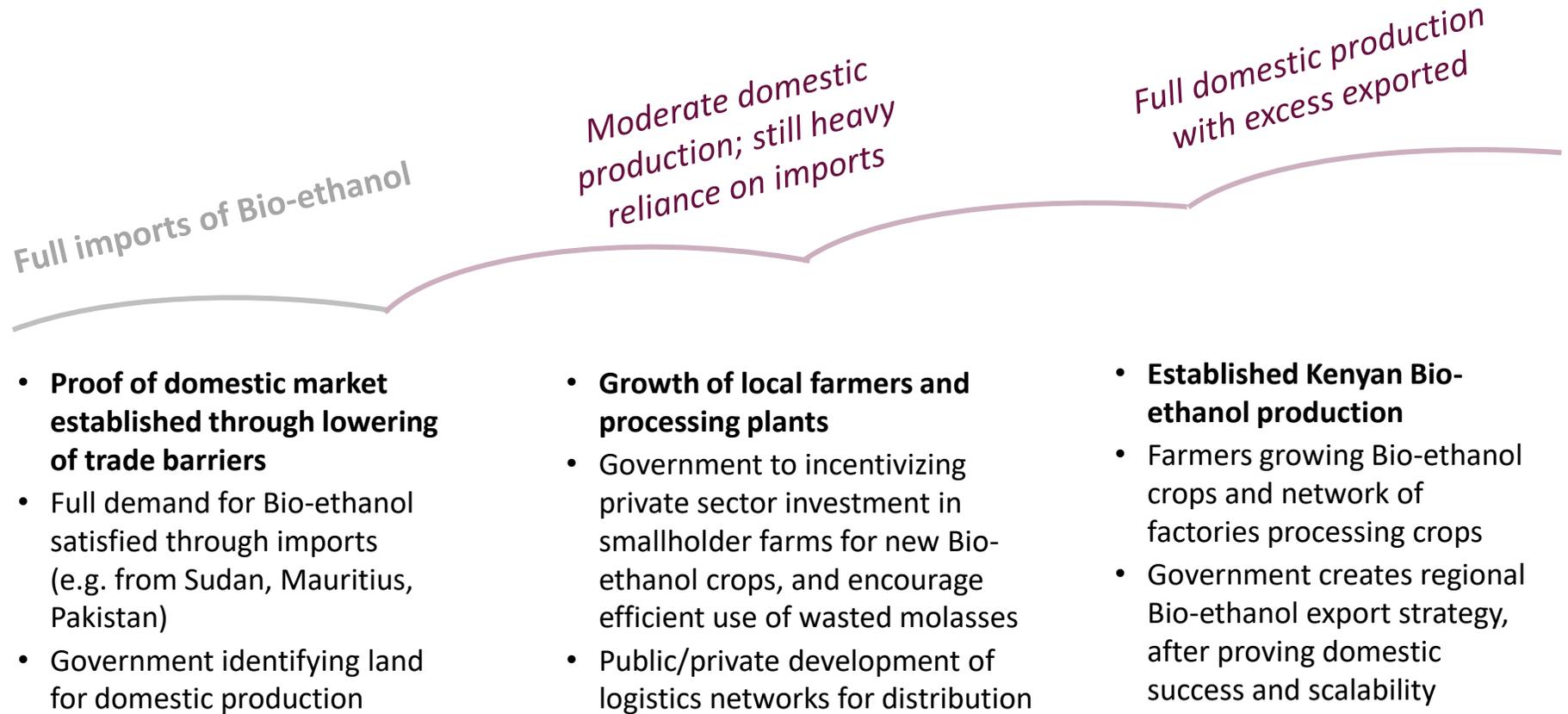


Assumptions: 100% of poorest, middle and upper income charcoal and kerosene users switch to Bio-ethanol; no LPG users switch to Bio-ethanol in lower, middle or wealthiest – these estimates are therefore the upper limit to savings

Source: (1) Household segmentation based on a triangulation of: Kenya Population and Housing Census 2009; Kenya National Bureau of Statistics, “FinAccess Household Survey” and “Kenya Integrated Household Budget Survey, 2016; Kenya Dalberg Nairobi household survey 2016; KOKO household survey 2017

# Proving the strength of urban markets will unlock the conditions to grow a domestic Bio-ethanol industry over medium to long term to meet demand

## Activities



**The Kenyan beverage alcohol market is a good example of how imports were used to prove latent demand; once this was clear, local molasses producers built Bio-ethanol plants in order to serve the beverage market. Now there are three Bio-ethanol producers in Kenya, producing 50mn liters annually and exporting to Uganda and Tanzania**

# Risks often associated with Bio-ethanol are overstated; in fact, the cooking Bio-ethanol industry can drive economic growth in Kenya

Potential risks associated with Bio-ethanol are often overstated and largely addressable

In fact, Bio-ethanol use presents opportunities to strengthen the Kenyan economy

## Tax revenue



**Largest potential negative tax impact** – revenues lost from kerosene imports – **will happen regardless**, since government advocating a Kerosene Free Kenya<sup>1</sup>

Domestic Bio-ethanol production will **create formal, income tax-paying jobs**

## Trade balance



**Initial negative impact** of imported Bio-ethanol **will decrease as domestic production develops**

In the future, **domestically produced Bio-ethanol could replace imported kerosene**, improving the trade balance; Kenya could one day be a regional net exporter of Bio-ethanol

## Jobs



**Jobs lost in the charcoal industry** are low quality, low paying, and highly seasonal and **likely to be lost anyway, given government's goals to curb charcoal production**

A **domestic Bio-ethanol industry** serving 500,000 customers **could create 40-70K new jobs, generating USD 17-35mn in incremental incomes<sup>2</sup>**

## Food security



**Negative impact of Bio-ethanol production on food security has not been observed** in other cases; in Kenya, < 1% of arable land would be required for Bio-ethanol production<sup>2</sup>

Charcoal production depletes non-renewable forests, leading to land degradation; **reducing charcoal use could actually enhance food security**

## Section V: Conclusions

1. Ultimately, the desired outcome underlying this report is that **Kenyan consumers have access to safe and clean cooking fuel options at the lowest possible cost**
2. Today, there are viable **clean cooking fuel options that can serve the Kenyan population** currently paying for their fuel – these users are **concentrated in urban Kenya**
3. **Bio-ethanol and LPG are indisputably cleaner and safer options** than charcoal, kerosene, and firewood – better for Kenyans and better for the environment as a whole
4. **Use of LPG has successfully expanded** and it remains a key solution; now, **Bio-ethanol too is well-positioned to be a mass-market solution for urban Kenya**
5. **The GoK and other stakeholders have been proactive in promoting clean fuels**; there remain opportunities to further eliminate barriers to drive adoption of clean fuels
6. **Bio-ethanol delivers equivalent health and environmental benefits as LPG**, and it can now be distributed at prices affordable to lower and middle income Kenyans
7. In order for the Bio-ethanol opportunity to be fully realized, **there needs to be a level playing field** to compete with other cooking fuels; specifically, **VAT and import tariffs need to be eliminated to reduce the end cost to Kenyan consumers**

# Comparison of primary cooking fuel options in Urban Kenya

|                              | Charcoal  | Kerosene  | Bio-ethanol   | LPG  |
|------------------------------|---|---|---|--|
| Impacts                      | <ul style="list-style-type: none"> <li>• Highest PM2.5 exposure and GHG emissions</li> <li>• Key driver of deforestation and, consequently, food insecurity</li> </ul>  | <ul style="list-style-type: none"> <li>• High PM2.5 exposure</li> <li>• Lower GHG emissions than charcoal, but still higher</li> <li>• Safety concerns (fires and burns)</li> <li>• Negative impact on trade balance given imports</li> </ul> | <ul style="list-style-type: none"> <li>• Low PM2.5 exposure</li> <li>• Lowest GHG emissions</li> <li>• Domestic production and job creation opportunity</li> <li>• Shorter-term negative impact on trade balance given imports (until domestic industry grows)</li> </ul>   | <ul style="list-style-type: none"> <li>• Lowest PM2.5 exposure</li> <li>• Low GHG emissions</li> <li>• Negative impact on trade balance</li> </ul>   |
| Affordability/ accessibility | <ul style="list-style-type: none"> <li>• Cheapest per unit price</li> <li>• Annual cost of cooking varies based on stove efficiency; historically low on average though now at high point</li> <li>• Relatively low upfront stove cost</li> </ul> | <ul style="list-style-type: none"> <li>• Widely available throughout mass-market neighborhoods at hyper-local distribution points</li> <li>• Lowest annual cost of cooking</li> <li>• Low upfront stove cost</li> </ul>                       | <ul style="list-style-type: none"> <li>• Not well-understood; low consumer awareness</li> <li>• Comparable annual cost of cooking to charcoal; prices inflated by disproportionate taxes</li> <li>• Relatively high upfront stove cost vs. baseline charcoal (competitive vs. clean fuel alternatives)</li> </ul> | <ul style="list-style-type: none"> <li>• High consumer awareness</li> <li>• Availability constrained outside of Nairobi, but access high in capital</li> <li>• Highest price and annual cost of cooking</li> <li>• Highest upfront stove cost</li> </ul> |
| Potential for scale          | <ul style="list-style-type: none"> <li>• Already available at scale</li> </ul>  | <ul style="list-style-type: none"> <li>• Already available at scale</li> </ul>  | <ul style="list-style-type: none"> <li>• Recent innovations have reduced capital required to scale</li> </ul>   | <ul style="list-style-type: none"> <li>• Highest capital expenditures required for scale</li> </ul>  |

Note: PM2.5 exposure and GHG emissions figures depend on combination of fuel and stove used; however, conclusions here take into consideration the range of likely combinations.

Source: Expert interviews

## Recommended policy changes for scaling up clean cooking in urban Kenya

The most cost-efficient and impactful way for GoK to scale up clean cooking is to level the playing field for emerging Bio-ethanol with LPG, increasing availability and affordability of clean cooking solutions to consumers.

The specific policy recommendations based on this study are:

- 1**  
**Grant denatured Bio-ethanol fuel a VAT-zero rating**
- 2**  
**Remove import duties and additional taxes on Bio-ethanol fuel and appliances**
- 3**  
**Establish and enforce safety and quality standards through regulatory bodies**

# APPENDIX

- A: Cooking Fuel Options in the Kenyan Market
- B: Potential of Bio-ethanol for Cooking in Kenya
- C: Bio-ethanol Policy Assessment
- D: Risks and Opportunities

## **A: Cooking Fuel Options in the Kenyan Market**

B: Potential of Bio-ethanol for Cooking in Kenya

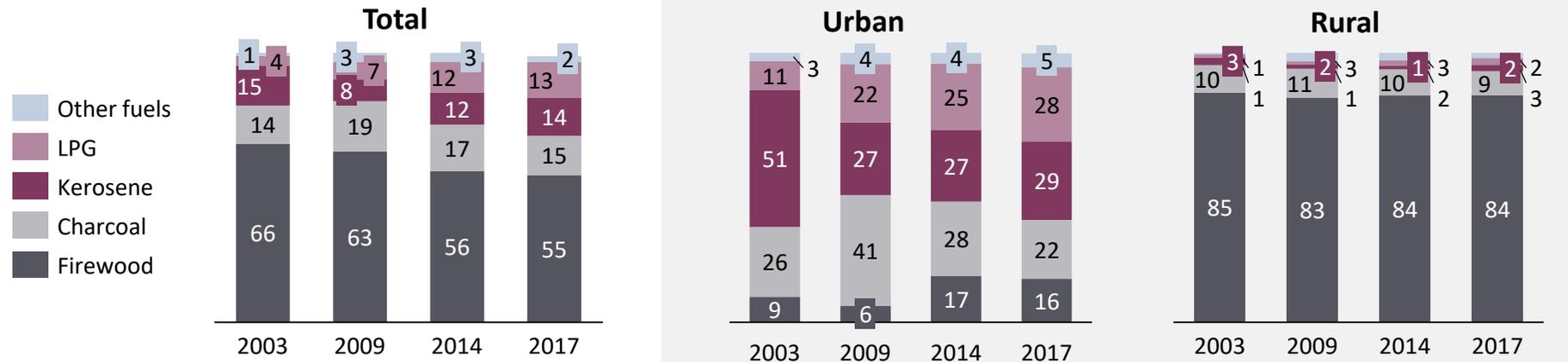
C: Bio-ethanol Policy Assessment

D: Risks and Opportunities

# Charcoal, kerosene, and LPG are the dominant cooking fuels in urban Kenya, while wood fuel cooking still dominates rural Kenya

## A: Cooking Fuel Options in the Kenyan Market

### Kenyan household use of primary cooking fuel (% of households)

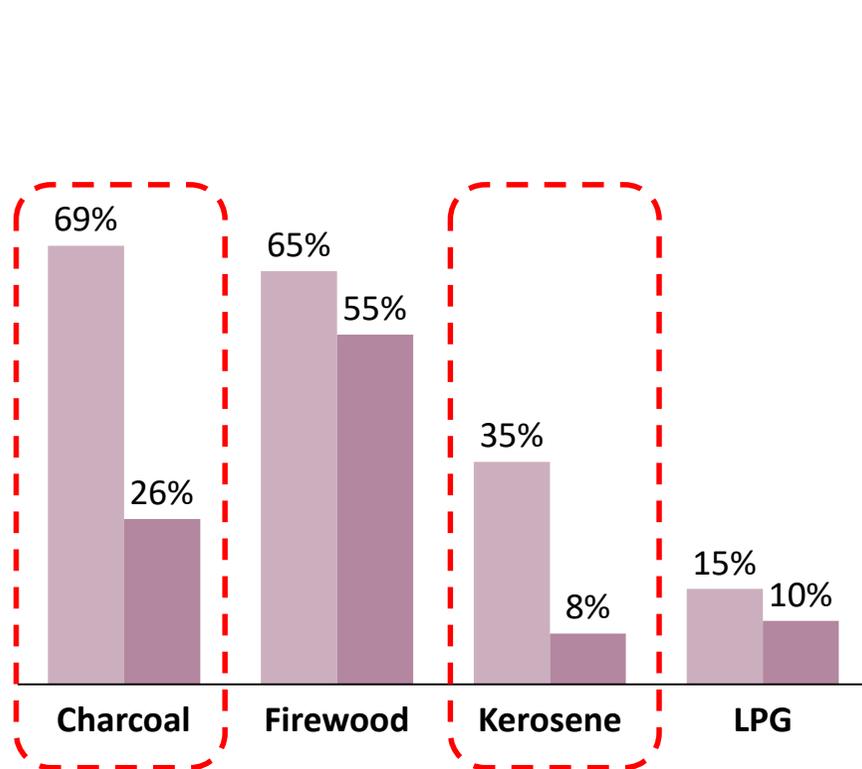


- **Firewood is still the dominant cooking fuel overall, though its share is declining overall with low levels of use in urban areas.** Wood use in urban Kenya (outside Nairobi) is still relatively high and may have risen in recent years due to high charcoal/kerosene prices
- **Increasing LPG adoption with high level of use in urban areas.** LPG share has increased 3-4x since the early 2000s. 28% of urban HH used LPG as their primary fuel in 2017, but rural LPG penetration remains low due to costs
- **Low use of “other” fuels,** including Bio-ethanol and electricity which offer health, environmental and socio-economic outcomes comparable to LPG; likely 0.5-1.5% share in urban Kenya for electricity and <10,000 HH for Bio-ethanol fuels (excluding Bio-ethanol gel)

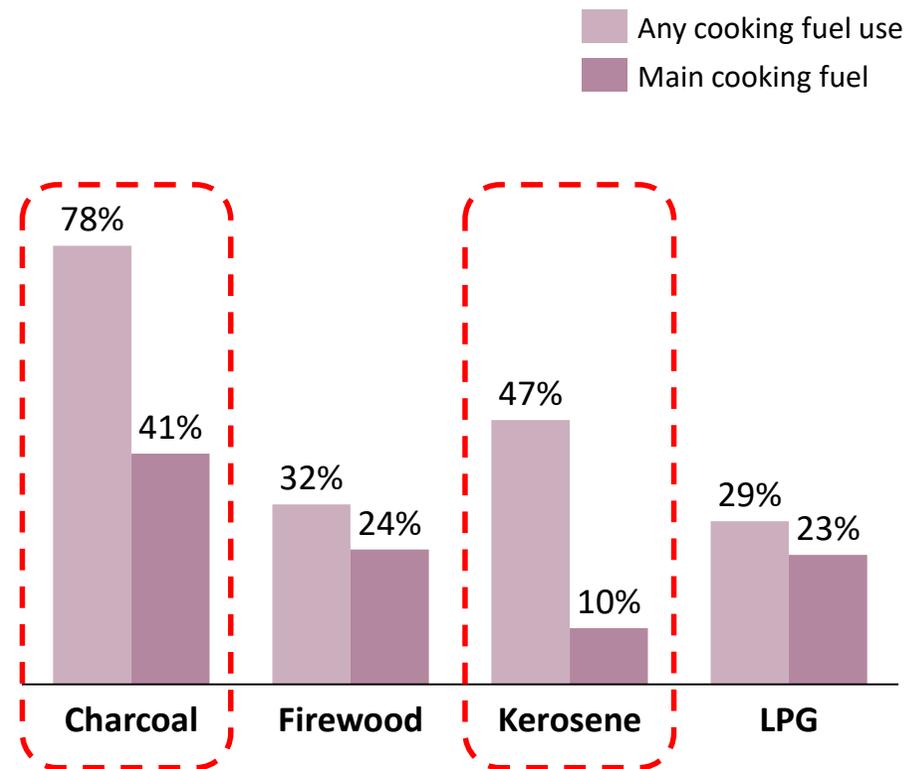
# Fuel stacking is a widespread phenomenon in Kenya; use of charcoal and kerosene are much more common than primary cooking fuel data indicate

## A: Cooking Fuel Options in the Kenyan Market

**All Kenya – any use of fuel vs. primary cooking fuel**  
(% of total HH, N=300, Dalberg 2015 survey)



**Urban Kenya – any use of fuel vs. primary cooking fuel**  
(% of total HH, N=~100, Dalberg 2015 survey)

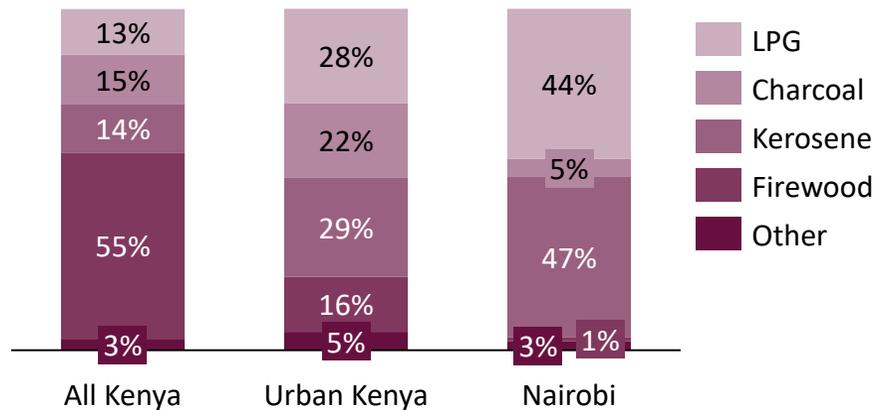


# LPG and kerosene dominate as primary cooking fuels in Nairobi

## A: Cooking Fuel Options in the Kenyan Market

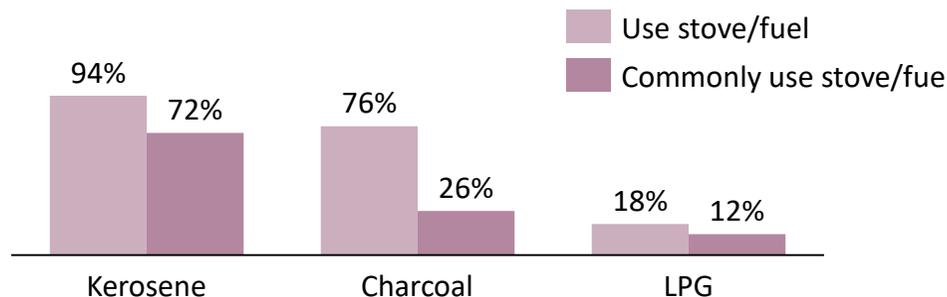
### Charcoal/kerosene are primary Nairobi cooking fuel (2018)<sup>1</sup>

(% of total HH, N=11,415 Kenya HH self-reported primary fuel)



### Charcoal + Kerosene are primary cooking fuels for Nairobi poor

(% of HH, n=1000 in Korogocho & Viwandani slums in Nairobi, 2016)<sup>2</sup>



- **Kerosene and LPG are the primary cooking fuel in Nairobi overall**, with low primary usage of charcoal; use is highly dependent on income level with top 25-30% of income distribution using LPG almost exclusively and next 20-30% using a mix of LPG with charcoal and kerosene; the rest only use LPG at low levels due to affordability<sup>3</sup>
- **The lower middle of the Nairobi income distribution (30-40% of HH)** primarily use kerosene and mix with charcoal for the bulk of their day-to-day cooking needs<sup>3</sup>
- **Kerosene is the dominant fuel for the poorest (15-20%) households in Nairobi** who use kerosene almost exclusively or in parallel with a low level of charcoal as a secondary cooking fuel<sup>4</sup>
- **Majority of HH engage in fuel stacking and charcoal is the most common secondary fuel across all income levels** aside from the most wealthy given ubiquity across Nairobi and a cultural preference for charcoal cooking for dishes (e.g., meat grilling)

# Charcoal is particularly harmful as it contributes more to household air pollution, GHG emissions, and deforestation than other fuels

## A: Cooking Fuel Options in the Kenyan Market

|   | Wood   | Charcoal  | Kerosene   |
|---|--|---|--|
| <b>Health</b>   | <ul style="list-style-type: none"> <li>Deaths and DALYs due to household air pollution from PM 2.5</li> <li>Quality of life diminution due to other hard to quantify health effects (eye irritation, cataracts, child malnutrition)</li> </ul> <p><i>~2k avoidable deaths, 165k aDALYs</i></p> | <ul style="list-style-type: none"> <li>Deaths and DALYs due to household air pollution from PM 2.5</li> <li>Quality of life diminution due to other hard to quantify health effects (eye irritation, cataracts, child malnutrition)</li> </ul> <p><i>~3k avoidable deaths, ~250k aDALYs</i></p>   | <ul style="list-style-type: none"> <li>Deaths and DALYs due to household air pollution from PM 2.5</li> <li>Incremental unquantified kerosene health harms (e.g., cancers from polycyclic aromatic hydrocarbons)</li> <li>Poisonings and burns, particularly for women and kids (e.g., 40-60% of pediatric poisoning cases in Kenya due to kerosene)</li> </ul> <p><i>~2-3k avoidable deaths, ~160k aDALYs</i></p> |
| <b>Environment &amp; Climate costs</b>                | <ul style="list-style-type: none"> <li>GHG (CO<sub>2</sub>, Black Carbon, other global warming Kyoto Particles)</li> <li>Contributor to deforestation and, consequently, food insecurity</li> </ul> <p><i>2.5-4.4 tCO<sub>2</sub>eq / urban HH annually</i></p>                                | <ul style="list-style-type: none"> <li>Very high GHG emissions per household (CO<sub>2</sub>, Black Carbon, other global warming Kyoto Particles from charcoal production and use)</li> <li>Substantial driver of deforestation and, consequently, food insecurity</li> <li>Negative impacts on food security due to forest loss</li> </ul> <p><i>3.6-5 tCO<sub>2</sub>eq / urban HH annually</i></p> | <ul style="list-style-type: none"> <li>Relatively low GHG emissions per HH but still 2-3x higher than for truly clean fuels like LPG and Bio-ethanol</li> </ul> <p><i>1 tCO<sub>2</sub>eq / urban HH annually</i></p>  |
| <b>Social opportunity costs</b>                       | <ul style="list-style-type: none"> <li>Time opportunity cost (time poverty) due to fuel collection, slower cooking times, need to clean up charred cooking pots and pans</li> </ul> <p><i>0.8-1.3 avoidable hrs per day per urban HH</i></p>   | <ul style="list-style-type: none"> <li>Time opportunity cost (time poverty) due to slower cooking times, need to clean up charred cooking pots/pans,</li> </ul> <p><i>0.3-0.4 avoidable hrs per day per urban HH</i></p>  | <ul style="list-style-type: none"> <li>No time poverty effects vs. alternatives</li> <li>Property damage from urban fires due to kerosene cooking</li> </ul> <p><i>No time poverty impact</i></p>  |
| <b>Household economics and macro-economic effects</b> | <ul style="list-style-type: none"> <li>Foregone incomes due to avoidable time spent cooking/cleaning</li> <li>Tax revenue loss for government given informality of market</li> </ul>   | <ul style="list-style-type: none"> <li>Foregone incomes due to avoidable time spent cooking and cleaning</li> <li>Avoidable spending on relative inefficient and high-cost cooking fuel</li> <li>Tax revenue loss for government given informality of market</li> </ul>   | <ul style="list-style-type: none"> <li>Negative balance of payments effects due to kerosene imports</li> </ul>   |

A: Cooking Fuel Options in the Kenyan Market

**B: Potential of Bio-ethanol for Cooking in Kenya**

C: Bio-ethanol Policy Assessment

D: Risks and Opportunities

# Thus far little attention has been paid to Bio-ethanol as a clean and easy-to-use cooking fuel for the Kenyan population

## B: Potential of Bio-ethanol for Cooking in Kenya

### Bio-ethanol is a viable and scalable alternative cooking fuel



- **Low costs:** Lower upfront costs than LPG, and similar ongoing fuel cost to LPG and kerosene, despite VAT and import tariffs being levied on Bio-ethanol only
- **Affordable bundles:** Bio-ethanol can be sold in small “refill bundles”, critical to serving lower-income “kidogo economy” segments
- **Clean:** Bio-ethanol burns cleanly with low particulate emissions, like LPG
- **Sustainable:** Unlike firewood and charcoal, Bio-ethanol can be produced sustainably in Kenya

# V2.0 Case Study: Leveraging sales points, and mobile / cloud tech, KOKO's model delivers fuel closer and more cheaply to customers

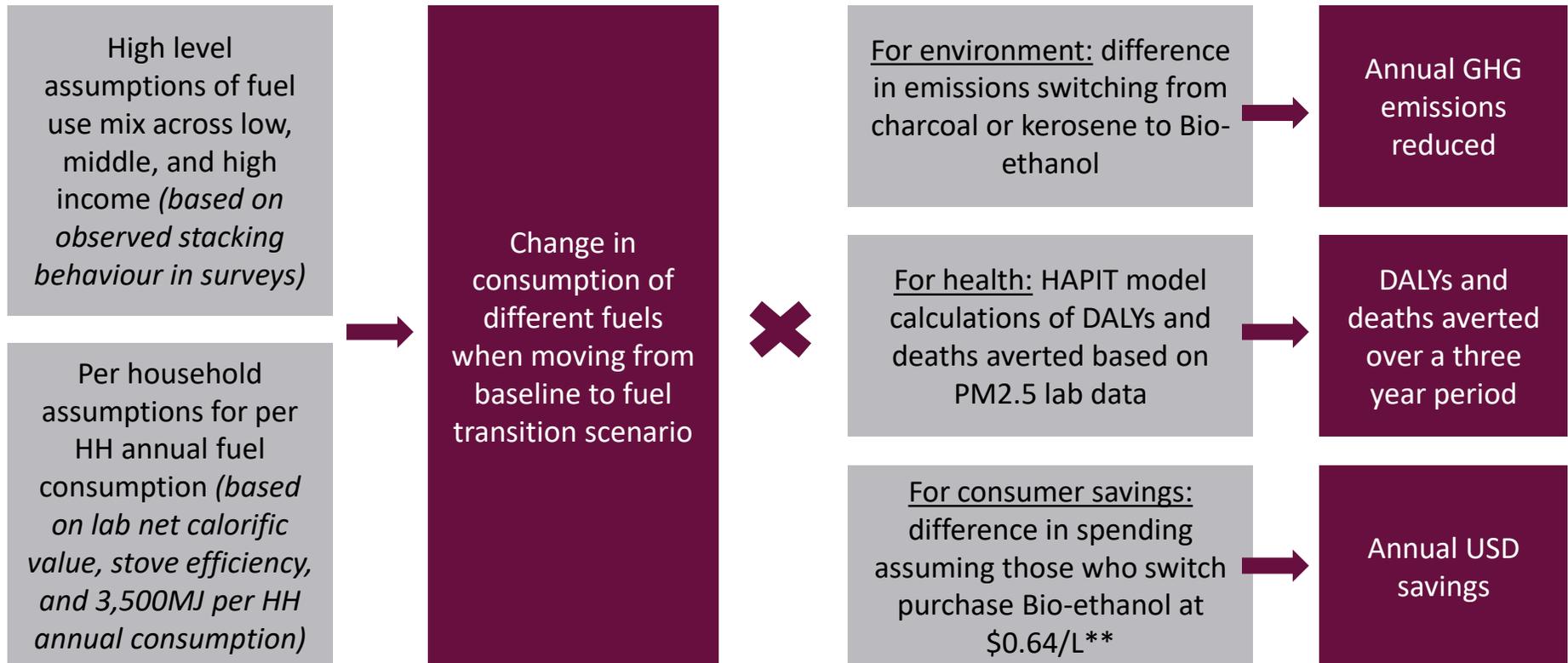
## B: Potential of Bio-ethanol for Cooking in Kenya



- Customers make upfront purchase of 1- or 2-burner Bio-ethanol stove, along with reusable 'Smart Canister'.
- KOKO's product offering provides consumers with an affordably-priced modern clean cooking solution.
- Stoves can be purchased with full amount paid upfront, or via layaway/savings programme whereby smaller deposits made over time (no difference to price).
- Vapor-tight "smart-valve" system ensures that the canister is the only way to obtain fuel from a KOKOpoint, or to add fuel to stove.
- Docking and valve system ensures that at no point is the customer exposed to the fuel itself.
- Optional customer smartphone app allows customers to manage accounts, share KOKO credit and earn money by signing up friends and family members.
- Referral programme incentivised through fuel credit and subsequently through direct mobile money payments for best customer promoters.

# Impact modelling methodology

## B: Potential of Bio-ethanol for Cooking in Kenya



**Analysis conducted for Nairobi**

\* We have used lab data here (despite its shortcomings) due to absence of reliable real-world data that controls for impact of ambient pollution

\*\* This retail price assumes zero VAT rating and no import tariffs

# Fuel consumption and expenditure at the household level: calculation and key assumptions

## B: Potential of Bio-ethanol for Cooking in Kenya

Annual cost of cooking = Annual HH fuel consumption x unit price to consumer

Annual HH fuel consumption = 3500MJ / (net calorific value x stove efficiency)

| Fuel        | Net calorific value (MJ/kg) * | Range of stove efficiencies from literature |     | Stove efficiency used for analysis | Average annual household fuel consumption (assuming 3,500MJ / HH annual consumption) | Price to consumer (USD) | Average annual cost of cooking (USD) (assuming 3,500MJ / HH annual consumption) |
|-------------|-------------------------------|---|-----|------------------------------------|--|-------------------------|---|
| LPG         | 46.6                          | 50%   | 60% | 55%                                | 137kg  | 1.70 / kg               | 233   |
| Kerosene    | 43.1                          | 25%   | 40% | 35%                                | 284L   | 0.79 / L                | 224   |
| Charcoal    | 28.2                          | 12%   | 43% | 21.9%                              | 569kg  | 0.40 / kg               | 228   |
| Bio-ethanol | 27.0                          | 58%   | 62% | 60%                                | 275L   | 0.82 / L                | 226   |

Source: LPG: Jeuland Fuel and Stove Survey 2012 (50-60%), Jeuland 2016 (53% average), GLPGA (55%); Kerosene Jeuland 2012 (25% - 40%); Charcoal: GACC Kenya cookstoves market assessment (12% and 20%); BURN (40%); Bio-ethanol: Project GAIA 2016; all: GACC Cookstove Database;

For pricing: KOKO Networks consumer surveys Nov 2016 to March 2018, Dalberg consumer survey Feb 2018, expert interviews

# Baseline: high-level fuel use assumptions

## B: Potential of Bio-ethanol for Cooking in Kenya

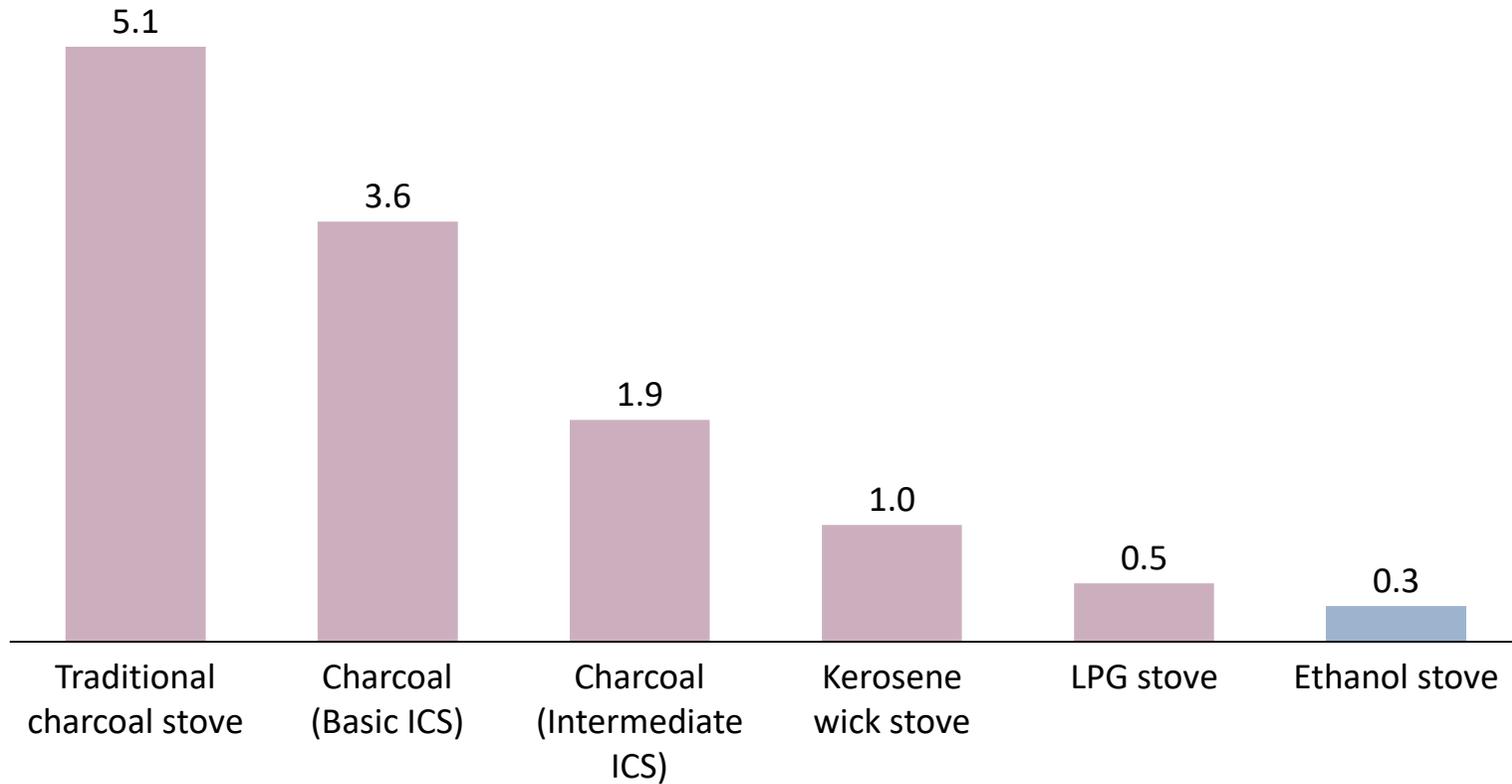
|                  | Low income     | Middle income     | High income   |
|------------------|----------------|-------------------|---------------|
| Definition       | <\$200 / month | \$200-500 / month | \$500 / month |
| Share of HH      | 50%            | 20%               | 30%           |
| # of HH          | 687,500        | 412,500           | 275,000       |
| LPG use (%)      | 0%             | 20%               | 60%           |
| Kerosene use (%) | 40%            | 50%               | 20%           |
| Charcoal (%)     | 60%            | 30%               | 20%           |
| Bio-ethanol (%)  | 0%             | 0%                | 0%            |

**In the absence of detailed data on primary and secondary fuel use, we have used high-level estimates based on observed stacking behavior and simplified by removing not considering fuels with negligible use**

# Environment impact: fuel/stove emissions data assumptions

## B: Potential of Bio-ethanol for Cooking in Kenya

Total CO<sub>2</sub>eq emissions (Kyoto particles + BC CO<sub>2</sub>eq) annually for fuel/stove combinations in urban areas  
*tonnes / year*

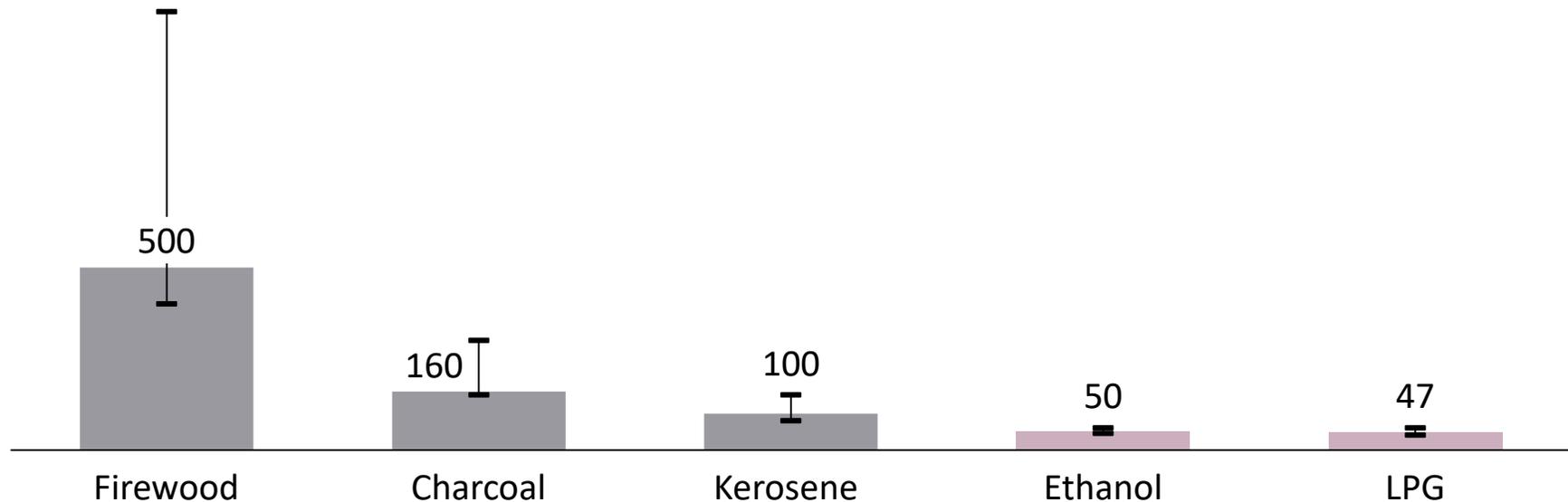


# Health impact: PM2.5 emissions assumptions

## B: Potential of Bio-ethanol for Cooking in Kenya

### PM2.5 Emissions by Fuel

*Average micrograms / cubic metre*



Note: Figures are averages based on wider literature and research since, as of March 2018, no personal exposure testing for all fuels has occurred in Nairobi  
Source: LPG: WHO Indoor Air Quality Guidelines; IPCBEE India Volume 10; Elsevier “Women’s Personal and Indoor Exposures to PM2.5 in Mysore”. Kerosene: “WHO Indoor Air Quality Guidelines: Household Fuel Combustion”, 2014; Charcoal: WHO Indoor Air Quality Guidelines; Clean Cookstoves 2015; Berkeley Air Monitoring 2015; GACC 2015; Project GAIA 2010; Firewood: Clean Cookstoves Testing 2015; Dalberg research

# Health impact: HAPIT calculations

## B: Potential of Bio-ethanol for Cooking in Kenya

| <b>Impact of charcoal users switching</b>     | <b>To LPG</b> | <b>To Bio-ethanol</b> |
|---|---------------|-----------------------|
| DALYs per 25,000                              | 6181          | 6050                  |
| DALYs per HH                                  | 0.25          | 0.24                  |
| Deaths averted per 25000                      | 58            | 52                    |
|   |               |                       |
| <b>Impact of kerosene users switching to:</b> | <b>To LPG</b> | <b>To Bio-ethanol</b> |
| DALYs per 25,000                              | 2651          | 2432                  |
| DALYs per HH                                  | 0.11          | 0.10                  |
| Deaths averted per 25000                      | 15            | 12                    |

Note: in reality, personal exposure levels of PM2.5 vary with e.g. ambient pollution levels, ventilation of cooking area in and condition of stove. In general studies find LPG and Bio-ethanol to be highly comparable in terms of beneficial health effects

Source: HAPIT model – Inputs take the pre-intervention exposure to be based on average PM2.5 data by fuel, and take the counterfactual exposure to be 10, in line with the HAPIT model's default assumptions. An important caveat for this data is that personal exposure testing in Nairobi is minimal, particularly for Bio-ethanol; Data: LPG: WHO Indoor Air Quality Guidelines; IPCBEE India Volume 10; Elsevier “Women’s Personal and Indoor Exposures to PM2.5 in Mysore”. Kerosene: “WHO Indoor Air Quality Guidelines: Household Fuel Combustion”, 2014; Charcoal: WHO Indoor Air Quality Guidelines; Clean Cookstoves 2015; Berkeley Air Monitoring 2015; GACC 2015; Project GAIA 2010; Firewood: Clean Cookstoves Testing 2015

A: Cooking Fuel Options in the Kenyan Market

B: Potential of Bio-ethanol for Cooking in Kenya

**C: Bio-ethanol Policy Assessment**

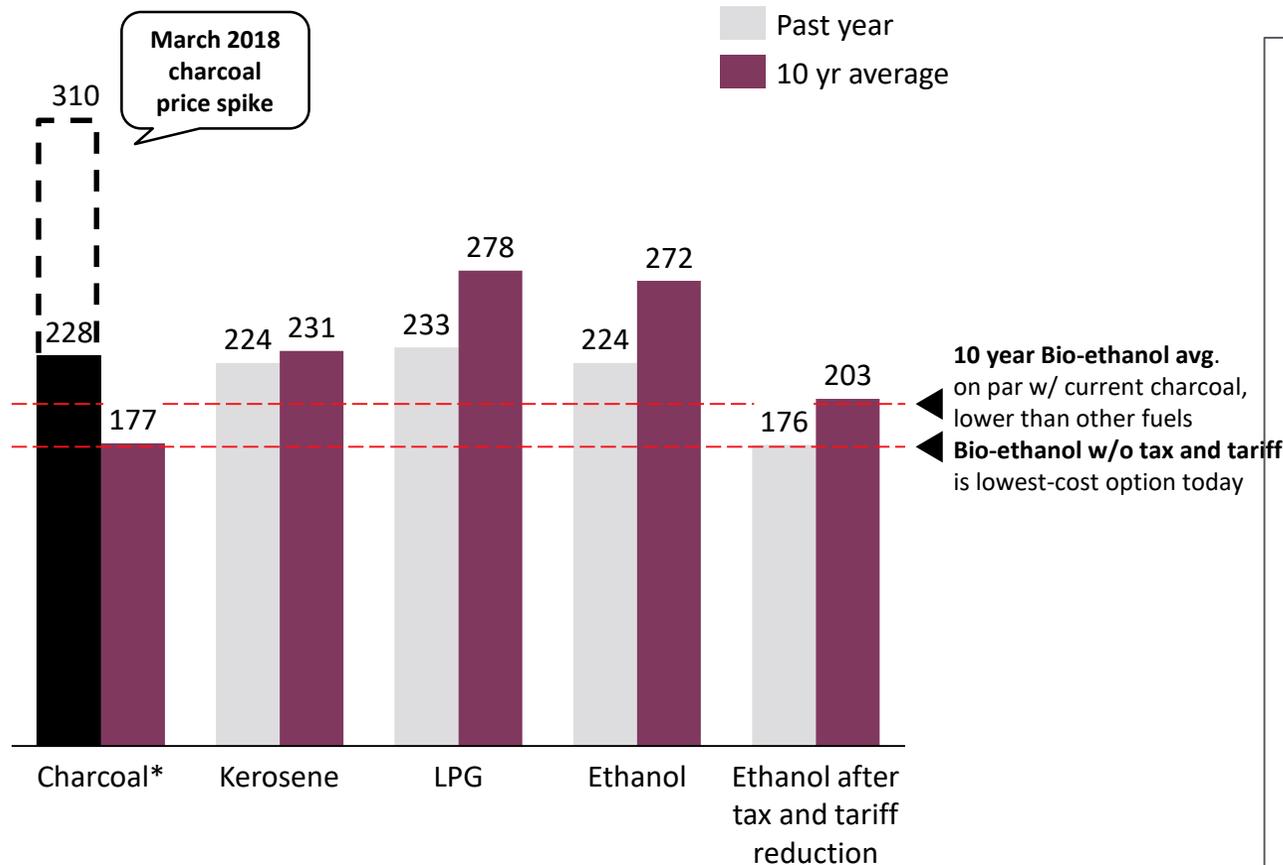
D: Risks and Opportunities

# Without taxes/tariffs the 10-year average price of Bio-ethanol is lower than those of LPG and kerosene, and 20% cheaper than charcoal's today

## C: Bio-ethanol Policy Assessment

Average annual fuel expenditure by fuel type to meet 3,500 MJ fuel consumption of a typical Nairobi household<sup>1</sup>

USD / year



- Bio-ethanol is a global commodity with prices that fluctuate over time and in the past have been up to 50% higher than today
- However, even over long term, tax/duty free Bio-ethanol would have been a lower cost fuel vs. LPG and kerosene
- With taxes and tariffs removed, even if global Bio-ethanol prices reverted to historical mean, Bio-ethanol would be cheaper than today's charcoal
- While charcoal has been cheaper in the past, its prices continue to trend upwards in Kenya

\* \$198 over past year assuming \$0.40/kg average for tin of 4kg; in recent month prices have spiked up to 0.46-5/kg, 0.46/kg yields \$226 cooking budget

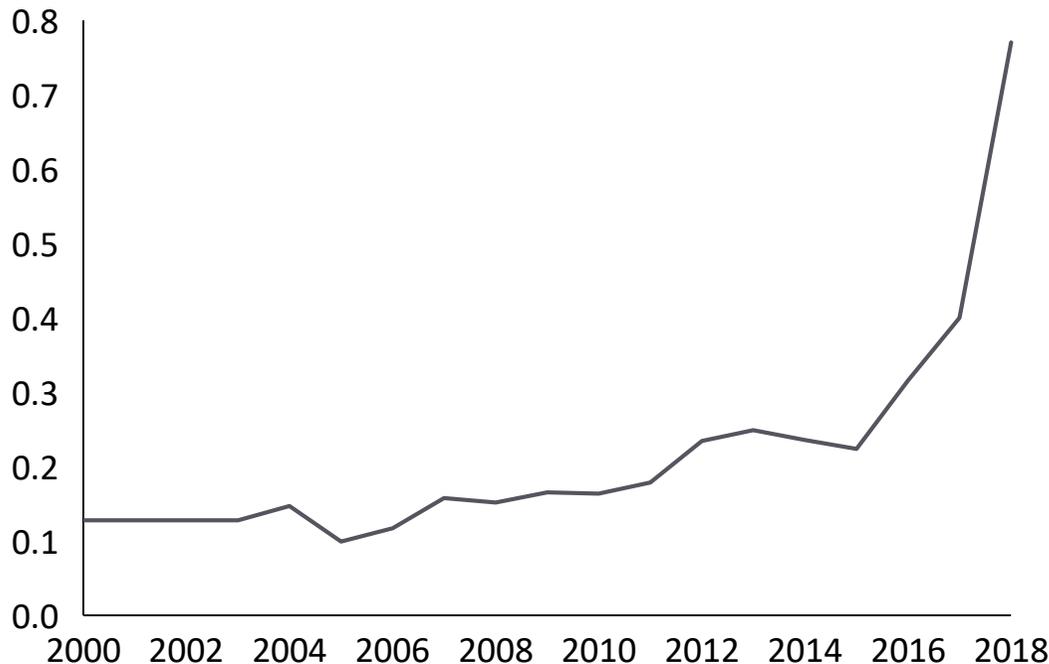
Source: Renetech 2017; TERI 2016; Kenya institute for Public Policy Research and Analysis 2010; KOKO Networks consumer research 2017; Dalberg Analysis

# Recent spikes in local Kenyan charcoal prices have reinforced the need for cheaper alternatives for the lowest income users

## C: Bio-ethanol Policy Assessment

### Average annual charcoal prices 2000 - 2018

2017 USD / kg



- The **price of charcoal has been trending upwards since mid 2005**
- Recent increases have been even more dramatic as a result of **local government commitments to curb illegal logging**
- Given the **lowest-income Kenyans'** disproportionate dependence on charcoal, they will be the ones to **suffer the most**

**While these conditions may be temporary, the situation reinforces the need for a cheaper, cleaner and reliable alternative to charcoal**

A: Cooking Fuel Options in the Kenyan Market

B: Potential of Bio-ethanol for Cooking in Kenya

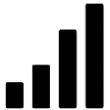
C: Bio-ethanol Policy Assessment

**D: Risks and Opportunities**

# The potential risks of cooking Bio-ethanol transition flagged by government stakeholders in our consultations are over-estimated and largely addressable

## D: Risks and Opportunities

- 1 Tax revenue**  

  - **Largest potential impact is tax revenues from kerosene** used for cooking as users shift to Bio-ethanol; however, the **government is already encouraging users to switch from kerosene**
  - **Tax revenues collected from Bio-ethanol used for cooking are negligible and charcoal is untaxed** and often produced informally<sup>1</sup>
- 2 Trade balance**  

  - **Potential negative impact of ~USD 60 mn annually** if all of Nairobi's cooking Bio-ethanol imported
  - **As domestic production develops, this will decrease**
- 3 Jobs**  

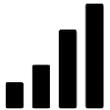
  - **Short-term negative impact on charcoal industry** as charcoal users substitute Bio-ethanol
  - However, **these jobs are low quality, low paying, and highly seasonal**<sup>2</sup>
  - Furthermore, the **government is already curbing production** of and encouraging users to switch from charcoal, so has already accepted the risk to these jobs
- 4 Food security**  

  - Argument around impact of Bio-ethanol production on food security is weak and has not been observed in other cases
  - **Kenya has abundant land suitable for sugarcane production, of which only a small percentage (~1%) would be needed for Bio-ethanol production**<sup>3</sup>
  - The land requirement is even lower when production processes are made more efficient

# In fact, for most potential risks raised, there are potential opportunities for strengthening the economy

## D: Risks and Opportunities

- 1 Tax revenue**  

  - **Domestic Bio-ethanol production has the potential to increase tax revenues in the long-run** as formal, income tax-paying jobs are created in the domestic Bio-ethanol industry
- 2 Trade balance**  

  - In the future, **domestically produced Bio-ethanol could replace imported kerosene**, improving the trade balance
  - **With enough investment into domestic production, Kenya could one day be a regional net exporter of Bio-ethanol** (vs. imports from Sudan, Mauritius, and Pakistan)
- 3 Jobs**  

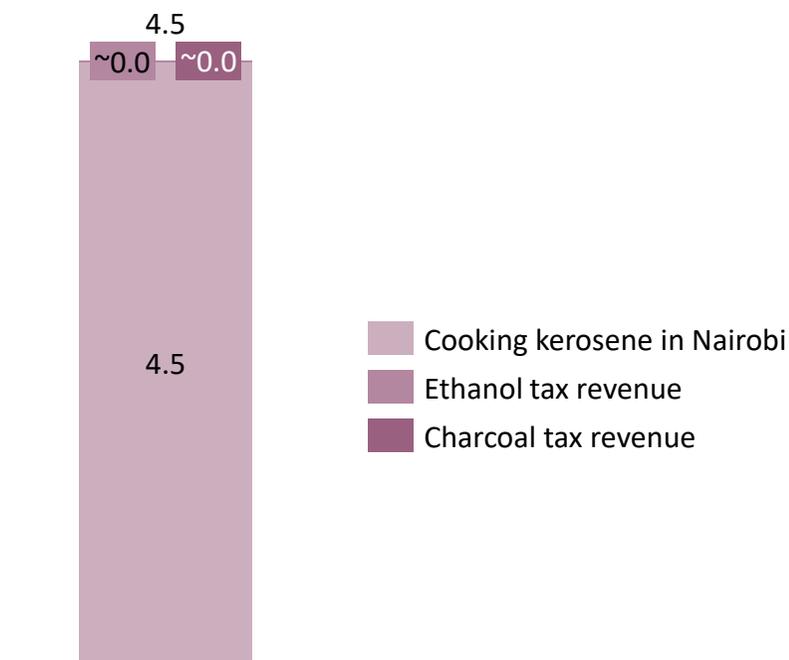
  - **Domestic Bio-ethanol industry will deliver better-paying, formal jobs** along the Bio-ethanol value chain, from farmers to distributors
  - Depending on business models adopted, an industry serving 500,000 customers could create **40-70K new jobs, generating USD 17-35mn in incremental incomes**
- 4 Food security**  

  - **Reducing charcoal use could enhance food security**
  - **~90% of charcoal for cooking is harvested from non-renewable forests**, driving food insecurity through negative impacts on water cycles and land degradation

# 1 The government stands to lose up to USD 4.5mn per year from foregone kerosene tax revenues – but this is consistent with the kerosene campaign

## Estimated yearly tax revenue from fuel imports

Mn USD/year



Estimated imported volumes for Nairobi: ~60mn litres of kerosene per annum

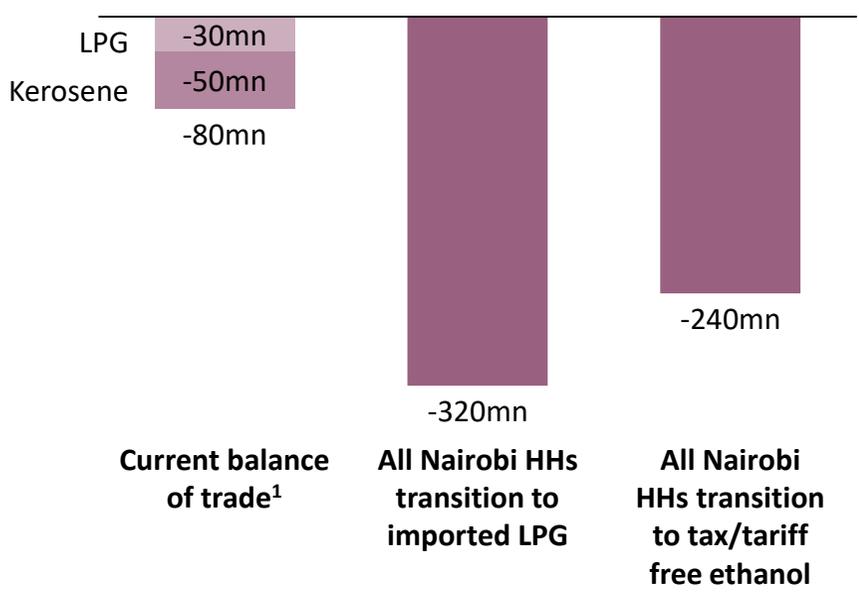
**Main potential loss of tax revenues is from kerosene imports; however, the government is already working to curb the use kerosene**

- Replacing all of the kerosene estimated to be used for cooking could result in a loss of up to \$4.5mn per year
- **Loss of kerosene revenues is an expected outcome of the government's Kerosene Free Kenya campaign** in any case and would only represent <0.1% of tax revenues
- Tax revenues collected from Bio-ethanol used for cooking are negligible and charcoal is untaxed and often produced informally

## 2 Loss of kerosene revenues are minimal; whilst initial balance of trade effects of imported Bio-ethanol will be negative, a domestic industry will lessen this

### Balance of trade from Nairobi cooking fuels

Mn USD / year



Estimated imported volumes for Nairobi: 125mn litres of kerosene and 32,000 tonnes of LPG / year

**While a negative impact on the trade balance is likely in the short-term, a full transition to Bio-ethanol without taxes and tariffs would have a smaller impact on the trade deficit than one to LPG**

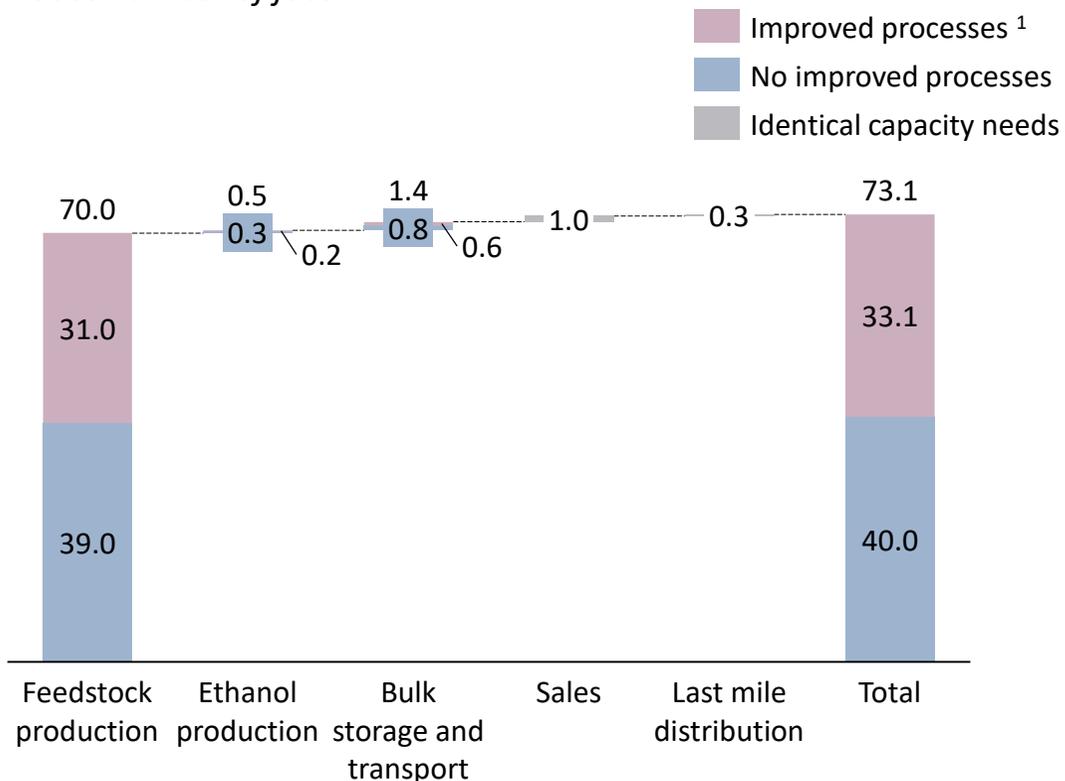
- Based on our modeling, the current trade balance for importing kerosene and LPG for cooking in Nairobi would be (-) ~USD180mn/year
- **A full transition of Nairobi households to LPG could exacerbate this by ~\$180mn, while a full transition to Bio-ethanol could exacerbate this by ~\$240mn**
- Unlike with kerosene or LPG, **there is a credible opportunity for developing a domestic Bio-ethanol industry**
- This would improve the trade balance in the long-run and could even transform Kenya into a net exporter of Bio-ethanol

(1) Charcoal is not taxed as is largely informal, and therefore not included here  
 Source: World Bank government data 2015; Kenyan tax and tariff schedule 2017; Dalberg analysis

### 3 An Bio-ethanol transition will support >70,000 jobs and boost incomes across value chain, particularly once demand for domestic Bio-ethanol is unlocked

#### Potential jobs created through domestic Bio-ethanol production

000s number of jobs



**When market reaches 500k Bio-ethanol cooking customers, using 54mn litres of locally produced Bio-ethanol per year, 40-70K jobs would support cooking ethanol value chain:**

- Lower range of job creation explained by potential efficiencies in Bio-ethanol production that could deliver an additional 30 mn litres<sup>1</sup>
- **Jobs will be displaced in charcoal value chain, particularly for charcoal producers, but this same displacement will result from the government’s encouragement of a transition to LPG**
- Furthermore, **charcoal jobs are low quality/income and economically and environmentally unsustainable in the long-term**

**Potential for a domestic industry that creates jobs is unique for Bio-ethanol among alternative fuels**

Note: Last mile distribution and sales are unaffected by improved upstream production processes and therefore same impact on jobs expected

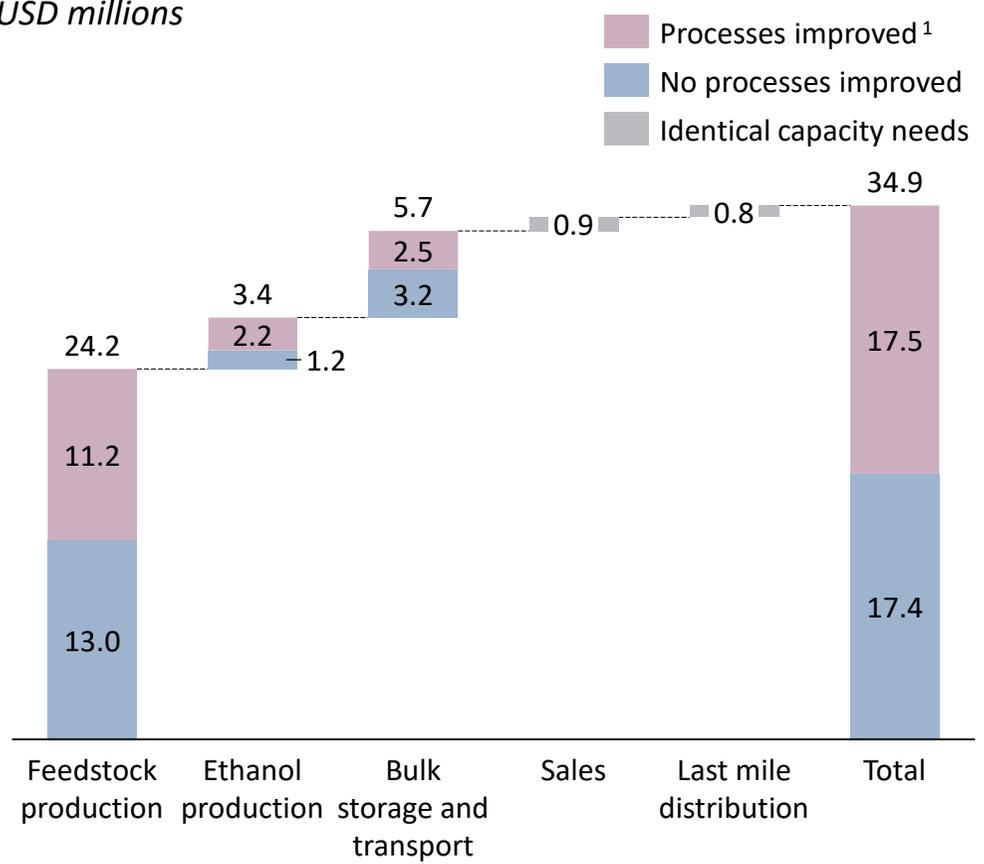
<sup>1</sup> Mismanagement of Bio-ethanol production process means factories run below capacity; many processing plants run at just 25% capacity. Improved processes could add up to 30mn litres of denatured technical Bio-ethanol per year using existing capacity and infrastructure

Source: Praj Industries; KOKO Networks; Food and Agriculture Data 2017 Sugarcane Yield by Country; Dalberg analysis

# 3 This could result in an additional \$35mn of additional income, particularly for smallholder farmers producing sugarcane

## Potential incremental incomes generated through domestic Bio-ethanol production

USD millions



**When market reaches 500k Bio-ethanol cooking customers, using 54mn litres of locally produced Bio-ethanol per year, USD 17-35mn in incomes and profits could be generated**

- This estimation uses a conservative median price for sugarcane, as feedstock incomes will vary with commodity prices
- **In the case of the KOKO last mile distribution model, an additional USD 1,000 – 1,500 taxable income could be generated per distribution point, translating into a total of USD 2mn – 3mn per year (assuming 2,000 distribution points)**

Note: Last mile distribution and sales are unaffected by improved upstream production processes and therefore same impact on incomes expected

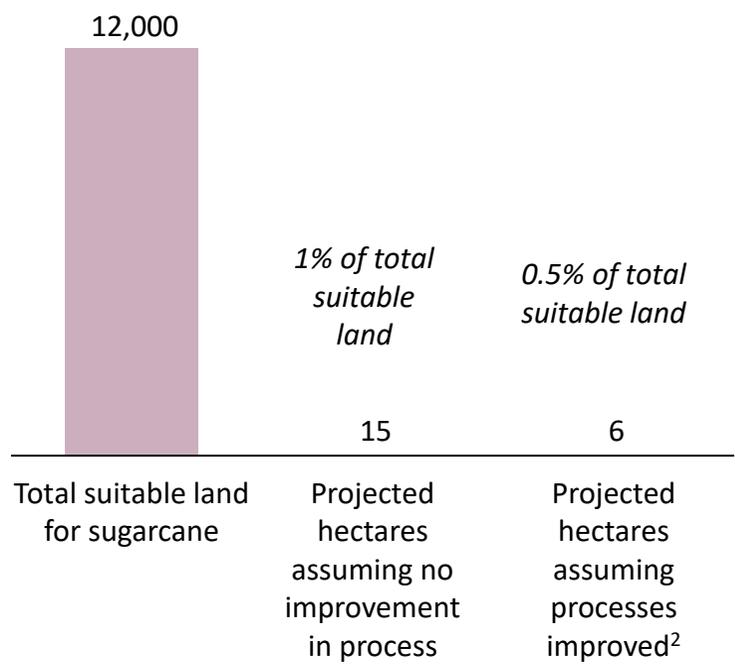
1 Mismanagement of Bio-ethanol production process means factories run below capacity; many processing plants run at just 25% capacity. Improved processes could add up to 30mn litres of denatured technical Bio-ethanol per year using existing capacity and infrastructure

Source: Praj Industries; KOKO Networks; Food and Agriculture Data 2017 Sugarcane Yield by Country; Dalberg analysis

# 4 Food security: Up to 30 mm litres of Bio-ethanol could be produced through more efficient processes, whilst Kenya has surplus land to meet requirements

## Additional hectares of sugarcane required to meet potential Bio-ethanol demand

000s hectares



**At most, ~1% of land suitable for planting sugarcane would be needed to meet the estimated Bio-ethanol demand of Nairobi<sup>1</sup>**

- Additional land needed would not encroach on land for food or livestock, as Kenya has abundant viable land currently not in use
- **Sugarcane in Kenya is not used for food**, and therefore would not redirect grains that could be used for food

**Domestic production of Bio-ethanol could even improve food security by reducing charcoal-related deforestation and climate change, which reduces agricultural potential**

Note: Mismanagement of Bio-ethanol production process means factories run below capacity; many processing plants run at just 25% capacity. Improved processes could add up to 30mn liters of denatured technical Bio-ethanol per year using existing capacity and infrastructure

Source: (1) Ndegwa et al, "Potential for Biofuel Feedstock in Kenya", 2011; (2) Expert interviews including Praj Industries

# Jobs impact assumptions

## D: Risks and Opportunities

| Item   | Full Production needs | Improved Processes |
|--|-----------------------|--------------------|
| <b>Feedstock production</b>                              |                       |                    |
| Average size of SHF (Ha) <sup>1</sup>                    | 0.47                  | 0.47               |
| Tonnes of sugarcane / hectare of land (T/Ha)             | 65                    | 65                 |
| L of Bio-ethanol / tonne of sugarcane (L/T) <sup>2</sup> | 75                    | 75                 |
| L of Bio-ethanol / hectare of land (L/Ha)                | 4875                  | 4875               |
| Total hectares of land needed (Ha) <sup>3</sup>          | 11077                 | 4923               |
| Average # of adults per farm                             | 3                     | 3                  |
| Average SHF revenue / tonne of sugar cane (USD/tonne)    | 35                    | 35                 |
| Average annual yield of sugarcane (Tonnes/hectare)       | 65                    | 65                 |
| <b>Bio-ethanol production</b>                            |                       |                    |
| Annual capacity of large processing plants (L)           | 12,000,000            | 12,000,000         |
| # of staff / plant                                       | 100                   | 100                |
| Monthly income for staff in plants (USD)                 | 400                   | 400                |

| Item   | Full production needs | Improved processes |
|--|-----------------------|--------------------|
| <b>Bulk storage and logistics<sup>4</sup></b>        |                       |                    |
| Size of storage facilities (L)                       | 20,000                | 20,000             |
| Number of staff per storage facility                 | 0.5                   | 0.5                |
| Monthly income for staff in storage facilities (USD) | 350                   | 350                |
| <b>Last mile distribution <sup>4</sup></b>           |                       |                    |
| Capacity of transport tankers (L) <sup>4</sup>       | 2000                  | 2000               |
| # of tankers   | 65                    | 65                 |
| # of petrol stations                                 | 60                    | 60                 |
| # of staff per petrol station                        | 2                     | 2                  |
| # of staff per tanker                                | 2                     | 2                  |
| Monthly income for transport staff (USD)             | 250                   | 250                |
| <b>Sales</b>   |                       |                    |
| # of KOKO points                                     | 2000                  | 2000               |
| # of agents / KOKO point                             | 0.5                   | 0.5                |
| Income per KP (USD)                                  | 150                   | 150                |

Note: Based on expert interviews, mismanagement of Bio-ethanol production process means factories run below capacity; many processing plants run at just 25% capacity. Improved processes could add up to 30mn liters of denatured technical Bio-ethanol per year using existing capacity and infrastructure

Source: (1) FAO, "Economic lives of smallholder farmers", 2015; Humanosphere, "Souring Sugar Industry in Kenya", 2017; (3) Calculation based on expert interviews and sources (1) and (2) with land to produce 1L of ethanol; (4) KOKO Networks processing data; expert interviews include: Praj Industries, Lake Oil